# NEET-UG Physics Sample Paper-17

**Duration: 1 Hour** **Maximum Marks: 180**

## Instructions

- This paper contains a total of **45** Multiple Choice Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

**Q1.** The density of a material in CGS system of units is 4 $g/cm^3$. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, the value of density of material will be:

(A) 0.4

(B) 40

(C) 400

(D) 0.04

**Q2.** The position $x$ of a particle with respect to time $t$ along x-axis is given by $x = 9t^2 - t^3$ where $x$ is in metres and $t$ in seconds. What will be the position of this particle when it achieves maximum speed?

(A) 54 m

(B) 81 m

(C) 24 m

(D) 32 m

**Q3.** A bus is moving with a speed of 10 m/s on a straight road. A scooterist wishes to overtake the bus in 100 s. If the bus is at a distance of 1 km from the scooterist, with what speed should the scooterist chase the bus?

(A) 10 m/s

(B) 20 m/s

(C) 40 m/s

(D) 25 m/s

**Q4.** A system consists of three masses $m_1, m_2$ and $m_3$ connected by a string passing over a pulley $P$. The mass $m_1$ hangs freely and $m_2$ and $m_3$ are on a rough horizontal table (the coefficient of friction = $\mu$). The pulley is frictionless and of negligible mass. The downward acceleration of mass $m_1$ is: (Assume $m_1 = m_2 = m_3 = m$)

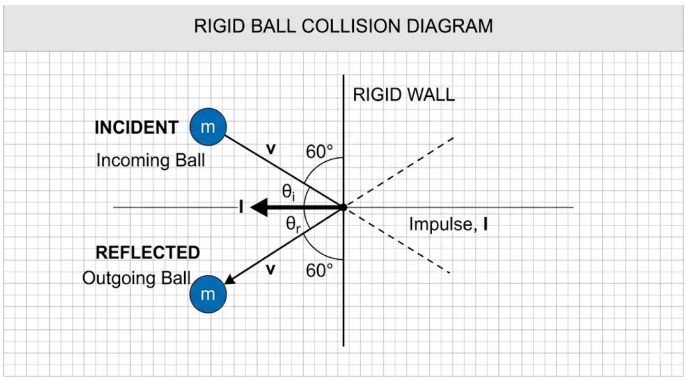
(A) $\frac{g(1-\mu)}{9}$

(B) $\frac{2g\mu}{3}$

(C) $\frac{g(1-2\mu)}{3}$

(D) $\frac{g(1-\mu)}{3}$

**Q5.** A rigid ball of mass $m$ strikes a rigid wall at 60° and gets reflected without loss of speed as shown in the figure. The value of impulse imparted by the wall on the ball is:




(A) $mv$

(B) $2mv$

(C) $mv/2$

(D) $mv/3$

**Q6.** A body of mass $m$ is accelerated uniformly from rest to a speed $v$ in a time $T$. The instantaneous power delivered to the body as a function of time $t$ is:

(A) $\frac{mv^2t}{T^2}$

(B) $\frac{mv^2t^2}{T}$

(C) $\frac{mv^2t}{T}$

(D) $\frac{1}{2}\frac{mv^2t^2}{T^2}$

**Q7.** A particle is projected with velocity $v$ making an angle $\theta$ with the horizontal. The surface is smooth. The magnitude of work done by gravity during its motion from point of projection to the maximum height is:

(A) $\frac{1}{2}mv^2\sin^2\theta$

(B) $mv^2\sin^2\theta$

(C) $\frac{1}{2}mv^2\cos^2\theta$

(D) Zero

**Q8.** A circular platform is mounted on a frictionless vertical axle. Its radius $R = 2$ m and its moment of inertia about the axle is 200 kg m$^2$. It is initially at rest. A 50 kg man stands on the edge of the platform and begins to walk along the edge at a speed of 1 m/s relative to the ground. Time taken by the man to complete one revolution is:

(A) $\pi$ s

(B) $3\pi/2$ s

(C) $2\pi$ s

(D) $4\pi$ s

**Q9.** A solid sphere is rotating freely about its symmetry axis in free space. The radius of the sphere is increased keeping its mass same. Which of the following physical quantities would remain constant for the sphere?

(A) Rotational kinetic energy

(B) Moment of inertia

(C) Angular velocity

(D) Angular momentum

**Q10.** A body weighs 200 N on the surface of the earth. How much will it weigh half way down to the centre of the earth?

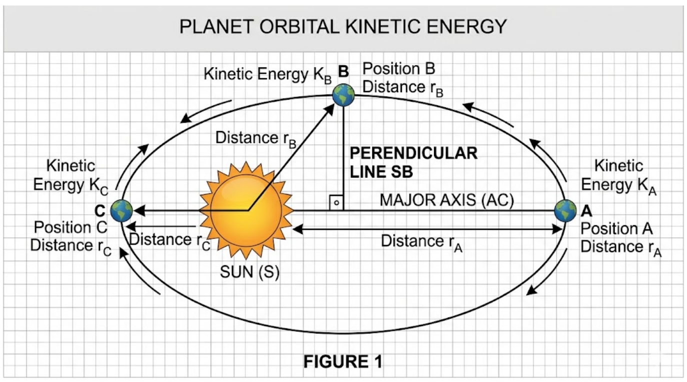
(A) 100 N

(B) 150 N

(C) 200 N

(D) 250 N

**Q11.** The kinetic energy of a planet in an elliptical orbit about the Sun, at positions $A, B$ and $C$ are $K_A, K_B$ and $K_C$, respectively. $AC$ is the major axis and $SB$ is perpendicular to $AC$ at the position of the Sun $S$ as shown in the figure. Then:




(A) $K_A < K_B < K_C$

(B) $K_A > K_B > K_C$

(C) $K_B < K_A < K_C$

(D) $K_B > K_A > K_C$

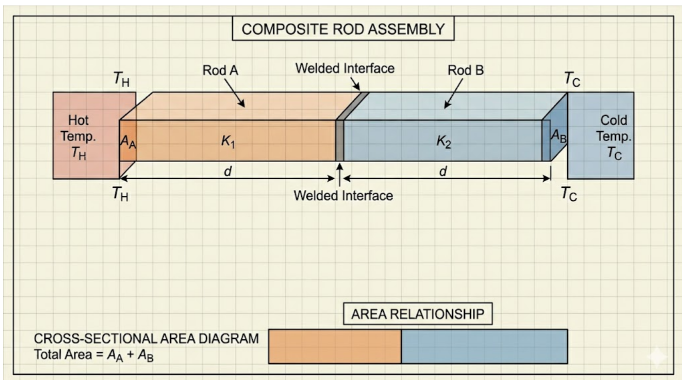
**Q12.** The cylindrical tube of a spray pump has radius $R$, one end of which has $n$ fine holes, each of radius $r$. If the speed of the liquid in the tube is $V$, the speed of the ejection of the liquid through the holes is:

(A) $\frac{VR^2}{nr^2}$
(B) $\frac{VR^2}{n^2r^2}$
(C) $\frac{VR^2}{r^2}$
(D) $\frac{V^2R}{nr}$

**Q13.** A small hole of area of cross-section 2 mm$^2$ is present near the bottom of a fully filled open tank of height 2 m. Taking $g = 10$ m/s$^2$, the rate of flow of water from the open hole would be nearly:

(A) $6.4 \times 10^{-6}$ m$^3$/s
(B) $12.6 \times 10^{-6}$ m$^3$/s
(C) $8.9 \times 10^{-6}$ m$^3$/s
(D) $1.26 \times 10^{-4}$ m$^3$/s

**Q14.** Two rods $A$ and $B$ of different materials are welded together as shown in figure. Their thermal conductivities are $K_1$ and $K_2$. The thermal conductivity of the composite rod will be:




(A) $\frac{3(K_1+K_2)}{2}$
(B) $K_1 + K_2$
(C) $2(K_1 + K_2)$
(D) $\frac{K_1+K_2}{2}$

**Q15.** A sample of 0.1 g of water at 100°C and normal pressure ($1.013 \times 10^5$ N/m$^2$) requires 54 cal of heat energy to convert to steam at 100°C. If the volume of the steam produced is 167.1 cc, the change in internal energy of the sample is:

(A) 104.3 J

(B) 208.7 J

(C) 42.2 J

(D) 84.5 J

**Q16.** One mole of an ideal gas goes from an initial state $A$ to final state $B$ via two processes: It first undergoes isothermal expansion from volume $V$ to $3V$ and then its volume is reduced from $3V$ to $V$ at constant pressure. The correct $P - V$ diagram representing the two processes is:

(A) A graph showing a curve for expansion and a horizontal line for compression.

(B) A graph showing two straight lines.

(C) A graph showing two curves.

(D) A graph showing a vertical line followed by a curve.

**Q17.** The volume of a gas is reduced adiabatically to $\frac{1}{4}$ of its initial volume at 27°C. If $\gamma = 1.5$, the final temperature of the gas is:

(A) 600 K

(B) 300 K

(C) 450 K

(D) 150 K

**Q18.** A particle is executing SHM with an amplitude $A$. At what distance from the mean position is its kinetic energy equal to its potential energy?

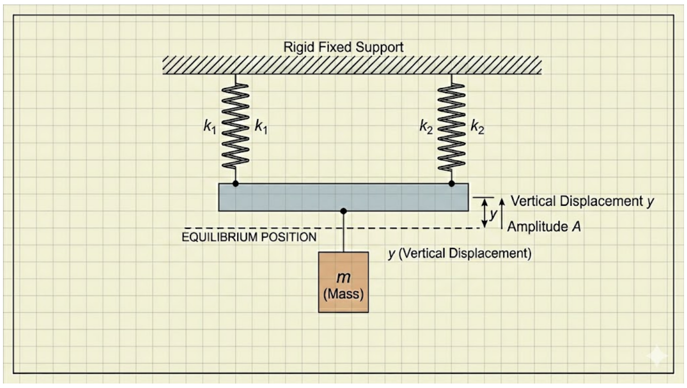
(A) $A/2$

(B) $A/\sqrt{2}$

(C) $A/\sqrt{3}$

(D) $A/4$

**Q19.** A mass $m$ is suspended from the two coupled identical springs of force constant $k$ as shown in the figure. The time period of vertical oscillations is:




(A) $2\pi\sqrt{\frac{m}{k}}$

(B) $2\pi\sqrt{\frac{m}{2k}}$

(C) $2\pi\sqrt{\frac{2m}{k}}$

(D) $2\pi\sqrt{\frac{m}{4k}}$

**Q20.** Two identical metal spheres $X$ and $Y$ carry charges $+Q$ and $-2Q$ respectively. They are brought into contact and then separated to their original distance. The ratio of the magnitude of the new force to the original force between them is:

(A) 1 : 8

(B) 1 : 4

(C) 1 : 2

(D) 1 : 1

**Q21.** Two identical capacitors $C_1$ and $C_2$ of equal capacitance are connected as shown in the circuit. Terminals $a$ and $b$ of the key $K$ are connected to charge capacitor $C_1$ using battery of emf $V$. Now disconnecting $a$ and $b$, terminals $b$ and $c$ are connected. The total electrostatic energy of the system:

(A) increases by a factor of 2

(B) increases by a factor of 4

(C) decreases by a factor of 2

(D) decreases by a factor of 4

**Q22.** A hollow metal sphere of radius $R$ is uniformly charged. The electric field due to the sphere at a distance $r$ from the centre:

(A) increases as $r$ increases for $r < R$ and for $r > R$

(B) zero as $r$ increases for $r < R$, decreases as $r$ increases for $r > R$

(C) zero as $r$ increases for $r < R$, increases as $r$ increases for $r > R$

(D) decreases as $r$ increases for $r < R$ and for $r > R$

**Q23.** The variation of drift velocity with electric field of a conductor is best represented by the graph:

(A) Linear passing through origin

(B) Horizontal straight line

(C) Parabolic curve

(D) Hyperbolic curve

**Q24.** The resistance in the two arms of the meter bridge are $5\Omega$ and $R\Omega$ respectively. When the resistance $R$ is shunted with an equal resistance, the new balance point is at $1.6l_1$. The resistance $R$ is:

(A) $10\Omega$

(B) $15\Omega$

(C) $20\Omega$

(D) $25\Omega$

**Q25.** A potential difference of $V$ is applied at the ends of a copper wire of length $l$ and diameter $d$. On doubling only $d$, drift velocity:

(A) becomes double

(B) becomes half

(C) remains unchanged

(D) becomes one-fourth

**Q26.** A wire in the shape of a square of side $a$ carries a current $I$. The magnetic field at the centre of the square is:

(A) $\frac{\mu_0 I}{\pi a}$

(B) $\frac{\sqrt{2}\mu_0 I}{\pi a}$

(C) $\frac{2\sqrt{2}\mu_0 I}{\pi a}$

(D) $\frac{\mu_0 I}{2\pi a}$

**Q27.** A galvanometer of resistance $G$ is shunted by a resistance $S$. To keep the main current in the circuit unchanged, the resistance to be put in series with the galvanometer is:

(A) $\frac{G^2}{(S+G)}$

(B) $\frac{S^2}{(S+G)}$

(C) $\frac{SG}{(S+G)}$

(D) $\frac{G}{(S+G)}$

**Q28.** A conducting square loop of side $L$ and resistance $R$ moves in its plane with a uniform velocity $v$ perpendicular to one of its sides. A magnetic field $B$, constant in time and space, pointing perpendicular and into the plane at the loop exists everywhere with half the loop outside the field. The induced EMF is:

(A) $BLv$

(B) $BLv/R$

(C) $2BLv$

(D) Zero

**Q29.** The magnetic susceptibility of a paramagnetic material is 0.003 at 27°C. At what temperature will its susceptibility be 0.002?

