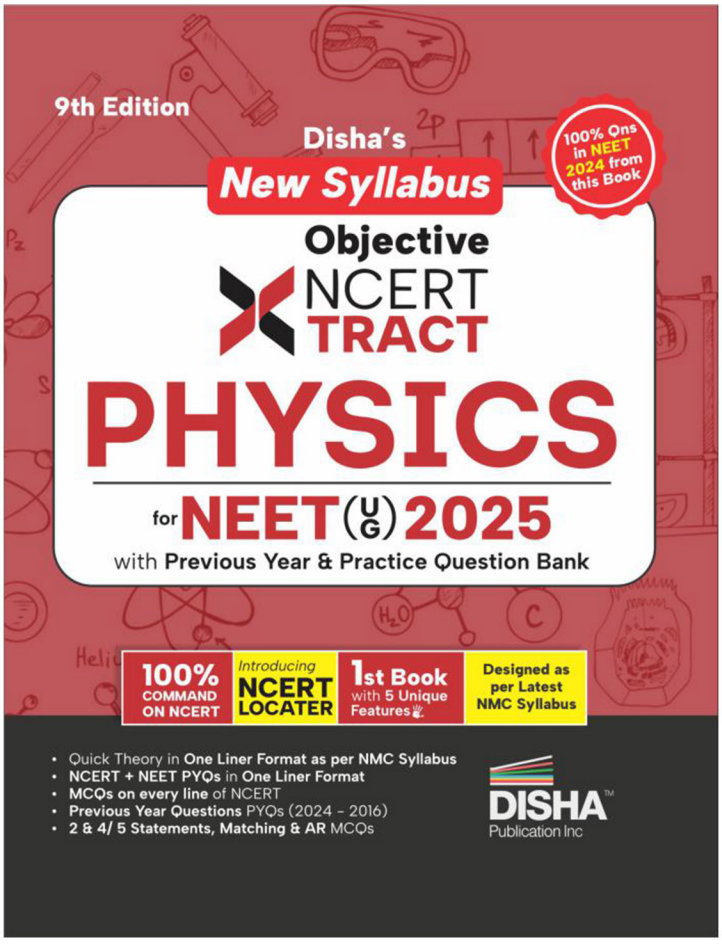
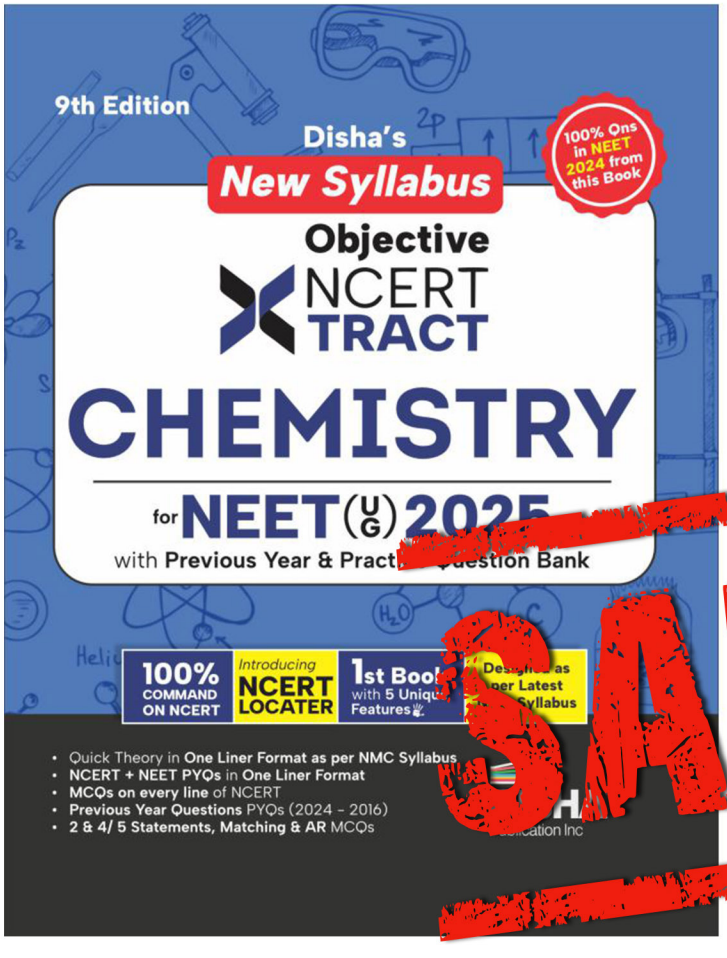
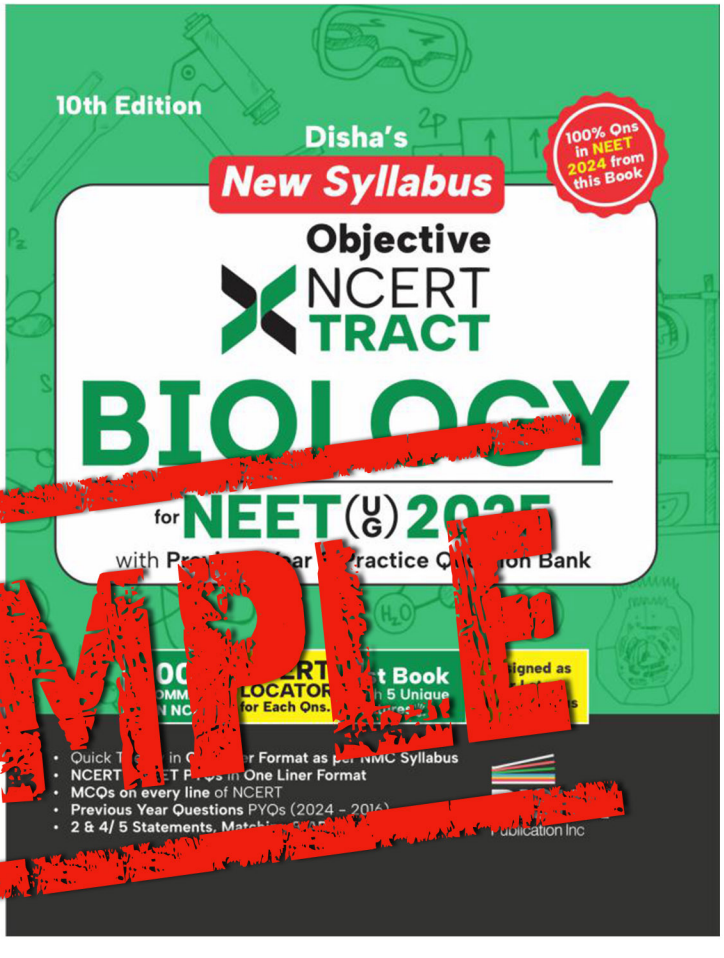

9th Edition
Disha's
New Syllabus
100% Qns in NEET 2024 from this Book
Objective
NCERT TRACT
PHYSICS
for NEET (UG) 2025
with Previous Year & Practice Question Bank
100% COMMAND ON NCERT
Introducing NCERT LOCATER
1st Book with 5 Unique Features
Designed as per Latest NMC Syllabus
Quick Theory in One Liner Format as per NMC Syllabus
NCERT + NEET PYQs in One Liner Format
MCQs on every line of NCERT
Previous Year Questions PYQs (2024 - 2016)
2 & 4/ 5 Statements, Matching & AR MCQs
DISHA
Publication Inc


9th Edition
Disha's
New Syllabus
100% Qns in NEET 2024 from this Book
Objective
NCERT TRACT
CHEMISTRY
for NEET (UG) 2025
100% COMMAND ON NCERT
Introducing NCERT LOCATER
Quick Theory in One Liner Format as per NMC Syllabus
NCERT + NEET PYQs in One Liner Format
MCQs on every line of NCERT
Previous Year Questions PYQs (2024 - 2016)
2 & 4/ 5 Statements, Matching & AR MCQs


10th Edition
Disha's
New Syllabus
100% Qns in NEET 2024 from this Book
Objective
NCERT TRACT
BIOLOGY
for NEET (UG) 2025

9th Edition

Disha's

New Syllabus

100% Qns in NEET 2024 from this Book

Objective NCERT TRACT

PHYSICS

for NEET (UG) 2025

with Previous Years & Practice Question Bank

100% COMMAND ON NCERT	Introducing NCERT LOCATOR	Best Book with 5 Unique Features	Designed as per Latest NMC Syllabus

- Quick Theory in **One Liner Format as per NMC Syllabus**
- **NCERT + NEET PYQs** in **One Liner Format**
- **MCQs on every line** of NCERT
- **Previous Year Questions** PYQs (2024 – 2016)
- **2 & 4/ 5 Statements, Matching & AR** MCQs

DISHA™
Publication Inc

DISHA Publication Inc.

A-23 FIEE Complex, Okhla Phase II

New Delhi-110020

Tel: 49842349/ 49842350

Edited By

Sanjeev Kumar Jha

Govind Thakur

Typeset By

DISHA DTP Team

Buying Books from Disha is always Rewarding

This time we are appreciating your writing Creativity.

Write a review of the product you purchased on Amazon/Flipkart

Take a screen shot / Photo of that review

Scan this QR Code ➔

Fill Details and submit | That's it ... Hold tight n wait.
At the end of the month, you will get a surprise gift from Disha Publication

Scan this QR code

Write To Us At

feedback_disha@aiets.co.in

DISHA™ Publication Inc

www.dishapublication.com

For future updates on NEET Scan the QR Code.
https://bit.ly/neet_exam_update
You also get Latest Syllabus, Past NEET Papers, Mock Tests and more content here.

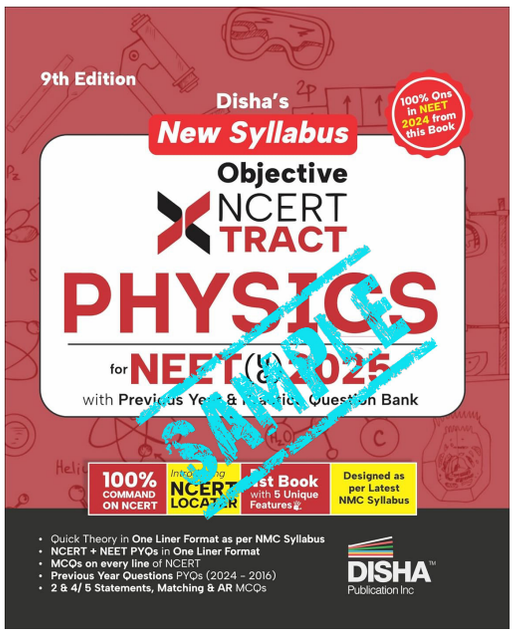
Free Sample Contents

Class XI

5. Work, Energy and Power **A69 – A87**

- Trend Analysis
- NCERT One-Liners
- 5.1 Introduction
- 5.2 Notions of Work and Kinetic Energy: The Work-energy Theorem
- 5.3 Work
- 5.4 Kinetic Energy
- 5.5 Work Done by a Variable Force
- 5.6 The Work-Energy Theorem for a Variable Force
- 5.7 The Concept of Potential Energy
- 5.8 The Conservation of Mechanical Energy
- 5.9 The Potential Energy of a Spring
- 5.10 Power
- 5.11 Collisions
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

This sample book is prepared from the book **"Disha's New Syllabus Objective NCERT Xtract Physics for NEET (UG) 2025 with Previous Year & Practice Question Bank 9th Edition | One Liner Theory, Tips on your Fingertips, PYQs | 3 Mock Tests ".**



ISBN - 978-9362251046

MRP- 925/-

In case you like this content, you can buy the **Physical Book** or **E-book** using the ISBN provided above.

The book & e-book are available on all leading online stores.

CONTENTS

Class XI

A1–A238

1. Units and Measurements A1 – A15
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 1.1 Introduction
- 1.2 The International System of Units
- Errors in measurement
- 1.3 Significant Figures
- 1.4 Dimensions of Physical Quantities
- 1.5 Dimensional Formulae and Dimensional Equations
- 1.6 Dimensional Analysis and its Applications
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

2. Motion in a Straight Line A16 – A32
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 2.1 Introduction
- Position, Path Length and Displacement
- 2.2 Instantaneous Velocity and Speed
- 2.3 Acceleration
- 2.4 Kinematic Equations for Uniformly Accelerated Motion
- Relative Velocity
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

3. Motion in a Plane A33 – A50
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 3.1 Introduction
- 3.2 Scalars and Vectors
- 3.3 Multiplication of Vectors by Real Numbers
- 3.4 Addition and Subtraction of Vectors-Graphical Method
- 3.5 Resolution of Vectors
- 3.6 Vector Addition-Analytical Method
- 3.7 Motion in a Plane
- 3.8 Motion in a Plane with Constant Acceleration
- Relative Velocity in Two Dimensions
- 3.9 Projectile Motion
- 3.10 Uniform Circular Motion
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

4. Laws of Motion A51 – A68
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 4.1 Introduction
- 4.2 Aristotle's Fallacy
- 4.3 The Law of Inertia
- 4.4 Newton's First Law of Motion
- 4.5 Newton's Second Law of Motion
- 4.6 Newton's Third Law of Motion
- 4.7 Conservation of Momentum
- 4.8 Equilibrium of a Particle
- 4.9 Common Forces in Mechanics
- 4.10 Circular Motion
- 4.11 Solving Problems in Mechanics
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

5. Work, Energy and Power A69 – A87
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 5.1 Introduction
- 5.2 Notions of Work and Kinetic Energy: The Work-energy Theorem
- 5.3 Work
- 5.4 Kinetic Energy
- 5.5 Work Done by a Variable Force
- 5.6 The Work-Energy Theorem for a Variable Force
- 5.7 The Concept of Potential Energy
- 5.8 The Conservation of Mechanical Energy
- 5.9 The Potential Energy of a Spring
- 5.10 Power
- 5.11 Collisions
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

6. System of Particles and Rotational Motion A88 – A106
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 6.1 Introduction
- 6.2 Centre of Mass
- 6.3 Motion of Centre of Mass
- 6.4 Linear Momentum of a System of Particles
- 6.5 Vector Product of Two Vectors
- 6.6 Angular Velocity and its Relation with Linear Velocity
- 6.7 Torque and Angular Momentum
- 6.8 Equilibrium of a Rigid Body
- 6.9 Moment of Inertia
- Theorems of Perpendicular and Parallel Axes
- 6.10 Kinematics of Rotational Motion about a Fixed Axis
- 6.11 Dynamics of Rotational Motion About a Fixed Axis
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

7. Gravitation A107 – A122
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 7.1 Introduction
- 7.2 Kepler's Laws
- 7.3 Universal Law of Gravitation
- 7.4 The Gravitational Constant
- 7.5 Acceleration Due to Gravity of the Earth
- 7.6 Acceleration due to Gravity below and above the Surface of Earth
- 7.7 Gravitational Potential Energy
- 7.8 Escape Speed
- 7.9 Earth Satellites
- 7.10 Energy of an Orbiting Satellite
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

8. Mechanical Properties of Solids A123 – A134
- ➲ Trend Analysis
- ➲ NCERT One-Liners
- 8.1 Introduction
- Elastic Behaviour of Solids
- 8.2 Stress and Strain
- 8.3 Hooke's Law
- 8.4 Stress-Strain Curve
- 8.5 Elastic Modulii
- 8.6 Applications of Elastic Behaviour of Materials
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4*

9. Mechanical Properties of Fluids **A135 – A151**
- Trend Analysis
- NCERT One-Liners
- 9.1 Introduction
- 9.2 Pressure
- 9.3 Streamline Flow
- 9.4 Bernoulli's Principle
- 9.5 Viscosity
- 9.6 Surface Tension
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

10. Thermal Properties of Matter **A152 – A169**
- Trend Analysis
- NCERT One-Liners
- 10.1 Introduction
- 10.2 Temperature and Heat
- 10.3 Measurement of Temperature
- 10.4 Ideal-gas Equation and Absolute Temperature
- 10.5 Thermal Expansion
- 10.6 Specific Heat Capacity
- 10.7 Calorimetry
- 10.8 Change of State
- 10.9 Heat Transfer
- 10.10 Newton's Law cooling
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

11. Thermodynamics **A170 – A185**
- Trend Analysis
- NCERT One-Liners
- 11.1 Introduction
- 11.2 Thermal Equilibrium
- 11.3 Zeroth Law of Thermodynamics
- 11.4 Heat, Internal Energy and Work
- 11.5 First Law of Thermodynamics
- 11.6 Specific Heat Capacity
- 11.7 Thermodynamic State Variables and Equation of State
- 11.8 Thermodynamic Processes
- 11.9 Second Law of Thermodynamics
- 11.10 Reversible and Irreversible Processes
- 11.11 Carnot Engine
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

12. Kinetic Theory **A186 – A199**
- Trend Analysis
- NCERT One-Liners
- 12.1 Introduction
- 12.2 Molecular Nature of Matter
- 12.3 Behaviour of Gases
- 12.4 Kinetic Theory of an Ideal Gas
- 12.5 Law of Equipartition of Energy
- 12.6 Specific Heat Capacity
- 12.7 Mean Free Path
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

13. Oscillations **A200 – A214**
- Trend Analysis
- NCERT One-Liners
- 13.1 Introduction
- 13.2 Periodic and Oscillatory Motions
- 13.3 Simple Harmonic Motion
- 13.4 Simple Harmonic Motion and Uniform Circular Motion
- 13.5 Velocity and Acceleration in Simple Harmonic Motion
- 13.6 Force Law for Simple Harmonic Motion
- 13.7 Energy in Simple Harmonic Motion
- 13.8 The Simple Pendulum
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

14. Waves **A215 – A230**
- Trend Analysis
- NCERT One-Liners
- 14.1 Introduction
- 14.2 Transverse and Longitudinal Waves
- 14.3 Displacement Relation in a Progressive Wave
- 14.4 The Speed of a Travelling Wave
- 14.5 The Principle of Superposition of Waves
- 14.6 Reflection of Waves
- 14.7 Beats
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

15. Experimental Skills in Physics (XI) **A231 – A238**

Note : * The four Exercises in each of the chapters are :
- Exercise 1 : NCERT Based Topic-wise MCQs
- Exercise 2 : NCERT Exempler & Past Years NEET
- Exercise 3 : Matching Statements & Assertion Reason Type
- Exercise 4 : Skill Enhancer MCQs

Hints & Solutions (Class 11th) A239–A342

1. Units and Measurements A239 – A245
2. Motion in a Straight Line A246 – A253
3. Motion in a Plane A254 – A260
4. Laws of Motion A261 – A268
5. Work, Energy and Power A269 – A279
6. System of Particles and Rotational Motion A280 – A287
7. Gravitation A288 – A294
8. Mechanical Properties of Solids A295 – A299
9. Mechanical Properties of Fluids A300 – A305
10. Thermal Properties of Matter A306 – A312
11. Thermodynamics A313 – A319
12. Kinetic Theory A320 – A325
13. Oscillations A326 – A333
14. Waves A334 – A340
15. Experimental Skills in Physics (XI) A341 – A342

Class XII

B1–B226

1. Electric Charges and Fields B1 – B19

- Trend Analysis
- NCERT One-Liners
- 1.1 Introduction
- 1.2 Electric Charge
- 1.3 Conductors and Insulators
- 1.4 Basic Properties of Electric Charge
- 1.5 Coulomb's Law
- 1.6 Forces between Multiple Charges
- 1.7 Electric Field
- 1.8 Electric Field Lines
- 1.9 Electric Flux
- 1.10 Electric Dipole
- 1.11 Dipole in a Uniform External Field
- 1.12 Continuous Charge Distribution
- 1.13 Gauss's Law
- 1.14 Applications of Gauss's Law
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

2. Electrostatic Potential and Capacitance B20 – B39

- Trend Analysis
- NCERT One-Liners
- 2.1 Introduction
- 2.2 Electrostatic Potential
- 2.3 Potential due to a Point Charge
- 2.4 Potential due to an Electric Dipole
- 2.5 Potential due to a System of Charges
- 2.6 Equipotential Surfaces
- 2.7 Potential Energy of a System of Charges
- 2.8 Potential Energy in an External Field
- 2.9 Electrostatics of Conductors
- 2.10 Dielectrics and Polarisation
- 2.11 Capacitors and Capacitance
- 2.12 The Parallel Plate Capacitor
- 2.13 Effect of Dielectric on Capacitance
- 2.14 Combination of Capacitors
- 2.15 Capacitors in Parallel
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

3. Current Electricity B40 –B58

- Trend Analysis
- NCERT One-Liners
- 3.1 Introduction
- 3.2 Electric Current
- 3.3 Electric Currents in Conductors
- 3.4 OHM's Law
- 3.5 Drift of Electrons and the Origin of Resistivity
- 3.6 Limitations of OHM's Law
- 3.7 Resistivity of Various Materials
- 3.8 Temperature Dependence of Resistivity
- 3.9 Electrical Energy, Power
- Combination of Resistors – Series and Parallel
- 3.10 Cells, EMF, Internal Resistance
- 3.11 Cells in Series and in Parallel
- 3.12 Kirchhoff's Rules
- 3.13 Wheatstone Bridge
- Meter Bridge
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

4. Moving Charges and Magnetism B59 – B75

- Trend Analysis
- NCERT One-Liners
- 4.1 Introduction
- 4.2 Magnetic Force
- 4.3 Motion in a Magnetic Field
- 4.4 Magnetic Field due to a Current Element, Biot-Savart's Law
- 4.5 Magnetic Field on the Axis of a Circular Current Loop
- 4.6 Ampere's Circuital Law
- 4.7 The Solenoid
- 4.8 Force between Two Parallel Currents, the Ampere
- 4.9 Torque on Current Loop, Magnetic Dipole
- 4.10 The Moving Coil Galvanometer
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

5. Magnetism and Matter B76 – B85

- Trend Analysis
- NCERT One-Liners
- 5.1 Introduction
- 5.2 The Bar Magnet
- 5.3 Magnetism and Gauss's Law
- 5.4 Magnetisation and Magnetic Intensity
- 5.5 Magnetic Properties of Materials
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

6. Electromagnetic Induction B86 – B100

- Trend Analysis
- NCERT One-Liners
- 6.1 Introduction
- 6.2 The Experiments of Faraday and Henry
- 6.3 Magnetic Flux
- 6.4 Faraday's Law of Induction
- 6.5 Lenz's Law and Conservation of Energy
- 6.6 Motional Electromotive Force
- Eddy Currents
- 6.7 Inductance
- 6.8 AC Generator
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

7. Alternating Current B101 – B115

- Trend Analysis
- NCERT One-Liners
- 7.1 Introduction
- 7.2 AC Voltage Applied to a Resistor
- 7.3 Representation of AC Current and Voltage by Rotating Vectors–Phasors
- 7.4 AC Voltage Applied to an Inductor
- 7.5 AC Voltage Applied to a Capacitor
- 7.6 AC Voltage Applied to a Series LCR Circuit
- 7.7 Power in AC Circuit: The Power Factor
- 7.8 Transformers
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

8. Electromagnetic Waves B116 – B128

- Trend Analysis
- NCERT One-Liners
- 8.1 Introduction
- 8.2 Displacement Current
- 8.3 Electromagnetic Waves
- 8.4 Electromagnetic Spectrum
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

9. Ray Optics and Optical Instruments B129 – B145

- Trend Analysis
- NCERT One-Liners
- 9.1 Introduction
- 9.2 Reflection of Light by Spherical Mirrors
- 9.3 Refraction
- 9.4 Total Internal Reflection
- 9.5 Refraction at Spherical Surfaces and by Lenses
- 9.6 Refraction through a Prism
- 9.7 Optical Instruments
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

10. Wave Optics B146 – B160

- Trend Analysis
- NCERT One-Liners
- 10.1 Introduction
- 10.2 Huygens Principle
- 10.3 Refraction and Reflection of Plane Waves Using Huygens Principle

- 10.4 Coherent and Incoherent Addition of Waves
- 10.5 Interference of Light Waves and Young's Experiment
- 10.6 Diffraction
- 10.7 Polarisation
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

11. Dual Nature of Radiation and Matter B161 – B172

- Trend Analysis
- NCERT One-Liners
- 11.1 Introduction
- 11.2 Electron Emission
- 11.3 Photoelectric Effect
- 11.4 Experimental Study of Photoelectric Effect
- 11.5 Photoelectric Effect and Wave Theory of Light
- 11.6 Einstein's Photoelectric Equation: Energy Quantum of Radiation
- 11.7 Particle Nature of Light: The Photon
- 11.8 Wave Nature of Matter
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

12. Atoms B173 – B184

- Trend Analysis
- NCERT One-Liners
- 12.1 Introduction
- 12.2 Alpha-particle Scattering and Rutherford's Nuclear Model of Atom
- 12.3 Atomic Spectra
- 12.4 Bohr Model of the Hydrogen Atom
- 12.5 The Line Spectra of the Hydrogen Atom
- 12.6 De Broglie's Explanation of Bohr's Second Postulate of Quantisation
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

13. Nuclei B185 – B194

- Trend Analysis
- NCERT One-Liners
- 13.1 Introduction
- 13.2 Atomic Masses and Composition of Nucleus
- 13.3 Size of the Nucleus
- 13.4 Mass-Energy and Nuclear Binding Energy
- 13.5 Nuclear Force
- 13.6 Radioactivity
- 13.7 Nuclear Energy
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

14. Semiconductor Electronics: Materials, Devices and Simple Circuits B195 – B213

- Trend Analysis
- NCERT One-Liners
- 14.1 Introduction
- 14.2 Classification of Metals, Conductors and Semiconductors
- 14.3 Intrinsic Semiconductor
- 14.4 Extrinsic Semiconductor
- 14.5 p-n Junction
- 14.6 Semiconductor Diode
- 14.7 Application of Junction Diode as a Rectifier
- Special Purpose P-n Junction Diodes
- Logic Gates
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4*

15. Experimental Skills in Physics (XII) B214 – B226

Note : * The four Exercises in each of the chapters are :

- Exercise 1 : NCERT Based Topic-wise MCQs
- Exercise 2 : NCERT Exempler & Past Years NEET
- Exercise 3 : Matching Statements & Assertion Reason Type
- Exercise 4 : Skill Enhancer MCQs

Hints & Solutions (Class 12th) B227–B302

1. Electric Charges and Fields B227 – B233
2. Electrostatic Potential and Capacitance B234 – B240
3. Current Electricity B241 – B248
4. Moving Charges and Magnetism B249 – B254
5. Magnetism and Matter B255 – B257
6. Electromagnetic Induction B258 – B262
7. Alternating Current B263 – B267
8. Electromagnetic Waves B268 – B271
9. Ray Optics and Optical Instruments B272 – B279
10. Wave Optics B280 – B284
11. Dual Nature of Radiation and Matter B285 – B289
12. Atoms B290 – B293
13. Nuclei B294 – B296
14. Semiconductor Electronics : Materials, Devices and Simple Circuits B297 – B300
15. Experimental Skills in Physics (XII) B301 – B302

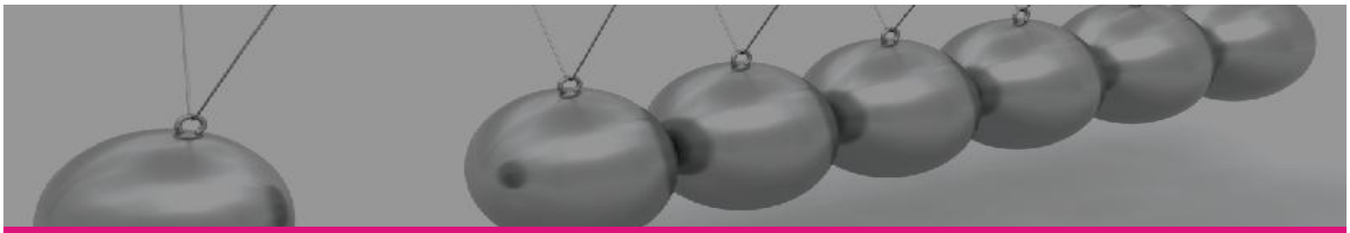
Mock Tests

Mock Test-1 MT1–MT3
Mock Test-2 MT4–MT6
Mock Test-3 MT7–MT9

Solutions

Mock Test-1 MT10–MT11
Mock Test-2 MT12–MT14
Mock Test-3 MT15–MT16

NOTE* These Topics are in new NCERT, but not in the new NEET 2024 Syllabus. These Topics have been retained in the book so as to match NCERT and any future amendments in NEET.
Questions on these Topics have also been marked with a * in the respective Exercises of the Chapters.



5 Work, Energy and Power

Trend Analysis NEET

	NEET	Remarks
Number of Questions from 2024-18	12	Higher weightage chapter for NEET
Weightage	3.4%	

			NEET	
Year	Topic Name	Concept Used	No. of Ques.	Difficulty Level
2024	Power, Collisions	Instantaneous Power, Completely inelastic collisions	2	Easy (1) Average(1)
2023	The potential energy of a spring	Potential energy, $u = \frac{1}{2}kx^2$	1	Average
2022	Energy, Power, Collisions	Energy = Power (kW) ×time(h) Power, P = F ×V, Conservation of momentum	3	Easy(1) Average (2)
2021	Power, P.E.	Potential Energy, Kinetic Energy, Power	2	Average (2)
2020	–	–	–	–
2019	Work done by force/Elastic potential energy	Work done, $W = \int_{y_i}^{y_f} F.dy$ Elastic potential energy	2	Easy Average
2018	Conservation of mechanical energy/collisions	Conservation of mechanical energy/Coeffici-ent of restitution	2	Average

NCERT ONE-LINERS
(Important Points to Remember)

5.1 Introduction

♦ Energy is our capacity to do work. In Physics too, the term 'energy' is related to work in this sense, but the term 'work' is defined much more precisely.

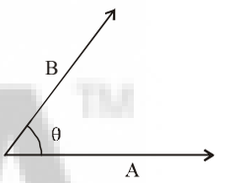
♦ Work is said to be done when a force applied on the body displaces the body through a certain distance in the direction of force.

The Scalar Product

♦ The scalar product or dot product of any two vectors **A** and **B**, denoted as **A·B** is defined as

$$\mathbf{A}\cdot\mathbf{B} = A\,B\cos\theta$$

where θ is the angle between the two vectors.



(a)

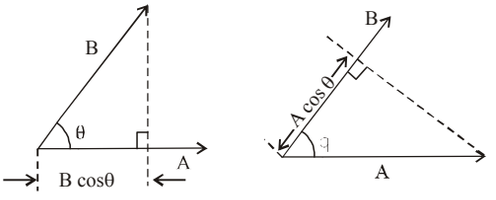
Fig.: (a) The scalar product of two vectors A and B is a scalar: A.B = AB cosθ.

♦ The dot product of **A** and **B** is a scalar quantity. Each vector, **A** and **B**, has a direction but their scalar product does not have a direction.

Two vectors $\vec{A}$ and $\vec{B}$ are said to be orthogonal if $\vec{A}.\vec{B} = 0$

NEET 2015

♦ **B** cos θ is the projection of **B** onto **A** and **A** cos θ is the projection of **A** onto **B.**



(b) (c)

Fig.: (b) B cosθ is the projection of B onto A. (c) A cosθ is the projection of A onto B.

- The scalar product follows the **commutative law**:

$$\mathbf{A}\cdot\mathbf{B} = \mathbf{B}\cdot\mathbf{A}$$

- Scalar product obeys the **distributive law**:

$$\mathbf{A}\cdot(\mathbf{B}+\mathbf{C}) = \mathbf{A}\cdot\mathbf{B} + \mathbf{A}\cdot\mathbf{C}$$

- For unit vectors $\hat{\mathbf{i}}, \hat{\mathbf{j}}, \hat{\mathbf{k}}$ we have

$$\hat{\mathbf{i}}\cdot\hat{\mathbf{i}} = \hat{\mathbf{j}}\cdot\hat{\mathbf{j}} = \hat{\mathbf{k}}\cdot\hat{\mathbf{k}} = 1$$

$$\hat{\mathbf{i}}\cdot\hat{\mathbf{j}} = \hat{\mathbf{j}}\cdot\hat{\mathbf{k}} = \hat{\mathbf{k}}\cdot\hat{\mathbf{i}} = 0$$

5.2 Notions of Work and Kinetic Energy: The Work-energy Theorem

- The change in kinetic energy of a particle is equal to the work done on it by the net force.

$$K_f - K_i = w$$

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \mathbf{ma.d} = \mathbf{F}\cdot\mathbf{d}$$

This is known as **work energy theorem**. NEET 2015, 2017

5.3 Work

- The **work** done by the force is defined to be the product of component of the force in the direction of the displacement and the magnitude of this displacement. Thus $W = (F\cos\theta)d = \mathbf{F}\cdot\mathbf{d}$

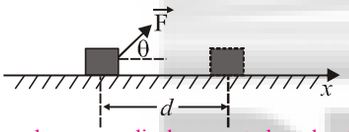


Fig.: An object undergoes a displacement d under the influence of the force F.

No work is done if :

- the displacement is zero. A weightlifter holding a 150kg mass steadily on his shoulder for 30 s does no work on the load during this time.
- the force is zero. A block moving on a smooth horizontal table is not acted upon by a horizontal force (since there is no friction), but may undergo a large displacement.
- the force and displacement are mutually perpendicular. This is so since, for $\theta = \pi/2$ rad (= 90°), $\cos(\pi/2) = 0$.

- In many examples the frictional force opposes displacement and $\theta = 180°$. Then the work done by friction is negative (cos 180° = –1).

5.4 Kinetic Energy

- If an object of mass m has velocity $\mathbf{v}$, its kinetic energy K is

$$K = \frac{1}{2}m\,\mathbf{v}\cdot\mathbf{v} = \frac{1}{2}mv^2$$

Relation between kinetic energy (K) and momentum (p) is given by

$$K = \frac{1}{2}\frac{m^2v^2}{m} = \frac{1}{2}\frac{p^2}{m}$$

- Kinetic energy is a scalar quantity. The kinetic energy of an object is a measure of the work an object can do by the virtue of its motion.
- The kinetic energy of a fast flowing stream has been used to grind corn. Sailing ships employ the kinetic energy of the wind.

5.5 Work Done by a Variable Force

- For a varying force the work done can be expressed as a definite integral of force over displacement.
- The work done by a variable force is

$$W = \int_{x_i}^{x_f} F(x)\,dx$$ NEET 2019

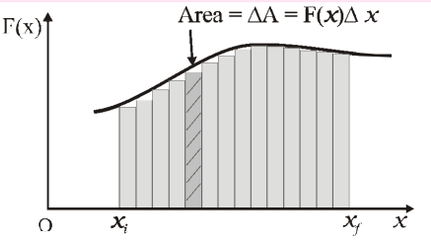


Fig.: The shaded rectangle represented the work done by the varying force F(x), over the small displacement Δx, ΔW = F(x) Δx.

5.6 The Work-Energy Theorem for a Variable Force

- The time rate of change of kinetic energy is

$$\frac{dK}{dt} = \frac{d}{dt}\left(\frac{1}{2}mv^2\right) = m\frac{dv}{dt}v$$

$$= \text{F } v \text{ (from Newton's Second Law)} = F\frac{dx}{dt}$$

Thus $dK = Fdx$

Integrating from the initial position (x_i) to final position (x_f), we have

$$\int_{K_i}^{K_f} dK = \int_{x_i}^{x_f} Fdx$$

where, K_i and K_f are the initial and final kinetic energies corresponding to x_i and x_f.

or $K_f - K_i = \int_{x_i}^{x_f} Fdx = W$

5.7 The Concept of Potential Energy

- Potential energy is the 'stored energy' by virtue of the position or configuration of a body.
- Gravitational potential energy of an object, as a function of the height h, is denoted by V(h) and it is the negative of work done by the gravitational force in raising the object to that height.

$$V(h) = mgh$$ NEET 2021

- If h is taken as a variable, the gravitational force F equals the negative of the derivative of $V(h)$ with respect to h.

$$F = -\frac{d}{dh}V(h) = mg$$

The negative sign indicates that the gravitational force is downward.

- Change in potential energy $(V_f - V_i) = \Delta V = V_f - V_i$

$$= \int_{x_i}^{x_f} F(x)\,dx = -W_{\text{conservative}}$$

- The work done by a **conservative force** such as gravity depends on the initial and final positions only.
- If the work done or the kinetic energy did depend on other factors such as the velocity or the particular path taken by the object, the force would be called **non-conservative**.
- When work is done upon a system by a conservative force then its potential energy increases. NEET 2011

5.8 The Conservation of Mechanical Energy

- Suppose that a body undergoes displacement Δx under the action of a conservative force F. Then from the *WE* theorem we have,

$$\Delta K = F(x)\,\Delta x$$

- If the force is conservative, the potential energy function $V(x)$ can be defined such that

$$\Delta V = -F(x)\,\Delta x$$

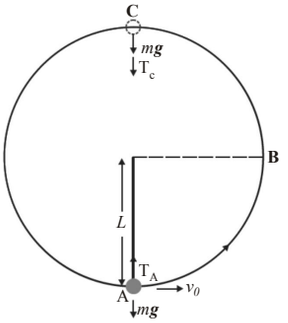
The above equations imply that

$$\Delta K + \Delta V = 0$$
$$\Delta(K + V) = 0$$

- Individually the kinetic energy (K) and potential energy V(x) may vary from point to point but the sum is a constant.
- The work done by the **conservative force** depends only on the end points. This can be seen from the relation,
Work done $W = K_f - K_i = V(x_i) - V(x_f)$
which depends on the end points.
- Work done by this force in a closed path is zero.
- The total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.

Vertical Circular Motion

- At the maximum height from the ground. The energy is purely potential (E = mgH). It is partially converted to kinetic at height h (E = mgh + ½ mv^2) and is fully kinetic at ground level (k = ½ mv^2).



- The potential energy of the system to be zero at the lowest point A. Thus, at A :

$$E = \frac{1}{2}mv_0^2;\ T_A - mg = \frac{mv_0^2}{L}\ \text{[Newton's Second Law]}$$

where T_A is the tension in the string at A.

- At the highest point C, the string slackens, as the tension in the string (T_C) becomes zero.
Thus, at C

$$E = \frac{1}{2}mv_c^2 + 2mgL;\ mg = \frac{mv_c^2}{L}\ \text{[Newton's Second Law]}$$

where v_C is the speed at C. $E = \frac{5}{2}mgL$

Equating this to the energy at A

$$\frac{5}{2}mgL = \frac{m}{2}v_0^2 \text{ or, } v_0 = \sqrt{5gL}$$

It is clear; $v_c = \sqrt{gL}$
At B, the energy is

$$E = \frac{1}{2}mv_B^2 + mgL$$

Equating this to the energy at A and employing the result namely $v_0^2 = 5gL$

$$\frac{1}{2}mc_B^2 + mgL = \frac{1}{2}mv_0^2 = \frac{5}{2}mgL \quad \therefore\ v_B = \sqrt{3gL}$$

The ratio of the kinetic energies at B and C is :

$$\frac{K_B}{K_C} = \frac{\frac{1}{2}mv_B^2}{\frac{1}{2}mv_C^2} = \frac{3}{1}$$

At point C, the string becomes slack and the velocity of the bob is horizontal and to the left.

- When one end of a string of length l is connected to a particle of mass m and the other end to a small peg on a smooth horizontal surface. Centripetal force for circular motion will be provided by the tension in string. NEET 2017

5.9 The Potential Energy of a Spring

- Force law for the spring is called Hooke's law and is mathematically stated as

$$F_s = -kx$$

The constant k is called the spring constant.

- The spring is said to be stiff if k is large and soft if k is small.
- If the extension is x_m, then work done by the spring force is

$$W_s = \int_0^{x_m} F_s\,dx = -\int_0^{x_m} kx\,dx = -\frac{kx_m^2}{2}$$ NEET 2015

$$\Rightarrow V_f - V_i = -W = \frac{kx_m^2}{2} \Rightarrow V = \frac{kx_m^2}{2}\ \text{[putting } V_i = 0 \text{ \& } V_f = V\text{]}$$

$V = \frac{1}{2}kx_m^2$ is the potential energy stored in spring in extension or compression x_m.

- If the block is moved from an initial displacement x_i to a final displacement x_f, the work done by the spring force W_s is

$$W_s = -\int_{x_i}^{x_f} kx\,dx = \frac{kx_i^2}{2} - \frac{kx_f^2}{2}$$ NEET 2023

- If the block is pulled from x_i and allowed to return to x_i;

$$W_s = -\int_{x_i}^{x_f} k\,x\,dx = \frac{k\,x_i^2}{2} - \frac{k\,x_i^2}{2} = 0$$

The **work done by the spring force in a cyclic process is zero**.

- Spring force (i) is position dependent only as first stated by Hooke ($F_s = -kx$); (ii) does work which only depends on the initial and final positions.
- The spring force is a **conservative force**.
- The potential energy $V(x)$ of the spring is zero when block and spring system is in the equilibrium position.

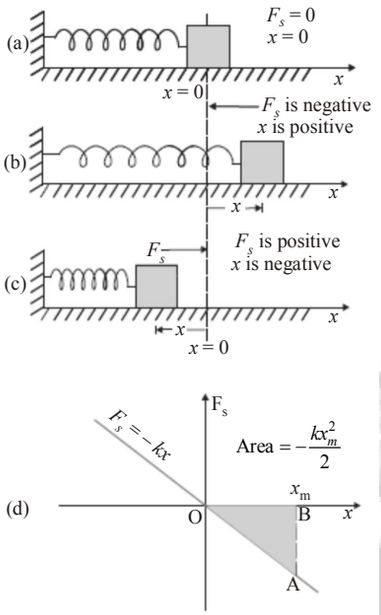
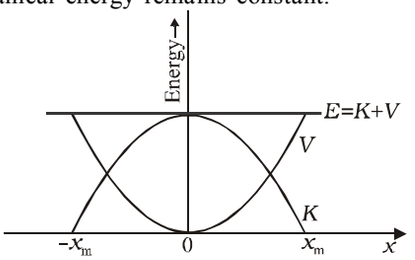


Fig.: *Illustration of the spring force with a block attached to the free end of the spring. (a) The spring force F_s is zero when the displacement x from the equilibrium position is zero. (b) For the stretched spring $x > 0$ and $F_s < 0$ (c) For the compressed spring $x < 0$ and $F_s > 0$.(d) The plot of F_s versus x. The area of the shaded triangle represents the work done by the spring force. Due to the opposing signs of F_s and x, this work done is negative, $W_s = -kx_m^2 / 2$.*

- The kinetic energy (K) of spring gets converted to potential energy (V) and vice versa, however, the total mechanical energy remains constant.



5.10 Power

- **Power** is defined as the time rate at which work is done or energy is transferred.
- The **average power** of a force is defined as the ratio of the work, W, to the total time t taken

$$P_{av} = \frac{W}{t}$$

- The **instantaneous power** is defined as the limiting value of the average power as time interval approaches zero,

$$P = \frac{dW}{dt}$$

- The work dW done by a force F for a displacement d**r** is $dW = \mathbf{F}\cdot d\mathbf{r}$.

- The instantaneous power can also be expressed as

$$P = F \cdot \frac{d\mathbf{r}}{dt} = \mathbf{F}\cdot\mathbf{v}$$ NEET 2016, 2022, 2024

where **v** is the instantaneous velocity when the force is **F**.

- There is another unit of power, namely the **horse-power** (hp)

$$1\ \text{hp} = 746\ \text{W}$$

This unit is still used to describe the output of automobiles, motorbikes, etc.

- 1 kilowatt hour (kWh) of energy. $= 3.6 \times 10^6$ J

Our electricity bills carry the energy consumption in units of kWh.

Power on turbine, $P = \frac{d(mgh)}{dt}$ NEET 2021

The energy radiated by 100 kW transmitter in

1 hour = 100 kW × 1hr = 100 kWh

$= 100 \times 3.6 \times 10^6\text{J} = 36\times10^7\text{J}$ NEET 2022

5.11 Collisions

- In **collision** a strong force acts between two or more bodies for a short time as a result of which the energy and momentum of the interacting particles change.

Elastic and Inelastic Collisions

- In all collisions the total linear momentum is conserved; the initial momentum of the system is equal to the final momentum of the system. NEET 2022
- The total kinetic energy of the system is not necessarily conserved. The impact and deformation during collision may generate heat and sound. Part of the initial kinetic energy is transformed into other forms of energy.
- A useful way to visualise the deformation during collision is in terms of a 'compressed spring'. If the 'spring' connecting the two masses regains its original shape without loss in energy, then the initial kinetic energy is equal to the final kinetic energy but the kinetic energy during the collision time Δt is not constant. Such a collision is called an **elastic collision**.
- A collision in which the two particles move together after the collision is called a **completely inelastic collision.**

- The intermediate case where the deformation is partly relieved and some of the initial kinetic energy is lost is more common and is appropriately called an **inelastic collision**.

Collisions in One Dimension

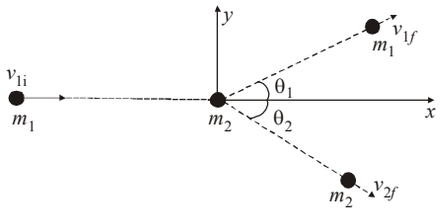


Fig.: Collision of mass m_1 with a stationary mass m_2.

- A **completely inelastic collision** in one dimension.
  $\theta_1 = \theta_2 = 0$
  $m_1 v_{1i} = (m_1 + m_2) v_f$ (momentum conservation)

$$v_f = \frac{m_1}{m_1 + m_2} v_{1i}$$ NEET 2024

The loss in kinetic energy on collision is

$$\Delta K = \frac{1}{2} m_1 v_{1i}^2 - \frac{1}{2}(m_1 + m_2) v_f^2$$

$$= \frac{1}{2} m_1 v_{1i}^2 - \frac{1}{2} \frac{m_1^2}{m_1 + m_2} v_{1i}^2 = \frac{1}{2} \frac{m_1 m_2}{m_1 + m_2} v_{1i}^2$$

the momentum and kinetic energy conservation equations are

$m_1 v_{1i} = m_1 v_{1f} + m_2 v_{2f}$ ...(i)

$m_1 v_{1i}^2 = m_1 v_{1f}^2 + m_1 v_{2f}^2 \therefore v_{2f} = v_{1i} + v_{1f}$

Substituting this in Eq. (i)

$$v_{1f} = \frac{(m_1 - m_2)}{m_1 + m_2} v_{1i} \text{ and } v_{2f} = \frac{2 m_1 v_{1i}}{m_1 + m_2}$$

- Coefficient of restitution, $e = \frac{\text{velocity of seperation}}{\text{velacity of approach}}$ NEET 2018

Case I: If the two masses are equal

$v_{1f} = 0$

$v_{2f} = v_{1i}$

Case II: If one mass dominates, e.g. $m_2 >> m_1$

$v_{1f} \simeq -v_{1i}$ $v_{2f} \simeq 0$

The heavier mass is undisturbed while the lighter mass reverses its velocity.

- If the initial velocities and final velocities of both the bodies are along the same straight line, then it is called a **one-dimensional collision**, or **head-on collision**.

When a body of mass m, collides with a body of mass m_2 in elastic and head on collision, energy lost by body of

$$\text{mass m} = \frac{4 m_1 m_2}{(m_1 + m_2)^2}$$ NEET 2019

Collisions in Two Dimensions

- Linear momentum is conserved. The *x*- and *y*-component equations are

$m_1 v_{1i} = m_1 v_{1f} \cos\theta_1 + m_2 v_{2f} \cos\theta_2$

$0 = m_1 v_{1f} \sin\theta_1 - m_2 v_{2f} \sin\theta_2$

If, the collision is elastic, $\frac{1}{2} m_1 v_{1i}^2 = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$

- In collision particles may or may not come in real touch.

In scattering, the velocities and directions in which the two particles go away depend on their initial velocities as well as the type of interactions between them, their masses shapes and sizes.

Tips/Tricks/Techniques ONE-LINERS
(Exam Special)

- If work is done on a body, its kinetic or potential energy increases. If work is done by the body, its potential or kinetic energy decreases.
- In the elastic collisions, the kinetic or mechanical energy is not converted into any other form of energy.
- The force involved in an inelastic collision is non-conservative in nature.
- If collision is head on the colliding bodies move along the same straight line before and after collision.
- If collision is oblique, the colliding bodies move at certain angles before and/or after the collisions.
- In static and dynamic equilibrium, work done is zero.
- Work done by a man holding the weight at fixed position is zero.
- Work done by a force depends on the frame of reference.
- Only tangential component of force is responsible for power dissipation. Power dissipated by radial component is zero. For example power dissipated by centripetal force is zero.
- In a perfectly elastic collision, in one dimension, when masses of the colliding particles are equal, their velocities get exchanged after collision.
- If a body starts rotating after collision, then both linear momentum and angular momentum are conserved.
- In the elastic collisions the forces involved are conservative.
- If the speed of water flowing through a pipe is v, then power is proportional to v^3.
- If n bullets are fired from a machine gun, each having kinetic energy k, then power of the machine gun will be nk.
- Work done by a body of mass m against friction on a rough horizontal surface of coefficient of friction μ is μmgx. Here, x is the distance moved by the body.
- Let h_1, h_2 ..... h_n be the heights of the body to which the body rebounds again and again, then

$$e = \sqrt{\frac{h_1}{h}} = \sqrt{\frac{h_2}{h_1}} = \sqrt{\frac{h_3}{h_2}}$$

Clearly $h_1 = e^2h$; $h_2 = e^4h$ and similarly, after nth rebound $h_n = (e^{2n})h$

- The velocity of an object depends on the choice of reference frame. Thus, kinetic energy also depends on the choice of the reference frame.
- Potential energy depends on the reference level. In case of spring, it is advised to assume zero potential energy at the natural length of the spring. In case of gravity any convenient level can be chosen as reference frame.
- If a ball is dropped from a height h_0 on a horizontal floor, then time taken by the ball to stop bouncing is given by

$$T = \left(\frac{1+e}{1-e}\right)\sqrt{\frac{2h_0}{g}}$$ (Here, e = coefficient of restitution)

- An engine pulls a train of mass m with constant velocity. If the rails are on a plane surface and there is no friction, the power dissipated by the engine is zero.
- When the momentum of a body is made n times then its kinetic energy is increased by factor n^2.
- Slope of work time graph = power.
- Area under power time curve = work done by/on the body.
- If a chain of length L and mass M is held on a frictionless table with $(1/n)^{th}$ of its length is hanging over the edge, then work done in pulling the hanging portion on the table is given by

$$W = \frac{MgL}{2n^2}$$

- The phrase 'calculate the work done' is incomplete. We should refer to the work done by a specific force or a group of forces on a given body over a certain displacement.
- Work done is a scalar quantity. It can be positive or negative unlike mass and kinetic energy which are positive scalar quantities. The work done by the friction or viscous force on a moving body is negative.
- For two bodies, the sum of the mutual forces exerted between them is zero from Newton's Third Law,

$$\mathbf{F}_{12} + \mathbf{F}_{21} = 0$$

But the sum of the work done by the two forces need not *always cancel, i.e.*

$$W_{12} + W_{21} \neq 0$$

However, it may sometimes be true.
- The work done by a force can be calculated sometimes even if the exact nature of the force is not known.
- The WE theorem is not independent of Newton's Second Law. The WE theorem may be viewed as a scalar form of the Second Law. The principle of conservation of mechanical energy may be viewed as a consequence of the WE theorem for conservative forces.
- The WE theorem holds in all inertial frames. It can also be extended to noninertial frames provided we include the pseudoforces in the calculation of the net force acting on the body under consideration.
- The potential energy of a body subjected to a conservative force is always undetermined upto a constant. For example, the point where the potential energy is zero is a matter of choice. For the gravitational potential energy mgh, the zero of the potential energy is chosen to be the ground. For the spring potential energy $kx^2/2$, the zero of the potential energy is the equilibrium position of the oscillating mass.
- Every force encountered in mechanics does not have an associated potential energy. For example, work done by friction over a closed path is not zero and no potential energy can be associated with friction.
- During a collision : (a) the total linear momentum is conserved at each instant of the collision ; (b) the kinetic energy conservation (even if the collision is elastic) applies after the collision is over and does not hold at every instant of the collision. In fact the two colliding objects are deformed and may be momentarily at rest with respect to each other.

