


## INSTRUCTIONS

1. This test will be a 3 hours Test.
2. This test consists of Physics, Chemistry and Mathematics questions with equal weightage of 100 marks.
3. Each question is of 4 marks.
4. There are three sections in the question paper consisting of Physics (Q.no. 1 to 30), Chemistry (Q.no. 31 to 60 ) and Mathematics (Q. no. 61 to 90 ). Each section is divided into two parts, Part I consists of 20 multiple choice questions \& Part II consists of 10 Numerical value type Questions.
5. There will be only one correct choice in the given four choices in Part I. For each question 4 marks will be awarded for correct choice, 1 mark will be deducted for incorrect choice for Part I Questions and zero mark will be awarded for not attempted question. For Part II Questions 4 marks will be awarded for correct answer and zero for unattempted and incorrect answer.
6. Any textual, printed or written material, mobile phones, calculator etc. is not allowed for the students appearing for the test.
7. All calculations / written work should be done in the rough space / sheet provided.

## PHYSICS

## PART-I (Multiple Choice Questions)

1. The reading of the ammeter for a silicon diode in the given circuit is :
(1) 0
(2) 15 mA
(3) 11.5 mA
(4) 13.5 mA

2. Given below are two statements: One is labelled as assertion (A) and the other is labelled as Reason (R).

Assertion (A): The stretching of a spring is determined by the shear modulus of the material of the spring.
Reason (R): A coil spring of copper has more tensile strength than a steel spring of same dimensions.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Both (A) and (R) are true and (R) is not the correct explanation of (A)
(2) (A) is true but (R) is false
(3) (A) is false but (R) is true
(4) Both (A) and (R) are true and (R) is the correct explanation of (A).
3. Two identical strings $X$ and $Z$ made of same material have tension $T_{X}$ and $T_{Z}$ in them. If their fundamental frequencies are 450 Hz and 300 Hz , respectively, then the ratio $T_{X} / T_{Z}$ is:
(1) 2.25
(2) 0.44
(3) 1.25
(4) 1.5
4. A conducting wire of cross-sectional area $1 \mathrm{~cm}^{2}$ has $3 \times 10^{23}$ charge carriers per $\mathrm{m}^{3}$. If wire carries a current of 24 mA , then drift velocity of carriers is
(1) $5 \times 10^{-2} \mathrm{~m} / \mathrm{s}$
(2) $0.5 \mathrm{~m} / \mathrm{s}$
(3) $5 \times 10^{-3} \mathrm{~m} / \mathrm{s}$
(4) $5 \times 10^{-6} \mathrm{~m} / \mathrm{s}$
5. Two stars each of mass $M$ and radius $R$ are approaching each other for a head-on collision. They start approaching each other when their separation is $r \gg R$. If their speeds at this separation are negligible, the speed $v$ with which they collide would be
(1) $v=\sqrt{G M\left(\frac{1}{R}-\frac{1}{r}\right)}$
(2) $v=\sqrt{G M\left(\frac{1}{2 R}-\frac{1}{r}\right)}$
(3) $v=\sqrt{G M\left(\frac{1}{R}+\frac{1}{r}\right)}$
(4) $v=\sqrt{G M\left(\frac{1}{2 R}+\frac{1}{r}\right)}$
6. A block of mass M is kept on a platform which is accelerated upward with a constant acceleration ' $a$ ' during the time interval $T$. The work done by normal reaction between the block and platform is

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(1) $-\frac{\mathrm{MgaT}^{2}}{2}$
(2) $\frac{1}{2} \mathrm{M}(g+a) \mathrm{aT}^{2}$
(3) $\frac{1}{2} \mathrm{Ma}^{2} \mathrm{~T}$
(4) Zero
7. A large number of water drops each of radius $r$ combine to have a drop of radius $R$. If the surface tension is $T$ and the mechanical equivalent of heat is J , then the rise in temperature will be
(1) $\frac{2 T}{r J}$
(2) $\frac{3 T}{R J}$
(3) $\frac{3 T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$
(4) $\frac{2 T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$
8. Three charges are placed at the vertices of an equilateral triangle of side ' $a$ ' as shown in the following figure. The force experienced by the charge placed at the vertex $A$ in a direction normal to $B C$ is

(1) $Q^{2} /\left(4 \pi \varepsilon_{0} a^{2}\right)$
(2) $-Q^{2} /\left(4 \pi \varepsilon_{0} a^{2}\right)$
(3) Zero
(4) $Q^{2} /\left(2 \pi \varepsilon_{0} a^{2}\right)$
9. Axis of a solid cylinder of infinite length and radius R lies along y-axis, it carries a uniformly distributed current $i$ along +y direction. Magnetic field at a point $\left(\frac{R}{2}, y, \frac{R}{2}\right)$ is
(1) $\frac{\mu_{0} \mathrm{i}}{4 \pi \mathrm{R}}(\hat{\mathrm{i}}-\hat{\mathrm{k}})$
(2) $\frac{\mu_{0} i}{2 \pi R}(\hat{j}-\hat{k})$
(3) $\frac{\mu_{0} \mathrm{i}}{4 \pi \mathrm{R}} \hat{\mathrm{j}}$
(4) $\frac{\mu_{0} \mathrm{i}}{4 \pi \mathrm{R}}(\hat{\mathrm{i}}+\hat{\mathrm{k}})$
10. Two identical short bar magnets, each having magnetic moment of $10 \mathrm{Am}^{2}$, are arranged such that their axial lines are perpendicular to each other and their centres be along the same straight line in a horizontal plane. If the distance between their centres is 0.2 m , the resultant magnetic induction at a point midway between them is

$$
\left(\mu_{0}=4 \pi \times 10^{-7} \mathrm{Hm}^{-1}\right)
$$

(1) $\sqrt{2} \times 10^{-7}$ tesla
(2) $\sqrt{5} \times 10^{-7}$ tesla
(3) $\sqrt{2} \times 10^{-3}$ tesla
(4) $\sqrt{5} \times 10^{-3}$ tesla
11. Two boys are standing at the ends $A$ and $B$ of a ground where $A B=a$. The boy at $B$ starts running in a direction perpendicular to $A B$ with velocity $v_{1}$. The boy at $A$ starts running simultaneously with velocity $v$ and catches the other boy in a time $t$, where $t$ is
(1) $a / \sqrt{v^{2}+v_{1}^{2}}$
(2) $a /\left(v+v_{1}\right)$
(3) $a /\left(v-v_{1}\right)$
(4) $\sqrt{a^{2} /\left(v^{2}-v_{1}^{2}\right)}$
12. A block is placed on a rough horizontal plane. A time dependent horizontal force $F=\mathrm{k} t$ acts on the block. Here, $k$ is a positive constant. The acceleration-time graph of the block is
(1)

(2)

(3)

(4)

13. A new system of units is proposed in which unit of mass is $a \mathrm{~kg}$, unit of length is $\beta \mathrm{m}$ and unit of time is $\gamma \mathrm{s}$. What wil be value of 5 J in this new system?
(1) $5 \alpha \beta^{2} \gamma^{-2}$
(2) $5 \alpha^{-1} \beta^{-2} \gamma^{2}$
(3) $5 \alpha^{-2} \beta^{-1} \gamma^{-2}$
(4) $5 \alpha^{-1} \beta^{2} \gamma^{2}$
14. When photon of energy 4.25 eV strike the surface of a metal A , the ejected photoelectrons have maximum kinetic energy $\mathrm{T}_{\mathrm{A}} \mathrm{eV}$ and de-Brolie wavelength $\lambda_{\mathrm{A}}$. The maximum kinetic energy of photoelectrons liberated from another metal $B$ by photon of energy 4.70 eV is $\mathrm{T}_{\mathrm{B}}=\left(\mathrm{T}_{\mathrm{A}}-1.50\right) \mathrm{eV}$. If the deBroglie wavelength of these photoelectrons is $\lambda_{\mathrm{B}}=2 \lambda_{\mathrm{A}}$, then
(1) the work function of A is 3.40 eV
(2) the work function of B is 6.75 eV
(3) $\mathrm{T}_{\mathrm{A}}=2.00 \mathrm{eV}$
(4) $\mathrm{T}_{\mathrm{B}}^{\mathrm{A}}=2.75 \mathrm{eV}$
15. Given is the graph between $\frac{P V}{T}$ and $P$ for 1 g of oxygen gas at two different temperatures $T_{1}$ and $T_{2}$, as shown in figure. Given, density of oxygen $=1.427 \mathrm{~kg} \mathrm{~m}^{-3}$. The value of $P V / T$ at the point $A$ and the relation between $T_{1}$ and $T_{2}$ are respectively

(1) $0.259 \mathrm{~J} \mathrm{~K}^{-1}$ and $T_{1}<T_{2}$
(2) $8.314 \mathrm{~J} \mathrm{~mol}^{-1} \mathrm{~K}^{-1}$ and $T_{1}>T_{2}$
(3) $0.259 \mathrm{~J} \mathrm{~K}^{-1}$ and $T_{1}>T_{2}$
(4) $4.28 \mathrm{~g} \mathrm{~J} \mathrm{~K}^{-1}$ and $T_{1}<T_{2}$
16. The figure shows a system of two concentric spheres of radii $r_{1}$ and $r_{2}$ are kept at temperatures $T_{1}$ and $T_{2}$, respectively. The radial rate of flow of heat in a substance between the two concentric spheres is proportional to
(1) $\operatorname{In}\left(\frac{r_{2}}{r_{1}}\right)$
(2) $\frac{\left(r_{2}-r_{1}\right)}{\left(r_{1} r_{2}\right)}$
(3) $\left(r_{2}-r_{1}\right)$
(4) $\frac{r_{1} r_{2}}{\left(r_{2}-r_{1}\right)}$

17. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process until its volume is again reduced to half. Then :
(1) Compressing the gas isothermally will require more work to be done.
(2) Compressing the gas through adiabatic process will require more work to be done.
(3) Compressing the gas isothermally or adiabatically will require the same amount of work.
(4) Which of the case (whether compression through isothermal or through adiabatic process) requires more work will depend upon the atomicity of the gas.
18. A ray $P Q$ incident on the refracting face $B A$ is refracted in the prism $B A C$ as shown in the figure and emerges from the other

refracting face $A C$ as $R S$ such that $A Q=A R$. If the angle of $\operatorname{prism} A=60^{\circ}$ and the refractive index of the material of prism is $\sqrt{3}$, then the angle of deviation of the ray is
(1) $60^{\circ}$
(2) $45^{\circ}$
(3) $30^{\circ}$
(4) None of these
19. Which of the following has/have zero average value in a plane electromagnetic wave?
(1) Both magnetic and electric field
(2) Electric field only
(3) Magnetic energy
(4) Electric energy
20. In a diffraction pattern due to a single slit of width ' $a$ ', the first minimum is observed at an angle $30^{\circ}$ when light of wavelength $5000 \AA$ is incident on the slit. The first secondary maximum is observed at an angle of :
(1) $\sin ^{-1}\left(\frac{1}{4}\right)$
(2) $\sin ^{-1}\left(\frac{2}{3}\right)$
(3) $\sin ^{-1}\left(\frac{1}{2}\right)$
(4) $\sin ^{-1}\left(\frac{3}{4}\right)$

## PART-II (Numerical Answer Questions)

21. An automobile moves on a road with a speed of $54 \mathrm{~km} \mathrm{~h}^{-1}$. The radius of its wheels is 0.45 m and the moment of inertia of the wheel about its axis of rotation is $3 \mathrm{~kg} \mathrm{~m}^{2}$. If the vehicle is brought to rest in 15 s , the magnitude of average torque (in $\mathrm{kgm}^{2} \mathrm{~s}^{-2}$ ) transmitted by its brakes to the wheel is :
22. A coil of effective area $4 \mathrm{~m}^{2}$ is placed at right angles to the magnetic induction B . The e.m.f. of 0.32 V is induced in the coil. When the field is reduced to $20 \%$ of its initial value in 0.5 sec . Find B (in $\mathrm{wb} / \mathrm{m}^{2}$ ).
23. Taking the wavelength of first Balmer line in hydrogen spectrum ( $\mathrm{n}=3$ to $\mathrm{n}=2$ ) as 660 nm , the wavelength (in nm ) of the $2^{\text {nd }}$ Balmer line ( $n=4$ to $n=2$ ) will be;
24. Two satellites $S_{1}$ and $S_{2}$ are orbiting around a planet of radius $R, S_{1}$ moves just above the surface of planet while $S_{2}$ is in orbit of radius 4R. The value of the ratio of orbital speed $\mathrm{v}_{0}\left(\mathrm{~S}_{1}\right)$ and orbital speed $\mathrm{v}_{0}\left(\mathrm{~S}_{2}\right)$ is $\qquad$ .
25. The mass defect in a particular nuclear reaction is 0.3 grams. The amount of energy liberated in kilowatt hour is $\qquad$ -. (Velocity of light $=3 \times 10^{8} \mathrm{~m} / \mathrm{s}$ )
26. Two pendulums having length 1.0 m and 1.21 m start oscillating simultaneously in same phase. They will again come in same phase after how many oscillations of smaller pendulum $\qquad$ .
27. The vectors $\vec{A}$ and $\vec{B}$ are such that

$$
|\overrightarrow{\mathrm{A}}+\overrightarrow{\mathrm{B}}|=|\overrightarrow{\mathrm{A}}-\overrightarrow{\mathrm{B}}|
$$

