# AMU

## Engineering Entrance Exam

# Solved Paper 2020

## Physics

**1.** If $L, C$ and $R$ represent inductance, capacitance and resistance respectively, then which of the following does not represent dimensions of frequency?

(a) $\frac{1}{RC}$ (b) $\frac{R}{L}$

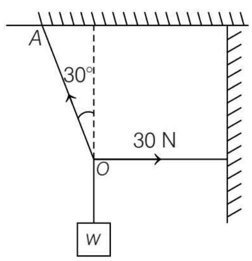
(c) $\frac{1}{\sqrt{LC}}$ (d) $\frac{C}{L}$

**2.** The pressure applied from all directions on a cube is $p$. How much its temperature should be raised to maintain the original volume? The volume elasticity of the cube is $\beta$ and the coefficient of volume expansion is $\alpha$.

(a) $\frac{p}{\alpha\beta}$ (b) $\frac{p\alpha}{\beta}$

(c) $\frac{p\beta}{\alpha}$ (d) $\frac{\alpha\beta}{p}$

**3.** As shown in figure, the tension in the horizontal cord is 30 N. The weight $w$ and tension in the string $OA$ in newton are



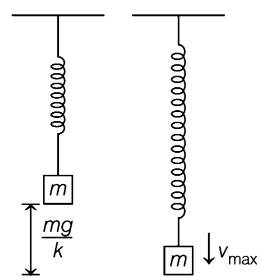

(a) $30\sqrt{3}$, 30 (b) $30\sqrt{3}$, 60

(c) $60\sqrt{3}$, 30 (d) None of these

**4.** A car turns a corner on a slippery road at a constant speed of 10 m/s. If the coefficient of friction is 0.5, the minimum radius of the arc in metre in which the car turns is

(a) 20 (b) 10 (c) 5 (d) 4

**5.** A particle suspended from a vertical spring oscillates 10 times per second. At the highest point of oscillation, the spring becomes unstretched. Find the speed when the spring is stretched by 0.20 cm.
(Take, $g = \pi^2$ m/s$^2$)




(a) 110.25 cm/s (b) 12.14 cm/s

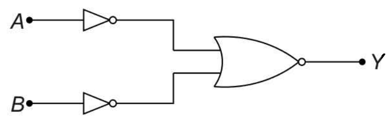
(c) 15.4 cm/s (d) 16.7 cm/s

**6.** Two cells of equal emf and of internal resistances $r_1$ and $r_2$ $(r_1 > r_2)$ are connected in series. On connecting this combination to an external resistance $R$, it is observed that the potential difference across the first cell becomes zero. The value of $R$ will be

(a) $r_1 + r_2$ (b) $r_1 - r_2$

(c) $\frac{r_1 + r_2}{2}$ (d) $\frac{r_1 - r_2}{2}$

**7.** Which logic gate is represented by the following combination of logic gates?




(a) OR (b) NAND
(c) AND (d) NOR

**8.** Calculate the electric and magnetic fields produced by the radiation coming from a $30\pi$W bulb at a distance of 3 m. Assume that the efficiency of the bulb is 10% and it is a point source.

(a) $0.22 \times 10^{-8}$ T
(b) $0.88 \times 10^{-6}$ T
(c) $0.22 \times 10^{-6}$ T
(d) $2.64 \times 10^{-8}$ T

**9.** One end of a uniform wire of length $L$ and of weight $w$ is attached rigidly to a point in the roof and a weight $w_1$ is suspended from its lower end. If $S$ is the area of cross-section of the wire, then the stress in the wire at a height $\frac{3L}{4}$ from its lower end is

(a) $\frac{w_1}{S}$ (b) $\frac{w_1 + (w/4)}{S}$
(c) $\frac{w_1 + (3w/4)}{S}$ (d) $\frac{w_1 + w}{S}$

**10.** When a tuning fork $A$ of frequency 100 Hz is sounded with a tuning fork $B$, the number of beats per second is 2. On putting some wax on the prongs of $B$, the number of beats per second becomes 1. The frequency of the fork $B$ is

(a) 98 Hz (b) 99 Hz
(c) 101 Hz (d) 102 Hz

**11.** A 200 km long telegraph wire has a capacitance of 0.014 $\mu$F/km. If it carries an alternating current of $50 \times 10^3$Hz, what should be the value of an inductance required to be connected in series, so that impedance is minimum?

(a) $0.48 \times 10^{-2}$ mH (b) $0.36 \times 10^{-2}$ mH
(c) $0.52 \times 10^{-2}$ mH (d) $0.49 \times 10^{-2}$ mH

**12.** The density of liquid contained in the tank of area 0.5 $m^2$ is 1200 kg/$m^2$. It has a hole of area 1 $cm^2$ near the bottom. A load of 30 kg is applied on the liquid at the top. Find the velocity of efflux when the height of liquid level is 75 cm above the bottom.
(Take, $g = 10$ m/$s^2$)

(a) 2 m/s (b) 4 m/s (c) 6 m/s (d) 8 m/s

**13.** The rear side of a truck is open and a box of mass 2 kg is placed on the truck 8 m away from the open end. The truck starts from rest with an acceleration of 2 m/$s^2$ on a straight road. The box will fall off the truck when it is at distance from the starting point equal to
(Given, $\mu = 0.1$ and $g = 10$ m/$s^2$).

(a) 4 m (b) 8 m (c) 12 m (d) 16 m

**14.** In Young's double slit experiment, one of the slit is wider than another, so that amplitude of the light from one slit is double of that from other slit. If $I_m$ be the maximum intensity, the resultant intensity $I$ when they interfere at phase difference $\phi$ is given by

(a) $\frac{I_m}{9}(4 + 5\cos\phi)$ (b) $\frac{I_m}{3}\left(1 + 2\cos^2\frac{\phi}{2}\right)$
(c) $\frac{I_m}{5}\left(1 + 4\cos^2\frac{\phi}{2}\right)$ (d) $\frac{I_m}{9}\left(1 + 8\cos^2\frac{\phi}{2}\right)$

**15.** The length of a magnet is large compared to its width and breadth. The time period of its oscillation in a vibration magnetometer is 2s. The magnet is cut along its length into three equal parts and three parts are then placed on each other with their like poles together. The time period of this combination will be

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

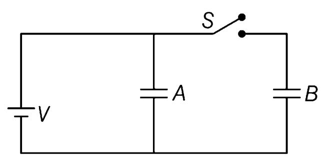
**16.** A cubical box with porous walls containing an equal number of $O_2$ and $H_2$ molecules is placed in a larger evacuated chamber. The entire system is maintained at constant temperature $T$. The ratio of $V_{rms}$ of $O_2$ molecules to that of the $V_{rms}$ of $H_2$ molecules, found in the chamber outside the box after a short interval is

(a) $\frac{1}{2\sqrt{2}}$ (b) $\frac{1}{4}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\sqrt{2}$

**17.** Two stretched wires are in unison. If the tension in one of the wire is increased by 1%, 3beats are produced in 2s. The initial frequency of each wire is

(a) 150 Hz (b) 200 Hz (c) 300 Hz (d) 450 Hz

**18.** Figure given below shows two identical parallel plate capacitors connected to a battery with switch $S$ closed. The switch is now opened and the free space between the plate of capacitors is filled with a dielectric of dielectric constant 2. What will be the ratio of total electrostatic energy stored in both capacitors before and after the introduction of the dielectric?

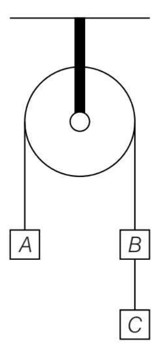



(a) 2 : 1 (b) 5 : 1 (c) 4 : 5 (d) 5 : 4

**19.** A bullet of mass 10 g moving horizontally at a speed of 140 m/s strikes a block of mass 100 g attached to a string like a simple pendulum. The bullet penetrates the block and emerges then on the other side. If the block rises by 80 cm, then find the final velocity of bullet.

(a) 80 m/s (b) 100 m/s
(c) 120 m/s (d) 140 m/s

**20.** Three blocks $A$, $B$ and $C$ each of mass 2 kg, are hanging over a fixed pulley as shown in the figure. The tension in the string connecting $B$ and $C$ is




(a) zero (b) 3.3 N (c) 13.3 N (d) 19.6 N

**21.** Two balls of masses $m$ and $2m$ are attached to the ends of a light rod of length $L$. The rod rotates with an angular speed $\omega$ about an axis passing through the centre of mass of system and perpendicular to the plane. Find the angular momentum of the system about the axis of rotation.

(a) $\frac{2}{3}m\omega L^2$ (b) $\frac{1}{3}\omega^2 Lm$
(c) $\frac{2}{3}\omega^2 Lm$ (d) $\frac{1}{3}Lm$

**22.** A ray of light is incident on a surface of glass slab at an angle 45°. If the lateral shift produced per unit thickness is $1/\sqrt{3}$, then the angle of refraction produced is

(a) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (b) $\tan^{-1}\left(1-\sqrt{\frac{2}{3}}\right)$
(c) $\sin^{-1}\left(1-\sqrt{\frac{2}{3}}\right)$ (d) $\tan^{-1}\left(\sqrt{\frac{2}{3-1}}\right)$

**23.** A shell bursts on contact with the ground and pieces from it fly in all directions with velocities upto 60 m/s. Find the time for which a man 180 m away is in danger.

(a) $2\sqrt{3}$ s (b) $6\sqrt{2}$ s
(c) $4\sqrt{3}$ s (d) None of these

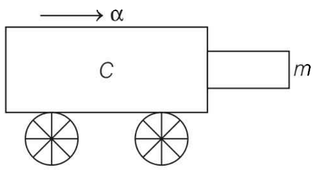
**24.** Two straight long conductors $AOB$ and $COD$ are perpendicular to each other and carry currents $i_1$ and $i_2$. The magnitude of the magnetic induction at a point $P$ at a distance a from the point $O$ in a direction perpendicular to the plane $ABCD$ is

(a) $\frac{\mu_0}{2\pi a}(i_1 + i_2)$ (b) $\frac{\mu_0}{2\pi a}(i_1 - i_2)$
(c) $\frac{\mu_0}{2\pi a}(i_1^2 + i_2^2)^{1/2}$ (d) $\frac{\mu_0}{2\pi a}\frac{i_1 i_2}{(i_1 + i_2)}$

**25.** The mean lives of a radioactive substance are 1620 yr and 405 yr for $\alpha$-emission and $\beta$-emission, respectively. Find out the time during which three-fourth of a sample will decay, if it is decaying both by $\alpha$-emission and $\beta$-emission simultaneously.

(a) 643 yr (b) 449 yr
(c) 528 yr (d) 279 yr

**26.** A block of mass $m$ is in contact with the cart $C$ as shown in the figure.




The coefficient of static friction between the block and the cart is $\mu$. The acceleration $\alpha$ of the cart that will prevent the block from falling satisfies.

(a) $\alpha > \frac{mg}{\mu}$ (b) $\alpha > \frac{g}{2\mu}$ (c) $\alpha \geq \frac{g}{\mu}$ (d) $\alpha < \frac{g}{\mu}$

**27.** Velocity of sound in a gaseous medium is $330 \text{ ms}^{-1}$. If the pressure is increased by 4 times without change in temperature, the velocity of sound in the gas is

(a) $330 \text{ ms}^{-1}$ (b) $660 \text{ ms}^{-1}$
(c) $156 \text{ ms}^{-1}$ (d) $990 \text{ ms}^{-1}$

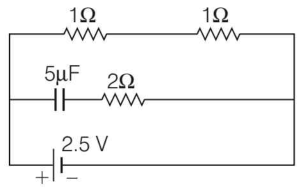
**28.** Kepler's third law states that the square of period of revolution ($T$) of a planet around the sun, is proportional to third power of average distance, $r$ between the sun and the planet
i.e. $T^2 = Kr^3$
Here, $K$ is constant.
If masses of the sun and the planet are $M$ and $m$ respectively, then as per Newton's law of gravitation, force of attraction between them is $F = \frac{GMm}{r^2}$, where $G$ is gravitational constant.
The relation between $G$ and $K$ is described as

(a) $GK = 4\pi^2$ (b) $GMK = 4\pi^2$
(c) $K = G$ (d) $K = 1/G$

**29.** Two positive ions, each carrying a charge $q$ are separated by a distance $d$. If $F$ is the force of repulsion between the ions, the number of electrons missing from each ion will be ($e$ being the charge on an electron)

(a) $\frac{4\pi\varepsilon_0 Fd^2}{e^2}$ (b) $\sqrt{\frac{4\pi\varepsilon_0 Fe^2}{d^2}}$
(c) $\sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$ (d) $\frac{4\pi\varepsilon_0 Fd^2}{q^2}$

**30.** A capacitor of capacitance $5\,\mu\text{F}$ is connected as shown in the figure. The internal resistance of the cell is $0.5\,\Omega$. The amount of charge on the capacitor plate is

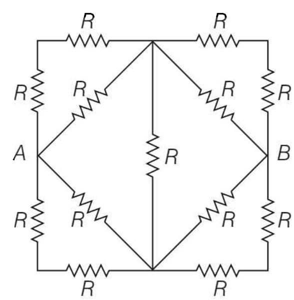



(a) zero (b) $5\,\mu\text{C}$ (c) $10\,\mu\text{C}$ (d) $25\,\mu\text{C}$

**31.** If pressure of $CO_2$ (real gas) in a container is given by $P = \frac{RT}{2v - b} - \frac{a}{4b^2}$, then mass of the gas in container is

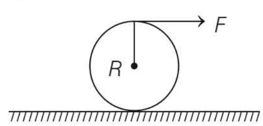
(a) 11 g (b) 22 g (c) 33 g (d) 44 g

**32.** Thirteen resistances each of resistance $R$ ohm are connected in the circuit as shown in the figure below. The effective resistance between $A$ and $B$ is



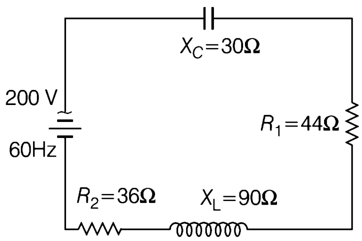

(a) $R\,\Omega$ (b) $\frac{2R}{3}\Omega$
(c) $\frac{4R}{3}\Omega$ (d) $2R\,\Omega$

**33.** A tangential force $F$ acts at the top of a thin spherical shell of mass '$m$' and radius $R$. The acceleration of the shell, if it rolls without slipping is




(a) $\frac{5F}{6m}$ (b) $\frac{6F}{5m}$ (c) $\frac{7m}{2F}$ (d) $\frac{2m}{7F}$

**34.** As given in the figure a series circuit connected across a 200 V, 60 Hz line consists of a capacitor of capacitive reactance 30 Ω, a non-inductive resistor of resistance 44 Ω, a coil of inductive reactance 90 Ω and another resistance of resistance 36 Ω. The power dissipated in the circuit is




(a) 320 W (b) 176 W (c) 144 W (d) 0 W

**35.** A cylindrical vessel of radius $r$ containing a liquid is rotating about a vertical axis through the centre of circular base. If the vessel is rotating with angular velocity ω, then what is difference of the height of liquid at the centre of vessel and edge?

(a) $\frac{r\omega}{2g}$ (b) $\frac{r^2\omega^2}{2g}$ (c) $\sqrt{2gr\omega}$ (d) $\frac{\omega^2}{2gr^2}$

**36.** Two water pipes of diameters 2 cm and 4 cm are connected with the main supply line. The velocity of flow of water in the pipe of 2 cm diameter is

(a) 4 times that in the other pipe
(b) $\frac{1}{4}$ times that in the other pipe
(c) 2 times that in the other pipe
(d) $\frac{1}{2}$ times that in the other pipe

**37.** A coil in the shape of an equilateral triangle of side $l$ is suspended between two pole pieces of a permanent magnet, such that magnetic field, $B$ is in plane of the coil. If due to a current I in the triangle, a torque τ acts on it, the side $l$ of the triangle is

(a) $2\left(\frac{\tau}{\sqrt{3}\,Bl}\right)^{\frac{1}{2}}$ (b) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bl}\right)$

(c) $2\left(\frac{\tau}{Bl}\right)^{\frac{1}{2}}$ (d) $\frac{1}{\sqrt{3}}\frac{\tau}{Bl}$

**38.** Two polaroids are crossed. If now one of them is rotated through an angle of 30° and unpolarised light of intensity $I_0$ is incident on the first polariod, then the intensity of transmitted light will be

(a) $\frac{I_0}{4}$ (b) $\frac{3I_0}{4}$ (c) $\frac{3I_0}{8}$ (d) $\frac{I_0}{8}$

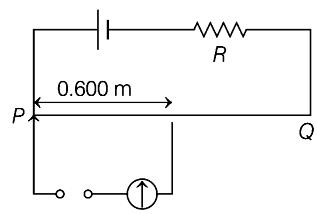
**39.** If a body coated black at 600 K surrounded by atmosphere at 300 K has cooling rate $r_0$, the same body at 900 K, surrounded by the same atmosphere will have cooling rate equal to

(a) $\frac{16}{3}r_0$ (b) $\frac{8}{16}r_0$ (c) $16\,r_0$ (d) $4\,r_0$

**40.** If force ($F$), length ($L$) and time ($T$) be considered fundamental units, then the units of mass will be

(a) $[F\,L\,T^{-2}]$ (b) $[F\,L^{-2}\,T^{-1}]$
(c) $[F\,L^{-1}\,T^{2}]$ (d) $[F^2\,L\,T^{-2}]$

**41.** Figure shows a simple potentiometer circuit for measuring a small emf produced by a thermocouple



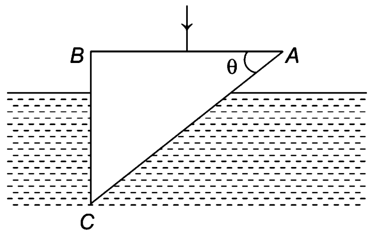

The meter wire $PQ$ has a resistance of 5 Ω and the driver cell has an emf of 2.00 V. If a balance point is obtained at 0.600 m along $PQ$, when measuring an emf of 6.00 mV, then what is the value of resistance $R$?