Exercise 1 : NCERT Based Topic-wise MCQs

5.1 Introduction

1. Let $A = \hat{i}A\cos\theta + \hat{j}A\sin\theta$ be any vector. Another vector B, which is normal to A can be expressed as

NCERT Page-115 / N-72

(a) $\hat{i}\,B\cos\theta - \hat{j}\,B\sin\theta$ (b) $\hat{i}\,B\cos\theta + \hat{j}\,B\sin\theta$
(c) $\hat{i}\,B\sin\theta - \hat{j}\,B\cos\theta$ (d) $\hat{i}\,B\sin\theta + \hat{j}\,B\cos\theta$

2. If $\vec{A} = 4\hat{i} + 3\hat{j}$ and $\vec{B} = 3\hat{i} + 4\hat{j}$ then cosine of angle between $\vec{A}$ and $\vec{A} + \vec{B}$ is NCERT Page-115 / N-72

(a) $\frac{9\sqrt{2}}{5}$ (b) $\frac{7}{5\sqrt{2}}$ (c) $\frac{5\sqrt{2}}{49}$ (d) $\frac{5\sqrt{2}}{28}$

3. A particle moves from position $3\hat{i} + 2\hat{j} - 6\hat{k}$ to $14\hat{i} + 13\hat{j} + 9\hat{k}$ due to a uniform force of $(4\hat{i} + \hat{j} + 3\hat{k})\,N$. If the displacement is in metre then work done will be

NCERT Page-115 / N-72

(a) 300 J (b) 250 J (c) 100 J (d) 0

4. If a vector $2\hat{i} + 3\hat{j} + 8\hat{k}$ is perpendicular to the vector $4\hat{j} - 4\hat{i} + \alpha\hat{k}$, then the value of α is NCERT Page-115 / N-72

(a) 1/2 (b) –1/2 (c) 1 (d) –1

5.2 Notions of Work and Kinetic Energy: The Work-energy Theorem

5. According to work-energy theorem, the work done by the net force on a particle is equal to the change in its

NCERT Page-116 / N-73

(a) kinetic energy (b) potential energy
(c) linear momentum (d) angular momentum

6. A body starts from rest and acquires a velocity V in time T. The work done on the body in time t will be proportional to

NCERT Page-116 / N-73

(a) $\frac{V}{T}t$ (b) $\frac{V^2}{T}t^2$ (c) $\frac{V^2}{T^2}t$ (d) $\frac{V^2}{T^2}t^2$

5.3 Work

7. When the force retards the motion of body, the work done is

NCERT Page-117 / N-74

(a) zero
(b) negative
(c) positive
(d) Positive or negative depending upon the magnitude of force and displacement

8. A man pushes a wall and fails to displace it, he does

NCERT Page-117 / N-74

(a) negative work
(b) positive but not maximum work
(c) no work at all
(d) maximum positive work

9. A boy carrying a box on his head is walking on a level road from one place to another is doing no work. This statement is

NCERT Page-117 / N-74

(a) correct (b) incorrect
(c) partly correct (d) cannot say

10. No work is done if NCERT Page-117 / N-74

(a) displacement is zero
(b) force is zero
(c) force and displacement are mutually perpendicular
(d) All of these

11. A particle is taken round a circle by application of force. The work done by the force is NCERT Page-117 / N-74

(a) positive non–zero (b) negative non–zero
(c) Zero (d) None of these

12. A porter lifts a heavy suitcase of mass 80 kg and at the destination lowers it down by a distance of 80 cm with a constant velocity. Calculate the work done by the porter in lowering the suitcase. (take g = 9.8 ms^{-2})

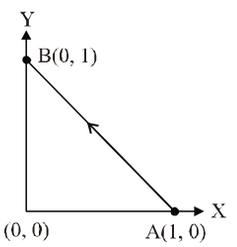
NCERT Page-117 / N-74

(a) –62720.0 J (b) –627.2 J
(c) +627.2 J (d) 784.0 J

13. Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force in moving a particle from point A(1, 0) to B(0, 1) along the line segment is: (all quantities are in SI units)

NCERT Page-117 / N-74

(a) 2J
(b) $\frac{1}{2}$J
(c) 1J
(d) $\frac{3}{2}$J



14. If W represents the work done, then match the two columns:

NCERT Page-117 / N-74

Column I	Column II
(A) Force is always along the velocity	(1) W = 0
(B) Force is always perpendicular to velocity	(2) W < 0
(C) Force is always perpendicular to acceleration	(3) W > 0
(D) The object is stationary but the point of application of the force moves on the object	

(a) (A)→(1); (B)→(2); C→(3); (D)→(2)
(b) (A)→(3); (B)→(1); C→(2,3); (D)→(1)
(c) (A)→(2); (B)→(3); C→(1); (D)→(2)
(d) (A)→(1); (B)→(2); C→(3); (D)→(1)

15. A particle moving in the xy plane undergoes a displacement of $\vec{s} = (2\hat{i} + 3\hat{j})$ while a constant force $\vec{F} = (5\hat{i} + 2\hat{j})$ N acts on the particle. The work done by the force F is

NCERT Page-117 / N-74

(a) 17 joule (b) 18 joule (c) 16 joule (d) 15 joule

16. A particle describe a horizontal circle of radius 0.5 m with uniform speed. The centripetal force acting is 10 N. The work done in describing a semicircle is NCERT Page-117 / N-74

(a) zero (b) 5 J (c) 5 π J (d) 10 π J

17. A force acts on a 30 g particle in such a way that the position of the particle as a function of time is given by $x = 3t - 4t^2 + t^3$, where x is in metres and t is in seconds. The work done during the first 4 seconds is NCERT Page-118 / N-74

(a) 576mJ (b) 450mJ (c) 490mJ (d) 530mJ

18. A cord is used to lower vertically a block of mass M, a distance d at a constant downward acceleration of g/4. The work done by the cord on the block is

NCERT Page-117 / N-74

(a) $Mg\frac{d}{4}$ (b) $3Mg\frac{d}{4}$ (c) $-3Mg\frac{d}{4}$ (d) Mg d

19. If a motorcyclist skids and stops after covering a distance of 15 m. The stopping force acting on the motorcycle by the road is 100 N, then the work done by the motorcycle on the road is NCERT Page-117 / N-74

(a) 1500 J (b) –1500 J (c) 750J (d) Zero

20. A ball moves in a frictionless inclined table without slipping. The work done by the table surface on the ball is

NCERT Page-117 / N-74

(a) positive (b) negative
(c) zero (d) None of these

21. A uniform force of $(3\hat{i} + \hat{j})$ newton acts on a particle of mass 2 kg. The particle is displaced from position $(2\hat{i} + \hat{k})$ meter to position $(4\hat{i} + 3\hat{j} - \hat{k})$ meter. The work done by the force on the particle is NCERT Page-117 / N-74

(a) 6 J (b) 13 J (c) 15 J (d) 9 J

22. A boy pushes a toy box 2.0 m along the floor by means of a force of 10 N directed downward at an angle of 60° to the horizontal. The work done by the boy is NCERT Page-117 / N-74

(a) 6 J (b) 8 J (c) 10 J (d) 12 J

23. A body moves a distance of 10 m along a straight line under the action of a force of 5 newtons. If the work done is 25 joules, the angle which the force makes with the direction of motion of body is NCERT Page-117 / N-74

(a) 0° (b) 30° (c) 60° (d) 90°

5.4 Kinetic Energy

24. A light and a heavy body have equal momentum. Which one has greater K.E.? NCERT Page-117 / N-74

(a) The lighter body (b) The heavier body
(c) Both have equal K.E. (d) Data given is incomplete

25. A particle of mass m has momentum p. Its kinetic energy will b NCERT Page-117 / N-74

(a) mp (b) p^2m (c) $\frac{p^2}{m}$ (d) $\frac{p^2}{2m}$

26. Kinetic energy, with any reference, must be NCERT Page-117 / N-74

(a) zero (b) positive
(c) negative (d) both (b) and (c)

27. If the momentum of a body is increased by 50%, then the percentage increase in its kinetic energy is NCERT Page-117 / N-74

(a) 50% (b) 100% (c) 125% (d) 200%

28. Four particles given, have same momentum. Which has maximum kinetic energy NCERT Page-117 / N-74

(a) Proton (b) Electron (c) Deutron (d) α-particles

29. The K.E. acquired by a mass m in travelling a certain distance d, starting form rest, under the action of a constant force is directly proportional to NCERT Page-117 / N-74

(a) m_1 (b) $\sqrt{m}$
(c) $\frac{1}{\sqrt{m}}$ (d) independent of m

30. A running man has half the kinetic energy of that of a boy of half of his mass. The man speeds up by 1m/s so as to have same K.E. as that of the boy. The original speed of the man will be NCERT Page-117 / N-74

(a) $\sqrt{2}$ m/s (b) $(\sqrt{2}-1)$m/s
(c) $\frac{1}{(\sqrt{2}-1)}$m/s (d) $\frac{1}{\sqrt{2}}$m/s

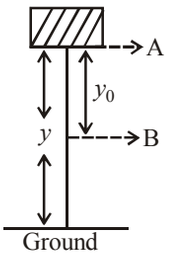
31. In the given figure, the block of mass m is dropped from the point 'A'. The expression for kinetic energy of block when it reaches point 'B' is : NCERT Page-117 / N-74

(a) $\frac{1}{2}mg\,y_0^2$

(b) $\frac{1}{2}mg\,y^2$

(c) $mg\,(y-y_0)$

(d) $mg\,y_0$



32. Two bodies A and B having masses in the ratio of 3 : 1 possess the same kinetic energy. The ratio of linear momentum of B to A is NCERT Page-117 / N-74

(a) 1 : 3 (b) 3 : 1 (c) $1:\sqrt{3}$ (d) $\sqrt{3}:1$

33. A small body is projected in a direction inclined at 45° to the horizontal with kinetic energy K. At the top of its flight, its kinetic energy will be NCERT Page-117 / N-74

(a) Zero (b) $K/2$ (c) $K/4$ (d) $K/\sqrt{2}$

34. A body accelerates uniformly from rest to a velocity of 1 ms^{-1} in 15 seconds. The kinetic energy of the body will be $\frac{2}{9}$ J when 't' is equal to [Take mass of body as 1 kg] NCERT Page-117 / N-74

(a) 4s (b) 8s (c) 10s (d) 12s

35. A bomb of mass 9 kg explodes into the pieces of masses 3 kg and 6 kg. The velocity of mass 3 kg is 16 m/s. The kinetic energy of mass 6 kg in joule is NCERT Page-117 / N-74

(a) 96 (b) 384 (c) 192 (d) 768

36. An athlete in the olympic games covers a distance of 100 m in 10 s. His kinetic energy can be estimated to be in the range NCERT Page-117 / N-74

(a) 200 J - 500 J (b) 2×10^5 J - 3×10^5 J
(c) 20, 000 J - 50,000 J (d) 2,000 J - 5, 000 J

5.5 Work Done by a Variable Force

37. A particle moves under the effect of a force F = cx from x = 0 to x = x_1, the work done in the process is NCERT Page-118 / N-75

(a) cx_1^2 (b) $\frac{1}{2}cx_1^2$ (c) $2cx_1^2$ (d) zero

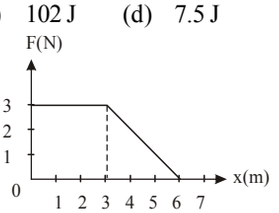
38. Calculate the work done on the tool by $\vec{F}$ if this displacement is along the straight line y = x that connects these two points. NCERT Page-118 / N-75

(a) 2.50 J (b) 500 J (c) 50.6 J (d) 2 J

39. Calculate the work done on the tool by $\vec{F}$ if the tool is first moved out along the x-axis to the point x = 3.00m, y = 0 and then moved parallel to the y-axis to x = 3.00m, y = 3.00 m. NCERT Page-118 / N-75

(a) 67.5 J (b) 85 J (c) 102 J (d) 7.5 J

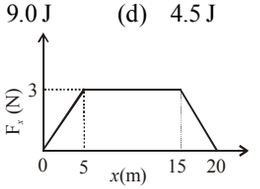
40. A force F acting on an object varies with distance x as shown here. The force is in N and x in m. The work done by the force in moving the object from x = 0 to x = 6 m is



NCERT Page-119 / N-76

(a) 18.0 J (b) 13.5 J (c) 9.0 J (d) 4.5 J

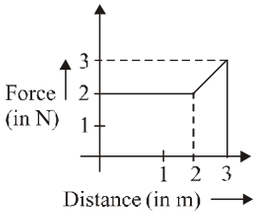
41. A force F_x acts on a particle such that its position x changes as shown in the figure. The work done by the particle as it moves from x = 0 to 20 m is



NCERT Page-119 / N-76

(a) 37.5 J (b) 10 J (c) 45 J (d) 22.5 J

42. A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the figure. The kinetic energy of the particle after it has travelled 3 m is : NCERT Page-118 / N-75



(a) 4 J (b) 2.5 J (c) 6.5 J (d) 5 J

5.6 The Work-energy Theorem for a Variable Force

43. A body of mass 0.5 kg travels on straight line path with velocity $v = (3x^2 + 4)$ m/s. The net workdone by the force during its displacement from $x = 0$ to $x = 2$ m is :

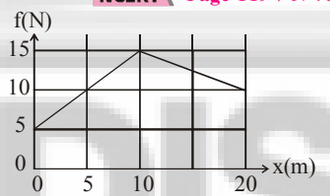
NCERT Page-119 / N-76

(a) 64 J (b) 60 J (c) 120 J (d) 128 J

44. A body of mass 20kg, moving in x-direction with a constant speed of 20 m/s, is subjected to a retarding force $F = 0.2x$ J/m during its travel from $x = 20$ m to 30 m. Its final kinetic energy will be NCERT Page-119 / N-76

(a) 50 J (b) 475 J
(c) 4000 J (d) 3250 J

45. Figure here shows the frictional force versus displacement for a particle in motion. The loss of kinetic energy in travelling over s = 0 to 20 m will be NCERT Page-119 / N-76



(a) 225 J
(b) 200 J
(c) 250 J
(d) 750 J

5.7 The Concept of Potential Energy

46. Work done by a conservative force is positive if NCERT Page-121 / N-78

(a) P.E. of the body increases
(b) P.E. of the body decreases
(c) K.E. of the body increases
(d) K.E. of the body decreases

47. For a conservative force in one dimension, potential energy function V(x) is related to the force F(x) as

NCERT Page-121 / N-78

(a) $F(x) = \frac{-dV(x)}{dx}$ (b) $F(x) = \frac{dV(x)}{dx}$

(c) $F(x) = V(x)\,dx$ (d) $F(x) = \int \frac{-dV(x)}{dx}$

48. One man takes 1 min. to raise a box to a height of 1 metre and another man takes 1/2 min. to do so. The energy of the NCERT Page-120 / N-77

(a) two is different (b) two is same
(c) first is more (d) second is more

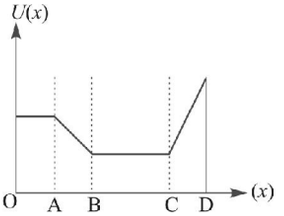
49. A ball dropped from a height of 2m reaches to a height of 1.5m before hitting the ground. Then the percentage of potential energy lost is NCERT Page-120 / N-77

(a) 25 (b) 30 (c) 50 (d) 100

50. The potential energy of a system increases if work is done NCERT Page-121 / N-78

(a) upon the system by a non conservative force
(b) by the system against a conservative force
(c) by the system against a non conservative force
(d) upon the system by a conservative force

51. The figure gives the potential energy function $U(x)$ for a system in which a particle is in one-dimensional motion. In which region the magnitude of the force on the particle is greatest :



NCERT Page-121 / N-78

(a) OA (b) AB (c) BC (d) CD

52. A rod of mass m and length ℓ is made to stand at an angle of 60° with the vertical. Potential energy of the rod in this position is NCERT Page-120 / N-77

(a) $mg\ell$ (b) $\frac{mg\ell}{2}$ (c) $\frac{mg\ell}{3}$ (d) $\frac{mg\ell}{4}$

53. The potential energy of a conservative system is given by $U = ay^2 - by$, where y represents the position of the particle and a as well as b are constants. What is the force acting on the system? NCERT Page-121 / N-78

(a) – ay (b) – by
(c) 2ay – b (d) b – 2ay

54. A body falls freely under gravity. Its velocity is v when it has lost potential energy equal to U. What is the mass of the body? NCERT Page-120, 121 / N-77, 78

(a) U^2/v^2 (b) $2U^2/v^2$ (c) $2U/v^2$ (d) U/v^2

5.8 The Conservation of Mechanical Energy

55. Total ....*X*.... energy of a system is conserved, if the forces, doing work on it, are .....*Y*..... . NCERT Page-121 / N-79

Here, *X* and *Y* refer to

(a) conservative, mechanical
(b) mechanical, conservative
(c) mechanical, non-conservative
(d) kinetic, conservative

56. A metallic wire of length L metre extends by ℓ metre when stretched by suspending a weight Mg from it. The mechanical energy stored in the wire is NCERT Page-121 / N-79

(a) 2 Mg ℓ (b) Mg ℓ (c) $\frac{Mg\ell}{2}$ (b) $\frac{Mg\ell}{4}$

57. A steel ball of mass 5g is thrown downward with velocity 10 m/s from height 19.5 m. It penetrates sand by 50 cm. The change in mechanical energy will be ($g = 10$ m/s^2)

NCERT Page-121 / N-79

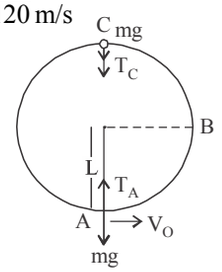
(a) 1J (b) 1.25 J (c) 1.5 J (d) 1.75 J

58. A ball is allowed to fall from a height of 10 m. If there is 40% loss of energy due to air friction, then velocity of the ball when it hit the ground is NCERT Page-121 / N-79

(a) $\sqrt{190}$ m/s (b) $\sqrt{180}$ m/s

(c) $\sqrt{150}$ m/s (d) $\sqrt{120}$ m/s

59. Figure shows a bob of mass *m* suspended from a string of length L. The velocity is V_0 at A, then the potential energy of the system is _____ at the lowest point A.



NCERT Page-122 / N-79

(a) $\frac{1}{2}mv_0^2$ (b) mgh (c) $\frac{-1}{2}mv_0^2$ (d) zero

60. Calculate the K.E and P.E. of the ball half way up, when a ball of mass 0.1 kg is thrown vertically upwards with an initial speed of 20 ms^{-1}. NCERT Page-121, 122 / N-79

(a) 10 J, 20 J (b) 10 J, 10 J

(c) 15 J, 8 J (d) 8 J, 16 J

61. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is NCERT Page-121 / N-79

(a) 20 m/s (b) 40 m/s (c) $10\sqrt{30}$ m/s (d) 10 m/s

62. A particle is moving in a circle of radius r under the action of a force $F = \alpha r^2$ which is directed towards centre of the circle. Total mechanical energy (kinetic energy + potential energy) of the particle is (take potential energy = 0 for r = 0) NCERT Page-121 / N-79

(a) $\frac{1}{2}\alpha r^3$ (b) $\frac{5}{6}\alpha r^3$ (c) $\frac{4}{3}\alpha r^3$ (d) αr^3

63. When a body is projected vertically up from the ground with certain velocity, its potential energy and kinetic energy at a point A are in the ratio 2 : 3. If the same body is projected with double the previous velocity, then at the same point A the ratio of its potential energy to kinetic energy is NCERT Page-121 / N-79

(a) 9 : 1 (b) 2 : 9 (c) 1 : 9 (d) 9 : 2

64. A mass m is revolving in a vertical circle at the end of a string of length 20 cm. By how much does the tension of the string at the lowest point exceed the tension at the topmost point? NCERT Page-122 / N-79

(a) 2 m g (b) 4 m g (c) 6 m g (d) 8 m g

65. A particle tied to a string describes a vertical circular motion of radius r continually. If it has a velocity $\sqrt{3\ gr}$ at the highest point, then the ratio of the respective tensions in the string holding it at the highest and lowest points is NCERT Page-122 / N-79

(a) 4 : 3 (b) 5 : 4 (c) 1 : 4 (d) 3 : 2

66. A particle of mass '*m*' tied to a string of length 'ℓ' and whirled in a horizontal circle. If the particles moves in circle with speed '*v*' then the net force on the particle will be (*T* = tensaion in the string) NCERT Page-122 / N-79

(a) $T+\frac{mv^2}{l}$ (b) $T-\frac{mv^2}{r}$

(c) T (d) zero

67. A body of mass 0.4 kg is whirled in a vertical circle making 2 rev/sec. If the radius of the circle is 1.2 m, then tension in the string when the body is at the top of the circle, is NCERT Page-122 / N-79

(a) 41.56 N (b) 89.86 N (c) 109.86 N (d) 115.86 N

68. A bucket tied at the end of a 1.6 m long string is whirled in a vertical circle with constant speed. What should be the minimum speed so that the water from the bucket does not spill when the bucket is at the highest position? NCERT Page-122 / N-79

(a) 4 m/sec (b) 6.25 m/sec

(c) 16 m/sec (d) None of these

5.9 The Potential Energy of a Spring

69. The work done in stretching a spring of force constant k from length ℓ_1 and ℓ_2 is NCERT Page-124 / N-81

(a) $k(\ell_2^2-\ell_1^2)$ (b) $\frac{1}{2}k(\ell_2^2-\ell_1^2)$

(c) $k(\ell_2-\ell_1)$ (d) $\frac{k}{2}(\ell_2+\ell_1)$

70. A spring of spring constant 5×10^3 N/m is stretched initially by 5 cm from the unstretched position. Then the work required to stretch it further by another 5 cm is NCERT Page-124 / N-81

(a) 18.75 J (b) 25.00 J (c) 6.25 J (d) 12.50 J

71. A spring whose unstretched length is *l* has a force constant *k*. The spring is cut into two pieces of unstretched lengths l_1 and l_2 where, $l_1 = nl_2$ and *n* is an integer. The ratio k_1/k_2 of the corresponding force constants, k_1 and k_2 will be: NCERT Page-123 / N-80

(a) n (b) $\frac{1}{n^2}$ (c) $\frac{1}{n}$ (d) n^2

72. The ...*X*... energy *V*(*x*) of the spring is said to be zero when block and spring system is in the ...*Y*... position.

Here, *X* and *Y* refer to NCERT Page-124 / N-81

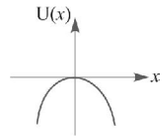
(a) potential, equilibrium (b) kinetic, equilibrium

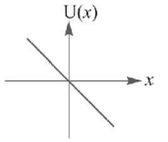
(c) mechanical, equilibrium (d) vibrational, left

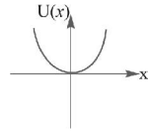
73. If stretch in a spring of force constant k is tripled then the ratio of elastic potential energy in the two cases will be NCERT Page-124 / N-81

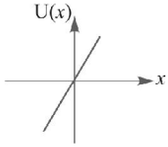
(a) 9 : 1 (b) 1 : 6 (c) 3 : 1 (d) 1 : 3

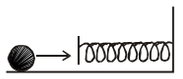
74. A particle is placed at the origin and a force $F = kx$ is acting on it (where *k* is positive constant). If $U(0) = 0$, the graph of $U(x)$ versus *x* will be (where *U* is the potential energy function) : NCERT Page-124 / N-81

(a) 

(b) 

(c) 

(d) 

75. A mass of m kg moving with a speed of 1.5 m/s on a horizontal smooth surface, collides with a nearly weightless spring of force constant k = 50 N/m. If the maximum compression of the spring is 0.15 m, the value of mass m is 

NCERT Page-124 / N-81

(a) 0.5 kg (b) 0.15 kg (c) 0.12 kg (d) 1.5 kg

76. Two spring P and Q of force constant k_p and $k_q\left(k_q = \frac{k_p}{2}\right)$ are stretched by applying forces of equal magnitude. If the energy stored in Q is E, then the energy stored in P is

NCERT Page-123 / N-80

(a) E (b) 2E (c) E/8 (d) E/2

77. Two springs have their force constant as k_1 and k_2 ($k_1 > k_2$). When they are stretched by the same force

NCERT Page-123 / N-80

(a) no work is done in case of both the springs.
(b) equal work is done in case of both the springs
(c) more work is done in case of second spring
(d) more work is done in case of first spring.

78. One end of a light spring of spring constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. In a displacement, the work done by the spring is 1/2 k x^2. The possible cases are

NCERT Page-123 / N-80

(a) the spring was initially compressed by a distance x, was finally in its natural length
(b) it was initially stretched by a distance x and was finally in its natural length
(c) it was initially in its natural length and finally in a compressed position
(d) it was initially in its natural length and finally in the stretched position

79. If the extension in a spring is increased to 4 times then the potential energy NCERT Page-124 / N-81

(a) remains the same (b) becomes 4 times
(c) becomes one fourth (d) becomes 16 times

80. A long string is stretched by 2 cm and the potential energy is V. If the spring is stretched by 10 cm, its potential energy will be NCERT Page-124 / N-81

(a) V/25 (b) V/5 (c) 5V (d) 25 V

5.10 Power

81. At time t = 0s particle starts moving along the x-axis. If its kinetic energy increases uniformly with time t, the net force acting on it must be proportional to

NCERT Page-128 / N-83

(a) $\sqrt{t}$ (b) constant (c) t (d) $\frac{1}{\sqrt{t}}$

82. If a force F is applied on a body and it moves with a velocity V, the power will be NCERT Page-128 / N-83

(a) F × v (b) F/v
(c) F/v^2 (d) $F \times v^2$

83. Sand is being dropped from a stationary dropper at a rate of 0.5 kgs^{-1} on a conveyor belt moving with a velocity of 5 ms^{-1}. The power needed to keep belt moving with the same velocity will be : NCERT Page-128 / N-83

(a) 1.25 W (b) 2.5 W (c) 6.25 W (d) 12.5 W

84. A body of mass m is accelerated uniformly from rest to a speed v in a time T. The instantaneous power delivered to the body as a function of time is given by

NCERT Page-128 / N-83

(a) $\frac{mv^2}{T^2}\cdot t^2$ (b) $\frac{mv^2}{T^2}\cdot t$ (c) $\frac{1}{2}\frac{mv^2}{T^2}\cdot t^2$ (d) $\frac{1}{2}\frac{mv^2}{T^2}\cdot t$

85. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude p_o. The instantaneous velocity of this car is proportiourl to: NCERT Page-128 / N-83

(a) $t^2 p_o$ (b) $t^{1/2}$ (c) $t^{-1/2}$ (d) $\frac{t}{\sqrt{m}}$

86. A vehicle is moving with a uniform velocity on a smooth horizontal road, then power delivered by its engine must be

NCERT Page-128 / N-83

(a) uniform (b) increasing
(c) decreasing (d) zero

87. How much water, a pump of 2 kW can raise in one minute to a height of 10 m, take g = 10 m/s^2? NCERT Page-128 / N-83

(a) 1000 (b) 1200 (c) 100 (d) 2000

88. The engine of a vehicle delivers constant power. If the vehicle is moving up the inclined plane then, its velocity,

NCERT Page-128 / N-83

(a) must remain constant
(b) must increase
(c) must decrease
(d) may increase, decrease or remain same.

89. A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time 't' is proportional to NCERT Page-128 / N-83

(a) $t^{3/4}$ (b) $t^{3/2}$ (c) $t^{1/4}$ (d) $t^{1/2}$

90. A body projected vertically from the earth reaches a height equal to earth's radius before returning to the earth. The power exerted by the gravitational force is greatest

NCERT Page-128 / N-83

(a) at the highest position of the body
(b) at the instant just before the body hits the earth
(c) it remains constant all through
(d) at the instant just after the body is projected

91. A body of mass 10 kg moves with a velocity v of 2 m/s along a circular path of radius 8 m. The power produced by the body will be NCERT Page-128 / N-83

(a) 10 J/s (b) 98 J/s (c) 49 J/s (d) zero

92. Johnny and his sister Jane race up a hill. Johnny weighs twice as much as jane and takes twice as long as jane to reach the top . Compared to Jane NCERT Page-128 / N-83

(a) Johnny did more work and delivered more power.
(b) Johnny did more work and delivered the same amount of power.
(c) Johnny did more work and delivered less power
(d) Johnny did less work and johnny delivered less power.

93. A constant power P is applied to a car starting from rest. If v is the velocity of the car at time t, then

NCERT Page-128 / N-83

(a) $v \propto t$ (b) $v \propto \frac{1}{t}$

(c) $v \propto \sqrt{t}$ (d) $v \propto \frac{1}{\sqrt{t}}$

94. If two persons A and B take 2 seconds and 4 seconds respectively to lift an object to the same height h, then the ratio of their powers is NCERT Page-128 / N-83

(a) 1 : 2 (b) 1 : 1
(c) 2 : 1 (d) 1 : 3

95. A 10 H.P. motor pumps out water from a well of depth 20 m and fills a water tank of volume 22380 litres at a height of 10 m from the ground. The running time of the motor to fill the empty water tank is ($g = 10ms^{-2}$) NCERT Page-128 / N-83

(a) 5 minutes (b) 10 minutes
(c) 15 minutes (d) 20 minutes

96. If a machine gun fires n bullets per second each with kinetic energy K, then the power of the machine gun is

NCERT Page-128 / N-83

(a) nK^2 (b) $\frac{K}{n}$ (c) n^2K (d) nK

97. A particle of mass 1 kg begins to move under the action of a time dependent force $\vec{F} = (4 + \hat{i} + 6\hat{j})N$ where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axis. What power will be developed by the force at the time t? NCERT Page-128 / N-83

(a) $(4t^2 + 6 + 4)W$ (b) $(4t^3 + 6 + 5)W$
(c) $(4t + 6t^2)W$ (d) $(4t^3 + 6t^4)W$

98. A force applied by an engine of a train of mass 2.05×10^6 kg changes its velocity from 5m/s to 25 m/s in 5 minutes. The power of the engine is NCERT Page-128 / N-83

(a) 1.025 MW (b) 2.05 MW (c) 5 MW (d) 6 MW

99. A 10 m long iron chain of linear mass density 0.8 kg m^{-1} is hanging freely from a rigid support. If g = 10 ms^{-2}, then the power required to left the chain upto the point of support in 10 second NCERT Page-128 / N-83

(a) 10 W (b) 20W (c) 30 W (d) 40 W

5.11 Collisions

100. Which one of the following statements is true?

NCERT Page-129 / N-84

(a) Momentum is conserved in elastic collisions but not in inelastic collisions
(b) Total kinetic energy is conserved in elastic collisions but momentum is not conserved in elastic collisions
(c) Total kinetic energy is not conserved but momentum is conserved in inelastic collisions
(d) Kinetic energy and momentum both are conserved in all types of collisions

101. When after collision the deformation is not relived and the two bodies move together after the collision, it is called

NCERT Page-129 / N-84

(a) elastic collision
(b) inelastic collision
(c) perfectly inelastic collision
(d) perfectly elastic collision

102. In an inelastic collision, which of the following does not remain conserved? NCERT Page-129 / N-84

(a) Momentum
(b) kinetic energy
(c) Total energy
(d) Neither momentum nor kinetic energy

103. In case of elastic collision, at the time of impact.

NCERT Page-129 / N-84

(a) total K.E. of colliding bodies is conserved.
(b) total K.E. of colliding bodies increases
(c) total K.E. of colliding bodies decreases
(d) total momentum of colliding bodies decreases.

104. In elastic collision, 100% energy transfer takes place when

NCERT Page-130 / N-84

(a) $m_1 = m_2$ (b) $m_1 > m_2$ (c) $m_1 < m_2$ (d) $m_1 = 2m_2$

105. If two equal masses ($m_1 = m_2$) collide elastically in one dimension, where m_2 is at rest and m_1 moves with a velocity u_1, then the final velocities of two masses are

NCERT Page-130 / N-84

(a) $V_1 = 0; V_2 = u_1$ (b) $V_1 = V_2 = 0$
(c) $V_1 = 0$ and $V_2 = -u_1$ (d) $V_1 = -u_1; V_2 = 0$

106. A particle A suffers an oblique elastic collision with a particle B that is at rest initially. If their masses are the same, then after collision NCERT Page-130, 131 / N-84, 85

(a) they will move in opposite directions
(b) A continues to move in the original direction while B remains at rest
(c) they will move in mutually perpendicular directions
(d) A comes to rest and B starts moving in the direction of the original motion of A

107. A metal ball of mass 2 kg moving with a velocity of 36 km/h has a head on collision with a stationary ball of mass 3 kg. If after the collision, the two balls move together, the loss in kinetic energy due to collision is

NCERT Page-129, 130 / N-84, 85

(a) 140 J (b) 100 J (c) 60 J (d) 40 J

108. Two particles having the position $\vec{r}_1 = (3\hat{i} + 5\hat{j})$ m and $\vec{r}_2 = (-5\hat{i} - 3\hat{j})$ m move with velocities $\vec{V}_1 = (4\hat{i} + 3\hat{j})\,m/s$ and $\vec{V}_2 = (a\hat{i} + 7\hat{j})\,m/s$. If the particles collide, then value of a must be

(a) 8 (b) 6
(c) 4 (d) 2

109. A mass of 20 kg moving with a speed of 10m/s collides with another stationary mass of 5 kg. As a result of the collision, the two masses stick together. The kinetic energy of the composite mass will be NCERT Page-129 / N-84

(a) 600 (b) 800
(c) 1000 (d) 1200

110. A mass m moving horizontally (along the x-axis) with velocity v collides and sticks to mass of 3m moving vertically upward (along the y-axis) with velocity 2v. The final velocity of the combination is NCERT Page-131 / N-85

(a) $\frac{1}{4}v\hat{i}+\frac{3}{2}v\hat{j}$ (b) $\frac{1}{3}v\hat{i}+\frac{2}{3}v\hat{j}$

(c) $\frac{2}{3}v\hat{i}+\frac{1}{3}v\hat{j}$ (d) $\frac{3}{2}v\hat{i}+\frac{1}{4}v\hat{j}$

111. A body of mass m moving with velocity v collides head on with another body of mass 2m which is initially at rest. The ratio of K. E. of colliding body before and after collision will be NCERT Page-130 / N-85

(a) 1 : 1 (b) 2 : 1
(c) 4 : 1 (d) 9 : 1

112. An object of mass 2.0 kg makes an elastic collision with another object of mass M at rest and continues to move in the original direction but with one-fourth of its original speed. What is the value of M? NCERT Page-131 / N-86

(a) 0.75 kg (b) 1.0 kg
(c) 1.2 kg (d) None of these

113. A bullet of mass 20g and moving with 600 m/s collides with a block of mass 4 kg hanging with the string. What is velocity of bullet when it comes out of block, if block rises to height 0.2 m after collision? NCERT Page-129, 130 / N-84, 85

(a) 200 m/s (b) 150 m/s
(c) 400 m/s (d) 300 m/s

114. A block of mass 0.50 kg is moving with a speed of 2.00 ms^{-1} on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is

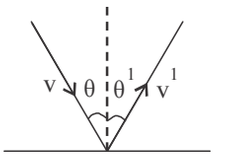
NCERT Page-129 / N-84

(a) 0.16 J (b) 1.00 J (c) 0.67 J (d) 0.34 J

115. If a shell fired from a cannon, explodes in mid air, then NCERT Page-129 / N-84

(a) its total kinetic energy increases
(b) its total momentum increases
(c) its total momentum decreases
(d) None of these

116. A ball of mass *m* hits the floor making an angle θ as shown in the figure. If e is the coefficient of restitution, then which relation is true, for the velocity component before and after collision?



NCERT Page-129, 130 / N-84, 85

(a) $V^1 \sin\theta = V \sin\theta$ (b) $V^1 \sin\theta' = -\sin\theta$
(c) $V^1 \cos\theta' = V \cos\theta$ (d) $V^1 \cos\theta' = -V \cos\theta$

117. Before a rubber ball bounces off from the floor, the ball is in contact with the floor for a fraction of second. Which of the following statements is correct?

NCERT Page-129, 131 / N-84, 85

(a) Conservation of energy is not valid during this period
(b) Conservation of energy is valid during this period
(c) As ball is compressed, kinetic energy is converted to compressed potential energy
(d) None of these

118. A bag of sand of mass 9.8 kg is suspended by a rope. A bullet of 200 g travelling with speed 10 ms^{-1} gets embedded in it, then loss of kinetic energy will be

NCERT Page-129, 130 / N-84, 85

(a) 4.9 J (b) 9.8 J (c) 14.7 (d) 19.6 J

119. A object of mass m_1 collides with another object of mass m_2, which is at rest. After the collision the objects move with equal speeds in opposite direction. The ratio of the masses $m_2 : m_1$ is: NCERT Page-129, 130 / N-84, 85

(a) 2 : 1 (b) 3 : 1 (c) 1 : 2 (d) 1 : 1

120. Two billiard balls of mass 0.05 kg each moving in opposite directions with 10 ms^{-1} collide and rebound with the same speed. If the time duration of contact is t = 0.005 s, then what is the force exerted on the ball due to each other?

NCERT Page-129, 130 / N-84, 85

(a) 100 N (b) 200 N (c) 300 N (d) 4000 N

Exercise 2 : NCERT Exemplar & Past Years NEET

NCERT Exemplar Questions

1. An electron and a proton are moving under the influence of mutual forces. In calculating the change in the kinetic energy of the system during motion, one ignores the magnetic force of one on another. This is, because

NCERT Page-117 / N-74

(a) the two magnetic forces are equal and opposite, so they produce no net effect
(b) the magnetic forces do not work on each particle
(c) the magnetic forces do equal and opposite (but non-zero) work on each particle
(d) the magnetic forces are necessarily negligible

2. A proton is kept at rest. A positively charged particle is released from rest at a distance *d* in its field. Consider two experiments; one in which the charged particle is also a proton and in another, a positron. In the same time *t*, the work done on the two moving charged particles is

NCERT Page-117 / N-74

(a) same as the same force law is involved in the two experiments
(b) less for the case of a positron, as the positron moves away more rapidly and the force on it weakens
(c) more for the case of a positron, as the positron moves away a larger distance
(d) same as the work done by charged particle on the stationary proton

3. A man squatting on the ground gets straight up and stand. The force of reaction of ground on the man during the process is NCERT Page-117 / N-74

(a) constant and equal to *mg* in magnitude
(b) constant and greater than *mg* in magnitude
(c) variable but always greater than *mg*
(d) at first greater than *mg* and later becomes equal to *mg*

4. A bicyclist comes to a skidding stop in 10 m. During this process, the force on the bicycle due to the road is 200N and is directly opposed to the motion. The work done by the cycle on the road is NCERT Page-117 / N-74

(a) +2000 J (b) −200 J (c) zero (d) −20,000 J

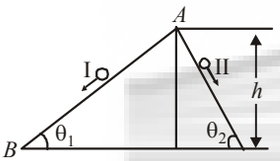
5. A body is falling freely under the action of gravity alone in vaccum. Which of the following quantities remain constant during the fall? NCERT Page-121 / N-78

(a) Kinetic energy
(b) Potential energy
(c) Total mechanical energy
(d) Total linear momentum

6. During inelastic collision between two bodies, which of the following quantities always remain conserved? NCERT Page-129 / N-84

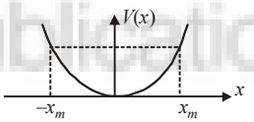
(a) Total kinetic energy (b) Total mechanical energy
(c) Total linear momentum (d) Speed of each body

7. Two inclined frictionless tracks, one gradual and the other steep meet at A from where two stones are allowed to slide down from rest, one on each track as shown in figure. Which of the following statement is correct? NCERT Page-121 / N-78



(a) Both the stones reach the bottom at the same time but not with the same speed
(b) Both the stones reach the bottom with the same speed and stone I reaches the bottom earlier than stone II
(c) Both the stones reach the bottom with the same speed and stone II reaches the bottom earlier than stone I
(d) Both the stones reach the bottom at different times and with different speeds

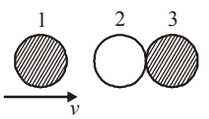
8. The potential energy function for a particle executing linear SHM is given by $V(x)=\frac{1}{2}kx^2$ where



k is the force constant of the oscillator (Fig.). For k = 0.5 N/m, the graph of $V(x)$ versus x is shown in the figure. A particle of total energy E turns back when it reaches $x = \pm x_m$. If V and K indicate the PE and KE, respectively of the particle at $x = +x_m$, then which of the following is correct? NCERT Page-124 / N-81

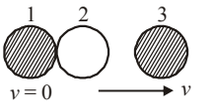
(a) $V = O,\ K = E$ (b) $V = E,\ K = O$
(c) $V < E,\ K = O$ (d) $V = O,\ K < E$

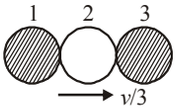
9. Two identical ball bearings in contact with each other and resting on a frictionless table are hit head-on by another ball bearing of the same mass moving initially with a speed v as shown in figure.

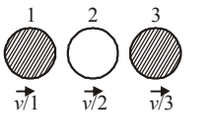


If the collision is elastic, which of the following (figure) is a possible result after collision? NCERT Page-129, 130 / N-84, 85

(a) 

(b) 

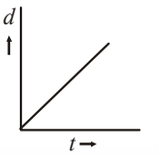
(c) 

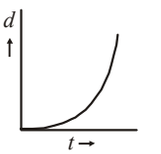
(d) 

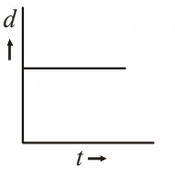
10. A body of mass 0.5 kg travels in a straight line with velocity $v = a\,x^{3/2}$ where a = 5 $m^{-1/2}s^{-1}$. The work done by the net force during its displacement from x = 0 to x = 2 m is NCERT Page-118 / N-75

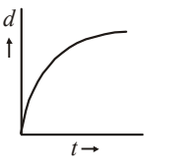
(a) 15 J (b) 50 J (c) 10 J (d) 100 J

11. A body is moving unidirectionally under the influence of a source of constant power supplying energy. Which of the diagrams shown in figure correctly shown the displacement-time curve for its motion? NCERT Page-128 / N-83

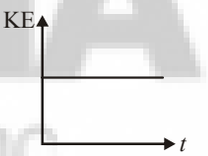
(a) 

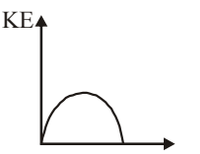
(b) 

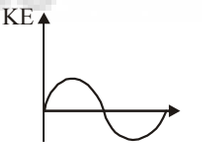
(c) 

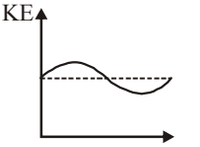
(d) 

12. Which of the diagrams shown in figure most closely shows the variation in kinetic energy of the earth as it moves once around the sun in its elliptical orbit? NCERT Page-117 / N-74

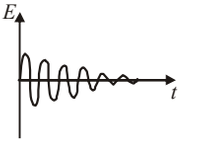
(a) 

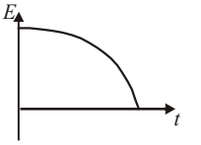
(b) 

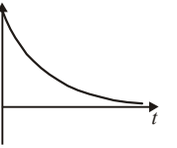
(c) 

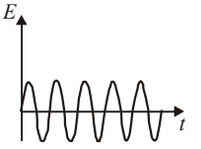
(d) 

13. Which of the diagrams shown in figure represents variation of total mechanical energy of a pendulum oscillating in air as function of time? NCERT Page-121 / N-78

(a) 

(b) 

(c) 

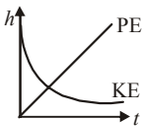
(d) 

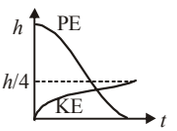
14. A mass of 5 kg is moving along a circular path of radius 1 m. If the mass moves with 300 rev/min, its kinetic energy would be **NCERT** Page-117 / N-74

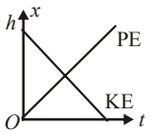
(a) $250\,\pi^2$ (b) $100\,\pi^2$
(c) $5\,\pi^2$ (d) 0

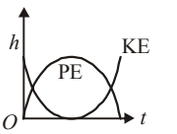
15. A raindrop falling from a height h above ground, attains a near terminal velocity when it has fallen through a height $(3/4)h$. Which of the diagrams shown in figure correctly shows the change in kinetic and potential energy of the drop during its fall up to the ground?

NCERT Page-121 / N-78

(a) 

(b) 

(c) 

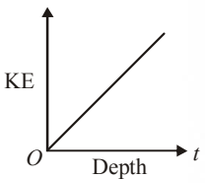
(d) 

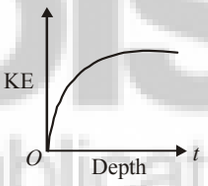
16. In a shotput event an athlete throws the shotput of mass 10 kg with an initial speed of 1 m s^{-1} at 45° from a height 1.5 m above ground. Assuming air resistance to be negligible and acceleration due to gravity to be 10 m s^{-2}, the kinetic energy of the shotput when it just reaches the ground will be **NCERT** Page-121 / N-78

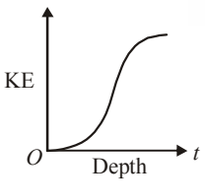
(a) 2.5 J (b) 5.0 J (c) 52.5 J (d) 155.0 J

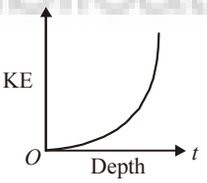
17. Which of the diagrams in figure correctly shows the change in kinetic energy of an iron sphere falling freely in a lake having sufficient depth to impart it a terminal velocity?

NCERT Page-117 / N-74

(a) 

(b) 

(c) 

(d) 

18. A cricket ball of mass 150 g moving with a speed of 126 km/h hits at the middle of the bat, held firmly at its position by the batsman. The ball moves straight back to the bowler after hitting the bat. Assuming that collision between ball and bat is completely elastic and the two remain in contact for 0.001s, the force that the batsman had to apply to hold the bat firmly at its place would be **NCERT** Page-129 / N-84

(a) 10.5 N (b) 21 N
(c) 1.05×10^4 N (d) 2.1×10^4 N

Past Years NEET

19. The heart of man pumps 5 litres of blood through the arteries per minute at a pressure of 150 mm of mercury. If the density of mercury be 13.6×10^3 kg/m^3 and g = 10m/s^2 then the power of heart in watt is :

NCERT Page-128 / N-83 | **AIPMT** 2015 RS, A

(a) 2.35 (b) 3.0 (c) 1.50 (d) 1.70

20. A ball is thrown vertically downwards from a height of 20 m with an initial velocity v_0. It collides with the ground loses 50 percent of its energy in collision and rebounds to the same height. The initial velocity v_0 is : (Take g = 10 ms^{-2})

NCERT Page-117 / N-74 | **AIPMT** 2015 RS, A

(a) 20 ms^{-1} (b) 28 ms^{-1} (c) 10 ms^{-1} (d) 14 ms^{-1}

21. A particle of mass m is driven by a machine that delivers a constant power of k watts. If the particle starts from rest the force on the particle at time t is

NCERT Page-128 / N-83 | **AIPMT** 2015, C

(a) $\sqrt{mk}\ t^{-1/2}$ (b) $\sqrt{2mk}\ t^{-1/2}$

(c) $\frac{1}{2}\sqrt{mk}\ t^{-1/2}$ (d) $\sqrt{\frac{mk}{2}}t^{-1/2}$

22. Two similar springs P and Q have spring constants K_P and K_Q, such that $K_P > K_Q$. They are stretched, first by the same amount (case a,) then by the same force (case b). The work done by the springs W_P and W_Q are related as, in case (a) and case (b), respectively

NCERT Page-123 / N-80 | **AIPMT** 2015, C

(a) $W_P = W_Q$; $W_P = W_Q$ (b) $W_P > W_Q$; $W_Q > W_P$
(c) $W_P < W_Q$; $W_Q < W_P$ (d) $W_P = W_Q$; $W_P > W_Q$

23. A block of mass 10 kg, moving in x direction with a constant speed of 10 ms^{-1}, is subject to a retarding force F = 0.1x J/m during its travel from x = 20 m to 30 m. Its final KE will be: **NCERT** Page-117 / N-74 | **AIPMT** 2015, S

(a) 450 J (b) 275 J (c) 250 J (d) 475 J

24. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F}=(2t\hat{i}+3t^2\hat{j})$ N, where $\hat{i}$ and $\hat{j}$ are unit vectors alogn x and y axis. What power will be developed by the force at the time t?

NCERT Page-128 / N-83 | **NEET** 2016, A

(a) $(2t^2 + 3t^3)$W (b) $(2t^2 + 4t^4)$W
(c) $(2t^3 + 3t^4)$ W (d) $(2t^3 + 3t^5)$W

25. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?

NCERT Page-117 / N-74 | **NEET** 2016, S

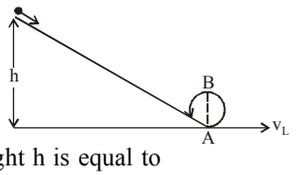
(a) 0.1 m/s^2 (b) 0.15 m/s^2
(c) 0.18 m/s^2 (d) 0.2 m/s^2

26. Consider a drop of rain water having mass 1 g falling from a height of 1 km. It hits the ground with a speed of 50 m/s. Take 'g' constant with a value 10 m/s^2.
The work done by the (i) gravitational force and the (ii) resistive force of air is

NCERT Page-116, 117 / N-73, 74 | **NEET** 2017, A

(a) (i) 1.25 J (ii) –8.25 J
(b) (i) 100 J (ii) 8.75 J
(c) (i) 10 J (ii) – 8.75 J
(d) (i) – 10 J (ii) –8.25 J

27. A body initially at rest and sliding along a frictionless track from a height h (as shown in the figure) just completes a vertical circle of diameter AB = D. The height h is equal to



NCERT Page-121 / N-78 | NEET 2018, A

(a) $\frac{3}{2}D$ (b) D (c) $\frac{5}{4}D$ (d) $\frac{7}{5}D$

28. A moving block having mass m, collides with another stationary block having mass 4m. The lighter block comes to rest after collision. When the initial velocity of the lighter block is v, then the value of coefficient of restitution (e) will be NCERT Page-129 / N-84 | NEET 2018, S

(a) 0.5 (b) 0.25 (c) 0.4 (d) 0.8

29. When a block of mass M is suspended by a long wire of length L, the length of the wire becomes (L + *l*). The elastic potential energy stored in the extended wire is :

NCERT Page-123 / N-80 | NEET 2019, S

(a) Mgl (b) MgL (c) $\frac{1}{2}Mgl$ (d) $\frac{1}{2}$MgL

30. A force F = 20 + 10*y* acts on a particle in *y*-direction where F is in newton and *y* in meter. Work done by this force to move the particle from *y* = 0 to *y* = 1 m is :

NCERT Page-118 / N-75 | NEET 2019, S

(a) 30 J (b) 5 J (c) 25 J (d) 20 J

31. A particle is released from height *S* from the surface of the Earth. At a certain height its kinetic energy is three times its potential energy. The height from the surface of earth and the speed of the particle at that instant are respectively

NCERT Page-117, 120 / N-74, 77 | NEET 2021, A

(a) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$ (b) $\frac{S}{4}, \frac{3gS}{2}$

(c) $\frac{S}{4}, \frac{\sqrt{3gS}}{2}$ (d) $\frac{S}{2}, \frac{\sqrt{3gS}}{2}$

32. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of the input energy. How much power is generated by the turbine? (g = 10 m/s^2)

NCERT Page-128 / N-83 | NEET 2021, A

(a) 7.0 kW (b) 10.2 kW (c) 8.1 kW (d) 12.3 kW

33. The energy that will be ideally rediated by a 100 kW transmitter in 1 hour is: NCERT Page-128 / N-83 | NEET 2022, C

(a) 36×10^4 J (b) 36×10^5 J

(c) 1×10^5 J (d) 36×10^7 J

34. An electric lift with a maximum load of 2000 kg (lift + passengers) is moving up with a constant speed of 1.5 ms^{-1}. The frictional force opposing the motion is 3000 N. The minimum power delivered by the motor to the lift in watts is: (g = 10 ms^{-2}) NCERT Page-128, 129 / N-83, 84 | NEET 2022, A

(a) 20000 (b) 34500 (c) 23500 (d) 23000

35. A shell of mass m is at rest initially. It explodes into three fragments having mass in the ratio 2 : 2 : 1. If the fragments having equal mass fly off along mutually perpendicular directions with speed v, the speed of the third (lighter) fragment is NCERT Page-129 / N-84 | NEET 2022, A

(a) $\sqrt{2}$ v (b) $2\sqrt{2}$ v (c) $3\sqrt{2}$ v (d) v

36. The potential energy of a long spring when stretched by 2 cm is U. If the spring is stretched by 8 cm, potential energy stored in it will be

NCERT Page-124 / N-82 | NEET 2023,A

(a) 2 U (b) 4 U (c) 8 U (d) 16 U

37. At any instant of time t, the displacement of any particle is given by 2t – 1 (SI unit) under the influence of force of 5N. The value of instantaneous power is (in SI unit):

NCERT Page-128 / N-83 | NEET 2024

(a) 10 (b) 5 (c) 7 (d) 6

38. Two bodies A and B of same mass undergo completely inelastic one dimensional collision. The body A moves with velocity v_1 while body B is at rest before collision. The velocity of the system after collision is v_2. The ratio $v_1 : v_2$ is NCERT Page-129 / N-84 | NEET 2024

(a) 1 : 2 (b) 2 : 1 (c) 4 : 1 (d) 1 : 4

Exercise 3 : Matching, Statement & Assertion-Reason Type

Match the Following

1. A small block of mass 200*g* is kept at the top of a an incline which is 10 *m* long and 3.2 *m* high. Match the columns

Column I	Column II
(A) Work done, to lift the block from the ground and put it at the top	(1) 6.4 J
(B) Work done to slide the block up the incline	(2) 7.2 J
(C) the speed of the block at the ground when left from the top of the incline to fall vertically	(3) 4 m/s
(D) The speed of the block at the ground when side along the incline	(4) 8 m/s

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(2)
(d) (A)→(1); (B)→(3); C→(1); (D)→(2)

2. If W represents the work done, then match the two columns:

Column I	Column II
(A) Force is always along the velocity	(1) W = 0
(B) Force is always perpendicular to velocity	(2) W < 0
(C) Force is always opposite to velocity	(3) W > 0
(D) The object is stationary but the point of application of the force moves on the object	

(a) (A)→(1); (B)→(2); C→(3); (D)→(2)
(b) (A)→(3); (B)→(1); C→(2); (D)→(1)
(c) (A)→(2); (B)→(3); C→(1); (D)→(2)
(d) (A)→(1); (B)→(2); C→(3); (D)→(1)

3.

Column I	Column II
(A) Kinetic Energy	(1) Stretched spring
(B) Potential Energy	(2) Watt
(C) Collision	(3) Elastic or inelastic
(D) Power	(4) A boy running on the roof

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(2)
(d) (A)→(4); (B)→(1); C→(3); (D)→(2)

Two-Statement Type Questions

Directions: *Read the statements carefully and answer the question on the basis of following options.*

(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

4. **Statement I:** The work done in moving a body over a closed loop is zero for every force in nature.
Statement II : Work done depends on nature of force.

5. **Statement I :** If collision occurs between two elastic bodies their kinetic energy decreases during the time of collision.
Statement II : During collision intermolecular space decreases and hence elastic potential energy increases.

6. **Statement I :** In an elastic collision of two billiard balls, the total kinetic energy is conserved during the short time of collision of the balls (*i.e.*, when they are in contact).
Statement II : Energy spent against friction follow the law of conservation of energy.

Four/Five Statement Type Questions

7. Which of the following statements are incorrect?
I. If there were no friction, work need to be done to move a body up an inclined plane is zero.
II. Kinetic energy. $Ek = \frac{1}{2} mv^2$
III. As the angle of inclination is increased, the normal reaction on the body placed on it increases.
IV. A duster weighing 0.5 kg is pressed against a vertical board with a force of 11 N. If the coefficient of friction is 0.5, the work done in rubbing it upward through a distance of 10 cm is 0.55J.
(a) I and II (b) I, II and IV
(c) I, III and IV (d) I, II, III and IV

8. Which of the following statements are incorrect ?
I. If there were no friction, work need to be done to move a body up an inclined plane is zero.
II. If there were no friction, moving vehicles could not be stopped even by locking the brakes.
III. As the angle of inclination is increased, the normal reaction on the body placed on it increases.
IV. A duster weighing 0.5 kg is pressed against a vertical board with a force of 11 N. If the coefficient of friction is 0.5, the work done in rubbing it upward through a distance of 10 cm is 0.55J.
(a) I and II (b) I, II and IV
(c) I, III and IV (d) I, II, III and IV

9. A force $F(x)$ is conservative, if
I. there is change in kinetic energy over a round trip.
II. it depends only on the end points.
III. work done by $F(x)$ in a closed path is zero.
IV. it depends on the path taken.
Which of the following option is correct ?
(a) Only I (b) I and III
(c) II and IV (d) II and III

10. Consider the following statements and select the correct statements.
I. Area under force- displacement curve with proper algebraic sign represents work done by the force.
II. Conservation of mechanical energy is a consequence of work energy theorem for conservative forces
III. Work energy theorem holds in all inertial frames
IV. Area under force-displacement gives kinetic energy.
(a) I and II (b) II and III
(c) I and IV (d) I, II and III

11. In elastic collision,
I. initial kinetic energy is equal to the final kinetic energy.
II. kinetic energy during the collision time Δt is constant.
III. total momentum is conserved.
IV. kinetic energy during the collision time Δt is not constant.
Which of the above statements is/are correct ?
(a) Only I (b) I, III and IV
(c) Only III (d) Only II

Assertion & Reason Questions

Directions : *These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.*

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect and Reason is correct.

12. **Assertion :** A force applied on the body always does work on the body.
Reason : If a force applied on a body displaces the body along the direction of force work done will be minimum.

13. **Assertion :** The change in kinetic energy of a particle is equal to the work done on it by the net force.
Reason : Change in kinetic energy of particle is equal to the work done only in case of a system of one particle.

14. **Assertion:** A light body and heavy body have same momentum. Then they have same kinetic energy.
Reason: Kinetic energy does not depend on mass of the body.

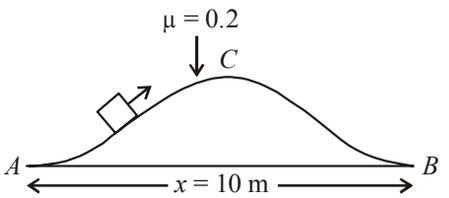
15. **Assertion :** When a machine gun fires n bullets per second each with kinetic energy K, the power of a gun is $P = nK$
Reason : Power P = work done / time also work done = change in kinetic energy.

16. **Assertion :** A point particle of mass m moving with speed V collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f = \left(\frac{M}{M+m}\right)$.