(A) 18°C

(B) 177°C

(C) 450°C

(D) 227°C

**Q30.** A bar magnet of magnetic moment $M$ is placed at right angles to a magnetic induction $B$. If a force $F$ is experienced by each pole of the magnet, the length of the magnet is:

(A) $MB/F$

(B) $F/MB$

(C) $MF/B$

(D) $BF/M$

**Q31.** 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) 450 V, 15 A

(B) 450 V, 13.5 A

(C) 600 V, 15 A

(D) 300 V, 15 A

**Q32.** The ratio of the magnitude of average energy density assciated with the magnetic field to that associated with the electric field in an electromagnetic wave is:

(A) $c$

(B) $c^2$

(C) 1

(D) $1/c$

**Q33.** A thin convergent lens is placed in contact with a thin divergent lens of the same focal length. The focal length of the combination is:

(A) $f$

(B) $2f$

(C) Zero

(D) Infinite

**Q34.** A astronomical telescope has an objective and eyepiece of focal lengths 40 cm and 4 cm respectively. To view an object 200 cm away from the objective, the lenses must be separated by a distance of:

(A) 46 cm

(B) 50 cm

(C) 54 cm

(D) 37.3 cm

**Q35.** A ray of light is incident at an angle of 45° on one face of a glass cube of refractive index $\mu = \sqrt{2}$. The light emerges from the opposite face. The angle of emergence is:

(A) 0°

(B) 30°

(C) 45°

(D) 60°

**Q36.** Two coherent sources of intensity ratio $\beta$ interfere. The ratio of $\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$ in the interference pattern is:

(A) $\frac{2\sqrt{\beta}}{1+\beta}$

(B) $\frac{\sqrt{\beta}}{1+\beta}$

(C) $\frac{2\beta}{1+\beta}$

(D) $\frac{\beta}{1+\beta}$

**Q37.** When the energy of the incident radiation is increased by 20%, the maximum kinetic energy of the photoelectrons emitted from a metal surface increases from 0.5 eV to 0.8 eV. The work function of the metal is:

(A) 0.65 eV

(B) 1.0 eV

(C) 1.3 eV

(D) 1.5 eV

**Q38.** The de Broglie wavelength of a neutron in thermal equilibrium with heavy water at a temperature $T$ (Kelvin) and mass $m$ is:

(A) $\frac{h}{\sqrt{3mkT}}$

(B) $\frac{h}{\sqrt{2mkT}}$

(C) $\frac{2h}{\sqrt{3mkT}}$

(D) $\frac{h}{\sqrt{mkT}}$

**Q39.** The ratio of the speed of the electron in the ground state of a hydrogen atom to the speed of light in vacuum is nearly:

(A) $1/137$

(B) $1/237$

(C) $1/100$

(D) $1/10$

**Q40.** The total energy of an electron in an atom in an orbit is $-3.4$ eV. Its kinetic and potential energies are, respectively:

(A) 3.4 eV, $-$ 6.8 eV

(B) 3.4 eV, 3.4 eV

(C) −3.4 eV, − 3.4 eV

(D) 3.4 eV, − 3.4 eV

**Q41.** The mass number of three nuclei $A, B$ and $C$ are $10, 20$ and $30$ respectively. Their binding energy per nucleon are 7 MeV, 8 MeV and 7 MeV respectively. In which of the following reactions is energy being released?

(A) $C \longrightarrow A + B$

(B) $A + B \longrightarrow C$

(C) $C \longrightarrow 3A$

(D) Energy is not released in any of these

**Q42.** For a transistor action, which of the following statements is correct?

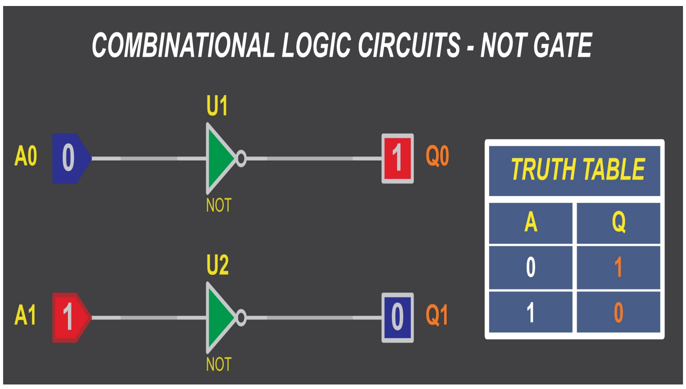
(A) Base, emitter and collector regions should have same size.

(B) Both emitter junction as well as the collector junction are forward biased.

(C) The base region must be very thin and lightly doped.

(D) Base, emitter and collector regions should have same doping concentrations.

**Q43.** In the following circuit, the output $Y$ for all possible inputs $A$ and $B$ is expressed by the truth table: A logic circuit where A and B are inputs to an OR gate, and the output of the OR gate along with a third input are connected to an AND gate.



(A) $Y = A \cdot B$

(B) $Y = A + B$

(C) $Y = \overline{A + B}$

(D) $Y = \overline{A \cdot B}$

**Q44.** Which of the following gates is called a universal gate?

(A) OR gate

(B) AND gate

(C) NAND gate

(D) NOT gate

**Q45.** In a common emitter transistor amplifier, the audio signal voltage across the collector is 3 V. The resistance of collector is 3 kΩ. If current gain is 100 and the base resistance is 2 kΩ, the voltage gain and the power gain of the amplifier is:

(A) 150, 15000

(B) 20, 2000

(C) 200, 1000

(D) 15, 1500

# Detailed Solutions

## Q1.

### Solution

**Concept:**
The numerical value of a physical quantity is inversely proportional to the unit size.

$$n_1 u_1 = n_2 u_2$$

For density, the dimensions are $[ML^{-3}]$. Thus, the conversion formula is:

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]^1 \left[\frac{L_1}{L_2}\right]^{-3}$$

**Solution:**
1. Given $n_1 = 4$ g/cm$^3$ in CGS system. 2. In CGS (system 1): $M_1 = 1$ g, $L_1 = 1$ cm. 3. In new system (system 2): $M_2 = 100$ g, $L_2 = 10$ cm. 4. Apply the conversion formula:

$$n_2 = 4\left[\frac{1}{100}\right]^1 \left[\frac{1}{10}\right]^{-3}$$

5. Simplify the terms:

$$n_2 = 4 \times \frac{1}{100} \times (10)^3$$

$$n_2 = 4 \times \frac{1}{100} \times 1000 = 40$$

**Final Answer:** The value in the new system is 40.

**Answer: (B)**

# Q2.

## Solution

**Concept:**

Speed $v$ is the first derivative of position $x$. To find the maximum speed, we must find the time $t$ where the acceleration $a$ (the derivative of speed) is zero.

$$v = \frac{dx}{dt}, \quad a = \frac{dv}{dt} = 0 \text{ (for max speed)}$$

**Solution:**

1. Given $x = 9t^2 - t^3$. 2. Find the velocity $v$:

$$v = \frac{dx}{dt} = 18t - 3t^2$$

3. Find the acceleration $a$ and set it to zero for maximum speed:

$$a = \frac{dv}{dt} = 18 - 6t = 0$$

$$6t = 18 \implies t = 3 \text{ s}$$

4. Substitute $t = 3$ back into the position equation to find the position at that moment:

$$x = 9(3)^2 - (3)^3$$

$$x = 9(9) - 27 = 81 - 27 = 54 \text{ m}$$

**Final Answer:** The position of the particle is 54 m.

**Answer: (A)**

## Q3.

### Solution

**Concept:**
This is a problem of relative motion. To overtake, the relative velocity of the scooterist with respect to the bus must cover the initial separation distance in the given time.