(a) 95 Ω (b) 995 Ω (c) 195 Ω (d) 1995

**42.** A beam of light (λ = 600 nm) from a distant source, falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between the first dark fringes on either side of the central bright fringe is

(a) 1.2 cm (b) 1.2 mm
(c) 2.4 cm (d) 2.4 mm

**43.** A glass prism $ABC$ (refractive index 1.5), immersed in water (refractive index $\frac{4}{3}$). A ray of light is incident normally on face $AB$. If it is totally reflected at face $AC$, then




(a) $\sin\theta \geq \frac{8}{9}$ (b) $\sin\theta \geq \frac{2}{3}$

(c) $\sin\theta > \frac{\sqrt{3}}{2}$ (d) $\frac{2}{3} < \sin\theta < \frac{8}{9}$

**44.** An ideal gas is taken through a cyclic thermodynamical process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960$ J, $Q_2 = -5585$ J, $Q_3 = -2980$ J and $Q_4 = 3645$ J, respectively. The corres- ponding works involved are $W_1 = 2200$ J, $W_2 = -825$ J, $W_3 = -1100$ J and $W_4$, respectively. The value of $W_4$ is

(a) 1315 J (b) 275 J (c) 765 J (d) 675 J

**45.** If the series limit wavelength of the Lyman series of hydrogen atom is 912 Å, then the series limit wavelength of the Balmer series of the hydrogen atom is

(a) 912 Å (b) $912 \times 2$ Å

(c) $912 \times 4$ Å (d) $\frac{912}{2}$ Å

**46.** A transformer having efficiency of 90% is working on 200 V and 3 kW power supply. If the current in the secondary coil is 6 A the voltage across the secondary coil and the current in the primary coil respectively are

(a) 300 V, 15 A (b) 450 V, 15 A

(c) 450 V, 13.5 A (d) 600 V, 15 A

**47.** A beam of light consisting of red, green and blue colours, is incident on a right-angled prism. The refractive indices of the material of the prism for the above red, green and blue wavelengths are 1.39, 1.44 and 1.47, respectively. The prism will

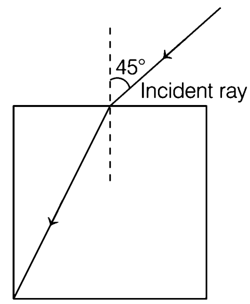
(a) separated part of the red colour from the green and blue colours

(b) separate part of the blue colour from the red and green colours

(c) separate all the three colours from one another

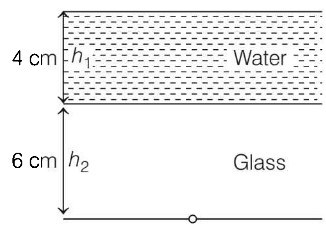
(d) not separate even partially any colour from the other two colours

**48.** A light ray falls on a square glass slab as shown in the figure. The index of refraction of the glass, if total internal reflection is occur at vertical face, is equal to




(a) $\frac{(\sqrt{2}+1)}{2}$ (b) $\sqrt{\frac{5}{2}}$ (c) $\frac{3}{2}$ (d) $\sqrt{\frac{3}{2}}$

**49.** A 4 cm thick layer of water covers a 6 cm thick glass slab. A coin is placed at the bottom of the slab and is being observed from the air side along the normal to the surface. Find the apparent position of the coin from




(a) 7.0 cm (b) 8.0 cm

(c) 10 cm (d) 5 cm

**50.** A train of 150 m length is going towards North direction at a speed of 10 $ms^{-1}$. A parrot files at a speed of 5 $ms^{-1}$ towards South direction parallel to the railway track. The time taken by the parrot to cross the train is equal to

(a) 12 s (b) 8 s (c) 15 s (d) 10 s

# Chemistry

**51.** If 1.4 g of $N_2(g)$ react with 1 g of $H_2(g)$ to form ammonia $(NH_3)$, then amount of $NH_3(g)$ formed and number of atoms present in $NH_3$ respectively are (in moles)

(a) 0.5 and 0.1 (b) 0.1 and 0.1
(c) 0.1 and 0.5 (d) 0.5 and 0.5

**52.** Which one among the following is not correct as per indicated property?

(a) $Br_2 < Cl_2 < F_2$ (Oxidising power)
(b) $Br_2 < F_2 < Cl_2$ (Electron gain enthalpy)
(c) $Br_2 < Cl_2 < F_2$ (Electronegativity)
(d) $Br_2 < Cl_2 < F_2$ (Bond energy)

**53.** Which of the following will form 1° alcohol?

(a) $R$ Mg$X$ + HCHO (followed by hydrolysis)
(b) $R$Mg$X$ + $CH_3COCH_3$ (followed by hydrolysis)
(c) $RX$ + Mg (in the presence of water)
(d) Amine + $CHCl_3 \longrightarrow$ in the presence of KOH

**54.** For three gases $A$, $B$ and $C$, the values of their critical temperatures $(T_C)$ are such that

$$T_C(A) > T_C(B) > T_C(C)$$

assuming identical value of '$b$'. Which gas can be most easily liquefied?

(a) $A$ (b) $B$
(c) $C$
(d) All at same temperature

**55.** Given, $S + \frac{3}{2}O_2 \longrightarrow SO_3 + 2x$ kcal

$$SO_2 + \frac{1}{2}O_2 \longrightarrow SO_3 + y \text{ kcal}$$

with the help of above reactions, find out the heat of formation of $SO_2$.

(a) $(2x - y)$ (b) $(x + y)$ (c) $(2x + y)$ (d) $(2x / y)$

**56.** Match the Lists I and II and pick the correct matching from the codes given below.

| | List I | | List II |
|---|---|---|---|
| (i) | Peroxy acetyl nitrate | 1. | Carcinogens |
| (ii) | Polycyclic aromatic hydrocarbons | 2. | Global warming |
| (iii) | IR active molecules | 3. | Photochemical smog |
| (iv) | Dioxins | 4. | Waste incineration |

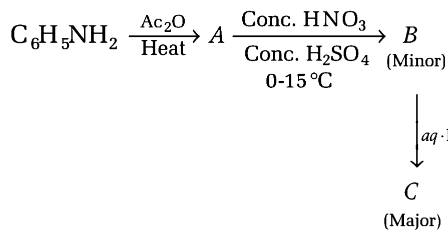
**Codes**

(a) (i)-3, (ii)-1, (iii)-4, (iv)-2
(b) (i)-3, (ii)-2, (iii)-4, (iv)-1
(c) (i)-3, (ii)-1, (iii)-2, (iv)-4
(d) (i)-4, (ii)-2, (iii)-1, (iv)-3

**57.** For the gaseous reaction involving complete combustion of isobutane (assuming all products and reactants are in gaseous state), the relation between $\Delta H$ and $\Delta E$ will be

(a) $\Delta H > \Delta E$ (b) $\Delta H = \Delta E$
(c) $\Delta H < \Delta E$ (d) $\Delta H = 0$ and $\Delta E = \infty$

**58.** Consider the following sequence of reactions.



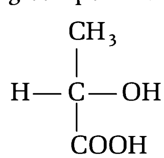

The major product $(C)$ is

(a) 2, 4, 6-trinitroaniline (b) $p$-nitroacetanilide
(c) $p$-nitroaniline (d) $m$-nitroaniline

**59.** Moist hydrogen cannot be dried over (conc.) $H_2SO_4$ because

(a) it catches fire
(b) it is reduced by $H_2SO_4$
(c) it is oxidised by $H_2SO_4$
(d) it decomposes $H_2SO_4$

**60.** Calculate the number of optical isomers in the following compound.




(a) 1
(b) 2
(c) 3
(d) None of these

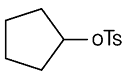
**61.** The correct order of increasing covalent character is

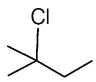
(a) $LiCl < NaCl < BeCl_2$ (b) $BeCl_2 < NaCl < LiCl_2$
(c) $NaCl < LiCl < BeCl_2$ (d) $BeCl_2 < LiCl < NaCl$

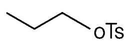
**62.** $H_3BO_3$ is a

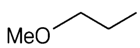
(a) monobasic and Lewis acid
(b) monobasic and Bronsted acid
(c) tribasic and Lewis acid
(d) tribasic and Bronsted acid

**63.** In the following compounds which gives fastest $S_N2$ reaction?

(a) 

(b) 


(c) 

(d) 


**64.** Among the following, achiral amino acid is

(a) ethylalanine
(b) methylglycine
(c) 2-hydroxymethyl serine
(d) tryptophan

**65.** Correct sequence of acidic character is

(a) $N_2O_5 > CO_2 > CO > SO_2$
(b) $N_2O_5 > SO_2 > CO_2 > CO$
(c) $CO > CO_2 > SO_2 > N_2O_5$
(d) $SO_2 > CO_2 > CO > N_2O_5$

**66.** Which reaction represents the oxidising behaviour of $H_2SO_4$?

(a) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$
(b) $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$
(c) $2HI + H_2SO_4 \longrightarrow I_2 + SO_2 + 2H_2O$
(d) $2PCl_5 + H_2SO_4 \longrightarrow 2POCl_3 + SO_2Cl_2 + 2HCl$

**67.** The highest magnetic moment is shown by the transition metal ion with outer electronic configuration

(a) $d^9$ (b) $d^7$
(c) $d^5$ (d) $d^3$

**68.** Which complex ion has no $d$-electron in the central metal atom?

(a) $[MnO_4]^-$
(b) $[Co(NH_3)_6]^{3+}$
(c) $[Fe(CN)_6]^{3-}$
(d) $[Cr(H_2O)_6]^{3+}$

**69.** Which of the following liquid on electrolysis produce $H_2$ at cathode and $Cl_2$ at anode?

(a) NaCl solution in water
(b) $CuCl_2$ solution in water
(c) Pure water
(d) $H_2SO_4$ solution

**70.** The standard reduction potentials of $Cu^{2+}/Cu$ and $Cu^{2+}/Cu^+$ are 0.337 and 0.153 volts respectively. The standard electrode potential for $Cu^{2+}/Cu$ half cell will be

(a) 0.490 V (b) 0.980 V
(c) 0.827 V (d) 0.521 V

**71.** For the reaction,

$$2A + B \longrightarrow C + D,$$

on the basis of the following data, find the order of reaction.

| Exp. No. | $[A]$ mol $L^{-1}$ | $[B]$ mol $L^{-1}$ | Initial rate (mol $L^{-1}$ $min^{-1}$) |
|---|---|---|---|
| 1. | 0.1 | 0.1 | $6 \times 10^{-3}$ |
| 2. | 0.3 | 0.2 | $7.2 \times 10^{-2}$ |
| 3. | 0.3 | 0.4 | $2.88 \times 10^{-1}$ |
| 4. | 0.4 | 0.1 | $2.40 \times 10^{-2}$ |

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

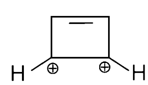
**72.** For the reaction,

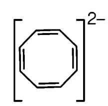
$$2N_2O_5 \longrightarrow 4NO_2 + O_2$$

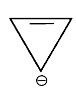
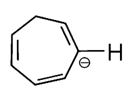
the values of rate constant and rate of reaction are respectively $3 \times 10^{-5} s^{-1}$ and $2.4 \times 10^{-5}$ mol $L^{-1}s^{-1}$. The concentration of $N_2O_5$ (in mol $L^{-1}$) will be

(a) 0.4 (b) 0.8
(c) 1.2 (d) 0.6

**73.** In the following compounds

I. 

II. 


III. 
IV. 

which is the correct pair of aromatic compound?

(a) I, III and IV (b) I and II
(c) III and IV (d) I and III

**74.** In which of the following compound, cations occupy alternate tetrahedral voids in cubic closed packing (ccp)?

(a) ZnS (b) NaCl (c) $Na_2O$ (d) $CaF_2$

**75.** Which of the following does not undergo Hell-Volhard-Zelinsky reaction?

(a) HCOOH (b) $CCl_3COOH$
(c) $C_6H_5COOH$ (d) All of the above

**76.** Which of the following transition of an electron in H-atom will emit maximum energy?

(a) $n_6 \longrightarrow n_5$ (b) $n_1 \longrightarrow n_2$
(c) $n_3 \longrightarrow n_2$ (d) $n_4 \longrightarrow n_3$

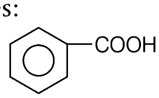
**77.** The correct set of quantum numbers for an element ($Z = 17$) for the unpaired electron will be

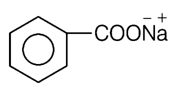
(a) 3, 1, 1, ±1/2 (b) 2, 0, 0, ±1/2
(c) 3, 0, 0, ±1/2 (d) 2, 1, 1, 0

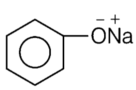
**78.** Which of the following is an energy releasing process?

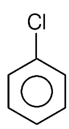
(a) $X(s) \longrightarrow X(g)$ (b) $O^-(g) \xrightarrow{e^-} O^{2-}(g)$
(c) $O(g) \longrightarrow O^+(g)^{+e^-}$ (d) $O(g) \xrightarrow{e^-} O^-(g)$

**79.** Toluene reacts with excess of $Cl_2$ in the presence of sunlight to give a product which on hydrolysis followed by reaction with NaOH gives:

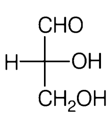
(a) 

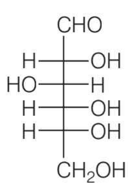

(b) 

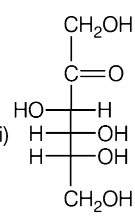

(c) 


(d) 


**80.** Among all the given compounds, which will have D-configuration?

(i) 


(ii) 


(iii) 


(a) (i), (ii) and (iii) (b) (ii) and (iii)
(c) (i) and (ii) (d) Only (iii)

**81.** Volume of an ideal gas is decreased by 5% at constant temperature such that there is an increase in pressure by $x$ %. The increase in pressure (in %) will be:

(a) 5% (b) 4.7%
(c) 5.26% (d) 95%

**82.** For the following equilibrium $N_2O_4 \rightleftharpoons 2NO_2$ in gaseous phase, $NO_2$ is 50% of the total volume, when equilibrium is set up. Hence, percent dissociation of $N_2O_4$ is:

(a) 50% (b) 25%
(c) 66.66% (d) 33.33%

**83.** In the redox reaction

$$MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$$

The correct coefficients of $C_2O_4^{2-}$ and $H^+$ ions in the balanced equation are

(a) 5 and 15 (b) 5 and 16
(c) 2 and 16 (d) 2 and 15

**84.** Substances used in bringing down the body temperature in high fever is called

(a) antiseptics (b) Pyretics
(c) antibiotics (d) antipyretics

**85.** The reagent(s) used in the preparation of aspirin from salicyclic acid is/are.

(a) $SOCl_2$ (b) $CH_3COOH$, HCl
(c) $CHCl_3$, $AlCl_3$ (d) $(CH_3CO)_2O$, $H^+$

**86.** Terylene is a condensation polymer of ethylene glycol and

(a) benzoic acid
(b) phthalic acid
(c) salicylic acid
(d) terephthalic acid

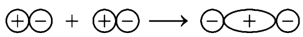
**87.** The correct increasing order of acidic strength of boron trihalides is

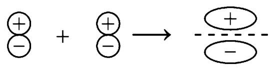
(a) $BI_3 < BBr_3 < BCl_3 < BF_3$
(b) $BF_3 < BCl_3 < BBr_3 < BI_3$
(c) $BF_3 < BI_3 < BBr_3 < BCl_3$
(d) $BI_3 < BF_3 < BBr_3 < BCl_3$

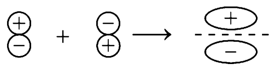
**88.** Sulphur(s) when react with $HNO_3$ (conc.) mainly gives

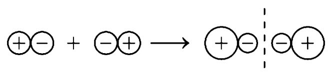
(a) $H_2SO_4$, $NO_2$ and $H_2O$
(b) $H_2S$, $N_2O_5$ and $SO_2$
(c) $H_2SO_3$, $NO_2$ and $SO_2$
(d) $SO_2$, $NO_2$ and $H_2O$

**89.** Which of the following is the correct representation of molecular orbitals?

(a) 

(b) 

(c) 

(d) 

**90.** On combustion of $x$-g of ethanol in bomb calorimeter, $y$-joules of heat energy is produced. The heat of combustion of ethanol ($\Delta H_{comb}$) is

(a) $\Delta H_{comb} = -x \cdot J$
(b) $\Delta H_{comb} = -yJ$
(c) $\Delta H_{comb} = -\frac{x}{y} \times 44 \text{ J mol}^{-1}$
(d) $\Delta H_{comb} = -\frac{y}{x} \times 44 \text{ J mol}^{-1}$

**91.** 0.005 mol of $Ba(OH)_2$ is dissolved in 100mL of water. Assuming complete ionisation of $Ba(OH)_2$ the pOH of the solution will be

(a) 1 (b) 5 (c) 2 (d) 14

**92.** Which of the following is used as a food preservative?

(a) Sodium benzoate (b) Potassium chloride
(c) Sodium bicarbonate (d) (b) and (c) both

**93.** Bakelite is obtained by reaction of phenol with

(a) acetaldehyde (b) acetal
(c) formaldehyde (d) chlorobenzene

**94.** When propyne is treated with $H_2SO_4(aq)$ in presence of $HgSO_4$, the major product is

(a) propanal
(b) $n$-propyl hydrogen sulphate
(c) acetone
(d) propanol

**95.** The Magnetic moment (spin only) of $[NiCl_4]^{2-}$ is

(a) 1.82 BM (b) 5.46 BM
(c) 2.82 BM (d) 1.41 BM

**96.** In aqueous solution Cu(+1) salts are unstable because

(a) Cu(+1) has $3d^{10}$ configuration.
(b) They disproportionate easily to Cu and $Cu^{2+}$ states.
(c) They disproportionate easily to $Cu^{2+}$ and $Cu^{3+}$ states
(d) Its change in free energy is zero

**97.** The atomic number of elements $A$, $B$, $C$ and $D$ are $Z-1$, $Z$, $Z+1$, $Z+2$ respectively. If $B$ is a noble gas, choose the correct option

(1) ($A$) has higher electron affinity.
(2) ($C$) exists in $+2$ oxidation state.
(3) ($D$) is an alkaline earth metal.