Reason : Maximum energy loss occurs when the particles get stuck together as a result of the collision.

Exercise 4 : Skill Enhancer MCQs

1. A block of mass 1 kg is pulled along the curve path ACB by a tangential force as shown in figure. The work done by the frictional force when the block moves from A to B is



(a) 5 J (b) 10 J
(c) 20 J (d) None of these

2. A bullet looses $\left(\frac{1}{n}\right)^{th}$ of its velocity passing through one plank. The number of such planks that are required to stop the bullet can be:

(a) $\frac{n^2}{2n-1}$ (b) $\frac{2n^2}{n-1}$ (c) infinite (d) n

3. A mass of M kg is suspended by a weightless string. The horizontal force that is required to displace it untill the string makes an angle of 45° with the initial vertical direction is :

(a) $Mg(\sqrt{2}-1)$ (b) $Mg(\sqrt{2}+1)$
(c) $Mg\sqrt{2}$ (d) $\frac{Mg}{\sqrt{2}}$

4. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2rt^2$ where k is a constant. The power delivered to the particles by the force acting on it is

(a) $2\pi mk^2r^2t$ (b) mk^2r^2t
(c) $\frac{(mk^4r^2t^5)}{3}$ (d) zero

5. A man of mass m on an initially stationary boat gets off the boat by jumping to the left in an exactly horizontal direction. Immediately after the jump, the boat of mass M, is observed to be moving to the right at speed v. How much work did the man do during the jump (both on his own body and on the boat)

(a) $\frac{1}{2}(M+m)v^2$ (b) $\frac{1}{2}\left(M+\frac{M^2}{m}\right)v^2$
(c) $\frac{1}{2}\left(\frac{Mm}{M+m}\right)v^2$ (d) None of these

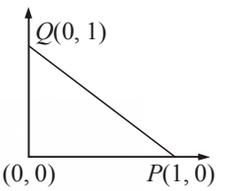
6. The potential energy of particle in a force field is $U = \frac{A}{r^2} - \frac{B}{r}$, where A and B are positive constants and r is the distance of particle from the centre of the field. For stable equilibrium, the distance of the particle is

(a) $B/2A$ (b) $2A/B$ (c) A/B (d) B/A

7. An electric pump is used to fill an overhead tank of capacity $9m^3$ kept at a height of 10m above the ground. If the pump takes 5 minutes to fill the tank by consuming 10 kW power the efficiency of the pump should be ($g = 10\ ms^{-2}$)

(a) 60% (b) 40% (c) 20% (d) 30%

8. Consider a force $F = -x\hat{i} + y\hat{j}$. The workdone by this force in moving a particle from point $P(1, 0)$ to $Q(0, 1)$ along the line segment is (all quantities are in SI units).



(a) $\frac{1}{2}$J (b) 1J (c) $\frac{3}{2}$J (d) zero

9. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0. The instantaneous velocity of this car is proportional to :

(a) t^2P_0 (b) $t^{1/2}$ (c) $t^{-1/2}$ (d) $\frac{t}{\sqrt{m}}$

10. A body of mass 5 kg explodes at rest into three fragments with masses in the ratio 1 : 1 : 3. The fragments with equal masses fly in mutually perpendicular directions with speeds of 21 m/s. The velocity of heaviest fragment in m/s will be

(a) $7\sqrt{2}$ (b) $5\sqrt{2}$ (c) $3\sqrt{2}$ (d) $\sqrt{2}$

11. A stationary particle explodes into two particles of masses m_1 and m_2 which move in opposite directions with velocities v_1 and v_2. The ratio of their kinetic energies E_1/E_2 is

(a) m_1v_2/m_2v_1 (b) m_2/m_1
(c) m_1/m_2 (d) 1

12. A bullet is fired and gets embedded in block kept on table. If table is frictionless, then

(a) kinetic energy gets conserved
(b) potential energy gets conserved
(c) momentum gets conserved
(d) both (a) and (c)

13. The speed of an object of mass m dropped from an inclined plane (frictionless), at the bottom of the plane, depends on:

(a) height of the plane above the ground
(b) angle of inclination of the plane
(c) mass of the object
(d) All of these

14. If two particles are brought near one another, the potential energy of the system will

(a) increase (b) decrease
(c) remains the same (d) equal to the K.E

15. A crate is pushed horizontally with 100 N across a 5 m floor. If the frictional force between the crate and the floor is 40 N, then the kinetic energy gained by the crate is
(a) 200 J (b) 240 J (c) 250 J (d) 300 J

16. A 2 kg block slides on a horizontal floor with a speed of 4m/s. It strikes a uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15N and spring constant is 10,000 N/m. The spring compresses by
(a) 8.5 cm (b) 5.5 cm (c) 2.5 cm (d) 11.0 cm

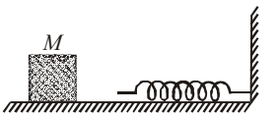
17. The kinetic energy of particle moving along a circle of radius R depends upon the distance covered S and is given by K = aS where a is a constant. Then the force acting on the particle is

(a) $\frac{aS}{R}$ (b) $\frac{2(aS)^2}{R}$ (c) $\frac{aS^2}{R^2}$ (d) $\frac{2aS}{R}$

18. A uniform chain of length 2 m and mass 0.1 kg overhangs a smooth table with its two third part lying on the table. Find the kinetic energy of the chain as it completely slips-off the table.

(a) $\frac{8}{9}$J (b) $\frac{12}{5}$J (c) $\frac{3}{7}$J (d) $\frac{11}{3}$J

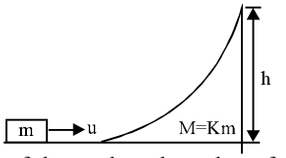
19. The block of mass M moving on the frictionless horizontal surface collides with the spring of spring constant k and compresses it by length L. The maximum momentum of the block after collision is



(a) $\frac{kL^2}{2M}$ (b) $\sqrt{Mk}\ L$

(c) $\frac{ML^2}{k}$ (d) zero

20. A block of mass m is moved towards a movable wedge of mass M = km and height h with velocity u (All the surface are smooth).



If the block just reaches the top of the wedge, the value of u is

(a) $\sqrt{2gh}$ (b) $\sqrt{\frac{2ghK}{1+K}}$

(c) $\sqrt{\frac{2gh(1+K)}{K}}$ (d) $\sqrt{2gh\left(1-\frac{1}{K}\right)}$

Answer Keys

Exercise 1 : (NCERT Based Topic-wise MCQs)																			
1	(c)	**13**	(c)	**25**	(d)	**37**	(b)	**49**	(a)	**61**	(b)	**73**	(a)	**85**	(b)	**97**	(b)	**109**	(b)
2	(b)	**14**	(b)	**26**	(b)	**38**	(c)	**50**	(d)	**62**	(b)	**74**	(a)	**86**	(d)	**98**	(b)	**110**	(a)
3	(c)	**15**	(c)	**27**	(c)	**39**	(a)	**51**	(d)	**63**	(c)	**75**	(a)	**87**	(b)	**99**	(d)	**111**	(d)
4	(b)	**16**	(a)	**28**	(b)	**40**	(b)	**52**	(d)	**64**	(c)	**76**	(d)	**88**	(a)	**100**	(c)	**112**	(d)
5	(a)	**17**	(a)	**29**	(d)	**41**	(c)	**53**	(d)	**65**	(c)	**77**	(c)	**89**	(b)	**101**	(c)	**113**	(a)
6	(d)	**18**	(c)	**30**	(c)	**42**	(c)	**54**	(c)	**66**	(c)	**78**	(a)	**90**	(b)	**102**	(b)	**114**	(c)
7	(b)	**19**	(d)	**31**	(d)	**43**	(b)	**55**	(b)	**67**	(a)	**79**	(d)	**91**	(d)	**103**	(c)	**115**	(a)
8	(c)	**20**	(c)	**32**	(c)	**44**	(d)	**56**	(c)	**68**	(a)	**80**	(d)	**92**	(b)	**104**	(a)	**116**	(a)
9	(a)	**21**	(d)	**33**	(b)	**45**	(a)	**57**	(b)	**69**	(b)	**81**	(d)	**93**	(a)	**105**	(a)	**117**	(b)
10	(d)	**22**	(c)	**34**	(c)	**46**	(b)	**58**	(d)	**70**	(a)	**82**	(a)	**94**	(c)	**106**	(c)	**118**	(b)
11	(c)	**23**	(c)	**35**	(c)	**47**	(a)	**59**	(d)	**71**	(c)	**83**	(d)	**95**	(c)	**107**	(c)	**119**	(b)
12	(b)	**24**	(a)	**36**	(d)	**48**	(b)	**60**	(b)	**72**	(a)	**84**	(b)	**96**	(d)	**108**	(a)	**120**	(b)
Exercise 2 : (NCERT Exemplar & Past Years NEET)																			
1	(b)	**5**	(c)	**9**	(b)	**13**	(c)	**17**	(b)	**21**	(d)	**25**	(a)	**29**	(c)	**33**	(d)	**37**	(a)
2	(c)	**6**	(c)	**10**	(b)	**14**	(a)	**18**	(c)	**22**	(b)	**26**	(c)	**30**	(c)	**34**	(b)	**38**	(b)
3	(d)	**7**	(c)	**11**	(b)	**15**	(b)	**19**	(d)	**23**	(d)	**27**	(c)	**31**	(a)	**35**	(b)		
4	(c)	**8**	(b)	**12**	(d)	**16**	(d)	**20**	(a)	**24**	(d)	**28**	(b)	**32**	(c)	**36**	(d)		
Exercise 3 : (Matching, Statement & Assertion-Reason Type)																			
1	(b)	**3**	(d)	**5**	(b)	**7**	(c)	**9**	(d)	**11**	(b)	**13**	(c)	**15**	(a)				
2	(b)	**4**	(b)	**6**	(d)	**8**	(c)	**10**	(d)	**12**	(d)	**14**	(d)	**16**	(a)				
Exercise 4 : (Skill Enhancer MCQs)																			
1	(c)	**3**	(a)	**5**	(b)	**7**	(d)	**9**	(b)	**11**	(b)	**13**	(a)	**15**	(d)	**17**	(d)	**19**	(b)
2	(a)	**4**	(b)	**6**	(b)	**8**	(b)	**10**	(a)	**12**	(c)	**14**	(a)	**16**	(b)	**18**	(a)	**20**	(c)

5 Work, Energy and Power

EXERCISE - 1

1. **(c)** The dot product should be zero.

2. **(b)**

3. **(c)** $S = \vec{r}_2 - \vec{r}_1 = (14\hat{i} + 13\hat{j} + 9\hat{k}) - (3\hat{i} + 2\hat{j} - 6\hat{k})$

$W = \vec{F} \cdot \vec{S} = (4\hat{i} + \hat{j} + 3\hat{k}) \cdot (11\hat{i} + 11\hat{j} + 15\hat{k})$

$= 4 \times 11 + 1 \times 11 + 3 \times 15 = 100\text{J}$

4. **(b)** For two vectors to be perpendicular to each other

$\vec{A} \cdot \vec{B} = 0$

$(2\hat{i} + 3\hat{j} + 8\hat{k}) \cdot (4\hat{j} + 4\hat{i} + \alpha\hat{k}) = 0$

$-8 + 12 + 8\alpha = 0$ or $\alpha = -\frac{4}{8} = -\frac{1}{2}$

5. **(a)** Work done by the net force = change in kinetic energy of the particle.
This is according to work energy theorem.

6. **(d)** Work done on the body is gain in the kinetic energy.
Acceleration of the body is a = V/T.

Velocity acquired in time t is $v = at = \frac{V}{T}t$

K.E. acquired $\propto v^2$. That is work done $\propto \frac{V^2t^2}{T^2}$

7. **(b)** When force retards motion *i.e.*, F –(ve) so, work done –(ve)

8. **(c)** When a man pushes a wall and fails to displace it, then displacement of wall = 0
$\therefore$ Work done by man = $F \times 0 = 0$
Therefore, man does no work at all.

9. **(a)** When a person carrying load on his head moves over a horizontal road, work done against gravitational force is zero.

10. **(d)** $W = FS\cos\theta$
$\therefore$ If F = 0; $W = 0$
If S = 0; $W = 0$
& if $\theta = 90°$; $\cos 90° = 0$ $\therefore$ W = 0.

11. **(c)** Displacement of the particle when it takes a complete round the circular path is zero.
$\therefore$ Work done = force × displacement
$W = F \times 0 = 0$
Therefore, work done by the force is zero.

12. **(b)** From work-energy theorem,

$W_{Porter} + W_{mg} = \Delta K.E. = 0$ ($\because$ velocity constant)

or, $W_{Porter} = -W_{mg} = -mgh$

$\therefore$ $W_{Porter} = -80 \times 9.8 \times \frac{80}{100} = -627.2\text{J}$

13. **(c)** Work done, $W = \int \vec{F} \cdot \vec{ds} = \left(-x\hat{i} + y\hat{j}\right) \cdot \left(d \times \hat{i} + dy\hat{j}\right)$

$\Rightarrow W = -\int_1^0 x\,dx + \int_0^1 y\,dy = \left(0 + \frac{1}{2}\right) + \frac{1}{2} = 1J$

14. **(b)** (A)→(3); (B)→(1); C→(2,3); (D)→(1)

15. **(c)** $W = \vec{F}.\vec{s} = (5\hat{i} + 2\hat{j}).(2\hat{i} + 3\hat{j}) = 10 + 6 = 16$ J.

16. **(a)** W = F s cos 90º = zero

17. **(a)** $x = 3t - 4t^2 + t^3$ $\frac{dx}{dt} = 3 - 8t + 3t^2$

Acceleration = $\frac{d^2x}{dt^2} = -8 + 6t$

Acceleration after 4 sec = $-8 + 6 \times 4 = 16$
Displacement in 4 sec $= 3 \times 4 - 4 \times 4^2 + 4^3 = 12$ m
$\therefore$ Work = Force × displacement
= Mass × acc. × disp. $= 3 \times 10^{-3} \times 16 \times 12 = 576$ mJ

18. **(c)** As the cord is trying to hold the motion of the block, work done by the cord is negative.

$W = -M(g - a)\,d = -M\left(g - \frac{g}{4}\right)d = \frac{-3Mgd}{4}$

19. **(d)** Though an equal and opposite force acts on the road but since road does not undergo any displacement, hence no work is done on the road.

20. **(c)** Motion without slipping implies pure rolling. During pure rolling work done by friction force is zero.

21. **(d)** Given : $\vec{F} = 3\hat{i} + \hat{j}$

$\vec{r}_1 = \left(2\hat{i} + \hat{k}\right)$, $\vec{r}_2 = \left(4\hat{i} + 3\hat{j} - \vec{k}\right)$

$\vec{r} = \vec{r}_2 - \vec{r}_1 = \left(4\hat{i} + 3\hat{j} - \vec{k}\right) - \left(2\hat{i} + \hat{k}\right)$

or $\vec{r} = 2\hat{i} + 3\hat{j} - 2\hat{k}$

So work done by the given force $w = \vec{f}.\vec{r}$

$= \left(3\hat{i} + \hat{j}\right).\left(2\hat{i} + 3\hat{j} - 2\hat{k}\right) = 6 + 3 = 9J$

22. **(c)** $W = F\,s\cos\theta = 10 \times 2\cos 60° = 10$ J.

23. **(c)** $W = F\,s\cos\theta$, $\cos\theta = \frac{W}{Fs} = \frac{25}{5 \times 10} = \frac{1}{2}$, $\theta = 60°$.

24. **(a)** Since momentum of both bodies are equal

So $p_1 = p_2 \Rightarrow \frac{M_1}{M_2} = \frac{u_2}{u_1} \Rightarrow u_2 > u_1$ (let $M_1 > M_2$)

so $\frac{E_{k_1}}{E_{k_2}} = \frac{P_1^2/2M_1}{P_2^2/2M_2} = \frac{M_2}{M_1} \Rightarrow E_{k_1} < E_{k_2}$

It means that light body has greater kinetic energy, if they have equal momentum.

25. **(d)** Let the velocity of the particle be *v m/s*.
Momentum of the particle (*p*) = mv
Kinetic energy of the particle

$(E) = \frac{1}{2}mv^2 = \frac{1}{2}.\frac{(mv)^2}{m} \Rightarrow E = \frac{p^2}{2m}$

26. **(b)** K. E = $\frac{1}{2}mv^2$ It is always positive

27. **(c)** Initial momentum (p_1) = p; Final momentum (p_2) = 1.5 p and initial kinetic energy (K_1) = K.

Kinetic energy $(K) = \frac{p^2}{2m} \propto p^2$

or, $\frac{K_1}{K_2} = \left(\frac{p_1}{p_2}\right)^2 = \left(\frac{p}{1.5p}\right)^2 = \frac{1}{2.25}$ or, $K_2 = 2.25\ K$.

Therefore, increase in kinetic energy is 2.25 K – K = 1.25 K or 125%.

28. **(b)** $E = \frac{P^2}{2m} \therefore E \propto \frac{1}{m}$ [If P = constant]

i.e., the lightest particle will possess maximum kinetic energy and in the given option mass of electron is minimum.

29. **(d)** K.E. = $\frac{1}{2}mv^2$

Further, $v^2 = u^2 + 2as = 0 + 2ad = 2ad = 2(F/m)d$

Hence, K.E. = $\frac{1}{2}m \times 2(F/m)d = Fd$

or, K.E. acquired = Work done = F × d = constant.

i.e., it is independent of mass m.

30. **(c)** Let m = mass of boy, M = mass of man

v = velocity of boy, V = velocity of man

$\frac{1}{2}MV^2 = \frac{1}{2}\left[\frac{1}{2}mv^2\right]$ ...(i)

$\frac{1}{2}M(V+1)^2 = 1\left[\frac{1}{2}mv^2\right]$ ...(ii)

Putting $m = \frac{M}{2}$ and solving $V = \frac{1}{\sqrt{2}-1}$

31. **(d)** By law of conservation of mechanical energy

$\Delta k = -\Delta U$

$\Rightarrow k_f - k_i = U_i - U_f$

$\Rightarrow k_f = mgy - mg[y - y_0]$

$[\because k_i = 0,\ U_i = mgy$ and $U_f = mg(y - y_0)]$

$\Rightarrow k_f = mgy_0$

32. **(c)** As $\frac{1}{2}m_A v_A^2 = \frac{1}{2}m_B v_B^2$

$\frac{v_A}{v_B} = \sqrt{\frac{m_B}{m_A}}$;

$\frac{P_B}{P_A} = \frac{m_B v_B}{m_A v_A} = \frac{m_B}{m_A}\sqrt{\frac{m_A}{m_B}} = \sqrt{\frac{m_B}{m_A}} = \frac{1}{\sqrt{3}}$

33. **(b)** At the top of flight, horizontal component of velocity = u $\cos 45° = u/\sqrt{2}$

$\therefore$ K.E. = $\frac{1}{2}m\left(\frac{u}{\sqrt{2}}\right)^2 = \frac{1}{2}\left(\frac{mu^2}{2}\right) = \frac{1}{2}K.$

34. **(c)** The uniform acceleration is $a = \frac{1-0}{15} = \frac{1}{15}$ ms^{-2}

Let v be the velocity at kinetic energy $\frac{2}{9}$J

therefore $\frac{1}{2} \times 1 \times v^2 = \frac{2}{9}$ or $v = \frac{2}{3}$ ms^{-1}

Using v = u + at

$\frac{2}{3} = 0 + \frac{1}{15} \times t \Rightarrow t = 10s$

35. **(c)** $v_2 = \frac{-m_1 v_1}{m_2} = \frac{-3}{6} \times 16 = -8\,m/s$

$E_2 = \frac{1}{2}m_2 v_2^2 = \frac{1}{2} \times 6(-8)^2 = 192\,J$

36. **(d)** The average speed of the athelete

$v = \frac{100}{10} = 10\,m/s$

$\therefore$ K.E. = $\frac{1}{2}mv^2$

If mass is 40 kg then, K.E. = $\frac{1}{2} \times 40 \times (10)^2 = 2000\,J$

If mass is 100 kg then,

K.E. = $\frac{1}{2} \times 100 \times (10)^2 = 5000\,J$

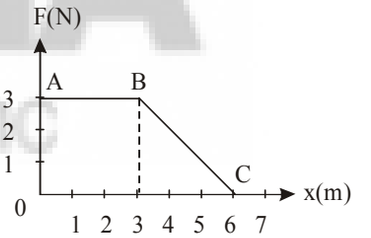
37. **(b)** $W = \int_0^{x_1} F\,dx = \int_0^{x_1} c\,x\,dx = \left[\frac{1}{2}cx^2\right]_0^{x_1}$

$= \frac{1}{2}c(x_1^2 - 0) = \frac{1}{2}cx_1^2$

38. **(c)**

39. **(a)**

40. **(b)**



Work done = area under F-x graph

= area of trapezium OABC = $\frac{1}{2}(3+6)(3) = 13.5$ J

41. **(c)** W = area of $F - x$ graph

= area of Δ + area of rectangle + area of Δ

= $\frac{5 \times 3}{2} + 10 \times 3 + \frac{5 \times 3}{2}$ = 45 J

42. **(c)** We know area under F-x graph gives the work done by the body

$\therefore W = \frac{1}{2} \times (3+2) \times (3-2) + 2 \times 2 = 2.5 + 4 = 6.5$ J

Using work energy theorem,

Δ K.E = work done

$\therefore \Delta$K.E = 6.5 J

43. **(b)** By work-energy thorem
$W = \Delta K$

$\Rightarrow W = \frac{1}{2} m (v_f^2 - v_i^2) \Rightarrow W = \frac{1}{2} \times 0.5 \times (16^2 - 4^2)$

$\Rightarrow W = \frac{1}{4} \times 240 \Rightarrow W = 60$ J

44. **(d)**

45. **(a)** Loss in K.E = Area under the curve $F - x$ = work done

46. **(b)**

47. **(a)** Conservative force is negative gradient of potential

$F(x) = \frac{-dV(x)}{dx}$

48. **(b)** Energy required = mgh
In both cases, h is the same. Hence energy both is the same.

49. **(a)** $U_1 = mgh_1$ and $U_2 = mgh_2$

% energy lost $= \frac{U_1 - U_2}{U_1} \times 100$

$= \frac{mgh_1 - mgh_2}{mgh_1} \times 100 = \left(\frac{h_1 - h_2}{h_1}\right) \times 100$

$= \frac{2 - 1.5}{2} \times 100 = 25\%$

50. **(d)** When work is done upon a system by a conservative force then its potential energy increases.

51. **(d)** $|F| = \frac{dU}{dx}$, which is greatest in the reagion *CD*.

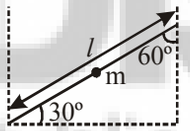
52. **(d)** For any uniform rod, the mass is supposed to be concentrated at its centre.

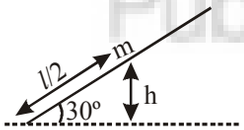
$\therefore$ height of the mass from ground is, $h = (l/2) \sin 30^\circ$

$\therefore$ Potential energy of the rod

$= m \times g \times \frac{\ell}{2} \sin 30^\circ$

$= m \times g \times \frac{\ell}{2} \times \frac{1}{2} = \frac{mg\ell}{4}$





53. **(d)** $F = -\frac{dU}{dy} = b - 2ay$

54. **(c)** $U = (1/2)Mv^2$

55. **(b)** The principle of conservation of total mechanical energy can be stated as, the total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.

56. **(c)** Weight Mg moves the centre of gravity of the spring through a distance $\frac{(0 + \ell)}{2} = \ell/2$

$\therefore$ Mechanical energy stored = Work done = Mg $\ell/2$.

57. **(b)** $v^2 = u^2 + 2gh = (10)^2 + 2 \times 10 \times 19.5 = 490$
K.E. at the ground

$= \frac{1}{2} mv^2 = \frac{1}{2} \times \frac{5}{1000} \times 490 = \frac{49}{40}$ J

P.E. $= mgh = \frac{5}{1000} \times 10 \times \left(\frac{-50}{100}\right) = -\frac{1}{40}$ J

$\therefore$ Change in energy $= \frac{49}{40} - \left(-\frac{1}{40}\right) = \frac{50}{40} = 1.25$J

58. **(d)**

59. **(d)** At the lowest point, h = 0 $\therefore$ P.E. = 0 (gravitational P.E.). There is no work done on the **bob** by the tension as it is perpendicular to the displacement.
$\therefore$ Potential energy is associated only to the gravitational force.

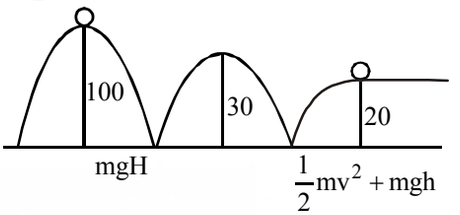
60. **(b)** Total energy at the time of projection

$= \frac{1}{2} m v^2 = \frac{1}{2} \times 0.1 (20)^2 = 20$J

Half way up, P.E. becomes half the P.E. at the top i.e.

P.E. $= \frac{20}{2} = 10$J $\quad \therefore$ K.E. $= 20 - 10 = 10$J.

61. **(b)**



Using conservation of energy,

$m(10 \times 100) = m\left(\frac{1}{2} v^2 + 10 \times 20\right)$

or $\frac{1}{2} v^2 = 800$ or $v = \sqrt{1600} = 40$ m/s

62. **(b)** As we know, dU = F·dr

$U = \int_0^r \alpha r^2 dr = \frac{ar^3}{3}$ ...(i)

As, $\frac{mv^2}{r} = \alpha r^2 = m^2 v^2 = m\alpha r^3$

or, $2m(KE) = \frac{1}{2} \alpha r^3$ ...(ii)

Total energy = Potential energy + kinetic energy
Now, from eqn (i) and (ii)

Total energy = K.E. + P.E. $= \frac{\alpha r^3}{3} + \frac{\alpha r^3}{2} = \frac{5}{6} \alpha r^3$

63. **(c)** Let *E* be the total energy then

$\frac{P.E}{K.E} = \frac{mgh}{E - mgh} = \frac{2}{3} \Rightarrow E = \frac{5}{2}$ mgh

When velocity is double then inital energy becomes 4*E*.

So, $\frac{mgh}{4E - mgh} = NL = \frac{mgh}{10mgh - mgh}$

On solving we get $\frac{P.E}{K.E} = \frac{1}{9}$.

64. **(c)** The tension T_1 at the topmost point is given by

$T_1 = \frac{m v_1^2}{20} - mg$

Centrifugal force acting outward while weight acting downward.

The tension T_2 at the lowest point $T_2 = \frac{mv_2^2}{20} + mg$

Centrifugal force and weight (both) acting downward

$T_2 - T_1 = \frac{mv_2^2 - mv_1^2}{20} + 2mg$

$v_1^2 = v_2^2 - 2gh$ or $v_2^2 - v_1^2 = 2g(40) = 80g$

$\therefore\ T_2 - T_1 = \frac{80mg}{20} + 2mg = 6mg$

65. **(c)** Tension at the highest point

$T_{top} = \frac{mv^2}{r} - mg = 2mg \quad (\therefore v_{top} = \sqrt{3gr})$

Tension at the lowest point

$T_{bottom} = 2mg + 6mg = 8mg$

$\therefore \frac{T_{top}}{T_{bottom}} = \frac{2mg}{8mg} = \frac{1}{4}.$

66. **(c)** Tension in the string, $T = \frac{mv^2}{\ell}$

67. **(a)** Given : Mass (m) = 0.4 kg

Its frequency (n) = 2 rev/sec

Radius (r) =1.2 m. We know that linear velocity of the body $(v) = \omega r = (2\pi n)r$

$= 2 \times 3.14 \times 1.2 \times 2 = 15.08$ m/s.

Therefore, tension in the string when the body is at the top of the circle (T)

$= \frac{mv^2}{r} - mg = \frac{0.4 \times (15.08)^2}{2} - (0.4 \times 9.8)$

$= 45.78 - 3.92 = 41.56\,N$

68. **(a)** Since water does not fall down, therefore the velocity of revolution should be just sufficient to provide centripetal acceleration at the top of vertical circle. So,

$v = \sqrt{(gr)} = \sqrt{\{10 \times (1.6)\}} = \sqrt{(16)} = 4$ m/sec.

69. **(b)** $W = \frac{1}{2}k\ell_2^2 - \frac{1}{2}k\ell_1^2 = \frac{1}{2}k(\ell_2^2 - \ell_1^2)$

70. **(a)** $W_1 = \frac{1}{2} \times 5 \times 10^3 (0.05)^2 \Rightarrow W_2 = \frac{1}{2} \times 5 \times 10^3 (0.10)^2$

$\therefore\ \Delta W = \frac{1}{2} \times 5 \times 10^3 \times 0.15 \times 0.05 = 18.75J.$

71. **(c)** $l_1 + l_2 = l$ and $l_1 = nl_2$

$\therefore \quad l_1 = \frac{nl}{n+1}$ and $l_2 = \frac{l}{n+1}$

As $k \propto \frac{1}{l}$, $\therefore \quad \frac{k_1}{k_2} = \frac{l/(n+1)}{(nl)/(n+1)} = \frac{1}{n}$

72. **(a)** We define the potential energy V(x) of the spring to be zero when block and spring system is in the equilibrium position.

73. **(a)** For a given spring, $u = \frac{1}{2}kx^2$

$\therefore \frac{u_2}{u_1} = \frac{\frac{1}{2}Kx_2^2}{\frac{1}{2}Kx_1^2} = \frac{(3x)^2}{x^2} = 9:1$

74. **(a)** $U = -\int_0^x F dx = -\int_0^x kx dx = -\frac{1}{2}kx^2.$

It is correctly drawn in (a)

75. **(a)** $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \Rightarrow mv^2 = kx^2$ or $m \times (1.5)^2 = 50 \times (0.15)^2$

$\therefore\ m = 0.5$ kg

76. **(d)**

77. **(c)** From Hooke's law

$F \propto x \Rightarrow F = kx.$, where k is spring constant

Since force is same in stretching for both spring so $F = k_1x_1 = k_2x_2 \Rightarrow x_1 < x_2$ because $k_1 > k_2$

so work done in case of first spring is $W_1 = \frac{1}{2}k_1x_1^2$ and work done in case of second spring is

$W_2 = \frac{1}{2}k_2x_2^2$ so $\frac{W_1}{W_2} = \frac{x_1}{x_2} \Rightarrow W_1 < W_2$

It means that more work is done in case of second spring (work done on spring is equal to stored elastic potential energy of the spring)

78. **(a)** Stored elastic potential energy of spring = ½kx^2 where x is compression or elongation of spring from its natural length. In this position the spring can do work on the block tied to it, which is equal to ½kx^2, so both option (a) & b are correct.

79. **(d)** P.E. = $\frac{1}{2}$ kx^2

$\therefore$ If x = 4x, then P.E = $\frac{1}{2}$ k(16x^2) = $16\left(\frac{1}{2}kx^2\right)$

80. **(d)** $V = \frac{1}{2}k(x)^2 = \frac{1}{2}k(2)^2$ or $k = \frac{2V}{4} = \frac{V}{2}$

$V' = \frac{1}{2}k(10)^2 = \frac{1}{2} \times \left(\frac{V}{2}\right)(10)^2 = 25V$

81. **(d)** Given, $\frac{dk}{dt} = \text{constant}$

$\Rightarrow \quad k \propto t \ \Rightarrow \ v \propto \sqrt{t}$

Also, $P = Fv = \frac{dk}{dt} = \text{constant}$

$\Rightarrow \quad F \propto \frac{1}{v} \ \Rightarrow \ F \propto \frac{1}{\sqrt{t}}$

82. **(a)**

83. **(d)** $F_{thrust} = V_{rel}\frac{dm}{dt}$

$= 5 \times 0.5 = 2.5$ N

So, Power = Force × Velocity

$= 2.5 \times 5 = 12.5$ watt.

84. **(b)** u = 0; v = u + aT; v = aT

Instantaneous power = F × v = m. a. at = m.a^2.t

$\therefore$ Instantaneous power = $m\frac{v^2}{T^2}t$

85. **(b)** Constant power of car $P_0 = F.V = ma.v$

$P_0 = m\frac{dv}{dt}.v$

$P_0 dt = mvdv$ Integrating

$P_0.t = \frac{mv^2}{2}$ $v = \sqrt{\frac{2P_0 t}{m}}$

$\because$ P_0, m and 2 are constant $\therefore$ $v \propto \sqrt{t}$

86. **(d)**

87. **(b)** $P = \frac{W}{t}$. Here, P = 2kW = 2000 W.

W = Mgh = M × 10 × 10 = 100 M and t = 60 s.

This gives, M = 1200 kg

Its volume = 1200 litre as 1 litre of water contains 1 kg of its mass.

88. **(a)**

89. **(b)** We know that F × v = Power

$\therefore F \times v = c$ where c = constant

$\therefore m\frac{dv}{dt} \times v = c \quad \left(\therefore F = ma = \frac{mdv}{dt}\right)$

$\therefore \int_0^v m v dv = c\int_0^t dt \quad \therefore \frac{1}{2}mv^2 = ct$

$\therefore v = \sqrt{\frac{2c}{m}} \times t^{1/2}$

$\therefore \frac{dx}{dt} = \sqrt{\frac{2c}{m}} \times t^{1/2}$ where $v = \frac{dx}{dt}$

$\therefore \int_0^x dx = \sqrt{\frac{2c}{m}} \times \int_0^t t^{1/2} dt$

$x = \sqrt{\frac{2c}{m}} \times \frac{2t^{3/2}}{3} \Rightarrow x \propto t^{3/2}$

90. **(b)** Power exerted by a force is given by P = F.v

When the body is just above the earth's surface, its velocity is greatest. At this instant, gravitational force is also maximum. Hence, the power exerted by the gravitational force is greatest at the instant just before the body hits the earth.

91. **(d)** The power of body is given by = $\vec{F}\cdot\vec{v}$ as the body is moving in circular path, centripetal force and velocity are at 90°, or power = 0.

92. **(b)** The work is done against gravity so it is equal to the change in potential energy. $W = E_p = mgh$

For a fixed height, work is proportional to weight lifted. Since Johnny weighs twice as much as Jane he works twice as hard to get up the hill.

Power is work done per unit time. For Johnny this is $W/\Delta t$. Jane did half the work in half the time, $(1/2\ W)/(1/2\ \Delta t) = W/\Delta t$ which is the same power delivered by Johnny.

93. **(a)** Power, P = F.v = $m\frac{dv}{dt}.v$

As P is constant, $\frac{v}{dt}$ = constant

$\Rightarrow v \propto dt \Rightarrow v \propto t$

94. **(c)** Power = $\frac{\text{work done}}{\text{time}}$

Therefore power of A, $P_A = \frac{mgh}{t_A}$

and power of B, $P_B = \frac{mgh}{t_B}$

$\therefore \frac{P_A}{P_B} = \frac{t_B}{t_A} = \frac{4}{2} = 2:1$

95. **(c)** Volume of water to raise = 22380 l = $22380\times10^{-3}m^3$

$P = \frac{mgh}{t} = \frac{V\rho gh}{t} \Rightarrow t = \frac{V\rho gh}{P}$

$t = \frac{22380\times10^{-3}\times10^3\times10\times10}{10\times746} = 15 \text{ min}$

96. **(d)** Power = $\frac{\text{total work done}}{\text{time}}$

$= \frac{\frac{1}{2}Mv^2}{t} = \frac{1}{2}(mv^2)n \left(\because \frac{M}{t} = mn\right)$

$= kn\left[\because K.E.K = \frac{1}{2}mv^2\right]$

97. **(b)** $\vec{F} = \frac{md\vec{v}}{dt} = 4t\hat{i} + 6t^2\hat{j}$ $(\because m = 1 \text{ kg})$

$\int_0^v dv = \int_0^t (4t\hat{i} + 6t^2\hat{j})dt \Rightarrow \vec{v} = t^2\hat{i} + t^3\hat{j}$

Power, $P = \vec{F}\cdot\vec{v}$

$= (4t\hat{i} + 6t^2 j)\cdot(t^2\hat{i} + t^3\hat{j})$

$= (4t^3 + 6t^5)W$

98. **(b)** Power = $\frac{\text{Work done}}{\text{Time}} = \frac{\frac{1}{2}m\left(v^2 - u^2\right)}{t}$

$P = \frac{1}{2}\times\frac{2.05\times10^6\times\left[(25)^2 - (5^2)\right]}{5\times60}$

P = 2.05 × 10^6 W = 2.05 MW

99. **(d)** $m = 10\times0.8\text{kg} = 8\text{kg}$

height of iron chain = 5m

$P = \frac{mgh}{t} = \frac{8\times10\times5}{10}W = 40W$

100. **(c)** The law of conservation of momentum is true in all type of collisions, but kinetic energy is conserved only in elastic collision. The kinetic energy is not conserved in inelastic collision but the total energy is conserved in all type of collisions.

101. **(c)** In a perfectly inelastic collision, the two bodies move together as one body.

102. **(b)** In an inelastic collision, momentum remains conserved, but K.E is changed.

103. **(c)**

104. **(a)** During elastic collision between two equal masses, the velocities get exchanged. Hence energy transfer is maximum when $m_1 = m_2$.

105. (a) In an elastic collision

$$V_1 = \frac{(m_1 - m_2)}{m_1 + m_2} u_1 \; ; V_2 = \frac{2m_1 u_1}{m_1 + m_2}$$

$\therefore$ if $m_1 = m_2$, then $V_1 = 0$; and $V_2 = \dfrac{2\cancel{m_1} v_1}{2\cancel{m_1}} = u_1$

106. (c)

107. (c) Apply conservation of momentum,

$m_1 v_1 = (m_1 + m_2)v$; $v = \dfrac{m_1 v_1}{(m_1 + m_2)}$

Here $v_1 = 36$ km/hr $= 10$ m/s, $m_1 = 2$ kg, $m_2 = 3$ kg

$$v = \frac{10 \times 2}{5} = 4 \text{ m/s}$$

$$\text{K.E. (initial)} = \frac{1}{2} \times 2 \times (10)^2 = 100 \text{J}$$

$$\text{K.E. (Final)} = \frac{1}{2} \times (3+2) \times (4)^2 = 40 \text{ J}$$

Loss in K.E. $= 100 - 40 = 60$ J

Alternatively use the formula

$$-\Delta E_k = \frac{1}{2} \frac{m_1 m_2}{(m_1 + m_2)} (u_1 - u_2)^2$$

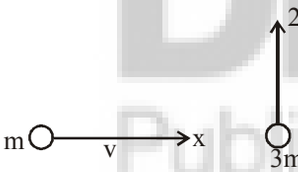
108. (a)

109. (b) $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_{sys.}$

$$20 \times 10 + 5 \times 0 = (20+5) v_{sys} \Rightarrow v_{sys} = 8 m/s$$

$$\text{K. E. of composite mass} = \frac{1}{2}(20+5) \times (8)^2 = 800 J$$

110. (a) As the two masses stick together after collision, hence it is inelastic collision. Therefore, only momentum is conserved.



$$\therefore m v \hat{i} + 3m(2v)\hat{j} = (4m)\vec{v}$$

$$\vec{v} = \frac{v}{4}\hat{i} + \frac{6}{4} v \hat{j} = \frac{v}{4}\hat{i} + \frac{3}{2} v \hat{j}$$

111. (d) K. E. of colliding body before collision $= \dfrac{1}{2} mv^2$

After collision its velocity becomes

$$v' = \frac{(m_1 - m_2)}{(m_1 + m_2)} v = \frac{m}{3m} v = \frac{v}{3}$$

$\therefore$ K. E. after collision $= \dfrac{1}{2} \dfrac{mv^2}{9}$

Ratio of kinetic energy $= \dfrac{K.E._{.before}}{K.E._{.after}} = \dfrac{\frac{1}{2} mv^2}{\frac{1 mv^2}{2 \times 9}} = 9:1$

112. (d) For the object of mass 2.0 kg.

$$\frac{\Delta k}{k} = \frac{k - k/4}{k} = \frac{3}{4}$$

Kinetic energy transferred

$$\frac{\Delta k}{k} = \frac{4 m_1 m_2}{(m_1 + m_2)^2}$$

Here, $m_1 = 2.0$ kg, $m_2 = M$

$$\therefore \frac{3}{4} = \frac{4 \times 2M}{(2+M)^2} \Rightarrow M = \frac{2}{3} \text{kg or } 6 \text{kg}$$

113. (a) $\text{Initial, K.E.} = \dfrac{1}{2} mv^2 = \dfrac{1}{2} \times \dfrac{20}{1000} \times 600 \times 600 = 3600 \text{ J}$

Change in K.E. = P.E.

$$\frac{1}{2} m(v^2 - v'^2) = mgh$$

$$\Rightarrow 3600 - \frac{1}{2} \times \frac{20}{1000} \times v_1^{\,2} = 4 \times 10 \times 80$$

$$\Rightarrow v_1 = 200 \text{ m/s}$$

114. (c) Initial kinetic energy of the system

$$\text{K.E}_i = \frac{1}{2} mu^2 + \frac{1}{2} M(0)^2 = \frac{1}{2} \times 0.5 \times 2 \times 2 + 0 = 1 \text{J}$$

For collision, applying conservation of linear momentum

$m \times u = (m + M) \times v$

$\therefore \; 0.5 \times 2 = (0.5 + 1) \times v$

$$\Rightarrow v = \frac{2}{3} \text{m/s}$$

Final kinetic energy of the system is

$$\text{K.E}_f = \frac{1}{2}(m+M)v^2 = \frac{1}{2}(0.5+1) \times \frac{2}{3} \times \frac{2}{3} = \frac{1}{3} \text{J}$$

$$\therefore \text{ Energy loss during collision} = \left(1 - \frac{1}{3}\right) \text{J} = 0.67 \text{J}$$

115. (a)

116. (a) As the floor exerts a force on the ball along the normal, & no force parallel to the surface, therefore the velocity component along the parallel to the floor remains constant. Hence V sin θ = V^1 sin θ^1.

117. (b) The law of conservation of energy is valid at any instant & in all circumstances.

118. (b) As no external force is acting on system so, $P_i = P_f$

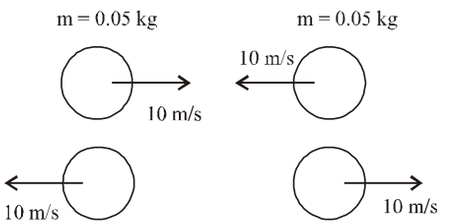
$0.2 \times 10 = 10 \times v \Rightarrow v = 0.2$ m/sec

$$\text{Loss in K.E.} = \frac{1}{2} \times (0.2) \times 10^2 - \frac{1}{2} \times 10 (0.2)^2$$

$$= \frac{1}{2} \times 10 \times (0.2)\,[10 - 0.2] = 9.8 \text{ J}$$

119. (b)

120. (b)



Chnage in momentum of any one ball

$$|\Delta \vec{P}| = 2 \times 0.05 \times 10 = 1$$

$$|\vec{F}_{av}| = \frac{|\Delta \vec{P}|}{\Delta t} = \frac{1}{0.005} = \frac{1000}{5} = 200 \text{ N}$$

EXERCISE - 2

1. **(b)** When electron and proton are moving under influence of their mutual forces, then according to the flemings left hand rule, the direction of force acting on a charge particle is perpendicular to the direction of motion.
In magnetic field, work-done = $F.\ s.\ \cos\theta$
$= F\ .\ s.\ \cos 90° = 0.$
So magnetic forces do not work on moving charge particle.

2. **(c)** Forces between two protons is same as that of between proton and a positron.
As positron is much lighter than proton, it moves away through much larger distance compared to proton.
Work done = Force × Distance
As forces are same in case of proton and positron but distance moved by positron is larger, hence, work done on positron will be more than proton.

3. **(d)** When the man squatting on the ground he is tilted somewhat, hence he also has to apply frictional force besides his weight.
R (reactional force) = friction force (f) + mg *i.e.*, $R > mg$
When the man does not squat and gets straight up in that case friction (f) ≈ 0
R (Reactional force) $\approx mg$
Hence, the reaction force (R) is larger when squatting and become equal to mg when no squatting.

4. **(c)** According to the question, work done by the frictional force on the cycle is :
$= 200 \times 10 = -2000$ J
As the road is not moving, hence work done by the cycle on the road is zero.

5. **(c)** As the body is falling freely under gravity and no external force act on body in vaccum so law of conservation, the potential energy decreases and kinetic energy increases because total mechanical energy (PE + KE) of the body and earth system will be remain constant.

6. **(c)** According to the question, consider the two bodies as system, the total external force on the system will be zero.
Hence, in an inelastic collision KE does not conserved but total linear momentum of the system remain conserved.

7. **(c)** As the (inclined surface) are frictionless, hence, mechanical energy will be conserved. As both the tracks having common height, h (and no external force acts on system).
KE & PE of stone I at top = KE + PE at bottom of I.
From conservation of mechanical energy,

$$0 + \frac{1}{2}mv_1^2 = mgh + 0 \ \Rightarrow v_1 = \sqrt{2gh} \text{ similarly } v_2 = \sqrt{2gh}$$

Hence, speed is same for both stones.
For stone I, acceleration along inclined plane $a_1 = g \sin\theta_1$
Similarly, for stone II $a_2 = g \sin\theta_2$
$\sin\theta_1 < \sin\theta_2$ Thus, $\theta_2 > \theta_1$ hence $a_2 > a_1$.
a_2 is greater than a_1 and both length for track II is also less hence, stone II reaches earlier than stone I.

8. **(b)** Total Mechanical energy is E = PE + KE at any instant.
When particle is at $x = x_m$ i.e., at extreme position, partical returns back and its velocity become zero for an instant.
Hence, at $x = x_m$; $x = 0$, K.E. = 0.
From Eq. (i), E = PE + 0 = PE = $V(x_m) = \frac{1}{2}kx_m^2$
but at mean position at origin $V(x_m) = 0$.

9. **(b)** If two bodies of equal masses collides elastically, their velocities are interchanged.
When ball 1 collides with ball-2, then velocity of ball-1, v_1 becomes zero and velocity of ball-2, v_2 becomes v, *i.e.*, similarly then its own all momentum is mV.
So, $v_1 = 0 \Rightarrow v_2 = v$, $P_1 = 0$, $P_2 = mV$
Now ball 2 collides to ball 3 and its transfer it's momentum is mV to ball 3 and itself comes in rest.
So, $v_2 = 0 \Rightarrow v_3 = v$, $P_2 = 0$, $P_3 = mV$
So, ball 1 and ball 2, become in rest and ball 3 move with velocity v in forward direction.

10. **(b)** As we know that,

$$\text{W.D.} = \int_{x_1}^{x_2} \vec{F} \cdot \overrightarrow{dx} = \int_{x_1}^{x_2} m\vec{a}_0 \cdot \overrightarrow{dx}$$

As given that, $m = 0.5$ kg, $a = 5\ \text{m}^{-1/2}\ \text{s}^{-1}$,

$$v = ax^{3/2}$$

We also know that Acceleration,

$$a_0 = \frac{dv}{dt} = v \cdot \frac{dv}{dx} = ax^{3/2}\frac{d}{dx}(ax^{3/2})$$

$$= ax^{3/2} \times a \times \frac{3}{2} \times x^{1/2} = \frac{3}{2}a^2x^2$$

Now, force = $ma_0 = m\frac{3}{2}a^2x^2$
From (i), work done $= \int_{x=0}^{x=2} Fdx$

$$= \int_0^2 \left[\frac{3}{2}ma^2x^2\right]dx = \frac{3}{2}ma^2 \times \left(\frac{x^3}{3}\right)_0^2 = \frac{1}{2}ma^2 \times 8 = 50 \text{ J}$$

11. **(b)** As given that power = constant
As we know that power (P)

$$P = \frac{dW}{dt} = \frac{\vec{F} \cdot \overrightarrow{dx}}{dt} = \frac{F\ dx}{dt}$$

As the body is moving unidirectionally.
Hence, $F \cdot dx = Fdx\cos 0° = Fdx$

$$P = \frac{Fdx}{dt} = \text{constant} \quad (\because\ P = \text{constant by question})$$

$L^2 \propto T^3 \Rightarrow L \propto T^{3/2} \Rightarrow$ Displacement (d) $\propto t^{3/2}$
Verifies the graph (b).

12. **(d)** **13.** **(c)**

14. **(a)** As given that, mass (m) = 5 kg, n = 300 revolution
Radius (R) = 1 m; t = 60 sec

$$\omega = \left(\frac{2\pi n}{t}\right) = (300 \times 2 \times \pi)\ \text{rad / 60s} = 10\ \pi\ \text{rad/s}$$

linear speed (v) = $\omega R = (10\pi \times 1) \Rightarrow v = 10\pi$ m/s

$$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 5 \times (10\pi)^2 = 250\pi^2 \text{J}$$

So, verifies the option (a).

15. **(b)** P.E. is maximum when drop start falling at $t = 0$ as it fall is P.E. decrease gradually to zero. So, it rejects the graph (a), (c) and (d).
K.E. at $t = 0$ is zero as drop falls with zero velocity, its velocity increases (gradually), hence, first KE also increases. After sometime speed (velocity) is constant this

is called terminal velocity, so, KE also become constant. It happens when it falls $\left(\frac{3}{4}\right)$ height or remains at $\left(\frac{4}{4}\right)$ from ground, then PE decreases continuously as the drop is falling continuously.
The variation in PE and KE is best represented by (b).

16. **(d)** As given that, $h = 1.5\text{m}, v = 1\text{m/s}, m = 10\text{kg}, g = 10\ \text{ms}^{-2}$
By the law of conservation of mechanical energy as no force acts on shotput after thrown.

$$(\text{PE})_i + (\text{KE})_i = (\text{PE})_f + (\text{KE})_f$$

$$mgh_i + \frac{1}{2}mv_i^2 = 0 + (\text{KE})_f$$

$$(\text{KE})_f = mgh_i + \frac{1}{2}mv_i^2$$

Total energy when it reaches ground, so

$$(\text{KE})_f = 10 \times 10 \times 1.5 + \frac{1}{2} \times 10 \times (1)^2$$

$$E = 150 + 5 = 155\ \text{J}.$$

17. **(b)** First velocity of the iron sphere $V = \sqrt{2gh}$ after sometime its velocity becomes constant, called terminal velocity. Hence, according first KE increases and then becomes constant due to resistance of sphere and water which is represented by (b).

18. **(c)** As given that,

$$m = 150\ \text{g} = \frac{150}{1000}\ \text{kg} = 0.15\ \text{kg}$$

Δt = time of contact = 0.001 s

$$u = 126\,\text{km/h} = \frac{126 \times 1000}{60 \times 60}\ \text{m/s} = 35\ \text{m/s}$$

$$v = -126\text{km/h} = -126 - \times\frac{5}{8} = -35\ \text{m/s}$$

So, final velocity is acc. to initial force applied by batsman.
So, change in momentum of the ball

$$\Delta p = m(v-u) = \frac{3}{20}(-35-35) = -\frac{21}{2}\text{kg-m/s}$$

As we know that, force

$$F = \frac{\Delta p}{\Delta t} = \frac{-21/2}{0.001}\text{N} = -1.05 \times 10^4\ \text{N}$$

Hence negative sign shown that direction of force will be opposite to initial velocity which taken positive direction. Hence verify the option (c).

19. **(d)** Power $\vec{F}.\vec{V} = PA\vec{V} = \rho ghAV \quad \left[\because P = \frac{F}{A} \text{ and } P = \rho gh\right]$

$$= 13.6 \times 10^3 \times 10 \times 150 \times 10^{-3} \times 0.5 \times 10^{-3}/60$$

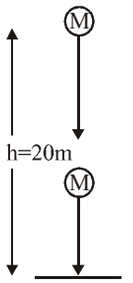
$$= \frac{102}{60} = 1.70\ \text{watt}$$

20. **(a)** When ball collides with the ground it loses its 50% of energy

$$\therefore \frac{\text{KE}_f}{\text{KE}_i} = \frac{1}{2} \Rightarrow \frac{\frac{1}{2}mV_f^2}{\frac{1}{2}mV_i^2} = \frac{1}{2}$$

or $\frac{V_f}{V_i} = \frac{1}{\sqrt{2}}$

or, $\frac{\sqrt{2gh}}{\sqrt{V_0^2 + 2gh}} = \frac{1}{\sqrt{2}}$



or, $4gh = V_0^2 + 2gh \quad v \qquad \therefore V_0 = 20\text{ms}^{-1}$

21. **(d)** As we know power $P = \frac{dw}{dt}$

$$\Rightarrow \quad w = Pt = \frac{1}{2}\ mV^2 \quad \text{So,} \quad v = \sqrt{\frac{2Pt}{m}}$$

Hence, acceleration $a = \frac{dV}{dt} = \sqrt{\frac{2P}{m}} \cdot \frac{1}{2\sqrt{t}}$

Therefore, force on the particle at time t

$$= ma = \sqrt{\frac{2Km^2}{m}} \cdot \frac{1}{2\sqrt{t}} = \sqrt{\frac{Km}{2t}} = \sqrt{\frac{mK}{2}}\ t^{-1/2}$$

22. **(b)** As we know work done in stretching spring

$$w = \frac{1}{2}kx^2$$

where k = spring constant
x = extension

Case (a) If extension (x) is same,

$$W = \frac{1}{2}K\,x^2 \text{. So, } W_P > W_Q \qquad (\because K_P > K_Q)$$

Case (b) If spring force (F) is same $W = \frac{F^2}{2K}$

So, $W_Q > W_P$

23. **(d)** From, F = ma

$$a = \frac{F}{m} = \frac{0.1x}{10} = 0.01x = V\frac{dV}{dx}$$

So, $\int_{v_1}^{v_2} vdV = \int_{20}^{30} \frac{x}{100}dx$

$$-\frac{V^2}{2}\Big|_{V_1}^{V_2} = \frac{x^2}{200}\Big|_{20}^{30} = \frac{30 \times 30}{200} - \frac{20 \times 20}{200} = 4.5 - 2 = 2.5$$

$$\frac{1}{2}m\left(V_2^2 - V_1^2\right) = 10 \times 2.5\ \text{J} = -25\text{J}$$

Final K.E. $= \frac{1}{2}mv_2^2 = \frac{1}{2}mv_1^2 - 25 = \frac{1}{2} \times 10 \times 10 \times 10 - 25$

$$= 500 - 25 = 475\ \text{J}$$

24. **(d)** Given force $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$

According to Newton's second law of motion,

$$m\frac{d\vec{v}}{dt} = 2t\hat{i} + 3t^2\hat{j}\ (m = 1\ \text{kg})$$

$$\Rightarrow \quad \int_0^{\vec{v}} d\vec{v} = \int_0^t \left(2t\hat{i} + 3t^2\hat{j}\right)dt \Rightarrow \quad \vec{v} = t^2\hat{i} + t^3\hat{j}$$

Power $P = \vec{F} \cdot \vec{v}\ (2t\,\hat{i} + 3t^2\hat{j}) \cdot (t^2\hat{i} + t^3\hat{j}) = (2t^3 + 3t^5)\text{W}$

25. **(a)** Given: Mass of particle, $M = 10\text{g} = \frac{10}{1000}\text{kg}$

radius of circle R = 6.4 cm
Kinetic energy E of particle = 8×10^{-4}J
acceleration a_t = ?

$$\frac{1}{2}mv^2 = E \quad \Rightarrow \quad \frac{1}{2}\left(\frac{10}{1000}\right)v^2 = 8 \times 10^{-4}$$

$\Rightarrow \quad v^2 = 16 \times 10^{-2} \Rightarrow v = 4 \times 10^{-1} = 0.4$ m/s
Now, using
$v^2 = u^2 + 2a_t s \quad (s = 4\pi R)$

$$(0.4)^2 = 0^2 + 2a_t\left(4 \times \frac{22}{7} \times \frac{6.4}{100}\right)$$

$$\Rightarrow \quad a_t = (0.4)^2 \times \frac{7 \times 100}{8 \times 22 \times 6.4} = 0.1\ \text{m/s}^2$$

26. **(c)** From work-energy theorem,

$W_g + W_a = \Delta K.E$ or, $mgh + W_a = \frac{1}{2}mv^2 - 0$

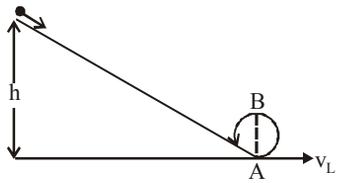
$10^{-3} \times 10 \times 10^3 + W_a = \frac{1}{2} \times 10^{-3} \times (50)^2 \Rightarrow W_a = -8.75$ J

which is the work done due to air resistance

Work done due to gravity = mgh

$= 10^{-3} \times 10 \times 10^3 = 10$ J

27. **(c)** As track is frictionless, so total mechanical energy will remain constant



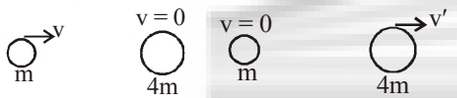
i.e., $0 + mgh = \frac{1}{2}mv_L^2 + 0$

Using $v^2 - u^2 = 2gh$, $h = \frac{v_L^2}{2g}$ ($\because u = 0$)

For completing the vertical circle, $v_L \geq \sqrt{5gR}$

or, $h = \frac{5gR}{2g} = \frac{5}{2}R = \frac{5}{4}D$

28. **(b)**



Before Collision After Collision

According to law of conservation of linear momentum,

$mv + 4m \times 0 = 4mv' + 0 \Rightarrow v' = \frac{v}{4}$

Coefficient of restitution,

$e = \frac{\text{Relative velocity of separation}}{\text{Relative velocity of approach}}$

$= \frac{\frac{v}{4}}{v}$ or, $e = \frac{1}{4} = 0.25$

29. **(c)** Here,

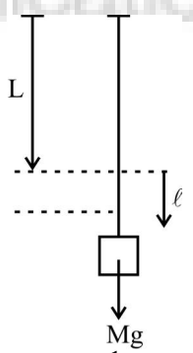
$kx_0 = Mg$

where K = force constant

$DE = \frac{1}{2}Kx_0^2$

$= \frac{1}{2}\frac{Mg}{x_0} \times x_0^2$

$= \frac{1}{2}Mgx_0$



Stored elastic potential energy in extended wire, $= \frac{1}{2}Mg\ell$

[here $x_0 = \ell$]

30. **(c)** Work done by variable force

Work done, $W = \int_{y_i}^{y_f} F dy \Rightarrow \int_{y=0}^{y_f=1} F \cdot dy$

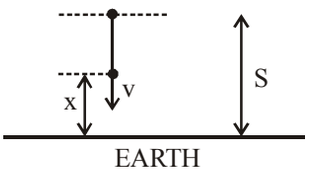
where, $F = 20 + 10y$

$\therefore \quad W = \int_0^1 (20 + 10y)dy = \left[20y + \frac{10y^2}{2}\right]_0^1 = 25\ J$

31. **(a)** Let the height from the surface of the earth be x.