$$v_{rel} = \frac{\text{Separation}}{\text{Time}}$$

**Solution:**
1. Given: $v_{bus} = 10$ m/s, Distance $s = 1$ km $= 1000$ m, Time $t = 100$ s. 2. Let $v_s$ be the speed of the scooterist. The relative speed in the same direction is:

$$v_{rel} = v_s - v_{bus} = v_s - 10$$

3. Using the relation $s = v_{rel} \times t$:

$$1000 = (v_s - 10) \times 100$$

4. Simplify the equation:

$$10 = v_s - 10$$

$$v_s = 20 \text{ m/s}$$

**Final Answer:** The scooterist should chase at 20 m/s.

**Answer: (B)**

## Q4.

### Solution

**Concept:**
Using Newton's Second Law for the whole system. The driving force is the weight of the hanging mass, while the resisting force is the friction acting on the masses on the table.

$$a = \frac{\text{Net Driving Force}}{\text{Total Mass}}$$

**Solution:**
1. Total Mass $M = m_1+m_2+m_3 = 3m$. 2. Driving force (weight of $m_1$): $F_{drive} = mg$. 3. Frictional force on $m_2$ and $m_3$: $f = \mu m_2 g + \mu m_3 g = 2\mu mg$. 4. Net force $F_{net} = mg - 2\mu mg = mg(1 - 2\mu)$. 5. Acceleration $a$:

$$a = \frac{mg(1 - 2\mu)}{3m} = \frac{g(1 - 2\mu)}{3}$$

**Final Answer:** The acceleration is $\frac{g(1-2\mu)}{3}$.

**Answer: (C)**

# Q5.

## Solution

**Concept:**
Impulse is the change in momentum ($\vec{J} = \Delta\vec{p}$). For reflection from a wall at an angle $\theta$ with the normal, the component of velocity parallel to the wall remains unchanged, while the component perpendicular to the wall reverses.

**Solution:**
1. Velocity component perpendicular to the wall (along the normal): $v_n = v\cos\theta$. 2. Initial momentum perpendicular: $p_i = mv\cos\theta$. 3. Final momentum perpendicular: $p_f = -mv\cos\theta$ (opposite direction). 4. Magnitude of change in momentum (Impulse):

$$J = |p_f - p_i| = |-mv\cos\theta - mv\cos\theta| = 2mv\cos\theta$$

5. Given $\theta = 60°$ (with the normal):

$$J = 2mv\cos 60° = 2mv\left(\frac{1}{2}\right) = mv$$

**Final Answer:** The impulse is $mv$.

**Answer: (A)**

## Q6.

### Solution

**Concept:**

Power is defined as the rate at which work is done. Instantaneous power $P$ can be calculated as the product of force $F$ and instantaneous velocity $v$:

$$P = F \cdot v$$

Since the body starts from rest and accelerates uniformly, we use the equations of motion: $v = at$.

**Solution:**

1. Acceleration $a$ is constant. Since the body reaches speed $v$ in time $T$:

$$a = \frac{v}{T}$$

2. The instantaneous velocity $v(t)$ at any time $t$ is:

$$v(t) = at = \frac{v}{T}t$$

3. The constant force $F$ required for this acceleration is:

$$F = ma = m\left(\frac{v}{T}\right)$$

4. Instantaneous power $P(t)$ is:

$$P(t) = F \cdot v(t) = \left(\frac{mv}{T}\right)\left(\frac{vt}{T}\right)$$

5. Simplify the expression:

$$P(t) = \frac{mv^2t}{T^2}$$

**Final Answer:** The instantaneous power is $\frac{mv^2t}{T^2}$.

**Answer: (A)**

## Q7.

### Solution

**Concept:**

Work done by a constant force is $W = \vec{F} \cdot \vec{d}$. For gravity, the force is $mg$ acting vertically downwards. Therefore, only the vertical displacement (height $H$) matters.

$$W_g = -mgH$$

The negative sign indicates gravity acts downwards while the displacement is upwards.

**Solution:**

1. The maximum height $H$ reached by a projectile is:

$$H = \frac{v^2 \sin^2 \theta}{2g}$$

2. The magnitude of work done by gravity as the particle moves from the ground to $H$:

$$|W_g| = |mg \times H|$$

3. Substitute the expression for $H$:

$$|W_g| = m \cdot g \cdot \frac{v^2 \sin^2 \theta}{2g}$$

4. Simplify:

$$|W_g| = \frac{1}{2}mv^2 \sin^2 \theta$$

**Final Answer:** The magnitude of work done is $\frac{1}{2}mv^2 \sin^2 \theta$.

**Answer: (A)**

# Q8.

## Solution

**Concept:**
In the absence of external torque, the total angular momentum of the system (man + platform) is conserved. Since the system starts from rest, the final total angular momentum must be zero.

$$L_{man} + L_{platform} = 0$$

**Solution:**
1. Let $\omega$ be the angular velocity of the platform. 2. Angular momentum of the man (moving at speed $v$ relative to ground):

$$L_m = mvr = 50 \times 1 \times 2 = 100 \text{ kg m}^2\text{/s}$$

3. Angular momentum of the platform:

$$L_p = I\omega = 200\omega$$

4. Since $L_m + L_p = 0$ (taking directions into account):

$$100 + 200\omega = 0 \implies \omega = -0.5 \text{ rad/s}$$

5. The speed of the man relative to the platform is:

$$v_{rel} = v_{man} - v_{platform} = 1 - (\omega R) = 1 - (-0.5 \times 2) = 2 \text{ m/s}$$

6. Time to complete one revolution relative to the platform:

$$t = \frac{\text{Distance}}{\text{Relative Speed}} = \frac{2\pi R}{v_{rel}} = \frac{2\pi(2)}{2} = 2\pi \text{ s}$$

**Final Answer:** Time taken is $2\pi$ s.

**Answer: (C)**

## Q9.

### Solution

**Concept:**
In free space, there are no external torques acting on the sphere. According to the Law of Conservation of Angular Momentum:

$$\vec{\tau}_{ext} = 0 \implies \vec{L} = \text{constant}$$

**Solution:**
1. Angular momentum is $L = I\omega$. 2. As the radius $R$ of the sphere increases, the moment of inertia $I$ ($= \frac{2}{5}MR^2$ for a solid sphere) also increases. 3. To keep $L$ constant, the angular velocity $\omega$ must decrease proportionally ($I_1\omega_1 = I_2\omega_2$). 4. Rotational Kinetic Energy $K = \frac{L^2}{2I}$. Since $L$ is constant and $I$ increases, $K$ must decrease. 5. Therefore, only the angular momentum remains unchanged.
**Final Answer:** Angular momentum remains constant.

**Answer: (D)**

## Q10.

### Solution

**Concept:**
The acceleration due to gravity $g'$ at a depth $d$ below the surface of the earth is:

$$g' = g\left(1 - \frac{d}{R}\right)$$

The weight of the body is $W = mg$.
**Solution:**
1. Given weight on the surface $W = mg = 200$ N. 2. The body is "half way down," so the depth $d = R/2$. 3. Calculate the new acceleration due to gravity $g'$:

$$g' = g\left(1 - \frac{R/2}{R}\right) = g\left(1 - \frac{1}{2}\right) = \frac{g}{2}$$

4. The new weight $W'$ at this depth is:

$$W' = mg' = m\left(\frac{g}{2}\right) = \frac{W}{2}$$

5. Substitute the surface weight:

$$W' = \frac{200}{2} = 100 \text{ N}$$

**Final Answer:** The body will weigh 100 N.

**Answer: (A)**

## Q11.

### Solution

**Concept:**
According to Kepler's Second Law (Law of Areas), a planet moves faster when it is closer to the Sun (Perihelion) and slower when it is farther away (Aphelion). The kinetic energy $K = \frac{1}{2}mv^2$ is maximum at the nearest point.