(a) (1) and (2)
(b) (2) and (3)
(c) (1) and (3)
(d) (1), (2) and (3)

**98.** Select the incorrect statement

(a) Physical adsorption is reversible, while chemical is irreversible.
(b) High pressure favours physical adsorption while low pressure favours chemical adsorption.
(c) Physical adsorption is not specific, while chemical adsorption is highly specific.
(d) High activation energy is required in chemical adsorption.

**99.** The chemical reaction $2O_3 \longrightarrow 3O_2$, proceeds as follows $O_3 \rightleftharpoons O_2 + O$ (fast)
$O + O_3 \longrightarrow 2O_2$ (slow)
the rate law for the above reaction can be

(a) $r = k'[O_3]^2$
(b) $r = k'[O_3]^2 [O_2]^{-1}$
(c) $r = k' [O_3] [O_2]$
(d) $r = k'[O_2] [O]$

**100.** Ionic product of water at 310 K is $2.7 \times 10^{-14}$. What is the pH of neutral water at this temperature?

(a) 7.00 (b) 5.98
(c) 6.78 (d) 4.58

# Mathematics

**101.** If $\alpha, \beta, \gamma$ are the angles which a directed line makes with the positive directions of the coordinate axes, then $\sin^2\alpha + \sin^2\beta + \sin^2\gamma$ is equal to

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

**102.** If $\mathbf{a}$ and $\mathbf{b}$ are two non-collinear vectors such that $|\mathbf{a}| = 3, |\mathbf{b}| = 4$ and $\mathbf{a} - \mathbf{b} = \hat{\mathbf{i}} + 2\hat{\mathbf{j}} + 3\hat{\mathbf{k}}$, then the value of $\left\{\frac{\mathbf{a}}{|\mathbf{a}|} - \frac{\mathbf{b}}{|\mathbf{b}|}\right\}^2$ is equal to

(a) $\frac{1}{24}$ (b) $\frac{5}{72}$ (c) $\frac{7}{72}$ (d) $\frac{7}{48}$

**103.** The acute angle between the lines whose direction ratios are given by $l + m - n = 0$ and $l^2 + m^2 - n^2 = 0$, is

(a) 0 (b) $\pi/6$ (c) $\pi/4$ (d) $\pi/3$

**104.** The number of 6-digit numbers that can be made with the digits 1, 2, 3 and 4 and having exactly two pairs of digits, is

(a) 480 (b) 540 (c) 1080 (d) 2040

**105.** Area of the region bounded by the curves $y = 2^x$, $y = 2x - x^2$, $x = 0$ and $x = 2$ is given by

(a) $\frac{3}{\log 2} - \frac{4}{3}$ (b) $\frac{3}{\log 2} + \frac{4}{3}$

(c) $3\log 2 - \frac{4}{3}$ (d) $3\log 2 + \frac{4}{3}$

**106.** The lengths of tangent, subtangent, normal and subnormal for the curve $y = x^2 + x - 1$ at $(1, 1)$ are $A, B, C$ and $D$ respectively, then their increasing order is

(a) $B, D, A, C$ (b) $B, A, C, D$

(c) $A, B, C, D$ (d) $B, A, D, C$

**107.** Let $f : R \to R$ be defined by

$$f(x) = \begin{cases} k - 2x, & \text{if } x \le -1 \\ 2x + 3, & \text{if } x > -1 \end{cases}.$$

If $f$ has a local minimum at $x = -1$, then a possible value of $k$ is

(a) $-1/2$ (b) $-1$ (c) 1 (d) 0

**108.** If a point $P(a, b, c)$ perpendiculars $PA$, $PB$ are drawn to $YZ$ and $ZX$ planes, then the equation of the plane $OAB$ is

(a) $bcx + cay + abz = 0$ (b) $bcx + cay - abz = 0$

(c) $bcx - cay + abz = 0$ (d) $-bcx + cay + abz = 0$

**109.** A circular ring of radius 3 cm is suspended horizontally from a point 4 cm vertically above the centre by 4 strings attached at equal intervals to its circumference. If the angle between two consecutive strings be $\theta$, then $\cos\theta$ is equal to

(a) $\frac{4}{5}$ (b) $\frac{4}{25}$

(c) $\frac{16}{25}$ (d) None of these

**110.** The value of

$$\sin^{-1}\left[\cot\left(\sin^{-1}\sqrt{\frac{2-\sqrt{3}}{4}}\right) + \cos^{-1}\frac{\sqrt{12}}{4} + \sec^{-1}\sqrt{2}\right]$$ is

(a) 0 (b) $\frac{\pi}{2}$

(c) $\frac{\pi}{3}$ (d) None of these

**111.** 900 distinct $n$-digit positive numbers are to be formed using only the digits 2, 5 and 7. The smallest value of $x$ for which this is possible, is

(a) 9 (b) 8 (c) 7 (d) 6

**112.** If the non-zero numbers $x, y, z$ are in AP and $\tan^{-1} x, \tan^{-1} y, \tan^{-1} z$ are also in AP, then

(a) $xy = yz$ (b) $z^2 = xy$

(c) $x = y = z$ (d) $x^2 = yz$

**113.** If $n$ is odd, then the sum of $n$ terms of the series $1^2 - 2^2 + 3^2 - 4^2 + 5^2 - 6^2 + \ldots$ is

(a) $\frac{n(n-1)}{2}$ (b) $\frac{n(n+1)}{2}$

(c) $\frac{-n(n-1)}{2}$ (d) $\frac{-n(n+1)}{2}$

**114.** A rectangle $ABCD$, where $A \equiv (0, 0)$ $B \equiv (4, 0)$, $C \equiv (4, 2)$, $D \equiv (0, 2)$, undergoes the following transformation successively

(i) $f_1\ (x, y) \to\ (y, x)$

(ii) $f_2\ (x, y) \to (x+3y, y)$

(iii) $f_3\ (x, y) \to (x-y)/2, (x+y)/2)$

The final figure will be

(a) a square (b) a parallelogram
(c) a rhombus (d) a rectangle

**115.** The order and degree of the differential equation $P = \dfrac{\left(1+\left(\dfrac{dy}{dx}\right)^2\right)^{3/2}}{\dfrac{d^2y}{dx^2}}$ are respectively

(a) 2, 2 (b) 2, 3
(c) 2, 1 (d) None of these

**116.** If $f(\theta) = 5\cos\theta + 3\cos\left(\theta + \dfrac{\pi}{3}\right) + 3$, then range of $f(\theta)$ is

(a) [– 5, 11] (b) [– 3, 9] (c) [– 2, 10] (d) [– 4, 10]

**117.** The coordinates of the foot of the perpendicular drawn from the point $A\,(1, 0, 3)$ to the join of the points $B\,(4, 7, 1)$ and $C\,(3, 5, 3)$ are

(a) (5, 7, 17) (b) $\left(\frac{-5}{7}, \frac{7}{3}, \frac{-17}{3}\right)$
(c) $\left(\frac{5}{7}, \frac{-7}{3}, \frac{17}{3}\right)$ (d) $\left(\frac{5}{3}, \frac{7}{3}, \frac{17}{3}\right)$

**118.** If $x = \cos\theta, y = \sin 5\theta$, then

$(1-x^2)\dfrac{d^2y}{dx^2} - x\dfrac{dy}{dx} =$

(a) – 5*y* (b) 5 *y* (c) 25 *y* (d) – 25 *y*

**119.** If the period of the function $f(x) = \dfrac{\sin(\sin(nx))}{\tan\left(\dfrac{x}{n}\right)}$, $n \in N$, is $6\pi$, then $n$ is equal to

(a) 3 (b) 2
(c) 1 (d) None of these

**120.** The set of points where the function $f(x) = [x] + |1-x|, -1 \le x \le 3$, where [.] denotes the greatest integer function, is not differentiable, is

(a) {– 1, 0, 1, 2, 3} (b) {– 1, 0, 2}
(c) {0, 1, 2, 3,} (d) {– 1, 0, 1, 2}

**121.** If $I_n = \int_0^{\pi/2} \dfrac{\cos^2 nx}{\sin x}\,dx$, then $I_2 - I_1, I_3 - I_2$, $I_4 - I_3$ are in

(a) GP (b) AP
(c) HP (d) None of these

**122.** If the coefficient of the 5th term is the numerically the greatest coefficient in the expansion of $(1-x)^n$, then the positive integral value of $n$ is

(a) 10 (b) 9 (c) 8 (d) 7

**123.** $\sim(p \Leftrightarrow \sim q)$ is equivalent to

(a) $p \Leftrightarrow \sim q$ (b) $p \Rightarrow q$
(c) $p \Leftrightarrow q$ (d) None of these

**124.** If the tangent at the point $P\,(2, 4)$ to the parabola $y^2 = 8x$ meets the parabola $y^2 = 8x + 5$ at $Q$ and $R$, then the mid-point of $QR$ is

(a) (4, 2) (b) (2, 4)
(c) (7, 9) (d) (9, 7)

**125.** The locus of the centres of the circles passing through the intersection of the circles $x^2 + y^2 = 1$ and $x^2 + y^2 - 2x + y = 0$, is

(a) $2x - y = 1$ (b) $x + 2y = 0$
(c) a circle (d) a pair of lines

**126.** The value of $\lim\limits_{x \to 0} \dfrac{\int_0^{x^2} \sec^2 t\,dt}{x \sin x}$ is

(a) 0 (b) 3 (c) 2 (d) 1

**127.** The number of real roots of $(6-x)^4 + (8-x)^4 = 16$ is

(a) 0 (b) 2 (c) 4 (d) 6

**128.** $10^{2n-1} + 1$ for all $n \in N$ is divisible by

(a) 2 (b) 3 (c) 7 (d) 11

**129.** If $f(x) = \begin{cases} \dfrac{1-\sqrt{2}\sin x}{\pi - 4x}, & x \ne \pi/4 \\ a, & x = \pi/4 \end{cases}$ is continuous at $x = \dfrac{\pi}{4}$, then $a =$

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

**130.** If $f(x) = a\log|x| + bx^2 + x$ has its extremum values at $x=-1$ and $x=2$, then

(a) $a=2, b=-1$ (b) $a=2, b=-1/2$
(c) $a=-2, b=\frac{1}{2}$ (d) None of these

**131.** Let $P=\{\theta : \sin\theta - \cos\theta = \sqrt{2}\cos\theta\}$ and, $Q=\{\theta : \sin\theta + \cos\theta = \sqrt{2}\sin\theta\}$ be two sets. Then,

(a) $P \subset Q$ and $Q-P \neq \phi$ (b) $Q \not\subset P$
(c) $P \not\subset Q$ (d) $P=Q$

**132.** Let the straight line $x=b$ divide the area enclosed by $y=(1-x)^2$, $y=0$ and $x=0$ into two parts $R_1$ $(0 \le x \le b)$ and $R_2 (b \le x \le 1)$ such that $R_1 - R_2 = \frac{1}{4}$. Then $b$ equals.

(a) $\frac{3}{4}$ (b) $\frac{1}{2}$ (c) $\frac{1}{3}$ (d) $\frac{1}{4}$

**133.** $\int_{-1}^{10} \text{sgn}(x-[-x])\,dx$ equal to

(a) 10 (b) 11 (c) 9 (d) $\frac{11}{2}$

**134.** The solution set of the equation $\cos^{-1}x - \sin^{-1}x = \sin^{-1}(1-x)$, is

(a) $\{-1,1\}$ (b) $\{0,1/2\}$
(c) $\{-1,0\}$ (d) None of these

**135.** Let $\mathbf{a} = \mathbf{i}+\mathbf{j}+\mathrm{k}$, $\mathbf{c}=\mathbf{j}-\mathbf{k}$. If $\mathbf{b}$ is a vector satisfying $\mathbf{a}\times\mathbf{b}=\mathbf{c}$ and $\mathbf{a}\cdot\mathbf{b}=3$, then $\mathbf{b}$ is

(a) $\frac{1}{3}(5\mathrm{i}+2\mathrm{j}+2\mathrm{k})$ (b) $\frac{1}{3}(5\mathrm{i}-2\mathrm{j}-2\mathrm{k})$
(c) $3\mathrm{i}-\mathrm{j}-\mathrm{k}$ (d) None of these

**136.** Let $T_n$ denote the number of triangles which can be formed using the vertices of an regular polygon of $n$ sides. If $T_{n+1} - T_n = 21$, then $n$ equals

(a) 5 (b) 7 (c) 6 (d) 4

**137.** The length of the shadows of a vertical pole of height $h$, thrown by the sun's rays at three different moments are $h$, 2h and $3h$. The sum of the angles of elevation of the rays at these three moments is equal to

(a) $\frac{\pi}{2}$ (b) $\frac{\pi}{3}$ (c) $\frac{\pi}{4}$ (d) $\frac{\pi}{6}$

**138.** If the arithmetic mean of the following data is 7, then $a+b=$

| $x_i$ | 4 | 6 | 7 | 9 |
|---|---|---|---|---|
| $f_i$ | a | 4 | b | 5 |

(a) 4 (b) 2
(c) 3 (d) cannot be determined

**139.** A straight line through the origin meets the parallel lines $4x+2y=9$ and $2x+y+6=0$ at point $P$ and $Q$ respectively. Then, the point $O$ divides the segment PQ in the ratio

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

**140.** The eccentricity of the ellipse, if the distance between the foci is equal to the length of the latusrectum, is

(a) $\frac{\sqrt{5}-1}{2}$ (b) $\frac{\sqrt{5}+1}{4}$ (c) $\frac{\sqrt{5}-1}{4}$ (d) $\frac{\sqrt{5}+1}{2}$

**141.** Gas is being pumped into a spherical balloon at the rate of $30\,\text{ft}^3$ / min. Then, the rate at which the radius increases when it reaches the value 15ft, is

(a) $\frac{1}{30\pi}$ ft/min (b) $\frac{1}{15\pi}$ ft/min
(c) $\frac{1}{20}$ ft/min (d) $\frac{1}{25}$ ft/min

**142.** In a $\Delta ABC$, medians $AD$ and $BE$ are drawn. If $AD=4$, $\angle DAB=\pi/6$ and $\angle ABE=\pi/3$, then the area of $\Delta ABC$ is

(a) $\frac{64}{3\sqrt{3}}$ (b) $\frac{8}{3\sqrt{3}}$ (c) $\frac{16}{3\sqrt{3}}$ (d) $\frac{32}{3\sqrt{3}}$

**143.** The sum of the series.
$1+\frac{1}{3^2}+\frac{1}{1}\cdot\frac{4}{2}\cdot\frac{1}{3^4}+\frac{1}{1}\cdot\frac{4}{2}\cdot\frac{7}{2}\cdot\frac{1}{3^6}+\ldots+$ is

(a) $\sqrt{\frac{3}{2}}$ (b) $\left(\frac{3}{2}\right)^{1/3}$ (c) $\sqrt{\frac{1}{3}}$ (d) $\left(\frac{1}{3}\right)^{1/3}$

**144.** If $f(1)=3$, $f'(1)=-\frac{1}{3}$, then the derivative of $\{x^{11}+f(x)\}^{-2}$ at $x=1$, is

(a) $-\frac{1}{2}$ (b) $-1$ (c) 1 (d) $f'(1)$

**145.** Let $R=\{(1,3),(4,2),(2,4),(2,3),(3,1)\}$ be a relation on the set $A=\{1,2,3,4\}$. The relation $R$ is

(a) reflexive (b) transitive
(c) not symmetric (d) a function

**146.** If $[\cdot]$ denotes the greatest integer function, then

$$f(x) = [x] + \left[x + \frac{1}{2}\right]$$

(a) is continuous at $x = \frac{1}{2}$

(b) is discontinuous at $x = \frac{1}{2}$

(c) $\lim_{x \to \frac{1}{2}^+} f(x) = 2$

(d) $\lim_{x \to \frac{1}{2}^-} f(x) = 1$

**147.** $\lim_{x \to \infty} \dfrac{\cot^{-1}(\sqrt{x+1} - \sqrt{x})}{\sec^{-1}\left\{\left(\dfrac{2x+1}{x-1}\right)^x\right\}}$ is equal to

(a) 1 (b) 0

(c) $\frac{\pi}{2}$ (d) Non-existent

**148.** If $y = \cos^{-1}(\cos x)$, then $\frac{dy}{dx}$ at $x = \frac{5\pi}{4}$, is

(a) 1 (b) – 1

(c) $\frac{1}{\sqrt{2}}$ (d) None of these

**149.** The median of 100 observations grouped in classes of equal width is 25. If the median class interval is 20 – 30 and the number of observations less than 20 is 45, then the frequency of median class is

(a) 20 (b) 12

(c) 10 (d) 15

**150.** Every term of G.P. is positive and also every term is the sum of two preceding terms. Then, the common ratio of the G.P. is

(a) $\frac{1-\sqrt{5}}{2}$ (b) $\frac{\sqrt{5}+1}{2}$

(c) $\frac{\sqrt{5}-1}{2}$ (d) 1

# Answers

## Physics

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (d) | 2. | (a) | 3. | (b) | 4. | (a) | 5. | (c) | 6. | (b) | 7. | (c) | 8. | (d) | 9. | (c) | 10. | (d) |
| 11. | (b) | 12. | (b) | 13. | (d) | 14. | (d) | 15. | (b) | 16. | (b) | 17. | (c) | 18. | (c) | 19. | (b) | 20. | (c) |
| 21. | (a) | 22. | (b) | 23. | (b) | 24. | (c) | 25. | (b) | 26. | (c) | 27. | (a) | 28. | (b) | 29. | (c) | 30. | (c) |
| 31. | (b) | 32. | (b) | 33. | (b) | 34. | (a) | 35. | (b) | 36. | (a) | 37. | (a) | 38. | (d) | 39. | (a) | 40. | (c) |
| 41. | (b) | 42. | (d) | 43. | (a) | 44. | (c) | 45. | (c) | 46. | (b) | 47. | (a) | 48. | (d) | 49. | (a) | 50. | (d) |

## Chemistry

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51. | (b) | 52. | (d) | 53. | (a) | 54. | (a) | 55. | (a) | 56. | (c) | 57. | (a) | 58. | (c) | 59. | (c) | 60. | (b) |
| 61. | (c) | 62. | (a) | 63. | (c) | 64. | (c) | 65. | (b) | 66. | (c) | 67. | (c) | 68. | (a) | 69. | (a) | 70. | (d) |
| 71. | (c) | 72. | (b) | 73. | (b) | 74. | (a) | 75. | (d) | 76. | (c) | 77. | (a) | 78. | (d) | 79. | (b) | 80. | (a) |
| 81. | (c) | 82. | (d) | 83. | (b) | 84. | (d) | 85. | (d) | 86. | (d) | 87. | (b) | 88. | (a) | 89. | (b) | 90. | (d) |
| 91. | (a) | 92. | (a) | 93. | (c) | 94. | (c) | 95. | (c) | 96. | (b) | 97. | (c) | 98. | (b) | 99. | (b) | 100. | (c) |

## Mathematics

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 101. | (d) | 102. | (c) | 103. | (d) | 104. | (c) | 105. | (a) | 106. | (d) | 107. | (b) | 108. | (d) | 109. | (c) | 110. | (a) |
| 111. | (c) | 112. | (c) | 113. | (b) | 114. | (b) | 115. | (a) | 116. | (d) | 117. | (d) | 118. | (d) | 119. | (a) | 120. | (c) |
| 121. | (c) | 122. | (c) | 123. | (c) | 124. | (b) | 125. | (b) | 126. | (d) | 127. | (d) | 128. | (d) | 129. | (d) | 130. | (b) |
| 131. | (d) | 132. | (b) | 133. | (b) | 134. | (b) | 135. | (a) | 136. | (b) | 137. | (a) | 138. | (d) | 139. | (b) | 140. | (a) |
| 141. | (a) | 142. | (d) | 143. | (b) | 144. | (d) | 145. | (c) | 146. | (b) | 147. | (a) | 148. | (b) | 149. | (c) | 150. | (b) |

# Answer *with* Solutions

## Physics

**1.** *(d)* We know that, $f = \frac{1}{2\pi\sqrt{LC}}$

$\therefore \frac{C}{L}$ does not represent the dimensions of frequency.