The angle between the two vectors is $\qquad$ .
28. A lead bullet strikes against a steel plate with a velocity $200 \mathrm{~ms}^{-1}$. If the impact is perfectly inelastic and the heat produced is equally shared between the bullet and the target, then the rise in temperature of the bullet is $\qquad$ ${ }^{\circ} \mathrm{C}$ (specific heat capacity of lead $=125 \mathrm{Jkg}^{-1} \mathrm{~K}^{-1}$ )
29. A parallel plate capacitor with air between the plates has a capacitance of 9 pF . The separation between its plates is ' d '. The space between the plates is now filled with two dielectrics. One of the dielectrics has dielectric constant $\mathrm{k}_{1}=$ 3 and thickness $\mathrm{d} / 3$ while the other one has dielectric constant $\mathrm{k}_{2}=6$ and thickness $2 \mathrm{~d} / 3$. Capacitance of the capacitor is now $\qquad$ pF .
30. If $i_{1}=3 \sin \omega t, i_{2}=4 \cos \omega t$, and $i_{3}=i_{0} \sin \left(\omega t+53^{\circ}\right)$, find the value of $\mathrm{i}_{0}$.


## CHEMISTRY

## PART-I (Multiple Choice Questions)

31. A process has $\Delta H=200 \mathrm{~J} \mathrm{~mol}^{-1}$ and $\Delta S=40 \mathrm{JK}^{-1} \mathrm{~mol}^{-1}$ Out of the values given below, the minimum temperature above which the process will be spontaneous:
(1) 20 K
(2) 12 K
(3) 5 K
(4) 4 K
32. Out of the following, which type of interaction is responsible for the stabilisation of a-helix structure of proteins?
(1) Ionic bonding
(2) Hydrogen bonding
(3) Covalent bonding
(4) vander Waals forces
33. Match the column-I with column-II and mark the appropriate choice.

## Column-I

(A) Clemmensen reduction
(B) Rosenmund reduction

Conc. KOH
(q) $\mathrm{Zn} / \mathrm{Hg}+$ conc. HCl reduction
(C) Iodoform reaction
(r) $\mathrm{H}_{2} / \mathrm{Pd}-\mathrm{BaSO}_{4}$
(D) Cannizzaro reaction
(1) $\mathrm{A} \rightarrow$ (p), $\mathrm{B} \rightarrow(\mathrm{r}), \mathrm{C} \rightarrow(\mathrm{q}), \mathrm{D} \rightarrow$ (s)
(2) $\mathrm{A} \rightarrow(\mathrm{r}), \mathrm{B} \rightarrow(\mathrm{s}), \mathrm{C} \rightarrow(\mathrm{p}), \mathrm{D} \rightarrow$ (q)
(3) $\mathrm{A} \rightarrow(\mathrm{q}), \mathrm{B} \rightarrow(\mathrm{r}), \mathrm{C} \rightarrow(\mathrm{s}), \mathrm{D} \rightarrow$ (p)
(4) $\mathrm{A} \rightarrow$ (s), $\mathrm{B} \rightarrow$ (p), $\mathrm{C} \rightarrow$ (q), $\mathrm{D} \rightarrow$ (r)
34. Assertion: Kohlrausch law helps to find the molar conductivity of weak electrolyte.
Reason: Molar conductivity of a weak electrolyte at infinite dilution cannot be determined experimentally.
(1) Ifboth Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(2) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(3) If the Assertion is correct but Reason is incorrect.
(4) If the Assertion is incorrect but Reason is correct.
35. Identify the incorrect statement.
(1) The transition metals and their compounds are known for their catalytic activity due to their ability to adopt multiple oxidation states and to form complexes.
(2) Interstitial compounds are those that are formed when small atoms like $\mathrm{H}, \mathrm{C}$ or N are trapped inside the crystal lattices of metals.
(3) The oxidation states of chromium in $\mathrm{CrO}_{4}^{2-}$ and $\mathrm{Cr}_{2} \mathrm{O}_{7}^{2-}$ are not the same.
(4) $\mathrm{Cr}^{2+}\left(\mathrm{d}^{4}\right)$ is a stronger reducing agent than $\mathrm{Fe}^{2+}\left(\mathrm{d}^{6}\right)$ in water.
36. The correct set of four quantum numbers for the valence electrons of rubidium atom $(Z=37)$ is:
(1)
$5,0,0,+\frac{1}{2}$
(2) $5,1,0,+\frac{1}{2}$
(3) $5,1,1,+\frac{1}{2}$
(4) $5,0,1,+\frac{1}{2}$
37. If 0.01 M solution of an electrolyte has a resistance of 40 ohms in a cell having a cell constant of $0.4 \mathrm{~cm}^{-1}$, then its molar conductance in ohm ${ }^{-1} \mathrm{~cm}^{2} \mathrm{~mol}^{-1}$.
(1) $10^{2}$
(2) $10^{4}$
(3) 10
(4) $10^{3}$
38. Statement I: Silicon has lower first ionisation enthalpy than carbon.
Statement II: Silicon occurs in free state in nature
(1) Both statement I and II are correct.
(2) Both statement I and II are incorrect.
(3) Statement I is correct but statement II is incorrect.
(4) Statement II is correct but statement I is incorrect.
39. $\mathrm{Na}^{+}, \mathrm{Mg}^{2+}, \mathrm{Al}^{3+}$ and $\mathrm{Si}^{4+}$ ions are isoelectronic. The of ionic radii of these ions.
(1) $\mathrm{Na}^{+}>\mathrm{Mg}^{2+}>\mathrm{Al}^{3+}>\mathrm{Si}^{4+}$
(2) $\mathrm{Na}^{+}<\mathrm{Mg}^{2+}<\mathrm{Al}^{3+}<\mathrm{Si}^{4+}$
(3) $\mathrm{Na}^{+}>\mathrm{Mg}^{2+}>\mathrm{Al}^{3+}<\mathrm{Si}^{4+}$
(4) $\mathrm{Na}^{+}<\mathrm{Mg}^{2+}>\mathrm{Al}^{3+}>\mathrm{Si}^{4+}$
40. Which is formed, when acetonitrile is hydrolysed partially with cold concentrated HCl ?
(1) Acetic acid
(2) Acetamide
(3) Methyl cyanide
(4) Acetic anhydrides
41. Consider the reaction: $\mathrm{N}_{2}(g)+3 \mathrm{H}_{2}(g) \rightarrow 2 \mathrm{NH}_{3}(g)$

The equality relationship between $\frac{\mathrm{d}\left[\mathrm{NH}_{3}\right]}{\mathrm{dt}}$ and $-\frac{\mathrm{d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}$ is
(1) $+\frac{\mathrm{d}\left[\mathrm{NH}_{3}\right]}{\mathrm{dt}}=-\frac{2}{3} \frac{\mathrm{~d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}$
(2) $+\frac{\mathrm{d}\left[\mathrm{NH}_{3}\right]}{\mathrm{dt}}=-\frac{3}{2} \frac{\mathrm{~d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}$
(3) $\frac{\mathrm{d}\left[\mathrm{NH}_{3}\right]}{\mathrm{dt}}=-\frac{\mathrm{d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}$
(4) $\frac{\mathrm{d}\left[\mathrm{NH}_{3}\right]}{\mathrm{dt}}=-\frac{1}{3} \frac{\mathrm{~d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}$
42. In qualitative analysis $\mathrm{NH}_{4} \mathrm{Cl}$ is added before $\mathrm{NH}_{4} \mathrm{OH}$
(1) to decrease $\left[\mathrm{OH}^{-}\right]$conc.
(2) to increase $\left[\mathrm{OH}^{-}\right]$conc.
(3) for making HCl
(4) to increase $\left[\mathrm{Cl}^{-}\right]$conc.
43. One part of an element A combines with two parts of another B. Six parts of the element C combine with four parts of the element B . If A and C combine together the ratio of their weights will be governed by
(1) Law of definite proportion
(2) Law of multiple proportion
(3) Law of reciprocal proportion
(4) Law of conservation of mass
44. Which of the following involves transfer of five electrons?
(1) $\mathrm{MnO}_{4}^{-} \rightarrow \mathrm{Mn}^{2+}$
(2) $\mathrm{CrO}_{4}^{2-} \rightarrow \mathrm{Cr}^{3+}$
(3) $\mathrm{MnO}_{4}^{2-} \rightarrow \mathrm{MnO}_{2}$
(4) $\mathrm{Cr}_{2} \mathrm{O}_{7}^{2-} \rightarrow 2 \mathrm{Cr}^{3+}$
45. The product(s) obtained via oxymercuration $\left(\mathrm{HgSO}_{4}+\right.$ $\mathrm{H}_{2} \mathrm{SO}_{4}$ ) of 1-butyne would be
(1)

(2) $\mathrm{CH}_{3}-\mathrm{CH}_{2}-\mathrm{CH}_{2}-\mathrm{CHO}$
(3) $\mathrm{CH}_{3}-\mathrm{CH}_{2}-\mathrm{CHO}+\mathrm{HCHO}$
(4) $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{COOH}+\mathrm{HCOOH}$
46. The crystal field stabilization energy (CFSE) is the highest for
(1) $\left[\mathrm{CoF}_{4}\right]^{2-}$
(2) $\left[\mathrm{Co}(\mathrm{NCS})_{4}\right]^{2-}$
(3) $\left[\mathrm{Co}\left(\mathrm{NH}_{3}\right)_{6}\right]^{3+}$
(4) $\left[\mathrm{CoCl}_{4}\right]^{2-}$
47. Identify the correct statement for change of Gibb's energy for a system $\left(\Delta G_{\text {system }}\right)$ at constant temperature and pressure
(1) If $\Delta G_{\text {system }}=0$, the system has attained equilibrium
(2) If $\Delta G_{\text {system }}=0$, the system is still moving in a particular direction
(3) If $\Delta G_{\text {system }}<0$, the process is not spontaneous
(4) If $\Delta G_{\text {system }}>0$, the process is not spontaneous
48. The strongest Lewis acid is -
(1) $\mathrm{BF}_{3}$
(2) $\mathrm{BCl}_{3}$
(3) $\mathrm{BBr}_{3}$
(4) $\mathrm{BI}_{3}$
49. Which of the following undergoes nucleophilic substitution exclusively by $\mathrm{S}_{\mathrm{N}} 1$ mechanism?
(1) Ethyl chloride
(2) Isopropyl chloride
(3) Chlorobenzene
(4) Benzyl chloride
50. Which of the following functional groups cannot be reduced to alcohol using $\mathrm{NaBH}_{4}$ in ethanolic solution?
(1) $\mathrm{R}-\mathrm{O}-\mathrm{R}$
(2) RCOCl
(3) $\mathrm{R}-\mathrm{COOH}$
(4) $\mathrm{R}-\mathrm{CHO}$

## PART-II (Numerical Answer Questions)

51. The de Broglie wavelength ( nm ) of an electron in the ground state of hydrogen atom is :
[K.E. $=13.6 \mathrm{eV} ; 1 \mathrm{eV}=1.602 \times 10^{-19} \mathrm{~J}$ ]
52. The mass of $\mathrm{BaCO}_{3}$ produced when excess $\mathrm{CO}_{2}$ is bubbled through a solution of $0.205 \mathrm{~mol} \mathrm{Ba}(\mathrm{OH})_{2}$ is $\qquad$ —.
53. For the first order reaction $A \rightarrow 2 B, 1$ mole of reactant $A$ gives 0.2 moles of $B$ after 100 minutes. The half life of the reaction is ...... min. (Round off to the nearest integer).
[Use : $\ln 2=0.69, \ln 10=2.3$
Properties of logarithms : $\ln x^{y}=y \ln x$;
$\left.\ln \left(\frac{x}{y}\right)=\ln x-\ln y\right]$
(Round off to the nearest integer)
54. The dipole moment of HBr is $1.6 \times 10^{-30}$ coulomb meter and interatomic spacing is $1 \AA$. What is the $\%$ ionic character of HBr ?
55. What is the number of geometrical isomers in case of a compound with the structure : $\mathrm{CH}_{3}-\mathrm{CH}=\mathrm{CH}-\mathrm{CH}=\mathrm{CH}-\mathrm{C}_{2} \mathrm{H}_{5}$
56. Naturally occurring boron consists of two isotopes whose atomic weights are 10.01 and 11.01. The atomic weight of natural boron is 10.81 . Calculate the percentage of isotope with atomic weight 11.01 in natural boron.