**Solution:**
1. In the elliptical orbit, $A$ is the Perihelion (closest point to the Sun) and $C$ is the Aphelion (farthest point). 2. Point $B$ is at an intermediate distance. 3. Therefore, the velocities satisfy: $v_A > v_B > v_C$. 4. Consequently, the kinetic energies satisfy: $K_A > v_B > K_C$.

**Final Answer:** $K_A > K_B > K_C$.

**Answer: (B)**

## Q12.

### Solution

**Concept:**
According to the Equation of Continuity for an incompressible fluid, the volume flow rate must remain constant throughout the system:

$$A_1 v_1 = A_2 v_2$$

**Solution:**
1. Area of the main tube: $A_1 = \pi R^2$. Speed in tube: $v_1 = V$. 2. There are $n$ holes, each with radius $r$. Total area of holes: $A_2 = n(\pi r^2)$. 3. Let the ejection speed be $v_2$. Applying the continuity equation:

$$(\pi R^2)V = (n\pi r^2)v_2$$

4. Solve for $v_2$:

$$v_2 = \frac{\pi R^2 V}{n\pi r^2} = \frac{VR^2}{nr^2}$$

**Final Answer:** The ejection speed is $\frac{VR^2}{nr^2}$.

**Answer: (A)**

## Q13.

### Solution

**Concept:**
The speed of efflux $v$ from a hole at depth $h$ is given by Torricelli's Law: $v = \sqrt{2gh}$. The volume flow rate ($Q$) is the product of the area of the hole ($A$) and the speed of efflux.

**Solution:**
1. Given: $h = 2$ m, $A = 2\text{ mm}^2 = 2 \times 10^{-6}\text{ m}^2$, $g = 10\text{ m/s}^2$. 2. Calculate speed of efflux $v$:

$$v = \sqrt{2 \times 10 \times 2} = \sqrt{40} \approx 6.32\text{ m/s}$$

3. Calculate volume flow rate $Q$:

$$Q = A \times v = (2 \times 10^{-6}) \times 6.32$$

$$Q = 12.64 \times 10^{-6}\text{ m}^3/\text{s}$$

**Final Answer:** The rate of flow is nearly $12.6 \times 10^{-6}\text{ m}^3/\text{s}$.

**Answer: (B)**

## Q14.

### Solution

**Concept:**
When rods are connected side-by-side (parallel), the equivalent thermal conductivity $K_{eq}$ is calculated based on the total heat flow being the sum of individual heat flows.

$$K_{eq} = \frac{K_1 A_1 + K_2 A_2}{A_1 + A_2}$$

**Solution:**
1. In the parallel configuration shown, both rods have the same length $L$ and (assuming they are identical in size) the same cross-sectional area $A$. 2. Total Area $A_{total} = A + A = 2A$. 3. Applying the formula:

$$K_{eq} = \frac{K_1 A + K_2 A}{2A} = \frac{A(K_1 + K_2)}{2A}$$

$$K_{eq} = \frac{K_1 + K_2}{2}$$

**Final Answer:** The thermal conductivity is $\frac{K_1 + K_2}{2}$.

**Answer: (D)**

## Q15.

### Solution

**Concept:**
From the First Law of Thermodynamics: $\Delta Q = \Delta U + \Delta W$. Work done by the system during expansion is $\Delta W = P\Delta V$.

**Solution:**
1. Total heat supplied $\Delta Q = 54$ cal. Convert to Joules (1 cal = 4.184 J):

$$\Delta Q = 54 \times 4.184 \approx 225.9 \text{ J}$$

2. Work done $W = P(V_{steam} - V_{water})$. Since $V_{water}$ is very small (0.1 cc), we use $V_{steam} = 167.1 \text{ cc} = 167.1 \times 10^{-6} \text{ m}^3$:

$$W = (1.013 \times 10^5) \times (167.1 \times 10^{-6}) \approx 16.9 \text{ J}$$

3. Change in internal energy $\Delta U = \Delta Q - W$:

$$\Delta U = 225.9 - 16.9 = 209 \text{ J}$$

4. Looking at the closest option (accounting for exact 4.18 vs 4.2 rounding): 208.7 J.
**Final Answer:** The change in internal energy is 208.7 J.

**Answer: (B)**

## Q16.

### Solution

**Concept:** An isothermal process follows the equation $PV$ = constant (represented by a hyperbola/curve on a $P - V$ graph). An isobaric process occurs at constant pressure ($P$ = constant), which is a horizontal line.
**Solution:** 1. **Process 1:** Isothermal expansion from $V$ to $3V$. Since $T$ is constant, $P \propto 1/V$. This is represented by a downward curve (hyperbolic). 2. **Process 2:** Volume reduction from $3V$ to $V$ at constant pressure (isobaric compression). This is represented by a horizontal line moving to the left. 3. Combining these, the graph starts with a curve and ends with a horizontal segment.
**Final Answer:** A graph showing a curve for expansion and a horizontal line for compression.

**Answer: (A)**

## Q17.

### Solution

**Concept:** For an adiabatic process, the relationship between temperature and volume is given by:

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

**Solution:** 1. Given $T_1 = 27°C = 300$ K, $V_2 = V_1/4$, and $\gamma = 1.5$. 2. Note that $\gamma - 1 = 1.5 - 1 = 0.5$.
3. Substitute into the formula:

$$300 \cdot V_1^{0.5} = T_2 \cdot (V_1/4)^{0.5}$$

4. Simplify the volume terms:

$$300 = T_2 \cdot (1/4)^{0.5}$$

$$300 = T_2 \cdot (1/2)$$

5. Solve for $T_2$:

$$T_2 = 300 \times 2 = 600 \text{ K}$$

**Final Answer:** The final temperature is 600 K.

**Answer: (A)**

## Q18.

### Solution

**Concept:** In SHM, Potential Energy $U = \frac{1}{2}kx^2$ and Kinetic Energy $K = \frac{1}{2}k(A^2 - x^2)$.
**Solution:** 1. Set the energies equal:

$$\frac{1}{2}kx^2 = \frac{1}{2}k(A^2 - x^2)$$

2. Cancel the common terms:

$$x^2 = A^2 - x^2$$

3. Solve for $x$:

$$2x^2 = A^2 \implies x^2 = \frac{A^2}{2}$$

$$x = \frac{A}{\sqrt{2}}$$

**Final Answer:** The distance is $A/\sqrt{2}$.

**Answer: (B)**

## Q19.

### Solution

**Concept:** When two springs are connected side-by-side (supporting the same mass and experiencing the same displacement), they are in **parallel**. The equivalent spring constant is:

$$k_{eq} = k_1 + k_2$$

**Solution:** 1. Since the springs are identical, $k_1 = k_2 = k$. 2. The equivalent force constant is $k_{eq} = k + k = 2k$. 3. The time period of a mass-spring system is:

$$T = 2\pi\sqrt{\frac{m}{k_{eq}}}$$

4. Substitute $k_{eq} = 2k$:

$$T = 2\pi\sqrt{\frac{m}{2k}}$$

**Final Answer:** The time period is $2\pi\sqrt{\frac{m}{2k}}$.

**Answer: (B)**

## Q20.

### Solution

**Concept:** 1. Initial Force: $F = k\frac{|q_1 q_2|}{r^2}$. 2. When identical spheres touch, the total charge is redistributed equally: $q' = \frac{q_1+q_2}{2}$.