When body from rest falls through height (S – x)

Then from $v^2 = u^2 + 2gs$



$v^2 = 0^2 + 2g(S - x)$

$\Rightarrow v = \sqrt{2g(S - x)}$ ...(i)

At this point,

U = mgx

From question, kinetic energy, K = 3U

$\therefore \frac{1}{2}m(v)^2 = 3 \times mg(x)$

$\Rightarrow \frac{1}{2} \times m \times 2g(S - x) = 3 \times mgx$ (using (i))

$\Rightarrow S - x = 3x$

$\therefore x = \frac{S}{4}$ ... (ii)

$\therefore v = \sqrt{2 \times g\left(S - \frac{S}{4}\right)} = \sqrt{\frac{3gS}{2}}$

32. **(c)** Power on turbine $P = \frac{d(mgh)}{dt}$

$= gh\frac{dm}{dt} = 10 \times 60 \times 15 = 9000$W

Due to frictional force, lossses are 10%

∴ Power generated

$= \left(1 - \frac{10}{100}\right) \times 9000 = 8.1$ kW

33. **(d)** Energy radiated = Power × time

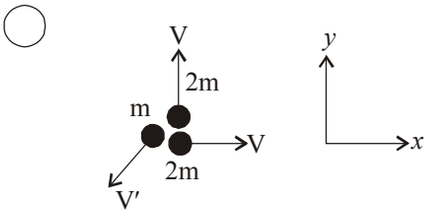
$= 100$ kW × 1 hr = 100 kWh = $100 \times 3.6 \times 10^6$ J = 3.6×10^8 J

$= 36 \times 10^7$ J

34. **(b)** Power = F × V

= (2000 g + 3000) × 1.5 = 23000 × 1.5 = 34500 watt

35. **(b)**



$\vec{P}_i = 0$

$\vec{P}_f = 2mv\hat{i} + 2mv\hat{j} + m\vec{v}^1$ as, $\vec{P}_i = \vec{P}_f$

$0 = m\vec{v}^1 + 2mv\hat{i} + 2mv\hat{j}$

$\vec{v} = -2v(\hat{i} + \hat{j}) \Rightarrow |\vec{v}| = 2v\sqrt{1^2 + 1^2} = 2\sqrt{2}v$

36. **(d)** Potential energy stored in spring (U) is given by

$U = \frac{1}{2}Kx^2$

Initially

$U_i = \frac{1}{2}K(2)^2$ where $x = 2$ cm

$\Rightarrow \quad U_i = \frac{1}{2}(K)\cdot(4) = 2K$ ...(i)

Finally

$U_f = \frac{1}{2}K(8)^2 = \frac{1}{2}K \times 64 = 32K$ ...(ii)

On dividing (i) by (ii)

$\frac{U_i}{U_f} = \frac{2K}{32K} = \frac{1}{16} \Rightarrow U_f = 16U$

37. **(a)** Given, displacement $x = 2t - 1$

$\therefore$ velocity

$v = \frac{dx}{dt} = 2ms^{-1}$

Therefore power $P = F.v = 2 \times 5 = 10$ W

38. **(b)** $\underset{\text{(Before collision)}}{(A) \to v_1 \; (B)_{\text{rest}}} \Rightarrow \underset{\text{(After collision)}}{(A)(B) \to v_2}$

By conservation of linear momentum,

$P_i = P_f$

$\Rightarrow \quad mv_1 = mv_2 + mv_2 \Rightarrow mv_1 = 2mv_2$

$\therefore \quad \frac{v_1}{v_2} = \frac{2}{1}$

EXERCISE-3

1. **(b)** (A) → (1); (B) → (1); (C) → (3); (D) → (3)

2. **(b)** (A)→(3); (B)→(1); C→(2); (D)→(1)

3. **(d)** (A)→(4); (B)→(1); C→(3); (D)→(2)

4. **(b)** In close loop, $s = 0$, and so $W = Fs = 0$.

5. **(b)**

6. **(d)** The billiard balls in an elastic collision are in a deformed state. Their total energy is partly kinetic and partly potential. So K.E. is less than the total energy. The energy spent against friction is dissipated as heat which is not available for doing work.

7. **(c)** If there were no friction, moving vehicles could not be stopped by looking the brakes. Vehicles are stopped by air friction only. So, this statement is correct.

8. **(c)** If there were no friction, moving vehicles could not be stopped by looking the brakes. Vehicles are stopped by air friction only. So, this statement is correct.

9. **(d)** force depends only on the end points.

This can be seen from the relation,

$W = K_f - K_i = V(X_i) - V(X_f)$

which depends on the end points.

A third definition states that the work done by this force in a closed path is zero. This is once again apparent from Eq. $K_i + v(X_i) = K_f + v(X_f)$, since $X_i = X_f$

10. **(d)**

11. **(b)** In elastic collision, total momentum and kinetic energy will remain conserved.

12. **(d)** Work done may be zero, even F is not zero.

also, $W = Fs\cos 0° = Fs$ (maximum). [when applied force and displacement is in the same direction]

13. **(c)** Change in kinetic energy = work done by net force. This relationship is valid for particle as well as system of particles.

14. **(d)** K.E. $= \frac{P^2}{2m} \Rightarrow E \propto \frac{1}{m}$ when P constant

15. **(a)** Power $= \frac{W}{t} = \frac{K}{1/n} = nK$

16. **(a)** Maximum energy loss $= \frac{P^2}{2m} - \frac{P^2}{2(m+M)}$

$\left[\because \text{K.E.} = \frac{P^2}{2m} = \frac{1}{2}mv^2\right]$

$= \frac{P^2}{2m}\left[\frac{M}{(m+M)}\right] = \frac{1}{2}mv^2\left\{\frac{M}{m+M}\right\}$

Reason is a case of perfectly inelastic collision.

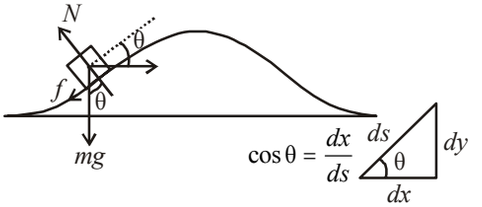
By comparing the equation given in Assertion with above equation, we get

$f = \left(\frac{M}{m+M}\right)$

EXERCISE-4

1. **(c)** Work done by friction

$= \int \vec{F}\cdot\vec{ds} = \int_0^x \mu mg\cos\theta\frac{dx}{\cos\theta} = \mu mg\,x = 20$ J



2. **(a)**

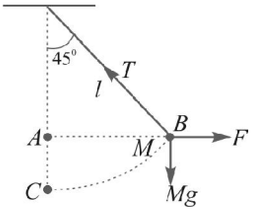
3. **(a)** By using work-energy theorem, $W_{all} = \Delta K$, we have

Work done by F + work done by $Mg = 0$

$F(AB) - Mg(AC) = 0$

$$F = Mg\left(\frac{AC}{AB}\right) = \left[\frac{l - l/\sqrt{2}}{l/\sqrt{2}}\right]$$

$$= Mg(\sqrt{2} - 1).$$



4. **(b)** The centripetal acceleration

$a_c = k^2 r t^2$ or $\frac{v^2}{r} = k^2 rt^2 \quad \therefore \quad v = krt$

So, tangential acceleration, $a_t = \frac{dv}{dt} = kr$

Work is done by tangential force.

Power = $F_t \cdot v \cdot \cos 0° = (ma_t)(krt) = (mkr)(krt) = mk^2r^2t$

5. **(b)** The required work done by man = kinetic energy of man + kinetic energy of boat

$= \frac{1}{2}\frac{p^2}{M} + \frac{1}{2}\frac{p^2}{m}$ (where $p = Mv$)

$$\therefore \quad W = \frac{1}{2}\left(\frac{M^2}{M} + \frac{M^2}{m}\right)v^2 = \frac{1}{2}\left(M + \frac{M^2}{m}\right)v^2$$

6. **(b)**

7. **(d)** $P_{out} = \frac{mgh}{t} = \frac{9000 \times 10 \times 10}{5 \times 60} = 3000\ W$

$P_{in} = 10 \times 10^3$ W.

$$\therefore \quad \eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{3000}{10 \times 10^3} \times 100 = 30\%$$

8. **(b)** Work done, $W = \int \vec{F} \cdot \vec{ds} = \left(-x\hat{i} \times y\hat{j}\right) \cdot \left(x\hat{i} + y\hat{j}\right)$

$$\Rightarrow W = \int_1^0 x dx + \int_0^1 y dy = \left(0 + \frac{1}{2}\right) + \frac{1}{2} = 1 \text{ J}.$$

9. **(b)** Constant power of car $P_0 = F \cdot V = ma \cdot v$

$$P_0 = m\frac{dv}{dt} \cdot v$$

$P_0 dt = mvdv$. Integrating $P_0 \cdot t = \frac{mv^2}{2}$

$v = \sqrt{\frac{2P_0 t}{m}}$ $\because$ P_0, m and 2 are constant $\quad \therefore \quad v \propto \sqrt{t}$

10. **(a)** Masses of the pieces are 1, 1, 3 kg. Hence $(1 \times 21)^2 + (1 \times 21)^2 = (3 \times V)^2$

That is, $V = 7\sqrt{2}$ m/s

11. **(b)**

12. **(c)** Only momentum is conserved. Some kinetic energy is lost when bullet penetrates the block.

13. **(a)** If an object of mass m is released from rest from top of a smooth inclined plane, its speed at the bottom is $\sqrt{2gh}$, independent of angle θ and mass.

14. **(a)**

15. **(d)** Here, F = 100 N, d = 5 m,

frictional force f_r = 40 N

$\therefore$ $F - f_r = ma$

$100 - 40 = ma$

Now kinetic energy gained is = ma × d

$= 60 \times 5 = 300$ J

16. **(b)** Let the blow compress the spring by x before stopping. Kinetic energy of the block = (P.E of compressed spring) + work done against function.

$$\frac{1}{2} \times 2 \times (4)^2 = \frac{1}{2} \times 10{,}000 \times x^2 + (+15) \times x$$

$10{,}000\,x^2 + 30x - 32 = 0$

$\Rightarrow 5000x^2 + 15x - 16 = 0$

$$\therefore \quad x = -\frac{15 \pm \sqrt{(15)^2 - 4 \times (5000)(-16)}}{2 \times 5000} = 0.055\text{m} = 5.5\text{cm}.$$

17. **(d)** Centripetal force

$$= \frac{mv^2}{R} = \left(\frac{1}{2}mv^2\right)\frac{2}{R} = \frac{2K}{R} = \frac{2aS}{R}$$

18. **(a)** $U_1 = \int_0^{\ell/3} -\frac{m}{\ell} gx dx = -\frac{1}{18} mg\ell;$

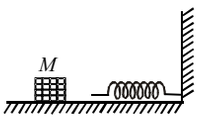
$$U_2 = \int_0^{\ell} -\frac{m}{\ell} gx dx = -\frac{1}{2} mg\ell$$

loss in P.E. $= U_1 - U_2 = \frac{4}{9} mgl$

$= \frac{4}{9} \times 0.1 \times 10 \times 2 = \frac{8}{9}$ J = Final K.E.

19. **(b)** $\frac{1}{2}Mv^2 = \frac{1}{2}kL^2$

$\Rightarrow v = \sqrt{\frac{k}{M}} . L$



Momentum = $M \times v = M \times \sqrt{\frac{k}{M}} . L = \sqrt{kM} . L$

20. **(c)**

9th Edition

Disha's

New Syllabus

100% Qns in NEET 2024 from this Book

Objective NCERT TRACT

CHEMISTRY

for NEET (UG) 2025

with Previous Year & Practice Question Bank

100% COMMAND ON NCERT	Introducing NCERT LOCATER	1st Book with 5 Unique Features	Designed as per Latest NMC Syllabus

- Quick Theory in **One Liner Format as per NMC Syllabus**
- **NCERT + NEET PYQs** in **One Liner Format**
- **MCQs on every line** of NCERT
- **Previous Year Questions** PYQs (2024 – 2016)
- **2 & 4/ 5 Statements, Matching & AR** MCQs

DISHA™
Publication Inc

DISHA Publication Inc.

A-23 FIEE Complex, Okhla Phase II

New Delhi-110020

Tel: 49842349/ 49842350

Edited By

Mohammad Salman
Kavita Aggarwal
Neetu Singh

Typeset By

DISHA DTP Team

Buying Books from Disha is always Rewarding

This time we are appreciating your writing Creativity.

Write a review of the product you purchased on Amazon/Flipkart

Take a screen shot / Photo of that review

Scan this QR Code ➔

Fill Details and submit | That's it ... Hold tight n wait.
At the end of the month, you will get a surprise gift from Disha Publication

Scan this QR code

Write To Us At

feedback_disha@aiets.co.in

www.dishapublication.com

DISHA™ Publication Inc

For future updates on NEET Scan the QR Code.

https://bit.ly/neet_exam_update

You also get Latest Syllabus, Past NEET Papers, Mock Tests and more content here.

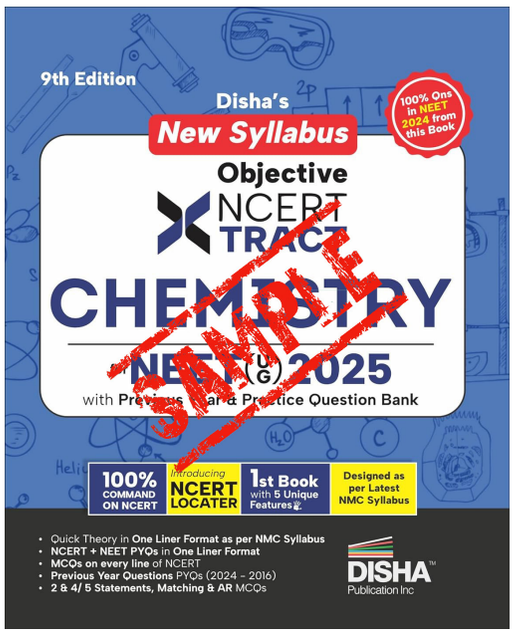
Free Sample Contents

Class XI

2. Structure of Atom **A15 – A38**

- Trend Analysis
- NCERT One-Liners
- 2.0 Introduction
- 2.1* Discovery of Sub-Atomic Particles
- 2.2* Atomic Models
- 2.3 Developments Leading to the Bohr's Model of Atom
- 2.4 Bohr's Model for Hydrogen Atom
- 2.5 Towards Quantum Mechanical Model of the Atom
- 2.6 Quantum Mechanical Model of Atom
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

This sample book is prepared from the book **"Disha's New Syllabus Objective NCERT Xtract Chemistry for NEET (UG) 2025 with Previous Year & Practice Question Bank 9th Edition | One Liner Theory, Tips on your Fingertips, PYQs | 3 Mock Tests".**



ISBN - 978-9362257697

MRP- 875/-

In case you like this content, you can buy the **Physical Book** or **E-book** using the ISBN provided above.

The book & e-book are available on all leading online stores.

Contents

Class XI

1. Some Basic Concepts of Chemistry **A1 – A14**

➲ Trend Analysis ➲ NCERT One-Liners

- 1.0 Introduction
- 1.1* Importance of Chemistry
- 1.2 Nature of Matter
- 1.3* Properties of Matter and their Measurement
- 1.4* Uncertainty in Measurement
- 1.5 Laws of Chemical Combinations
- 1.6 Dalton's Atomic Theory
- 1.7 Atomic and Molecular Masses
- 1.8 Mole Concept and Molar Masses
- 1.9 Percentage Composition
- 1.10 Stoichiometry and Stoichiometric Calculations

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

2. Structure of Atom **A15 – A38**

➲ Trend Analysis ➲ NCERT One-Liners

- 2.0 Introduction
- 2.1* Discovery of Sub-Atomic Particles
- 2.2* Atomic Models
- 2.3 Developments Leading to the Bohr's Model of Atom
- 2.4 Bohr's Model for Hydrogen Atom
- 2.5 Towards Quantum Mechanical Model of the Atom
- 2.6 Quantum Mechanical Model of Atom

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

3. Classification of Elements and Periodicity in Properties **A39 – A54**

➲ Trend Analysis ➲ NCERT One-Liners

- 3.0 Introduction
- 3.1* Why do We Need to Classify Elements ?
- 3.2* Genesis of Periodic Classification
- 3.3 Modern Periodic Law and the Present Form of the Periodic Table
- 3.4* Nomenclature of Elements with Atomic Numbers > 100
- 3.5* Electronic Configurations of Elements and the Periodic Table
- 3.6 Electronic Configurations and Types of Elements: *s*-, *p*-, *d*-, *f*- Blocks
- 3.7 Periodic Trends in Properties of Elements

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

4. Chemical Bonding and Molecular Structure **A55 – A74**

➲ Trend Analysis ➲ NCERT One-Liners

- 4.0 Introduction
- 4.1 Kössel-Lewis Approach to Chemical Bonding
- 4.2 Ionic or Electrovalent Bond
- 4.3* Bond Parameters
- 4.4 The Valence Shell Electron Pair Repulsion (VSEPR) Theory
- 4.5 Valence Bond Theory
- 4.6 Hybridisation
- 4.7 Molecular Orbital Theory
- 4.8 Bonding in Some Homonuclear Diatomic Molecules
- 4.9 Hydrogen Bonding

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

5. Thermodynamics **A75 – A92**

➲ Trend Analysis ➲ NCERT One-Liners

- 5.0 Introduction
- 5.1 Thermodynamic Terms
- 5.2 Applications
- 5.3* Measurement of ΔU and ΔH : Calorimetry
- 5.4 Enthalpy Change, $\Delta_r H$ of a Reaction – Reaction Enthalpy
- 5.5 Enthalpies for Different Types of Reactions
- 5.6 Spontaneity
- 5.7 Gibbs Energy Change and Equilibrium

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

6. Equilibrium **A93 – A114**

➲ Trend Analysis ➲ NCERT One-Liners

- 6.0 Introduction
- 6.1 Equilibrium in Physical Processes
- 6.2 Equilibrium in Chemical Processes – Dynamic Equilibrium
- 6.3 Law of Chemical Equilibrium and Equilibrium Constant
- 6.4 Homogeneous Equilibria
- 6.5 Heterogeneous Equilibria
- 6.6 Applications of Equilibrium Constants
- 6.7 Relationship Between Equilibrium Constant K, Reaction Quotient Q and Gibbs Energy G
- 6.8 Factors Affecting Equilibria
- 6.9 Ionic Equilibrium in Solution
- 6.10 Acids, Bases and Salts
- 6.11 Ionization of Acids and Bases
- 6.12 Buffer Solutions
- 6.13 Solubility Equilibria of Sparingly Soluble Salts

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

7. Redox Reactions **A115 – A128**

➲ Trend Analysis ➲ NCERT One-Liners

- 7.0 Introduction
- 7.1* Classical Idea of Redox Reactions – Oxidation and Reduction Reactions
- 7.2 Redox Reactions in Terms of Electron Transfer Reactions
- 7.3 Oxidation Number
- 7.4* Redox Reactions and Electrode Processes

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

A1–A190

8. The *p* -Block Elements (Group 13 and 14) A129 – A138

➲ Trend Analysis ➲ NCERT One-Liners

- 8.0 Introduction
- 8.1 Group 13 Elements: The Boron Family
- 8.2 Important Trends and Anomalous Properties of Boron
- 8.3 Group 14 Elements: The Carbon Family
- 8.4 Important Trends and Anomalous Behaviour of Carbon
- 8.5 Allotropes of Carbon

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

9. Organic Chemistry – Some Basic Principles & Techniques A139 – A160

➲ Trend Analysis ➲ NCERT One-Liners

- 9.0 Introduction
- 9.1 General Introduction
- 9.2 Tetravalence of Carbon: Shapes of Organic Compounds
- 9.3* Structural Representations of Organic Compounds
- 9.4 Classification of Organic Compounds
- 9.5 Nomenclature of Organic Compounds
- 9.6 Isomerism
- 9.7 Fundamental Concepts in Organic Reaction Mechanism
- 9.8 Methods of Purification of Organic Compounds
- 9.9 Qualitative Analysis of Organic Compounds
- 9.10 Quantitative Analysis

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

10. Hydrocarbons A161 – A190

➲ Trend Analysis ➲ NCERT One-Liners

- 10.0 Introduction
- 10.1 Classification
- 10.2 Alkanes
- 10.3 Alkenes
- 10.4 Alkynes
- 10.5 Aromatic Hydrocarbon
- 10.6* Carcinogenicity and Toxicity

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

Hints & Solutions (Class 11th) A191–A270

1. Some Basic Concepts of Chemistry A191 – A200
2. Structure of Atom A201 – A209
3. Classification of Elements and Periodicity in Properties A210 – A214
4. Chemical Bonding and Molecular Structure A215 – A224
5. Thermodynamics A225 – A231
6. Equilibrium A232 – A243
7. Redox Reactions A244 – A249
8. The p -Block Elements (Group 13 and 14) A250 – A252
9. Organic Chemistry – Some Basic Principles & Techniques A253 – A260
10. Hydrocarbons A261 – A270

Class XII

B1–B238

1. Solutions **B1 – B18**

- Trend Analysis
- NCERT One-Liners
- 1.0 Introduction
- 1.1* Types of Solutions
- 1.2 Expressing Concentration of Solutions
- 1.3 Solubility
- 1.4 Vapour Pressure of Liquid Solutions
- 1.5 Ideal and Non-ideal Solutions
- 1.6 Colligative Properties and Determination of Molar Mass
- 1.7 Abnormal Molar Masses
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

2. Electrochemistry **B19 –B38**

- Trend Analysis
- NCERT One-Liners
- 2.0 Introduction
- 2.1 Electrochemical Cells
- 2.2 Galvanic Cells
- 2.3 Nernst Equation
- 2.4 Conductance of Electrolytic Solutions
- 2.5* Electrolytic Cells and Electrolysis
- 2.6 Batteries
- 2.7 Fuel Cells
- 2.8* Corrosion
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

3. Chemical Kinetics **B39 – B58**

- Trend Analysis
- NCERT One-Liners
- 3.0 Introduction
- 3.1 Rate of a Chemical Reaction
- 3.2 Factors Influencing Rate of a Reaction
- 3.3 Integrated Rate Equations
- 3.4* Pseudo First Order Reaction
- 3.5 Temperature Dependence of the Rate of a Reaction
- 3.6 Collision Theory of Chemical Reactions
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

4. The *p* –Block Elements (Group 15, 16, 17 and 18) **B59 – B68**

- Trend Analysis
- NCERT One-Liners
- 4.0 Introduction
- 4.1 Group 15 Elements
- 4.2 Group 16 Elements
- 4.3 Group 17 Elements
- 4.4 Group 18 Elements
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 3

5. The *d*- and *f*- Block Elements **B69 – B88**

- Trend Analysis
- NCERT One-Liners
- 5.0 Introduction
- 5.1 Position in the Periodic Table
- 5.2 Electronic Configurations of the d-Block Elements
- 5.3 General Properties of the Transition Elements (d-Block)
- 5.4 Some Important Compounds of Transition Elements
- 5.5 The Lanthanoids
- 5.6 The Actinoids
- 5.7* Some Applications of d- and f-Block Elements
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

6. Coordination Compounds **B89 – B108**

- Trend Analysis
- NCERT One-Liners
- 6.0 Introduction
- 6.1 Werner's Theory of Coordination Compounds
- 6.2 Definitions of Some Important Terms Pertaining to Coordination Compounds
- 6.3 Nomenclature of Coordination Compounds
- 6.4 Isomerism in Coordination Compounds
- 6.5 Bonding in Coordination Compounds
- 6.6* Bonding in Metal Carbonyls
- 6.7* Stability of Coordination Compounds
- 6.8* Importance and Applications of Coordination Compounds
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

7. Haloalkanes and Haloarenes **B109 – B132**

- Trend Analysis
- NCERT One-Liners
- 7.0 Introduction
- 7.1 Classification
- 7.2 Nomenclature
- 7.3 Nature of C-X Bond
- 7.4 Methods of Preparation of Haloalkanes
- 7.5 Preparation of Haloarenes
- 7.6 Physical Properties
- 7.7 Chemical Reactions
- 7.8 Polyhalogen Compounds
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

8. Alcohols, Phenols and Ethers **B133 – B154**

- Trend Analysis
- NCERT One-Liners
- 8.0 Introduction
- 8.1 Classification
- 8.2 Nomenclature
- 8.3 Structures of Functional Groups
- 8.4 Alcohols and Phenols
- 8.5 Some Commercially Important Alcohols
- 8.6 Ethers
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

9. Aldehydes, Ketones and Carboxylic Acids **B155 – B180**

- Trend Analysis
- NCERT One-Liners
- 9.0 Introduction
- 9.1 Nomenclature and Structure of Carbonyl Group
- 9.2 Preparation of Aldehydes and Ketones
- 9.3 Physical Properties
- 9.4 Chemical Reactions
- 9.5 Uses of Aldehydes and Ketones
- 9.6 Nomenclature and Structure of Carboxyl Group
- 9.7 Methods of Preparation of Carboxylic Acids
- 9.8 Physical Properties
- 9.9 Chemical Reactions
- 9.10 Uses of Carboxylic Acids
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

10. Amines B181 – B198

- Trend Analysis
- NCERT One-Liners
- 10.0 Introduction
- 10.1 Structure of Amines
- 10.2 Classification
- 10.3 Nomenclature
- 10.4 Preparation of Amines
- 10.5 Physical Properties
- 10.6 Chemical Reactions
- 10.7 Methods of Preparation of Diazonium Salts
- 10.8 Physical Properties
- 10.9 Chemical Reactions
- 10.10 Importance of Diazonium Salts in Synthesis of Aromatic Compounds
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

11. Biomolecules B199 – B218

- Trend Analysis
- NCERT One-Liners
- 11.0 Introduction
- 11.1 Carbohydrates
- 11.2 Proteins
- 11.3 Enzymes
- 11.4 Vitamins
- 11.5 Nucleic Acids
- 11.6 Hormones
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 4

12. Principles Related to Practical Chemistry B219 – B238

- Introduction
- Detection of Extra Elements (N, S, Halogens) in Organic Compounds.
- Detection of Functional Groups in Organic Compounds
- Preparation of Organic Compounds
- Preparation of Inorganic Compounds
- Chemical Principles Involved in Qualitative Salt Analysis
- Principles Involved in Titrimetric Exercises.
- Principles Involved in Calorimetry, Preparation of Colloidal Sols, and Kinetic study of Reaction between I^- with H_2O_2.
- Tips/Tricks/Techniques One-Liners
- Exercise 1 to Exercise 3

Note : The four Exercises in each of the chapters are :

- Exercise 1 : NCERT Based Topic-wise MCQs
- Exercise 2 : NCERT Exemplar Past Years NEET
- Exercise 3 : Matching Statements & Assertion Reason Type
- Exercise 4 : Skill Enhancer MCQs

Hints & Solutions (Class 12th) B239–B334

1. Solutions B239 – B247
2. Electrochemistry B248 – B257
3. Chemical Kinetics B258 – B267
4. The p –Block Elements (Group 15, 16, 17 and 18) B268 – B269
5. The d- and f- Block Elements B270 – B276
6. Coordination Compounds B277 – B285
7. Haloalkanes and Haloarenes B286 – B295
8. Alcohols, Phenols and Ethers B296 – B303
9. Aldehydes, Ketones and Carboxylic Acids B304 – B316
10. Amines B317 – B324
11. Biomolecules B325 – B330
12. Principles Related to Practical Chemistry B331 – B334

Mock Tests

Mock Test-1 MT1–MT4
Mock Test-2 MT5–MT8
Mock Test-3 MT9–MT14
Solutions of Mock Tests (1–3) **MT15–MT28**

NOTE* These Topics are in new NCERT, but not in the new NEET 2024 Syllabus. These Topics have been retained in the book so as to match NCERT and any future amendments in NEET.
Questions on these Topics have also been marked with a * in the respective Exercises of the Chapters.

2 Structure of Atom

Trend Analysis NEET

	NEET	Remarks
Number of Questions from 2024-18	8	Minimum one question has been asked every year in NEET.
Weightage	2.41%	

			NEET	
Year	Topic Name	Concept Used	No. of Ques.	Difficulty Level
2024	Bohr's model, Quantum numbers	Energy of 'n^{th}' state, Significance of quantum numbers	2	Average / Easy
2023	Discovery of Sub - Atomic Particles, Bohr's model of H-atom, Towards Quantum mechanical model of an atom	Sub - Atomic particles / Orbital energy	2	Easy
2022	Bohr's model for H atom/dual nature of electromagnetic radiation/Quantum mechanical model of atom	Bohr's orbit	1	Average
2021	—	—	—	—
2020	—	—	—	—
2019	Bohr's model of H-atom / Towards Quantum mechanical model of an atom	Bohr's model of H-atom / Orbital energy and stability	2	Easy / Average
2018	Bohr's model of H-atom	Bohr's model of H-atom	1	Easy

NCERT ONE-LINERS
(Important Points to Remember)

*Included in NCERT but not in NMC NEET Syllabus

2.0 Introduction

- **Dalton's atomic theory**, regarded the atom as the ultimate particle of matter. Dalton's atomic theory was able to explain the law of conservation of mass, law of constant composition and law of multiple proportion. NEET 2023
- It failed to explain the results of many experiments, for example, it was known that substances like glass or ebonite when rubbed with silk or fur get electrically charged.

2.1 Discovery of Sub-Atomic Particles

- **Faraday** studied electrical discharge in partially evacuated tubes, known as **cathode ray discharge tubes**.

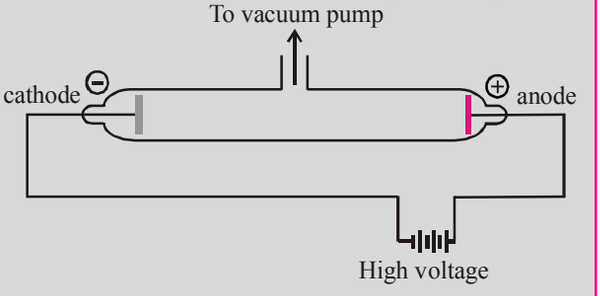


Fig.: *A cathode ray discharge tube*

- The electrical discharge through the gases could be observed only at **very low pressures** and at **very high voltages**.
- At high voltage, current starts flowing through a stream of particles moving in the tube from the negative electrode (**cathode**) to the positive electrode (**anode**). These were called **cathode rays or cathode ray particles.**
- In the absence of electrical or magnetic field, these rays travel in straight lines. But in its presence cathode rays get deviated which confirms that they are composed of negatively charged particles, called **electrons.** AIPMT 1994

- The characteristics of **cathode rays** do not depend upon the **material of electrodes** and the **nature of the gas** present in the cathode ray tube.
- **J.J. Thomson** measured the ratio of electrical charge (e) to the mass of electron (m_e) by using cathode ray tube and applying electrical and magnetic field perpendicular to each other as well as to the path of electrons.
- Thomson argued that the amount of **deviation of the particles** from their path in the presence of electrical or magnetic field depends upon:
  - The **magnitude of the negative charge** on the particle, greater the magnitude of the charge on the particle, greater is the interaction with the electric or magnetic field and thus greater is the deflection.
  - **The mass of the particle** — lighter the particle, greater the deflection.
  - The **strength of the electrical or magnetic field** — the deflection of electrons from its original path increases with the increase in the voltage across the electrodes, or the strength of the magnetic field. Thomson determine the value of **e/m_e** as:

$$\frac{e}{m_e} = 1.758820 \times 10^{11}\ \text{C kg}^{-1}$$

  Where m_e is the mass of the electron in kg. e is the magnitude of the charge on the electron in coulomb (C).
- **R.A. Millikan** (1868-1953) devised a method known as **oil drop experiment** (1906-14), to determine the charge on the electrons.
- Millikan concluded that the **magnitude of electrical charge**, q, on the droplets is always an integral multiple of the electrical charge, e, that is, $q = n\,e$, where $n = 1, 2, 3...$
- The charge on the electron was found to be **-1.6×10^{-19} C**. The present accepted value of electrical charge is **$-1.602176 \times 10^{-19}$ C**.
- The **mass of the electron** (m_e) was determined by combining these results with **Thomson's** value of e/m_e ratio.

$$m_e = \frac{e}{e/m_e} = \frac{1.602176 \times 10^{-19}\ \text{C}}{1.758820 \times 10^{11}\ \text{C kg}^{-1}}$$

$$= 9.1094 \times 10^{-31}\ \text{kg}$$ **NEET 2023**

- Electrical discharge carried out in the modified cathode ray tube led to the discovery of **canal rays** carrying positively charged particles.
- The characteristics of these positively charged particles are
  - Unlike cathode rays, **mass of positively charged particles** depends upon the **nature of gas** present in the cathode ray tube. These are simply the positively charged gaseous ions.
  - The **e/m_e** of the particles **depends on the gas** from which these originate.
  - The behaviour of these particles in the magnetic or electrical field is opposite to that observed for electron or cathode rays.
- The smallest and lightest positive ion was obtained from hydrogen and was called **proton**.
- The **neutrons (electrically neutral particles)** were discovered by **Chadwick** (1932) by bombarding a thin sheet of **beryllium** by **α-particles**.
- Neutrons are electrically neutrals particles having a mass slightly greater than that of the protons.

Table : Properties of Fundamental Particles

Name	Symbol	Absolute charge/C	Relative charge	Mass/kg	Mass/u	Approx. mass/u
Electron	e	$-1.602176 \times 10^{-19}$	−1	9.109382×10^{-31}	0.00054	0
Proton	p	$+1.602176 \times 10^{-19}$	+1	$1.6726216 \times 10^{-27}$	1.00727	1
Neutron	n	0	0	1.674927×10^{-27}	1.00867	1

2.2 Atomic Models

- **J. J. Thomson model of an atom :** In **atom** possesses a **spherical shape** (radius approximately 10^{-10} m) in which the positive charge is **uniformly distributed**. The electrons are embedded into it in such a manner as to give the most stable **electrostatic arrangement**.
- The other name of this model is **plum pudding, raisin pudding or watermelon**.
- An important **feature** of this model is that the **mass of the atom** is assumed to be **uniformly distributed** over the atom.
- **Rutherford** found that **α-rays** consist of high energy particles carrying two units of positive charge and four unit of atomic mass.
- **α-rays** are **negatively charged** particles similar to electrons.
- **α-rays** are high energy radiations like **X-rays**, are **neutral in nature** and do not consist of particles.
- **Penetrating power** of rays are: **γ-rays > X rays > β-rays > α-rays**
- **Rutherford's Nuclear model of an atom :** α-particle scattering experiments.
- A stream of **high energy** α–particles from a radioactive source was directed at a **thin foil** (thickness ~ 100 nm) of **gold metal**.
- **Observation :**
  - most of the α–particles passed through the gold foil undeflected.
  - a small fraction of the α–particles was deflected by small angles.
  - a very few α–particles **(~1 in 20,000)** bounced back, that is, were deflected by nearly **180°**.

♦ **Conclusions :**

- ❖ Most of the space in the atom is empty as most of the α–particles passed through the foil undeflected.
- ❖ A few positively charged α–particles were deflected. The deflection must be due to enormous repulsive force showing that the positive charge of the atom is not spread throughout the atom as Thomson had presumed. The positive charge has to be concentrated in a very small volume that repelled and deflected the positively charged α–particles.
- ❖ Calculations by Rutherford showed that the volume occupied by the nucleus is negligibly small as compared to the total volume of the atom. The **radius of the atom** is about **10^{-10} m**, while that of **nucleus is 10^{-15} m**.

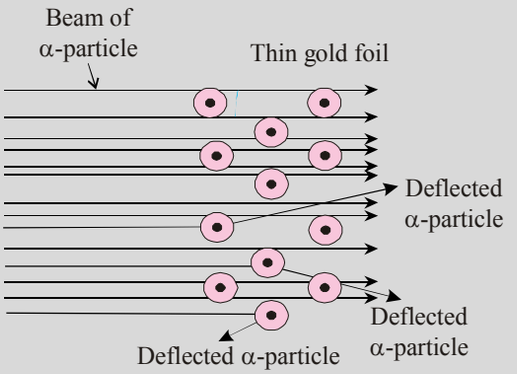


Fig. : *Schematic molecular view of the gold foil*

♦ On the basis of above **observations and conclusions**, Rutherford proposed the **nuclear model** of atom. According to this model:

- ❖ The positive charge and most of the mass of the atom was densely concentrated in extremely small region. This very small portion of the atom was called **nucleus** by Rutherford.
- ❖ The nucleus is surrounded by electrons that move around the nucleus with a very high speed in circular paths called **orbits**. Thus, Rutherford's model of atom resembles the solar system in which the nucleus plays the role of sun and the electrons that of revolving planets.
- ❖ **Electrons** and the **nucleus** are held together by **electrostatic forces of attraction**.

♦ **Wilhelm Röentgen discovered X-rays**

♦ **X rays** are not deflected by the electric and magnetic fields and have a very **high penetrating power** through the matter and that is the reason these rays are **used** to study the **interior of the objects**.

♦ **X rays** are of very short wavelengths (~0.1 nm) and possess electro-magnetic character.

♦ **Henri Becqueral** (1852-1908) observed that there are certain elements which emit radiation on their own and named this phenomenon as **radioactivity** and the elements known as **radioactive elements**.

Atomic Number and Mass Number :

♦ **Atomic number** (Z) = number of **protons** in the nucleus of an atom = number of **electrons** in a nuetral atom.

♦ **Mass number (A)** = number of **protons** (Z) + number of **neutrons** (n)

For example : $^{175}_{71}Lu$

Atomic number = number of protons = number of electrons = 71

Number of neutrons = 175 – 71 = 104. **AIPMT** 2014, 2000, 1997

♦ **Isobars** are the atoms with same **mass number** but different **atomic number** for example, $^{14}_{6}C$ and $^{14}_{7}N$.

♦ **Isotopes** are the atoms with same **atomic number** but different **mass number** for example, $_1H^1$, $_1H^2$ and $_1H^3$.

Drawbacks of Rutherford Model :

♦ The **coulomb force** between electron and the nucleus is mathematically similar to the **gravitational force**. However, when a body is moving in an **orbit**, it undergoes **acceleration** even if it is moving with a **constant speed** in an orbit because of **changing direction**.

♦ According to the **electromagnetic theory of Maxwell**, charged particles when accelerated should **emit electromagnetic radiation**. Therefore, an electron in an orbit will emit radiation, the energy carried by radiation comes from **electronic motion**. The orbit will thus continue to **shrink**.

♦ Calculations show that it should take an electron only 10^{-8} s to spiral into the nucleus. But this does not happen. Thus, the Rutherford model cannot explain the **stability of an atom**.

♦ Another **drawback** of the Rutherford model is that it says nothing about **distribution** of the electrons around the nucleus and the **energies** of these electrons.

2.3 Developments Leading to the Bohr's Model of Atom

♦ Two **developments** played a major role in the formulation of **Bohr's model of atom**. These were:

- ❖ **Dual character** of the **electromagnetic radiation** which means that radiations possess both **wave** like and **particle** like properties.
- ❖ Experimental results regarding atomic spectra.

Wave Nature of Electromagnetic Radiation :

♦ **James Maxwell** suggested that when **electrically charged particle** moves under **accelaration**, alternating electrical and magnetic fields are produced and transmitted. These fields are transmitted in the forms of waves called **electromagnetic waves** or **electromagnetic radiation.**

♦ Electric and magnetic field components have the same **wavelength**, **frequency**, **speed** and **amplitude**, but they vibrate in two mutually **perpendicular planes**.

♦ Unlike sound waves or waves produced in water, electromagnetic waves do not require medium and can move in **vacuum**.

♦ There are many types of electromagnetic radiations, which differ from one another in wavelength (or frequency). These constitute what is called **electromagnetic spectrum.**

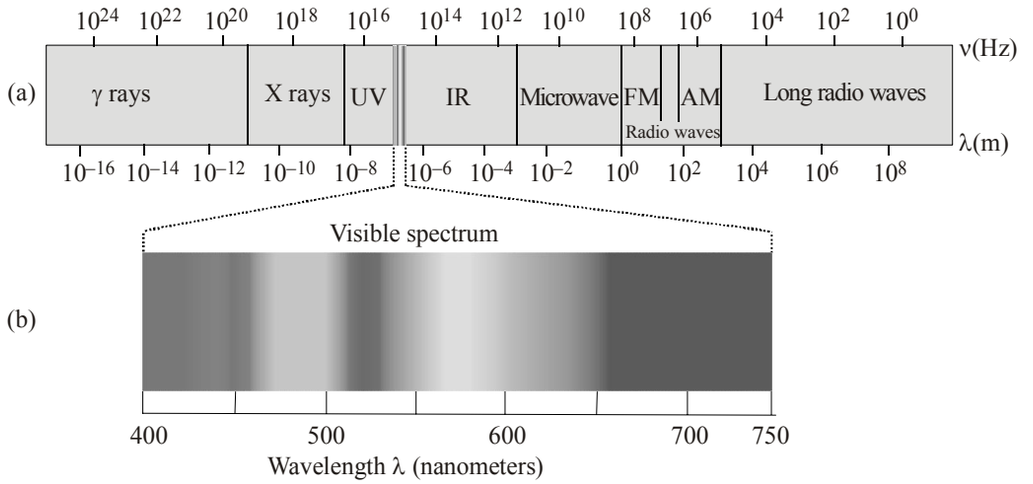


Fig.: *(a) The spectrum of electromagnetic radiation. (b) Visible spectrum. The visible region is only a small part of the entire spectrum.*

- These radiations are characterised by the properties, namely, **frequency (ν)**, **wavelength (λ)**, **velocity (c)** and **wave number** $(\bar{\nu})$.
- **Frequency** is defined as the number of waves that pass a given point in one second. The **SI unit** of frequency is **hertz** (Hz, s^{-1}).
- **Wavelength** is the distance between any two consecutive crests or troughs. The **SI unit** of wavelength is meter but is expressed in angstrom (10^{-10} m), picometer (10^{-12} m) and nanometer(10^{-9} m).
- In vacuum all types of electromagnetic radiations, regardless of wavelength, travel at the same speed, i.e., **3.0×10^8** m s^{-1} (**2.997925×10^8** m s^{-1}, to be precise). This is called **speed of light (c)**. The frequency, wavelength and velocity of light are related by the equation, **$c = \nu\lambda$.**

NEET 2021, 2013

- The **wave number** is defined as the number of wavelengths per unit length. Its **SI unit** is m^{-1}. However commonly used unit is cm^{-1} (**not SI unit**). The relation between wave number and wavelength is $\bar{\nu} = \frac{1}{\lambda}$.

Particle Nature of Electromagnetic Radiation: Planck's Quantum Theory

- An ideal body, which emits and absorbs radiations of all frequencies uniformly, is called a **black body** and the radiation emitted by such a body is called **black body radiation**.
- The **energy** (E) of a **quantum** of radiation is proportional to its frequency (ν) and is expressed by equation, $E = h\nu$ The proportionality constant, **'h'** is known as **Planck's constant** and has the value **6.626×10^{-34} J s**.

$$E = h\nu = \frac{hc}{\lambda}$$ AIPMT 2014, 2003, 2000

- With this theory, Planck was able to explain the **distribution of intensity** in the radiation from black body as a function of frequency or wavelength at different temperatures.
- The energy can take any one of the values from the following set, but cannot take on any values between them. E = 0, $h\nu$, $2h\nu$, $3h\nu$....$nh\nu$.

Photoelectric Effect:

- **H. Hertz** performed a_x experiment in which electrons (or electric current) were ejected when certain metals (K, Rb, Cs etc.) were exposed to a beam of light. The phenomenon is called **Photoelectric effect**.
- The **results** observed in this experiment were:
  - The electrons are ejected from the metal surface as soon as the beam of light strikes the surface.
  - The **number of electrons** ejected is proportional to the **intensity or brightness of light**.
  - For each metal, there is a characteristic minimum frequency, ν_0 (**threshold frequency**) below which photoelectric effect is not observed.
  - At a frequency $\nu > \nu_0$, the ejected electrons come out with certain **kinetic energy**. The **kinetic energies** of these electrons **increase** with the **increase** of **frequency** of the light used. AIPMT 1994
- The kinetic energy of the ejected electron is given by the following equation

$$h\nu = h\nu_0 + \frac{1}{2}m_e\nu^2$$

where m_e = mass of the electron
ν = velocity associated with the ejected electron.
$h\nu$ = energy of the striking photons
$h\nu_0$= minimum energy required to eject the electron (also called work function, w_0).

Dual Behaviour of Electromagnetic Radiation

- When radiation interacts with matter, it displays **particle** like properties in contrast to the wavelike properties (**interference and diffraction**), which it exhibits when it **propagates**.
- Ordinary white light consists of waves with all the wavelengths in the visible range, a ray of white light is spread out into a series of coloured bands called **spectrum**.
- The spectrum of white light, that we can see, ranges from violet at 7.50×10^{14} Hz to red at 4×10^{14} Hz. Such a spectrum is called **continuous spectrum**. Continuous because violet merges into blue, blue into green and so on.

- The spectrum of radiation emitted by a substance that has absorbed energy is called an **emission spectrum**.
- The **emission spectra** of atoms, in the gas phase, do not show a continuous spread of wavelength from red to violet, rather they emit light only at **specific wavelengths** with dark spaces between them. Such spectra are called **line spectra or atomic spectra** because the **emitted radiation** is identified by the appearance of **bright lines** in the spectra.
- A continuum of radiation is passed through a sample which absorbs radiation of certain wavelengths. The missing wavelength which corresponds to the radiation **absorbed** by the matter, leave **dark spaces** in the bright **continuous spectrum**.
- The study of emission or absorption spectra is referred to as **spectroscopy**.
- When an electric discharge is passed through gaseous hydrogen, the H_2 molecules dissociate and the energetically excited hydrogen atoms produced emit electromagnetic radiation of **discrete frequencies**.
- **Balmer** showed in 1885 on the basis of **experimental observations** that if spectral lines are expressed in terms of wave number $(\bar{\nu})$, then the visible lines of the hydrogen spectrum obey the following formula: NEET 2019

$$\bar{\nu} = 109.677\left(\frac{1}{2^2} - \frac{1}{n^2}\right)\text{cm}^2$$

where n is an integer equal to or greater than 3 (i.e., $n = 3,4,5,....$)
The series of lines described by this formula are called the **Balmer series**.
- **Johannes Rydberg**, noted that all series of lines in the hydrogen spectrum could be described by the following expression :

$$\bar{\nu} = 109.677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{cm}^{-1}$$

where $n_1 = 1,2.....$ and $n_2 = n_1 + 1, n_1 + 2.....$
- The value 109,677 cm^{-1} is called the **Rydberg constant** for hydrogen. The first five series of lines that correspond to n_1 = 1, 2, 3, 4, 5 are known as **Lyman, Balmer, Paschen, Bracket** and **Pfund** series, respectively. Following table shows these series of transitions in the hydrogen spectrum. NEET 2019

Series	n_1	n_2	Spectral Region
Lyman	1	2, 3…..	Ultraviolet
Balmer	2	3, 4…..	Visible
Paschen	3	4, 5…..	Infrared
Brackett	4	5, 6…..	Infrared
Pfund	5	6, 7…..	Infrared

- Of all the elements, hydrogen atom has the **simplest line spectrum**. Line spectrum becomes more and more complex for heavier atom.

2.4 Bohr's Model for Hydrogen Atom

- **Neils Bohr** (1913) was the first to explain quantitatively the general features of the structure of hydrogen atom and its spectrum. He used Planck's concept of quantisation of energy.
- Bohr's model for hydrogen atom is based on the following postulates:
  - The electron in the hydrogen atom can move around the nucleus in a circular path of fixed radius and energy. These paths are called **orbits**, **stationary states or allowed energy states**. These orbits are arranged concentrically around the nucleus.
  - The energy of an electron in the orbit does not change with time. However, the electron will move from a lower stationary state to a higher stationary state when required amount of energy is absorbed by the electron or energy is emitted when electron moves from higher stationary state to lower stationary state. The energy change does not take place in a continuous manner.
  - The **frequency of radiation** absorbed or emitted when transition occurs between two stationary states that differ in energy by ΔE, is given by:

$$\nu = \frac{\Delta E}{h} = \frac{E_2 - E_1}{h}$$

This expression is commonly known as **Bohr's frequency rule**.
  - The **angular momentum** of an electron is quantised. In a given stationary state it can be expressed as

$$m_e v r = n\frac{h}{2\pi} n = 1, 2, 3.....$$

  - An electron can move only in those orbits for which its **angular momentum** is integral multiple of $h/2\pi$. That means angular momentum is **quantised**.
  - **Radiation** is **emitted or absorbed** only when transition of electron takes place from one quantised value of angular momentum to another. Therefore, **Maxwell's electromagnetic** theory does not apply here that is why only certain fixed orbits are allowed.
- According to **Bohr's theory** for hydrogen atom:
  - The **stationary states** for electron are numbered n = 1,2,3.....
  These integral numbers are known as **Principal quantum numbers**.
  - The **radii** of the stationary states are expressed as:

$$r_n = n^2 a_0$$

  where a_0 = 52.9 pm. Thus the radius of the first stationary state, called the Bohr orbit, is 52.9 pm.
  - The most important property associated with the electron, is the **energy** of its **stationary state**. It is given by the expression

$$E_n = -R_H\left(\frac{1}{n^2}\right) \qquad n = 1, 2, 3.....$$

  where R_H is called **Rydberg constant** and its value is 2.18×10^{-18} J.

- ❖ When the electron is free from the influence of nucleus, the energy is taken as zero. The electron in this situation is associated with the stationary state of Principal Quantum number *n* and is called as ionized hydrogen atom.
- ❖ The energies of the stationary states associated with hydrogen like species (He^+, Li^{2+}, Be^{3+}) are given by the expression

$$E_n = -2.18\times10^{-18}\left(\frac{Z^2}{n^2}\right)\text{J}$$

and radii by the expression

$$r_n = \frac{52.9(n^2)}{Z}\text{pm}$$ NEET 2024

- ❖ Qualitatively the magnitude of velocity of electron increases with increase of positive charge on the nucleus and decreases with increase of principal quantum number.

♦ The energy (ΔE) , frequency (υ) and wavenumbers ($\bar{\nu}$) associated with the absorption and emission of the photon can be evaluated by using following equation

$$\Delta E = \left(-\frac{R_H}{n_i^2}\right)-\left(-\frac{R_H}{n_f^2}\right) = 2.18\times10^{-18}\,\text{J}\left(\frac{1}{n_i^2}-\frac{1}{n_f^2}\right)$$

$$\nu = \frac{\Delta E}{h} = \frac{R_H}{h}\left(\frac{1}{n_i^2}-\frac{1}{n_f^2}\right) = 3.29\times10^{15}\left(\frac{1}{n_i^2}-\frac{1}{n_f^2}\right)\text{Hz}$$

$$\bar{\nu} = \frac{\nu}{c} = \frac{R_H}{hc}\left(\frac{1}{n_i^2}-\frac{1}{n_f^2}\right) = 1.09677\times10^{7}\left(\frac{1}{n_i^2}-\frac{1}{n_f^2}\right)\text{m}^{-1}$$

(where n_i and n_f stand for initial orbit and final orbits)

♦ In case of **absorption** spectrum, $n_f > n_i$ and the term in the parenthesis is **positive** and energy is absorbed. On the other hand in case of **emission** spectrum $n_i > n_f$, ΔE is **negative** and energy is released.

♦ In case of **large number of hydrogen atoms**, different possible transitions can be observed and thus leading **to large number of spectral lines**.

♦ The brightness or **intensity** of **spectral lines** depends upon the **number of photons** of same wavelength or frequency absorbed or emitted.

Limitations of Bohr's Model :

♦ **Bohr's model** was too simple to account for the following points.

- ❖ This model **fails** to account for the **finer details** (doublet, that is two closely spaced lines) of the **hydrogen atom** spectrum observed by using sophisticated spectroscopic techniques.
- ❖ This model is **unable** to explain the **spectrum of atoms other than hydrogen**, for example, helium atom which possesses only two electrons
- ❖ Bohr's theory was also **unable** to explain the **splitting of spectral lines** in the presence of magnetic field (**Zeeman effect**) or an electric field (**Stark effect**).
- ❖ It could **not explain** the **ability of atoms to form molecules** by chemical bonds.