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57. The value of $\mathrm{P}^{\circ}$ for benzene is 640 mm of Hg . The vapour pressure of solution containing 2.5 g substance in 39 g benzene is 600 mm of Hg . What is the molecular mass of X ?
58. The heat of neutralization of strong base and strong acid is 57.0 kJ . The heat released when 0.5 mole of $\mathrm{HNO}_{3}$ is added to 0.20 mole of NaOH solution in kJ is $\qquad$ -.
59. Among $\mathrm{NH}_{3}, \mathrm{HNO}_{3}, \mathrm{NaN}_{3}$ and $\mathrm{Mg}_{3} \mathrm{~N}_{2}$ the number of molecules having nitrogen in negative oxidation state is
$\qquad$ _.
60. Rate of a reaction can be expressed by following rate expression Rate $=k[\mathrm{~A}]^{2}[\mathrm{~B}]$, if concentration of A is increased by 3 times, and concentration of $B$ is increased by 2 times, how many times rate of reaction increases?

## MATHEMATICS

## PART-I (Multiple Choice Questions)

61. For $x>0, \lim _{x \rightarrow 0}\left((\sin x)^{1 / x}+\left(\frac{1}{x}\right)^{\sin x}\right)$ is
(1) 0
(2) -1
(3) 1
(4) 2
62. A line is drawn through the point $P(3,11)$ to cut the circle $x^{2}+y^{2}=9$ at $A$ and $B$. Then $P A \cdot \mathrm{~PB}$ is equal to
(1) 9
(2) 121
(3) 205
(4) 139
63. Domain of definition of the function $f(x)=\frac{3}{4-x^{2}}+\log _{10}\left(x^{3}-x\right)$, is
(1) $(-1,0) \cup(1,2) \cup(2, \infty)$
(2) $(0,2)$
(3) $(-1,0) \cup(0,2)$
(4) $(1,2) \cup(2, \infty)$
64. Let $k$ be an integer such that triangle with vertices $(k,-3 k),(5, k)$ and $(-k, 2)$ has area 28 sq. units. Then the orthocentre of this triangle is at the point :
(1) $\left(2, \frac{1}{2}\right)$
(2) $\left(2,-\frac{1}{2}\right)$
(3) $\left(1, \frac{3}{4}\right)$
(4) $\left(1,-\frac{3}{4}\right)$
65. If vectors $\vec{a}, \vec{b}, \vec{c}$ satisfy the condition $|\vec{a}-\vec{c}|=|\vec{b}-\vec{c}|$, then $(\vec{b}-\vec{a}) \cdot\left(\vec{c}-\frac{\vec{a}+\vec{b}}{2}\right)$ is equal to
(1) 0
(2) -1
(3) 1
(4) 2
66. The value of $a$ so that the sum of the squares of the roots of the equation $x^{2}-(a-2) x-a+1=0$ assume the least value, is
(1) 2
(2) 1
(3) 3
(4) 0
67. The value of $\frac{\sin 300^{\circ} \tan 330^{\circ} \sec 420^{\circ}}{\tan 135^{\circ} \sin 210^{\circ} \sec 315^{\circ}}$ is equal to :
(1) $\frac{1}{\sqrt{2}}$
(2) $\sqrt{2}$
(3) $\frac{1}{\sqrt{3}}$
(4) $\sqrt{3}$
68. A particular solution of
$\log \left(\frac{d y}{d x}\right)=3 x+4 y, y(0)=0$ is
(1) $e^{3 x}+3 e^{-4 y}=4$
(2) $4 e^{3 x}-3 e^{-4 y}=3$
(3) $3 e^{3 x}+4 e^{4 y}=7$
(4) $4 e^{3 x}+3 e^{-4 y}=7$
69. If $f(x)=\frac{1}{2} x-1$, then on the interval $[0, \pi]$
(1) $\tan [\mathrm{f}(\mathrm{x})]$ and $1 / \mathrm{f}(\mathrm{x})$ are both continuous
(2) $\tan [f(x)]$ and $1 / f(x)$ are both discontinuous
(3) $\tan [f(x)]$ and $f^{-1}(x)$ are both continuous
(4) $\tan [f(x)]$ is continuous but $1 / f(x)$ is not
70. If $\frac{a+b x}{a-b x}=\frac{b+c x}{b-c x}=\frac{c+d x}{c-d x}, \mathrm{x} \neq 0$, then $a, b, c, d$, are in
(1) A. P.
(2) G.P.
(3) $\mathrm{a}^{2}=\mathrm{bc}$
(4) None
71. The value of $\int_{2}^{4}\{|x-2|+|x-3|\} d x$
(1) 1
(2) 2
(3) 3
(4) 5
72. If $x+\frac{1}{x}=2 \cos \theta$, then $x^{3}+\frac{1}{x^{3}}$ is equal to
(1) $\sin 3 \theta$
(2) $2 \sin 3 \theta$
(3) $\cos 3 \theta$
(4) $2 \cos 3 \theta$
73. The locus of the centres of the circles which touch externally the circles $x^{2}+y^{2}=a^{2}$ and $x^{2}+y^{2}=4 a x$, will be
(1) $12 x^{2}-4 y^{2}-24 a x+9 a^{2}=0$
(2) $12 x^{2}+4 y^{2}-24 a x+9 a^{2}=0$
(3) $12 x^{2}-4 y^{2}+24 a x+9 a^{2}=0$
(4) $12 x^{2}+4 y^{2}+24 a x+19 a^{2}=0$
74. The foot of the perpendicular from $(2,4,-1)$ to the line $x+5=\frac{1}{4}(y+3)=-\frac{1}{9}(z-6)$
(1) $(-4,1,-3)$
(2) $(4,-1,-3)$
(3) $(-4,-1,3)$
(4) $(-4,-1,-3)$
75. Let r be the range and $S^{2}=\frac{1}{n-1} \sum_{i=1}^{n}\left(x_{i}-\bar{x}\right)^{2}$ be the S.D. of a set of observations $x_{1}, x_{2}, \ldots . \mathrm{x}_{\mathrm{n}}$, then
(1) $\mathrm{S} \leq r \sqrt{\frac{n}{n-1}}$
(2) $\mathrm{S}=r \sqrt{\frac{n}{n-1}}$
(3) $\mathrm{S} \geq r \sqrt{\frac{n}{n-1}}$
(4) None of these
76. If $\vec{a}+\vec{b}+\vec{c}=0,|\vec{a}|=3,|\vec{b}|=5,|\vec{c}|=7$, then the angle between $\vec{a}$ and $\vec{b}$ is :
(1) $\frac{\pi}{4}$
(2) $\frac{\pi}{3}$
(3) $\frac{2 \pi}{3}$
(4) $\frac{\pi}{6}$
77. If at least one value of the complex number $z=x+i y$ satisfy the condition $|z+\sqrt{2}|=a^{2}-3 a+2$ and the inequality $|z+i \sqrt{2}|<a^{2}$, then
(1) $a>2$
(2) $a=2$
(3) $a<2$
(4) None of these
78. A letter is known to have come either from LONDON or CLIFTON; on the postmark only the two consecutive letters ON are legible. The probability that it came from LONDON is
(1) $\frac{5}{17}$
(2) $\frac{12}{17}$
(3) $\frac{17}{30}$
(4) $\frac{3}{5}$
79. If $\int f(x) \sin x \cos x d x=\frac{1}{2\left(b^{2}-a^{2}\right)} \log _{e}(f(x))+A$,
$\mathrm{b} \neq \pm \mathrm{a}$, then $\{\mathrm{f}(\mathrm{x})\}^{-1}$ is equal to
(1) $a^{2} \sin ^{2} x+b^{2} \cos ^{2} x+C$
(2) $a^{2} \sin ^{2} x-b^{2} \cos ^{2} x+C$
(3) $a^{2} \cos ^{2} x+b^{2} \sin ^{2} x+C$
(4) $a^{2} \cos ^{2} x-b^{2} \sin ^{2} x+C$
80. If $f(x)$ is differentiable and strictly increasing function, then the value of $\lim _{x \rightarrow 0} \frac{f\left(x^{2}\right)-f(x)}{f(x)-f(0)}$ is
(1) 1
(2) 0
(3) -1
(4) 2

## PART-II (Numerical Answer Questions)

81. Assuming the balls to be identical except for difference in colours, the number of ways in which one or more balls can be selected from 10 white, 9 green and 7 black balls is $\qquad$ .
82. The number of integral points (integral point means both the coordinates should be integer) exactly in the interior of the triangle with vertices $(0,0),(0,21)$ and $(21,0)$, is $\qquad$ .
83. The argument of $\frac{(1-i \sqrt{3})}{(1+i \sqrt{3})}$ is $\mathrm{k}^{\circ}$ then value of k is $\qquad$ -
84. Find the number of irrational terms in the expansion of $(\sqrt[8]{5}+\sqrt[6]{2})^{100}$ $\qquad$ .
85. The area enclosed by $2|x|+3|y| \leq 6$ is
86. If $\cos ^{-1} \sqrt{p}+\cos ^{-1} \sqrt{1-p}+\cos ^{-1} \sqrt{1-q}=\frac{3 \pi}{4}$ then the value of q is equal to $\qquad$ -.
87. If $\left[\begin{array}{lll}1 & x & 1\end{array}\right]\left[\begin{array}{lll}1 & 2 & 3 \\ 0 & 5 & 1 \\ 0 & 3 & 2\end{array}\right]\left[\begin{array}{c}x \\ 1 \\ -2\end{array}\right]=\mathrm{O}$, then $x=$ $\qquad$ .
88. The total number of local maxima and local minima of the function $f(x)=\left\{\begin{array}{ll}(2+x)^{3} & ,-3<x \leq-1 \\ x^{2 / 3} & ,-1<x<2\end{array}\right.$ is .
89. A coin is tossed until a head appears or until the coin has been tossed five times. If a head does not occur on the first two tosses, then the probability that the coin will be tossed 5 times is $\qquad$ -.
90. A survey of 500 television viewers produced the following information, 285 watch football, 195 watch hockey, 115 watch basket-ball, 45 watch football and basket ball, 70 watch football and hockey, 50 watch hockey and basket ball, 50 do not watch any of the three games. The number of viewers, who watch exactly one of the three games are $\qquad$ .