**Solution:** 1. Initial charges: $q_1 = +Q, q_2 = -2Q$. 2. Initial Force magnitude:

$$F_1 = k\frac{Q \cdot 2Q}{r^2} = \frac{2kQ^2}{r^2}$$

3. New charge after contact:

$$q' = \frac{Q + (-2Q)}{2} = \frac{-Q}{2}$$

4. New Force magnitude:

$$F_2 = k\frac{(Q/2) \cdot (Q/2)}{r^2} = \frac{kQ^2}{4r^2}$$

5. Find the ratio $F_2/F_1$:

$$\frac{F_2}{F_1} = \frac{kQ^2/4r^2}{2kQ^2/r^2} = \frac{1/4}{2} = \frac{1}{8}$$

**Final Answer:** The ratio is 1 : 8.

**Answer: (A)**

## Q21.

### Solution

**Concept:**
This problem involves two main principles:

(a) **Energy Stored in a Capacitor:** The electrostatic energy ($U$) stored in a capacitor of capacitance $C$ charged to a potential difference $V$ is given by $U = \frac{1}{2}CV^2$.

(b) **Conservation of Charge:** In an isolated system, the total electric charge is conserved. When charge is redistributed between capacitors, total initial charge equals total final charge.

**Solution:**

(a) **Initial State (Terminals 'a' and 'b' connected):** Capacitor $C_1$ is charged by the battery of emf $V$. The energy stored in $C_1$ is the initial energy of the system.

- Let the capacitance of both identical capacitors be $C$ (so $C_1 = C_2 = C$).
- Initial energy, $U_{initial} = \frac{1}{2}C_1V^2 = \frac{1}{2}CV^2$.
- The initial charge on $C_1$ is $Q_{initial} = C_1V = CV$.

(b) **Final State (Terminals 'b' and 'c' connected):** $C_1$ and $C_2$ are connected in parallel, creating an isolated system. The total charge $Q_{initial}$ redistributes until both reach a common potential, $V_{common}$.

- The equivalent capacitance for a parallel combination is $C_{eq} = C_1 + C_2 = C + C = 2C$.
- By conservation of charge, the total charge in this combination is $Q_{total} = Q_{initial} = CV$.
- The common potential is $V_{common} = \frac{Q_{total}}{C_{eq}} = \frac{CV}{2C} = \frac{V}{2}$.
- The total final energy of the system is $U_{final} = \frac{1}{2}C_{eq}(V_{common})^2 = \frac{1}{2}(2C)\left(\frac{V}{2}\right)^2$.
- Simplify to find $U_{final} = C \times \frac{V^2}{4} = \frac{1}{4}CV^2$.

(c) **Comparison:** Compare the final and initial energies.

$$U_{final} = \frac{1}{4}CV^2 = \frac{1}{2}\left(\frac{1}{2}CV^2\right) = \frac{1}{2}U_{initial}$$

The total electrostatic energy decreases by a factor of 2.
**Final Answer:** The total electrostatic energy decreases by a factor of 2.

**Answer: (C)**

# Q22.

## Solution

**Concept:**

According to Gauss's Law, the electric flux through a closed surface is proportional to the enclosed charge:

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enclosed}}{\epsilon_0}$$

For a hollow metal sphere (spherical shell) of radius $R$:

(a) Inside ($r < R$), the enclosed charge $q = 0$.

(b) Outside ($r \geq R$), the entire charge $Q$ is enclosed.

**Solution:**

1. **Case 1: Inside the sphere ($r < R$)** Construct a Gaussian surface of radius $r < R$. Since it is a hollow metal sphere, all charges reside on the outer surface. Thus, $q_{enclosed} = 0$.

$$E \times 4\pi r^2 = \frac{0}{\epsilon_0} \implies E = 0$$

The field is zero for all points inside.

2. **Case 2: Outside the sphere ($r > R$)** Construct a Gaussian surface of radius $r > R$. This surface encloses the total charge $Q$.

$$E \times 4\pi r^2 = \frac{Q}{\epsilon_0} \implies E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$$

As $r$ increases, $E$ decreases ($E \propto 1/r^2$).

3. **Conclusion:** The electric field is zero for $r < R$ and decreases as $1/r^2$ for $r > R$.

**Final Answer:** Option (B) is correct.

**Answer: (B)**

## Q23.

### Solution

**Concept:**

The drift velocity ($v_d$) of free electrons in a conductor is directly proportional to the applied electric field ($E$). The relationship is given by:

$$v_d = \left(\frac{e\tau}{m}\right) E = \mu E$$

where $\mu$ is the mobility of the charge carrier.

**Solution:**

1. From the relation $v_d = \mu E$, it is clear that $v_d \propto E$. 2. Comparing this with the equation of a straight line $y = mx + c$:

- $y = v_d$
- $x = E$
- $m = \mu$ (Slope)
- $c = 0$ (Intercept)

3. Since the intercept $c$ is zero, the graph is a straight line passing through the origin.

**Final Answer:** The variation is represented by a linear graph passing through the origin. Option (A) is correct.

**Answer: (A)**

## Q24.

### Solution

**Concept:** The balancing condition for a meter bridge is given by:

$$\frac{R_{left}}{R_{right}} = \frac{l}{100 - l}$$

When a resistance $R$ is shunted with another resistance $S$, the effective resistance becomes $R' = \frac{RS}{R+S}$.

**Solution:** 1. **Initial Condition:** With $5\,\Omega$ and $R\,\Omega$:

$$\frac{5}{R} = \frac{l_1}{100 - l_1} \implies \frac{1}{R} = \frac{l_1}{5(100 - l_1)} \quad ...(i)$$

2. **Shunted Condition:** $R$ is shunted with $R$, so $R_{new} = R/2$. The new length is $1.6l_1$:

$$\frac{5}{R/2} = \frac{1.6l_1}{100 - 1.6l_1} \implies \frac{10}{R} = \frac{1.6l_1}{100 - 1.6l_1} \quad ...(ii)$$

3. **Substitution:** Put (i) into (ii):

$$10\left[\frac{l_1}{5(100 - l_1)}\right] = \frac{1.6l_1}{100 - 1.6l_1}$$

$$\frac{2}{100 - l_1} = \frac{1.6}{100 - 1.6l_1} \implies 200 - 3.2l_1 = 160 - 1.6l_1$$

$$40 = 1.6l_1 \implies l_1 = 25 \text{ cm}$$

4. **Calculation of R:**

$$\frac{5}{R} = \frac{25}{100 - 25} = \frac{25}{75} = \frac{1}{3} \implies R = 15\,\Omega$$

**Final Answer:** The resistance $R$ is $15\,\Omega$.

**Answer: (B)**

## Q25.

### Solution

**Concept:** The drift velocity ($v_d$) of electrons in a conductor is related to the applied potential difference ($V$) and length ($l$) by the formula:

$$v_d = \frac{e\tau E}{m} = \frac{e\tau V}{ml}$$

where $e$ is electron charge, $\tau$ is relaxation time, and $m$ is electron mass.
**Solution:** 1. From the formula $v_d = \frac{e\tau V}{ml}$, we observe the parameters that affect drift velocity. 2. The drift velocity depends on the potential difference ($V$), the length ($l$), and the nature of the material ($\tau$). 3. The diameter ($d$) or cross-sectional area ($A$) of the wire does not appear in this expression for a fixed potential $V$. 4. Therefore, if only the diameter $d$ is doubled while $V$ and $l$ remain constant, the drift velocity $v_d$ remains unchanged.
**Final Answer:** The drift velocity remains unchanged. Option (C) is correct.