2.5 Towards Quantum Mechanical Model of the Atom

Dual Behaviour of Matter:

♦ **De Broglie** proposed that matter, like **radiation**, should also exhibit dual behaviour i.e., both **particle** and **wave** like properties.

♦ **De Broglie** gave the following relation between **wavelength** (λ) and **momentum** (p) of a material particle. NEET 2017

$$\lambda = \frac{h}{m\nu} = \frac{h}{p}$$

Where m is the mass of the particle, v its velocity and p its momentum.

Heisenberg's Uncertainty Principle:

♦ According to **Heisenberg's Uncertainty Principle** "it is impossible to determine simultaneously, the **exact position** and **exact momentum** (or velocity) of an electron". Mathematically, it can be given as

$$\Delta x\times\Delta p_x \geq \frac{h}{4\pi}$$

or $\Delta x\times\Delta(\text{m}\,v_x) \geq \frac{h}{4\pi}$ NEET 2017

or $\Delta x\times\Delta v_x \geq \frac{h}{4\pi m}$

where Δx is the uncertainty in position and Δp_x (or Δv_x) is the uncertainty in momentum (or velocity) of the particle.

♦ Heisenberg Uncertainty Principle is significant only for motion of **microscopic objects** and is **negligible** for that of **macroscopic** objects.

♦ **Bohr model** of the hydrogen atom not only ignores **dual behaviour** of matter but also contradicts Heisenberg uncertainty principle.

2.6 Quantum Mechanical Model of Atom

♦ The branch of science that takes into account **dual behaviour** of matter is called **quantum mechanics.**

♦ **Quantum mechanics** is a theoretical science that deals with the study of the motions of the **microscopic objects** that have both observable wave like and particle like properties.

♦ **Quantum mechanics** was developed independently in 1926 by **Werner Heisenberg** and **Erwin Schrödinger.**

♦ For a system (such as an atom or a molecule whose energy does not change with time) the Schrödinger equation is written as $\hat{H}\Psi = E\Psi$ where $\hat{H}$ is a mathematical operator called **Hamiltonian**.

- The **total energy** of the system takes into account the kinetic energies of all the **subatomic particles** (**electrons, nuclei**), attractive potential between the electrons and nuclei and repulsive potential among the electrons and nuclei individually.
- Solution of **Schrödinger** equation gives **E and Ψ**.
- When Schrödinger equation is solved for hydrogen atom, the solution gives the possible energy levels the electron can occupy and the corresponding wave function(s) (Ψ) of the electron associated with each energy level.
- The **quantized energy states** and corresponding wave functions which are characterized by a set of three quantum numbers (**principal quantum number n, azimuthal quantum number *l* and magnetic quantum number m**) arise as a natural consequence in the solution of the Schrödinger equation.
- The **wave function** is a **mathematical function** whose value depends upon the coordinates of the electron in the atom and does not carry any physical meaning.
- The **wave functions** of hydrogen or hydrogen like species with **one electron** are called **atomic orbitals**.
- The **probability** of finding an electron at a point within an atom is proportional to the square of the orbital wave function $|\Psi|^2$ is known as **probability density** and is **always positive**.
- The **Schrödinger equation** cannot be solved exactly for a **multi-electron atom**. This difficulty can be overcome by using **approximate methods**.
- **Atomic orbitals** are precisely distinguished by what are known as **quantum numbers**. Each **orbital** is designated by **three quantum numbers** labelled as n, l and m_l .
- The **principal quantum number 'n'** is a **positive integer** with value of n = 1,2,3..... The principal quantum number **determines** the **size** and to large extent the **energy** of the orbital. It also identifies the **shell**. **NEET** 2024, 2016
- With the increase in the value of 'n', the **number of allowed orbital** increases and are given by **'n^2'**
- All the orbitals of a given value of 'n' constitute a single shell of atom and are represented by the following letters **n** = 1, 2, 3, 4, ... **Shell** = K, L, M, N, ...
- **Azimuthal quantum number. 'l'** is also known as **orbital angular momentum or subsidiary quantum number.**
- **"*l*"** defines the **three-dimensional shape** of the orbital. For a given value of **n**, ***l*** can have **n** values ranging from **0** to **n – 1**

NEET 2024, 2016

- Each **shell** consists of one or more **subshells** or **sub-levels**. The **number of sub-shells** in a principal shell is equal to the value of **n**.
- Each **sub-shell** is assigned an **azimuthal quantum number (*l*).** Sub-shells corresponding to different values of ***l*** are represented by the following symbols.

Value for l : 0 1 2 3 4 5 .....
notation for sub-shell: s p d f g h .....

- **Magnetic orbital quantum number. 'm_l'** gives information about the **spatial orientation** of the orbital with respect to standard set of co-ordinate axis. For any sub-shell (defined by **'l'** value) **$2l + 1$** values of **m_l** are possible and these values are given by :
$m_l = -l, -(l-1), -(l-2)... 0,1... (l-2), (l-1), l$

NEET 2024, 2023, 2016

- The following chart gives the relation between the **subshell** and the number of **orbitals** associated with it.

Value of *l*	0	1	2	3	4	5
Subshell notation	*s*	*p*	*d*	*f*	*g*	*h*
Number of orbitals	1	3	5	7	9	11

- **George Uhlenbeck and Samuel Goudsmit** proposed the presence of the **fourth quantum number** known as the electron **spin quantum number.** **NEET** 2024, 2016
- **Spin angular momentum** of the electron, a vector quantity, can have two orientations relative to the chosen axis.
- The **two orientations** are distinguished by the spin quantum numbers **m_s** which can take the values of **+½ or –½.**
- Two electrons that have different m_s values (one +½ and the other –½) are said to have opposite spins.
- An orbital cannot hold more than **two electrons** and these two electrons should have opposite spins.
- According to the German physicist, **Max Born**, the square of the wave function (i.e., Ψ^2) at a point gives the probability density of the electron at that point. The variation of Ψ^2 as a function of r for 1s and 2s orbitals is given as

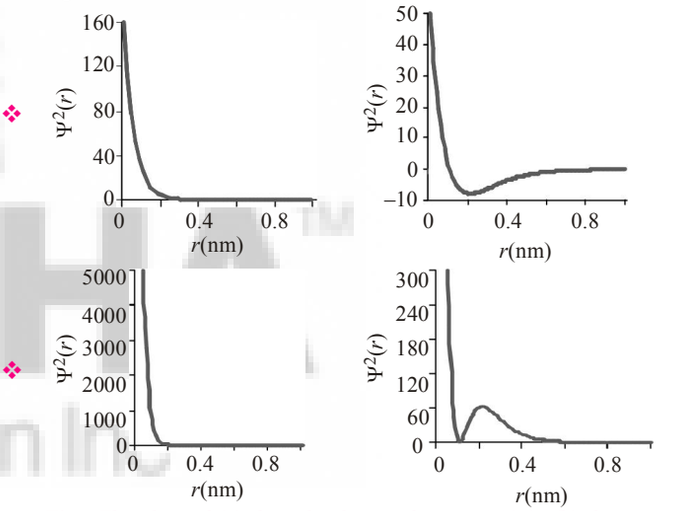


Fig.: *The plots of (a) the orbital wave function Ψ(r); (b) the variation of probability density Ψ² (r) as a function of distance r of the electron from the nucleus for 1s and 2s orbitals*

- The probability density variation can be visualised in terms of **charge cloud diagrams**.
- **Boundary surface diagrams** of constant probability density for different orbitals give a fairly good representation of the shapes of the orbitals.
  - ***s*-orbitals :** Boundary surface diagram for an s orbital is actually a **sphere centred** on the nucleus.

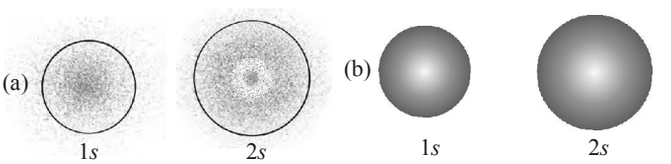


Fig.: *(a) Probability density plots of 1s and 2s atomic orbitals. The density of the dots represents the probability density of finding the electron in that region. (b) Boundary surface diagram for 1s and 2s orbitals.*

- **s-orbitals**, increases in **size** and **energy** with increase in the principal quantum number.

♦ ***p*-Orbitals:**

- Each *p* orbital consists of two sections called **lobes** that are on either side of the **plane** that passes through the nucleus.
- The **probability density function** is **zero** on the **plane** where the two lobes touch each other.
- The **size, shape** and **energy** of the three orbitals are **identical**. They **differ** however, in the way the lobes are **oriented**.
- Since the **lobes** may be considered to lie along the x, y or z axis, they are given the designations $2p_x$, $2p_y$, and $2p_z$.
- Like *s* orbitals, *p* orbitals increase in **size** and **energy** with increase in the principal quantum number

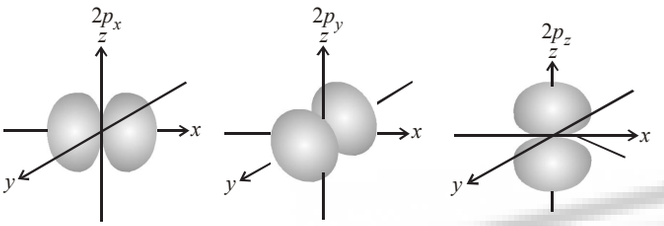


Fig.: *Boundary surface diagrams of the three 2p orbitals.*

♦ ***d*-Orbitals :**

- There are five m_l values (– 2, –1, 0, +1 and +2) for $l = 2$ and thus there are five *d* orbitals.
- The **boundary surface diagram** of *d* orbitals are shown in fig. The five *d*-orbitals are designated as d_{xy}, d_{yz}, d_{xz}, $d_{x^2-y^2}$ and d_{z^2}.

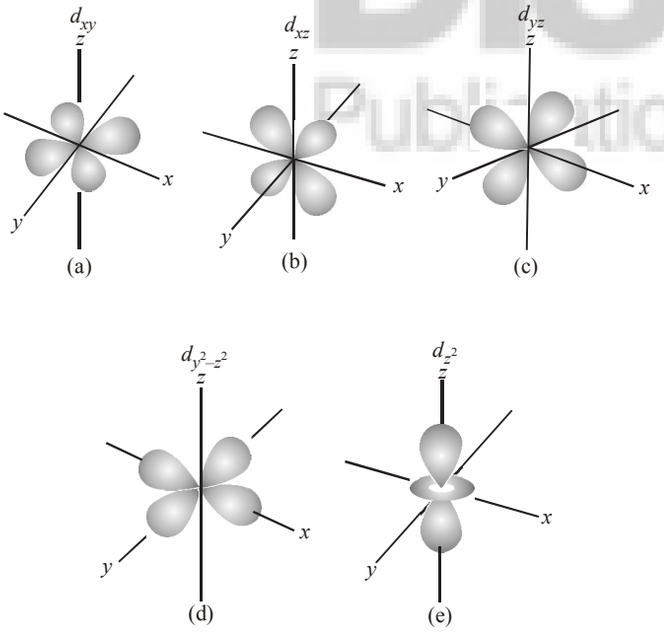


Fig.: *Boundary surface diagrams of the five 3d orbitals*

♦ The **nodal plane** are also called **angular nodes** and **number of angular nodes** are given by '*l*', i.e., one angular node for *p* orbitals, two angular nodes for '*d*' orbitals etc.

♦ The **total number of nodes** are given by (**n–1**), i.e., sum of *l* **angular nodes** and (**n – *l* – 1**) **radial nodes**.

NEET Odisha 2019

♦ The energy of an electron in a hydrogen atom is determined solely by the principal quantum number. Thus the energy of the orbitals in hydrogen atom increases as follows :

$1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f <$ **NEET** 2019

♦ The **orbitals** having the same **energy** are called **degenerate**.

♦ Within a given principal quantum number, the energy of orbitals increases in the order $s<p<d<f$

♦ The only **electrical interaction** present in **hydrogen atom** is the attraction between the negatively charged electron and the positively charged nucleus.

♦ In **multielectron atoms**, besides the presence of **attraction** between the **electron** and **nucleus**, there are **repulsion** between every **electron** and other **electrons** present in the atom. Thus the stability of an electron in a **multi-electron** atom is because total **attractive interactions** are more than the **repulsive interactions**.

♦ Due to the presence of electrons in the inner shells, the electron in the outer shell will not experience the full positive charge of the nucleus.

♦ The effect will be lowered due to the **partial screening** of **positive charge** on the nucleus by the **inner shell electrons**. This is known as the shielding of the outer shell electrons from the nucleus by the inner shell electrons, and the net positive charge experienced by the outer electrons is known as **effective nuclear charge (Z_{eff}).**

♦ If two orbitals have the same value of (**n + l**), the orbital with lower value of *n* will have the lower energy.

♦ **Aufbau Principle:**In the ground state of the atoms, the orbitals are filled in order of their increasing energies. 1*s*, 2*s*, 2*p*, 3*s*, 3*p*, 4*s*, 3*d*, 4*p*, 5*s*, 4*d*, 5*p*, 4*f*, 5*d*, 6*p*, 7*s*...

♦ **Pauli Exclusion Principle**: No two electrons in an atom can have the same set of four quantum numbers. Pauli exclusion principle can also be stated as : "Only two electrons may exist in the same orbital and these electrons must have opposite spin." **NEET** 2016

♦ The maximum number of electrons in the shell with principal quantum number *n* is equal to $2n^2$.

♦ **Hund's Rule of Maximum Multiplicity**: Pairing of electrons in the orbitals belonging to the same subshell (*p*, *d* or *f*) does not take place until each orbital belonging to that subshell has got one electron each i.e., it is singly occupied.

♦ The distribution of electrons into orbitals of an atom is called its **electronic configuration**.

- $s^a\ p^b\ d^c$ ..... notation
- Orbital diagram

- The **ground state electronic configuration** of the atom of an element always corresponds to the state of the lowest total electronic energy.
- **Symmetrical distribution of electrons:** The completely filled or half filled subshells have symmetrical distribution of electrons in them and are therefore more **stable**.
- The **stabilizing effect** arises whenever two or more electrons with the same spin are present in the degenerate orbitals of a subshell.
- The electrons tend to exchange their positions and the energy released due to this exchange is called **exchange energy**.
- The number of exchanges that can take place is maximum when the subshell is either **half filled** or **completely filled**.
- Higher the exchange energy, higher will be the stability.
- The extra stability of **half-filled** and **completely filled subshell** is also due to:
  - relatively **small shielding**
  - **smaller coulombic** repulsion energy
  - **larger exchange** energy

Tips/Tricks/Techniques ONE-Liners
(Exam Special)

- **(n + l) rule**

  This rule states that electrons are filled in orbitals according to their increasing values of $n + \ell$. When $(n + \ell)$ is same for sub energy levels, the electrons first occupy the sublevels with lowest "n" value. Thus, order of filling up of orbitals is as follows:

  $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d$

- Orbital angular momentum $= \frac{h}{2\pi}\sqrt{\ell(\ell+1)}$
- Spin Angular Momentum $= \frac{h}{2\pi}\sqrt{s(s+1)}$
- **Relation Between Potential energy (P.E), Kinetic energy (K.E) & Total energy**

$$\text{T.E.} = \frac{\text{P.E.}}{2} = -\text{K.E.}$$

$$\text{P.E.} = -\frac{Ze^2}{r}, \quad \text{K.E.} = \frac{1}{2}\frac{Ze^2}{r}, \quad \text{T.E.} = -\frac{1}{2}\frac{Ze^2}{r}$$

- **Nodal Point :** The nucleus of an atom is called nodal point.
- **Isodiaphers :** The elements which have same value of $(n - p)$ are called isodiaphers.
- **Isomorphous :** The two different types of compounds which contain same crystalline structure are called isomorphous and this property is called isomorphism.
- Substances which have same number of electrons and atoms called isosters.
- **Promotion :** The transfer of electrons between subshells in an orbit is called promotion, while the transfer of electrons from one energy level to another is called transition. After the completion of promotion, the transition process occurrs.

Exercise 1 : NCERT Based Topic-wise MCQs

2.0 Introduction

1. Dalton's atomic theory failed to explain

NCERT Page-29 / N-29

(a) law of conservation of mass
(b) law of constant composition
(c) law of multiple proportion
(d) Electrical properties of matter

2.1 Discovery of Sub-Atomic Particles

2*. What is the optimum conditions required to study the conduction of electricity through gases.

NCERT Page-30 / N-30

(a) High pressure and low voltage
(b) High pressure and high voltage
(c) Low pressure and high voltage
(d) Low pressure and low voltage

3*. In discharge tube experiment stream of negatively charged particles travel from NCERT Page-30 / N-30

(a) anode to cathode
(b) cathode to anode
(c) Both (a) and (b)
(d) Electrons does not travel

4*. Which one of the following can be used to predict the flow of cathode rays? NCERT Page-30 / N-30

(a) $ZnSO_4$ (b) $ZnCl_2$
(c) NaCl (d) ZnS

5*. Which of the following statement is incorrect about cathode rays? NCERT Page-30 / N-30

(a) Cathode rays are consists of electrons
(b) The characteristic of cathode rays do not depend upon the material of electrodes and nature of the gas present in the cathode ray tube.
(c) The deviation of the cathode rays from their path in the presence of electrical or magnetic field depends upon the magnitude of the negative charge on the cathode rays.
(d) The deflection of electrons from its original path increases with the decrease in the voltage across the electrodes.

6*. Millikan performed an experiment method to determine which of the following? NCERT Page-31 / N-31

(a) Mass of the electron
(b) Charge of the electron
(c) e/m ratio of electron
(d) Both (a) and (b)

7*. The number of electrons in any particle whose caries a charge of 3.2044×10^{-16} C , is NCERT Page N-31

(a) 0.02×10^4
(b) 2×10^{-3}
(c) 2×10^3
(d) 200

8*. The mass of positively charged particles depends upon

(a) material of electrodes NCERT Page N-32
(b) nature of gas
(c) nature of fluorescent materials
(d) nature of electric and magnetic field

9*. Which is correct statement about proton?

NCERT Page-32 / N-32

(a) Proton is nucleus of deuterium
(b) Proton is α-particle
(c) Proton is ionized hydrogen molecule
(d) Proton is ionized hydrogen atom

10*. Neutron is discovered by NCERT Page-32 / N-32

(a) Chadwick
(b) Rutherford
(c) Yukawa
(d) Dalton

11*. When beryllium is bombarded with alpha particles (Chadwick's experiment), extremely penetrating radiations, which cannot be deflected by electrical or magnetic field are given out. These are : NCERT Page N-32

(a) A beam of protons
(b) Alpha rays
(c) A beam of neutrons
(d) A beam of neutrons and protons

12*. What is the ratio of mass of an electron to the mass of a proton? NCERT Page N-33

(a) 1 : 2 (b) 1 : 1
(c) 1 : 1837 (d) 1 : 3

2.2 Atomic Models

13*. After the discovery of subatomic particles, there are sum hurdles were seen before scientist. Find the incorrect statement regarding the major hurdles from the following

NCERT Page N-32

(a) How to compare the behaviour of elements in terms of both physical and chemical properties

(b) How to explain the formation of different kinds of molecules by the combination of different atoms

(c) How to understand the origin and nature of the characteristics of electromagnetic radiation absorbed or emitted by atoms.

(d) How to account for the stability of molecules

14*. What was the major focused of the J.J Thomson model?

(a) Stability of elements NCERT Page-33 / N-33

(b) Spectra of the atom

(c) Properties of elements

(d) Uniformly distribution of the mass of the atom

15*. X rays are used to study the interior of the objects due to

NCERT Page-33 / N-33

(a) high energy and low penetration power

(b) high mass and low penetration power

(c) high penetration power

(d) low penetration power

16*. The correct order of the penetrating power of the different rays is NCERT Page-33 & 34 / N-33 & 34

(a) α-rays > X rays < β-rays > γ-rays

(b) γ-rays > X rays < α-rays > β-rays

(c) γ-rays > X rays < β-rays > α-rays

(d) β-rays > X rays < γ-rays > α-rays

17*. When atoms are bombarded with alpha particles, only a few in million suffer deflection, others pass out undeflected. NCERT Page N-34

This is because

(a) the force of repulsion on the moving alpha particle is small

(b) the force of attraction between alpha particle and oppositely charged electrons is very small

(c) there is only one nucleus and large number of electrons

(d) the nucleus occupies much smaller volume compared to the volume of the atom

18*. Rutherford's α-particle dispersion experiment concludes

NCERT Page-34 / N-34

(a) all positive ions are deposited at small part

(b) all negative ions are deposited at small part

(c) proton moves around the electron

(d) neutrons are charged particles.

19*. Rutherford's experiment on the scattering of α -particles showed for the first time that the atom has :

NCERT Page-35 / N-35

(a) electrons (b) protons

(c) nucleus (d) neutrons'

20*. Number of protons, neutrons and electrons in the element $_{89}X^{231}$ is NCERT Page-35 / N-35

(a) 89, 89, 242 (b) 89, 142, 89

(c) 89, 71, 89 (d) 89, 231, 89

21*. Which of the following does not contain number of neutrons equal to that of $^{40}_{18}Ar$? NCERT Page-35 / N-35

(a) $^{41}_{19}K$ (b) $^{43}_{21}Sc$ (c) $^{40}_{21}Sc$ (d) $^{42}_{20}Ca$

22*. Which of the following pairs will have same chemical properties ? NCERT Page-35 / N-35

(a) $^{14}_{6}C$ and $^{15}_{7}N$ (b) O^{2-} and F^{-}

(c) $^{40}_{18}Ar$ and $^{40}_{19}K$ (d) $^{35}_{17}Cl$ and $^{37}_{17}Cl$

23*. Hydrogen has three isotopes : protium (^1H), deuterium (^2H or D) and tritium (^3H or T). They have nearly same chemical properties but different physical properties. They differ in NCERT Page N-35

(a) number of protons

(b) atomic number

(c) electronic configuration

(d) atomic mass

2.3 Developments Leading to the Bohr's Model of Atom

24. The number of electrons, neutrons and protons in a species are equal to 10, 8 and 8 respectively. The proper symbol of the species is NCERT Page N-35

(a) $^{16}O_8$ (b) $^{18}O_8$ (c) $^{18}Ne_{10}$ (d) $^{16}O_8^{2-}$

25. The electromagnetic theory of Maxwell does not exist for planet because NCERT Page N-36

(a) they are charged

(b) they are uncharged

(c) they are larger in size

(d) they are charged and uncharged both.

26. Which of the following is a drawback of Rutherford model?

NCERT Page-36 / N-36

(a) The orbital revolution of the electron is not expected to be stable

(b) The electrons will follow a spiral path and then fall into the nucleus

(c) Both (a) and (b)

(d) None of the above

27. Which of the following statements are not correct about electromagnetic radiation ? NCERT Page-37 & 38 / N-37 & 38

(i) Electromagnetic waves require medium to travel.

(ii) Different electromagnetic radiations travel at same speed in vaccum.

(iii) The oscillating electric and magnetic fields produced by oscillating charged particles are perpendicular to each other, but not to the direction of propagation.

(iv) The oscillating electric field and magnetic field are perpendicular to each other, and also to the direction of propagation.

(a) (i), (ii) and (iii) (b) (ii) and (iii)

(c) (i) and (iii) (d) (i) and (iv)

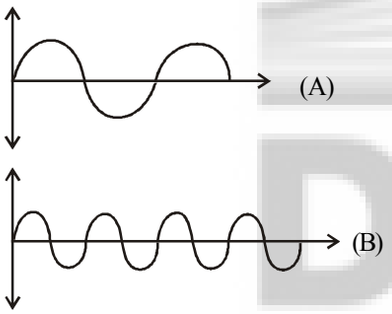
28. The SI unit of frequency (ν) , wavelength (λ) and wave number $(\bar{\nu})$ is NCERT Page-37 / N-38

(a) Hz, cm, cm^{-1} (b) m^{-1}, m, Hz

(c) Hz, m, m^{-1} (d) Hz, m, m

29. What will be the difference between electromagnetic radiation shown in A and B respectively?

NCERT Page-37 / N-38



(i) Velocity (ii) Wavelength

(iii) Frequency (iv) Energy

(a) (ii) only (b) (ii) and (iv)

(c) (ii), (iii) and (iv) (d) (iv) only

30. Arrange the electromagnetic radiations a, b, c, d and e in increasing order of energy. Frequencies of a, b and c are 10^{15}, 10^{14} and 10^{17} respectively whereas wavelength of (d) and (e) are 350 nm and 100 nm respectively ?

NCERT Page N-38

(a) a, b, c, d, e (b) a, b, d, e, c

(c) a, d, b, e, c (d) b, d, a, e, c

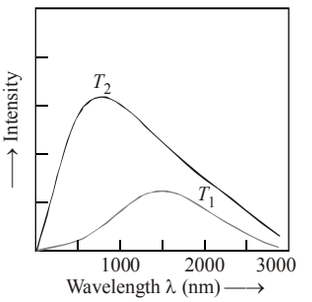
31. The minimum energy that must be possessed by photons in order to produce the photoelectric effect with platinum metal is: NCERT Page N-41

[**Given:** The threshold frequency of platinum is $1.3 \times 10^{15}\ s^{-1}$ and $h = 6.6 \times 10^{-34}$ J s.]

(a) 3.21×10^{-14} J (b) 6.24×10^{-16} J

(c) 8.58×10^{-19} J (d) 9.76×10^{-20} J

32. Observe the given figure carefully NCERT Page-40 / N-40



Select the incorrect statement from the following.

(a) As the temperature increases, maxima of the curve shift to short wavelength.

(b) The amount of light emitted (*i.e.*, intensity of radiation) from a black body and its spectral distribution depends only on its temperature.

(c) For the given figure, $T_1 > T_2$.

(d) At a given temperature, intensity of radiation emitted increases with the increase of wavelength, reaches a maximum value at a given wavelength and then starts decreasing with further increase of wavelength.

33. Which one of the following is not the characteristic of Planck's quantum theory of radiation ?

NCERT Page-40 & 41 / N-40 & 41

(a) The energy is not absorbed or emitted in whole number or multiple of quantum

(b) Radiation is associated with energy

(c) Radiation energy is not emitted or absorbed continuously but in the form of small packets called quanta

(d) This magnitude of energy associated with a quantum is proportional to the frequency.

34. The value of Planck's constant is 6.63×10^{-34} Js. The velocity of light is $3.0 \times 10^{8}\ m\ s^{-1}$. Which value is closest to the wavelength in nanometers of a quantum of light with frequency of $8 \times 10^{15}\ s^{-1}$? NCERT Page N-38 & 41

(a) 3×10^{7} (b) 2×10^{-25}

(c) 5×10^{-18} (d) 4×10^{1}

35. A 600 W mercury lamp emits monochromatic radiation of wavelength 331.3 nm. How many photons are emitted from the lamp per second ? ($h = 6.626 \times 10^{-34}$ Js; velocity of light $= 3 \times 10^{8}\ ms^{-1}$) NCERT Page N-38 & 41

(a) 1×10^{19} (b) 1×10^{20}

(c) 1×10^{21} (d) 1×10^{23}

36. In photoelectric effect, at which frequency, electron will be ejected with certain kinetic energy (ν_0 = threshold frequency). NCERT Page-41 / N-41

(a) $\nu > \nu_0$ (b) $\nu_0 > \nu$

(c) $\nu_0 \geq \nu$ (d) $\nu \geq \nu_0$

37. Calculate the velocity of ejected electron from the metal surface when light of frequency 2×10^{15} Hz fall on the metal surface and the threshold frequency is 7×10^{14} Hz for metal ? NCERT Page-43 / N-42

(a) 1.37×10^6 (b) 1.26×10^6

(c) 1.45×10^7 (d) 1.37×10^7

38. In the photo-electron emission, the energy of the emitted electron is NCERT Page N-42

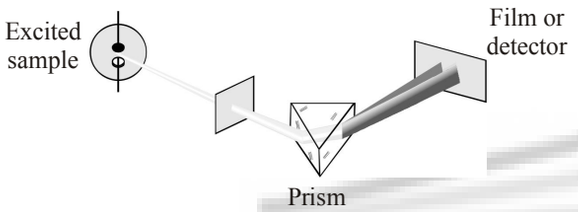
(a) greater than the incident photon

(b) same as than of the incident photon

(c) smaller than the incident photon

(d) proportional to the intensity of incident photon

39. Which of the following types of spectrum is best depicted by the given figure? NCERT Page-45 / N-45



(a) Atomic absorption spectra

(b) Atomic emission spectra

(c) Continuous spectra

(d) None of these

40. Given below are the spectral lines for an atom of hydrogen. Mark the lines which are not correctly matched with the values of n_1 and n_2. NCERT Page-45 / N-45

	Series	n_1	n_2	Spectral Region
(i)	Lyman	1	2, 3, ...	Ultraviolet
(ii)	Balmer	2	3, 4, ...	Infrared
(iii)	Paschen	3	4, 5, ...	Infrared
(iv)	Pfund	4	5, 6, ...	Infrared

(a) (i) and (ii) (b) (i) and (iii)

(c) (ii) and (iv) (d) (i) and (iv)

2.4 Bohr's Model for Hydrogen Atom

41. The third line of the Balmer series, in the emission spectrum of the hydrogen atom, is due to the transition from the NCERT Page N-45

(a) fourth Bohr orbit to the first Bohr orbit

(b) fifth Bohr orbit to the second Bohr orbit

(c) sixth Bohr orbit to the third Bohr orbit

(d) seventh Bohr orbit to the third Bohr orbit

42. An electron from one Bohr stationary orbit can go to next higher orbit NCERT Page-46 / N-46

(a) by emission of electromagnetic radiation

(b) by absorption of any electromagnetic radiation

(c) by absorption of electromagnetic radiation of particular frequency

(d) without emission or absorption of electromagnetic radiation

43. According to Bohr's theory, the angular momentum of an electron in 5th orbit is NCERT Page N-46

(a) $10\,h/\pi$ (b) $2.5\,h/\pi$

(c) $25\,h/\pi$ (d) $1.0\,h/\pi$

44. An electron, e_1 is moving in the fifth stationary state, and another electron e_2 is moving in the fourth stationary state. The radius of orbit of electron, e_1 is five times the radius of orbit of electron, e_2 calculate the ratio of velocity of electron e_1 (v_1) to the velocity of electron e_2 (v_2). NCERT Page N-46

(a) 5 : 1 (b) 4 : 1

(c) 1 : 5 (d) 1 : 4

45. If r is the radius of the first orbit, the radius of n^{th} orbit of H-atom is given by NCERT Page N-47

(a) rn^2 (b) rn

(c) r/n (d) $r^2\,n^2$

46. The energy of second Bohr orbit of the hydrogen atom is -328 kJ mol^{-1}; hence the energy of fourth Bohr orbit would be: NCERT Page-47 / N-47

(a) -41 kJ mol^{-1} (b) -82 kJ mol^{-1}

(c) -164 kJ mol^{-1} (d) -1312 kJ mol^{-1}

47. What does negative sign in the electronic energy for hydrogen atom convey. NCERT Page N-47

(a) Energy of electron when $n = \infty$

(b) The energy of electron in the atom is lower than the energy of a free electron in motion

(c) The energy of electron in the atom is lower than the energy of a free electron of rest

(d) The energy of electron decreases as it moves away from nucleus

48. If the radius of the 3rd Bohr's orbit of hydrogen atom is r_3 and the radius of 4th Bohr's orbit is r_4. NCERT Page N-48

Then :

(a) $r_4 = \frac{9}{16} r_3$ (b) $r_4 = \frac{16}{9} r_3$

(c) $r_4 = \frac{3}{4} r_3$ (d) $r_4 = \frac{4}{3} r_3$

49. Bohr's theory can be applied to which of the following ions. NCERT Page N-49

(a) Na^+ (b) Be^{2+}

(c) Li^+ (d) Li^{2+}

50. Among species H, Li^{2+}, He^{+}, Be^{3+} and Al^{3+}, Bohr's model was able to explain the spectra of NCERT Page-46 / N-49

(a) All of these
(b) None of these
(c) all other species except Be^{3+}
(d) all other species except Al^{3+}

51. The energy of an electron in second Bohr orbit of hydrogen atom is : NCERT Page N-48

(a) -5.44×10^{-19} eV (b) -5.44×10^{-19} cal
(c) -5.44×10^{-19} kJ (d) -5.44×10^{-19} J

52. According to Bohr's theory the energy required for an electron in the Li^{2+} ion to be emitted from $n = 2$ state is (given that the ground state ionization energy of hydrogen atom is 13.6 eV) NCERT Page N-48

(a) 61.2 eV (b) 13.6 eV
(c) 30.6 eV (d) 10.2 eV

53. The ionisation potential of a hydrogen atom is –13.6 eV. What will be the energy of the atom corresponding to $n = 2$. NCERT Page N-48

(a) – 3.4 eV (b) – 6.8 eV
(c) – 1.7 eV (d) –2.7 eV

54. The radius of hydrogen atom in the ground state is 0.53 Å. The radius of Li^{2+} ion (atomic number = 3) in a similar state is NCERT Page N-48

(a) 0.17 Å (b) 0.265 Å
(c) 0.53 Å (d) 1.06 Å

55. Bohr model can explain : NCERT Page-46 / N-46

(a) the solar spectrum
(b) the spectrum of hydrogen molecule
(c) spectrum of any atom or ion containing one electron only
(d) the spectrum of hydrogen atom only

56. The Bohr orbit radius for the hydrogen atom (n = 1) is approximately 0.530 Å. The radius for the first excited state ($n = 2$) orbit is (in Å) NCERT Page N-48

(a) 0.13 (b) 1.06 (c) 4.77 (d) 2.12

57. What is the expression of frequency (ν) associated with absorption spectra of the photon. NCERT Page-48 / N-48

(a) $\nu = \frac{R_H}{h}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) n_i > n_f$

(b) $\nu = \frac{R_H}{h}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) n_f > n_i$

(c) $\nu = -\frac{R_H}{h}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) n_f > n_i$

(d) All the above are correct

58. For Balmer series in the spectrum of atomic hydrogen, the wave number of each line is given by $\overline{\nu} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R_H is a constant and n_1 and n_2 are integers. Which of the following statement(s) is (are) correct?

(i) As wavelength decreases, the lines in the series converge. NCERT Page N-48
(ii) The integer n_1 is equal to 2.
(iii) The ionization energy of hydrogen can be calculated from the wave number of these lines.
(iv) The line of longest wavelength corresponds to $n_2 = 3$.

(a) (i), (ii) and (iii) (b) (ii), (iii) and (iv)
(c) (i), (ii) and (iv) (d) (ii) and (iv)

59. The wavelength of the radiation emitted, when in a hydrogen atom electron falls from infinity to stationary state 1, would be (Rydberg constant = 1.097×10^7 m^{-1}) NCERT Page N-48

(a) 406 nm (b) 192 nm
(c) 91 nm (d) 9.1×10^{-8} nm

60. The frequency of radiation emitted when the electron falls from $n = 4$ to $n = 1$ in a hydrogen atom will be (Given : ionization energy of H = 2.18×10^{-18} J $atom^{-1}$ and $h = 6.625 \times 10^{-34}$ J s) NCERT Page N-48

(a) 1.54×10^{15} s^{-1} (b) 1.03×10^{15} s^{-1}
(c) 3.08×10^{15} s^{-1} (d) 2.00×10^{15} s^{-1}

61. The wavelength (in cm) of second line in the Lyman series of hydrogen atomic spectrum is (Rydberg constant = R cm^{-1}) NCERT Page N-48

(a) $\left(\frac{8R}{9}\right)$ (b) $\left(\frac{9}{8R}\right)$
(c) $\left(\frac{4}{3R}\right)$ (d) $\left(\frac{3R}{4}\right)$

62. Which of the following transitions of electrons in the hydrogen atom will emit maximum energy? NCERT Page N-48

(a) $n_5 \rightarrow n_4$ (b) $n_4 \rightarrow n_3$
(c) $n_3 \rightarrow n_2$ (d) all will emit same energy

63. The shortest wavelength in hydrogen spectrum of Lyman series when $R_H = 109678$ cm^{-1} is NCERT Page N-47

(a) 1002.7 Å (b) 1215.67 Å
(c) 1127.30 Å (d) 911.7 Å

64. Splitting of spectral lines under the influence of magnetic field is called NCERT Page N-49

(a) Stark effect (b) Zeeman effect
(c) photoelectric effect (d) screening effect

2.5 Towards Quantum Mechanical Model of the Atom

65. If electron, hydrogen, helium and neon nuclei are all moving with the velocity of light, then the wavelength associated with these particles are in the order NCERT Page N-50

(a) Electron > hydrogen > helium > neon
(b) Electron > helium > hydrogen > neon
(c) Electron < hydrogen < helium < neon
(d) Neon < hydrogen < helium < electron

66. Arrange the following elements in the order of ease of detection of wave properties, in the de Broglie experiment.

H, Li, Be, B, K NCERT Page N-50

(a) H < Be, B < Li < K. (b) H > Li > K > Be > B
(c) H > Li > Be > B > K (d) H < Li < Be < B < K

67. The de Broglie wavelength of a tennis ball of mass 60 g moving with a velocity of 10 metres per second is approximately NCERT Page N-50

(a) 10^{-31} metres (b) 10^{-16} metres
(c) 10^{-25} metres (d) 10^{-33} metres

Planck's constant, $h = 6.63 \times 10^{-34}$ Js

68. If the energy difference between the ground state of an atom and its excited state is 4.4×10^{-4} J, the wavelength of photon required to produce the transition :

(a) 2.26×10^{-12} m (b) 1.13×10^{-22} m
(c) 4.52×10^{-16} m (d) 4.52×10^{-22} m

69. The mass of a photon with a wavelength equal to 1.54×10^{-8} cm is NCERT Page-50 / N-50

(a) 0.8268×10^{-34} kg (b) 1.2876×10^{-33} kg
(c) 1.4285×10^{-32} kg (d) 1.8884×10^{-32} kg

70. The de Broglie wavelength of a car of mass 1000 kg and velocity 36 km/hr is : NCERT Page-50 / N-50

(a) 6.626×10^{-34} m (b) 6.626×10^{-38} m
(c) 6.626×10^{-31} m (d) 6.626×10^{-30} m

71. The velocity of particle A is 0.1 ms^{-1} and that of particle B is 0.05 ms^{-1}. If the mass of particle B is five times that of particle A, then the ratio of de-Broglie wavelengths associated with the particles A and B is NCERT Page N-50

(a) 2 : 5 (b) 3 : 4 (c) 6 : 4 (d) 5 : 2

72. Heisenberg's uncertainity principle is applicable to NCERT Page N-51

(a) atoms only (b) electron only
(c) nucleus only (d) any moving object

73. The position of both, an electron and a helium atom is known within 1.0 nm. Further the momentum of the electron is known within 5.0×10^{-26} kg ms^{-1}. The minimum uncertainty in the measurement of the momentum of the helium atom is NCERT Page N-51

(a) 50 kg ms^{-1} (b) 80 kg ms^{-1}
(c) 8.0×10^{-26} kg ms^{-1} (d) 5.0×10^{-26} kg ms^{-1}

74. The Heisenberg uncertainity principle will be most significant for which of the following object ?

NCERT Page-51 / N-51

(a) Object A of mass 9.11×10^{-30} kg
(b) Object B of mass 9.11×10^{-28} g
(c) Object C of mass 9.11×10^{-24} mg
(d) Object D of mass 9.11×10^{-28} kg

75. The measurement of the electron position is associated with an uncertainty in momentum, which is equal to 1×10^{-18} g cm s^{-1}. The uncertainty in electron velocity is, (mass of an electron is 9×10^{-28} g) NCERT Page-51 / N-51

(a) 1×10^{9} cm s^{-1} (b) 1×10^{6} cm s^{-1}
(c) 1×10^{5} cm s^{-1} (d) 1×10^{11} cm s^{-1}

76. In an atom, an electron is moving with a speed of 600 m/s with an accuracy of 0.005%. Certainty with which the position of the electron can be located is ($h = 6.6 \times 10^{-34}$ kg $m^2 s^{-1}$, mass of electron, $e_m = 9.1 \times 10^{-31}$ kg) NCERT Page N-51

(a) 5.10×10^{-3} m (b) 1.92×10^{-3} m
(c) 3.84×10^{-3} m (d) 1.52×10^{-4} m

77. Uncertainty in position of an electron (mass = 9.1×10^{-28} g) moving with a velocity of 3×10^{4} cm/s accurate upto 0.001% will be (use $h/4\pi$ in uncertainty expression where $h = 6.626 \times 10^{-27}$ erg-second). NCERT Page-52 / N-52

(a) 1.93 cm (b) 3.84 cm (c) 5.76 cm (d) 7.68 cm

2.6 Quantum Mechanical Model of Atom

78. Identify the incorrect statement from the following.

NCERT Page N-53

(a) A circular path around the nucleus in which an electron moves is proposed as Bohr's orbit.
(b) An orbital is the one electron wave function (ψ) in an atom.
(c) The existence of Bohr's orbits is supported by hydrogen spectrum.
(d) Atomic orbital is characterised by the quantum numbers n and l only

79. The quantum numbers determined by the Schrödinger equation are NCERT Page N-55

(a) n, l, m, s (b) n, s, l (c) n, l, m (d) n, m, s

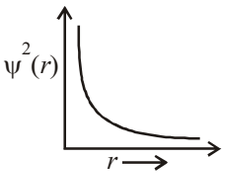
80. The probability of finding out an electron at a point within an atom is proportional to the NCERT Page N-54

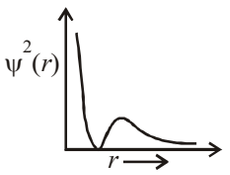
(a) square of the orbital wave function *i.e.*, Ψ^2
(b) orbital wave function *i.e.*, Ψ
(c) Hamiltonian operator i.e., H
(d) principal quantum number i.e., n

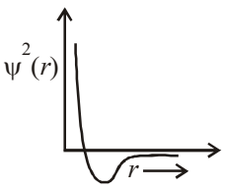
81. What is the lowest value of n that allows g orbital to exist? NCERT Page N-55

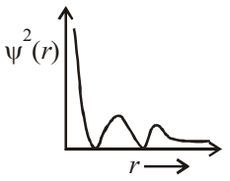
(a) 6 (b) 7 (c) 4 (d) 5

82. Which of the following is the correct plot for the probability density $\psi^2(r)$ as a function of distance 'r' of the electron form the nucleus for 2s orbital? NCERT Page N-57

(a) 

(b) 

(c) 

(d) 

83. Maximum number of electrons in a subshell of an atom is determined by the following: NCERT Page N-56

(a) $2l+1$ (b) $4l-2$ (c) $2n^2$ (d) $4l+2$

84. The orientation of an atomic orbital is governed by NCERT Page N-56

(a) Spin quantum number
(b) Magnetic quantum number
(c) Principal quantum number
(d) Azimuthal quantum number

85. For which one of the following sets of four quantum numbers, an electron will have the heighest energy? NCERT Page N-61

	n	l	m	s
(a)	3	2	1	1/2
(b)	4	2	–1	1/2
(c)	4	1	0	–1/2
(d)	5	0	0	–1/2

86. Which of the following sets of quantum numbers is correct for an electron in 4f orbital ? NCERT Page-56 / N-56

(a) $n=4, l=3, m=+1, s=+½$
(b) $n=4, l=4, m=-4, s=-½$
(c) $n=4, l=3, m=+4, s=+½$
(d) $n=3, l=2, m=-2, s=+½$

87. What is the correct orbital designation of an electron with the quantum number, $n=4, l=3, m=-2, s=1/2$? NCERT Page N-55

(a) 3s (b) 4f (c) 5p (d) 6s

88. Which of the following represents correct set of the four quantum numbers for an electron in a 4d subshell ? NCERT Page N-56

(a) 4, 2, 1, 0 (b) 4, 2, 1, – 1/2
(c) 4, 3, 2, + 1/2 (d) 4, 3, – 2, – 1/2

89. The total number of electrons that can be accommodated in all orbitals having principal quantum number 2 and azimuthal quantum number 1 is NCERT Page N-62

(a) 2 (b) 4
(c) 6 (d) 8

90. Which of the following is **not** permissible arrangement of electrons in an atom? NCERT Page N-56

(a) $n=5, l=3, m=0, s=+1/2$
(b) $n=3, l=2, m=-3, s=-1/2$
(c) $n=3, l=2, m=-2, s=-1/2$
(d) $n=4, l=0, m=0, s=-1/2$

91. Which set of quantum numbers are not possible? NCERT Page-57 / N-56

	n	l	m	s
(a)	3	2	0	+1/2
(b)	2	2	1	+1/2
(c)	1	0	0	–1/2
(d)	3	2	–2	+1/2

92. What will be the sum of all possible values of l and m for $n=5$? NCERT Page N-56

(a) 12 (b) 13
(c) 4 (d) 9

93. The number of orbitals present in the fifth shell will be NCERT Page N-56

(a) 25 (b) 10
(c) 50 (d) 20

94. Which combinations of quantum numbers, n, l, m and s for the electron in an atom does not provide a permissible solution of the wave equation ? NCERT Page N-56

(a) $3, 2, 1, \frac{1}{2}$ (b) $3, 1, 1, -\frac{1}{2}$

(c) $3, 3, 1, -\frac{1}{2}$ (d) $3, 2, -2, \frac{1}{2}$

95. The following quantum numbers are possible for how many orbital(s) $n=3, l=2, m=+2$? NCERT Page N-56

(a) 1 (b) 3
(c) 2 (d) 4

96. Given NCERT Page N-56

(i) $n=5, m_\ell=+1$
(ii) $n=2, \ell=1, m_\ell=-1, m_s=-1/2$

The maximum number of electron(s) in an atom that can have the quantum numbers as given in (a) and (b) are respectively:

(a) 25 and 1 (b) 8 and 1
(c) 2 and 4 (d) 4 and 1

97. Which of the following statements are **correct** ?

NCERT Page N-59 & 62

(A) The electronic configuration of Cr is [Ar] $3d^5\ 4s^1$.

(B) The magnetic quantum number may have a negative value.

(C) In the ground state of an atom, the orbitals are filled in order of their increasing energies.

(D) The total number of nodes are given by n – 2 .

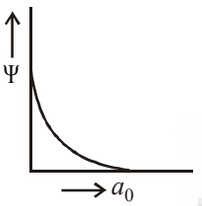
Choose the **most appropriate** answer from the options given below :

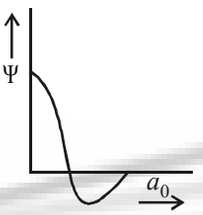
(a) (A), (C) and (D) only (b) (A) and (B) only

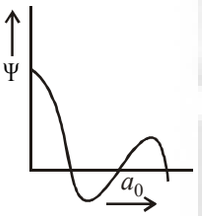
(c) (A) and (C) only (d) (A), (B) and (C) only

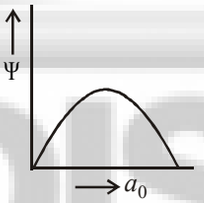
98. Which of the following graph correspond to one node

NCERT Page-57 / N-57

(a) 

(b) 

(c) 

(d) 

99. The five *d*-orbitals are designated as $d_{xy}, d_{yz}, d_{xz}, d_{x^2-y^2}$ and d_{z^2}. Choose the correct statement NCERT Page-59 / N-59

(a) The shapes of the first three orbitals are similar but that of the fourth and fifth orbitals are different

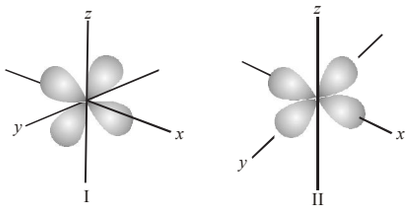
(b) The shapes of all five *d*-orbitals are similar

(c) The shapes of the first four orbitals are similar but that of the fifth orbital is different

(d) The shapes of all five *d*-orbitals are different

100. Observe the given boundary surface diagrams of two orbitals I and II and choose the correct option.

NCERT Page-59 / N-59



(a) I – $d_{x^2-y^2}$, II – d_{yz} (b) I – d_{yz}, II – $d_{x^2-y^2}$

(c) I – d_{xz}, II – d_{z^2} (d) I – d_{xy}, II – d_{xz}

101. If there are five radial nodes, then what can be the correct representation of the orbital for $n = 8$. NCERT Page N-59

(a) 8*d* (b) 8*s*

(c) 8*p* (d) 8*f*

102. What can be the representation of the orbital having 3 angular nodes and $n = 5$. NCERT Page N-59

(a) 5*d* (b) 5*f* (c) 5*p* (d) 5*s*

103. The correct order of increasing energy of atomic orbitals is

NCERT Page-62 / N-62

(a) $5p < 4f < 6s < 5d$ (b) $5p < 6s < 4f < 5d$

(c) $5p < 5d < 4f < 6s$ (d) None of these

104. Consider the following statements : NCERT Page N-55

(A) The principal quantum number '*n*' is a positive integer with values of '*n*' = 1, 2, 3, ….

(B) The azimuthal quantum number '*l*' for a given '*n*' (principal quantum number) can have values as '*l*' = 0, 1, 2, …. *n*

(C) Magnetic orbital quantum number 'm_l' for a particular '*l*' (azimuthal quantum number) has $(2l + 1)$ values.

(D) ±1/2 are the two possible orientations of electron spin.

(E) For $l = 5$, there will be a total of 9 orbital.

Which of the above statements correct?

(a) (A), (B) and (C) (b) (A), (C), (D) and (E)

(c) (A), (C) and (D) (d) (A), (B), (C) and (D)

105. An electron can enter into the orbital when

NCERT Page N-55

(a) value of *n* is minimum

(b) value of *l* is minimum

(c) value of $(n + l)$ is minimum

(d) value of $(n + m)$ is minimum.

106. The orbital diagram in which the Aufbau principle is violated is : NCERT Page-62 / N-62

	2s	2p
(a)	↑↓	↑↓ ↑
(b)	↑	↑↓ ↑ ↑
(c)	↑↓	↑ ↑ ↑
(d)	↑↓	↑↓ ↑ ↑

107. In a given atom, no two electrons can have the same values for all the four quantum numbers. This is called

NCERT Page-62 / N-62

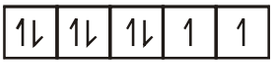
(a) Hund's Rule

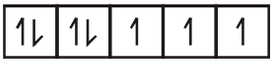
(b) Aufbau principle

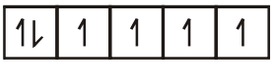
(c) Uncertainty principle

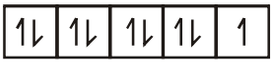
(d) Pauli's exclusion principle

108. Which of the following electronic configuration of *d*-orbital will have highest affinity for gaining an electron?

(a) 

(b) 

(c) 

(d) 

NCERT Page N-64

109. The electronic configuration of Cu (atomic number 29) is

NCERT Page-63 / N-63

(a) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 3d^9$

(b) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^1$

(c) $1s^2, 2s^2 2p^6, 3p^2 3p^6, 4s^2 4p^6, 5s^2 5p^1$

(d) $1s^2, 2s^2 2p^6, 3p^2 3p^6, 4s^2 4p^6 3d^3$

110. Given below are the quantum numbers for 4 electrons.

NCERT Page N-61

(A) $n = 3, l = 2, m_l = 1, m_s = +1/2$

(B) $n = 4, l = 1, m_l = 0, m_s = +1/2$

(C) $n = 4, l = 2, m_l = -2, m_s = -1/2$

(D) $n = 3, l = 1, m_l = -1, m_s = +1/2$

The correct order of increasing energy is :

(a) D < B < A < C

(b) D < A < B < C

(c) B < D < A < C

(d) B < D < C < A

Exercise 2 : NCERT Exemplar & Past Years NEET

NCERT Exemplar Questions

1*. Which of the following conclusions could not be derived from Rutherford's α-particle scattering experiment?

NCERT Page-34 / N-34

(a) Most of the space in the atom is empty.

(b) The radius of the atom is about 10^{-10} m while that of nucleus is 10^{-15} m.

(c) Electrons move in a circular path of fixed energy called orbits.

(d) Electrons and the nucleus are held together by electrostatic forces of attraction.

2. Which of the following options does not represent ground state electronic configuration of an atom?

NCERT Page-63 / N-63

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

(b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^2$

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

(d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

3*. Which of the following statement is not correct about the characteristics of cathode rays?

NCERT Page-30 / N-30

(a) They start from the cathode and move towards the anode.

(b) They travel in straight line in the absence of an external electrical or magnetic field.

(c) Characteristics of cathode rays do not depend upon the material of electrodes in cathode ray tube.

(d) Characteristics of cathode rays depend upon the nature of gas present in the cathode ray tube.

4*. Which of the following statements about the electron is incorrect?

NCERT Page-31 / N-31

(a) It is a negatively charged particle.

(b) The mass of electron is equal to the mass of neutron.

(c) It is a basic constituent of all the atoms.

(d) It is a constituent of cathode rays.

5*. Which of the following properties of atom could be explained correctly by Thomson model of atom?

(a) Overall neutrality of atom NCERT Page-33 / N-33

(b) Spectra of hydrogen atom

(c) Position of electrons, protons and neutrons in atom

(d) Stability of atom

6*. Two atoms are said to be isobars if NCERT Page-35 / N-35

(a) they have same atomic number but different mass number

(b) they have same number of electrons but different number of neutrons

(c) they have same number of neutrons but different number of electrons

(d) sum of the number of protons and neutrons is same but the number of protons is different

7. The number of radial nodes for 3*p* orbital is ..... .
NCERT Page-59 / N-59
(a) 3 (b) 4 (c) 2 (d) 1

8. Number of angular nodes for 4*d* orbital is ..... .
NCERT Page-59 / N-59
(a) 4 (b) 3 (c) 2 (d) 1

9. Which of the following is responsible to rule out the existence of definite paths or trajectories of electrons?
(a) Pauli's exclusion principle NCERT Page N-51
(b) Heisenberg's uncertainty principle
(c) Hund's rule of maximum multiplicity
(d) Aufbau principle

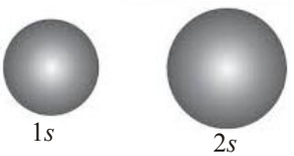
10. Total number of orbitals associated with third shell will be ..... .
NCERT Page N-55
(a) 2 (b) 4 (c) 9 (d) 3

11. Orbital angular momentum depends on ..... .
NCERT Page-55 / N-55
(a) *l* (b) *n* and *l*
(c) *n* and *m* (d) *m* and *s*

12. Chlorine exists in two isotopic forms Cl-37 and Cl-35, but its atomic mass is 35.5. This indicates the ratio of Cl-37 and Cl-35 is approximately
(a) 1 : 2 (b) 1 : 1 (c) 1 : 3 (d) 3 : 1

13*. If travelling at same speeds, which of the following matter waves have the shortest wavelength? NCERT Page N-50
(a) Electron (b) Alpha particle (He^{2+})
(c) Neutron (d) Proton

14. The probability density plots of 1*s* and 2*s* orbitals are given in figure.
NCERT Page-58 / N-58



The density of dots in a region represents the probability density of finding electrons in the region.
On the basis of above diagram which of the following statements is incorrect?
(a) 1*s* and 2*s* orbitals are spherical in shape.
(b) The probability of finding the electron is maximum near the nucleus.
(c) The probability of finding the electron at a given distance is equal in all directions.
(d) The probability density of electrons for 2*s* orbital decreases uniformly as distance from the nucleus increases.