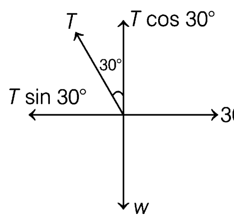
**2.** *(a)* If coefficient of volume expansion is $\alpha$ and rise in temperature is $\Delta\theta$, then $\Delta V = V\alpha\Delta\theta$

$$\Rightarrow \quad \frac{\Delta V}{V} = \alpha\Delta\theta$$

$\therefore$ Volume elasticity, $\beta = \frac{p}{\Delta V / V} = \frac{p}{\alpha\Delta\theta}$

$$\Rightarrow \quad \Delta\theta = \frac{p}{\alpha\beta}$$

**3.** *(b)* Horizontal and vertical components of tension are shown in the figure.




From the figure, $T\sin 30° = 30$ ...(i)

$T\cos 30° = w$ ...(ii)

By solving Eqs. (i) and (ii), we get

$$w = 30\sqrt{3}\text{ N} \text{ and } T = 60\text{ N}$$

**4.** *(a)* Given, $v = 10$ m/s $\mu = 0.5$

We know that $v_{\max} = \sqrt{\mu g R}$

On squaring both sides, we get

$$R = \frac{v^2}{\mu g}$$

$$= \frac{100}{0.5 \times 10} = 20$$

**5.** *(c)* When a spring is in equilibrium, its extension $= \frac{mg}{k}$

At the highest point of block, spring is in its natural length.

Hence, amplitude, $A = \frac{mg}{k}$

Given, $f = 10$ Hz

$$\omega = 2\pi f = 20\pi \text{ rad/s}$$

$$\therefore \quad \omega = \sqrt{\frac{k}{m}}$$

On squaring both sides, we get

$$\frac{k}{m} = \omega^2$$

$$\Rightarrow \quad v_{\max} = A\omega$$

$$= \frac{m}{k} g\omega = \frac{g\omega}{\omega^2}$$

$$= \frac{g}{\omega} = \frac{\pi^2}{20\pi} = \frac{\pi}{20} \text{ m/s}$$

$$\therefore \quad A = \frac{mg}{k} = \frac{g}{\omega^2}$$

$$= \frac{\pi^2}{400\,\pi^2} = \frac{0.25}{100} \text{ m} = 0.25 \text{ cm}$$

Now, when extension is 0.20 cm, then displacement from equilibrium position

$$= 0.25 - 0.20 = 0.05 \text{ cm}$$

$$x = 0.05 \text{ cm}$$

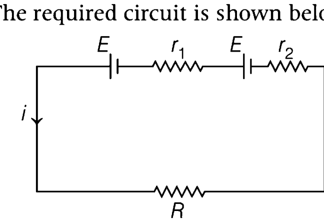
$$\therefore \quad v = \omega\sqrt{A^2 - x^2}$$

$$= 20\pi\sqrt{(0.25)^2 - (0.05)^2}$$

$$= 2\pi\sqrt{6} \text{ cm/s}$$

$$= 15.4 \text{ cm/s}$$

**6.** *(b)* The required circuit is shown below.




$$i = \frac{2E}{R + r_1 + r_2}$$

Potential difference across first cell,

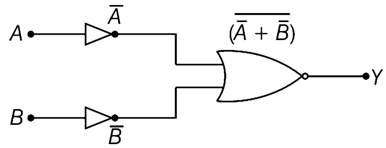
$$V_1 = E - ir_1$$

$$0 = E - \frac{2E}{R + r_1 + r_2} \cdot r_1$$

$$R + r_1 + r_2 = 2r_1$$

$$R = r_1 - r_2$$

**7.** *(c)*

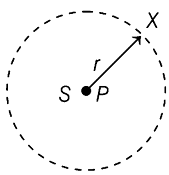



**Truth table**

| $A$ | $B$ | $\overline{A}$ | $\overline{B}$ | $\overline{A}+\overline{B}$ | $\overline{(\overline{A}+\overline{B})}$ |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 |

(i.e., AND Gate)

**8.** *(d)* Let $r$ be the distance between the points $S$ and $X$.




Intensity at distance $r$ from a point source,

$$I = \frac{P}{4\pi r^2}$$

$\therefore$ Efficiency, $\eta = \frac{\text{Output}}{\text{Input}} = \frac{P}{P'}$

$$P = \eta P'$$

$$= \left(\frac{10}{100}\right)(30\,\pi) = 3\pi \text{ W}$$

$$I = \frac{P}{4\pi r^2} = \frac{3\pi}{4\pi(3)^2}$$

$$= \frac{1}{12}\frac{\text{W}}{\text{m}^2} = \frac{1}{2}\varepsilon_0 E_0^2 c$$

$$\frac{1}{12} = \frac{1}{2}\varepsilon_0 E_0^2 \times 3\times 10^8$$

$$E_0^2 = \frac{10^{-8}}{18\varepsilon_0} = \frac{10^{-8}}{18\times 8.85\times 10^{-12}}$$

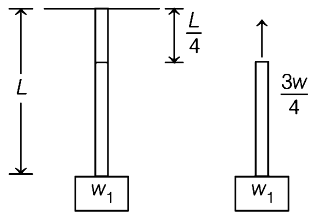
$$= \frac{10^4}{18\times 8.85}$$

$\Rightarrow$ $$E_0 = \frac{10^2}{\sqrt{18\times 8.85}} = 7.92 \text{ V/m}$$

$\therefore$ $$B_0 = \frac{E_0}{c} = \frac{2.92}{3\times 10^8}$$

$$= 2.64\times 10^{-8} \text{ T}$$

**9.** *(c)*




$$T = w_1 + \frac{3w}{4}$$

$\therefore$ $$\sigma = \frac{T}{A} = \frac{w_1 + (3w/4)}{S}$$

**10.** *(d)* Possible frequencies of $B : 100 \pm 2 = 102$ Hz or 98 Hz. Frequency of $A$ : 100 Hz.

When wax is used on $B$, $f_B$:↓ beat frequency decreases, this is possible at $f_B = 102$ Hz.

**11.** *(b)* Given, $C' = 0.014\,\mu\text{F/km}$

$$f = 50\times 10^3 \text{ Hz}$$

Total capacitance,

$$C = C'\times 200 = 0.014\,\mu\text{F}\times 200 = 28\,\mu\text{F}$$

For impedance to be minimum

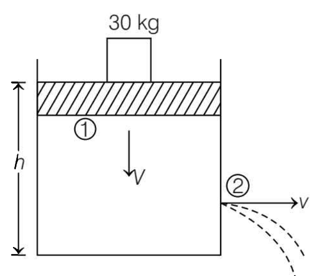
$$X_L = X_C, \text{ i.e. } \omega L = \frac{1}{\omega C}$$

$$L = \frac{1}{\omega^2 C} = \frac{1}{4\pi^2 f^2 C}$$

$$= \frac{1}{4\pi^2\times(50\times 10^3)^2\times 28\times 10^{-6}}$$

$$= 0.36\times 10^{-3}\text{ H} = 0.36\times 10^{-2}\text{ mH}$$

**12.** *(b)* Let the velocity of efflux at point 2 is $v$.




Given, $a = 1\text{ cm}^2$, $A = 0.5\,\text{m}^2 = 0.5\times 10^4\text{ cm}^2$

Applying continuity equation,

$$AV = av$$

$$V = \frac{a}{A}v$$

Since, $a \ll A$, $V \ll v$, $V^2$ is negligible.

Pressure at 1, $p_1 = p_0 + \frac{mg}{A}$

$$= p_0 + \frac{30 \times 10}{0.5} = p_0 + 600$$

Pressure at (2),

$$p_2 = p_0$$

where, $p_0$ is atmospheric pressure.

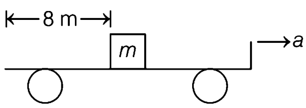
Applying Bernoulli's equation between (1) and (2),

$$p_1 + \rho g h + \frac{1}{2}\rho V^2 = p_2 + \frac{1}{2}\rho v^2$$

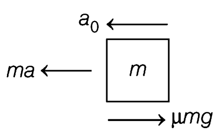
$V^2$ is negligible, then

$$p_0 + 600 + 1200 \times 10 \times 0.75$$
$$= p_0 + \frac{1}{2} \times 1200 v^2$$
$$600 v^2 = 9600 \Rightarrow v^2 = 16 \Rightarrow v = 4 \text{ m/s}$$

**13.** *(d)* Let a be the acceleration of truck.




For block,




$$ma - \mu mg = ma_0$$
$$a_0 = a - \mu g = 2 - 0.1 \times 10 = 1 \text{ m/s}^2$$
$$8 = \frac{1}{2} a_0 t^2 = \frac{1}{2} \times 1 \times t^2$$
$$\Rightarrow \quad t = 4 \text{ s}$$

The block will fall off the truck after 4 s.

For truck,

Distance travelled by the truck in this time.

$$s = \frac{1}{2} a t^2 = \frac{1}{2} \times 2 \times 4^2 = 16 \text{ m}$$

**14.** *(d)* Given, $a_1 = 2a_2$

$$I_1 = 4I', I_2 = I'$$

We know that, $I_m = (\sqrt{I_1} + \sqrt{I_2})^2$

$$= (\sqrt{4I'} + \sqrt{I'})^2 = 9I'$$

$$\therefore I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos\phi$$
$$= 4I' + I' + 2\sqrt{4I' \cdot I'} \cos\phi$$
$$= 4I' + I' + 4I' \cos\phi$$
$$= 5I' + 4I' \cos\phi$$
$$= I'(5 + 4\cos\phi)$$
$$= \frac{I_m}{9}\left[5 + 4(2\cos^2\frac{\phi}{2} - 1\right]$$
$$= \frac{I_m}{9}\left[5 + 8\cos^2\frac{\phi}{2} - 4\right]$$
$$= \frac{I_m}{9}\left[1 + 8\cos^2\frac{\phi}{2}\right]$$

**15.** *(b)* $T = 2\pi\sqrt{\frac{I}{MB}} = 2$

Moment of inertia of each part $= \frac{I}{27}$ and

magnetic moment $= \frac{M}{3}$

New moment of inertia, $I' = 3 \times \frac{I}{27} = \frac{I}{9}$

New magnetic moment, $M' = 3 \times \frac{M}{3} = M$

$$\therefore \quad T' = 2\pi\sqrt{\frac{I/9}{MB}} = \frac{2}{3} \text{ s}$$

**16.** *(b)* According to question, $\frac{(V_{rms})_{O_2}}{(V_{rms})_{H_2}}$

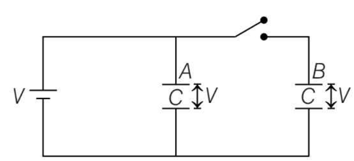
$$= \sqrt{\frac{(M_0)_{H_2}}{(M_0)_{O_2}}} = \sqrt{\frac{2}{32}} = \frac{1}{4}$$

**17.** *(c)* $n_1 = k\sqrt{T}$, $n_2 = k\sqrt{1.01T}$

$$\because \quad n_2 - n_1 = \frac{3}{2}$$
$$k(\sqrt{1.01T} - \sqrt{T}) = 1.5$$
$$k\sqrt{T}\,[(1 + 0.01)^{1/2} - 1] = 1.5$$
$$k\sqrt{T}\,[1 + \frac{1}{2} \times 0.01 - 1] = 1.5$$
$$k\sqrt{T} = \frac{1.5 \times 2}{0.01}$$
$$\therefore \quad n_1 = k\sqrt{T} = \frac{1.5 \times 2}{0.01} = 300 \text{ Hz}$$

We know that beat frequency is the difference of two frequencies, i.e. $f_1 - f_2$.

**18.** *(c)* When switch ( $S$) is closed,



$$U_i = \frac{1}{2}CV^2 + \frac{1}{2}CV^2 = CV^2$$

Charge on $B$, $Q = CV$

When switch ($S$) is open and dielectric ($K = 2$) is inserted in both capacitors, potential of $A$ remains same while charge on $B$ remains same.

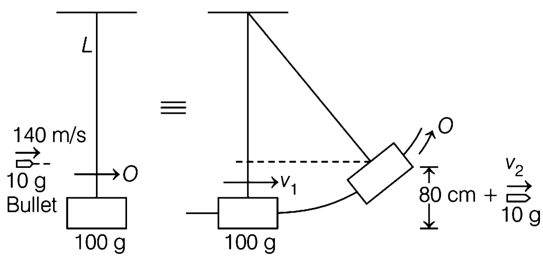
$$U_f = \frac{1}{2}\cdot 2C\cdot V^2 + \frac{Q^2}{2\cdot 2C}$$

$$= CV^2 + \frac{C^2V^2}{4C}$$

$$= \frac{5}{4}CV^2$$

$$\frac{U_i}{U_f} = \frac{4}{5}$$

**19.** *(b)*




Let the speed of the bullet be $v_1$. Let the common velocity of the bullet and the block, after the bullet is attached like a simple pendulum is $v_2$.

By the principle of conservation of linear momentum

$$\frac{10}{1000}\times 140 + \frac{100}{1000}\times 0 = \frac{100}{1000}v_1 + \frac{10}{1000}v_2$$

$$140 = 10v_1 + v_2 \qquad \ldots\text{(i)}$$

For the block, $0 = v_1^2 - 2g\left(\frac{80}{100}\right)$

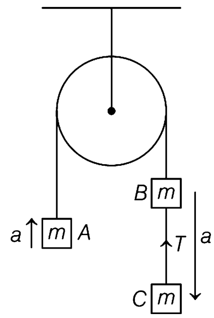
$\Rightarrow \quad v_1 = 4\text{ m/s}$

$\Rightarrow \quad 140 = 10\times 4 + v_2 \qquad$ [from Eq. (i)]

$\Rightarrow \quad v_2 = 100\text{ m/s}$

Final velocity of bullet $= 100$ m/s

**20.** *(c)* The combination of blocks $A$, $B$ and $C$ is shown in figure.

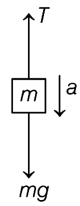



$$a = \frac{(m+m)g - mg}{(m+m)+m} = \frac{g}{3}$$

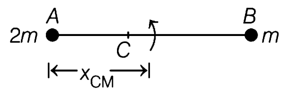
$$mg - T = ma = \frac{mg}{3}$$

$$T = \frac{2mg}{3} = \frac{2}{3}\times 2\times 10$$

$$= 13.3\text{ N}$$




**21.** *(a)*




Location of CM,

$$x_{CM} = \frac{2m\times 0 + m\times L}{2m+m} = \frac{L}{3}$$

The velocity of ball $A$ w.r.t. the centre of mass $C$ is

$$v_A = \omega x_{CM} = \frac{\omega L}{3}$$

$$v_B = \omega(L - x_{CM}) = \frac{2\omega L}{3}$$

Thus, angular momentum of a system about $C$,

$$L = 2mv_A\, x_{CM} + mv_B(L - x_{CM})$$

$$= 2m\times\frac{\omega L}{3}\times\frac{L}{3} + m\times\frac{2\omega L}{3}\times\frac{2L}{3}$$

$$= \frac{2m\omega L^2}{3}$$

**22.** *(b)* Lateral shift, $Y = \frac{t\sin(i-r)}{\cos r}$

$$\frac{Y}{t} = \frac{\sin(i-r)}{\cos r} = \frac{\sin i\cos r - \cos i\sin r}{\cos r}$$

[using identity,

$\sin(A-B) = \sin A\cdot\cos B - \cos A\cdot\sin B$]

$$= \sin i - \cos i\tan r$$

$$\Rightarrow \quad \frac{1}{\sqrt{3}} = \sin 45^\circ - \cos 45^\circ$$

$$\tan r = \frac{1}{\sqrt{2}}(1 - \tan r)$$

$$\Rightarrow \quad \sqrt{\frac{2}{3}} = 1 - \tan r \Rightarrow \tan r = 1 - \sqrt{\frac{2}{3}}$$

$$\therefore \quad r = \tan^{-1}\left(1 - \sqrt{\frac{2}{3}}\right)$$

**23.** *(b)* Given, $u = 60$ m/s, $R = 180$ m

$$\therefore \quad R = \frac{u^2}{g}\sin 2\theta$$

$$180 = \frac{(60)^2}{10}\sin 2\theta$$

$$\Rightarrow \quad \sin 2\theta = \frac{1}{2}$$

$$\Rightarrow \quad \theta = 15^\circ$$

As there are always two directions of projections $\theta$ and $(90^\circ - \theta)$ for the given range, hence two directions of projection, i.e. $15^\circ$ and $90^\circ - 15^\circ$, i.e. $15^\circ$ and $75^\circ$.