**Answer: (C)**

## Q26.

### Solution

**Concept:** The magnetic field at a distance $r$ from a finite straight wire carrying current $I$ is:

$$B = \frac{\mu_0 I}{4\pi r}(\sin\theta_1 + \sin\theta_2)$$

For a square, the field at the center is the sum of the fields produced by its four sides.
**Solution:** 1. Distance from a side to the center $r = a/2$. 2. For each side, $\theta_1 = \theta_2 = 45°$. 3. Field due to one side $B_{side} = \frac{\mu_0 I}{4\pi(a/2)}(\sin 45° + \sin 45°)$:

$$B_{side} = \frac{\mu_0 I}{2\pi a}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) = \frac{\mu_0 I}{2\pi a}(\sqrt{2})$$

4. Total field $B_{total} = 4 \times B_{side} = 4 \times \frac{\sqrt{2}\mu_0 I}{2\pi a} = \frac{2\sqrt{2}\mu_0 I}{\pi a}$.
**Final Answer:** $\frac{2\sqrt{2}\mu_0 I}{\pi a}$.

**Answer: (C)**

## Q27.

### Solution

**Concept:** To keep the main current unchanged, the equivalent resistance of the modified circuit must equal the original resistance of the galvanometer ($G$).

**Solution:** 1. The resistance of the galvanometer shunted with $S$ is $R_p = \frac{GS}{G+S}$. 2. Let $R_x$ be the resistance added in series. The total resistance is $R_{eq} = R_x + \frac{GS}{G+S}$. 3. Setting $R_{eq} = G$:

$$R_x = G - \frac{GS}{G+S}$$

$$R_x = \frac{G^2 + GS - GS}{G+S} = \frac{G^2}{G+S}$$

**Final Answer:** The required series resistance is $\frac{G^2}{G+S}$. Option (A) is correct.

**Answer: (A)**

## Q28.

### Solution

**Concept:** Motional EMF is induced in a conductor moving through a magnetic field, given by $\epsilon = Blv$.

**Solution:** 1. The loop moves perpendicular to one of its sides. Only the side(s) perpendicular to the velocity and inside the magnetic field contribute to the EMF. 2. The problem states half the loop is outside the field. This means one vertical side is inside the field $B$ while the opposite side is outside. 3. The EMF induced in the side within the field is $\epsilon = BLv$. 4. The horizontal sides move parallel to their lengths (or the velocity is parallel), so they contribute zero EMF. 5. Net induced EMF = $BLv + 0 = BLv$.

**Final Answer:** The induced EMF is $BLv$. Option (A) is correct.

**Answer: (A)**

## Q29.

### Solution

**Concept:** Curie's Law for paramagnetic materials states that susceptibility $\chi$ is inversely proportional to the absolute temperature $T$ (in Kelvin):

$$\chi \propto \frac{1}{T} \implies \chi_1 T_1 = \chi_2 T_2$$

**Solution:** 1. Given $\chi_1 = 0.003, T_1 = 27°C = 300$ K. 2. Given $\chi_2 = 0.002, T_2 =?$. 3. Apply the ratio:

$$0.003 \times 300 = 0.002 \times T_2$$

$$0.9 = 0.002 T_2 \implies T_2 = \frac{0.9}{0.002} = 450 \text{ K}$$

4. Convert back to Celsius: $450 - 273 = 177°C$.

**Final Answer:** 177°C.

**Answer: (B)**

## Q30.

### Solution

**Concept:** 1. The magnetic moment ($M$) of a bar magnet is given by $M = m \cdot L$, where $m$ is the pole strength and $L$ is the magnetic length. 2. The force ($F$) experienced by a magnetic pole of strength $m$ in a magnetic field $B$ is given by $F = mB$.

**Solution:** 1. From the force equation, we can express the pole strength as:

$$m = \frac{F}{B}$$

2. Substitute this expression for $m$ into the magnetic moment formula:

$$M = \left(\frac{F}{B}\right) \cdot L$$

3. Rearranging the equation to solve for the length $L$:

$$L = \frac{M \cdot B}{F}$$

**Final Answer:** The length of the magnet is $MB/F$. Option (A) is correct.

**Answer: (A)**

## Q31.

### Solution

**Concept:** Efficiency $\eta = \frac{P_{out}}{P_{in}}$. Input power $P_{in} = V_p I_p$ and output power $P_{out} = V_s I_s$.
**Solution:** 1. Given $P_{in} = 3000$ W and $V_p = 200$ V. 2. Calculate primary current $I_p$:

$$I_p = \frac{P_{in}}{V_p} = \frac{3000}{200} = 15 \text{ A}$$

3. Calculate output power $P_{out}$:

$$P_{out} = \eta \times P_{in} = 0.9 \times 3000 = 2700 \text{ W}$$

4. Given $I_s = 6$ A. Calculate secondary voltage $V_s$:

$$V_s = \frac{P_{out}}{I_s} = \frac{2700}{6} = 450 \text{ V}$$

**Final Answer:** 450 V, 15 A.

**Answer: (A)**

## Q32.

### Solution

**Concept:** Energy density of electric field $u_E = \frac{1}{2}\epsilon_0 E^2$. Energy density of magnetic field $u_B = \frac{B^2}{2\mu_0}$.
**Solution:** 1. In an EM wave, $E = cB$ and $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$. 2. Substitute $B = E/c$:

$$u_B = \frac{(E/c)^2}{2\mu_0} = \frac{E^2}{2\mu_0 c^2}$$

3. Substitute $c^2 = \frac{1}{\mu_0 \epsilon_0}$:

$$u_B = \frac{E^2}{2\mu_0(1/\mu_0\epsilon_0)} = \frac{1}{2}\epsilon_0 E^2 = u_E$$

4. Since $u_E = u_B$, the ratio is 1.
**Final Answer:** 1.

**Answer: (C)**

## Q33.

### Solution

**Concept:** The effective focal length ($F$) of two thin lenses in contact is given by:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

By sign convention:

- Focal length of a convergent lens is positive ($+f$).
- Focal length of a divergent lens is negative ($-f$).

**Solution:** 1. Let the focal length of the convergent lens be $f_1 = f$. 2. Let the focal length of the divergent lens be $f_2 = -f$ (since they are of the same magnitude). 3. Using the combination formula:

$$\frac{1}{F} = \frac{1}{f} + \frac{1}{-f}$$

$$\frac{1}{F} = \frac{1}{f} - \frac{1}{f} = 0$$

4. Therefore, $F = \frac{1}{0} = \infty$.
**Final Answer:** The focal length of the combination is infinite. Option (D) is correct.