15. The pair of ions having same electronic configuration is ..... .
NCERT Page N-63
(a) Cr^{3+}, Fe^{3+} (b) Fe^{3+}, Mn^{2+}
(c) Fe^{3+}, Co^{3+} (d) Sc^{3+}, Cr^{3+}

16. For the electrons of oxygen atom, which of the following statements is correct?
NCERT Page N-56
(a) Z_{eff} for an electron in a 2*s* orbital is the same as Z_{eff} for an electron in a 2*p* orbital.
(b) An electron in the 2*s* orbital has the same energy as an electron in the 2*p* orbital.
(c) Z_{eff} for an electron in 1*s* orbital is the same as Z_{eff} for an electron in a 2*s* orbital.
(d) The two electrons present in the 2*s* orbital have spin quantum numbers m_s but of opposite sign.

Past Years NEET

17. The energy of an electron in the ground state (n = 1) for He^+ ion is –x J, then that for an electron in n = 2 state for Be^{3+} ion in J is
NCERT Page-N-48 | NEET 2024
(a) –x (b) $-\frac{x}{9}$
(c) –4x (d) $-\frac{4}{9}x$

18. Match List I with List II

List I (Quantum Number)		List II (Information provided)
A.	m_l	I. Shape of orbital
B.	m_s	II. Size of orbital
C.	l	III. Orientation of orbital
D.	n	IV. Orientation of spin of electron

Choose the correct answer from the options given below :
NCERT Page-N-55, 56 | NEET 2024
(a) A-I, B-III, C-II, D-IV
(b) A-III, B-IV, C-I, D-II
(c) A-III, B-IV, C-II, D-I
(d) A-II, B-I, C-IV, D-III

19. Select the correct statements from the following
NCERT Page-35 / N-35 | NEET 2023, C
A. Atoms of all elements are composed of two fundamental particles.
B. The mass of the electron is 9.10939×10^{-31} kg.
C. All the isotopes of a given element show same chemical properties.

D. Protons and electrons are collectively known as nucleons.

E. Dalton's atomic theory, regarded the atom as an ultimate particle of matter.

Choose the correct answer from the options given below

(a) A, B and C only

(b) C, D and E only

(c) A and E only

(d) B, C and E only

20. The relation between n_m, (n_m = the number of permissible values of magnetic quantum number (m)) for a given value of azimuthal quantum number (l), is

NCERT Page-55 / N-55 | NEET 2023, S

(a) $l = \frac{n_m - 1}{2}$ (b) $l = 2n_m + 1$

(c) $n_m = 2l2 + 1$ (d) $n_m = l + 2$

21. If radius of second Bohr orbit of the He^+ ion is 105.8 pm, what is the radius of third Bohr orbit of Li^{2+} ion?

NCERT Page-48 / N-48 | NEET 2022, A

(a) 15.87 pm (b) 1.587 pm

(c) 158.7 Å (d) 158.7 pm

22. Which of the following series of transitions in the spectrum of hydrogen atom falls in visible region ?

NCERT Page-45 / N-45 | NEET 2019, C

(a) Lyman series (b) Balmer series

(c) Paschen series (d) Brackett series

23. 4*d*, 5*p*, 5*f* and 6*p* orbitals are arranged in the order of decreasing energy. The correct option is:

NCERT Page-62 / N-68 | NEET 2019, C

(a) $5f > 6p > 5p > 4d$

(b) $6p > 5f > 5p > 4d$

(c) $6p > 5f > 4d > 5p$

(d) $5f > 6p > 4d > 5p$

24. The angular speed of the electron in n^{th} orbit of Bohr hydrogen atom is NCERT Page-47 / N-47 | NEET 2018, C

(a) Directly proportional to n

(b) Inversely proportional of $\sqrt{n}$

(c) Inversely proportional to n^2

(d) Inversely proportional to n^3

25. Which one is the wrong statement ?

NCERT Page-61 / N-61 | NEET 2017, C

(a) The uncertainty principle is $\Delta E \times \Delta t \geq h / 4\pi$

(b) Half filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement.

(c) The energy of 2*s* orbital is less than the energy of 2*p* orbital in case of Hydrogen like atoms

(d) de-Broglies's wavelength is given by $\lambda = \frac{h}{m\nu}$, where m = mass of the particle, ν = group velocity of the particle

26. Two electrons occupying the same orbital are distinguished by NCERT Page-56 / N-56 | NEET 2016, C

(a) Principal quantum number

(b) Magnetic quantum number

(c) Azimuthal quantum number

(d) Spin quantum number

Exercise 3 : Matching, Statement & Assertion Reason Type

Match the Followings

1. Match List-I with List-II

List-I	List-II
(A) $\Psi_{MO} = \Psi_A - \Psi_B$	(p) Dipole moment
(B) $\mu = Q \times r$	(q) Bonding molecular orbital
(C) $\frac{N_b - N_a}{2}$	(r) Anti-bonding molecualr orbital
(D) $\Psi_{MO} = \Psi_A + \Psi_B$	(s) Bond order

(a) A – (q), B – (p), C – (s), D – (r)

(b) A – (r), B – (s), C – (p), D – (q)

(c) A – (r), B – (p), C – (s), D – (q)

(d) A – (r), B – (s), C – (q), D – (p)

2. Match Column-I with Column-II.

Column-I	Column-II
(A) X-rays	(p) $\nu = 10^0 - 10^4$ Hz
(B) UV	(q) $\nu = 10^{10}$ Hz
(C) Long radio waves	(r) $\nu = 10^{16}$ Hz
(D) Microwave	(s) $\nu = 10^{18}$ Hz

(a) A – (s), B – (r), C – (p), D – (q)

(b) A – (r), B – (s), C – (p), D – (q)

(c) A – (s), B – (p), C – (r), D – (q)

(d) A – (s), B – (r), C – (q), D – (p)

3. Match Column-I with Column-II.

Column-I		Column-II	
(A)	$\|\Psi\|^2$	(p)	Energy can be emitted or absorbed in packets
(B)	de Broglie	(q)	Significant only for motion of microscopic objects.
(C)	Heisenberg	(r)	The probability of finding an electron at a point within an atom
(D)	Planck	(s)	Every object in motion has a wave character.

(a) A – (q), B – (s), C – (r), D – (p)
(b) A – (r), B – (p), C – (q), D – (s)
(c) A – (r), B – (s), C – (q), D – (p)
(d) A – (s), B – (p), C – (r), D – (q)

4. Match Column-I with Column-II.

Column-I (Quantum number)		Column-II (Information provided)	
(A)	Principal	(p)	orientation of the orbital quantum number
(B)	Azimuthal	(q)	energy and size of orbital quantum number
(C)	Magnetic	(r)	spin of electron quantum number
(D)	Spin quantum	(s)	shape of the orbital number

(a) A – (q), B – (s), C – (p), D – (r)
(b) A – (s), B – (q), C – (p), D – (r)
(c) A – (q), B – (p), C – (s), D – (r)
(d) A – (q), B – (s), C – (r), D – (p)

5. Match Column-I with Column-II.

Column-I (Rules)		Column-II (Statements)	
(A)	Hund's Rule	(p)	No two electrons in an atom can have the same set of four quantum numbers.
(B)	Aufbau Principle	(q)	In the ground state of atoms, orbitals are filled in the order of their increasing energies.
(C)	Pauli Exclusion Principle	(r)	Pairing of electrons in the orbitals belonging to the same subshell does not take place until each orbital is singly occupied.
(D)	Heisenberg's Uncertainty Principle	(s)	It is impossible to determine the exact position and exact momentum of a subatomic particle simultaneously.

(a) A – (r), B – (p), C – (q), D – (s)
(b) A – (r), B – (q), C – (s), D – (p)
(c) A – (r), B – (q), C – (p), D – (s)
(d) A – (q), B – (r), C – (p), D – (s)

Two-Statement Type Questions

DIRECTIONS: *Read the statements carefully and answer the question on the basis of following options.*

(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

6. **Statement I:** Angular quantum number determines the three dimensional shape of the orbital.
Statement II: The principal quantum number determines the orientation and energy of the orbital.

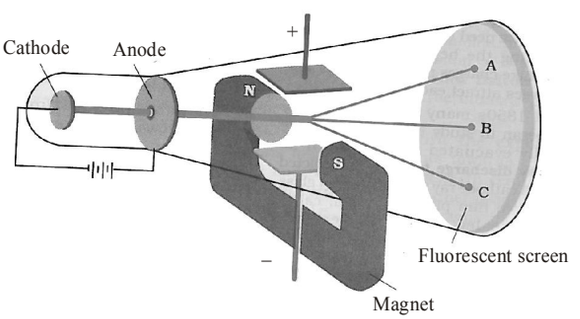
7. **Statement I :** Magnetic quantum number determines the size of the orbital.
Statement II: Spin quantum number of an electron determines the orientation of the spin of electron relative to the chosen axis.

8*. **Statement I :** Chemical properties of atoms are controlled by the number of protons, which are determined by the number of electrons in the valance shell.
Statement II : The number of proton is equal to the number of electron in an electrically neutral atom.

9. **Statement I :** The amount of light emitted (intensity of radiation) from a black body and its spectral distribution depends only on its temperature.
Statement II : When a ray of white light is passed through a prism, the wave with shorter wavelength bends more than the one with a longer wavelength.

Four / Five Statement Type Questions

10*. On the basis of figure given below which of the following statement(s) is/are correct ?



Electron strikes:

(i) At point B, when only electric field is applied.
(ii) At point C, when both electric and magnetic field is applied.
(iii) At point B, when both electric and magnetic fields are balanced.
(iv) At point C, when only magnetic field is applied.

(a) (i) and (ii) (b) only (iii)
(c) (iii) and (iv) (d) (i) and (iii)

11. Which of the following statements are not correct about electromagnetic radiation ?
(i) Electromagnetic waves require medium to travel.
(ii) Different electromagnetic radiations travel at same speed in vaccum.
(iii) The oscillating electric and magnetic fields produced by oscillating charged particles are perpendicular to each other, but not to the direction of propagation.
(iv) The oscillating electric field and magnetic field are perpendicular to each other, and also to the direction of propagation.

(a) (i), (ii) and (iii) (b) (ii) and (iii)
(c) (i) and (iii) (d) (i) and (iv)

12. Which of the following statement(s) is/are incorrect regarding photoelectric effect?
(i) The number of electrons ejected is proportional to the intensity of light.
(ii) There is some time lag between the striking of light beam on the metal surface and the ejection of electrons.
(iii) The kinetic energy of ejected electrons depends upon the brightness of light.
(iv) The kinetic energy of the ejected electron is proportional to the frequency of the incident radiation.

(a) (i) and (ii) (b) (ii) and (iii)
(c) (ii) only (d) (ii) and (iv)

13. Which of the following statements concerning the quantum numbers are correct ?
(i) Angular quantum number determines the three-dimensional shape of the orbital.
(ii) The principal quantum number determines the orientation and energy of the orbital.
(iii) Magnetic quantum number determines the size of the orbital.
(iv) Spin quantum number of an electron determines the orientation of the spin of electron relative to the chosen axis.

The correct set of option is

(a) (i) and (ii) (b) (i) and (iv)
(c) (iii) and (iv) (d) (ii), (iii) and (iv)

Assertion & Reason Questions

DIRECTIONS : *These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.*

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect but Reason is correct.

14. **Assertion :** Black body is an ideal body that emits and absorbs radiations of all frequencies.
Reason : The frequency of radiation emitted by a body goes from a lower frequency to higher frequency with an increase in temperature.

15*. **Assertion :** An atom is electrically neutral
Reason : Atom contains equal number of protons and neutrons.

16. **Assertion :** All photons possess the same amount of energy.
Reason : Energy of photon depend upon wavelength of light used.

17. **Assertion :** For Balmer series of hydrogen spectrum, the value $n_1 = 2$ and $n_2 = 3, 4, 5$.
Reason : The value of n for a line in Balmer series of hydrogen spectrum having the highest wavelength is 4 and 6.

18. **Assertion :** Absorption spectrum consists of some bright lines separated by dark spaces.
Reason : Emission spectrum consists of bright lines.

19. **Assertion :** Threshold frequency is the maximum frequency required for the ejection of electron from the metal surface.
Reason : Threshold frequency is characteristic of a metal.

20. **Assertion :** The kinetic energy of photoelectron ejected increases with the frequency of incident light.
Reason : Increase in intensity of incident light increases the photoelectric current.

Exercise 4 : Skill Enhancer MCQs

1. Assume that 2×10^{-17} J of light energy is needed by the interior of the human eye to see an object. How many photons of yellow light with $\lambda = 595.2$ nm are needed to generate this minimum energy?

(a) 6 (b) 30
(c) 45 (d) 60

2. In a multi-electron atom, which of the following orbitals described by the three quantum members will have the same energy in the absence of magnetic and electric fields?

(A) $n=1, l=0, m=0$ (B) $n=2, l=0, m=0$
(C) $n=2, l=1, m=1$ (D) $n=3, l=2, m=1$
(E) $n=3, l=2, m=0$

(a) (D) and (E) (b) (C) and (D)
(c) (B) and (C) (d) (A) and (B)

3. If the shortest wavelength of the spectral line of H-atom in the Lyman series is x, then the longest wavelength of the line in Balmer series of Li^{2+} is

(a) $9x$ (b) $\frac{x}{9}$
(c) $\frac{5x}{4}$ (d) $\frac{4x}{5}$

4. A hydrogen atom in the ground state is excited by monochromatic radiation of wavelength λ Å. The resulting spectrum consists of maximum 15 different lines. What is the wavelength λ? ($R_H = 109737\ cm^{-1}$)

(a) 937.3 Å (b) 1025 Å
(c) 1236 Å (d) None of these

5. If an electron undergoes transition from $n = 2$ to $n = 1$ in Li^{2+} ion, the energy of photon radiated will be best given by

(a) hv (b) $hv_1 + hv_2$
(c) $hv_1 + hv_2 + hv_3$ (d) all of these

6. If λ_0 and λ be the threshold wavelength and the wavelength of incident light, the speed of photoelectrons ejected from the metal surface is :

(a) $\sqrt{\frac{2h}{m}\lambda_0 - \lambda}$ (b) $\sqrt{\frac{2hc}{m}\lambda_0 - \lambda}$
(c) $\sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$ (d) $\sqrt{\frac{2h}{m}\left(\frac{1}{\lambda_0} - \frac{1}{\lambda}\right)}$

7. The wave number of electromagnetic radiation emitted during the transition in between two energy levels of Li^{2+} ion whose principal quantum number sum is 4 and difference is 2, is

(a) $3.5\,R_H$ (b) $4\,R_H$
(c) $8\,R_H$ (d) $\frac{8}{9}R_H$

8. If two particles are associated with same kinetic energy, then the de Broglie's wavelength (λ) of these particles is

(a) directly proportional to the velocity
(b) inversely proportional to the velocity
(c) independent of mass and velocity
(d) can not be predicted

9. Which of the following statement concerning probability density (ψ^2) and radial distribution function ($4\pi r^2\psi^2$) for an *s*-orbital of H-like species is correct?

(a) ψ^2 is minimum at nucleus but $4\pi r^2\psi^2$ is maximum at nucleus.
(b) ψ^2 is maximum at nucleus but $4\pi r^2\psi^2$ is minimum at nucleus.
(c) Both ψ^2 and $4\pi r^2\psi^2$ are maximum at nucleus.
(d) Both ψ^2 and $4\pi r^2\psi^2$ are minimum at nucleus.

10. If radiation corresponding to second line of "Balmer series" of Li^{2+} ion, knocked out electron from first excited state of H-atom, then kinetic energy of ejected electron would be:

(a) 2.55 eV (b) 4.25 eV
(c) 11.25 eV (d) 19.55 eV

11. Li^{3+} and a proton are accelerated by the same potential, then de-Broglie wavelengths λ_{Li} and λ_p have the ratio (assume $m_{Li} = 9\,m_p$)

(a) $1 : 3\sqrt{3}$ (b) 1 : 1
(c) 1 : 2 (d) 1 : 4

12. If the de-Broglie wavelength of a particle of mass m is 100 times its velocity, then its value in terms of its mass (m) and Planck's constant (h) is

(a) $\frac{1}{10}\sqrt{\frac{m}{h}}$ (b) $10\sqrt{\frac{h}{m}}$
(c) $\frac{1}{10}\sqrt{\frac{h}{m}}$ (d) $10\sqrt{\frac{m}{h}}$

13. A hydrogen-like atom with atomic number Z is in the higher excited state of quantum number n. This excited state atom can make a transition to the 1st excited state by successively emitting two photons of energies 10 eV and 17eV, respectively. Alternatively, the atom from the same excited state can make a transition to 2nd excited state by emitting two photons of energies 4.25 eV and 5.95 eV, respectively. Determine Z and n.

(a) $n = 6, Z = 3$ (b) $n = 3, Z = 6$

(c) $n = 2, Z = 4$ (d) $n = 9, Z = 9$

14. 1.5 L He gas is taken at 500K and 560 mm pressure in which 90% He are converted into He^+ ions. Spectral line analysis shows that 85% ions exist in the 3rd level, 10% in the 2nd level and rest in the ground level. Calculate the total energy evolved when all ions return back to ground state.

(a) 101 kJ (b) 957 kJ

(c) 212 kJ (d) 149 kJ

15. The radii of maximum probability for 3*s*, 3*p* and 3*d* electrons are in the order

(a) $(r_{max})_{3d} > (r_{max})_{3p} > (r_{max})_{3s}$

(b) $(r_{max})_{3d} > (r_{max})_{3s} > (r_{max})_{3p}$

(c) $(r_{max})_{3s} > (r_{max})_{3p} > (r_{max})_{3d}$

(d) None of these

Answer Keys

Exercise - 1 : (NCERT Based Topic-wise MCQs)																			
1	(d)	**12**	(c)	**23**	(d)	**34**	(d)	**45**	(a)	**56**	(d)	**67**	(d)	**78**	(d)	**89**	(c)	**100**	(b)
2	(c)	**13**	(d)	**24**	(d)	**35**	(c)	**46**	(b)	**57**	(b)	**68**	(d)	**79**	(c)	**90**	(b)	**101**	(a)
3	(b)	**14**	(d)	**25**	(b)	**36**	(a)	**47**	(c)	**58**	(c)	**69**	(c)	**80**	(a)	**91**	(b)	**102**	(b)
4	(d)	**15**	(c)	**26**	(c)	**37**	(a)	**48**	(b)	**59**	(c)	**70**	(b)	**81**	(d)	**92**	(b)	**103**	(b)
5	(d)	**16**	(c)	**27**	(c)	**38**	(c)	**49**	(d)	**60**	(c)	**71**	(d)	**82**	(b)	**93**	(a)	**104**	(c)
6	(b)	**17**	(d)	**28**	(c)	**39**	(b)	**50**	(d)	**61**	(a)	**72**	(d)	**83**	(d)	**94**	(c)	**105**	(c)
7	(b)	**18**	(a)	**29**	(c)	**40**	(c)	**51**	(d)	**62**	(c)	**73**	(d)	**84**	(b)	**95**	(c)	**106**	(b)
8	(b)	**19**	(c)	**30**	(d)	**41**	(b)	**52**	(c)	**63**	(d)	**74**	(b)	**85**	(b)	**96**	(b)	**107**	(d)
9	(d)	**20**	(b)	**31**	(c)	**42**	(c)	**53**	(a)	**64**	(b)	**75**	(a)	**86**	(a)	**97**	(d)	**108**	(d)
10	(a)	**21**	(c)	**32**	(c)	**43**	(b)	**54**	(a)	**65**	(a)	**76**	(b)	**87**	(b)	**98**	(b)	**109**	(b)
11	(c)	**22**	(d)	**33**	(a)	**44**	(d)	**55**	(c)	**66**	(c)	**77**	(a)	**88**	(b)	**99**	(c)	**110**	(b)
Exercise - 2 : (NCERT Exemplar & Past Years NEET)																			
1	(c)	**4**	(b)	**7**	(d)	**10**	(c)	**13**	(b)	**16**	(d)	**19**	(d)	**22**	(b)	**25**	(c)		
2	(b)	**5**	(a)	**8**	(c)	**11**	(a)	**14**	(d)	**17**	(a)	**20**	(a)	**23**	(a)	**26**	(d)		
3	(d)	**6**	(d)	**9**	(b)	**12**	(c)	**15**	(b)	**18**	(b)	**21**	(d)	**24**	(d)				
Exercise - 3 : (Matching, Statement & Assertion-Reason Type)																			
1	(c)	**3**	(c)	**5**	(c)	**7**	(d)	**9**	(a)	**11**	(c)	**13**	(b)	**15**	(c)	**17**	(c)	**19**	(d)
2	(a)	**4**	(a)	**6**	(c)	**8**	(d)	**10**	(c)	**12**	(b)	**14**	(b)	**16**	(d)	**18**	(d)	**20**	(b)
Exercise - 4 : (Skill Enhancer MCQs)																			
1	(d)	**3**	(d)	**5**	(a)	**7**	(c)	**9**	(b)	**11**	(a)	**13**	(a)	**15**	(c)				
2	(a)	**4**	(a)	**6**	(c)	**8**	(a)	**10**	(d)	**12**	(b)	**14**	(a)						

2 Structure of Atom

EXERCISE - 1

1. **(d)** Substance like glass or ebonite when rubbed with silk or fur get electrically charged. Dalton's theory was failed explain the result.

2. **(c)** The electrical discharge through the gases could be observed only at low pressure and high voltage.

3. **(b)** The cathode rays (negatively charged particles stream) originates from cathode and move towards anode.

4. **(d)** Phosphorescent material (zinc sulphide) is used to predict the flow of cathode rays.

5. **(d)** The deflection of electrons from its original path increases with the increase in the voltage across the electrodes, or the strength of the magnetic field.

6. **(b)** Millikan determined the value of charge of the electron by using oil drop experiment.

7. **(b)** Charge carried by one electron = 1.6022×10^{-19} C
Electrons present in 3.2044×10^{-16} C = $3.2044 \times 10^{-16} / 1.6022 \times 10^{-19} = 2 \times 10^{3}$

8. **(b)** Unlike cathode rays, mass of positively charged particles depends upon the nature of gas present in the cathode ray tube.

9. **(d)** Proton is the nucleus of H-atom (H-atom devoid of its electron)

10. **(a)** James Chadwick in 1932 discovered the neutrons.

11. **(c)** As the neutron is a chargeless particle, hence, the beam of neutrons is not deflected by electrical or magnetic field.

12. **(c)** $m_e : m_p = 1 : 1837$

13. **(d)**

14. **(d)** The main focused of the J.J Thomson model was about the uniformly distribution of the mass of the atom.

15. **(c)** X rays have a very high penetrating power through the matter and that is the reason these rays are used to study the interior of the objects.

16. **(c)** The correct order is γ-rays > X rays < β-rays > α-rays

17. **(d)** The nucleus occupies much smaller volume compared to the volume of the atom.

18. **(a)** All positive ions are deposited at small part. (nucleus of atom).

19. **(c)** Rutherford's α-ray scattering experiment first showed the existence of a small positivily charged entity in the centre of atom, called nucleus.

20. **(b)** Number of p = number of e^- = 89 and neutrons 231 – 89 = 142.

21. **(c)** $_{18}Ar^{40}$ contains 22 neutrons and $_{21}Sc^{40}$ contains 19 neutrons. The number of neutrons = (A – Z)

22. **(d)** $_{17}Cl^{35}$ and $_{17}Cl^{37}$ are isotopes, so they will have same chemical properties.

23. **(d)** Isotopes have same atomic number but different mass number. They have different number of neutrons which results in different mass number.

24. **(d)** Atomic number = No. of protons = 8
Mass number = No. of protons + No. of neutrons
= 8 + 8 = 16
Since the no. of electrons are two more than the no. of protons, hence, it is a binegative species. Thus, the species is $^{16}O_8^{2-}$.

25. **(b)** According to the electromagnetic theory of Maxwell, charged particles when accelerated should emit electromagnetic radiation .This feature does not exist for planets since they are uncharged.

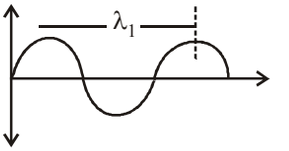
26. **(c)** The major drawback of Rutherford experiment is that the orbital revolution of the electron is not expected to be stable. According to Rutherford's model, the electrons, while moving in their orbits, would give up energy. This would make them slow down, gradually and move towards the nucleus. The electrons will follow a spiral path and then fall into the nucleus. Ultimately, the atom would collapse. But in reality the atom is stable.

27. **(c)** The oscillating fields are perpendicular to the direction of propagation.

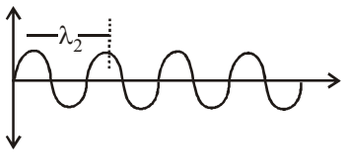
28. **(c)** The correct SI unit of frequency (ν) , wavelength (λ) and wave number $(\bar{\nu})$ is Hz, m, m^{-1}

29. **(c)** Electromagnetic waves shown in figure (A) has higher wavelength in comparison to EM waves shown in figure (B).
Thus, these waves also differ in frequency and energy.

$$\nu = \frac{c}{\lambda}$$



(A) $\Rightarrow E_1 = \frac{hc}{\lambda_1}$



(B) $\Rightarrow E_2 = \frac{hc}{\lambda_2}$

$\lambda_1 > \lambda_2 \Rightarrow E_1 < E_2$

30. **(d)** $E = h\nu$

and $\nu = \left(\frac{c}{\lambda}\right)$

$\nu_a = 10^{15}$, $\nu_b = 10^{14}$

$\nu_c = 10^{17}$, $\nu_d = 0.85 \times 10^{15}$

and $\nu_e = 10 \times 10^{15}$

31. **(c)** $W = h\nu = 6.6 \times 10^{-34} \times 1.3 \times 10^{15} = 8.58 \times 10^{-19}$ J

32. **(c)** For the given figure, $T_2 > T_1$.

33. **(a)** Energy is always absorbed or emitted in whole number or multiples of quantum.

34. **(d)** $E = h\nu = \frac{hc}{\lambda}$ or $\lambda = \frac{c}{\nu}$

$\Rightarrow \lambda = \frac{3\times10^8}{8\times10^{15}} = 3.75\times10^{-8}$ m

In nanometer $\lambda = 3.75\times 10$ nm

which is closest to 4×10^1 nm

35. **(c)** Energy of a photon, $E = \frac{hc}{\lambda}$

$= \frac{6.6\times10^{-34}(\text{Js})\times3\times10^8(\text{ms}^{-1})}{331.3\times10^{-9}(\text{m})} = 6\times10^{-19}$ J

No. of photons emitted per second

$= \frac{600\,(\text{J})}{6\times10^{-19}(\text{J})} = 10^{21}$ [1 watt – second = joule]

36. **(a)** At a frequency $\nu > \nu_0$, the ejected electrons come out with certain kinetic energy.

37. **(a)** $\frac{1}{2}m\nu^2 = h\nu - h\nu_0$

$\Rightarrow \frac{1}{2}m\nu^2 = h(\nu - \nu_0) \Rightarrow \nu = \sqrt{\frac{2h}{m}(\nu - \nu_0)}$

$\Rightarrow \nu = \sqrt{\frac{2\times6.626\times10^{-34}}{9.1\times10^{-31}}\left(2\times10^{15} - 7\times10^{14}\right)}$

$= \sqrt{1.89\times10^{12}} = 1.37 \times 10^6$ ms^{-1}.

38. **(c)** K.E. of emitted electron

$= h\nu - h\nu_0$ (*i.e.* smaller than $h\nu$).

39. **(b)** The light emitted by a sample (excited hydrogen atom or any other element), which is passed through a prism and then separated into certain discrete wavelength is called atomic emission spectrum.

40. **(c)** (ii) Balmer, $n_1 = 2$; $n_2 = 3, 4$; region - visible

(iv) Pfund, $n_1 = 5$; $n_2 = 6, 7$; region - infrared

41. **(b)** For emission spectrum Balmer series $n_1 = 5$, $n_2 = 2$ for third line.

42. **(c)** Since the energy difference between two consecutive Bohr orbits is quantized and the energy of higher orbit is more than that of lower orbit, so an electron from one Bohr stationary orbit can go to next higher orbit by absorption of electromagnetic radiation of particular wavelength or frequency.

43. **(b)** Angular momentum of an electron in n^{th} orbit is given by $mvr = \frac{nh}{2\pi}$

For $n = 5$, we have

Angular momentum of electron $= \frac{5h}{2\pi} = \frac{2.5h}{\pi}$

44. **(d)** From the expression of Bohr's theory, we know that

$m_e v_1 r_1 = n_1 \frac{h}{2\pi}$; $m_e v_2 r_2 = n_2 \frac{h}{2\pi}$

$\frac{m_e v_1 r_1}{m_e v_2 r_2} = \frac{n_1}{n_2}\frac{h}{2\pi} \times \frac{2\pi}{h}$

Given, $r_1 = 5\,r_2$, $n_1 = 5$, $n_2 = 4$

$\frac{m_e \times v_1 \times 5r_2}{m_e \times v_2 \times r_2} = \frac{5}{4}$

$\Rightarrow \frac{v_1}{v_2} = \frac{5}{4\times5} = \frac{1}{4} = 1:4$

45. **(a)** Radius of n^{th} orbit $= r\,n^2$. (for H-atom)

46. **(b)** We know that $E_n = \frac{R_H}{n^2}$ kJ mol^{-1}

$\Rightarrow -328 = \frac{-R_H}{2^2}$

$\Rightarrow R_H = 1312$

Thus, $E_4 = \frac{-1312}{4^2} = -82$ kJ mol^{-1}

47. **(c)** Energy of free e^- at rest ($n = \infty$) is zero.

48. **(b)** $r = 0.529 \times \frac{n^2}{Z}$ Å

$$r_3 = 0.529 \times \frac{3^2}{1}$$

$$\Rightarrow \quad r_4 = 0.529 \times \frac{4^2}{1}$$

$$\frac{r_4}{r_3} = \frac{4^2}{3^2} = \frac{16}{9}$$

$$\Rightarrow \quad r_4 = \frac{16 r_3}{9}$$

49. **(d)** Bohr's model can be applied to one electron system only.

50. **(d)** Except Al^{3+}, all contain one electron and Bohr's model could explain the spectra for one electron system, Bohr's model was not able to explain the spectra of multielectron system.

51. **(d)** For H atom, $E_n = -\frac{13.6 Z^2}{n^2}$ eV

For second orbit, n = 2

Z = At. no. = 1 (for hydrogen)

$$\therefore \quad E_2 = -\frac{13.6 \times (1)^2}{(2)^2} = \frac{-13.6}{4} \text{eV}$$

$$= \frac{-13.6 \times 1.6 \times 10^{-19}}{4} \text{J} = -5.44 \times 10^{-19} \text{J}$$

52. **(c)** Energy of electron in 2nd orbit of $Li^{+2} = -13.6 \frac{Z^2}{n^2}$

$$= \frac{-13.6 \times (3)^2}{(2)^2} = -30.6 \text{ eV}$$

Energy required = 0 – (–30.6) = 30.6 eV

53. **(a)** Energy of an electron $E_n = \frac{-E_0}{n^2}$

[E_0 corresponds to $n = 1 \rightarrow n = \infty$]

For energy level ($n = 2$)

$$E_n = -\frac{13.6}{(2)^2} = \frac{-13.6}{4} = -3.4 \text{ eV}.$$

54. **(a)** For hydrogen atom (n) = 1 (ground state)

Radius of hydrogen atom (r) = 0.53 Å.

Atomic number of Li (Z) = 3.

Radius of Li^{2+} ion $= r \times \frac{n^2}{Z} = 0.53 \times \frac{(1)^2}{3} = 0.17$ Å

55. **(c)** Bohr model can explain spectrum of any atom or ion containing one electron only (that is H-like species)

56. **(d)** Given : Radius of hydrogen atom = 0.530 Å, Number of excited state (n) = 2 and atomic number of hydrogen atom (Z) = 1. We know that the Bohr radius

$$(r) = \frac{n^2}{Z} \times \text{radius of atom} = \frac{(2)^2}{1} \times 0.530$$

$$= 4 \times 0.530 = 2.12 \text{ Å}$$

57. **(b)** An e^- absorbs energy to transit to higher state.

58. **(c)** (i) As wavelength decreases, wave number will increase because $\bar{\nu} = 1/\lambda$. Wave number is defined as number of wavelengths per unit length. Thus, lines in the series will converge.

(ii) $n_1 = 2$ is fixed for Balmer series.

(iii) For calculation of ionization energy, $n_1 = 1$ and $n_2 = \infty$. Thus, it cannot be calculated from the wave number of lines for Balmer series.

(iv) Longest wavelength corresponds to lowest energy, which will be the first line of Balmer series, i.e. $n_1 = 2$ and $n_2 = 3$.

Hence, (i), (ii) and (iv) are correct statements.

59. **(c)** $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{1} - \frac{1}{\infty}\right) = 1.097 \times 10^7 \text{ m}^{-1}$$

$$\lambda = 91.15 \times 10^{-9} \text{ m} \approx 91 \text{nm}$$

60. **(c)** $\nu = \frac{1}{h} \times \text{IE} \times \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$= \frac{2.18 \times 10^{-18}}{6.625 \times 10^{-34}} \times \left[\frac{1}{1} - \frac{1}{16}\right] = 3.08 \times 10^{15} \text{ s}^{-1}$$

61. **(a)** $\bar{\upsilon} = \frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

For second line in lyman series

$n_2 = 3$

$$\therefore \quad \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = R\left[\frac{1}{1} - \frac{1}{9}\right] = \frac{8R}{9}$$

62. **(c)** ΔE for two energy levels $= 21.79\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ J/atom.

Emmitted energy decreases for electron transition between two immediate states as we move to higher principle states. Mathematically also, value of

$\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ will decrease.

63. **(d)** The shortest wavelength in hydrogen spectrum of Lyman series is given by formula :

$$\frac{1}{\lambda}=\frac{R_H}{n^2}=\frac{R_H}{1^2}=\frac{109678}{1}$$

$\Rightarrow \quad \lambda = 9.117\times10^{-6}\text{ cm} = 911.7\times10^{-10}\text{ m} = 911.7\text{ Å}.$

64. **(b)**

65. **(a)** $\lambda = h/m\text{v}$; for the same velocity, λ varies inversely with the mass of the particle.

66. **(c)** The wavelengths of elements decreases with increase in their mass. $\left(\because \lambda=\frac{h}{m\text{v}}\right)$

67. **(d)** $\lambda=\frac{h}{m\text{v}}=\frac{6.6\times10^{-34}}{60\times10^{-3}\times10}=10^{-33}\text{ m}$

68. **(d)** Given $\Delta E = 4.4\times10^{-4}\text{ J}$, $\lambda = ?$

$$\lambda=\frac{hc}{\Delta E}=\frac{6.6\times10^{-34}\times3\times10^{8}}{4.4\times10^{-4}}=4.5\times10^{-22}\text{ m}$$

69. **(c)** We know that $\lambda=\frac{h}{m\text{v}}$; $\therefore m=\frac{h}{\text{v}\lambda}$

The velocity of photon (v) = 3×10^{8} m sec^{-1}

$\lambda = 1.54\times10^{-8}\text{ cm} = 1.54\times10^{-10}$ meter

$$\therefore m=\frac{6.626\times10^{-34}\text{ Js}}{1.54\times10^{-10}\text{ m}\times3\times10^{8}\text{ m sec}^{-1}}$$

$$=1.4285\times10^{-32}\text{ kg}$$

70. **(b)** $\lambda=\frac{h}{m\text{v}}$

$$\text{v} = 36\text{ km/hr}=\frac{36\times10^{3}}{60\times60}\text{ m/sec} = 10\text{ m/sec}$$

$$\therefore \quad \lambda=\frac{6.6\times10^{-34}}{10^{3}\times10}=6.6\times10^{-38}\text{ m}$$

71. **(d)** Given, $\text{v}_A = 0.1\text{ ms}^{-1}$ and $\text{v}_B = 0.05\text{ ms}^{-1}$ also, $m_B = 5m_A$

de-Broglie wavelength, $\lambda=\frac{h}{m\text{v}}$

$$\therefore \frac{\lambda_A}{\lambda_B}=\frac{h/m_A\text{v}_A}{h/m_B\text{v}_B}=\frac{m_B\text{v}_B}{m_A\text{v}_A}$$

$$=\frac{5m_A\times0.05}{m_A\times0.1}=5\times0.5=2.5=5/2$$

$\therefore \ \lambda_\text{A} : \lambda_\text{B} = 5:2$

72. **(d)** Heisenberg's uncertainty principle is applicable to any moving object.

73. **(d)** By Heisenberg uncertainty principle, $\Delta x\times\Delta p=\frac{h}{4\pi}$ (which is constant)

As Δx for electron and helium atom is same thus momentum of electron and helium will also be same therefore the momentum of helium atom is equal to 5×10^{-26} kg ms^{-1}.

74. **(b)** $\Delta x.\Delta v$ value will be large for object of smallest mass and is therefore, the most significant for calculating uncertainity. Object B has smallest mass i.e., 9.11×10^{-28}g $= 9.11\times10^{-31}$ Kg. So it will be most significant.

75. **(a)** $\Delta p = m\Delta\text{v}$

Substituting the given values of Δp and m, we get

$1\times10^{-18}\text{ g cm s}^{-1} = 9\times10^{-28}\text{ g}\times\Delta\text{v}$

or $\Delta\text{v}=\frac{1\times10^{-18}}{9\times10^{-28}}=1.1\times10^{9}\text{ cm s}^{-1}\simeq1\times10^{9}\text{ cm s}^{-1}$

i.e. option (a) is correct.

76. **(b)** According to Heisenberg uncertainty principle.

$$\Delta x.m\Delta\text{v}=\frac{h}{4\pi} \quad\Rightarrow\quad \Delta x=\frac{h}{4\pi m\Delta\text{v}}$$

Here, $\Delta\text{v}=\frac{600\times0.005}{100}=0.03$

So, $\Delta x=\frac{6.6\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times0.03}=1.92\times10^{-3}\text{ meter}$

77. **(a)** Accuracy in velocity $= 0.001\% = \frac{0.001}{100}$;

Actual velocity of the electron

$$(\Delta\text{v})=3\times10^{4}\times\frac{0.001}{100}=0.3\text{ cm/s}.$$

Planck's constant (h) = 6.626×10^{-27}erg-sec.

$\therefore$ Uncertainty in the position of the electron

$$(\Delta x)=\frac{h}{4\pi m\Delta\text{v}}=\frac{6.626\times10^{-27}\times7}{4\times22\times(9.1\times10^{-28})\times0.3}=1.93\text{ cm}$$

78. **(d)** Atomic orbital is characterised by n, l, m.

79. **(c)** Only quantum numbers, n, l, m are determined by the Schrödinger equation.

80. **(a)**

81. **(d)** For g orbital, value of l is 4.
Since $l = n-1$, n should be 5.

82. **(b)** $\psi^2(r) \Rightarrow$ always positive
no. of radial nodes = $n - \ell - 1$
For 2s, $n = 2$, $\ell = 0$, no. of radial nodes = $2 - 0 - 1 = 1$

83. **(d)** The number of sub shell is $(2l + 1)$. The maximum number of electrons in the sub shell is $2(2l + 1) = (4l + 2)$.

84. **(b)** Magnetic quantum no. represents the orientation of atomic orbitals in an atom. For example p_x, p_y & p_z have orientation along X-axis, Y-axis & Z-axis respectively.

85. **(b)** The sub-shell are $3d$, $4d$, $4p$ and $4s$, $4d$ has highest energy as $n + \ell$ value is maximum for this.

86. **(a)** The possible quantum numbers for $4f$ electron are

$n = 4$, $\ell = 3$, $m = -3, -2, -1, 0, 1, 2, 3$ and $s = \pm\frac{1}{2}$

Of various possiblities only option (a) is possible.

87. **(b)** $n = 4$ represents 4th orbit
$\ell = 3$ represents f subshell
$m = -2$ represents orientation of f-orbital
$s = 1/2$ represents direction of spin of electron.
$\therefore$ The orbital is $4f$.

88. **(b)** For $4d$ orbitals, $n = 4$, $l = 2$, $m = -2, -1, 0, +1$ or $+2$

$s = +\frac{1}{2}$ and $-\frac{1}{2}$

Thus choice b having $n = 4$, $l = 2$, $m = 1$ and $s = \frac{-1}{2}$ is correct.

89. **(c)** $n = 2$, $l = 1$ means $2p$–orbital. Electrons that can be accommodated = 6 as p sub-shell has 3 orbital and each orbital contains 2 electrons.

90. **(b)** $m = -l$ to $+l$, through zero thus for $l = 2$, values of m will be $-2, -1, 0, +1, +2$.
Therefore for $l = 2$, m cannot have the value -3.

91. **(b)** Value of $l = 0$ .....$(n-1)$
l cannot be equal to n.

92. **(b)** For n = 5, $l = n - 1 = 5 - 1 = 4$
$m = 2l + 1 = 2(4) + 1 = 9$
Sum of values of l and $m = 9 + 4 = 13$

93. **(a)** The number of allowed orbitals are given by n^2.
Thus, when $n = 5$, number of orbitals = $(5)^2 = 25$

94. **(c)** Possible values of l and m depend upon the value of n
$l = 0$ to $(n-1)$

$m = -l$ to $+l$ through zero, $s = +\frac{1}{2}$ and $-\frac{1}{2}$

Thus, for $n = 3$, l may be 0, 1 or 2; but not 3

95. **(c)** $n = 3$ and $l = 2$ means the orbital is in 3d-subshell.

For a d-orbital : $m = 0$ for d_{z^2} orbital

$m = \pm 1$ for d_{yz} and d_{zx} orbitals.

and $m = \pm 2$ for d_{xy} and $d_{x^2-y^2}$ orbital.

Thus, $m = +2$ is possible for 2 orbitals.

96. **(b)** (i) n = 5 means $\ell = 0, 1, 2, 3, 4$
since m = + 1
hence total number of electrons will be
= 0 (from s) + 2 (from p) + 2 (from d)
+ 2 (from f) + 2 (from g)
$= 0 + 2 + 2 + 2 + 2 = 8$

(ii) $n = 2$, $\ell = 1$, $m_\ell = -1$, $m_s = -1/2$ represent $2p$ orbital with one electron

97. **(d)** Total number of nodes (angular + radial) = $n - 1$

98. **(b)** $\psi = 0$ at only one point, at which $\psi^2 = 0$.

99. **(c)** First four orbitals contain four lobes, while fifth orbital consists of only two lobes. The lobes of d_{xy} orbital lie between x and y axis. Similarly in the case of d_{yz} and d_{zx}. their lobes lie between yz and zx axis respectively. Four lobes of $d_{x^2-y^2}$ orbital are lying along x and y axis while two lobes of d_{z^2} orbital are lying along z axis.

100. **(b)** In boundary surface diagram (1) the four lobes lie between y and z-axis (d_{yz}) whereas, in boundary surface diagram (2) the four lobes lie on the x and y-axis ($d_{x^2-y^2}$).

101. **(a)** As $n - l - 1 = 5$ or $8 - l - 1 = 5 \Rightarrow l = 2$.

102. **(b)** According to given information $n = 5$ and $l = 3$.

103. **(b)** $n + \ell = 5p$: $5 + 1 = 6$; $6s$: $6 + 0 = 6$
$n + \ell = 4f$: $4 + 3 = 7$; $5d$: $5 + 2 = 7$
When values of $(n + \ell)$ are equal, then, the orbital with higher value of n will have higher energy.
Hence, the order is $5p < 6s < 4f < 5d$.

104. **(c)**
(A) Values of principal quantum number n = 1, 2, 3 ..... ∞
(B) Values of azimuthal quantum number ranges from $l = 0$ to $(n-1)$
(C) Values of magnetic orbital quantum number
$m_l = -l$ to $+l$
Total values of $m_l = 2l + 1$
(D) Values of spin quantum number $m_s = \pm\frac{1}{2}$
(E) For $l = 5$, number of orbitals = $2l + 1 = 2 \times 5 + 1 = 11$

105. **(c)** The electron will enter into an orbital with minimum value of $n + l$.

106. **(b)** According to Aufbau principle, the orbital of lower energy (2*s*) should be fully filled before the filling of orbital of higher energy starts.

Option (a) violates Hund's rule.

107. **(d)** This is as per the definition of Pauli's exclusion principle.

108. **(d)** The *d*-orbital represented by option (d) will become completely filled after gaining an electron. Therefore, option (d) is correct.

109. **(b)** Electronic configuration of Cu (29) is $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^1$ and not $1s^2, 2s^2\,2p^6\,3s^2\,3p^6\,3d^9 4s^2$ due to extra stability of fully filled orbitals.

110. **(b)** Lower the value of (n + l) for an orbital, lower is its energy. If two orbitals have same value of (n + *l*) then lower value of n will have the lower energy

A $\Rightarrow$ 3d $\Rightarrow$ $n + l = 3 + 2 = 5$

B $\Rightarrow$ 4p $\Rightarrow$ $n + l = 4 + 1 = 5$

C $\Rightarrow$ 4d $\Rightarrow$ $n + l = 4 + 2 = 6$

D $\Rightarrow$ 3s $\Rightarrow$ $(n + l) = 3 + 0 = 3$

order is D < A < B < C

EXERCISE - 2

1. **(c)** The concept of electrons move in a circular path of fixed energy called orbits was given by Bohr and not derived from Rutherford's scattering experiment.

2. **(b)** The correct configuration for copper ($z = 29$) should be $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$. Due to extra stability of fully filled orbital of *d*-subshell, the last electron enter into *d*-orbital instead of *s*-orbital.

3. **(d)** The characteristics of cathode rays do not depend upon the material of electrodes and the nature of the gas present in the cathode ray tube.

4. **(b)** The mass of electron is very small as compared to the mass of the neutron.

Mass of electron = 9.1×10^{-31} kg

Mass of neutron = 1.67×10^{-27} kg

5. **(a)** J. J. Thomson, in 1898, proposed plum pudding model of atom. An important feature of this model is that the mass of the atom is assumed to be uniformly distributed over the atom. This model was able to explain the overall neutrality of the atom.

6. **(d)** Isobars have the same mass number (*i.e.*, sum of protons and neutrons) but different atomic number (*i.e.*, number of protons) *e.g.*, $_{26}Fe^{58}$ and $_{27}Ni^{58}$ are isobars.

7. **(d)** number of radial nodes = $n - l - 1$, $l = 1$ for *p*-orbital

Number of radial nodes for 3*p* orbital = 3 – 1 – 1 = 1

8. **(c)** Number of angular nodes = *l*

$l = 2$ for *d*-orbital $\therefore$ Number of angular nodes = 2

9. **(b)** The important implications of Heisenberg uncertainty principle is that it rules out existence of definite paths or trajectories of electrons and other similar particles.

10. **(c)** Total number of orbitals associated with n^{th} shell $= n^2$

$\therefore$ Total number of orbitals associated with third shell = $(3)^2 = 9$

11. **(a)** Orbital angular momentum, $mvr = \frac{h}{2\pi}\sqrt{l(\ell+1)}$

Hence, it depends only on '*l*', *l* can have values ranging from 0 to $(n-1)$.

12. **(c)** The fractional atomic mass (35.5) of chlorine is due to the fact that in ordinary chlorine atom, Cl-37 and Cl-35 are present in the ratio of 1 : 3.

$$\therefore \text{Average atomic mass of Cl} = \frac{3\times 35 + 1\times 37}{4} = 35.5 \text{ amu}$$

13. **(b)** From de-Broglie equation, wavelength, $\lambda = \frac{h}{mv}$

For same speed of different particles, $\lambda \propto \frac{1}{m}$

As *h* is constant, greater the mass of matter waves, lesser is wavelength and vice-versa. Among these matter waves, alpha particle (He^{2+}) has higher mass, therefore, shortest wavelength.

14. **(d)** The probability density of electrons in 2*s* orbital first increases then decreases and after that it increases again as distance increases from nucleus.

15. **(b)**

$_{24}Cr = [Ar]3d^5, 4s^1$	$Cr^{3+} = [Ar]3d^3$
$_{26}Fe = [Ar]3d^6, 4s^2$	$Fe^{3+} = [Ar]3d^5$
$_{25}Mn = [Ar]3d^5, 4s^2$	$Mn^{2+} = [Ar]3d^5$
$_{27}Co = [Ar]3d^7, 4s^2$	$Co^{3+} = [Ar]3d^6$
$_{21}Sc = [Ar]3d^1, 4s^2$	$Sc^{3+} = [Ar]$

Thus, Fe^{3+} and Mn^{2+} have the same electronic configuration.

16. **(d)** For the two electrons of 2*s* orbital, the value of m_s is $+\frac{1}{2}$ and $-\frac{1}{2}$.

17. **(a)** For H-like species:

$$E = -2.18\times 10^{-18}\left(\frac{Z^2}{n^2}\right) J$$

For n = 1 of He+:

$$E = -2.18\times 10^{-18}\left(\frac{2^2}{1^2}\right)$$

$= -2.18 \times 10 - 18 \times 4$

$= -x$ (Given)

For n = 2 of Be^{3+}: $E = -2.18 \times 10^{-18}\left(\frac{4^2}{2^2}\right)$

$= 2.18 \times 10^{-18} \times 4 = -x$

Thus, Energy of Be^{3+} for n = 2 would be –x Joules.

18. **(b)** n = principal quantum number ⟶ size of orbital/shell.
l = Azimuthal quantum number ⟶ shape of orbital
m_l = Magnetic orbital quantum number ⟶ orientation of orbital.
m_s = Magnetic spin quantum number ⟶ spin of electron.

19. **(d)** (A) Atoms consist of three fundamental particles : Electrons, protons and neutrons

(D) Protons and neutrons present in the nucleus are collectively called as nucleons.

So, the correct statements are B, C, E only.

20. **(a)** $n_m = 2l + 1 \Rightarrow l = \frac{n_m - 1}{2}$

21. **(d)** According to Bohr's atomic model

$r \propto \frac{n^2}{z}$ 3rd orbit of Li^{2+} $n_1 = 3, z_1 = 3$

$\Rightarrow 2^{nd}$ orbit of He^+ $n_2 = 2, z_2 = 2$

$$\frac{(r_3)_{Li^{+2}}}{(r_2)_{He^+}} = \frac{n_1^2}{n_2^2} \times \frac{z_2}{z_1} \Rightarrow \frac{(r_3)_{Li^{+2}}}{105.8 \text{ pm}} = \frac{(3)^2}{(2)^2} \times \frac{2}{3}$$

$(r_3)_{Li^{+2}} = 158.7$ pm

22. **(b)** Balmer series

23. **(a)** $5f, 5+3=8$; $6p$, $6+1=7$
$5p, 5+1=6$; $4d$, $4+2=6$
$5f > 6p > 5p > 4d$

24. **(d)** Angular speed is $\frac{V}{r}$. $V_n \propto \frac{1}{n}$ and $r_n \propto n^2$.

$\therefore$ Angular speed is inversely proportional to n^3.

25. **(c)** For hydrogen like atoms, energy of 2*s*-orbital and 2*p*-orbital is equal.

26. **(d)** Two electrons occupying the same orbital should have opposite spins *i.e.* they differ in spin quantum number.

EXERCISE - 3

1 **(c)**

(A)	$\Psi_{MO} = \Psi_A - \Psi_B$	(r)	ABMO
(B)	$\mu = Q \times r$	(p)	Dipole moment
(C)	$\frac{N_b - N_a}{2}$	(s)	Bond order
(D)	$\Psi_{MO} = \Psi_A + \Psi_B$	(q)	BMO

2. **(a)** A – (s), B – (r), C – (p), D – (q)

3. **(c)** A – (r), B – (s), C – (q), D – (p)

4. **(a)** A – (q), B – (s), C – (p), D – (r)

5. **(c)** A – (r), B – (q), C – (p), D – (s)

6. **(c)** The principal quantum number determines the shape and energy of the orbital, not orientation.

7. **(d)** Magnetic quantum number determines the orientation of the orbital.

8. **(d)** Chemical properties of atoms are controlled by the number of electrons, which are determined by the number of protons in the nucleus.

9. **(a)** Both statements are correct.

10. **(c)** When both electric and magnetic field is applied, electron strikes at point B, and at point C when only magnetic field is applied.

11. **(c)**

12. **(b)** For statement (ii) there is no time lag between striking of light beam and the ejection of electrons. For statement (iii) refer statement (iv).

13. **(b)** Angular quantum number determines the 3-D shape of the orbital.

14. **(b)**

15. **(c)** Atom is electrically neutral. Atoms necessarily contain equal number of protons and electrons, but not neutrons.

16. **(d)** Energy of a photon = $h\nu = h\frac{c}{\lambda}$.

So, energy depends upon wavelength.

17. **(c)** The value of *n* for a line in Balmer series of hydrogen spectrum having the highest wavelength will be $n_1 = 2$ and $n_2 = 3$ because this transition will have lowest energy and so highest wavelength.

18. **(d)** Absorption spectrum consists of dark lines separated by bright space and emission spectrum consists of bright lines.

19. **(d)** The threshold frequency is the minimum frequency required for the ejection of electron from the metal surface.

20. **(b)** K.E. = $h(\nu - \nu_0)$; K.E. increases linearly with ν, the frequency. The rate of emission of photoelectrons i.e., the photoelectric current is directly proportional to the rate of impinging photons i.e. the intensity of light.

EXERCISE - 4

1. **(d)** $E = n\frac{hc}{\lambda} \Rightarrow 2 \times 10^{-17} = n \times \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{595.2 \times 10^{-9}}$

$\Rightarrow n = 60$

2. **(a)** The energy of an orbital is given by $(n + l)$. In (D) and (E), $(n + l)$ value is $(3 + 2) = 5$, hence they will have same energy, since here *n* values are also same.

($h = 6.63 \times 10^{-34}$ Js)

3. **(d)** $\frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

To calculate shortest wavelength take $n_2 = \infty$ and longest wavelength take nearest value of n_2.
For H-atom, to calculate

$$\frac{1}{\lambda_{\text{shortest}}}, n_2 = \infty, Z = 1, n_1 = 1 \therefore \quad \frac{1}{x} = R_H \text{(Lyman series)}$$

For $\frac{1}{\lambda_{\text{longest}}}$ for $Li^{2+}, Z = 3, n_1 = 2, n_2 = 3$ (Balmer series)

$$\frac{1}{\lambda_{\text{longest}}} = \frac{1}{x} \times 3^2 \left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5}{4x} \quad \therefore \quad \lambda_{\text{longest}} = \frac{4x}{5}$$

4. **(a)** Total number of spectral lines given by

$$\frac{1}{2}[n-1] \times n = 15; \quad \therefore \; n = 6$$

Thus, electron is excited upto 6^{th} energy level from ground state. Therefore,

$$\frac{1}{\lambda} = R_H \left[\frac{1}{1^2} - \frac{1}{6^2}\right] = 109737 \times \frac{35}{36};$$

$$\lambda = 9.373 \times 10^{-6} \text{ cm} = 937.3 \text{ Å}$$

5. **(a)** There is only one type of transition from $n = 2$ to $n = 1$ and hence emitted radiation will constitute only one frequency.