Let $T_1$ and $T_2$ be the times of flight in the two cases, where

$$T_1 = \frac{2u\sin 15^\circ}{g}$$

and $$T_2 = \frac{2u\sin 75^\circ}{g}$$

The man is in danger for a time

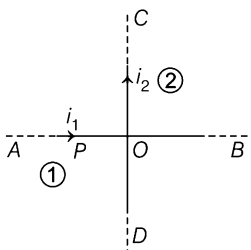
$$T_2 - T_1 = \frac{2u}{g}(\sin 75^\circ - \sin 15^\circ)$$

$$= \frac{2u}{g}(2\cos 45^\circ \sin 30^\circ)$$

[using identity,
$\sin C - \sin D = 2\cos\frac{C+D}{2}\sin\frac{C-D}{2}$]

$$= \frac{2\times 60}{10} \times 2 \times \frac{1}{\sqrt{2}} \times \frac{1}{2} = 6\sqrt{2}\text{ s}$$

**24.** *(c)* Conductors $AOB$ and $COD$ are perpendicular to each other shown in figure.




At distance $a$ above $O$,

$$B_1 = \frac{\mu_0 i_1}{2\pi a} \quad \text{and} \quad B_2 = \frac{\mu_0 i_2}{2\pi a}$$

$B_1$ is perpendicular to $B_2$.

Resultant of $B_1$ and $B_2$,

$$B = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0}{2\pi a}\sqrt{i_1^2 + i_2^2}$$

**25.** *(b)* $$\lambda = \lambda_\alpha + \lambda_\beta$$

$$= \frac{1}{T_\alpha} + \frac{1}{T_\beta} \qquad \left[\because \lambda = \frac{1}{T}\right]$$

$$= \frac{1}{1620} + \frac{1}{405}$$

[given, $T_\alpha = 1620$ yr and $T_\beta = 405$ yr]

$$= \frac{5}{1620}\text{ yr}^{-1}$$

$\frac{3}{4}$ th sample will decay, i.e. remaining 1/4 th,

$$N = N_0\left(\frac{1}{2}\right)^n$$

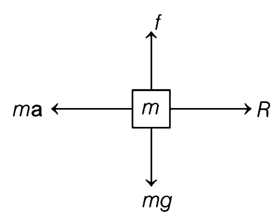
$$\frac{N_0}{4} = N_0\left(\frac{1}{2}\right)^n$$

$$\Rightarrow \quad n = 2$$

$$\therefore \quad t = nT_{1/2} = n\frac{\ln 2}{\lambda}$$

$$= 2 \times \frac{0.693}{5/1620} = 449\text{ yr}$$

**26.** *(c)* When cart moves with some acceleration towards right then a pseudo force ($ma$) acts on block towards left




This force ($m\alpha$) is action force by a block on cart. Now, block will remain static with respect to the cart, if frictional force

$$f = mg$$

$$\because \quad f \le \mu R \Rightarrow \mu R \ge mg$$

$$\Rightarrow \quad \mu m\alpha \ge mg \qquad [R = m\alpha]$$

$$\alpha \ge \frac{g}{\mu}$$

**27.** *(a)* We know the velocity of sound in a gaseous medium is given by

$$V = \sqrt{\frac{\gamma p}{\rho}}$$

At constant temperature $pV$ = constant

Volume of gas, $V = \frac{M}{\rho}$

$$\Rightarrow \quad \frac{PM}{\rho} = \text{Constant}$$

As $M$ is constant, therefore $\frac{P}{\rho}$ = Constant

Hence, change in pressure has no effect on velocity of sound.

**28.** *(b)* As, $\frac{GMm}{r^2} = \frac{mv^2}{r}$ = Centripetal force

$$\Rightarrow \quad v^2 = \frac{GM}{r} \quad \Rightarrow \quad T = \frac{2\pi r}{v}$$

$$\Rightarrow \quad T^2 = \frac{4\pi^2 r^2}{v^2}$$

On putting the value of $v^2$, we get

$$T^2 = \frac{4\pi^2 r^2}{\left(\frac{GM}{r}\right)} \quad \Rightarrow T^2 = \frac{4\pi^2 r^3}{GM} \quad \Rightarrow T^2 = Kr^3$$

Here, $K$ is given by,

$$\frac{4\pi^2}{GM} = K \quad \Rightarrow \quad GMK = 4\pi^2$$

**29.** *(c)* From Coulomb's law force of repulsion is

$$F = k\frac{qq}{d^2} \quad \Rightarrow \quad F = \frac{1}{4\pi\varepsilon_0}\frac{qq}{d^2}$$

where, $q = ne$

$$\therefore \quad F = \frac{1}{4\pi\,\varepsilon_0}\frac{n^2e^2}{d^2} \Rightarrow \quad n = \sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$$

**30.** *(c)* We know that capacitor offers infinite resistance for $DC$ source (Battery is DC source).

Current taken from the cell.

$$I = \frac{E}{R+r} = \frac{2.5}{1+1+0.5} = 1\text{ A}$$

Potential drop across capacitance

$$V = E - Ir = 2.5 - 1\times 0.5 = 2\text{V}$$

The current in 2 Ω resistor is zero charge on capacitor

$$Q = CV = 5\times 2 = 10\,\mu\text{C}$$

**31.** *(b)* van der Waal's gas equation for $\mu$ mole of real gas

$$\left(P + \frac{\mu^2 a}{V^2}\right)(V - \mu b) = \mu RT$$

$$\Rightarrow \quad P = \left(\frac{\mu RT}{V - \mu b}\right) - \frac{\mu^2 a}{V^2}$$

Given equation $P = \left(\frac{RT}{2V - b} - \frac{a}{4b^2}\right)$

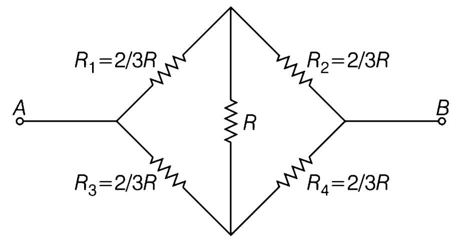
On comparing the given equation with this standard equation, we get $\mu = \frac{1}{2}$

$$\because \quad \mu = \frac{m}{M}$$

$\therefore$ Mass of gas

$$m = \mu M = \frac{1}{2}\times 44 = 22\text{ g}$$

**32.** *(b)* Equivalent circuit will be

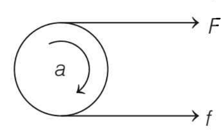



Now above circuit is a wheat stone's bridge.
By solving we get.

$$R_{AB} = \frac{\frac{4}{3}R\times\frac{4}{3}R}{\frac{4}{3}R + \frac{4}{3}R} = \frac{2}{3}R$$

**33.** *(b)* Let $f$ be force of friction between the shell and horizontal surface

For translation motion we have,




$$F + f = ma \qquad \ldots\text{(i)}$$

For rotational motion,

$$FR - fR = I\alpha = I\frac{a}{R} \quad [\therefore a = R\alpha \text{ for pure rolling}]$$

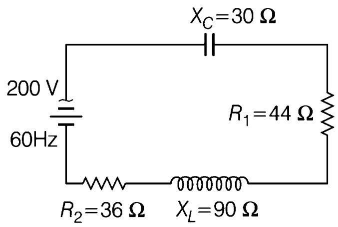
$$\Rightarrow \quad F - f = I\frac{a}{R^2} \qquad \ldots\text{(ii)}$$

On adding Eqs. (i) and (ii), we get

$$2F = \left(m + \frac{I}{R^2}\right)a, = \left(m + \frac{2}{3}m\right)a = \frac{5}{3}ma$$

$$\Rightarrow \quad F = \frac{5}{6}ma \quad \Rightarrow \quad a = \frac{6F}{5m}$$

**34.** *(a)* Consider the given curcuit as shown below,




Given $R_1 = 44\ \Omega$

$R_2 = 36\ \Omega$

$X_L = 90\ \Omega$

$X_C = 30\ \Omega$

Total resistance of the circuit is

$$R = R_1 + R_2$$
$$= 44 + 36 = 80\ \Omega$$

Impedance of the circuit,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$\Rightarrow \quad Z = \sqrt{(80)^2 + (60)^2}$

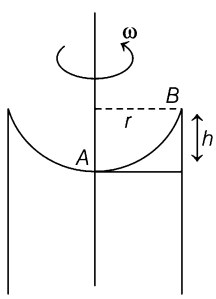
$\Rightarrow \quad Z = \sqrt{6400 + 3600} = 100\ \Omega$

Current, $\quad I = \dfrac{V}{Z} = \dfrac{200}{100} = 2\text{A}$

Power dissipated in the coil, $P_{av} = I^2R$

$$= (2)^2 \times 80 = 320 \text{ watt}$$

**35.** *(b)* From Bernoulli's theorem we have,




$$P_A + \frac{1}{2}dV_A^2 + dgh_A = P_B + \frac{1}{2}dV_B^2 + dgh_B$$

$\Rightarrow \quad P_A + \dfrac{1}{2}dV_A^2 = p_B + \dfrac{1}{2}dB^2$

$\Rightarrow \quad P_A - P_B = \dfrac{1}{2}d(V_B^2 - V_A^2)$

Now, $\quad v_A = 0, v_B = r\omega$

$$P_A - P_B = hdg$$

$\Rightarrow \quad hdg = \dfrac{1}{2}dr^2\omega^2 \quad \Rightarrow \quad h = \dfrac{r^2\omega^2}{2g}$

**36.** *(a)* Given, $d_A = 2\text{cm}$ and $d_B = 4\text{cm}$

$\therefore \quad r_A = 1$ cm and $r_B = 2\text{cm}$

From equation of continuity

$$av = \text{constant}$$

$\therefore \quad \dfrac{v_A}{v_B} = \dfrac{a_B}{a_A} = \dfrac{\pi\,(r_B)^2}{\pi\,(r_A)^2} = \left(\dfrac{2}{1}\right)^2$

$\Rightarrow \quad v_A = 4v_B$

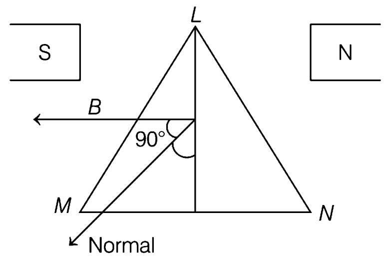
**37.** *(a)* Torque acting on an equilateral triangle in a magnetic field $B$ is

$$\tau = IAB\sin B$$

Area of $\Delta LMN : A = \dfrac{\sqrt{3}}{4}l^2$

and $\quad \theta = 90°$

Substituting the given values in the expression for torque, we have




$$\tau = I \times \frac{\sqrt{3}}{4}\,l^2\,B\sin 90° = \frac{\sqrt{3}}{4}\,I\,l^2\,B$$

$\therefore \quad l = 2\left(\dfrac{\tau}{\sqrt{3}\,BI}\right)^{\frac{1}{2}}$

**38.** *(d)* Intensity through first polaroid,

$$I_1 = \frac{I_0}{2}$$

$\therefore$ Intensity of transmitted light, $I = I_1\,\cos^2 0°$

$$= \frac{I_0}{2}\cos^2(90° - 30°) = \frac{I_0}{2}\cos^2 60° = \frac{I_0}{8}$$

**39.** *(a)* Cooling rate $\propto T^4 - T_0^4$

$\Rightarrow \quad r = \left[\dfrac{(900)^4 - (300)^4}{(600)^4 - (300)^4}\right]r_0$

$\Rightarrow \quad r = \dfrac{16}{3}r_0$

**40.** *(c)* Let $\quad M \propto [\text{F}^a\ \text{L}^b\ \text{T}^c]$

Writing dimensions on both sides and using the principle of homogeneity of dimensions we have,

$$[\text{M}^1\ \text{L}^0\ \text{T}^0] = \text{k}[\text{M L T}^{-2}]^a\ [\text{L}]^b\ [\text{T}]^c$$

on comparing the power on both sides we get

$$a = 1,\ a + b = 0$$

and $\quad -2a + c = 0$

on solving we have

$$b = -1, c = 2, a = 1$$

$\therefore$ units of mass is $[F\ L^{-1}\ T^2]$

**41.** *(b)* The voltage per unit length on the meter wire $PQ$ is $\frac{6.00\ \text{mV}}{0.60\ \text{m}} = 10\ \text{mV/m}$

Hence potential across the meter wire $PQ$ is 10 mV. Current drawn from the drives cell is.

$$I = \frac{10\ \text{mV}}{5\ \Omega} = 2\ \text{mA}$$

Value of resistance is,

$$R = \frac{2V - 10\ \text{mV}}{2\ \text{mA}} = \frac{1990\ \text{mV}}{2\ \text{mA}} = 995\ \Omega$$

**42.** *(d)* Distance between 1st order dark fringes = width of principle maximum

$$X = \frac{2\lambda D}{d} = \frac{2 \times 600 \times 10^{-9} \times 2}{10^{-3}}$$

$$= 2400 \times 10^{-6} = 24 \times 10^{-3}\ \text{m}$$

$$= 2.4\ \text{mm}$$

**43.** *(a)* For total internal reflection at face $AC$

$$\sin \hat{\mathbf{i}} > \frac{\mu_w}{\mu_g}$$

$$\Rightarrow \quad \sin\theta \ge \frac{4}{3 \times 1.5} \Rightarrow \sin\theta \ge \frac{8}{9}$$

**44.** *(c)* As, $\Delta Q = Q_1 + Q_2 + Q_3 + Q_4$

$$= 5960 - 5585 - 2980 + 3645$$

$$= 1040\ \text{J}$$

Also, $\Delta W = W_1 + W_2 + W_3 + W_4$

$$= 2200 - 825 - 1100 + W_4$$

$$= 275 + W_4$$

For a cyclic process, $\Delta U = 0$

i.e., $\quad U_f - U_i = 0,$

From first law of thermodynamics,

$$\Delta Q = \Delta U + \Delta W$$

$$1040 = 0 + 275 + W_4 \text{ or } W_4 = 765\ \text{J}$$

**45.** *(c)* For series limit of Balmer series,

$$n_2 = 2, n_1 = \infty$$

$$\frac{1}{\lambda} = R\left[\frac{1}{n_2^2} - \frac{1}{n_1^2}\right]$$

$$= \left[\frac{1}{(2)^2} - \frac{1}{(\infty)^2}\right] = \frac{R}{4}$$

$$\therefore \quad \lambda = \frac{4}{R} = \frac{4}{10967800}\ \text{m}$$

$$= 4 \times 912 \times 10^{-10}\ \text{m} = 4 \times 912\ \text{Å}$$

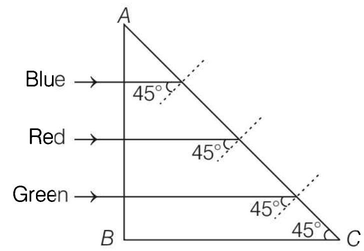
**46.** *(b)* Power output $= 3\ \text{kW} \times \frac{90}{100} = 27\ \text{kW}$

$$I_s = 6\ \text{A}$$

$$\therefore \quad V_s = \frac{2.7\ \text{kW}}{6\ \text{A}} = 450\ \text{V}$$

$$\Rightarrow \quad I_p = \frac{3\ \text{kW}}{200\ \text{V}} = 15\ \text{A}$$

**47.** *(a)* The situation is shown in figure



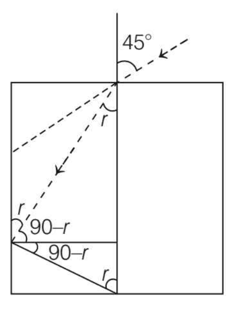

At face $AB$, $i = 0$. So, $r = 0$, i.e., light will be incident on face $AC$ at an angle of incidence 45°. The face $AC$ will not transmit the light for which $i > C$.

i.e. $\quad \sin i > \sin C$

$$\Rightarrow \quad \sin 45° > \frac{1}{\mu} \quad \text{or} \quad \frac{1}{\sqrt{2}} > \frac{1}{\mu} \Rightarrow \mu > \sqrt{2}$$

As refractive index for red colour is 1.39 which is less than $\sqrt{2}$, so red will be transmitted through face $AC$ while green and blue will be reflected.