## RESPONSE SHEET

## PHYSICS

| 1. | (1) (2) (3) 4 | 2. | (1) (2)(3)(4) | 3. | (1) (2)(3)4 | 4. | (1) (2) (3) 4 ) | 5. | (1) (2) (3) 4 ) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6. | (1) (2) (3) 4 | 7. | (1) (2) (3) (4) | 8. | (1) (2) (3) (4) | 9. | (1) (2) (3) (4) | 10. | (1) (2) (3) (4) |
| 11. | (1)(2)(3)(4) | 12. | (1) (2) (3) (4) | 13. | (1) (2)(3)4 | 14. | (1) (2)(3)(4) | 15. | (1)(2)(3)(4) |
| 16. | (1) (2) (3)(4) | 17. | (1) (2) (3) (4) | 18. | (1) (2) (3) (4) | 19. | (1)(2)(3)(4) | 20. | (1)(2)(3)(4) |
| 21. |  | 22. |  | 23. |  | 24. |  | 25. |  |
| 26. |  | 27. |  | 28. |  | 29. |  | 30. |  |
|  |  |  |  |  | CMISTRY |  |  |  |  |
| 31. | (1) (2) (3) (4) | 32. | (1) (2) (3) (4) |  | (1) (2) (3) (4) | 34. | (1)(2)(3)(4) | 35. | (1) (2) (3)(4) |
| 36. | (1) (2) (3)(4) | 37. | (1) (2)(3)(4) |  | (1) (2) (3) (4) | 39. | (1) (2)(3)(4) | 40. | (1) (2) (3) (4) |
| 41. | (1) (2) (3) (4) | 42. | (1) (2)(3)(4) | 43. | (1) (2) (3) (4) | 44. | (1) (2) (3) (4) | 45. | (1) (2) (3)(4) |
| 46. | (1) (2) (3) (4) | 47. | (1) (2) (3) (4) | 48. | (1) (2) (3) (4) | 49. | (1) (2) (3) (4) | 50. | (1) (2) (3)(4) |
| 51. |  | 52. |  | 53. | -1 | 54. |  | 55. |  |
| 56. |  | 57. |  | 58. |  | 59. |  | 60. |  |
|  |  |  |  | MAT | HEMATICS |  |  |  |  |
| 61. | (1) (2) (3) (4) | 62. | (1) (2) (3) (4) | 63. | (1) (2)(3)(4) | 64. | (1) (2) (3)(4) | 65. | (1) (2) (3)(4) |
| 66. | (1) (2) (3) (4) | 67. | (1) (2) (3) (4) | 68. | (1) (2)(3)4 | 69. | (1) (2) (3)(4) | 70. | (1) (2) (3)(4) |
| 71. | (1) (2) (3) (4) | 72. | (1) (2) (3)(4) | 73. | (1) (2) (3) (4) | 74. | (1) (2) (3)(4) | 75. | (1)(2)(3)(4) |
| 76. | (1) (2) (3) (4) | 77. | (1) (2) (3) (4) | 78. | (1) (2)(3)4 | 79. | (1) (2) (3) (4) | 80. | (1) (2) (3) (4) |
| 81. |  | 82. |  | 83. |  | 84. |  | 85. |  |
| 86. |  | 87. |  | 88. |  | 89. |  | 90. |  |

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## MOCK TEST-1

## PHYSICS

1. (3) Clearly from fig. given in question, Silicon diode is in forward bias.
$\therefore$ Potential barrier across diode
$\Delta \mathrm{V}=0.7$ volts
Current, $\mathrm{I}=\frac{\mathrm{V}-\Delta \mathrm{V}}{\mathrm{R}}=\frac{3-0.7}{200}=\frac{2.3}{200}=11.5 \mathrm{~mA}$
2. (2) By stretching coil's, shape changes whereas its length of wire remains same. Due to which shear modules of elasticity is involved so assertion is correct. Elasticity of steel is more than that of copper and also has more tensile stress. So reason is false.
3. (1) Using $f=\frac{1}{2 \ell} \sqrt{\frac{T}{\mu}}$,
where, $T=$ tension and $\mu=\frac{\text { mass }}{\text { length }}$
$f_{x}=\frac{1}{2 \ell} \sqrt{\frac{T_{x}}{\mu}}$ and $f_{z}=\frac{1}{2 \ell} \sqrt{\frac{T_{z}}{\mu}}$
$\frac{f_{x}}{f_{z}}=\frac{450}{300}=\sqrt{\frac{T_{x}}{T_{z}}} \therefore \frac{T_{x}}{T_{z}}=\frac{9}{4}=2.25$.
4. (3) $\mathrm{I}=\mathrm{neA} v_{d}$; I is current in amperes, n is no. density of electrons.

$$
v_{d}=\frac{I}{\text { neA }}=\frac{24 \times 10^{-3}}{3 \times 10^{23} \times 1.6 \times 10^{-19} \times 10^{-4}}
$$

$$
=5 \times 10^{-3} \mathrm{~m} / \mathrm{sec}
$$

5. (2) Since the speeds of the stars are negligible when they are at a distance $r$, hence the initial kinetic energy of the system is zero. Therefore, the initial total energy of the system is
$E_{i}=K E+P E=0+\left(-\frac{G M M}{r}\right)=-\frac{G M^{2}}{r}$
where $M$ represents the mass of each star and $r$ is initial separation between them.
When two stars collide their centres will be at a distance twice the radius of a star i.e. $2 R$.
Let $v$ be the speed with which two stars collide. Then total energy of the system at the instant of their collision is given by
$E_{f}=2 \times\left(\frac{1}{2} M v^{2}\right)+\left(-\frac{G M M}{2 R}\right)=M v^{2}-\frac{G M^{2}}{2 R}$
According to law of conservation of mechanical energy,
$E_{f}=E_{i}$
$M v^{2}-\frac{G M^{2}}{2 R}=-\frac{G M^{2}}{r}$ or $v^{2}=G M\left(\frac{1}{2 R}-\frac{1}{r}\right)$
or $v=\sqrt{G M\left(\frac{1}{2 R}-\frac{1}{r}\right)}$
6. (2)


Work done by normal reaction

$$
=\mathrm{Nh}=\mathrm{M}(\mathrm{~g}+\mathrm{a}) \frac{1}{2} \mathrm{aT}^{2}=\frac{1}{2} \mathrm{M}(\mathrm{~g}+\mathrm{a}) \mathrm{aT}^{2}
$$

7. (3) Rise in temperature, $\Delta \theta=\frac{3 T}{J S d}\left(\frac{1}{r}-\frac{1}{R}\right)$

$$
\therefore \Delta \theta=\frac{3 T}{J}\left(\frac{1}{r}-\frac{1}{R}\right) \quad(\text { For water } \mathrm{S}=1 \text { and } \mathrm{d}=1)
$$

8. (3) $\left|\overrightarrow{F_{B}}\right|=\left|\overrightarrow{F_{C}}\right|=k \cdot \frac{Q^{2}}{a^{2}}$


Hence force experienced by the charge at A in the direction normal to BC is zero.
9. (1) The magnitude of magnetic field at $P\left(\frac{R}{2}, y, \frac{R}{2}\right)$ is $B=\frac{\mu_{0} \mathrm{Jr}}{2}=\frac{\mu_{0} \mathrm{i}}{2 \pi \mathrm{R}^{2}} \times \frac{\mathrm{R}}{\sqrt{2}}=\frac{\mu_{0} \mathrm{i}}{2 \sqrt{2} \pi \mathrm{R}}$ (independent on y -coordinate)


Unit vector in direction of magnetic field is
$\hat{\mathrm{B}}=\frac{\hat{\mathrm{i}}-\hat{\mathrm{k}}}{\sqrt{2}}$ ( shown by dotted lines)
$\therefore \vec{B}=B \hat{B}=\frac{\mu_{0} i}{4 \pi R}(\hat{\mathrm{i}}-\hat{\mathrm{k}})$
10. (4)


From figure $B_{n e t}=\sqrt{B_{a}^{2}+B_{e}^{2}}$

$$
\begin{aligned}
& =\sqrt{\left(\frac{\mu_{0}}{4 \pi} \cdot \frac{2 M}{d^{3}}\right)^{2}+\left(\frac{\mu_{0}}{4 \pi} \cdot \frac{M}{d^{3}}\right)^{2}} \\
& =\sqrt{5} \cdot \frac{\mu_{0}}{4 \pi} \cdot \frac{M}{d^{3}}=\sqrt{5} \times 10^{-7} \times \frac{10}{(0.1)^{3}}=\sqrt{5} \times 10^{-3} \text { tesla }
\end{aligned}
$$

11. (4)


Velocity of A relative to $B$ is given by

$$
\begin{equation*}
\overrightarrow{v_{A / B}}=\overrightarrow{v_{A}}-\overrightarrow{v_{B}}=\vec{v}-\overrightarrow{v_{1}} \tag{1}
\end{equation*}
$$

Bytaking x -components of equation (1), we get

$$
\begin{equation*}
0=v \sin \theta-v_{1} \Rightarrow \sin \theta=\frac{v_{1}}{v} \tag{2}
\end{equation*}
$$

By taking $Y$-components of equation (1), we get

$$
\begin{equation*}
v_{y}=v \cos \theta \tag{3}
\end{equation*}
$$

Time taken by boy at $A$ to catch the boy at $B$ is given by

$$
\begin{aligned}
\mathrm{t} & =\frac{\text { Relative displacement along Y-axis }}{\text { Relative velocity along Y-axis }} \\
& =\frac{a}{v \cos \theta}=\frac{a}{v \cdot \sqrt{1-\sin ^{2} \theta}}=\frac{a}{v \cdot \sqrt{1-\left(\frac{v_{1}}{v}\right)^{2}}}
\end{aligned}
$$

[From equation (1)]
$=\frac{a}{v \cdot \sqrt{\frac{v^{2}-v_{1}^{2}}{v^{2}}}}=\frac{a}{\sqrt{v^{2}-v_{1}^{2}}}=\sqrt{\frac{a^{2}}{v^{2}-v_{1}^{2}}}$
12. (3)
13. (2) Joule is a unit of ernergy.

SI
New system
$\mathrm{n}_{1}=5$
$\mathrm{n}_{2}=$ ?
$\mathrm{M}_{1}=1 \mathrm{~kg}$
$\mathrm{M}^{2}=a \mathrm{~kg}$
$\mathrm{L}_{1}=1 \mathrm{~m}$
$\mathrm{L}^{2}=\beta \mathrm{m}$
$\mathrm{T}_{1}=1 \mathrm{~s}$
$\mathrm{T}^{2}=\gamma \mathrm{s}$
Dimensional formula of energy is comparing with,
[ $\mathrm{M}^{\mathrm{a}} \mathrm{L}^{\mathrm{b}} \mathrm{T}^{\mathrm{c}}$ ], we get
$a=1, b=2, c=-2$
As $n_{2}=n_{1}\left(\frac{M^{1}}{M^{2}}\right)^{a}\left(\frac{L^{1}}{L^{2}}\right)^{b}\left(\frac{T_{1}}{T_{2}}\right)^{c}$
$=5\left(\frac{1 k g}{\alpha k g}\right)^{1}\left(\frac{1 m}{\beta m}\right)^{2}\left(\frac{1 s}{\gamma s}\right)^{-2}=\frac{5 \gamma^{2}}{\alpha \beta^{2}}=\frac{5 \gamma^{2}}{\alpha \beta^{2}}=5 \alpha^{-1} \beta^{-2} \gamma^{2}$
14. (3) $K_{\max }=E-W_{0}$
$\therefore \quad \mathrm{T}_{\mathrm{A}}=4.25-\left(\mathrm{W}_{0}\right)_{\mathrm{A}}$

$$
\mathrm{T}_{\mathrm{B}}=\left(\mathrm{T}_{\mathrm{A}}-1.5\right)=4.70-\left(\mathrm{W}_{0}\right)_{\mathrm{B}}
$$

Equation (i) and (ii) gives $\left(\mathrm{W}_{0}\right)_{\mathrm{B}}-\left(\mathrm{W}_{0}\right)_{\mathrm{A}}=1.95 \mathrm{eV}$
De Broglie wave length $\lambda=\frac{h}{\sqrt{2 m \mathrm{~K}}} \Rightarrow \lambda \propto \frac{1}{\sqrt{\mathrm{~K}}}$
$\Rightarrow \frac{\lambda_{\mathrm{B}}}{\lambda_{\mathrm{A}}}=\sqrt{\frac{\mathrm{K}_{\mathrm{A}}}{\mathrm{K}_{\mathrm{B}}}} \Rightarrow 2=\sqrt{\frac{\mathrm{T}_{\mathrm{A}}}{\mathrm{T}_{\mathrm{B}}-1.5}} \Rightarrow \mathrm{~T}_{\mathrm{A}}=2 \mathrm{eV}$
From equation (i) and (ii)
$\mathrm{W}_{\mathrm{A}}=2.25 \mathrm{eV}$ and $\mathrm{W}_{\mathrm{B}}=4.20 \mathrm{eV}$.
15. (3) $P V=\mu R T=\frac{m}{M} R T$,
where $m=$ mass of the gas
and $\frac{m}{M}=\mu=$ number of moles.
$\frac{P V}{T}=\mu R=$ a constant for all values of $P$.
That is why, ideally it is a straight line.
$\therefore \quad \frac{P V}{T}=\frac{1 \mathrm{~g}}{32 \mathrm{~g} \mathrm{~mol}^{-1}} \times 8.31 \mathrm{~J} \mathrm{~mol}^{-1} \mathrm{~K}^{-1}=0.259 \mathrm{~J} \mathrm{~K}^{-1}$
Also, $T_{1}>T_{2}$
16. (4) Consider a shell of thickness ( $d r$ ) and of radii $(r)$ and the temperature of inner and outer surfaces of this shell be $T,(T-d T)$
$\frac{d Q}{d t}=$ rate of flow of heat through it

$$
\begin{aligned}
& =\frac{K A[(T-d T)-T]}{d r}=\frac{-K A d T}{d r} \\
& =-4 \pi K r^{2} \frac{d T}{d r} \quad\left(\because A=4 \pi r^{2}\right)
\end{aligned}
$$