6. **(c)** As per Einstein's equation of photoelectric effect
$h\nu = h\nu_o + K.E.$

$$\therefore \quad \frac{1}{2}m\nu^2 = h\nu - h\nu_o = \frac{hc}{\lambda} - \frac{hc}{\lambda_o}$$

$$\nu^2 = \frac{2hc}{m}\left(\frac{1}{\lambda} - \frac{1}{\lambda_o}\right); \quad \nu = \left[\frac{2hc}{m}\left(\frac{1}{\lambda} - \frac{1}{\lambda_o}\right)\right]^{1/2}$$

$$\Rightarrow \quad \left[\frac{2hc}{m}\left(\frac{\lambda_o - \lambda}{\lambda\lambda_o}\right)\right]^{1/2}$$

7. **(c)** $n_1 + n_2 = 4$ ..... (i) $\quad n_2 - n_1 = 2$ ..... (ii)
$n_1 = 1, n_2 = 3$

$$\nu = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = R_H \times 3^2 \times \left[\frac{1}{1^1} - \frac{1}{3^2}\right] = 8\, R_H$$

8. **(a)** We know $\boxed{\lambda = \frac{h}{mv}}$ and $\boxed{\text{K.E.} = \frac{1}{2}mv^2}$

From the above relation, we get

$$K.E. = \frac{hv}{2\lambda}$$

$$\left[\because K.E. = \frac{1}{2}m\nu^2 \right.$$
$$\left. \therefore m\nu = \frac{2K.E.}{\nu}; \lambda = \frac{h\nu}{2K.E.} \text{ or } K.E. = \frac{h\nu}{2\lambda}\right]$$

Since K.E. for two particles is same, so $\lambda \propto \nu$ *i.e.,* option (a).

9. **(b)** Ψ^2 gives the probabilitiy of finding an electron in a given volume of space. The 1*s* orbital is spherically symmetrical so the probability of finding electron at any given point depends only on its distance from the nucleus. The probability density is greatest at $r = 0$ (at nucleus) and decreases with increasing distance.
In contrast, the surface area of each spherical shell is equal to $4\pi r^2$, which increases very rapidly with increasing r. The radial probability distribution function $4\pi r^2\psi^2$ is equal to zero at nucleus ($r = 0$).

10. **(d)** Energy of photon corresponding to second line of Balmer series for Li^{2+} ion

$$= (13.6) \times (3)^2 \left[\frac{1}{2^2} - \frac{1}{4^2}\right] = 13.6 \times \frac{27}{16}$$

Energy needed to eject electron from n = 2 level in H-atom;

$$= 13.6 \times 1^2 \times \left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] \Rightarrow \frac{13.6}{4}$$

K.E. of ejected electron

$$= 13.6 \times \frac{9 \times 3}{16} - \frac{13.6}{4} = 13.6 \times \left(\frac{27 - 4}{16}\right) \Rightarrow 19.55 \text{ eV}$$

11. **(a)** From de-Broglie equation,

$$\lambda = \frac{h}{\sqrt{2me^{\nu}}}; \; \lambda_p = \frac{h}{\sqrt{2mp^{ev}}} \text{ (for proton)}$$

$$\lambda_{Li^{3+}} = \frac{h}{\sqrt{2(3eV)m_{Li}}} \text{ (for } Li^{3+})$$

$$\therefore \quad \frac{\lambda_{Li^{3+}}}{\lambda_p} = \frac{\sqrt{2Vem_p}}{\sqrt{6eVm_p \times 9}} = \frac{1}{3\sqrt{3}}$$

12. **(b)** Let wavelength of particle be x

So, velocity (v) $= \frac{x}{100}$

$\lambda = \frac{h}{m\text{v}}$; $x = \frac{h \times 100}{m \times x}$

$x^2 = 100\frac{h}{m}$ or $x = 10\sqrt{\frac{h}{m}}$

13. **(a)** $E_n - E_2 = 10 + 17 = 27$ eV ....(i)

$E_n - E_3 = 4.25 + 5.95 = 10.2$ eV ....(ii)

Substracting eq. (ii) from eq. (i):

$E_3 - E_2 = 16.8$ eV

$\Rightarrow \quad -\frac{13.6Z^2}{3^2} + \frac{13.6Z^2}{2^2} = 16.8 \Rightarrow \quad Z = 3$

From eq. (i): $-\frac{13.6Z^2}{n^2} + \frac{13.6Z^2}{4} = 27$

$\Rightarrow \quad -\frac{13.6 \times 9}{n^2} + \frac{13.6 \times 9}{4} = 27$

$\Rightarrow \quad n^2 = 36 \quad \Rightarrow \quad n = 6$

14. **(a)** Number of moles of He gas

$$\text{n} = \frac{PV}{RT} = \frac{\left(\frac{560}{760}\right) \times 1.5}{0.0822 \times 500} = 0.027 \text{ moles}$$

Number of moles of He^+ ions $= 0.027 \times \frac{90}{100} = 0.024$

Number of moles in $n = 3$ level $= 0.02$ moles

Number of moles in $n = 2$ level $= 0.002$ moles

Energy evolved $\Delta\text{E} = 2.18 \times 10^{-18} \times \text{Z}^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ J

Energy evolved from transition $n = 3$ to $n = 1$

$\Delta\text{E} = 2.18 \times 10^{-18} \times 2^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$ J

$\Delta\text{E} = 7.75 \times 10^{-18}$ J

From 0.02 moles:

$\Delta\text{E}_1 = 0.02 \times 6.023 \times 10^{23} \times 7.75 \times 10^{-18}$ J

$\Delta\text{E}_1 = 93.36$ kJ

Energy evolved from transition $n = 2$ to $n = 1$

$\Delta\text{E} = 2.18 \times 10^{-18} \times 2^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$ J

$\Delta\text{E} = 6.54 \times 10^{-18}$J

From 0.002 moles:

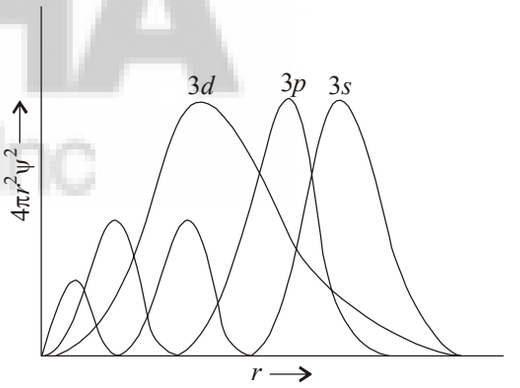
$\Delta\text{E}_2 = 0.002 \times 6.023 \times 10^{23} \times 6.54 \times 10^{-18}$J

$\Delta\text{E}_2 = 7.88$ kJ

Total energy evolved $= \Delta\text{E}_1 + \Delta\text{E}_2 = (93.36 + 7.88)$kJ

≈ 101 kJ

15. **(c)** The 3*s*-orbital is more extended/spread out in space than the 3*p*-orbital which is in turn more extended than 3d-orbital. Thus, radii of maximum probability decreases in the order : $(r_{max})3s > (r_{max})3p > (r_{max})3d$



10th Edition

Disha's

New Syllabus

100% Qns in NEET 2024 from this Book

Objective NCERT TRACT

BIOLOGY

for NEET (UG) 2025

with Previous Year & Practice Question Bank

100% COMMAND ON NCERT | **NCERT LOCATOR for Each Qns.** | **1st Book with 5 Unique Features** | **Designed as per Latest NMC Syllabus**

- Quick Theory in **One Liner Format as per NMC Syllabus**
- **NCERT + NEET PYQs** in **One Liner Format**
- **MCQs on every line** of NCERT
- **Previous Year Questions** PYQs (2024 - 2016)
- **2 & 4/ 5 Statements, Matching & AR** MCQs

DISHA™ Publication Inc

DISHA Publication Inc.

A-23 FIEE Complex, Okhla Phase II

New Delhi-110020

Tel: 49842349/ 49842350

Edited By

Rashi Chauhan

Priyanka Jajoo

Typeset By

DISHA DTP Team

Buying Books from Disha is always Rewarding

This time we are appreciating your writing Creativity.

Write a review of the product you purchased on Amazon/Flipkart

Take a screen shot / Photo of that review

Scan this QR Code ➔

Fill Details and submit | That's it ... Hold tight n wait.
At the end of the month, you will get a surprise gift from Disha Publication

Scan this QR code

Write To Us At

feedback_disha@aiets.co.in

DISHA™ Publication Inc

www.dishapublication.com

For future updates on NEET Scan the QR Code.
https://bit.ly/neet_exam_update
You also get Latest Syllabus, Past NEET Papers, Mock Tests and more content here.

Free Sample Contents

Class XI

3. Plant Kingdom (Botany) **A27-A42**

- ➲ Trend Analysis
- • 3.0 Introduction
- • 3.1 Algae
- • 3.2 Bryophytes
- • 3.3 Pteridophytes
- • 3.4 Gymnosperms
- • 3.5* Angiosperm
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

This sample book is prepared from the book **"Disha's New Syllabus Objective NCERT Xtract Biology for NEET (UG) 2025 with Previous Year & Practice Question Bank 10th Edition | One Liner Theory, Tips on your Fingertips, PYQs | 3 Mock Tests".**

ISBN - 978-9362254931

MRP- 1000/-

In case you like this content, you can buy the **Physical Book** or **E-book** using the ISBN provided above.

The book & e-book are available on all leading online stores.

CONTENTS

Class XI

1. The Living World (Botany) A1-A10
- ➲ Trend Analysis
- • 1.1 What is 'Living'?
- • 1.2 Diversity in the Living World
- • 1.3 Taxonomic Categories
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

2. Biological Classification (Botany) A11-A26
- ➲ Trend Analysis
- • 2.0 Introduction
- • 2.1 Kingdom Monera
- • 2.2 Kingdom Protista
- • 2.3 Kingdom Fungi
- • 2.4 Kingdom Plantae
- • 2.5 Kingdom Animalia
- • 2.6 Viruses, Viroids, Prions and Lichens
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

3. Plant Kingdom (Botany) A27-A42
- ➲ Trend Analysis
- • 3.0 Introduction
- • 3.1 Algae
- • 3.2 Bryophytes
- • 3.3 Pteridophytes
- • 3.4 Gymnosperms
- • 3.5* Angiosperm
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

4. Animal Kingdom (Zoology) A43-A64
- ➲ Trend Analysis
- • 4.0 Introduction
- • 4.1 Basis of Classification
- • 4.2 Classification of Animals
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

5. Morphology of Flowering Plants (Botany) A65-A86
- ➲ Trend Analysis
- • 5.0 Introduction
- • 5.1 The Root
- • 5.2 The Stem
- • 5.3 The Leaf
- • 5.4 The Inflorescence
- • 5.5 The Flower
- • 5.6 The Fruit
- • 5.7 The Seed
- • 5.8 Semi-Technical Description of a Typical Flowering Plant
- • 5.9 Description of Some Important Families
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

6. Anatomy of Flowering Plants (Botany) A87-A102
- ➲ Trend Analysis
- • 6.0 Introduction
- • 6.1 The Tissues
- • 6.2 The Tissue System
- • 6.3 Anatomy of Dicotyledonous and Monocotyledonous Plants
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

7. Structural Organisation in Animals (Zoology) A103-A118
- ➲ Trend Analysis
- • 7.0 Introduction
- • 7.1 Animal Tissues
- • 7.2 Organ and Organ System
- • 7.3 Frogs
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

8. Cell: The Unit of Life (Botany) A119-A138
- ➲ Trend Analysis
- • 8.0 Introduction
- • 8.1 What is a Cell?
- • 8.2 Cell Theory
- • 8.3 An Overview of Cell
- • 8.4 Prokaryotic Cells
- • 8.5 Eukaryotic Cells
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

9. Biomolecules (Zoology) A139-A156
- ➲ Trend Analysis
- • 9.0 Introduction
- • 9.1 How to Analyse Chemical Composition?
- • 9.2 Primary and Secondary Metabolites
- • 9.3 Biomarcomolecules
- • 9.4 Proteins
- • 9.5 Polysaccharides
- • 9.6 Nucleic Acids
- • 9.7 Structure of Proteins
- • 9.8 Enzymes
- • 9.9 Classification and Nomenclature of Enzymes
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

10. Cell Cycle and Cell Division (Botany) A157-A170
- ➲ Trend Analysis
- • 10.0 Introduction
- • 10.1 Cell Cycle-Interphase
- • 10.2 M Phase (Mitosis Phase)
- • 10.3 Significance of Mitosis
- • 10.4 Meiosis
- • 10.5 Significance of Meiosis
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

11. Photosynthesis in Higher Plants (Botany) A171-A188
- ➲ Trend Analysis
- • 11.0 Introduction
- • 11.1 What Do We Know
- • 11.2 Early Experiments
- • 11.3 Where Does Photosynthesis Take Place?
- • 11.4 How Many Types of Pigments are Involved in Photosynthesis?
- • 11.5 What is Light Reaction?
- • 11.6 The Electron Transport
- • 11.7 Where are the ATP and NADPH used?
- • 11.8 The C_4 Pathway
- • 11.9 Photorespiration
- • 11.10 Factors Affecting Photosynthesis
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

12. Respiration in Plants (Botany) A189-A204
- ➲ Trend Analysis
- • 12.0 Introduction
- • 12.1 Do Plants Breathe?

A1–A314

- 12.2 Glycolysis
- 12.3 Fermentation
- 12.4 Aerobic Respiration
- 12.5 The Respiratory Balance Sheet
- 12.6 Amphibolic Pathway
- 12.7 Respiratory Quotient

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

13. Plant Growth and Development (Botany) A205-A218

➲ Trend Analysis

- 13.0 Introduction
- 13.1 Growth
- 13.2 Differentiation, De-differentiation and Re-differentiation
- 13.3 Development
- 13.4 Plant Growth Regulators

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

14. Breathing and Exchange of Gases (Zoology) A219-A236

➲ Trend Analysis

- 14.0 Introduction
- 14.1 Respiratory Organs
- 14.2 Mechanism of Breathing
- 14.3 Exchange of Gases
- 14.4 Transport of Gases
- 14.5 Regulation of Respiration
- 14.6 Disorders of Respiratory System

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

15. Body Fluids and Circulation (Zoology) A237-A252

➲ Trend Analysis

- 15.0 Introduction
- 15.1 Blood
- 15.2 Lymph (Tissue Fluid)
- 15.3 Circulatory Pathways
- 15.4 Double Circulation
- 15.5 Regulation of Cardiac Activity
- 15.6 Disorders of Circulatory System

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

16. Excretory Products and their Elimination (Zoology) A253-A268

➲ Trend Analysis

- 16.0 Introduction
- 16.1 Human Excretory System
- 16.2 Urine Formation
- 16.3 Function of the Tubules
- 16.4 Mechanism of Concentration of the Filtrate
- 16.5 Regulation of Kidney Function
- 16.6 Micturition
- 16.7 Role of other Organs in Excretion
- 16.8 Disorders of the Excretory System

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

17. Locomotion and Movement (Zoology) A269-A284

➲ Trend Analysis

- 17.0 Introduction
- 17.1 Types of Movement
- 17.2 Muscle
- 17.3 Skeletal System (To be deal with relevant practical syllabus)
- 17.4 Joints
- 17.5 Disorders of Muscular and Skeletal System

NEET One-Liners

Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

18. Neural Control and Coordination (Zoology) A285-A296

➲ Trend Analysis

- 18.0 Introduction
- 18.1 Neural System
- 18.2 Human Neural System
- 18.3 Neuron as Structural and Functional Unit of Neural System
- 18.4 Central Neural System

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

19. Chemical Coordination and Integration (Zoology) A297-A314

➲ Trend Analysis

- 19.0 Introduction
- 19.1 Endocrine Glands And Hormones
- 19.2 Human Endocrine System
- 19.3 Hormones of Heart, Kidney and Gastrointestinal Tract
- 19.4 Mechanism of Hormone Action

➲ Tips/Tricks/Techniques One-Liners

➲ Exercise 1 to Exercise 4

Hints & Solutions (Class 11th) A315–A410

1.	The Living World	A315-A317	11.	Photosynthesis in Higher Plants	A363-A368
2.	Biological Classification	A318-A322	12.	Respiration in Plants	A369-A373
3.	Plant Kingdom	A323-A326	13.	Plant Growth and Development	A374-A376
4.	Animal Kingdom	A327-A332	14.	Breathing and Exchange of Gases	A377-A381
5.	Morphology of Flowering Plants	A333-A337	15.	Body Fluids and Circulation	A382-A388
6.	Anatomy of Flowering Plants	A338-A341	16.	Excretory Products and their Elimination	A389-A393
7.	Structural Organisation in Animals	A342-A344	17.	Locomotion and Movement	A394-A400
8.	Cell: The Unit of Life	A345-A350	18.	Neural Control and Coordination	A401-A403
9.	Biomolecules	A351-A357	19.	Chemical Coordination and Integration	A404-A410
10.	Cell Cycle and Cell Division	A358-A362			

Class XII

B1–B226

1. Sexual Reproduction in Flowering Plants (Botany) B1-B18
- ➲ Trend Analysis
- • 1.1 Flower- A Fascinating Organ of Angiosperms
- • 1.2 Pre-fertilisation: Structures and Events
- • 1.3 Double Fertilisation
- • 1.4 Post-fertilisation: Structures and Events
- • 1.5 Apomixis and Polyembryony
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

2. Human Reproduction (Zoology) B19-B40
- ➲ Trend Analysis
- • 2.1 The Male Reproductive System
- • 2.2 The Female Reproductive System
- • 2.3 Gametogenesis
- • 2.4 Menstrual Cycle
- • 2.5 Fertilisation and Implantation
- • 2.6 Pregnancy and Embryonic Development
- • 2.7 Parturition and Lactation
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

3. Reproductive Health (Zoology) B41-B54
- ➲ Trend Analysis
- • 3.0 Introduction
- • 3.1 Reproductive Health- Problems and Strategies
- • 3.2 Population Stabilisation and Birth control
- • 3.3 Medical Termination of Pregnancy (MTP)
- • 3.4 Sexually Transmitted Infections (STIs)
- • 3.5 Infertility
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

4. Principles of Inheritance and Variation (Botany) B55-B76
- ➲ Trend Analysis
- • 4.0 Introduction
- • 4.1 Mendel's Laws of Inheritance
- • 4.2 Inheritance of One Gene
- • 4.3 Inheritance of Two Genes
- • 4.4 Polygenic Inheritance
- • 4.5 Pleiotropy
- • 4.6 Sex Determination
- • 4.7 Mutation
- • 4.8 Genetic Disorders
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

5. Molecular Basis of Inheritance (Botany) B77-B102
- ➲ Trend Analysis
- • 5.0 Introduction
- • 5.1 The DNA
- • 5.2 The Search for Genetic Material
- • 5.3 RNA World
- • 5.4 Replication
- • 5.5 Transcription
- • 5.6 Genetic Code
- • 5.7 Translation (Protein Biosynthesis)
- • 5.8 Regulation of Gene Expression
- • 5.9 Human Genome Project
- • 5.10 DNA Fingerprinting
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

6. Evolution (Zoology) B103-B120
- ➲ Trend Analysis
- • 6.0 Introduction
- • 6.1 Origin of Life
- • 6.2 Evolution of Life Forms-A Theory
- • 6.3 What are the Evidences for Evolution?
- • 6.4 What is Adaptive Radiation?
- • 6.5 Biological Evolution
- • 6.6 Mechanism of Evolution
- • 6.7 Hardy-Weinberg Principle
- • 6.8 A Brief Account of Evolution
- • 6.9 Origin and Evolution of Man
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

7. Human Health and Disease (Zoology) B121-B140
- ➲ Trend Analysis
- • 7.0 Introduction
- • 7.1 Common Diseases in Humans / Dengue / Chikungunya
- • 7.2 Immunity
- • 7.3 AIDS
- • 7.4 Cancer
- • 7.5 Drugs / Alcohol Abuse / Tobacco Abuse
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

8. Microbes in Human Welfare (Botany) B141-B156
- ➲ Trend Analysis
- • 8.0 Introduction
- • 8.1 Microbes in Household Products
- • 8.2 Microbes in Industrial Products
- • 8.3 Microbes in Sewage Treatment
- • 8.4 Microbes in Production of Biogas
- • 8.5 Microbes as Biocontrol Agents
- • 8.6 Microbes as Biofertilisers
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

9. Biotechnology : Principles and Processes (Zoology) B157-B172
- ➲ Trend Analysis
- • 9.0 Introduction
- • 9.1 Principles of Biotechnology
- • 9.2 Tools of Recombinant DNA Technology
- • 9.3 Processes of Recombinant DNA Technology
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

10. Biotechnology and its Applications (Zoology) B173-B184
- ➲ Trend Analysis
- • 10.0 Introduction
- • 10.1 Biotechnological Applications in Agriculture

- 10.2 Biotechnological Applications in Medicine
- 10.3 Transgenic Animals
- 10.4 Ethical Issues
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

11. Organisms and Populations (Botany) B185-B204

- ➲ Trend Analysis
- 11.0 Introduction
- 11.1 Organism and Its Environment
- 11.2 Populations
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

12. Ecosystem (Botany) B205-B214

- ➲ Trend Analysis
- 12.0 Introduction
- 12.1 Ecosystem – Structure and Function
- 12.2 Productivity
- 12.3 Decomposition
- 12.4 Energy Flow
- 12.5 Ecological Pyramids
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

13. Biodiversity and Conservation (Botany) B215-B226

- ➲ Trend Analysis
- 13.1 Biodiversity
- 13.2 Biodiversity conservation
- ➲ Tips/Tricks/Techniques One-Liners
- ➲ Exercise 1 to Exercise 4

Note : The four Exercises in each of the chapters are :

- Exercise 1 : NCERT Based Topic-wise MCQs
- Exercise 2 : NCERT Exempler & Past Years NEET
- Exercise 3 : Matching Statements & Assertion Reason Type
- Exercise 4 : Skill Enhancer MCQs

Hints & Solutions (Class 12th) B227–B302

1.	Sexual Reproduction in Flowering Plants	B227-B232	8.	Microbes in Human Welfare	B271-B275
2.	Human Reproduction	B233-B238	9.	Biotechnology : Principles and Processes	B276-B280
3.	Reproductive Health	B239-B242	10.	Biotechnology and its Applications	B281-B285
4.	Principles of Inheritance & Variation	B243-B250	11.	Organisms and Population	B286-B293
5.	Molecular Basis of Inheritance	B251-B257	12.	Ecosystem	B294-B297
6.	Evolution	B258-B263	13.	Biodiversity and Conservation	B298-B302
7.	Human Health and Disease	B264-B270			

Mock Tests

Mock Test-1 MT1–MT8

Mock Test-2 MT9–MT16

Mock Test-3 MT17–MT24

Solutions

Mock Test-1 MT25–MT28

Mock Test-2 MT29–MT31

Mock Test-3 MT32–MT36

NOTE* These Topics are in new NCERT, but not in the new NEET 2024 Syllabus. These Topics have been retained in the book so as to match NCERT and any future amendments in NEET.
Questions on these Topics have also been marked with a * in the respective Exercises of the Chapters.

Botany

3 Plant Kingdom

Trend Analysis NEET

	NEET	Remarks
Number of Questions from 2024-18	21	2-3 Questions every year
Weightage	3.2%	

			NEET	
Year	Topic Name	Concept Used	No. of Questions	Difficulty Level
2024	Algae	Phaeophyceae	1	Difficult
2023	Bryophytes/ Pteridophytes/ Gymnosperms	Reproduction/ Reproduction/ Pinus	3	Easy/ Difficult
2022	Algae/ Pteridophyta	Classification of algae/ Reproduction	4	Easy/ Difficult
2021	Algae/ Bryophytes/ Pteridophytes	Reserve food Material/ Spores/ Phaeophyceae	4	Easy/ Average
2020	Algae/ Pterido Phytes/ Gymnosperms	Rhodophyceae/ Reproduction	5	Easy/ Average/ Difficult
2019	Gymnosperms/ Pteridophyte	Pinus/ General characteristics of Pteridophytes	2	Average/ Difficult
2018	Gymnosperms/ Bryophytes	Features of Gymnosperms/ Reproduction	2	Average/ Difficult

NCERT ONE-LINERS
(Important Points to Remember)

3.0 Introduction

- **Whittaker (1969)** wherein he suggested the Five Kingdom classification viz. **Monera**, **Protista**, **Fungi**, **Animalia** and **Plantae**.
- Fungi, and members of the Monera and Protista having cell walls have now been excluded from Plantae though earlier classifications placed them in the same kingdom.
- So, the **cyanobacteria** that are also referred to as **blue green algae** are not 'algae' any more.
- The earliest systems of classification used only gross superficial morphological characters such as habit, colour, number and shape of leaves, etc. They were based mainly on vegetative characters or on the androecium structure (system given by Linnaeus). Such systems were **artificial;** they separated the closely related species since they were based on a few characteristics.
- The artificial systems gave equal weightage to vegetative and sexual characteristics; this is not acceptable since we know that often the vegetative characters are more easily affected by environment. **NEET 2013**
- As against this, **natural classification systems** developed, which were based on natural affinities among the organisms and consider, not only the external features, but also internal features, like ultrastructure, anatomy, embryology and phytochemistry. Such a classification for flowering plants was given by **George Bentham** and **Joseph Dalton Hooker**.
- At present **phylogenetic classification systems** based on evolutionary relationships between the various organisms are acceptable.
- **Numerical Taxonomy** is based on all observable characteristics.
- Number and codes are assigned to all the characters and the data are then processed. In this way each character is given equal importance and at the same time hundreds of characters can be considered.
- **Cytotaxonomy** that is based on cytological information like chromosome number, structure, behaviour and **chemotaxonomy** that uses the chemical constituents of the plant to resolve confusions, are also used by taxonomists these days.

3.1 Algae

- **Algae** are chlorophyll-bearing, simple, thalloid, autotrophic and largely aquatic (both fresh water and marine) organisms.
- They occur in a variety of other habitats: moist stones, soils and wood.
- Some of them also occur in association with fungi (**lichen**) and animals (e.g., on **sloth bear**).

- The form and size of algae is highly variable, ranging from colonial forms like *Volvox* and the filamentous forms like *Ulothrix* and *Spirogyra* **NEET 2017**
- A few of the marine forms such as **kelps**, form massive plant bodies.
- The algae reproduce by vegetative, asexual and sexual methods.
- Vegetative reproduction is by **fragmentation**. Each fragment develops into a thallus.
- Asexual reproduction is by the production of different types of spores, the most common being the **zoospores**.
- They are flagellated (motile) and on germination gives rise to new plants.
- Sexual reproduction takes place through fusion of two gametes.
- These gametes can be flagellated and similar in size (as in *Ulothrix*) or non-flagellated (non-motile) but similar in size (as in *Spirogyra*). Such reproduction is called **isogamous**.
- Fusion of two gametes dissimilar in size, as in species of *Eudorina* is termed as **anisogamous**.
- Fusion between one large, nonmotile (static) female gamete and a smaller, motile male gamete is termed **oogamous**, e.g., *Volvox*, *Fucus*.

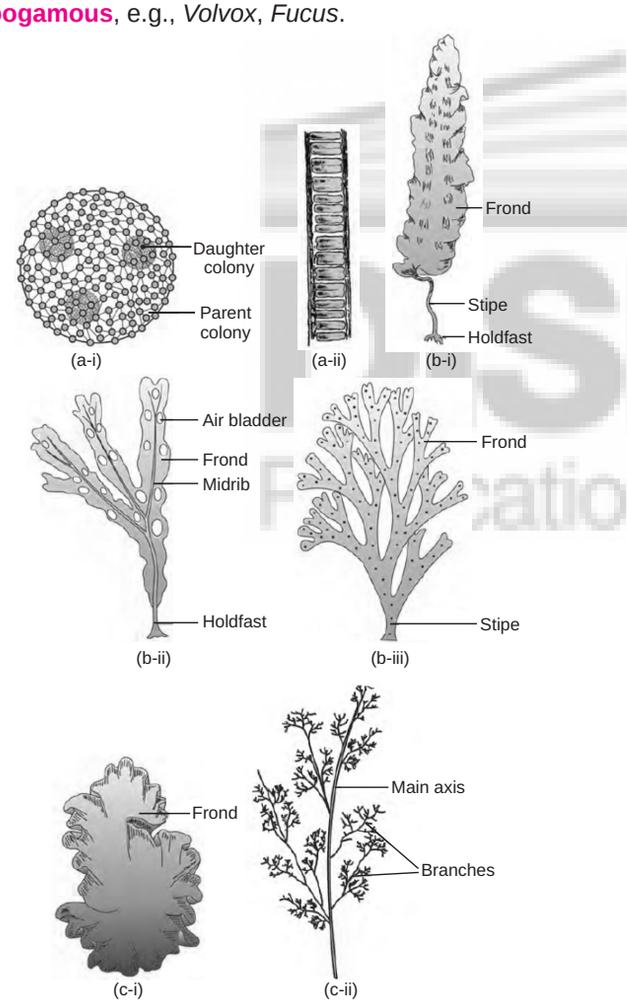


Fig. : Algae :
(a) Green algae (i) Volvox (ii) Ulothrix
(b) Brown algae (i) Laminaria (ii) Fucus (iii) Dictyota
(c) Red algae (i) Porphyra (ii) Polysiphonia

- Algae are useful to man in a variety of ways. At least a half of the total carbon dioxide fixation on earth is carried out by algae through photosynthesis.
- Being photosynthetic they increase the level of dissolved oxygen in their immediate environment.
- They are of paramount importance as primary producers of energy-rich compounds which form the basis of the food cycles of all aquatic animals.
- Many species of *Porphyra, Laminaria* and *Sargassum* are among the 70 species of marine algae used as food.
- Certain marine brown and red algae produce large amounts of **hydrocolloids** (water holding substances), e.g., **algin** (brown algae) and **carrageen** (red algae) which are used commercially. **AIPMT 2012 & NEET 2021**
- **Agar**, one of the commercial products obtained from *Gelidium* and *Gracilaria* are used to grow microbes and in preparations of ice-creams and jellies.
- *Chlorella* a unicellular alga rich in proteins is used as food supplement even by space travellers.
- The algae are divided into three main classes: **Chlorophyceae, Phaeophyceae** and **Rhodophyceae**.

Chlorophyceae

- The members of chlorophyceae are commonly called **green algae**. The plant body may be unicellular, colonial or filamentous. They are usually grass green due to the dominance of pigments chlorophyll *a* and *b* **AIPMT 2014**
- The pigments are localised in definite chloroplasts. The chloroplasts may be discoid, plate-like, reticulate, cup-shaped, spiral or ribbon-shaped in different species.
- Most of the members have one or more storage bodies called **pyrenoids** located in the chloroplasts. Pyrenoids contain protein besides starch.
- Some algae may store food in the form of oil droplets. Green algae usually have a rigid cell wall made of an inner layer of cellulose and an outer layer of pectose.
- Vegetative reproduction usually takes place by fragmentation or by formation of different types of spores.
- Asexual reproduction is by flagellated zoospores produced in zoosporangia. The sexual reproduction shows considerable variation in the type and formation of sex cells and it may be isogamous, anisogamous or oogamous. Some commonly found green algae are: *Chlamydomonas, Volvox, Ulothrix, Spirogyra* and *Chara*.

Phaeophyceae

- The members of phaeophyceae or **brown algae** are found primarily in marine habitats. They show great variation in size and form. They range from simple branched, filamentous forms (*Ectocarpus*) to profusely branched forms as represented by kelps, which may reach a height of 100 metres.
- They possess **chlorophyll a, c, carotenoids** and **xanthophylls**. **NEET 2024**
- They vary in colour from olive green to various shades of brown depending upon the amount of the **xanthophyll pigment**, **fucoxanthin** present in them.
- Food is stored as complex carbohydrates, which may be in the form of laminarin or mannitol. The vegetative cells have a cellulosic wall usually covered on the outside by a gelatinous coating of **algin**. **NEET 2021, 2024**

- The protoplast contains, in addition to plastids, a centrally located vacuole and nucleus. The plant body is usually attached to the substratum by a **holdfast**, and has a stalk, the **stipe** and leaf like photosynthetic organ – the **frond**.
- Vegetative reproduction takes place by fragmentation. Asexual reproduction in most brown algae is by biflagellate zoospores that are pear-shaped and have two unequal laterally attached flagella. **NEET 2024**
- Sexual reproduction may be **isogamous**, **anisogamous** or **oogamous**. Union of gametes may take place in water or within the oogonium (oogamous species). **NEET 2024**
- The gametes are pyriform (pear-shaped) and bear two laterally attached flagella. The common forms are *Ectocarpus, Dictyota, Laminaria, Sargassum* and *Fucus*.

Rhodophyceae

- The members of rhodophyceae are commonly called **red algae** because of the predominance of the red pigment, **r-phycoerythrin** in their body. Majority of the red algae are marine with greater concentrations found in the warmer areas.
- They occur in both well-lighted regions close to the surface of water and also at great depths in oceans where relatively little light penetrates.
- The red thalli of most of the red algae are multicellular.
- Some of them have complex body organisation.
- The food is stored as **floridean starch** which is very similar to **amylopectin** and **glycogen** in structure. **NEET 2020**
- The red algae usually reproduce vegetatively by fragmentation. They reproduce asexually by non-motile spores and sexually by non-motile gametes.
- Sexual reproduction is oogamous and accompanied by complex post fertilisation developments. The common members are: *Polysiphonia, Porphyra, Gracilaria* and *Gelidium*.

Table 3.1 : Divisions of Algae and their Main Characteristics

Classes	Common Name	Major Pigments	Stored Food	Cell Wall	Flagellar Number and Position of Insertions	Habitat
Chlorophyceae	Green algae	Chlorophyll a, b	Starch	Cellulose	2-8, equal, apical	Fresh water, brackish water, salt water
Phaeophyceae	Brown algae	Chlorophyll a, c, fucoxanthin	Mannitol, laminarin	Cellulose and algin	2, unequal, lateral	Fresh water (rare) brackish water, salt water
Rhodophyceae	Red algae	Chlorophyll a, d, phycoerythrin	Floridean starch	Cellulose, pectin and poly sulphate esters	Absent	Fresh water (some), brackish water, salt water (most)

3.2 Bryophytes

- **Bryophytes** include the various mosses and liverworts that are found commonly growing in moist shaded areas in the hills.

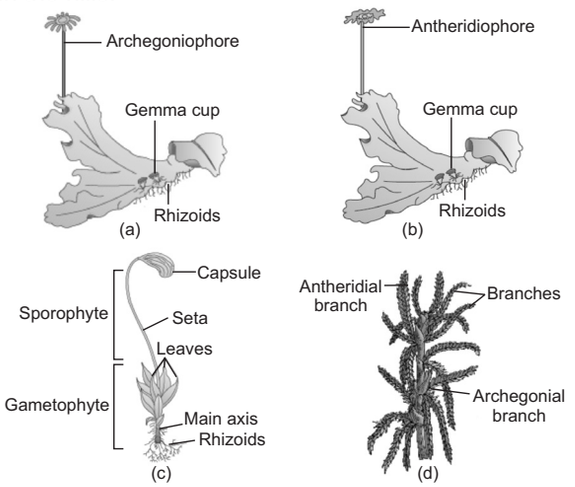


Fig.: Bryophytes: A liverwort – Marchantia (a) Female thallus (b) Male thallus Mosses – (c) Funaria, gametophyte and sporophyte (d) Sphagnum gametophyte

- Bryophytes are also called **amphibians** of the plant kingdom because these plants can live in soil but are dependent on water for sexual reproduction. They usually occur in damp, humid and shaded localities. **AIPMT 2012 & 2015**
- They play an important role in plant succession on bare rocks/soil.
- The plant body of bryophytes is more differentiated than that of algae. It is thallus-like and prostrate or erect, and attached to the substratum by unicellular or multicellular rhizoids.
- They lack true roots, stem or leaves. They may possess root-like, leaf-like or stem-like structures.
- The main plant body of the bryophyte is haploid. It produces gametes, hence is called a **gametophyte**.
- The sex organs in bryophytes are multicellular. The male sex organ is called **antheridium**. They produce biflagellate **antherozoids**. The female sex organ called **archegonium** is flask-shaped and produces a single egg. **AIPMT 2014**
- The antherozoids are released into water where they come in contact with archegonium. An antherozoid fuses with the egg to produce the zygote. Zygotes do not undergo reduction division immediately. They produce a multicellular body called a **sporophyte**.
- The sporophyte is not free-living but attached to the photosynthetic gametophyte and derives nourishment from it. Some cells of the sporophyte undergo reduction division (meiosis) to produce haploid spores. These spores germinate to produce gametophyte.

- Bryophytes in general are of little economic importance but some mosses provide food for herbaceous mammals, birds and other animals. Species of *Sphagnum*, a moss, provide peat that have long been used as fuel, and as packing material for trans-shipment of living material because of their capacity to hold water.
- **Mosses** along with lichens are the first organisms to colonise rocks and hence, are of great ecological importance. They decompose rocks making the substrate suitable for the growth of higher plants.
- Since mosses form dense mats on the soil, they reduce the impact of falling rain and prevent soil erosion. The bryophytes are divided into liverworts and mosses.

Liverworts

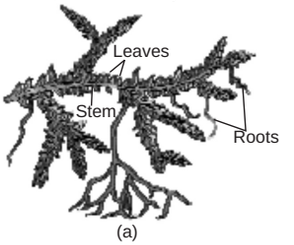
- The liverworts grow usually in moist, shady habitats such as banks of streams, marshy ground, damp soil, bark of trees and deep in the woods.
- The plant body of a liverwort is thalloid, e.g., *Marchantia*. The thallus is dorsiventral and closely appressed to the substrate. The leafy members have tiny leaf-like appendages in two rows on the stem-like structures.
- Asexual reproduction in liverworts takes place by fragmentation of thalli, or by the formation of specialised structures called **gemmae** (sing. gemma). NEET 2021
- Gemmae are green, multicellular, asexual buds, which develop in small receptacles called **gemma cups** located on the thalli.
- The gemmae become detached from the parent body and germinate to form new individuals.
- During sexual reproduction, male and female sex organs are produced either on the same or on different thalli. The sporophyte is differentiated into **a foot**, **seta** and **capsule**. After meiosis, spores are produced within the capsule. These spores germinate to form free-living gametophytes.

Mosses

- The predominant stage of the life cycle of a moss is the gametophyte which consists of two stages. The first stage is the **protonema** stage, which develops directly from a spore. It is a creeping, green, branched and frequently filamentous stage. NEET 2023
- The second stage is the **leafy stage**, which develops from the secondary protonema as a lateral bud. They consist of upright, slender axes bearing spirally arranged leaves.
- They are attached to the soil through multicellular and branched rhizoids. This stage bears the sex organs.
- Vegetative reproduction in mosses is by fragmentation and budding in the secondary protonema.
- In sexual reproduction, the sex organs antheridia and archegonia are produced at the apex of the leafy shoots.
- After fertilisation, the zygote develops into a sporophyte, consisting of a foot, seta and capsule
- The sporophyte in mosses is more elaborate than that in liverworts.
- The capsule contains spores.
- Spores are formed after meiosis.
- The mosses have an elaborate mechanism of spore dispersal. Common examples of mosses are *Funaria, Polytrichum* and *Sphagnum*.

3.3 Pteridophytes

- The Pteridophytes include **horsetails** and **ferns**. Pteridophytes are used for medicinal purposes and as soil-binders. They are also frequently grown as ornamentals.
- They are the first terrestrial plants to possess vascular tissues – **xylem** and **phloem**.
- The pteridophytes are found in cool, damp, shady places though some may flourish well in sandy-soil conditions.
- Pteridophytes, the main plant body is a sporophyte which is differentiated into true root, stem and leaves.
- These organs possess well-differentiated vascular tissues. The leaves in pteridophyta are small (microphylls) as in *Selaginella* or large (macrophylls) as in ferns.
- The sporophytes bear sporangia that are subtended by leaf-like appendages called **sporophylls**.
- In some cases sporophylls may form distinct compact structures called **strobili** or **cones** (*Selaginella, Equisetum*). NEET 2020
- The sporangia produce spores by meiosis in spore mother cells. The spores germinate to give rise to inconspicuous, small but multicellular, free-living, mostly photosynthetic thalloid gametophytes called **prothallus**.
- These gametophytes require cool, damp, shady places to grow.
- Because of this specific restricted requirement and the need for water for fertilisation, the spread of living pteridophytes is limited and restricted to narrow geographical regions.
- The gametophytes bear male and female sex organs called **antheridia** and **archegonia**, respectively. Water is required for transfer of antherozoids – the male gametes released from the antheridia, to the mouth of archegonium.
- Fusion of male gamete with the egg present in the archegonium result in the formation of zygote.
- Zygote thereafter produces a multicellular well-differentiated sporophyte which is the dominant phase of the pteridophytes. In majority of the pteridophytes all the spores are of similar kinds; such plants are called **homosporous**.
- Genera like *Selaginella* and *Salvinia* which produce two kinds of spores, macro (large) and micro (small) spores, are known as **heterosporous**. NEET 2021, 2023
- The megaspores and microspores germinate and give rise to female and male gametophytes, respectively.
- The female gametophytes in these plants are retained on the parent sporophytes for variable periods. NEET 2019
- The development of the zygotes into young embryos take place within the female gametophytes. This event is a precursor to the **seed habit** considered an important step in evolution. NEET 2019
- The pteridophytes are further classified into four classes: Psilopsida (*Psilotum*); Lycopsida (*Selaginella, Lycopodium*), Sphenopsida (*Equisetum*) and Pteropsida (*Dryopteris, Pteris, Adiantum*).



(a)

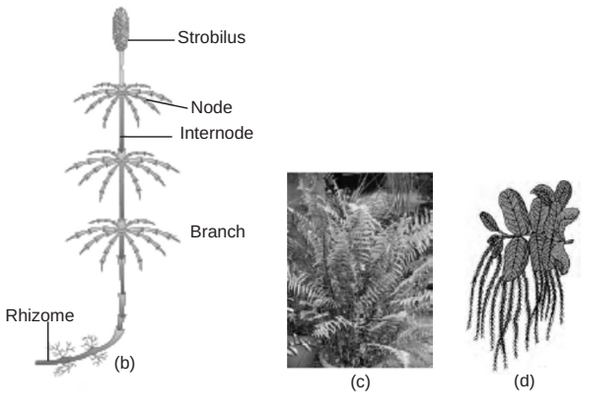


Fig.: Pteridophytes : (a) *Selaginella* (b) *Equisetum* (c) *Fern* (d) *Salvinia*

3.4 Gymnosperms

- The gymnosperms (*gymnos* : naked, *sperma* : seeds) are plants in which the ovules are not enclosed by any ovary wall and remain exposed, both before and after fertilisation.
- The seeds that develop post-fertilisation, are not covered, *i.e.,* are naked. Gymnosperms include medium-sized trees or tall trees and shrubs.
- One of the gymnosperms, the giant redwood tree *Sequoia* is one of the tallest tree species. The roots are generally tap roots. **NEET** 2016
- *Roots* in some genera have *fungal association* in the form of *mycorrhiza (Pinus)*, while in some others (*Cycas*) small specialised roots called **coralloid roots** are associated with N_2- fixing cyanobacteria. **NEET** 2019
- The stems are unbranched (*Cycas*) or branched (*Pinus, Cedrus*). The leaves may be simple or compound. In *Cycas* the pinnate leaves persist for a few years. **NEET** 2019
- The leaves in gymnosperms are well-adapted to withstand extremes of temperature, humidity and wind. In conifers, the needle-like leaves reduce the surface area.
- Their thick cuticle and sunken stomata also help to reduce water loss.
- The gymnosperms are heterosporous; they produce haploid microspores and megaspores. **NEET** 2016 & 2017
- The two kinds of spores are produced within sporangia that are borne on sporophylls which are arranged spirally along an axis to form lax or compact strobili or **cones**.
- The strobili bearing **microsporophylls** and **microsporangia** are called microsporangiate or **male strobili**.
- The microspores develop into a male gametophytic generation which is highly reduced and is confined to only a limited number of cells.
- This reduced gametophyte is called a **pollen grain**. The development of pollen grains take place within the microsporangia. The cones bearing megasporophylls with ovules or megasporangia are called **macrosporangiate** or **female strobili**.
- The male or female cones or strobili may be borne on the same tree (*Pinus*).
- However, in *cycas* male cones and megasporophylls are borne on different trees. The megaspore mother cell is differentiated from one of the cells of the nucellus.
- The nucellus is protected by envelopes and the composite structure is called an **ovule**. **NEET** 2018
- The ovules are borne on megasporophylls which may be clustered to form the female cones. **NEET** 2018
- The megaspore mother cell divides meiotically to form four megaspores.
- One of the megaspores enclosed within the **megasporangium** develops into a multicellular female gametophyte that bears two or more **archegonia** or female sex organs. **NEET** 2023
- The multicellular female gametophyte is also retained within megasporangium.
- Unlike bryophytes and pteridophytes, in gymnosperms the male and the female gametophytes do not have an independent free-living existence. **AIPMT** 2015
- They remain within the sporangia retained on the sporophytes.
- The pollen grain is released from the microsporangium. They are carried in air currents and come in contact with the opening of the ovules borne on megasporophylls.
- The pollen tube carrying the male gametes grows towards archegonia in the ovules and discharge their contents near the mouth of the archegonia.
- Zygote develops into an embryo and the ovules into seeds. These seeds are not covered.

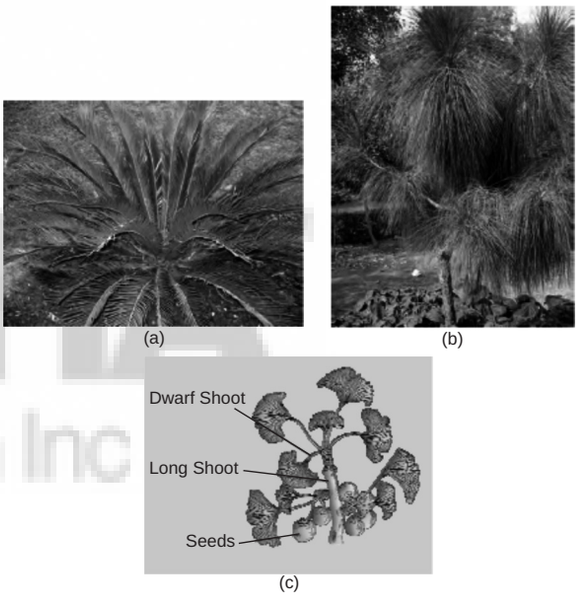


Fig.: Gymnosperms: (a) *Cycas* (b) *Pinus* (c) *Ginkgo*

Included in NCERT but not in NMC NEET Syllabus

3.5 Angiosperms

Unlike the gymnosperms where the ovules are naked, in the angiosperms or flowering plants, the pollen grains and ovules are developed in specialised structures called flowers. In angiosperms, the seeds are enclosed in fruits. The angiosperms are an exceptionally large group of plants occurring in wide range of habitats. They range in size from the smallest Wolffia to tall trees of Eucalyptus (over 100 metres). They provide us with food, fodder, fuel, medicines and several other commercially important products. They are divided into two classes : the dicotyledons and the monocotyledons.

(a)

(b)

Fig.: Angiosperms : (a) A dicotyledon (b) A monocotyledon

Tips/Tricks/Techniques ONE-Liners
(Exam Special)

- *Spirullina* – BGA and *chorella* is used as a source of food and O_2 by space travellers.
- Algin protects seaweeds against dessication and shocks.
- Gaidukov's effect is found in both red algae and blue green algae.
- Mossess along with *lichens* are the first organisms to colums rocks hence are of great ecological importance.
- *Ephedra* and *taxus* are medicinal gymnosperms.
- The angiosperms are divided into two classes - the dicotyledons and the monocotyledons.

Exercise 1 : NCERT Based Topic-wise MCQs

3.0 Introduction

1. Classification of plants proposed by Carolus Linnaeus was artificial because it was based on
NCERT Page-29 / N-23
(a) only a few morphological characters.
(b) evolutionary tendencies which are diverse.
(c) anatomical characters which are adaptive in nature.
(d) physiological traits alongwith morphological characters.

2. Chemotaxonomy is connected with
NCERT Page-30 / N-24
(a) classification of chemicals found in plants.
(b) uses the chemical constituent of plant for classification.
(c) application of chemicals on herbarium sheets.
(d) use of statistical methods in chemical yielding plants.

3. Cytological information like chromosome number, structure, behaviour are related with
NCERT Page-30 / N-24
(a) numerical taxonomy
(b) cytotaxonomy
(c) chemotaxonomy
(d) all of these

4. Phylogenetic classification system is based on the
NCERT Page-30 / N-24
(a) morphological characters of various organisms.
(b) anatomical characters of various organisms.
(c) physiological characters of various organisms.
(d) evolutionary relationships between various organisms.

5. The natural system of classification for flowering plants was given by
NCERT Page-30 / N-23
(a) Carolus Linnaeus
(b) Bentham and Hooker
(c) Engler and Prantl
(d) R. H. Whittaker

6. Artificial systems gave equal weightage to vegetative and sexual characteristics; this is not acceptable because often _____ characters are more easily affected by environment.
NCERT Page-30 / N-23
(a) vegetative (b) sexual
(c) anatomical (d) physiological

7. Each character is given equal importance and at the same time hundreds of characters can be considered in
NCERT Page-30 / N-24
(a) cytotaxonomy (b) morphotaxonomy
(c) chemotaxonomy (d) numerical taxonomy

8. Select the incorrect pair. NCERT Page-30 / N-24
(a) Numerical taxonomy – All observable characteristics
(b) Cytotaxonomy – Cytological information
(c) Chemotaxonomy – Chromosome number and structure
(d) Cladistic taxonomy – Origin from a common ancestor

3.1 Algae

9. Mannitol is the stored food in NCERT Page-33 / N-27
(a) *Chara*
(b) *Porphyra*
(c) *Fucus*
(d) *Gracilaria*

10. *Ulothrix* can be described as a NCERT Page-30 / N-26
(a) non-motile colonial alga lacking zoospores
(b) filamentous alga lacking flagellated reproductive stages
(c) membranous alga producing zoospores
(d) filamentous alga with flagellated reproductive stages

11. Alginates (alginin), used as highly efficient gauze in internal operations are obtained from cell walls of NCERT Page-32 / N-26
(a) Cyanophyceae
(b) Phaeophyceae
(c) Rhodophyceae
(d) All of these

12. Why rhodophyta exhibit a red colour ? NCERT Page-33 / N-27
(a) Since most rhodophyta grow at great depths, the chlorophyll can only absorb light in the red area of the spectrum.
(b) The wavelengths of light that are absorbed by chlorophyll are passed to phycoerythrin (a red pigment).
(c) Red pigment of rhodophyta absorbs all the light waves.
(d) The light reaching the greatest depth in water is in the blue-green region of the spectrum, is absorbed by phycoerythrin.

13. Algin, carrageen and proteins are obtained from NCERT Page-33 / N-26
(a) red algae, brown algae, green algae respectively.
(b) brown algae, red algae, green algae respectively.
(c) red algae, green algae, brown algae respectively.
(d) green algae, brown algae, red algae respectively.

14. Pyrenoids in green algal cells are related to NCERT Page-32 / N-26
(a) starch formation
(b) protein storage
(c) general metabolism
(d) enzyme secretion

15. Which one of the following statements concerning the algae is incorrect ? NCERT Page-30 / N-24
(a) Most algae are photosynthetic.
(b) Algae can be classified according to their pigments.
(c) All algae are filamentous.
(d) *Spirogyra* does not produce zoospores.

16. Which of the following example belong to the same class of algae? NCERT Page-32 / N-26
(a) *Chara*, *Fucus*, *Polysiphonia*
(b) *Volvox*, *Spirogyra*, *Chlamydomonas*
(c) *Porphyra*, *Ectocarpus*, *Ulothrix*
(d) *Sargassum*, *Laminaria*, *Gracilaria*

17. A research student collected certain alga and found that its cells contained both chlorophyll *a* and chlorophyll *d* as well as phycoerythrin. On the basis of his observation, the students conclude that the alga belongs to NCERT Page-33 / N-27
(a) rhodophyceae (b) bacillariophyceae
(c) chlorophyceae (d) phaeophyceae

18. If you are asked to classify the various algae into distinct groups then which of the following characters you should choose for the classification?
(a) Nature of habitat NCERT Page-33 / N-23
(b) Structural organization of thallus
(c) Chemical composition of the cell wall
(d) Types of pigments present in the cell

19. Which of the following pairs is incorrectly matched? NCERT Page-33 / N-27
(a) Chlorophyceae – Major pigments are chl *a* and *b*.
(b) Phaeophyceae – Cell wall is made up of cellulose and algin.
(c) Rhodophyceae – Stored food is mannitol.
(d) Chlorophyceae – Cell wall is made up of cellulose.

20. A student was given a sample to observe under the microscope. He observed and found that the sample is the most common type of spore involved in asexual reproduction in algae. Identify the spore. NCERT Page-30 / N-24
(a) Zoospore (b) Endospore
(c) Hypnospore (d) None of these

21. In class phaeophyceae, the plant body is usually attached to the substratum by a ___A___ and has a stalk, the ___B___ and leaf like photosynthetic organ-the ___C___. NCERT Page-31 / N-26
(a) A – holdfast, B – stipe, C – frond
(b) A – stipe, B – holdfast, C – frond
(c) A – frond, B – stipe, C – holdfast
(d) A – stipe, B – frond, C – holdfast

3.2 Bryophytes

22. A bryophyte suddenly started reproducing partheno-genetically. The number of chromosomes of the second generation compared to parent plant will be
(a) same (b) one-half
(c) double (d) triple

23. A bryophyte differs from pteridophytes in having
(a) archegonia. NCERT Page-35 / N-29
(b) lack of vascular tissue.
(c) swimming antherozoids.
(d) independent gametophytes.

24. Protonema NCERT Page-36 / N-30
(a) is a stage of gametophytic generation.
(b) is a creeping, green, branched and develops directly from a spore.
(c) Filamentous stage.
(d) All of the above

25. Mosses are of great ecological importance because of NCERT Page-35 / N-30
(a) its contribution to prevent soil erosion.
(b) its contribution in ecological succession.
(c) its capability to remove CO from the atmosphere.
(d) both (a) and (b)

26. Mosses do not have 'true leaves' because their leaf-like structures lack NCERT Page-35 / N-30
(a) starch in their chloroplast.
(b) vascular tissues.
(c) chlorophyll.
(d) cellulose in their cell walls.

27. Bryophytes resemble algae in the following aspects NCERT Page-35 / N-29
(a) filamentous body, presence of vascular tissues and autotrophic nutrition
(b) differentiation of plant body into root, stem and leaves and autotrophic nutrition
(c) thallus like plant body, presence of root and autotrophic nutrition
(d) thallus like plant body, lack of vascular tissues and autotrophic nutrition

28. You are given an unknown plant to study in the laboratory. You find that it has chlorophyll, no xylem. Its multicellular sex organs are enclosed in a layer of jacket cells. Its gametophyte stage is free living. The plant probably belongs to NCERT Page-35 / N-29
(a) chlorophyceae (b) bryophyte
(c) pteridophyte (d) gymnosperm

29. Moss peat is used as a packing material for sending flowers and live plants to distant places because
(a) it reduces transpiration. NCERT Page-35 / N-30
(b) it serves as a disinfectant.
(c) it is easily available.
(d) it is hygroscopic.

30. The unique feature of bryophytes compared to other plant groups is that NCERT Page-34 / N-29
(a) they produce spores.
(b) they lack vascular tissues.
(c) they lack roots.
(d) their sporophyte is attached to the gametophyte.