**48.** *(d)* From figure, we get




$$r = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

For critical angle, $\sin C = \frac{1}{\mu}$

Now, by Snell's law, we have

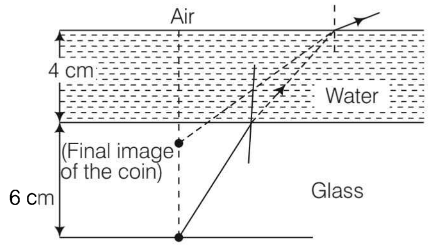
$$\frac{\mu}{1} = \frac{\sin i}{\sin r} = \frac{\sin 45°}{\sin\left(\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)\right)} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{3}}}$$

$$\Rightarrow \qquad \mu = \sqrt{\frac{3}{2}}$$

**49.** *(a)* Using equation, the total apparent shift is

$$s = h_1\left(1 - \frac{1}{\mu_1}\right) + h_2\left(1 - \frac{1}{\mu_2}\right)$$

or $$s = 4\left(1 - \frac{1}{4/3}\right) + 6\left(1 - \frac{1}{3/2}\right) = 3.0\,\text{cm}$$




(Original position of the coin)

Thus, $h = h_1 + h_2 - s$

$= 4 + 6 - 3 = 7.0\,\text{cm}$

**50.** *(d)* Relative velocity of the parrot w.r.t the train

$$= [10 - (-5)]\,\text{ms}^{-1} = 15\,\text{ms}^{-1}$$

Time taken by the parrot to cross then train

$$= \frac{150}{15} = 10\,\text{s}$$

## Chemistry

**51.** *(b)* The relation used for formation of ammonia is

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Relation by mass = 28 : 6 : 34

(or) 14 : 3 : 17

Given, $N_2(g) = 1.4\,\text{g} \Rightarrow H_2(g) = 1\,\text{g}$

Thus, $N_2(g)$ behave as a limiting reagent and $NH_3(g)$ will formed as per amount of $N_2$ used.

Therefore, 14 g of $N_2$ give $NH_3 = 17\text{g}$

$\therefore$ 1.4 g of $N_2$ give $NH_3 = \frac{17 \times 1.4}{14}$

Amount of $NH_3$ (g) $= 1.7\,\text{g}$

No. of moles of $NH_3$, $n = \frac{w}{M}$

$$n = \frac{1.7}{17} = 0.1\text{ mol.}$$

Also No. of moles of $NH_3 \equiv$ No. of atoms of N in $NH_3$

$\therefore$ If no. of moles of $NH_3 = 0.1$

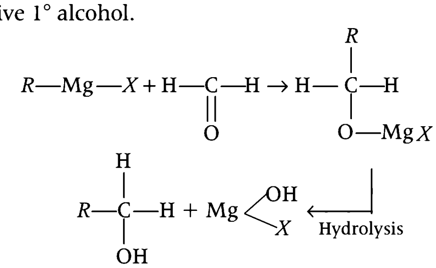
Then, no. of moles of N-atoms in $NH_3 = 0.1$ mol

Hence, No. of moles of $NH_3 = 0.1$ mol

No. of moles of N-atoms = 0.1 mol

**52.** *(b)* Due to small size and high electron density, electron-electron repulsion between two F-atom, causes increase in bond-length and thus decrease in bond energy. Hence, correct order is
$F_2 < Br_2 < Cl_2$.

**53.** *(a)* $R$Mg$X$ with HCHO followed by hydrolysis will give 1° alcohol.




(1° alcohol)

**54.** *(a)* Relation used $T_C = \frac{8a}{27Rb}$

where, $a$ and $b$ are van der Waals' constant.

Keeping value of b constant, we have, $T_C \propto a$

As we know, more be the value of '$a$', more easily we can liquefy the gas. Hence, more be the value of $T_C$, more easily that gas will be liquefied i.e. A

**55.** *(a)* Our required equation will be

$$S + O_2 \longrightarrow SO_2$$

Given, $S + \frac{3}{2}SO_2 \longrightarrow SO_3 + 2x$ kcal ...(i)

$SO_2 + \frac{1}{2}O_2 \longrightarrow SO_3 + y$ kcal ...(ii)

So, to get the required equation, we will subtract Eq. (ii) from Eq. (i), thus we get,

$S + O_2 \longrightarrow SO_2$ and $(2x - y)$

as heat of formation of $SO_2$.

**56.** *(c)* (i) –3, (ii) –1 , (iii) –2 , (iv) –4

**57.** *(a)* Equation of combustion of isobutane will be as follows:

$$C_4H_{10}(g) + \frac{13}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(g)$$

$\because \quad \Delta H = \Delta E + \Delta nRT$

where, $\Delta n$ = no. of gaseous moles (products) –

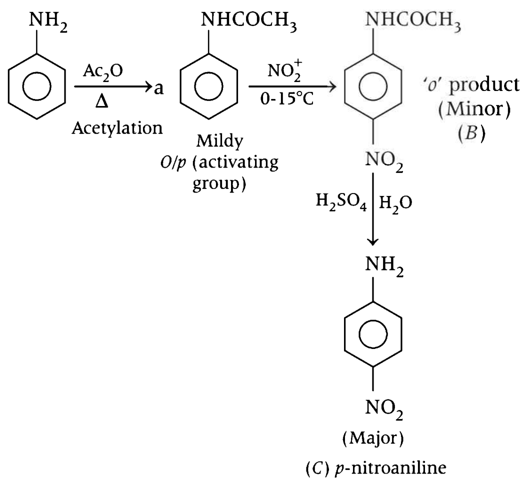
$\Delta n = (4 + 5) - \left(1 + \frac{13}{2}\right)$ number of moles of gaseous reactants.

$$\Delta n = + \frac{3}{2} (+\text{ve})$$

Since, $\Delta n$ is +ve $\Delta H$ must be greater than $\Delta E$.

$\therefore \quad \Delta H > \Delta E$.

**58.** *(c)*




**59.** *(c)* Moist hydrogen cannot be dried over conc. $H_2SO_4$ because it is oxidised by $H_2SO_4$ and catches fire.

$$H_2SO_4 + H_2 \longrightarrow 2H_2O + SO_2(g)$$

**60.** *(b)* $H-\underset{COOH}{\overset{CH_3}{C^*}}-OH$ (1 chiral centre present)

When $n = 1$ and no element of symmetry $d$ and $l$ forms = $2^n = 2$

*meso* form = 0

Total optical isomers = 2

**61.** *(c)* As per Fajan's rule

(i) More be the charge on cation/anion, more be the covalent nature.

(ii) For similar charges, smaller be the size of cation, more be the covalent nature.
Thus, correct order of covalent nature is

$$BeCl_2 > LiCl > NaCl$$

**62.** *(a)* $H_3BO_3$ accepts $OH^-$ ion and acts as a weak monobasic Lewis acid.

$$H_3BO_3 + H_2O \longrightarrow B(OH)_4^- + H^+$$

$$K_a = 10^{-9}$$

Since, value of $K_a$ is very small hence, $H_3BO_3$ is a weak acid.

**63.** *(c)* $CH_3CH_2OTs + \bar{C}N \longrightarrow CH_3CH_2CH_2CN + O^-Ts$

$[O^-T_s$ is a best leaving group and this reaction is 1° displacement reaction ($S_N2$).

**64.** *(c)* $HOH_2\overset{3}{C}-\overset{2}{C}(H_2N)(COOH)-CH_2OH$ 2-hydroxymethyl

serine does not containing chiral carbon and hence is optically inactive.

**65.** *(b)*

(i) Higher be the positive oxidation value of non-metal oxide, higher be the acidic nature.

(ii) For same value of oxidation number, more electronegative element associated with oxygen shows more acidic nature.

Thus, correct order of acidic character is

$$\underset{(+5)}{N_2O_5} > \underset{(+4)}{SO_2} > \underset{(+4)}{CO_2} > \underset{(+2)}{CO}$$

**Note** CO is a neutral oxide.

**66.** *(c)* $2I^- \longrightarrow I_2 + 2e^-$ (oxidation)

$2e^- + \underset{(+6)}{SO_4^{2-}} \longrightarrow \underset{(+4)}{SO_2}$ (reduction)

**67.** *(c)* More be the number of unpaired electrons, more be the value of magnetic moment.
$d^5$-configuration contains maximum number of unpaired electrons i.e. (= 5).
Thus, show maximum dipole moment as per the following relation,

$$\mu = \sqrt{n(n+2)} \text{ BM}$$

(Magnetic moment)
where, $n$ = no. of unpaired electrons.

**68.** *(a)* In $MnO_4^-$, oxidation number of Mn is +7 means all the
3 $d$ and 4$s$ electrons are lost to form $[MnO_4]^-$ complex.

Hence, has no $d$-electron.

**69.** *(a)* NaCl solution in water gives $H_2$ at cathode and $Cl_2$ at anode because of low discharge potential of $H^+$ ions as compared to $Na^+$ (at cathode) and of $Cl^-$ as compared to $OH^-$ ions (due to over voltage).

$$2H^+ \xrightarrow{+2e^-} H_2(g) \quad \text{(at cathode)}$$

$$2Cl^- \xrightarrow{-2e^-} Cl_2(g) \text{ (at anode)}$$

**70.** *(d)* Required relation

$$E_3 = \frac{n_1E_1 - n_2E_2}{n_3}$$

$\because$ Given, $+2 \to 0$ ...(i)

$+2 \to +1$ ...(ii)

Required, $+1 \to 0$

$\therefore$ Subtract Eq. (ii) from Eq. (i).

Here, $n_1 = 2,\ E_1 = 0.337\text{ V}$ ...(iii)

$n_2 = 1,\ E_2 = 0.153\text{ V}$ ...(iv)

$n_3 = 1,$

$$\therefore \quad E_3 = \frac{2 \times 0.337 - 1 \times 0.153}{1}$$

$$E_3 = 0.521\text{ V}$$

**71.** *(c)* Relation used, $r \propto [\text{conc.}]^x$

(i) From exp. no. 1 and 4,

$$r_A \propto [\text{conc.}]^x \Rightarrow 4 \propto (4)^1$$

$\therefore$ Order of reaction for reactant $A = 1$

(ii) From exp no. 2 and 3,

$$r_B \propto [\text{conc.}]^x \Rightarrow 4 \propto (2)^x$$

Order of reaction for reactant $B = 2$

Thus, order of reaction $= 1 + 2 = 3$

**72.** *(b)* Since, unit of rate constant is $3.0 \times 10^{-5}\ s^{-1}$, means order of reaction is one.

Thus, our rate law will be

$$r = k[N_2O_5]^1$$

Given, $r = 2.4 \times 10^{-5}$

$k = 3 \times 10^{-5}$

$$\therefore \quad [N_2O_5] = \frac{r}{k} = \frac{2.4 \times 10^{-5}}{3 \times 10^{-5}} = 0.8\text{ mol L}^{-1}$$

**73.** *(b)* Compounds I and II have $2\pi$-system and $10\pi$ system respectively. Both follow Huckel's rule $(4n + 2)\pi e^-$ $(n = 0, 1, 2..)$.

But III and IV system does not follow Huckel' rule.

**74.** *(a)* Zns has fcc (ccp) type structure, in which $S^{2-}$ ions occupy corner and face centre positions, while $Zn^{2+}$ ions are placed at alternate tetrahedral voids.

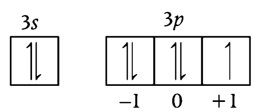
**75.** *(d)* None of these contain $\alpha$-H atom hence, (d) is correct.

**76.** *(c)* An electron in hydrogen atom will only emit energy when it jumps from higher energy level to a lower energy level.
Order of energy change i.e. emition of energy is follows :

$$n_2 \to n_1 > n_3 \to n_2 > n_4 \to n_3 > n_5 \to n_4 > n_6 \to n_5 \ldots\ldots$$

Hence, among the given options, maximum energy emitted by an electron during its transition from $n_3 \to n_2$.

**77.** *(a)* For $Z = 17$, outer most electronic configuration is $\to 3s^2, 3p^5$. $(n = 3)$

= 


Therefore, set of quantum number
$n = 3,\ l = +1$
$m = \pm 1$ i.e. 1 (in this case) and $s = \pm \frac{1}{2}$

Hence, correct option is (a).

**78.** *(d)* $X(s) \to X(g)$, requires energy to change the state from solid to gas.

$O^-(g)$ has already one electron more than protons in nucleus. Therefore, it will repel the next incoming electron. So, energy is required to make

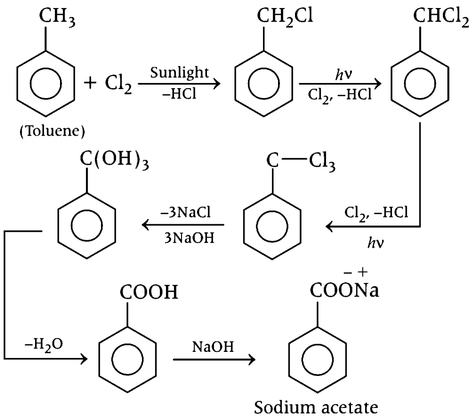
$$O^-(g) \longrightarrow O^{2-}(g)$$

$$O(g) \longrightarrow O^+(g) + e^-$$

is an endothermic process. It requires energy to remove the electron from $O(g)$.

Only option (d) indicates release of energy due to electron gain enthalpy $[\Delta H = (-)\text{ ve}]$.

**79.** *(b)*




**80.** *(a)* In all the given three structures [(i), (ii) and (iii)], —OH group at second-last position is on the right hand side of chiral C-atom. Therefore,all have D-configuration.

**81.** *(c)* Let initial pressure = $p$

and initial volume = 100 unit.
Then, final volume = 95 unit
final pressure = ?
∵ The relation for an ideal gas is:

$$p_1V_1 = p_2V_2$$
$$p \times 100 = p_2 \times 95$$
$$p_2 = \frac{p \times 100}{95}$$
$$= 1.0526\, p$$

∴ Increase in pressure $= 1.0526\, p - p$
$= 1.0526 \times 100$ (for %) $- 100$
$= 105.26 - 100 = 5.26\%$

**82.** *(d)*

| | $N_2O_4 \rightleftharpoons$ | $2NO_2$ |
|---|---|---|
| Initially | 1 | 0 |
| At equilibrium | $1 - x$ | $2x$ |

Total number of moles $= 1 - x + 2x$
$= 1 + x$

∴ % of $NO_2$ by volume $= \dfrac{2x}{1+x} \times 100$
$= 50$

i.e. $x = \frac{1}{3}$ (i.e. 0.333)

Hence, % dissociation = 33.33%.

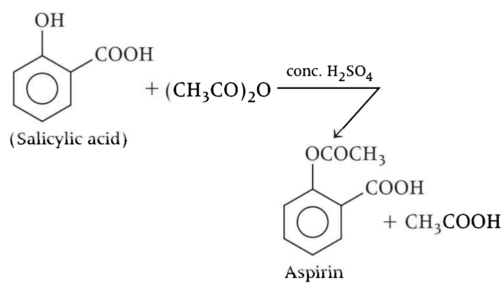
**83.** *(b)* The correct balanced chemical equation is

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2\,Mn^{2+} + 10\,CO_2 + 8H_2O$$

Hence, correct cofficients for $C_2O_4^{2-}$ and $H^+$ ions are 5 and 16 respectively.

**84.** *(d)* The chemical substances (drugs) used to bring down the body temperature in case of high fever are called antipyretics.
e.g., phenacetin, paracetamol etc.

**85.** *(d)* Preparation of aspirin from salicylic acid




**86.** *(d)* $n$HOOC—$C_6H_4$—COOH (Terephthalic acid)

$+ \, n \cdot HOCH_2$—$CH_2OH$ (Ethylene glycol) $\xrightarrow{-H_2O}$

$-[OC \cdot C_6H_4COOCH_2 \cdot CH_2—O—]_n$ (Terylene or dacron)

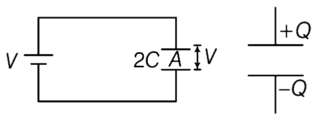
**87.** *(b)* Boron trihalides are Lewis acids. The order of their acidic strength is $BF_3 < BCl_3 < BBr_3 < BI_3$
In boron halides, a $p\pi - p\pi$ back bonding arises due to empty orbital of boron and filled orbitals of halogen. This $p\pi - p\pi$ bonding has maximum effect in $BF_3$ as the size of B and F atoms are comparative. This effect decreases as the size of halogen atom increases. Due to this effect, tendency of accepting lone pair of electron of boron decreases, i.e. Lewis acid character decreases.

**88.** *(a)* The reaction between $HNO_3$ (conc.) and sulphur (s) is as follows:

$$S + 6\,HNO_3 \longrightarrow H_2SO_4 + 6\,NO_2 + 2\,H_2O$$

Here, sulphur oxidised as $H_2SO_4$ and $HNO_3$ reduced to $NO_2$.
Hence, we get, $H_2SO_4$, $NO_2$ and $H_2O$ as main products.

**89.** ***(b)*** When two waves are in same phase i.e. (+, +) or (–, –) overlap over each other they form bonding molecular orbitals while when they are in opposite phase i.e. (+, – or –, +), they form antibonding molecular orbitals as follows:




**90.** ***(d)*** Molar mass of ethanol ($CH_3CHO$)

$$= 12 + (3 \times 1) + 12 + 1 + (16 \times 1)$$
$$= 12 + 3 + 12 + 1 + 16 = 44$$

Heat of combustion is the heat produced due to combustion of 1 mol (44 g) of ethanol.

As $x$ g of ethanol give $y$ J of heat energy

$\therefore$ 44 g of ethanol gives heat energy $= \dfrac{y \times 44}{x}$ J mol$^{-1}$

As combustion is an exothermic process.

Heat of combustion of ethanol $= -\dfrac{y}{x} \times 44$ J mol$^{-1}$

**91.** ***(a)*** 100mL of solution contain 0.005 moles of $Ba(OH)_2$.

$\therefore$1 L (1000 mL) of solution contain

$= 10 \times 0.005$ mole of $Ba(OH)_2$

Concentration of $Ba(OH)_2$ (i.e., moles in litres.)

$= 0.05$ M

Each $Ba(OH)_2$ give $2OH^-$ ions.

Thus, moles of $OH^-$ (per L.) $= 2 \times 0.05 = 0.1$

(iii) $\because$ $pOH = -\log[OH^-]$

$pOH = -\log[0.1] = -\log 10^{-1}$

$pOH = \log 10 = 1$

**92.** ***(a)*** Food preservations prevent spoilage of food due to microbial growth. Sodium benzoate can be used as food preservative.

**93.** ***(c)*** Bakelite is condensed polymer of phenol ($C_6H_5 - OH$) and formaldehyde (HCHO)

**94.** ***(c)*** $CH_3 \cdot C \equiv CH + H_2O \xrightarrow[MgSO_4]{H_2SO_4} [CH_3C(OH) = CH_2]$

$\updownarrow$ Tautomerisation

$CH_3 \cdot CO \cdot CH_3$
Acetone

**95.** ***(c)*** $[NiCl_4]^{2-}$; Oxidation state of Ni is $x - 4 = -2$

$x = +2$

Ni (28) = [Ar] $3d^8\,4s^2$

$\therefore [NiCl_4]^{2-}$ has two unpaired electrons.