To measure the radial rate of heat flow, integration technique is used, since the area of the surface through which heat will flow is not constant.
Then, $\left(\frac{d Q}{d t}\right) \int_{\eta_{1}}^{r_{2}} \frac{1}{r^{2}} d r=-4 \pi K \int_{T_{1}}^{T_{2}} d T$

$$
\frac{d Q}{d t}\left[\frac{1}{r_{1}}-\frac{1}{r_{2}}\right]=-4 \pi K\left[T_{2}-T_{1}\right]
$$

or $\quad \frac{d Q}{d t}=\frac{-4 \pi K r_{1} r_{2}\left(T_{2}-T_{1}\right)}{\left(r_{2}-r_{1}\right)}$
$\therefore \quad \frac{d Q}{d t} \propto \frac{r_{1} r_{2}}{\left(r_{2}-r_{1}\right)}$
17. (2) $\mathrm{W}_{\text {ext }}=$ negative of area with volume-axis $\mathrm{W}($ adiabatic $)>\mathrm{W}($ isothermal $)$

18. (1)


Given $A Q=A R$ and $\angle A=60^{\circ}$
$\therefore \quad \angle \mathrm{AQR}=\angle \mathrm{ARQ}=60^{\circ}$
$\therefore \quad \mathrm{r}_{1}=\mathrm{r}_{2}=30^{\circ}$
Applying Snell's law on face AB.

$$
\begin{aligned}
& \text { 1. } \sin i_{1}=\mu \sin r_{1} \\
& \Rightarrow \sin i_{1}=\sqrt{ } 3 \sin 30^{\circ}=\sqrt{3} \times \frac{1}{2}=\frac{\sqrt{3}}{2} \\
& \therefore \quad i_{1}=60^{\circ}
\end{aligned}
$$

Similarly, $i_{2}=60^{\circ}$
In a prism, deviation
$\delta=\mathrm{i}_{1}+\mathrm{i}_{2}-\mathrm{A}=60^{\circ}+60^{\circ}-60^{\circ}=60^{\circ}$
19. (1) Both magnetic and electric fields have zero average value in a plane e.m. wave.
20. (4) For the first minima,
$\theta=\frac{\eta \lambda}{\mathrm{a}} \Rightarrow \sin 30^{\circ}=\frac{\lambda}{\mathrm{a}}=\frac{1}{2}$
First secondary maxima will be at,
$\sin \theta=\frac{3 \lambda}{2 \mathrm{a}}=\frac{3}{2}\left(\frac{1}{2}\right) \Rightarrow \theta=\sin ^{-1}\left(\frac{3}{4}\right)$
21. (6.66) Given : Speed $V=54 \mathrm{kmh}^{-1}=15 \mathrm{~ms}^{-1}$

Moment of inertia, $\mathrm{I}=3 \mathrm{kgm}^{2}$
Timet $=15 \mathrm{~s}$
$\omega_{\mathrm{i}}=\frac{\mathrm{V}}{\mathrm{r}}=\frac{15}{0.45}=\frac{100}{3} \quad \omega_{\mathrm{f}}=0$
$\omega_{\mathrm{f}}=\omega_{\mathrm{i}}+\alpha \mathrm{t}$
$0=\frac{100}{3}+(-\alpha)(15) \Rightarrow \alpha=\frac{100}{45}$
Average torque transmitted by brakes to the wheel
$\tau=(\mathrm{I})(\alpha)=3 \times \frac{100}{45}=6.66 \mathrm{kgm}^{2} \mathrm{~s}^{-2}$
22. (0.05) Given : $\mathrm{A}=4 \mathrm{~m}^{2}, \mathrm{e}=0.32 \mathrm{~V}, \mathrm{dt}=0.5 \mathrm{sec}$.
$B_{1}$ is the initial magnetic induction and when it is reduced to $20 \% \mathrm{~B}_{2}=0.2 \mathrm{~B}_{1}$

$$
\mathrm{e}=\frac{\mathrm{d} \phi}{\mathrm{dt}}=\frac{\mathrm{A}\left(\mathrm{~B}_{1}-\mathrm{B}_{2}\right)}{\Delta \mathrm{t}} \text { or } 0.32=\frac{4\left(\mathrm{~B}_{1}-0.2 \mathrm{~B}_{1}\right)}{0.5}
$$

Magnetic induction $\mathrm{B}_{1}=\frac{0.16}{3.2}=0.05 \mathrm{~Wb} / \mathrm{m}^{2}$
23. (488.9) $\frac{1}{\lambda_{1}}=R\left(\frac{1}{2^{2}}-\frac{1}{3^{2}}\right)=\frac{5 R}{36}$

$$
\begin{aligned}
& \frac{1}{\lambda_{2}}=R\left(\frac{1}{2^{2}}-\frac{1}{4^{2}}\right)=\frac{3 R}{16} \\
& \therefore \frac{\lambda_{2}}{\lambda_{1}}=\frac{80}{108} \\
& \lambda_{2}=\frac{80}{108} \lambda_{1}=\frac{80}{108} \times 660=488.9 \mathrm{~nm}
\end{aligned}
$$

24. (2/1) The orbital speed, $v_{0}=\sqrt{\frac{\mathrm{GM}}{\mathrm{r}}}$

$$
\therefore \frac{\mathrm{v}_{0}\left(\mathrm{~S}_{1}\right)}{\mathrm{v}_{0}\left(\mathrm{~S}_{2}\right)}=\sqrt{\frac{4 \mathrm{R}}{\mathrm{R}}}=\frac{2}{1}
$$

25. $\left(7.5 \times 10^{6}\right)$

$$
\begin{aligned}
& \mathrm{E}=\Delta \mathrm{m} . \mathrm{c}^{2} \Rightarrow \mathrm{E}=\frac{0.3}{1000} \times\left(3 \times 10^{8}\right)^{2}=2.7 \times 10^{13} \mathrm{~J} \\
& =\frac{2.7 \times 10^{13}}{3.6 \times 10^{6}}=7.5 \times 10^{6} \mathrm{kWh} .
\end{aligned}
$$

26. (22) $\mathrm{T}_{1}=2 \pi \sqrt{\frac{1}{\mathrm{~g}}}=2 \mathrm{sec}$.

$$
\mathrm{T}_{2}=2 \pi \sqrt{\frac{1.21}{\mathrm{~g}}}=2.2 \mathrm{sec}
$$

$\mathrm{T}_{2} \times 10=22 \mathrm{sec}$.
$\mathrm{T}_{1} \times 11=22 \mathrm{sec}$.
27. (90) $|\overrightarrow{\mathrm{A}}+\overrightarrow{\mathrm{B}}|^{2}=|\overrightarrow{\mathrm{A}}|^{2}+|\overrightarrow{\mathrm{B}}|^{2}+2 \overrightarrow{\mathrm{~A}} \cdot \overrightarrow{\mathrm{~B}}$

$$
=\mathrm{A}^{2}+\mathrm{B}^{2}+2 \mathrm{AB} \cos \theta
$$

$|\overrightarrow{\mathrm{A}}-\overrightarrow{\mathrm{B}}|^{2}=|\overrightarrow{\mathrm{A}}|^{2}+|\overrightarrow{\mathrm{B}}|^{2}-2 \overrightarrow{\mathrm{~A}} \cdot \overrightarrow{\mathrm{~B}}=\mathrm{A}^{2}+\mathrm{B}^{2}-2 \mathrm{AB} \cos \theta$
So, $\mathrm{A}^{2}+\mathrm{B}^{2}+2 \mathrm{AB} \cos \theta=\mathrm{A}^{2}+\mathrm{B}^{2}-2 \mathrm{AB} \cos \theta$
$4 \mathrm{AB} \cos \theta=0 \Rightarrow \cos \theta=0 \quad \therefore \quad \theta=90^{\circ}$
So, angle between $\mathrm{A} \& \mathrm{~B}$ is $90^{\circ}$.
28. (80) $m s \Delta T=\frac{1}{2}\left(\frac{1}{2} m v^{2}\right)$
$\Delta T=\frac{v^{2}}{4 s}=\frac{(200)^{2}}{4 \times 125}=\frac{4 \times 10^{4}}{4 \times 125}=80^{\circ} \mathrm{C}$.
29. (40.5)

$C_{a i r}=\frac{\varepsilon_{0} A}{d}=9, \frac{1}{C_{\text {med }}}=\frac{1}{C_{1}}+\frac{1}{C_{2}}=\frac{d_{1}}{k_{1} \varepsilon_{0} A}+\frac{d_{2}}{k_{2} \varepsilon_{0} A}$
$\Rightarrow C_{\text {med }}=\frac{k_{1} k_{2} \varepsilon_{0} A}{k_{1} d_{2}+k_{1} d_{1}}$
$=\frac{3 \times 6 \times \varepsilon_{0} A}{3 \times 2 d / 3+6 \times d / 3}=\frac{18}{4} \times 9=40.5 \mathrm{pF}$.
30. (5) From Kirchoff's current law,
$\mathrm{i}_{3}=\mathrm{i}_{1}+\mathrm{i}_{2}=3 \sin \omega \mathrm{t}+4 \sin \left(\omega \mathrm{t}+90^{\circ}\right)$
$\Rightarrow \mathrm{i}_{3}=\mathrm{i}_{0} \sin (\omega \mathrm{t}+\phi)$
where $\mathrm{i}_{0}=\sqrt{3^{2}+4^{2}+2(3)(4) \cos 90^{\circ}}$
and $\tan \phi=\frac{4 \sin 90^{\circ}}{3+4 \cos 90^{\circ}}=\frac{4}{3}$
$\therefore \mathrm{i}_{3}=5 \sin \left(\omega \mathrm{t}+53^{\circ}\right)$

## CHEMISTRY

31. (3) $\Delta H=200 \mathrm{~J} \mathrm{~mol}^{-1}$
$\Delta S=40 \mathrm{JK}^{-1} \mathrm{~mol}^{-1}$
For spontaneous reaction,

$$
\begin{aligned}
& \quad \Delta G<0 \\
& \Delta H-T \Delta S<0 ; \Delta H<T \Delta S ; \frac{\Delta \mathrm{H}}{\Delta \mathrm{~S}}<T ; \frac{200}{40}<T \\
& 5<T
\end{aligned}
$$

So, minimum temperature is 5 K
32. (2) Hydrogen bonding is responsible for stabilisation of a-helix structure of proteins.
33. (3)
34. (1)
35. (3) Oxidation state of Cr in $\mathrm{CrO}_{4}^{2-}$ and $\mathrm{Cr}_{2} \mathrm{O}_{7}^{2-}$ is +6 i.e. oxidation states are same.
36. (1) The electronic configuration of Rubidium $(\mathrm{Rb}=37)$ is
$1 s^{2} 2 s^{2} 2 p^{6} 3 s^{2} 3 p^{6} 3 d^{10} 4 s^{2} 4 p^{6} 5 s^{1}$
Since last electron enters in $5 s$ orbital
Hence $n=5, l=0, m=0, s= \pm \frac{1}{2}$
37. (4) Molarity $=0.01 \mathrm{M}$; Resistance $=40$ ohm;

Cell constant $\left(\frac{l}{A}\right)=0.4 \mathrm{~cm}^{-1}$.
Specific conductivity $(\kappa)=\frac{\text { cell constant }}{\text { resistance }}$
$=\frac{0.4}{40}=0.01 \mathrm{ohm}^{-1} \mathrm{~cm}^{-1}$
Molar conductance $\left(\Lambda_{\mathrm{m}}\right)=\frac{1000 \kappa}{\text { Molarity }}$
$=\frac{1000 \times 0.01}{.01}=10^{3} \mathrm{ohm}^{-1} \mathrm{~cm}^{2} \mathrm{~mol}^{-1}$
38. (3) Silicon occurs in combined state in nature as silica, $\mathrm{SiO}_{2}$.
39. (1) Species $\mathrm{Na}^{+} \quad \mathrm{Mg}^{2+} \quad \mathrm{Al}^{3+} \quad \mathrm{Si}^{4+}$

| Protons | 11 | 12 | 13 | 14 |
| :--- | :--- | :--- | :--- | :--- |
| Electrons | 10 | 10 | 10 | 10 |

Size of isoelectronic cations decreases with increase in magnitude of nuclear charge
$\therefore$ Order of decreasing size is $\mathrm{Na}^{+}>\mathrm{Mg}^{2+}>\mathrm{Al}^{3+}>\mathrm{Si}^{4+}$
40. (2) Methyl cyanide on treatment with conc. HCl give acetamide.