31. In bryophytes, male and female sex organs are called _____ and _____ respectively. NCERT Page-35 / N-29
(a) microsporangia; macrosporangia
(b) male strobili; female strobili
(c) antheridia; archegonia
(d) androecium; gynoecium

32. Protonema and leafy stage are the predominant stage of the life cycle of NCERT Page-36 / N-30
(a) moss
(b) dicots
(c) liverwort
(d) gymnosperm

33. Which of the following statement(s) is/are correct about mosses? NCERT Page-35 & 36 / N-30
(a) The predominant stage of its life cycle is the gametophyte which consists of two stages – protonema and leafy stages.
(b) Leafy stage are attached to the soil through multi-cellular and branched rhizoids.
(c) Sex organs-antheridia and archegonia are produced at the apex of the leafy shoots.
(d) All of the above

3.3 Pteridophytes

34. Fern plant is a NCERT Page-36 / N-30
(a) haploid gametophyte
(b) diploid gametophyte
(c) diploid sporophyte
(d) haploid sporophyte

35. Which one of the following is a correct statement? NCERT Page-35 / N-30
(a) Pteridophyte gametophyte has a protonemal and leafy stage.
(b) In gymnosperms, female gametophyte is free-living.
(c) Antheridiophores and archegoniophores are present in pteridophytes.
(d) Origin of seed habit can be traced in pteridophytes.

36. Which of the following statements is incorrect? NCERT Page-36 / N-30
(a) Pyrenoids contain protein besides starch.
(b) Sexual reproduction may be isogamous, oogamous and anisogamous in green and brown algae.
(c) Some of the members of algae also occur in association with fungi (lichen) and animals (eg, on sloth bear).
(d) The leaves in pteridophyta are small (macrophyll) and large (microphyll) Horsetails and ferns.

37. The heterosporous pteridophyte belonging to the class lycopsida is NCERT Page-38 / N-32
(a) *Selaginella* (b) *Psilotum*
(c) *Equisetum* (d) *Pteris*

38. Which of the following pteridophytes belong to class pteropsida? NCERT Page-38 / N-32
(a) *Equisetum* and *Psilotum*
(b) *Lycopodium* and *Adiantum*
(c) *Selaginella* and *Pteris*
(d) *Pteris* and *Adiantum*

39. Which one of the following is the major difference between mosses and ferns? NCERT Page-37 / N-32
(a) Ferns lack alternation of generation while mosses show the same.
(b) Mosses are facultative aerobes while ferns are obligate aerobes.
(c) Vascular bundles of ferns show xylem vessels while those of mosses lack it.
(d) Sporophytes of ferns live much longer as compared to the sporophytes of mosses.

40. The spreading of living pteridophytes is limited and restricted to narrow geographical region because
NCERT Page-38 / N-32
(a) gametophytic growth needs cool, damp and shady places.
(b) it requires water for fertilization.
(c) due to absence of stomata in leaf and absence of vascular tissue.
(d) both (a) and (b)

3.4 Gymnosperm

41. *Cycas* and *Adiantum* resemble each other in having
NCERT Page-38 / N-32
(a) seeds (b) motile sperms
(c) cambium (d) vessels

42. Fruits are not formed in gymnosperms because of
(a) absence of pollination. NCERT Page-38 / N-33
(b) absence of seed.
(c) absence of fertilization.
(d) absence of ovary.

43. _____ represent the reproductive organs amongst gymnosperms. NCERT Page-39 / N-33
(a) Prothallus (b) Capsules
(c) Setae (d) Cones

3.5 Angiosperms

44. Dicotyledons and monocotyledons are the classes of
NCERT Page-40 / N-34
(a) Gymnosperrms (b) Algae
(c) Pteridophytes (d) Angiosperms

45. In the flowering plants, the pollen grains and ovules are developed in specialised structures called
NCERT Page-40 / N-34
(a) Flowers (b) Leaf
(c) Root (d) Bud

Exercise 2 : NCERT Exemplar & Past Years NEET

NCERT Exemplar Questions

1. Fusion of two motile gametes which are dissimilar in size is termed as NCERT Page-30 / N-24
(a) oogamy (b) isogamy
(c) anisogamy (d) zoogamy

2. Holdfast, stipe and frond constitutes the plant body in case of NCERT Page-31 / N-25
(a) Rhodophyceae (b) Chlorophyceae
(c) Phaeophyceae (d) All of these

3. A plant shows thallus level of organisation. It shows rhizoids and is haploid. It needs water to complete its life cycle because the male gametes are motile. Identify the group to which it belongs to
NCERT Page-34, 35 / N-28, 29
(a) pteridophytes (b) gymnosperms
(c) monocots (d) bryophytes

4. A prothallus is NCERT Page-38 / N-32
(a) a structure in pteridophytes formed before the thallus develops
(b) a sporophytic free living structure formed in pteridophytes
(c) a gametophyte free living structure formed in pteridophytes
(d) a primitive structure formed after fertilisation in pteridophytes

5. Plants of this group are diploid and well adapted to extreme conditions. They grow bearing sporophylls in compact structures called cones. The group in reference is
NCERT Page-38 / N-33
(a) monocots (b) dicots
(c) pteridophytes (d) gymnosperms

6. Protonema is NCERT Page-36 / N-30
(a) haploid and is found in mosses
(b) diploid and is found in liverworts
(c) diploid and is found in pteridophytes
(d) haploid and is found in pteridophytes

7. The giant redwood tree (*Sequoia sempervirens*) is a/an
NCERT Page-38 / N-32
(a) angiosperm (b) free fern
(c) pteridophyte (d) gymnosperm

Past Years NEET

8. In bryophytes and pteridophytes, transport of male gametes requires NCERT Page-35 & 36 / N-29, 30 | 2016, C
(a) Wind (b) Insects
(c) Birds (d) Water

9. Select the correct statement
NCERT Page-38 / N-32 | 2016, C
(a) Gymnosperms are both homosporous and heterosporous
(b) *Salvinia*, *Ginkgo* and *Pinus* all are gymnosperms
(c) *Sequoia* is one of the tallest trees
(d) The leaves of gymnosperms are not well adapted to extremes of climate

10. An example of colonial alga is
NCERT Page-30 / N-26 | 2017, C
(a) *Volvox* (b) *Ulothrix*
(c) *Spirogyra* (d) *Chlorella*

11. Zygotic meiosis is characteristic of 2017, C
(a) *Fucus* (b) *Funaria*
(c) *Chlamydomonas* (d) *Marchantia*

12. Select the mismatch NCERT Page-38 / N-32 | 2017, C
(a) *Cycas* – Dioecious
(b) *Salvinia* – Heterosporous
(c) *Equisetum* – Homosporous
(d) *Pinus* – Dioecious

13. Winged pollen grains are present in 2018, C
(a) Mustard (b) *Cycas*
(c) *Pinus* (d) Mango

14. Which of the following statements is correct?
NCERT Page-38, 39 / N-30, 31 | 2018, C
(a) Ovules are not enclosed by ovary wall in gymnosperms
(b) *Selaginella* is heterosporous, while *Salvinia* is homosporous
(c) Stems are usually unbranched in both Cycas and *Cedrus*
(d) Horsetails are gymnosperms

15. Pinus seed **cannot** germinate and establish without fungal association. This is because:
NCERT Page-38 / N-32 | 2019, C
(a) its embryo is immature.
(b) it has obligate association with mycorrhizae.
(c) it has very hard seed coat.
(d) its seeds contain inhibitors that prevent germination.

16. From evolutionary point of view, retention of the female gametophyte with developing young embryo on the parent sporophyte for some time, is first observed in:
NCERT Page-37 / N-30 | 2019, C
(a) Liverworts (b) Mosses
(c) Pteridophytes (d) Gymnosperms

17. Which of the following pairs is of unicellular algae?
(a) *Gelidium* and *Gracilaria* 2020, C
(b) *Anabaena* and *Volvox*
(c) *Chlorella* and *Spirulina*
(d) *Laminaria* and *Sargassum*

18. Strobili or cones are found in
NCERT Page-36 / N-33 | 2020, C
(a) *Pteris* (b) *Marchantia*
(c) *Equisetum* (d) *Salvinia*

19. Floridean starch has structure similar to
NCERT Page-33 / N-27 | 2020, S
(a) Amylopectin and glycogen
(b) Mannitol and algin
(c) Laminarin and cellulose
(d) Starch and cellulose

20. Phycoerythrin is the major pigment in
NCERT Page-33 / N-27 | PH-II 2020
(a) Brown algae (b) Red algae
(c) Blue green algae (d) Green algae

21. Male and female gametophytes do not have an independent free living existence in:
NCERT Page-39 / N-33 | PH-II 2020
(a) Bryophytes (b) Pteridophytes
(c) Algae (d) Angiosperms

22. Which of the following algae produce Carrageen?
NCERT Page-33 / N-26 | 2021, C
(a) Blue-green algae (b) Green algae
(c) Brown algae (d) Red algae

23. Which of the following algae contains mannitol as reserve food material? NCERT Page-33 / N-26 | 2021, C
(a) *Ulothrix* (b) *Ectocarpus*
(c) *Gracilaria* (d) *Volvox*

24. Gemmae are present in NCERT Page-35 / N-29 | 2021, C
(a) Some Liverworts (b) Mosses
(c) Pteridophytes (d) Some Gymnosperms

25. Genera like Selaginella and Salvinia produce two kinds of spores. Such plants are known as:
NCERT Page-38 / N-32 | 2021, C
(a) Heterosporous (b) Homosorus
(c) Heterosorus (d) Homosporous

26. Hydrocolloid carrageen is obtained from:
NCERT Page-32 / N-26 | 2022, C
(a) Phaeophyceae and Rhodophyceae
(b) Rhodophyceae only
(c) Phaeophyceae only
(d) Chlorophyceae and Phaeophyceae

27. Which of the following is incorrectly matched?
NCERT Page-32 & 33 / N-26, 27 | 2022, S
(a) *Ulothrix* - Mannitol
(b) *Porphyra* - Floridian Starch
(c) *Volvox* - Starch
(d) *Ectocarpus* - Fucoxanthin

28. Match the plant with the kind of life cycle it exhibits:
NCERT Page-38 & 39 / N-26, 30, 32 | 2022, C

List-I		List-II	
A.	Spirogyra	I.	Dominant diploid sporophyte vascular plant, with highly reduced male or female gametophyte
B.	Fern	II.	Dominant haploid free-living gametophyte
C.	Funaria	III.	Dominant diploid sporophyte alternating with reduced gametophyte called prothallus
D.	Cycas	IV.	Dominant haploid leafy gametophyte alternating with partially dependent multicellular sporophyte

Choose the **correct** answer from the options given below:
(a) (A)-(ii),(B)-(iii), (C)-(iv), (D)-(i)
(b) (A)-(iii), (B)-(iv), (C)-(i), (D)-(ii)
(c) (A)-(ii), (B)-(iv), (C)-(i), (D)-(iii)
(d) (A)-(iv), (B)-(i), (C)-(ii), (D)-(iii)

29. Match List -I with List -II :
NCERT Page-32, 36, 38 | PH-II 2022

List-I	List-II
(A) *Chlamydomonas*	(i) Moss
(B) *Cycas*	(ii) Pteridophyte
(C) *Selaginella*	(iii) Alga
(D) *Sphagnum*	(iv) Gymnosperm

Choose the correct answer from the options given below.
(a) (A) - (ii), (B) - (iii), (C) - (i), (D) - (iv)
(b) (A) - (iii), (B) - (i), (C) - (ii), (D) - (iv)
(c) (A) - (iii), (B) - (iv), (C) - (ii), (D) - (i)
(d) (A) - (iii), (B) - (ii), (C) - (i), (D) - (iv)

30. Given below are two statements : One labelled as Assertion A and the other labelled as Reason R:

NCERT Page-36 / N-30 | 2023

Assertion A : The first stage of gametophyte in the life cycle of moss is protonema stage.

Reason R : Protonema develops directly from spores produced in capsule.

In the light of the above statements, choose the most appropriate answer from options given below:

(a) Both A and R are correct and R is the correct explanation of A
(b) Both A and R are correct but R is NOT the correct explanation of A
(c) A is correct but R is not correct
(d) A is not correct but R is correct

31. Identify the pair of heterosporous pteridophytes among the following :

NCERT Page-38 / N-32 | 2023

(a) *Lycopodium* and *Selaginella*
(b) *Selaginella* and *Salvinia*
(c) *Psilotum* and *Salvinia*
(d) *Equisetum* and *Salvinia*

32. Given below are two statements : One labelled as Assertion A and the other labelled as Reason R :

NCERT Page-39 / N-33 | 2023

Assertion A : In gymnosperms the pollen grains are released from the microsporangium and carried by air currents.

Reason R : Air currents carry the pollen grains to the mouth of the archegonia where the male gametes are discharged and pollen tube is not formed.

In the light of the above statements, choose the correct answer from the options given below :

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the current explanation of A
(c) A is true but R is false
(d) A is false but R is true

33. Read the following statements and choose the set of correct statements:

NCERT Page-N-26, 27 | 2024

In the members of Phaeophyceae,

A. Asexual reproduction occurs usually by biflagellate zoospores.
B. Sexual reproduction is by oogamous method only.
C. Stored food is in the form of carbohydrates which is either mannitol or laminarin.
D. The major pigments found are chlorophyll a, c and carotenoids and xanthophyll.
E. Vegetative cells have a cellulosic wall, usually covered on the outside by gelatinous coating of algin.

Choose the correct answer from the options given below:

(a) A, B, C and D only (b) B, C, D and E only
(c) A, C, D and E only (d) A, B, C and E only

Exercise 3 : Matching, Statement & Assertion Reason Type

Match the Following

1. Match the column-I with column-II and choose the correct option.

NCERT Page-29 & 30 / N-23, 24

Column-I (System of classification)		Column-II (Characteristics)	
A.	Artificial system of classification	I.	Based on few morphological characters
B.	Natural system of classification	II.	Based on evolutionary relationships between the various organisms
C.	Phylogenetic system of classification	III.	Based on natural affinities among the organisms and consider external as well as internal features.
D.	Numerical Faxonomy	IV.	Carried out using computer

(a) A – II; B – I; C – III; D – IV
(b) A – I; B – III; C – II; D – IV
(c) A – III; B – II; C – I; D – IV
(d) A – I; B – II; C – III; D – IV

2. Match the following columns.

NCERT Page-35,36 & 38 / N-29, 30

Column-I		Column-II	
A.	*Chlorella*	I.	Pteropsida
B.	*Adiantum*	II.	Marine algae
C.	*Sargassum*	III.	Moss
D.	Prothallus	IV.	Pteritophyta
		V.	Unicellular alga rich in proteins

(a) A – II; B – V; C – I; D – III
(b) A – V; B – IV; C – III; D – II
(c) A – V; B – I; C – II; D – IV
(d) A – III; B – II; C – I; D – V

3. Match the following NCERT Page-38 / N-32

Column-I (Classes)		Column-II (Examples)	
A.	Psilopsida	I.	*Dryopteris, Pteris, Adiantum*
B.	Lycopsida	II.	*Equisetum*
C.	Sphenopsida	III.	*Selaginella*
D.	Pteropsida	IV.	*Lycopodium*
		V.	*Psilotum*

(a) A – V; B – III; C – II; D – I
(b) A – I; B – II; C – III; D – IV
(c) A – IV; B – III; C – II; D – I
(d) A – III; B – V; C – I; D – II

4. Match column-I with column-II and choose the correct option. NCERT Page-30,36 & 38 / N-26, 27, 29 & 30

Column-I		Column-II	
A.	Phaeophyceae	I.	Have an elaborate mechanism of spore dispersal
B.	Rhodophyceae	II.	First terrestrial plant with vascular tissue-phloem and xylem
C.	Mosses	III.	Asexual reproduction by biflagellate zoosposes
D.	Pteridophytes	IV.	Polysiphonia, Porphyra, Gracilaria

(a) A – III; B – IV; C – I; D – II
(b) A – IV; B – III; C – I; D – II
(c) A – IV; B – III; C – II; D – I
(d) A – IV; B – I; C – III; D – II

5. Match the column-I with column-II and select the correct answer using the codes given below. NCERT Page-30,36 & 38 / N-24, 30, 34

Column-I (Group of Plant Kindgdom)		Column-II (Examples)	
A.	Algae	I.	*Solanum tuberosum*
B.	Fungi	II.	*Equisetum*
C.	Angiosperm	III.	*Cycas*
D.	Pteridophyte	IV.	*Chlamydomonas*
		V.	*Rhizopus*

(a) A – V; B – IV; C – I; D – II
(b) A – IV; B – V; C – I; D – II
(c) A – IV; B – I; C – V; D – II
(d) A – IV; B – I; C – V; D – III

6. Match the column-I with column-II and choose the correct option. NCERT Page-36,37 & 38 / N-29, 30, 34

Column-I		Column-II	
A.	Amphibian of the plant kingdom	I.	*Sphagnum*
B.	Specialized structures in liverworts for asexual reproduction	II.	Angiosperms
C.	Monocotyledons and dicotyledons	III.	Bryophytes
D.	A plant which has capacity to holding water	IV.	Gemmae

(a) A – III; B – IV; C – I; D – II
(b) A – III; B – IV; C – II; D – I
(c) A – IV; B – III; C – II; D – I
(d) A – III; B – II; C – IV; D – I

7. Select the correct match of the feature present in column I with its respective terms given in column II. NCERT Page-30,32 & 38 / N-24, 29, 30, 32, 34

Column-I (features)		Column-II (term)	
A.	Presence of tap roots and coralloid roots	I.	Bryophyte
B.	The synergids and antipodal cells degenerates after fertilization	II.	Pteridophytes
C.	The food is stored as floridean starch which is very similar to amylopectin and glycogen in structure	III.	Red algae
D.	Presence of sporophyte which is not free living but attached to the photosynthetic gametophytes and derives nourishment from it	IV.	Angiosperms
		V.	Gymnosperms

(a) A – I; B – II; C – III; D – IV
(b) A – III; B – V; C – II; D – IV
(c) A – III; B – I; C – V; D – II
(d) A – V; B – IV; C – III; D – I

Two Statement Type Questions

DIRECTION: *Read the statements carefully and answer the question on the basis of following options.*

(a) Both Statement I and Statement II are incorrect
(b) Statement I is correct but Statement II is incorrect
(c) Statement I is incorrect but Statement II is correct
(d) Both Statement I and Statement II are correct

8. **Statement I:** The pteridophytes are found in cool, damp, shady places
Statement II: In pteridophytes, the main plant body is a sporophyte. NCERT Page-36 / N-30

9. **Statement I:** Bryophytes are known as amphibians of the plant kingdom.
Statement II: The dominant phase in all Byophytes is gametophyte. NCERT Page-35 / N-29

10. **Statement I:** In numerical taxonomy observable characters are not given equal importance.
Statement II: More than 20 characters can't be studied at a time in numerical taxonomy. NCERT Page-30 / N-24

11. **Statement I:** Bryophytes are amphibians of plant kingdom.
Statement II: They live in soil but depend on water for sexual reproduction. NCERT Page-35 / N-29

12. **Statement I:** Main plant body of bryophytes is sporophytic.
Statement II: Main plant body of pteridophytes is gametophytic. NCERT Page-35, 36 / N-29, 30

Four/Five Statement Type Questions

13. Which of the following statement(s) about algae is/are correct? NCERT Page-32 / N-24
(i) Algae are chlorophyll bearing simple, thalloid, heterotrophic and aquatic (both fresh water and marine) organisms.
(ii) Algae reproduce by vegetative means only.
(iii) Fusion of two gametes dissimilar in size is termed as oogamous.
(iv) A few of the massive forms of algae such as kelps, form massive plant bodies.
(v) Algae are not useful to man.
(a) Only (i) (b) Both (i) and (v)
(c) Only (iv) (d) All of these

14. Which of the following statement(s) is/are correct about gemmae? NCERT Page-35 / N-29
(i) These are specialised structures by which asexual reproduction take place in liverworts.
(ii) They are green, multicellular and asexual buds.
(iii) They develop in small receptacles called gemma cups.
(iv) They detach from parent body and germinate to form new individuals.
(a) (i) and (ii) only
(b) (ii) and (iii) only
(c) (i), (ii) and (iii) only
(d) All of these

15. Refer to the following statement(s) and identify the group of plant which is being described by the given statements? NCERT Page-35 / N-29
(i) They include various mosses and liverworts that are found commonly growing in moist shaded areas in the hills.
(ii) They lack true roots, stem or leaves.
(iii) The main plant body is haploid.
(iv) They produce a multicellular body sporophyte which is not free living but attached to the photosynthetic gametophyte and derives nourishment from it.
(v) Its plant body is more differentiated than that of algae.
(a) Algae (b) Fungi
(c) Bryophytes (d) Pteridophytes

16. Which of the following group of plant is being described by the given statements? NCERT Page-38, 39 / N-32, 33
(i) They are plants in which the ovules are not enclosed by any ovary wall and remain exposed before and after fertilization.
(ii) The giant red wood tree *Sequoia* is one of the tallest tree species of the group.
(iii) The roots are generally tap roots.
(iv) They are heterosporous and they produce haploid microspores and megaspores.
(v) Roots in some genera have fungal association.
(a) Algae (b) Bryophytes
(c) Gymnosperms (d) Pteridophytes

17. Which of the following statements with respect to gymnosperms and angiosperms is/are correct? NCERT Page-38, 39, 40 / N-32, 33, 34
(i) The process of double fertilization is present in gymnosperms.
(ii) Angiosperms range in size from microscopic *Wolffia* to tall trees of *Sequoia.*
(iii) In gymnosperms, the seeds are not covered.
(iv) In gymnosperms, the male and female gametophytes have an independent free living existence.
Of the above statements
(a) (i) and (ii) (b) (iii) only
(c) (ii) and (iii) (d) (iii) and (iv)

18. Choose the correct statement about liverworts. NCERT Page-35, 36 / N-29, 30
(i) In liverworts, the antheridium and archegonium produce the antherozoid and the egg which fuse during sexual reproduction.
(ii) Both male and female sex organs may be present on same thalli or different thalli.
(iii) A sporophyte is formed from the zygote which is differentiated into the foot, seta and capsule.
(iv) Meiosis occurs in some cells of the capsule giving rise to haploid spores.
(v) The spores germinate to form free - living sporophytes.
(a) (i) and (v) only (b) (i), (ii) and (iii) only
(c) (iii) and (iv) only (d) (i), (ii), (iii) and (iv)

19. The correct statements about bryophytes are: NCERT Page-35 / N-29
(i) Sex organ in bryophytes are multicellular
(ii) The sperms are released into water which swim through water to fuse with the egg to produce the zygote outside the body.
(iii) Immediate reduction division occurs in zygotes.
(iv) A multicellular body called a sporophyte is then produced.
(v) The sporophyte is not -free living but attached to photosynthetic gametophyte.
(a) (i), (ii) and (iii) only (b) (i), (ii) and (iv), (v)
(c) (i) and (iv) only (d) (iii) and (iv) only

20. In mosses, the second gametophytic stage is leafy stage. Consider and choose the correct statements about leafy stage. NCERT Page-36 / N-30

(i) They consist of upright, slender axes bearing spirally arranged leaves.
(ii) This leafy stage bears the sex organs.
(iii) They are attached to the soil through multicellular rhizoids.
(iv) Leafy stage is produced from the secondary protonema as a lateral bud.

(a) (i) and (ii) only (b) (i), (iii) and (iv) only
(c) (iii) and (iv) only (d) (i), (ii), (iii) and (iv)

21. How many of the following statements is/are correct ? NCERT Page-36 / N-30

(i) In *Equisetum,* the female gametophyte is retained on the parent sporophyte.
(ii) In *Ginkgo,* male gametophyte is not independent.
(iii) The sporophyte in *Riccia* is more developed than that in *Polytrichum.*
(iv) Sexual reproduction in *Volvox* is isogamous.

(a) Two (b) Three
(c) Four (d) One

Assertion & Reason Questions

DIRECTION: *These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.*

(a) Both (A) and (R) are correct but (R) is not the correct explanation of (A)
(b) (A) is correct but (R) is not correct
(c) (A) is not correct but (R) is correct
(d) Both (A) and (R) are correct and (R) is the correct explanation of (A)

22. **Assertion :** *Chlorella* could be utilised to keep the air pure in space vehicles.
Reason : The space travellers feed on *Chlorella* soup. NCERT Page-32 / N-26

23. **Assertion:** The colour of brown algae varies from olive green to brown.
Reason: In brown algae, fucoxanthin is responsible for colour variation. NCERT Page-32 / N-26

24. **Assertion:** Archegonium is the female sex organ in bryophytes.
Reason: Algae also possess the archegonium. NCERT Page-35 / N-29

25. **Assertion:** Liverworts fail to spread to a new locality through fragmentation.
Reason: Gemmae are helpful in propagating liverworts in different locality. NCERT Page-35 / N-29

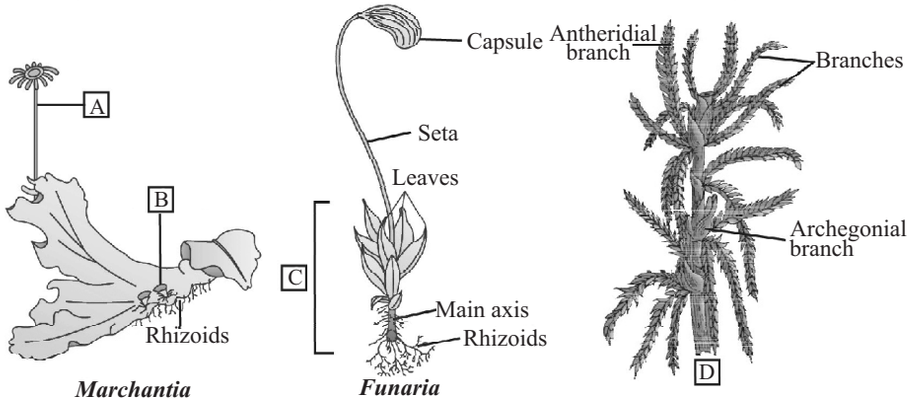
26. **Assertion:** *Selaginella* and *Salvinia* are homosporous.
Reason: In *Selaginella* and *Salvinia*, different kind of spores are produced. NCERT Page-38 / N-32

Exercise 4 : Skill Enhancer MCQs

1. Deep in the tropical rain forest, a botanist discovered an unusual plant with vascular tissues, stomata, a cuticle, flagellated sperm, cone-like reproductive structures bearing seeds, and an alternation-of-generations life cycle. He was very excited about this discovery because it would be rather unusual for a plant to have both

(a) a cuticle and flagellated sperm.
(b) vascular tissues and alternation of generations.
(c) seeds and flagellated sperm.
(d) alternation of generations and seeds

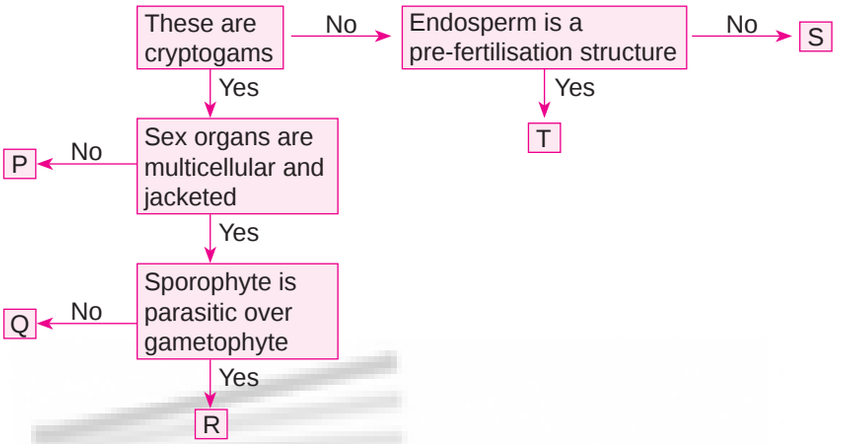
2. The given figures represent the examples of bryophytes. In them few structures/parts are marked as A, B, C and D.



Identify the option which shows the correct labelling of A, B, C and D.

S. No.	A	B	C	D
(a)	Gemma cup	Archegoniophore	Sporophyte	*Sphagnum*
(b)	Archegoniophore	Gemma cup	Gametophyte	*Sphagnum*
(c)	Archegonia	Antheridia	Gemma cup	*Sphagnum*
(d)	Antheridia	Archegonia	Gemma cup	*Sphagnum*

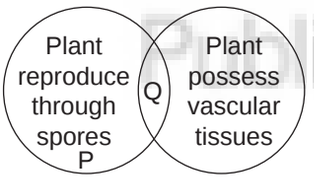
3. Refer to the given flow chart regarding different groups of kingdom plantae.



Which of the following is true regarding P,Q, R, S and T?

(a) Examples of group 'P' include *Riccia, Marchantia, Sphagnum* etc.
(b) Members of group 'R' can be both homosporous as well as heterosporous.
(c) Group 'Q' includes seedless vascular plants having sporophytic plant body.
(d) Group 'S' is more ancient than group 'T' and formed a dominant vegetation on earth same 200 million years back in Mesozoic era.

4. Refer to the given Venn diagram and select the correct option regarding P and Q



(a) P could be an alga or a bryophyte whereas Q could be a pteridophyte.
(b) True roots, stems and leaves are present in P but absent in Q.
(c) Anthridium in Q is sessile whereas that in P (If present is stalked)
(d) P is exclusively xerophytic whereas Q is amphibious by nature.

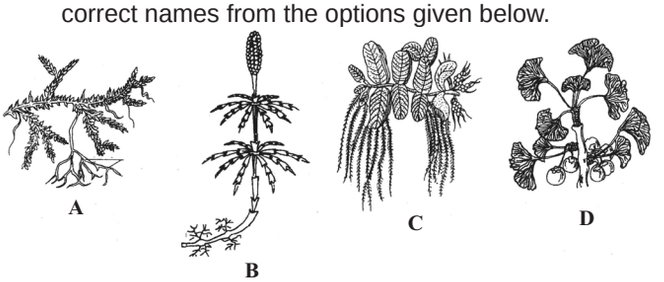
5. Refer the given table

	Vascular tissue	Seeds	Fruits
Plant W	✓	✓	✓
Plant X	×	×	×
Plant Y	✓	×	×
Plant Z	✓	✓	×

Identify plants W, X, Y & Z and select the incorrect option regarding them.

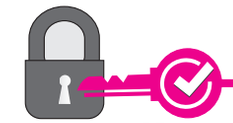
(a) X could be a moss wherein capsule consists of peristome teeth and sterile columnella.
(b) Y could be a fern whose stems are used in scouring and polishing metals.
(c) Z could be a conifer which possesses triploid endosperm as a post-fertilisation structure.
(d) W could be a dicot that undergoes double fertilisation.

6. Identify the plants (A, B, C and D) and choose their correct names from the options given below.



S. No.	A	B	C	D
(a)	*Equisetum*	*Ginkgo*	*Selaginella*	*Lycopodium*
(b)	*Selaginella*	*Equisetum*	*Salvinia*	*Ginkgo*
(c)	*Funaria*	*Adiantum*	*Salvinia*	*Riccia*
(d)	*Chara*	*Marchantia*	*Fucus*	*Pinus*

7. Refer to the statement and answer the question.
"They usually reproduce vegetatively by fragmentation and asexually by non - motile spores and sexually by non - motile gametes."
Identify the group of plants and its example.
(a) Mosses, *Funaria*
(b) Red algae, *Polysiphonia*
(c) Brown algae, *Laminaria*
(d) Pteridophytes, *Selaginella*



Answer Keys

Exercise-1 (NCERT Based Topic-wise MCQs)																			
1	(a)	**6**	(a)	**11**	(b)	**16**	(b)	**21**	(a)	**26**	(b)	**31**	(c)	**36**	(d)	**41**	(b)		
2	(b)	**7**	(d)	**12**	(b)	**17**	(a)	**22**	(a)	**27**	(d)	**32**	(a)	**37**	(a)	**42**	(d)		
3	(b)	**8**	(c)	**13**	(b)	**18**	(d)	**23**	(b)	**28**	(b)	**33**	(d)	**38**	(d)	**43**	(d)		
4	(d)	**9**	(c)	**14**	(a)	**19**	(c)	**24**	(a)	**29**	(d)	**34**	(c)	**39**	(d)	**44**	(d)		
5	(b)	**10**	(d)	**15**	(c)	**20**	(a)	**25**	(d)	**30**	(d)	**35**	(d)	**40**	(d)	**45**	(a)		
Exercise-2 (NCERT Exemplar & Past Years NEET)																			
1	(c)	**5**	(d)	**9**	(c)	**13**	(c)	**17**	(c)	**21**	(d)	**25**	(a)	**29**	(c)	**33**	(c)		
2	(c)	**6**	(a)	**10**	(a)	**14**	(a)	**18**	(c)	**22**	(d)	**26**	(b)	**30**	(a)				
3	(d)	**7**	(d)	**11**	(c)	**15**	(b)	**19**	(d)	**23**	(b)	**27**	(a)	**31**	(b)				
4	(c)	**8**	(d)	**12**	(d)	**16**	(c)	**20**	(b)	**24**	(a)	**28**	(a)	**32**	(c)				
Exercise-3 (Matching, Statement & Assertion Reason Type)																			
1	(b)	**4**	(a)	**7**	(d)	**10**	(a)	**13**	(c)	**16**	(c)	**19**	(b)	**22**	(a)	**25**	(a)		
2	(c)	**5**	(b)	**8**	(d)	**11**	(d)	**14**	(d)	**17**	(b)	**20**	(d)	**23**	(d)	**26**	(c)		
3	(a)	**6**	(b)	**9**	(d)	**12**	(a)	**15**	(c)	**18**	(d)	**21**	(a)	**24**	(b)				
Exercise-4 (Skill Enhancer MCQs)																			
1	(c)	**2**	(b)	**3**	(c)	**4**	(a)	**5**	(c)	**6**	(b)	**7**	(b)						

3 Plant Kingdom

EXERCISE - 1

1. **(a)** Plant classification proposed by Carolus Linneaus was artificial because it was based on a few morphological characters such as habit, colour, number and shape of leaves, etc.

2. **(b)** Chemotaxonomy is based on chemical products particularly secondary metabolites. Various families of plants have been identified on the basis of **raphides** (Crystals of calcium oxalates).

3. **(b)** Cytotaxonomy is the classification of organisms based on cellular structure and function, especially on the structure and number of chromosomes.

4. **(d)** Phylogenetic system of classification indicates the evolutionary as well as genetic relationships among organisms. It is based on fossil record, biochemical, anatomical, morphological, embryological, physiological, genetics, karyotype and other studies.

5. **(b)** The natural system of classification for higher plants was given by **Bentham** and **Hooker** in their ***Genera Plantarum*** (1862 - 1883). The characters employed in this system include those of study of form (morphology), internal structure (anatomy), development (embryology), reproduction, cell structure (cytology), life processes, (physiology), behaviour and biochemistry.

6. **(a)**

7. **(d)** Numerical taxonomy evaluates resemblances and differences or primitiveness and advancement through statistical methods based on a large number of characters obtained from all disciplines of biology. This is followed by assigning them number and code of computer like plus (+) and minus (–) followed by computer analysis. In this way, each character is given equal importance and at the same time hundreds of characters can be considered.

8. **(c)** Chemotaxonomy is based upon the characteristics of various contituents of organisms.

9. **(c)** **10.** **(d)** **11.** **(b)**

12. **(b)** Rhodophyta are commonly called as red algae because of the predominance of the red pigment (r – phycoerythrin) in their body. They occur in both well lighted regions close to the surface of water and also at great depths in ocean where relatively little light penetrates. They exhibit a red colour because the wavelengths of light that are absorbed by chlorophyll are passed to phycoerythrin.

13. **(b)** Certain marine brown and red algae produce large amounts of hydrocolloids (water holding substances), e.g., **algin** (brown algae) and **carrageen** (red algae) which are used commercially. *Chlorella* and *Spirullina* are unicellular green algae, which are rich in proteins and used as food supplements.

14. **(a)** Pyrenoids are the rounded bodies found in the chloroplast of green algae and are the centres of conversion of glucose to starch and also collection of starch.

15. **(c)** Algae are defined as chlorophyllous, thalloid avascular plants with no cellular differentiation. The size and form of algae is highly variable. Not all the algae are filamentous. The size ranges from the microscope unicellular forms to colonial forms and to the filamentous forms.

16. **(b)** *Chlamydomonas*, *Volvox, Ulothrix, Spirogyra* and *Chara* are green algae. The common forms of brown algae are *Ectocarpus*, *Dictyota*, *Laminaria, Sargassum* and *Fucus*. *Polysiphonia, Porphyra, Gracilaria* and the *Gelidium* are members of red algae.

17. **(a)** In green algae (chlorophyceae), the photosynthetic pigments are chlorophyll *a* and *b*, carotenes and xanthophylls. In phaeophyceae (brown algae), the pigments are chlorophyll *a, c* and carotenes and fucoxanth. Rhodophyceae are red algae and contain the major pigment as chlorophyll a and phycoerythrin. Phycoerythrin gives red colour to rhodophyceae.

18. **(d)** The classification of algae can be visually done easily on the basis of colours, due to the presence of different pigments inside them.

19. **(c)** Rhodophyceae is red algae in which food is stored as floridean starch which is very similar to amylopectin and glycogen in structure.

20. **(a)** Asexual reproduction (in algae) is by the production of different types of spores, and the most common type is zoospore. Zoospores are flagellated (motile) and on germination give rise to new plants.

21. **(a)** In class phaeophyceae, the plant body is usually attached to the substratum by a **holdfast** (A), and has a stalk, the **stipe** (B) and leaf like photosynthetic organ - the **frond** (C).

22. **(a)** The number of chromosomes of the second generation will be same because no reduction division take place.

23. **(b)** Bryophytes completely lack vascular tissue system and absorb water by generally body surface. Whereas pteridophytes are the first terrestrial plants to possess vascular tissues -xylem and phloem.

24. **(a)** A protonema is a creeping, green, filamentous, thread-like chain of cells which is produced by the germination of the spores and forms the earliest stage (the haploid phase) of a bryophyte life cycle. When a moss first grows from the spore, it grows as a protonema which develops into a leafy gametophore.

25. **(d)** Mosses along with lichens are the first organisms to colonise rocks and hence, are of great ecological importance. They decompose rocks making the substrate suitable for the growth of higher plants. Since mosses form dense mats on the soil, they reduce the impact of falling rain and prevent soil - erosion.

26. **(b)** Mosses are non-vascular plants which means they cannot transport water and nutrients to the aerial parts of the plant.

27. **(d)** Bryophytes have thallus like body and lack vascular tissue.

28. **(b)** According to the features described, the unknown plant belongs to bryophytes. Bryophytes refer to a group of plants comprising the mosses, liverworts, and hornworts. They do not have a true vascular system and are unable to pull water and nutrients up from the ground at any significant distance. This distinguishes bryophytes from ferns and flowering plants.

29. **(d)** Species of *Sphagnum*, a moss, provides peat that have long been used as a packing material for sending flowers and live plants to distant places because it is hygroscopic.

30. **(d)** In bryophytes, zygotes donot undergo reduction division immediately. They produce a multicellular body called a sporophyte. The sporophyte is not a free-living but attached to the photosynthetic gametophyte and derives nourishment from it.

31. **(c)** In bryophytes, sex organs are of two types, male antheridium and female archegonium. They are multicellular and jacketed, *i.e*., covered by jacket of sterile cells.

32. **(a)** The predominant stage of the moss is the presence of gametophyte which consists of two stages – the first stage is protonema and the second stage is leafy stage. Protonema stage develops directly from the spores and leafy stage develops from the secondary protonema as a lateral bud.

33. **(d)** All the given statements are correct.

34. **(c)** Fusion of male gamete with the egg results in the formation of zygote. This zygote produces a multi-cellular well differentiated sporophyte which is the dominant phase of the pteridophytes.

35. **(d)** Gametophyte of bryophytes bears protonemal and leafy stage. In gymnosperm, female gametophyte is not free living. Antheridiophores and archegoniophores are present in *Marchantia* which is a bryophyte. Origin of seed habit started in pteridophyte.

36. **(d)** The leaves in gymnosperms are well adapted to withstand extremes of temperature, humidity and wind. In conifers, the needle like leaves reduces surface area. Their thick cuticle and sunken stomata also help to reduce water loss.

37. **(a)** *Selaginella* is a member of lycopsida, which produce two kinds of spores-macro (large) and micro (small) spores. Thus, known as heterosporous pteridophytes.

38. **(d)** Pteridophytes are classified into four classes: Psilopsida (*Psilotum*), Lycopsida (*Selaginella, Lycopodium*), Sphenopsida (*Equisetum*) and Pteropsida (*Dryopteris, Pteris, Adiantum*).

39. **(d)** Mosses and ferns belong to bryophtes and pteridophytes respectively. In bryophytes, the dominant phase in the life cycle is the gametophytic plant body. However, in pteridophytes, the main plant body is a sporophyte, which is differentiated into true root, stem and leaves. These organs possess well – differentiated vascular tissues.

40. **(d)** Pteridophytes are the vascular plants (those having xylem and phloem tissues) that reproduce by releasing spores rather than seeds, and they include the highly diverse true ferns and other graceful, primarily forest-dwelling plants. The spreading of living pteridophytes is limited and is restricted to narrow geographical region because its gametophytes require cool, damp, shady places to grow and also it requires water for fertilization.

41. **(b)** *Cycas* (a gymnosperm) and *Adiantum* (known as Maiden hair fern, a pteridophyte) resemble each other in having motile sperms. Seeds, cambium are common in gymnosperms but absent in pteridophytes. True vessels are absent in both pteridophytes and gymnosperms.

42. **(d)** The ovules are not enclosed inside the ovary. Instead they are borne naked on the leafy sporophylls, and hence the name gymnosperms (gymnos- naked sperma- seed) is given Double fertilization is absent in gymnosperms.

43. **(d)** In gymnosperms, the reproductive structures are mostly in the form of compact cones except female organs of *Cycas*. There are two types of sporophylls, usually segregated to form distinct cones or strobili (male and female cones).

44. **(d)** **45.** **(a)**

EXERCISE - 2

NCERT Exemplar Questions

1. **(c)** Lower group of plants like algae exhibit great variation in mode of sexual and asexual reproduction. Some algae produce gametes which are not similar in shape, size and structure. Their fusion is called anisogamy. e.g., *Chlamydomonas*. Isogamy is the fusion of similar gametes, zoogamy is sexual reproduction of animals.

2. **(c)** **Phaeophyceae :** In the members of the class-Phaeophyceae, the plant body is usually attached to the substratum by means of a holdfast and has a stalk called stipe and a leaf like photosynthetic organ called frond.

3. **(d)** **Bryophyta** is a group of plants which have gametophytic haploid thalloid body. The motile male gametes are produced in special male reproductive structures called antheridia.
These gametes need thin film of water to swim and reach the female reproductive organ called archegonia. Pteridophytes, gymnosperm and monocots show higher level of organisation.

4. **(c)** **Prothallus** is usually a gametophytic phase in the life of a pteridophyte. Spore germinates to form a prothalium, it is short lived inconspicuous heart shaped structure with a number of rhizoids developed beneath and bears sex organs, archegonium and antheridium.

5. **(d)** **Gymnosperms** include medium sized or tall trees and shrubs. Their plants are well adapted to withstand extremes of temperature, humidity and wind. Reproductive organs are usually in the form of cones or strobili.
The male cones are made up of microsporophyll and female cones are made up of megasporophyll. The presence of sporophyll (micro and megasporophyll) shows the development of seed habit but seeds develop from naked ovule and are not covered.

6. **(a)** The germination of **haploid** spores of mosses produced by sporophyte after reductional division form the protonema. This structure later develops into an independent gametophytic plant.

7. **(d)** *Sequoia sempervirens* is a gymnosperm. It has thick, woody and branched stems. The plant also shows some xeric adaptations which helps it to survive in adverse climatic conditions.

Past Years NEET

8. **(d)** Bryophytes neither have pollen nor flowers and rely on water to carry the male gametes (sperm) to the female gametes (eggs). The antherozoids (male gametes of pteridophytes) are armed with hair-like or whip-like cilia or flagellae and are able to swim through water; they do not travel great distances and are only released when free water is available.

9. **(c)** *Sequoia semepervirans* is one of the tallest trees.

10. **(a)** *Volvox* is motile colonial fresh water green alga. It forms spherical colonies.
11. **(c)** *Chlamydomonas* has haplontic life cycle hence, shows zygotic meiosis.
12. **(d)** *Pinus* is a monoecious plant comprising of both male and female cones on same plant.
13. **(c)** Winged pollen grains are present in *Pinus*. Each pollen grain has two wing-like structures which enables it to float in air, as an adaptation for dispersal by the wind.
14. **(a)** The gymnosperms are a group of seed-producing plants. The name is based on the unenclosed condition of their seeds (called ovules in their unfertilized state).
15. **(b)** Fungus associated with roots of *Pinus* increases minerals & water absorption for the plant by increasing surface area and in turn fungus gets food from plant. Therefore, mycorrhizal association is obligatory for *Pinus* seed germination.
16. **(c)** In Pteridophyte, megaspore is retained for some time in female gametophyte, however the permanent retention is required for seed formation in Gymnosperms. That's why Pteridophytes exhibit precursor to seed habit only.
17. **(c)** *Chlorella* and *Spirulina* are unicellular algae. *Gelidium*, *Gracilaria*, *Laminaria* and *Sargassum* are multicellular. Volvox is colonial.
18. **(c)** Strobili or cones are found in *Equisetum*. Strobili or **cones** are the dense and compact structure **present** on non flowering plants. They contain sporangia and perform function of protecting spores from wild animals and harsh conditions of environment.
19. **(d)** Floridean starch is stored food material in red algae. Its structure is similar to Amylopectin and Glycogen.
20. **(b)** Phycoerythrin is the major pigment in red algae or rhodophytes. The photosynthetic pigments in red algae include chlorophyll-a, carotenoids and phycobilins. Phycoerythrin belongs to the phycobilins. These pigments are soluble in water.
Phycoerythrin (PE) is a red protein pigment complex produced by the light-harvesting phycobiliprotein family. It is present in red algae and cryptophytes as an accessory to the main chlorophyll pigments responsible for photosynthesis.
21. **(d)** Male and female gametophyte do not have an independent free-living existence in gmnosperms and angiosperms. In them they remains within the sporangia retained on the sporophytes. The pollen grain is released from the microsporangium and are carried in air currents and come in contact with the opening of the ovules borne on megasporophylls. The pollen tube carrying the male gametes grows towards archegonia in the ovules and discharge their contents near the mouth of the archegonia.
22. **(d)** Algae are eukaryotic organisms with different chemical components in their cell wall.
Algae cell wall is composed of agar, carrageen and funori along with cellulose.
Cell wall of brown algae contains algin while in green alage it is composed of cellulose and pectin.
In blue green algae cell wall is composed of mucopeptides.
23. **(b)** *Ectocarpus* belongs to class-Phaeophyceae, in which reserve food is found in form of laminarin, mannitol and oil.
Ulothrix and *Volvox* belong to chlorophyceae (green algae). Members of this class have starch as reserve food material. Gracilaria is a member of red alage (Rhodophyceace). This class is characterised by having Floridean starch as stored food material.
24. **(a)** The gemmae are green, small discs of haploid tissue, and they directly give rise to new gametophytes. They are produced by some liverworts like marchantia.
Mosses reproduce vegatatively by fragmentation and budding of protonema.
Pteridophytes and Gymnosperms **normally do not reproduce asexually**.
25. **(a)** Genera like Selaginella and Salvinia which produce two kinds of spores i.e. macro (large) and micro (small) spores, are known as **heterosporous**.
Most of the pteridophytes produce single type of spores and are called **homosporus**.
Sorus are brownish or yellowish cluster of spores producing structures located on the lower surface of fern leaves.
26. **(b)** Hydrocolloid carrageen is obtained from red algae (rhodophyceae).
27. **(a)** Ulothrix belong to Chlorophyceae (green algae). Members of this class have starch as reserve food material.
28. **(a)** Spirogyra is a green algae which have dominant haploid –free living gametophyte. Fern is a pteridophyte having dominant sporophyte alternating with reduced gametophyte.
29. **(c)**
30. **(a)** Both the assertion and reason is correct and reason is the correct explanation of assertion. The predominant stage of life cycle of moss is gametophyte which consist of 2 stages. The first stage is protonema that directly develops from spore.
31. **(b)** Pteridophytes that produce two types of spores are known as heterosporous. *Selaginella* and *Salvinia* are heterosporous pteridophytes.
32. **(c)** Assertion is correct but reason is false as in gymnosperms the pollen grains are released from the microsporangium and they are carried in air currents. They come in contact with the opening of the ovules borne on megasporophylls. The pollen tube carrying the male gametes grows towards archegonia in the ovules and discharge their contents near the mouth of the archegonia.
33. **(c)** In Phaeophyceae sexual reproduction can occur by oogamy, isogamy or anisogamy .
Hence correct statements are A, C, D and E.

EXERCISE - 3

1. **(b)** A – I, B – III, C – II, D – IV
2. **(c)** A – V, B – I, C – II, D – IV
3. **(a)** A – V, B – III, C – II, D – I
4. **(a)** A – III, B – IV, C – I, D – II
5. **(b)** A – IV, B – V, C – I, D – II
6. **(b)** A – III, B – IV, C – II, D – I
7. **(d)** A – V, B – IV, C – III, D – I
8. **(d)** **9.** **(d)**
10. **(a)** In numerical taxonomy numbers and codes are assigned to each observable characteristics and the data is then processed. In this way each character is given equal importance and at the same time hundreds of characters can be considersed.
11. **(d)** Bryophytes are known as 'amphibians of plant kingdom'. In their vegetative structure, bryophytes have become adapted to land but they depend on water for sexual reproduction because the swimming habit is retained by their sperms.

12. **(a)** Main plant body is gametophytic in bryophytes and sporophytic in pteridophytes.

13. **(c)** Algae are chlorophyll bearing simple, thalloid, autotrophic and largely aquatic organisms. They reproduce by vegetative, asexual and sexual methods. Fusion of two gametes dissimilar in size is termed as anisogamous.

14. **(d)** Gemmae are a means of asexual reproduction found in many bryophytes (e.g, liverworts). They are 1 to many celled, specially produced clonal plant fragments. They are green, multicellular, asexual buds which develop in small receptacles (called gemma cups) located on the thalli. Gemmae become detached from the parent body and germinate to form new individuals.

15. **(c)** Bryophytes are small, non-vascular plants, such as mosses, liverworts and hornworts. Bryophytes do not have seeds or flowers. Instead they reproduce via spores.

16. **(c)** Gymnosperms are seed-bearing vascular plants, such as cycads, ginkgo, yews and conifers, in which the ovules or seeds are not enclosed in an ovary. Gymnosperm seeds develop either on the surface of scale or leaf-like appendages of cones or at the end of short stalk. The largest group of living gymnosperms are the conifers (pines, cypresses and relatives) and the smallest is ginkgo, a single living plant species found in China.

17. **(b)** Double fertilization is a characteristic of angiosperms not gymnosperms. But in both of these two groups, gametophytic phase is highly reduced and is retained inside sporophytic structures. Sequoia is the tallest gymnosperm not angiosperm. Tallest angiosperm belong to the genus *Eucalyptus*.

18. **(d)** Sexual reproduction occurs by the formation of sex organs born on special branches. The male antheridia are produced on antheridiophore and the female reproductive organs are 'archegonia'. They are borne on special stalked structures called archegoniophore. Both male and female sex organs may be present on same thalli or different thalli. After fertilisation, the egg becomes zygote, which grows to form sporophyte. It is differentiated into foot, seta and capsule. Inside the capsule, the diploid spore mother cells divide by meiosis and produce haploid spores. These spores germinate to form free-living gametophytes.

19. **(b)** Minute, slender, spirally curved body furnished with two long, terminal whiplash type flagella is usually seen in bryophyte sperms. The sperms once liberated from antheridia, in the presence of water swim and are attracted towards the archegonium. They enter and fertilise the egg in the archegonia and form a zygote. The zygote does not undergo immediate reduction division. A multicellular body called a sporophyte is produced.

20. **(d)** All the statements are correct. In mosses, vegetative reproduction occurs through fragmentation or through bud in secondary protonema.

21. **(a)** Statement (i) and (ii) are correct.
Riccia is liverwort in which simplest sporophyte consists of capsule only while *Polytrichum* is moss in which sporophyte consists of foot, seta & capsule. *Volvox* is a fresh water green colonial alga. Reproduction is both sexual and asexual in *Volvox*. Sexual reproduction is of oogamous type.

22. **(a)** Chlorella could be utilised to keep the air in space vehicles pure and supply food in space stations and prolonged space flight trips. The space travellers could feed on Chlorella soup. It is nourishing but not appetizing food.

23. **(d)** Brown algae show a range of colour from olive green to various shades of brown depending upon the amount of fucoxanthin, xanthophyll pigment, present in them.

24. **(b)** Archegonium is the female sex organ of the bryophytes. It appears for the first time in the liverworts and mosses and continues in the pteridophytes. Archegonium is absent in thallophytes (algae and fungi).

25. **(a)** Fragmentation leads to an increase in the number of plants in a locality but it does not permit the spread of the plant to an entirely new locality. Gemmae are easily carried as they are small and sufficiently buoyant. They spread by water and wind currents to new habitats when detached, and each grows into a new individual immediately.

26. **(c)** All the spores are of similar kinds in majority of the pteridophytes; such plants are called homosporous. Genera like Selaginella and Salvinia produce two kinds of spores i.e. macro (large) spores and micro (small) spores, hence, are known as heterosporous.

EXERCISE - 4

1. **(c)** No known seed plant has flagellated sperms.

2. **(b)** A – Archegonia, B – Gemma cup, C – Gametophyte, D – *sphagnum*

3. **(c)** Cryptogams are the plants without seeds. In the given flow chart 'P' represent algae in which sex organ are usually unicellular and non-jacketed. 'Q' represent pteridophytes, in which both sporophytic and gametophytic generation are independent. In pteridophytes, the main plant body is sporophyte which is differentiated into tree root, stem and leaves. 'R' represent bryophytes in which diploid sporophytic lives as a parasite on an independent haploid gametophyte. All known members of bryophytes have been found to be homosporus. 'S' and 'T' respectively represent angiosperm and gymnosperm which are included under phanerogams. Gymnosperms evolved earlier and thus are more ancient than angiosperms. Gymnosperms formed dominant flora on earth about 200 million years ago in the Mesozoic era.

4. **(a)** According to the given Venn diagram, P could be an alga or a bryophyte and Q could be a pteridophyte. Algae are aquatic and bryophytes are amphibious. Pteridophytes also inhabit moist and shady places butsome are xerophytic also.

5. **(c)** In the given table, W is an angiosperm, X could be an alga or bryophyte, Y is a pteridophyte and Z is a gymnosperm. In gymnosperms, endosperm is haploid pre-fertilisation structure.

6. **(b)** The correct name of the plants A, B, C and D are respectively *Selaginella*, *Equisetum*, *Salvinia* and *Ginkgo*. The first three plants belong to pteridophytes and the fourth one belongs to gymnosperms.

7. **(b)** The red algae usually reproduce vegetatively by fragmentation, asexually by non-motile spores and sexually by non-motile gametes. Red algae is the common name of Rhodophyta. They are called red algae because of the presence of red pigment, r-phycoerythrin.