Magnetic moment ($\mu$) $= \sqrt{n(n+2)}$ BM

where, $n$ = number of unpaired electrons.

$\mu = \sqrt{2\,(2+2)} = \sqrt{8} = 2.82$ BM

**96.** ***(b)*** Cu(+1) salts are unstable because $Cu^+$ salts disproportionates to Cu and $Cu^{2+}$ salts, in aqueous solution.

**97.** ***(c)*** Atomic number of (B) = $Z$ and is a noble gas.

Atomic No. of (A) = $Z-1$ (i.e., is a Halogen)

Atomic No. of (C), $= Z+1$ (i.e., is a alkaliu metal)

At No. of $(D) = Z + 2$ (i.e., alkaline earth metal)

Hence, element ($A$) must be a Halogen, so has highest electron affinity among the given species. ($C$) is an alkali metal and ($D$) is an alkaline earth metal.

**98.** ***(b)*** Physical as well as chemical, both type of adsorption are favoured by high pressure.

Decrease in pressure causes de sorption in case of physical adsorption while not in case of chemical adsorption.

**99.** ***(b)*** As $r = k[O]\,[O_3]$ ...(i)

To eliminate [O] from fast step

$$K_c = \frac{[O]\,[O_2]}{[O_3]} \text{ or, } [O] = \frac{K_c\,[O_3]}{[O_2]}$$

Substituting this value in Eq. (i) we have

$$r = \frac{K.K_c.[O_3]\,[O_3]}{[O_2]}$$

Let, $K.K_c = K'$

$$r = K'\,[O_3]^2 \cdot [O_2]^{-1}$$

**100.** ***(c)*** $K_\omega = [H^+] \cdot [OH^-]$ and for neutral water,

$[H^+] = [OH^-]$, therefore $K_\omega = [H^+]^2$

$[H^+] = \sqrt{K_\omega} = \sqrt{27 \times 10^{-14}} = 1.63 \times 10^{-7}$ M

$\therefore$ $pH = -\log[H^+] = -\log[1.643 \times 10^{-7}] = 6.78$

## Mathematics

**101.** *(d)* The direction cosines of the line are

$$l = \cos\alpha,\ m = \cos\beta,\ n = \cos\gamma$$

Now, $l^2 + m^2 + n^2 = 1$

$\Rightarrow \cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

$\Rightarrow 1 - \sin^2\alpha + 1 - \sin^2\beta + 1 - \sin^2\gamma = 1$

$\Rightarrow \sin^2\alpha + \sin^2\beta + \sin^2\gamma = 2$

**102.** *(c)* We know that,

$$\left\{\frac{a}{|a|} - \frac{b}{|b|}\right\}^2 = \left\{\frac{a-b}{|a||b|}\right\}^2 = \frac{|a-b|^2}{|a|^2\,|b|^2}$$

$$= \frac{1+4+9}{9\times 16} = \frac{14}{9\times 16} = \frac{7}{72}$$

**103.** *(d)* We have,

$$l + m - n = 0$$

and $l^2 + m^2 - n^2 = 0$

$\Rightarrow l + m = n$ and $l^2 + m^2 = n^2$

$\Rightarrow l^2 + m^2 = (l+m)^2$

$\Rightarrow 2lm = 0$

$\Rightarrow l = 0$ or $m = 0$

If $l = 0$, then $m = n$

$\therefore \frac{l}{0} = \frac{m}{1} = \frac{n}{1}$

If $m = 0$, then

$$l = n$$

$\therefore \frac{l}{1} = \frac{m}{0} = \frac{n}{1}$

Thus, the dr's of the lines are proportional to 0, 1, 1 and 1, 0, 1.

Therefore, angle $\theta$ between them is given by

$$\cos\theta = \frac{0\times 1 + 1\times 0 + |1\times 1|}{\sqrt{0+1+1}\,\sqrt{1+0+1}} = \frac{1}{2} \Rightarrow \theta = \frac{\pi}{3}$$

**104.** *(c)* The number of 6-digits has two pairs of digits and 2 different digits.

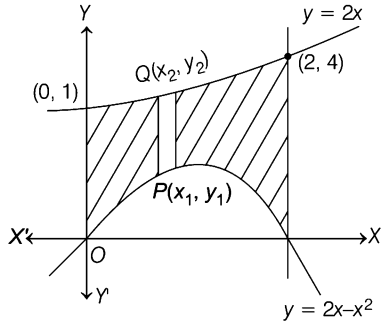
The number of ways of selecting 2 digits for two pairs and 2 other digits $= {}^4C_2 \times {}^2C_2$.

Now, we arrange these six digits which consists of two pairs and 2 different digits. This can be done in $\frac{6!}{2!\,2!}$ ways.

$\therefore$ Required number of numbers

$$= {}^4C_2 \times {}^2C_2 \times \frac{6!}{2!\,2!} = 1080$$

**105.** *(a)*




Let the required area be $A$ sq units. Then,

$$A = \int_0^2 (y_2 - y_1)\,dx$$

$$= \int_0^2 [2^x - (2x - x^2)]\,dx$$

$$= \left[\frac{2^x}{\log 2} - x^2 + \frac{x^3}{3}\right]_0^2$$

$$= \frac{4}{\log 2} - 4 + \frac{8}{3} - \frac{1}{\log 2}$$

$$= \frac{3}{\log 2} - \frac{4}{3} \text{ sq units}$$

**106.** *(d)* The equation of the curve is

$$y = x^2 + x - 1$$

$\therefore \frac{dy}{dx} = 2x + 1$

$\Rightarrow \left(\frac{dy}{dx}\right)_{(1,1)} = 3$

Now, $A$ = Length of the tangent at (1, 1)

$$= \frac{\sqrt{1 + \left(\frac{dy}{dx}\right)^2}}{\frac{dy}{dx}} = \frac{\sqrt{1+3^2}}{3} = \frac{\sqrt{10}}{3}$$

$B$ = Length of the subtangent at (1, 1)

$$= \frac{y}{\left(\frac{dx}{dy}\right)} = \frac{1}{3}$$

$C$ = Length of the normal at (1, 1)

$$= \sqrt{1 + \left(\frac{dy}{dx}\right)^2} = \sqrt{1+3^2} = \sqrt{10}$$

$D$ = Length of the subnormal at (1, 1)

$\Rightarrow D = y\frac{dy}{dx} = 1\times 3 = 3$

Thus, we have $B < A < D < C$.

**107.** *(b)* If $f(x)$ has a local minimum at $x=-1$, then

$$\lim_{x\to -1^+} f(x) = \lim_{x\to -1^-} f(x)$$

$$\Rightarrow \quad \lim_{x\to -1^+} 2x+3 = \lim_{x\to -1^-} k-2x$$

$$\Rightarrow \quad -2+3 = k+2 \Rightarrow k=-1$$

**108.** *(d)* The coordinates of $A$ and $B$ are $(0, b, c)$ and $(a, 0, c)$ respectively.

The equation of a plane passing through $O(0, 0, 0)$ is

$$Px + Qy + Rz = 0 \quad \text{...(i)}$$

It passes through $A$ and $B$

$\therefore \quad P\times 0 + Q\times b + R\times c = 0$

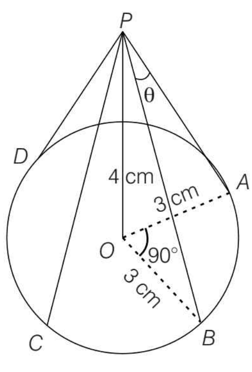
and $\quad P\times a + Q\times 0 + R\times c = 0$

$$\Rightarrow \quad \frac{P}{bc} = \frac{Q}{ac} = \frac{R}{-ab}$$

Substituting the values of $P$, $Q$ and $R$ in Eq. (i), we get

$$bcx + acy - abz = 0.$$

**109.** *(c)* Let $O$ be the centre of the circular ring which is suspended by the strings $PA$, $PB$, $PC$ and $PD$ in such a way that $P$ is just above the point $O$ and arc $AB$ = arc $BC$ = arc $CD$ = arc $AD$.




$\therefore \quad \angle AOB = 90°$

Also, in $\Delta AOP$, we have

$$AP = \sqrt{OA^2 + OP^2} = \sqrt{3^2+4^2} = 5\text{ cm}$$

$$\Rightarrow \quad BA = AP = 5\text{ cm}$$

In $\Delta APB$, we have

$$\cos\theta = \frac{AP^2 + BP^2 - AB^2}{2AP\cdot BP} = \frac{5^2+5^2-(3\sqrt{2})^2}{2\times 5\times 5}$$

[In $\Delta AOB$, $AB^2 = OA^2 + OB^2$]

$$\Rightarrow \quad \cos\theta = \frac{16}{25}$$

**110.** *(a)*

$$\sin^{-1}\left(\cot\left(\sin^{-1}\sqrt{\frac{2-\sqrt{3}}{4}} + \cos^{-1}\frac{\sqrt{12}}{4} + \sec^{-1}\sqrt{2}\right)\right)$$

$$= \sin^{-1}\left(\cot\left(\sin^{-1}\left(\frac{\sqrt{3}-1}{2\sqrt{2}}\right) + \cos^{-1}\frac{\sqrt{3}}{2} + \cos^{-1}\frac{1}{\sqrt{2}}\right)\right)$$

$$= \sin^{-1}[\cot(15° + 30° + 45°)]$$

$$= \sin^{-1}(\cot(90°)) = \sin^{-1}(0) = 0$$

**111.** *(c)* There are three ways to fill up each place. So, $n$ places can be filled in $3^n$ ways.

Therefore, total number of $n$ digit numbers $= 3^n$.

Now, $\quad 3^n \geq 900 \Rightarrow n \geq 7$

Hence, the smallest value of $n$ is 7.

**112.** *(c)* We have, $x, y, z$ are in AP.

$$\Rightarrow \quad 2y = x + z \quad \text{...(i)}$$

Also,

$\tan^{-1}x, \tan^{-1}y, \tan^{-1}z$ are in AP.

$$\Rightarrow \quad 2\tan^{-1}y = \tan^{-1}x + \tan^{-1}z$$

$$\Rightarrow \quad \tan^{-1}\left(\frac{2y}{1-y^2}\right) = \tan^{-1}\left(\frac{x+z}{1-xz}\right)$$

$$\Rightarrow \quad \frac{2y}{1-y^2} = \frac{x+z}{1-xz}$$

$$\Rightarrow \quad 1-y^2 = 1-xz \quad \text{[using Eq. (i)]}$$

$$y^2 = xz$$

$\Rightarrow \quad x, y, z$ are in GP ...(ii)

Using Eqs. (i) and (ii), we get $x = y = z$

**113.** *(b)* If $n$ is odd, then required sum is given by

$$1^2 - 2^2 + 3^2 - 4^2 + 5^2 - 6^2 + \dots + \{(n-2)^2 - (n-1)^2\} + n^2$$

$$= (1-2)(1+2) + (3-4)(3+4) + (5-6)(5+6) + \dots + \{(n-2)-(n-1)\}\{(n-2)+(n-1)\} + n^2$$

$$= -(1+2+3+\dots+(n-2)+(n-1)) + n^2)$$

$$= -\frac{n(n-1)}{2} + n^2 = \frac{n(n+1)}{2}.$$

**114.** *(b)* Clearly, $A$ will remain as $(0, 0)$; $f_1$ will make $B$ as $(0, 4)$, $f_2$ will make it $(12, 4)$ and $f_3$ will make it $(4, 8)$; $f_1$ will make $C$ as $(2, 4)$, $f_2$ will make it $(14, 4)$, and $f_3$ will make it $(5, 9)$. Finally, $f_1$ will make $D$ as $(2, 0)$, $f_2$ will make it $(2, 0)$ and $f_3$ will make it $(1, 1)$. So, finally we get $A \equiv (0, 0)$, $B \equiv (4, 8)$, $C \equiv (5, 9)$ and $D \equiv (1, 1)$. Therefore,

$$m_{AB} = \frac{8}{4},\ m_{BC} = \frac{9-8}{5-4} = 1,$$

$$m_{CD} = \frac{9-1}{5-1} = \frac{8}{4},$$

$$m_{AD} = 1, m_{AC} = \frac{9}{5}, m_{BD} = \frac{8-1}{4-1} = \frac{7}{3}$$

Hence, the final figure will be a parallelogram.

**115.** *(a)* The given equation when expressed as a polynomial in derivatives is

$$P^2\left(\frac{d^2y}{dx^2}\right)^2 = \left\{1+\left(\frac{dy}{dx}\right)^2\right\}^3$$

Clearly, it is a second order differential equation of degree 2.

**116.** *(d)* We have,

$$f(\theta) = 5\cos\theta + 3\cos\left(\theta + \frac{\pi}{3}\right) + 3$$

$$= 5\cos\theta + \frac{3}{2}\cos\theta - \frac{3\sqrt{3}}{2}\sin\theta + 3$$

$$= \frac{13}{2}\cos\theta - \frac{3\sqrt{3}}{2}\sin\theta + 3$$

$$= \sqrt{\frac{169}{4} + \frac{27}{4}}\sin(\theta - \alpha) + 3$$

$$= 7\sin(\theta - \alpha) + 3$$

Thus, the range of $f(\theta)$ is $[-4, 10]$.

**117.** *(d)* Let $D$ be the foot of the perpendicular and let it divide $BC$ in the ratio $\lambda : 1$. Then, the coordinates of $D$ are

$$\left(\frac{3\lambda+4}{\lambda+1}, \frac{5\lambda+7}{\lambda+1}, \frac{3\lambda+1}{\lambda+1}\right).$$

Now, $\quad AD \perp BC$

$\Rightarrow \quad AD \cdot BC = 0$

$\Rightarrow \quad -(2\lambda+3) - 2(5\lambda+7) - 4 = 0$

$\Rightarrow \quad \lambda = -\frac{7}{4}$

So, the coordinates of $D$ are $\left(\frac{5}{3}, \frac{7}{3}, \frac{17}{3}\right)$.

**118.** *(d)* We have,

$$x = \cos\theta, \quad y = \sin 5\theta$$

$$\therefore \quad \frac{dy}{dx} = \frac{\frac{dy}{d\theta}}{\frac{dx}{d\theta}} = -\frac{5\cos 5\theta}{\sin\theta}$$

$$\Rightarrow \quad \frac{d^2y}{dx^2} = -5\frac{d}{d\theta}\left(\frac{\cos 5\theta}{\sin\theta}\right)\cdot\frac{d\theta}{dx}$$

$$= \frac{-25\sin\theta\sin 5\theta - 5\cos\theta\cos 5\theta}{\sin^3\theta}$$

$$\therefore \quad (1-x^2)\frac{d^2y}{dx^2} - x\frac{dy}{dx}$$

$$= (1-\cos^2\theta)\left[\frac{-25\sin\theta\sin 5\theta - 5\cos\theta\cos 5\theta}{\sin^3\theta}\right] - \cos\theta\left[\frac{-5\cos 5\theta}{\sin\theta}\right]$$

$$= -25\sin 5\theta = -25y$$

**119.** *(a)* Period of $\sin(\sin(nx))$ is $\frac{2\pi}{n}$ and that of $\tan\left(\frac{x}{n}\right)$ is $n\pi$.

For $n = 3$, we find that

Period of $\sin(\sin(nx))$ is $\frac{2\pi}{3}$ and that of $\tan\left(\frac{x}{n}\right)$ is $3\pi$.

$\therefore$ Period of $f(x)$ is $6\pi$.

**120.** *(c)* We have,

$$f(x) = \begin{cases} -x, & -1 \le x < 0 \\ 1-x, & 0 \le x < 1 \\ x, & 1 \le x < 2 \\ 1+x, & 2 \le x < 3 \\ 5, & x = 3 \end{cases}$$

Clearly, $f(x)$ is discontinuous at $x = 0, 1, 2$ and 3. So, it is not differentiable at these points.

At $x = -1$, we have

$$\lim_{x \to -1^+} f(x) = \lim_{x \to -1^+} -x = 1 = f(-1)$$

So, it is continuous at $x = -1$.

Also, (RHD at $x = -1$) $= -1$ (a finite number).

Therefore, $f(x)$ is differentiable at $x = -1$.

**121.** *(c)* We have,

$$I_n - I_{n-1} = \int_0^{\pi/2}\frac{\cos^2 nx - \cos^2(n-1)x}{\sin x}\,dx$$

$$= \int_0^{\pi/2}\frac{\sin^2(n-1)x\,\sin^2 nx}{\sin x}\,dx$$

$$= \int_0^{\pi/2}\sin(2n-1)x\,dx$$

$$= \frac{1}{2n-1}[\cos(2n-1)x]_0^{\pi/2} = \frac{-1}{2n-1}$$

$$\therefore I_2 - I_1 = -\frac{1}{3},$$

$$I_3 - I_2 = -\frac{1}{5},$$

$$I_4 - I_3 = -\frac{1}{7}$$

Clearly, $I_2 - I_1, I_3 - I_4, I_4 - I_3$ are in HP.

**122.** *(c)* We know that, the coefficient of the middle term is the numerically greatest coefficient in the expansion of $(1-x)^n$ or $(1+x)^n$ and its value is $^nC_{n/\alpha}$ or $\frac{^nC_{n+1}}{2}=\frac{^nC_{n-1}}{2}$ according as $n$ is even or odd.

It is given that the coefficient of the 5th term is the greatest. Therefore, 5th term is the middle term. Thus, there are 9 terms. Hence, $n=8$.