41. (1) If we write rate of reaction in terms of concentration of $\mathrm{NH}_{3}$ and $\mathrm{H}_{2}$, then
Rate of reaction $=\frac{1}{2} \frac{\mathrm{~d}\left[\mathrm{NH}_{3}\right]}{\mathrm{dt}}=-\frac{1}{3} \frac{\mathrm{~d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}$
So, $\frac{\mathrm{d}\left[\mathrm{NH}_{3}\right]}{\mathrm{dt}}=-\frac{2}{3} \frac{\mathrm{~d}\left[\mathrm{H}_{2}\right]}{\mathrm{dt}}$
42. (1) HCl is added before $\mathrm{NH}_{4} \mathrm{OH}$ to decrease conc. of $\left[\mathrm{OH}^{-}\right]$
43. (3) The weight of two elements combining with a fixed amount of the third element will bear the same ratio (or simple multiple of it) in which they themselves react.
44. (1) $\mathrm{O} . \mathrm{N}$. of Mn in $\mathrm{MnO}_{4}^{-}$is +7 and in $\mathrm{Mn}^{2+}$ it is +2 . The difference is of 5 electrons.
45. (1)


46. (3) Higher the oxidation state of the metal, greater the crystal field splitting energy. In options (1), (2) and (4), Co is present in +2 oxidation state and in (3) it is present in +3 oxidation state and hence has a higher value of CFSE.
47. (1) If $\Delta G_{\text {system }}=0$ the system has attained equilibrium is right choice.
In it alternative (4) is most confusing as when $\Delta G>0$, the process may be spontaneous when it is coupled with a reaction which has $\Delta G<0$ and total $\Delta G$ is negative, so right answer is (1).
48. (4) The order of strength of Lewis acid character for boron halides is, $\mathrm{BF}_{3}<\mathrm{BCl}_{3}<\mathrm{BBr}_{3}<\mathrm{BI}_{3}$ (due to back bonding)
49. (4) $\mathrm{S}_{\mathrm{N}} 1$ reactions involve the formation of carbocation, more is stability of carbocation, higher will be the probability of alkyl halide to undergo $\mathrm{S}_{\mathrm{N}} 1$ mechanism. Thus decreasing order of $\mathrm{S}_{\mathrm{N}} 1$ mechanisms follows order Benzyl > allyl > tertiary alkyl halide> secondary alkyl halide $>$ primary alkyl halides


Obtained from $\mathrm{S}_{\mathrm{N}} 1$ path. This molecule is resonance stabilised.
50. (1) Compounds having $-\stackrel{\text { ® }}{\mathrm{C}}-$ moiety in their structure are reduced to alcohols using $\mathrm{NaBH}_{4}$ in ethanolic solution. Thus $\stackrel{\stackrel{\mathrm{O}}{\|}}{\mathrm{R}-\stackrel{\mathrm{O}}{\mathrm{C}}-\mathrm{Cl},} \stackrel{\mathrm{R}}{\mathrm{C}}-\stackrel{\mathrm{O}}{\mathrm{C}}-\mathrm{OH}$ and $\mathrm{R}-\stackrel{\text { - }}{\mathrm{C}}-\mathrm{H}$ are reduced while, $\mathrm{R}-\mathrm{O}-\mathrm{R}$ (ethers) are inert and can't be reduced by $\mathrm{NaBH}_{4}$.
51. (0.3328) For electron in the ground state,
$m v r=\frac{h}{2 \pi} \Rightarrow m v=\frac{h}{2 \pi r}$
Now, $m v=\frac{h}{\lambda}$
So, $\frac{h}{\lambda}=\frac{h}{2 \pi r} \Rightarrow \lambda=2 \pi r$

$$
\begin{aligned}
\lambda & =2 \times 3.14 \times 0.53 \AA=3.328 \AA \\
& =3.328 \times 10^{-10} \mathrm{~m} \\
& =0.3328 \times 10^{-9} \mathrm{~m}=0.3328 \mathrm{~nm}
\end{aligned}
$$

on solving $\lambda=9.96 \times 10^{-8} \mathrm{~cm}=9.96 \times 10^{-10} \mathrm{~m}$
52. (40.5) $\mathrm{Ba}(\mathrm{OH})_{2}+\mathrm{CO}_{2} \rightarrow \mathrm{BaCO}_{3}+\mathrm{H}_{2} \mathrm{O}$

Atomic wt. of $\mathrm{BaCO}_{3}=137+12+16 \times 3=197$
No. of mole $=\frac{\text { wt. of substance }}{\text { mol wt. }}$
$\because 1$ mole of $\mathrm{Ba}(\mathrm{OH})_{2}$ gives 1 mole of $\mathrm{BaCO}_{3}$
$\therefore 0.205$ mole of $\mathrm{Ba}(\mathrm{OH})_{2}$ will give 0.205 mole of $\mathrm{BaCO}_{3}$
$\therefore$ wt. of 0.205 mole of $\mathrm{BaCO}_{3}$ will be
$0.205 \times 197=40.385 \mathrm{~g} \approx 40.5 \mathrm{~g}$.
53. (654.3)

$$
\begin{array}{ccc} 
& \mathrm{A} \longrightarrow 2 \mathrm{~B} \\
\mathrm{t}=0 & 1 \text { mole } & 0 \\
\mathrm{t}=100 \mathrm{~min} & 1-\mathrm{x} & 2 \mathrm{x} \\
& =0.9 \mathrm{~mol} & =0.2 \mathrm{~mol}
\end{array}
$$

$2 x=0.2$
$x=\frac{0.2}{2}=0.1$
$\mathrm{k}=\frac{2.303}{\mathrm{t}} \log \frac{\left[\mathrm{A}_{\mathrm{o}}\right]}{\mathrm{A}_{\mathrm{t}}}$
$\mathrm{k}=\frac{2.303}{100} \log \frac{1}{0.9}$
$\mathrm{k}=1.059 \times 10^{-3}$
$\because \mathrm{t}_{1 / 2}=\frac{0.693}{\mathrm{k}}=\frac{0.693}{1.059 \times 10^{-3}}$
$=654.3$.
54. (10) Charge of $\mathrm{e}^{-}=1.6 \times 10^{-19} \mathrm{C}$

Dipole moment of $\mathrm{HBr}=1.6 \times 10^{-30} \mathrm{Cm}$
Inter atomic spacing $=1 \AA=1 \times 10^{-10} \mathrm{~m}$
$\%$ of ionic character in
$\mathrm{HBr}=\frac{\text { dipole moment of } \mathrm{HBr} \times 100}{\text { inter spacing distance } \times \mathrm{q}}$
$=\frac{1.6 \times 10^{-30}}{1.6 \times 10^{-19} \times 10^{-10}} \times 100$
$=10^{-30} \times 10^{29} \times 100=10^{-1} \times 100=0.1 \times 100=10 \%$
55. (4) Given alkene is unsymmetrical and has two double bonds, the number of geometrical isomers is given by $2^{n}$. Since $n=2$, therefore number of geometrical isomers will be $2^{2}=4$.
56. (80) Let the percentage of isotope with atomic wt. $10.01=x$ $\therefore$ Percentage of isotope with atomic wt. $11.01=100-x$

Average atomic wt. $=\frac{m_{1} x_{1}+m_{2} x_{2}}{x_{1}+x_{2}}$
or Average atomic wt. $=\frac{x \times 10.01+(100-x) \times 11.01}{100}$
$10.81=\frac{x \times 10.01+(100-x) \times 11.01}{100}$
$x=20$
$\therefore \%$ of isotope with atomic wt. $10.01=20$
$\%$ of isotope with atomic wt. $11.01=100-x=80$
57. (80) $\frac{P^{\circ}-P}{P^{\circ}}=\frac{n_{2}}{n_{1}+n_{2}}$
$\frac{640-600}{640}=\frac{2.5 / x}{39 / 78}$
$x=\frac{640 \times 78 \times 2.5}{39 \times 40}=80$
58. (11.4) Given
$\underset{\substack{1 \mathrm{~mol} \\ 0.2 \mathrm{~mol} \\ \mathrm{NaOH}} \underset{\substack{1 \mathrm{~mol} \\ 0.5 \mathrm{~mol}}}{\mathrm{HNO}_{3}} \rightarrow \mathrm{NaNO}_{3}+\mathrm{H}_{2} \mathrm{O}}{\substack{\Delta \mathrm{H}=57.0 \mathrm{~kJ} \\ \Delta \mathrm{H}=\text { ? }}}$
Given heat of neutralisation of strong acid by strong base $=57.0 \mathrm{~kJ}$
$\because \quad 0.2$ mole NaOH is limiting reagent.
$\therefore \quad$ Heat of neutralization $=0.2 \times 57=11.4 \mathrm{~kJ}$
59. (3) Calculating the oxidation state of nitrogen in given molecules;

Oxidation state of N in $\mathrm{NH}_{3}$ is $x+3 \times(+1)=0$ or $x=-3$
Oxidation state of N in $\mathrm{NaNO}_{3}$ is $1+x+3 \times(-2)=0$ or $x=+5$
Oxidation state of N in $\mathrm{NaN}_{3}$ is $+1+3 x=0$ or $x=-\frac{1}{3}$ 。
Oxidation state of N in $\mathrm{Mg}_{3} \mathrm{~N}_{2}$ is $3 \times 2+2 x=0$ or $x=-3$
Thus 3 molecules (i.e. $\mathrm{NH}_{3}, \mathrm{NaN}_{3}$ and $\mathrm{Mg}_{3} \mathrm{~N}_{2}$ ) have nitrogen in negative oxidation state.
60. (18) Reaction Rate $r_{1}=k[\mathrm{~A}]^{2}[\mathrm{~B}]$

Now increase conc. of A by three times and conc. of B by two times. Then new rate
$r_{2}=k[3 \mathrm{~A}]^{2}[2 \mathrm{~B}]$
$\frac{r_{1}}{r_{2}}=\frac{k[\mathrm{~A}]^{2}[\mathrm{~B}]}{k[3 \mathrm{~A}]^{2}[2 \mathrm{~B}]}=\frac{1}{3^{2}} \times \frac{1}{2}=\frac{1}{18}$
$r_{2}=18 \times r_{1}$
Hence rate increases by 18 times.