**123.** *(c)* Let $r_1$ be the statement $\sim(p \Leftrightarrow \sim q)$. Then,

$$r_1 = \sim(p \Leftrightarrow \sim q)$$

$$\Rightarrow \quad r_1 = \sim\{(\sim p \vee \sim q) \wedge (p \vee q)\}$$

$$[\because p \Leftrightarrow q = (p \vee \sim q) \wedge (q \vee \sim p)]$$

$$\Rightarrow \quad r_1 = \sim\{\sim(p \wedge q) \wedge (p \vee q)\}$$

$$\Rightarrow \quad r_1 = (p \wedge q) \vee (\sim p \wedge \sim q)$$

$$\Rightarrow \quad r_1 = \{(p \wedge q) \vee \sim p\} \wedge \{(p \wedge q) \vee \sim q\}$$

$$\Rightarrow \quad r_1 = \{(p \vee \sim p) \wedge (q \vee \sim p\} \wedge \{(p \vee \sim q) \wedge (q \vee \sim q)\}$$

$$\Rightarrow \quad r_1 = \{t \wedge (q \vee \sim p)\} \wedge \{(p \vee \sim q) \wedge t\}$$

$$\Rightarrow \quad r_1 = (q \vee \sim p) \wedge (p \vee \sim q)$$

$$\Rightarrow \quad r_1 = (p \Leftrightarrow q)$$

**124.** *(b)* The equation of the tangent $y^2=8x$ at $P(2,4)$ is

$$4y = 4(x+2)$$

$$\Rightarrow \quad x-y+2=0 \qquad \text{...(i)}$$

Let $(x_1, y_1)$ be the mid-point of chord $QR$. Then, equation of $QR$ is

$$yy_1 - 4(x+x_1) - 5 = y_1^2 - 8x_1 - 5$$

$$\Rightarrow \quad 4x - yy_1 - 4x_1 + y_1^2 = 0 \qquad \text{...(ii)}$$

Clearly, Eqs. (i) and (ii) represent the same line.

$$\therefore \quad \frac{4}{1} = \frac{-y_1}{-1} = \frac{-4x_1+y_1^2}{2}$$

$$\Rightarrow \quad y_1 = 4 \text{ and } 8 = -4x_1, + y_1^2$$

$$\Rightarrow \quad y_1 = 4 \text{ and } x_1 = 2$$

**125.** *(b)* The equation of a family of circles passing through the intersection of given circle is

$$x^2+y^2-2x+y+\lambda(2x-y-1)=0$$

or $\quad x^2+y^2-2(1-\lambda)x+(1-\lambda)y-\lambda=0$

Let $C(h,k)$ be its centre. Then, $h=1-\lambda$

and $\quad k=-\left(\frac{1-\lambda}{2}\right)$

$$\Rightarrow \quad h=-2k$$

Hence, the locus of $(h,k)$ is $x=-2y$

or $\quad x+2y=0$

**126.** *(d)* We have, $\lim_{x\to 0}\frac{\int_0^{x^2}\sec^2 t\,dt}{x\sin x}$

$$= \lim_{x\to 0}\frac{2x\sec^2 x^2}{x\cos x+\sin x} \quad \text{[using L's Hospital's Rule]}$$

$$= \lim_{x\to 0}\frac{2\sec^2 x^2}{\cos x+\frac{\sin x}{x}} = 2\left(\frac{1}{1+1}\right)=1$$

**127.** *(d)* Let $y=7-x$. Then, the given equation becomes

$$(y+1)^4+(y-1)^4=16$$

$$y^4+6y^2-7=0$$

$$\Rightarrow \quad (y^2-1)(y^2+7)=0$$

$$\Rightarrow \quad y^2-1=0 \qquad [\because y^2+7\neq 0]$$

$$\Rightarrow \quad y=\pm 1$$

$$\Rightarrow \quad 7-x=\pm 1 \Rightarrow x=6,8$$

**128.** *(d)* For $n=1$, we have

$10^{2n-1}+1=10+1=11$, which is divisible by 11.

For $n=2$, we have

$10^{2n-1}+1=10^3+1=1001$, which is divisible by 11.

$\therefore \; 10^{2n-1}+1$ is divisible by 11.

**129.** *(d)* Since, $f(x)$ is continuous at $x=\pi/4$

$$\therefore \quad \lim_{x\to\pi/4} f(x)=f(\pi/4)$$

$$\Rightarrow \quad \lim_{x\to\frac{\pi}{4}}\frac{1-\sqrt{2}\sin x}{\pi-4x}=a = \lim_{x\to\frac{\pi}{4}}\frac{-\sqrt{2}\cos x}{-4}=a$$

[using De L'Hospital's Rule]

$$\Rightarrow \quad \frac{1}{2\sqrt{2}}\cos\frac{\pi}{4}=a \Rightarrow a=\frac{1}{4}$$

**130.** *(b)* We have,

$$f(x)=a\log|x|+bx^2+x$$

$$\Rightarrow \quad f'(x)=\frac{a}{x}+2bx+1$$

Since, $f(x)$ attains its extremum values at $x=-1,2$

$$\therefore \quad f'(-1)=0 \text{ and } f'(2)=0$$

$$\Rightarrow -a-2b+1=0 \text{ and } \frac{a}{2}+4b+1=0$$

$$\Rightarrow \quad a=2 \text{ and } b=-\frac{1}{2}$$

**131.** *(d)* Let, $Q\in P$

$$\Rightarrow \quad \sin\theta-\cos\theta=\sqrt{2}\cos\theta$$

$$\Rightarrow \quad (\sin\theta-\cos\theta)^2=2\cos^2\theta$$

$$\Rightarrow \quad \sin^2\theta+\cos^2\theta-2\sin\theta\cos\theta=2\cos^2\theta$$

$\Rightarrow \quad \cos^2\theta + 2\sin\theta\cos\theta + \sin^2\theta = 2\sin^2\theta$

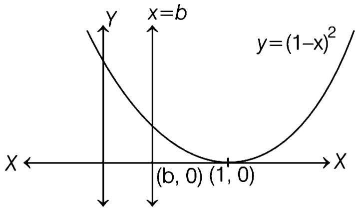
$\Rightarrow \quad (\cos\theta + \sin\theta)^2 = 2\sin^2\theta$

$\Rightarrow \quad \cos\theta + \sin\theta = \sqrt{2}\sin\theta$

$\Rightarrow \quad \theta \in Q$

$\therefore \quad P = Q$

**132.** *(b)*




$\therefore \quad R_1 = \int_0^b (1-x)^2\,dx$ and $R_2 = \int_b^1 (1-x^2)\,dx$

$\Rightarrow \quad R_1 = \left[\frac{(x-1)^3}{3}\right]_0^b$ and $R_2 = \left[\frac{(x-1)^3}{3}\right]_b^1$

$\Rightarrow \quad R_1 = \frac{(b-1)^3}{3} + \frac{1}{3}$ and $R_2 = \frac{-(b-1)^3}{3}$

$\therefore \quad R_1 - R_2 = \frac{1}{4}$

$\Rightarrow \quad \frac{2}{3}(b-1)^3 + \frac{1}{3} = \frac{1}{4}$

$\Rightarrow \quad \frac{2}{3}(b-1)^3 = \frac{-1}{12}$

$\Rightarrow \quad (b-1)^3 = \frac{-1}{8}$

$\Rightarrow \quad b - 1 = \frac{-1}{2} \Rightarrow b = \frac{1}{2}$

**133.** *(b)* We have,

$$\operatorname{sgn}(x-[x]) = \begin{cases} 1, \text{if } x \text{ is not an integer} \\ 0, \text{if } x \text{ is an integer} \end{cases}$$

$\therefore \int_{-1}^{10} \operatorname{sgn}(x-[x])\,dx = 11\ (1-0) = 11$

**134.** *(b)* We have,

$\cos^{-1} x - \sin^{-1} x = \sin^{-1}(1-x)$

$\Rightarrow \quad \frac{\pi}{2} - 2\sin^{-1} = \sin^{-1}(1-x)$

$\Rightarrow \quad \frac{\pi}{2} - \sin^{-1}(1-x) = 2\sin^{-1} x$

$\Rightarrow \quad \cos^{-1}(1-x) = \cos^{-1}(1-2x^2)$

$\Rightarrow \quad 1 - x - 1 - 2x^2$

$\Rightarrow \quad 2x^2 - x = 0 \Rightarrow x = 0, \frac{1}{2}$

**135.** *(a)* Let $\mathbf{b} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$. Then,

$\mathbf{a} \cdot \mathbf{b} = 3 \Rightarrow x + y + z = 3$

and $\mathbf{a} \times \mathbf{b} = \mathbf{c}$

$\Rightarrow \quad (z-y)i + (x-z)j + (y-x)k = j - k$

$\Rightarrow \quad z - y = 0,\ x - z = 1$ and $y - x = -1$

Solving these equations, we get

$x = \frac{5}{3},\ y = \frac{2}{3},\ z = \frac{2}{3}$

$\therefore \quad b = \frac{1}{3}(5i + 2j + 2k)$

**136.** *(b)* We have,

$T_n = {}^nC_3$

$\therefore \quad T_{n+1} - T_n = 21$

$\Rightarrow \quad {}^{n+1}C_3 - {}^nC_3 = 21$

$\Rightarrow \quad {}^nC_2 + {}^nC_3 - {}^nC_3 = 21 \quad [\because {}^nC_r + {}^nC_3 - {}^nC_3 = 21]$

$\Rightarrow \quad {}^nC_2 = 21$

$\Rightarrow \quad \frac{n(n-1)}{2} = 21$

$\Rightarrow \quad n^2 - n - 42 = 0$

$\Rightarrow \quad (n-7)(n+6) = 0 \Rightarrow n = 7 \quad [\because n \geq 1]$

**137.** *(a)* Let $OA$ be the vertical pole of height $h$ and $OP_1$, $OP_2$, $OP_3$ be the lengths of shadow.

In $\Delta AOP_1$ we have

$\tan\theta_1 = \frac{OA}{OP_1} = \frac{h}{h} = 1 \Rightarrow \theta_1 = \frac{\pi}{4}$

In $\Delta AOP_1$ we have,

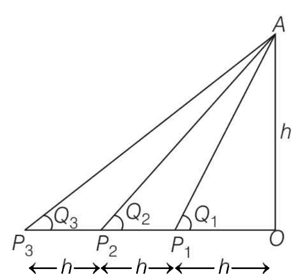
$\tan\theta_2 = \frac{OA}{OP_2} = \frac{2}{2h} = \frac{1}{2} \Rightarrow \theta_2 = \tan^{-1}\frac{1}{2}$

Similarly, $\tan\theta_3 = \frac{OA}{OP_3} = \frac{h}{3h} = \frac{1}{3}$

$\theta_3 = \tan^{-1}\frac{1}{3}$

$\therefore$ Sum of the angles

$= \theta_1 + \theta_2 + \theta_3 = \frac{\pi}{4} + \tan^{-1}\frac{1}{2} + \tan^{-1}\frac{1}{3}$



$$= \frac{\pi}{4} + \tan^{-1}\left(\frac{1/2+1/3}{1-1/2\times1/3}\right)$$

$$= \frac{\pi}{4} + \tan^{-1}1 = \frac{\pi}{4} + \frac{\pi}{4} = \frac{\pi}{2}$$

**138.** *(d)* We have

$$7 = \frac{4a+24+7b+45}{a+4+b+5}$$

$\Rightarrow\ 4a+7b+69 = 7a+7b+63$

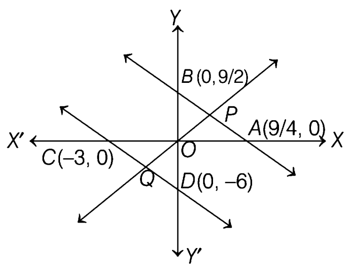
$\Rightarrow\ a = 2$

But $b$ cannot be determined.

**139.** *(b)* Clearly, triangles $OPA$ and $OQC$ are similar

$\Rightarrow\ \frac{OP}{OQ} = \frac{OA}{OC}$

$\Rightarrow\ \frac{OP}{OQ} = \frac{9/4}{3} = \frac{3}{4}$




**140.** *(a)* We have,

$$2ae = \frac{2b^2}{a} \Rightarrow a^2e = b^2$$

$\Rightarrow\ a^2e = a^2(1-e)^2$

$\Rightarrow\ e^2 + e - 1 = 0$

$\Rightarrow\ e = \frac{\sqrt{5}-1}{2}$

**141.** *(a)* Let $r$ be the radius of the spherical balloon and $v$ be its volume.

It is given that $\frac{dv}{dt} = 30\ \text{ft}^3/\text{min}$

Now, $V = \frac{4}{3}\pi r^3$

$\Rightarrow\ \frac{dv}{dt} = 4\pi r^2 \frac{dr}{dt}$

$\Rightarrow\ 30 = 4\pi(15)^2 \frac{dr}{dt}$

$\Rightarrow\ \frac{dr}{dt} = \frac{1}{30\pi}$ ft / min

**142.** *(d)* In $\Delta ABG$, we have

$$\cos\frac{\pi}{6} = \frac{AG}{AB} = \frac{\sqrt{3}}{2} = \frac{8}{3AB}$$

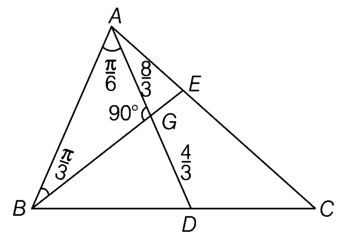
$\Rightarrow\ AB = \frac{16}{3\sqrt{3}}$

$\therefore$ Area of $\Delta ABD = \frac{1}{2} AB \cdot AD \sin\frac{\pi}{6}$

$= \frac{1}{2} \times \frac{16}{3\sqrt{3}} \times 4 \times \frac{1}{2} = \frac{16}{3\sqrt{3}}$ sq units

$\therefore$ Area of $\Delta ABC = 2$ Area of $\Delta ABD$

$= \frac{32}{3\sqrt{3}}$ sq units.




**143.** *(b)* Comparing the given series with

$1 + nx + \frac{n(n-1)}{2!}x^2 + \ldots$, we get

$$nx = \frac{1}{9} \text{ and } \frac{n(n-1)}{2!}x^2 = \frac{4}{162}$$

$\therefore\ \frac{n-1}{2n} = 2 \Rightarrow n-1 = 2n$

$\Rightarrow\ n = -\frac{1}{3}$

and $\frac{-1}{3}\cdot x = \frac{1}{9} \Rightarrow x = -\frac{1}{3}$

$\therefore$ Sum of series

$$= \left(\frac{1-1}{3}\right)^{-1/3} = \left(\frac{2}{3}\right)^{-1/3} = \left(\frac{3}{2}\right)^{1/3}.$$

**144.** *(d)* Let $g(x) = \{x^{11} + f(x)\}^{-2}$. Then,

$$g'(x) = -2\{x^{11} + f(x)\}^{-3}\{11x^{10} + f'(x)\}$$

$\Rightarrow\ g'(1) = -2\{1 + f(1)\}^{-3}\{11 + f'(1)\}$

$\Rightarrow\ g'(1) = -2\,(1+3)^{-3}\left(11 - \frac{1}{3}\right) = \frac{-1}{3} = f'(1)$

**145.** *(c)* Clearly, (1, 1), (2, 2), (3, 3) and (4, 4) are not in $R$.

So, it is not reflexive

We observe that $(2, 3) \in R$ but $(3, 2) \notin R$, it is not symmetric.

Clearly, $(1, 3) \in R$ and $(3, 1) \in R$ but $(1, 1) \notin R$.

So, it is not transitive.

Since, (2, 4) and (2, 3) are in $R$. So, it is not a function.

**146.** *(b)* We have,

$$f(x) = [x] + \left[x + \frac{1}{2}\right] = \begin{cases} 0, & 0 < x < \frac{1}{2} \\ 1, & x = \frac{1}{2} \\ 1, & \frac{1}{2} < x < 1 \end{cases}$$

Clearly, $f(x)$ is discontinuous at $x = \frac{1}{2}$

Also, $\lim_{x \to \frac{1}{2}^-} f(x) = 0$ and $\lim_{x \to \frac{1}{2}^+} f(x) = 1$

**147.** *(a)* $\lim_{x \to \infty} \dfrac{\cot^{-1}(\sqrt{x+1} - \sqrt{x})}{\sec^{-1}\left\{\left(\frac{2x+1}{x-1}\right)^x\right\}}$

$$= \lim_{x \to \infty} \frac{\cot^{-1}\left(\frac{1}{\sqrt{x+1} + \sqrt{x}}\right)}{\sec^{-1}\left\{\left(2 + \frac{3}{x-1}\right)^x\right\}}$$

$$= \frac{\cot^{-1}(0)}{\sec^{-1}(\infty)} = \frac{\frac{\pi}{2}}{\frac{\pi}{2}} = 1$$

**148.** *(b)* We have,

$$y = \cos^{-1}(\cos x) = \begin{cases} x, & \text{if } 0 \le x \le \pi \\ 2\pi - x, & \text{if } \pi \le x \le 2\pi \end{cases}$$

$$\therefore \left(\frac{dy}{dx}\right)_{x = \frac{5\pi}{4}} = \left(\frac{d}{dx}(2\pi - x)\right)_{x = \frac{5\pi}{4}} = -1$$

**149.** *(c)* We have,

$N = 100$, $F = 45$, $l = 20$, $h = 10$ and Median = 25.

Let $f$ be the frequency of the mediana class.

Then, $\text{Median} = l + \dfrac{\frac{N}{2} - F}{f} \times h$

$$\Rightarrow \quad 25 = 20 + \frac{50 - 45}{f} \times 10$$

$$\Rightarrow \quad 5 = \frac{50}{f} \Rightarrow f = 10$$

**150.** *(b)* Let $a$ be the first term and $r$ be the common ratio of the G.P. Then, $a > 0$ and $r > 0$.

Now,

$$a_n = a_{n-1} + a_{n-2}, n > 2$$

$$\Rightarrow \quad ar^{n-1} = ar^{n-2} + ar^{n-3}$$

$$\Rightarrow \quad r^2 = r + 1 \Rightarrow r^2 - r - 1 = 0$$

$$\Rightarrow \quad r = \frac{1 \pm \sqrt{5}}{2} \Rightarrow r = \frac{1 + \sqrt{5}}{2} \quad [\because r > 0]$$