## MATHEMATICS

61. (3) $\lim _{x \rightarrow 0}(\sin x)^{1 / x}+\lim _{x \rightarrow 0}\left(\frac{1}{x}\right)^{\sin x}$

$$
=0+\lim _{x \rightarrow 0} e^{\log \left(\frac{1}{x}\right)^{\sin x}}\left\{\begin{aligned}
\text { as, }(\text { decimal })^{\infty} & \rightarrow 0 \\
\lim _{x \rightarrow 0}(\sin x)^{1 / x} & \rightarrow 0
\end{aligned}\right\}
$$

$=\mathrm{e}^{\lim _{\mathrm{x} \rightarrow 0} \frac{\log \left(\frac{1}{\mathrm{x}}\right)}{\operatorname{cosec} \mathrm{x}}}$, applying L-Hospital's rule, we get

$$
=\mathrm{e}^{\lim _{\mathrm{x} \rightarrow 0} \frac{\mathrm{x}\left(-\frac{1}{\mathrm{x}^{2}}\right)}{\operatorname{cosec} \mathrm{x} \cot \mathrm{x}}}=\mathrm{e}^{\lim _{x \rightarrow 0} \frac{\sin \mathrm{x}}{\mathrm{x}} \tan \mathrm{x}}=\mathrm{e}^{0}=1
$$

62. (2) Given circle, $x^{2}+y^{2}=9$
$(3,11)$

$P A \times P B=P T^{2}$
[By Geometry]
$P A \times P B=(3)^{2}+(11)^{2}-9=121$
63. (1) $f(x)=\frac{3}{4-x^{2}}+\log _{10}\left(x^{3}-x\right)$

$$
4-x^{2} \neq 0 ; x^{3}-x>0
$$

$$
x \neq \pm \sqrt{4} \text { and }-1<x<0 \text { or } 1<x<\infty
$$


64. (1) We have

$$
\begin{aligned}
& \frac{1}{2}\left\|\begin{array}{ccc}
\mathrm{k} & -3 \mathrm{k} & 1 \\
5 & \mathrm{k} & 1 \\
-\mathrm{k} & 2 & 1
\end{array}\right\|=28 \\
& \Rightarrow 5 \mathrm{k}^{2}+13 \mathrm{k}-46=0 \quad \text { or } \quad 5 \mathrm{k}^{2}+13 \mathrm{k}+66=0 \\
& \text { Now, } 5 \mathrm{k}^{2}+13 \mathrm{k}-46=0 \\
& \Rightarrow \quad \mathrm{k}=\frac{-13 \pm \sqrt{1089}}{10} \quad \therefore \mathrm{k}=\frac{-23}{5} ; \mathrm{k}=2
\end{aligned}
$$

since k is an integer, $\therefore \mathrm{k}=2$
Also $5 \mathrm{k}^{2}+13 \mathrm{k}+66=0$
$\Rightarrow \mathrm{k}=\frac{-13 \pm \sqrt{-1151}}{10}$. So no real solution exist
For orthocentre $\mathrm{BH} \perp \mathrm{AC}$
$\therefore\left(\frac{\beta-2}{\alpha-5}\right)\left(\frac{8}{-4}\right)=-1 \Rightarrow \alpha-2 \beta=1$
Also $\mathrm{CH} \perp \mathrm{AB}$
$\therefore \quad\left(\frac{\beta-2}{\alpha+2}\right)\left(\frac{8}{3}\right)=-1$
$\Rightarrow 3 \alpha+8 \beta=10$
Solving (i) and (ii), we get $\alpha=2, \beta=\frac{1}{2}$ orthocentre is $\left(2, \frac{1}{2}\right)$.
65. (1) $(\vec{a}-\vec{b}) \cdot\left(\vec{c}-\frac{\vec{a}+\vec{b}}{2}\right)=\vec{b} \cdot \vec{c}-\vec{b}\left(\frac{\vec{a}+\vec{b}}{2}\right)-\vec{a} \cdot \vec{c}+\frac{\vec{a}}{2}(\vec{a}+\vec{b})$
$\operatorname{and}|\vec{a}-\vec{c}|=|\vec{b}-\vec{c}| \Rightarrow|\vec{a}-\vec{c}|^{2}=|\vec{b}-\vec{c}|^{2}$
$\therefore \vec{a}+\vec{b}=2 \vec{c}$
Therefore, $(\vec{b}-\vec{a}) \cdot\left(\vec{c}-\frac{\vec{a}+\vec{b}}{2}\right)=0$.
66. (2) Let $\alpha, \beta$ be the roots of the equation
$x^{2}-(a-2) x-a+1=0$,
then $\alpha+\beta=a-2, \alpha \beta=-\mathrm{a}+1$
$\therefore \mathrm{z}=\alpha^{2}+\beta^{2}=(\alpha+\beta)^{2}-2 \alpha \beta$
$=(a-2)^{2}+2(a-1)=a^{2}-2 a+2$
$\frac{d z}{d a}=2 a-2=0 \Rightarrow a=1$
$\frac{d^{2} z}{d a^{2}}=2>0$, so $z$ has minima at $a=1$.
So $\alpha^{2}+\beta^{2}$ has least value for $a=1$. This is because we have only one stationary value at which we have minima. Hence $a=1$.
67. (2) We have
$\sin \left(300^{\circ}\right)=\sin \left(270+30^{\circ}\right)=\sin \left(3 \times 90^{\circ}+30^{\circ}\right)$
$=-\cos 30^{\circ}=-\frac{\sqrt{3}}{2}$
$\tan \left(330^{\circ}\right)=\tan \left(270^{\circ}+60^{\circ}\right)=\tan \left(3 \times 90^{\circ}+60^{\circ}\right)$
$=-\cot 60^{\circ}=-\frac{1}{\sqrt{3}}$
$\sec \left(420^{\circ}\right)=\sec \left(4 \times 90^{\circ}+60^{\circ}\right)=\sec 60^{\circ}=2$
$\tan \left(135^{\circ}\right)=\tan \left(90^{\circ}+45^{\circ}\right)=-\cot 45^{\circ}=-1$
$\sin \left(210^{\circ}\right)=\sin \left(2 \times 90^{\circ}+30^{\circ}\right)$
$=-\sin 30^{\circ}=-\frac{1}{2}$
$\sec \left(315^{\circ}\right)=\sec \left(270^{\circ}+45^{\circ}\right)$
$=\operatorname{cosec} 45^{\circ}=\sqrt{2}$
Now, $\frac{\sin 300^{\circ} \tan 330^{\circ} \cdot \sec 420^{\circ}}{\tan 135^{\circ} \sin 210^{\circ} \sec 315^{\circ}}$

$$
=\frac{-\frac{\sqrt{3}}{2} \times\left(-\frac{1}{\sqrt{3}}\right) \times 2}{-1 \times\left(-\frac{1}{2}\right) \times \sqrt{2}}=\sqrt{2}
$$

68. (4) Given differential equation is

$$
\log \left(\frac{d y}{d x}\right)=3 x+4 y, y(0)=0
$$

$\Rightarrow \frac{d y}{d x}=e^{3 x+4 y}=e^{3 x} \cdot e^{4 y}$
$\Rightarrow \int e^{-4 y} d y=\int e^{3 x} d x$
$\Rightarrow \frac{e^{-4 y}}{-4}=\frac{e^{3 x}}{3}+c$
By using $y=0$ when $x=0$, we get $c=-\frac{7}{12}$
$\therefore$ Particular solution is $4 e^{3 x}+3 e^{-4 y}=7$
69. (2) We have, $f(x)=\frac{1}{2} x-1$ for $0 \leq x \leq \pi$
$\therefore[f(x)]=\left\{\begin{array}{r}-1,0 \leq x<2 \\ 0,2 \leq x \leq \pi\end{array}\right.$
$\Rightarrow \tan [\mathrm{f}(\mathrm{x})]=\left\{\begin{array}{r}\tan (-1), 0 \leq \mathrm{x}<2 \\ \tan 0, \\ 2 \leq \mathrm{x} \leq \pi\end{array}\right.$
$\therefore \lim _{\mathrm{x} \rightarrow 2^{-}} \tan [\mathrm{f}(\mathrm{x})]=-\tan 1$ and $\lim _{\mathrm{x} \rightarrow 2^{+}} \tan [\mathrm{f}(\mathrm{x})]=0$
So, $\tan f(x)$ is not continuous at $x=2$
Now $f(x)=\frac{1}{2} x-1 \Rightarrow f(x)=\frac{x-2}{2}$
$\Rightarrow \frac{1}{\mathrm{f}(\mathrm{x})}=\frac{2}{\mathrm{x}-2}$
Clearly, $\frac{1}{f(x)}$ is not continuous at $\mathrm{x}=2$.
So, $\tan [f(x)]$ and $\left[\frac{1}{f(x)}\right]$ are both discontinuous at $\mathrm{x}=2$.
70. (2) $\frac{a+b x}{a-b x}=\frac{b+c x}{b-c x}=\frac{c+d x}{c-d x}$
$\Rightarrow \frac{a}{b x}=\frac{b}{c x}=\frac{c}{d x}$
(using componendo and dividendo)
$\Rightarrow \frac{a}{b}=\frac{b}{c}=\frac{c}{d}$
71. (3) $\int_{2}^{4}\{|x-2|+|x-3|\} d x$

$$
\begin{aligned}
& =\int_{2}^{3}\{(x-2)-(x-3)\} d x+\int_{3}^{4}\{(x-2)+(x-3)\} d x \\
& =\int_{2}^{3} d x+\int_{3}^{4}(2 x-5) d x=[x]_{2}^{3}+\left[\frac{2 x^{2}}{2}-5 x\right]_{3}^{4} \\
& =(3-2)+[(16-20)-(9-15)]=1-4+6=3
\end{aligned}
$$

72. (4) Given $x+\frac{1}{x}=2 \cos \theta$

Cubing on both side of equation (i), we get

$$
\begin{align*}
& \left(x+\frac{1}{x}\right)^{3}=8 \cos ^{3} \theta \\
& \Rightarrow \quad x^{3}+\frac{1}{x^{3}}+3 x \frac{1}{x^{2}}+3 x^{2} \frac{1}{x}=8 \cos ^{3} \theta \\
& \quad\left[\text { Using }(a+b)^{3}=a^{3}+b^{3}+3 a^{2} b+3 b^{2} a\right] \\
& \Rightarrow \quad x^{3}+\frac{1}{x^{3}}+3\left(x+\frac{1}{x}\right)=8 \cos ^{3} \theta \\
& \Rightarrow \quad x^{3}+\frac{1}{x^{3}}+6 \cos \theta=8 \cos ^{3} \theta  \tag{i}\\
& \therefore \quad x^{3}+\frac{1}{x^{3}}=2 \cos 3 \theta
\end{align*}
$$

73. (1) Let centre of the circle is, $C=(h, k)$ and radius $=r$

Co-ordinates of $A \equiv\left[\frac{a h}{a+r}, \frac{a k}{a+r}\right]$
Co-ordinates of $B \equiv\left[\frac{2 a r+2 a h}{2 a+r}, \frac{2 a k}{2 a+r}\right]$


Putting co-ordinates of $A$ and $B$ in $S_{1}, S_{2}$ respectively and eliminating $r$, $12 x^{2}-4 y^{2}-24 a x+9 a^{2}=0$.
74. (1) Given equation of line is
$x+5=\frac{1}{4}(y+3)=-\frac{1}{9}(z-6)$
or $\frac{x+5}{1}=\frac{y+3}{4}=\frac{z-6}{-9}=\lambda($ say $)$
$x=\lambda-5, y=4 \lambda-3, z=-9 \lambda+6$
$(x, y, z) \equiv(\lambda-5,4 \lambda-3,-9 \lambda+6)$
Let it is foot of perpendicular
So, d.r.'s of $\perp$ line is
$(\lambda-5-2,4 \lambda-3-4,-9 \lambda+6+1)$
$\equiv(\lambda-7,4 \lambda-7,-9 \lambda+7)$
D.r.'s of given line is $(1,4,-9)$ and both lines are $\perp$
$\therefore \quad(\lambda-7) .1+(4 \lambda-7) .4+(-9 \lambda+7)(-9)=0$
$\Rightarrow 98 \lambda=98 \Rightarrow \lambda=1$
$\therefore \quad$ Point is $(-4,1,-3) . \quad[$ Substituting $\lambda=1$ in (i)]
75. (1) $\because r=\max _{i \neq j}\left|x_{i}-x_{j}\right|$ and $\mathrm{S}^{2}=\frac{1}{n-1} \sum_{i=1}^{n}\left(x_{i}-\bar{x}\right)^{2}$

Now, consider $\left(x_{i}-\bar{x}\right)^{2}=\left(x_{i}-\frac{x_{1}+x_{2}+\ldots .+x_{n}}{n}\right)^{2}$
$=\frac{1}{n^{2}}\left[\left(x_{i}-x_{1}\right)+\left(x_{i}-x_{2}\right)+\ldots .+\left(x_{i}-x_{i}-1\right)\right.$

$$
\left.+\left(x_{i}-x_{i}+1\right)+\ldots+\left(x_{i}-x_{n}\right)\right]^{2} \leq \frac{1}{n^{2}}[(n-1) r]^{2}
$$

$$
\left[\because\left|x_{i}-x_{j}\right| \leq r\right]
$$

$\Rightarrow\left(x_{i}-\bar{x}\right)^{2} \leq r^{2} \Rightarrow \sum_{i=1}^{n}\left(x_{i}-\bar{x}\right)^{2} \leq n r^{2}$
$\Rightarrow \frac{1}{n-1} \sum_{i=1}^{n}\left(x_{i}-\bar{x}\right)^{2} \leq \frac{n r^{2}}{(n-1)} \Rightarrow \mathrm{S}^{2} \leq \frac{n r^{2}}{(n-1)}$
$\Rightarrow \mathrm{S} \leq r \sqrt{\frac{n}{n-1}}$
76. (2) If $\vec{a}+\vec{b}+\vec{c}=0,|\vec{a}|=3,|\vec{b}|=5,|\vec{c}|=7$
$\Rightarrow \quad \vec{a}+\vec{b}=-\vec{c} \Rightarrow(\vec{a}+\vec{b})^{2}=\vec{c}^{2}$
$\Rightarrow \vec{a}^{2}+\vec{b}^{2}+2 \vec{a} \cdot \vec{b} \cos \theta=\vec{c}^{2}$
$\Rightarrow 3^{2}+5^{2}+2 \times 3 \times 5 \cos \theta=7^{2}$
$\Rightarrow 9+25+30 \cos \theta=49$
$\Rightarrow 30 \cos \theta=49-34$
$\Rightarrow 30 \cos \theta=15 \Rightarrow \cos \theta=\frac{15}{30}$
$\Rightarrow \cos \theta=\frac{1}{2} \Rightarrow \cos \theta=\cos \frac{\pi}{3}$
$\Rightarrow \theta=\frac{\pi}{3}$
77. (1) If $z=x+i y$ is a complex number satisfying the given conditions, then
$a^{2}-3 a+2=|z+\sqrt{2}|=|z+i \sqrt{2}+\sqrt{2}-i \sqrt{2}|$
$\leq|z+i \sqrt{2}|+\sqrt{2}|1-i|<a^{2}+2$
$\Rightarrow-3 a<0 \Rightarrow a>0$
Since $|z+\sqrt{2}|=a^{2}-3 a+2$ represents a circle with centre at $A(-\sqrt{2}, 0)$ and radius $\sqrt{a^{2}-3 a+2}$, and $|z+i \sqrt{2}|<a^{2}$ represents the interior of the circle with centre at $B(0,-\sqrt{2})$ and radius $a$.
Therefore there will be a complex number satisfying the given condition and the given inequality if the distance $A B$ is less than the sum or difference of the radii of the two circles, i.e., if
$\sqrt{(-\sqrt{2}-0)^{2}+(0+\sqrt{2})^{2}}<\sqrt{a^{2}-3 a+2} \pm a$
$\Rightarrow 2 \pm a<\sqrt{a^{2}-3 a+2} \Rightarrow 4+a^{2} \pm 4 a<a^{2}-3 a+2$
$\Rightarrow-a<-2$ or $7 a<-2 \Rightarrow a>2$ or $a<-\frac{2}{7}$
But $a>0$ from (i), therefore $a>2$.
78. (2) We define the following events:
$A_{1}$ : Selecting a pair of consecutive letter from the word LONDON.
$\mathrm{A}_{2}$ : Selecting a pair of consecutive letters from the word CLIFTON
$E$ : Selecting a pair of letters 'ON'.
Then $P\left(A_{1} \cap E\right)=\frac{2}{5}$; as there are 5 pairs of consecutive letters out of which 2 are ON.
$P\left(A_{2} \cap E\right)=\frac{1}{6}$; as there are 6 pairs of consecutive
letters of which one is ON.
$\therefore$ the required probability is

$$
P\left(\frac{A_{1}}{E}\right)=\frac{P\left(A_{1} \cap E\right)}{P\left(A_{1} \cap E\right)+P\left(A_{2} \cap E\right)}=\frac{\frac{2}{5}}{\frac{2}{5}+\frac{1}{6}}=\frac{12}{17}
$$

79. (1) $\int f(x) \sin x \cos x d x=\frac{1}{2\left(b^{2}-a^{2}\right)} \log (f(x))+C$ therefore
$f(x) \sin x \cos x=\frac{1}{2\left(b^{2}-a^{2}\right)} \cdot \frac{1}{f(x)} f^{\prime}(x)$
[by differentiating both the sides]
$\Rightarrow 2\left(\mathrm{~b}^{2}-\mathrm{a}^{2}\right) \sin \mathrm{x} \cos \mathrm{x}=\frac{\mathrm{f}^{\prime}(\mathrm{x})}{(\mathrm{f}(\mathrm{x}))^{2}}$
$\int\left(2 b^{2} \sin x \cos x-2 a^{2} \sin x \cos x\right) d x=\int \frac{f^{\prime}(x)}{(f(x))^{2}} d x$
[by integrating both the sides]
$\Rightarrow-b^{2} \cos ^{2} x-a^{2} \sin ^{2} x-C=-\frac{1}{f(x)}$
80. (3) Let $L=\lim _{x \rightarrow 0} \frac{f\left(x^{2}\right)-f(x)}{f(x)-f(0)}$

Using L.H. Rule, we get
$L=\lim _{x \rightarrow 0} \frac{f^{\prime}\left(x^{2}\right) \cdot 2 x-f^{\prime}(x)}{f^{\prime}(x)}$
$=\lim _{x \rightarrow 0} \frac{f^{\prime}\left(x^{2}\right) \cdot 2 x}{f^{\prime}(x)}-1\left[\begin{array}{l}\because f^{\prime}(a)>0, f \text { being } \\ \text { strictly increasing }\end{array}\right]$
$=0-1=-1$
81. (879) Number of white balls $=10$

Number of green balls $=9$
and number of black balls $=7$
$\therefore$ Required ways
$=(10+1)(9+1)(7+1)-1$
$=11.10 .8-1=879$
$[\because$ The total number of ways of selecting one or more items from $p$ identical items of one kind, $q$ identical items of second kind; $r$ identical items of third kind is $(p+1)$ $(q+1)(r+1)-1]$
82. (190) Equation of $A B$ is,

$$
\frac{x}{21}+\frac{y}{21}=1 \Rightarrow x+y=21
$$



Let $(h, k)$ be any point inside the $\triangle O A B$ then

$$
\begin{align*}
& h<21, h>0  \tag{i}\\
& k<21, k>0  \tag{ii}\\
& \text { and } h+k<21
\end{align*}
$$

For integral values of ( $h, k$ ) satisfying (i), (ii) and (iii) simultaneously, let
Total number of points

$$
h=1 \text { then } k=1,2,3 \ldots 19
$$

$h=2$ then $k=1,2,3 \ldots 18 \quad 18$
$h=3$ then $k=1,2,3 \ldots 17 \quad 17$
$\begin{array}{lcl}: & : & \vdots \\ \vdots & \vdots & \vdots\end{array}$
$\therefore$ Total number of integral points
$=19+18+17+\ldots+1$

$$
=\frac{19 \times 20}{2}=190 .
$$

83. (60) Let $z=\frac{1-i \sqrt{3}}{1+i \sqrt{3}}=\frac{(1-i \sqrt{3})}{(1+i \sqrt{3})} \times \frac{(1-i \sqrt{3})}{(1-i \sqrt{3})}$
$=\frac{1+3 i^{2}-2 \sqrt{3} i}{1-3 i^{2}}=\frac{1-3-2 \sqrt{3} i}{1+3}\left[\because i^{2}=-1\right]$
$=\frac{-1-i \sqrt{3}}{2}=-\frac{1}{2}-\frac{\sqrt{3}}{2} i$
$\because \tan \theta=\frac{\sqrt{3} / 2}{1 / 2}=\sqrt{3} \quad\left[\begin{array}{l}\because \tan \theta=\frac{y}{x} \\ \text { where } z=x+i y\end{array}\right]$
$\therefore \quad$ Argument of $z=\theta=\tan ^{-1}(\sqrt{3})=\frac{\pi}{3}=60^{\circ}=\mathrm{k}^{\circ}$
$\Rightarrow \mathrm{k}=60$
84. (97) $t_{r+1}={ }^{100} \mathrm{C}_{r}(\sqrt[8]{5})^{100-r} \cdot(\sqrt[6]{2})^{r}$

As 2 and 5 are coprime, $t_{r+1}$ will be rational if $100-r$ is a multiple of 8 and $r$ is a multiple of 6 .
Also $0 \leq r \leq 100$
$\therefore \quad r=0,6,12, \ldots ., 96$
$\therefore \quad 100-r=4,10,16, \ldots ., 100$
But $100-r$ is to be a multiple of 8 .
So, $100-r=0,8,16,24$, 96
The common terms in (i) and (ii) are 16, 40, 64, and 88
$\therefore \quad r=84,60,36,12$ give rational terms.
$\therefore$ the number of irrational terms $=101-4=97$
85. (12) $2|x|+3|y| \leq 6$ can be written as
$l_{1}: 2 x-3 y=6$, points are $(3,0),(0,-2)$
$l_{2}:-2 x+3 y=6$, points are $(-3,0),(0,2)$
$l_{3}: 2 x+3 y=6$, points are $(3,0),(0,2)$
$l_{4}:-2 x-3 y=6$, points are $(-3,0),(0,-2)$
Required area $=$ area of quadrilateral $A B C D$

$$
=\operatorname{area}(\triangle A D C)+\operatorname{area}(\triangle A B C)
$$


$=\frac{1}{2} A C \times D O+\frac{1}{2} \times B O \times A C$
$=\frac{1}{2} A C(B O+O D)=\frac{1}{2} \times 4(3+3)$
$=2 \times 6=12$ square units.
86. (0.5) $\cos ^{-1} \sqrt{\mathrm{p}}=\frac{\pi}{4}, \cos ^{-1} \sqrt{1-\mathrm{p}}$ and $\cos ^{-1} \sqrt{1-\mathrm{q}}=\frac{\pi}{4}$
$\Rightarrow \sqrt{1-q}=\cos \frac{\pi}{4}=\frac{1}{\sqrt{2}} \Rightarrow q=\frac{1}{2}=0.5$
87. (1.25) $\left[\begin{array}{lll}1 & x & 1\end{array}\right]\left[\begin{array}{lll}1 & 2 & 3 \\ 0 & 5 & 1 \\ 0 & 3 & 2\end{array}\right]\left[\begin{array}{c}x \\ 1 \\ -2\end{array}\right]=O$
$\Rightarrow\left[\begin{array}{lll}1 & 2+5 x+3 & 3+x+2\end{array}\right]\left[\begin{array}{c}x \\ 1 \\ -2\end{array}\right]=\mathrm{O}$
$\Rightarrow x+(2+5 x+3)+(-2)(3+x+2)=0 \Rightarrow x=\frac{5}{4}$.
88. (2) $f(x)= \begin{cases}(2+x)^{3}, & -3<x \leq-1 \\ x^{2 / 3}, & -1<x<2\end{cases}$
$\Rightarrow f^{\prime}(x)=\left\{\begin{array}{lr}3(2+x)^{2} ; & -3<x \leq-1 \\ \frac{2}{3} x^{-1 / 3} ; & -1<x<2\end{array}\right.$
For $-3<x \leq-1, f^{\prime}(x)>0$.
But $-1<x<0, f^{\prime}(x)<0$
So, we have one local max. at $x=-1$
Further for $0<x<2, f^{\prime}(x)>0$
$\therefore$ also, we have one local minima.
89. (0.25) $P\left(\right.$ tail in $\left.3^{\text {rd }}\right) \cdot P\left(\right.$ tail in $\left.4^{\text {th }}\right)=\frac{1}{2} \cdot \frac{1}{2}=\frac{1}{4}$
90. (325)

$\mathrm{a}+\mathrm{e}+\mathrm{f}+\mathrm{g}=285, \mathrm{~b}+\mathrm{d}+\mathrm{f}+\mathrm{g}=195$
$\mathrm{c}+\mathrm{d}+\mathrm{e}+\mathrm{g}=115, \mathrm{e}+\mathrm{g}=45, \mathrm{f}+\mathrm{g}=70, \mathrm{~d}+\mathrm{g}=50$
$\mathrm{a}+\mathrm{b}+\mathrm{c}+\mathrm{d}+\mathrm{e}+\mathrm{f}+\mathrm{g}=500-50=450$
We obtain $\mathrm{a}+\mathrm{f}=240, \mathrm{~b}+\mathrm{d}=125, \mathrm{c}+\mathrm{e}=65$
$\mathrm{a}+\mathrm{e}=215, \mathrm{~b}+\mathrm{f}=145 ; \mathrm{b}+\mathrm{c}+\mathrm{d}=165$
$\mathrm{a}+\mathrm{c}+\mathrm{e}=255 ; \mathrm{a}+\mathrm{b}+\mathrm{f}=335$
Solving we get
$\mathrm{b}=95, \mathrm{c}=40, \mathrm{a}=190, \mathrm{~d}=30, \mathrm{e}=25, \mathrm{f}=50$ and $\mathrm{g}=20$
Desired quantity $=a+b+c=325$
Get set go for


## Main



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