**Answer: (D)**

## Q34.

### Solution

**Concept:** Distance between lenses $L = |v_o| + |f_e|$ for normal adjustment (final image at infinity). For a finite object distance $u_o$, we must first find the image distance $v_o$ using the lens formula.
**Solution:** 1. Objective: $f_o = 40$ cm, $u_o = -200$ cm.

$$\frac{1}{40} = \frac{1}{v_o} - \frac{1}{-200} \implies \frac{1}{v_o} = \frac{1}{40} - \frac{1}{200}$$

$$\frac{1}{v_o} = \frac{5-1}{200} = \frac{4}{200} \implies v_o = 50 \text{ cm}$$

2. For the final image to be at infinity, the intermediate image must fall at the focus of the eyepiece: $u_e = f_e = 4$ cm. 3. Separation $L = v_o + f_e = 50 + 4 = 54$ cm.
**Final Answer:** 54 cm.

**Answer: (C)**

## Q35.

### Solution

**Concept:** When light passes through a glass block with parallel faces, the angle of incidence at the first face is equal to the angle of emergence from the second face ($i = e$), provided the surrounding medium is the same.

**Solution:** 1. First face: $\sin 45^\circ = \sqrt{2}\sin r \implies \frac{1}{\sqrt{2}} = \sqrt{2}\sin r \implies \sin r = \frac{1}{2} \implies r = 30^\circ$. 2. In a cube, the second face is parallel to the first. The angle of incidence at the second face $r'$ is equal to $r = 30^\circ$ (alternate interior angles). 3. Apply Snell's Law at emergence: $\sqrt{2}\sin 30^\circ = 1 \cdot \sin e$.

$$\sqrt{2} \cdot \frac{1}{2} = \sin e \implies \sin e = \frac{1}{\sqrt{2}}$$

$$e = 45^\circ$$

**Final Answer:** $45^\circ$.

**Answer: (C)**

## Q36.

### Solution

**Concept:** The maximum and minimum intensities in an interference pattern are given by:

$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2 \quad \text{and} \quad I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$$

Given the intensity ratio $\beta = I_1/I_2$.

**Solution:** 1. Let $I_1 = \beta I$ and $I_2 = I$. 2. $I_{max} = (\sqrt{\beta I} + \sqrt{I})^2 = I(\sqrt{\beta} + 1)^2$ 3. $I_{min} = (\sqrt{\beta I} - \sqrt{I})^2 = I(\sqrt{\beta} - 1)^2$ 4. Calculate the required ratio:

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{I[(\beta + 1 + 2\sqrt{\beta}) - (\beta + 1 - 2\sqrt{\beta})]}{I[(\beta + 1 + 2\sqrt{\beta}) + (\beta + 1 - 2\sqrt{\beta})]}$$

$$= \frac{4\sqrt{\beta}}{2\beta + 2} = \frac{2\sqrt{\beta}}{1 + \beta}$$

**Final Answer:** The ratio is $\frac{2\sqrt{\beta}}{1+\beta}$. Option (A) is correct.

**Answer: (A)**

## Q37.

### Solution

**Concept:** Einstein's photoelectric equation is $E = \phi_0 + K_{max}$, where $E$ is incident energy, $\phi_0$ is the work function, and $K_{max}$ is the maximum kinetic energy.

**Solution:** 1. **Case 1:** $E = \phi_0 + 0.5$ eV ...(i) 2. **Case 2:** New energy $E' = E + 0.2E = 1.2E$.

$$1.2E = \phi_0 + 0.8 \text{ eV} \quad \text{...(ii)}$$

3. Substitute (i) into (ii):

$$1.2(\phi_0 + 0.5) = \phi_0 + 0.8$$

$$1.2\phi_0 + 0.6 = \phi_0 + 0.8$$

$$0.2\phi_0 = 0.2 \implies \phi_0 = 1.0 \text{ eV}$$

**Final Answer:** The work function of the metal is 1.0 eV. Option (B) is correct.

**Answer: (B)**

## Q38.

### Solution

**Concept:** The de Broglie wavelength is $\lambda = \frac{h}{p}$. For a particle of mass $m$ at temperature $T$, the average thermal kinetic energy is $K = \frac{3}{2}kT$.

**Solution:** 1. The momentum $p$ is related to kinetic energy $K$ by $p = \sqrt{2mK}$. 2. Substituting $K = \frac{3}{2}kT$:

$$p = \sqrt{2m\left(\frac{3}{2}kT\right)} = \sqrt{3mkT}$$

3. The de Broglie wavelength is:

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{3mkT}}$$

**Final Answer:** The wavelength is $\frac{h}{\sqrt{3mkT}}$. Option (A) is correct.

**Answer: (A)**

## Q39.

### Solution

**Concept:** In the Bohr model, the velocity of an electron in the ground state ($n = 1$) of a hydrogen atom is $v = \frac{e^2}{2\epsilon_0 h}$. The ratio $v/c$ is the fine structure constant $\alpha$.

**Solution:** 1. The expression for the ratio of electron speed to the speed of light is:

$$\frac{v}{c} = \frac{e^2}{2\epsilon_0 hc}$$

2. This value is a fundamental constant in physics, approximately:

$$\alpha \approx \frac{1}{137}$$

3. Thus, the electron moves at approximately 0.73% of the speed of light in the ground state.

**Final Answer:** The ratio is nearly $1/137$. Option (A) is correct.

**Answer: (A)**

## Q40.

### Solution

**Concept:** In a Bohr orbit, the kinetic energy ($K$), potential energy ($U$), and total energy ($E$) of an electron are related as:

$$K = -E$$

$$U = 2E$$

where $E = K + U$.

**Solution:** 1. Given total energy $E = -3.4$ eV. 2. The kinetic energy is:

$$K = -E = -(-3.4 \text{ eV}) = 3.4 \text{ eV}$$

3. The potential energy is:

$$U = 2E = 2 \times (-3.4 \text{ eV}) = -6.8 \text{ eV}$$

4. Therefore, $K = 3.4$ eV and $U = -6.8$ eV.

**Final Answer:** Kinetic energy is 3.4 eV and potential energy is −6.8 eV. Option (A) is correct.

**Answer: (A)**

## Q41.

### Solution

**Concept:** Energy is released in a nuclear reaction if the total binding energy (BE) of the products is greater than the total binding energy of the reactants ($\Delta BE > 0$).

$$\text{Total BE} = (\text{BE per nucleon}) \times (\text{Mass number } A)$$

**Solution:** 1. $BE_A = 7 \times 10 = 70$ MeV 2. $BE_B = 8 \times 20 = 160$ MeV 3. $BE_C = 7 \times 30 = 210$ MeV 4. Check Reaction (A): $C \rightarrow A + B$. Product $BE = 70 + 160 = 230$. Reactant $BE = 210$. $\Delta BE = 230 - 210 = 20$ MeV. (Released) 5. Check Reaction (B): $A + B \rightarrow C$. Product $BE = 210$. Reactant $BE = 230$. $\Delta BE = -20$ MeV. (Absorbed) 6. Check Reaction (C): $C \rightarrow 3A$. Product $BE = 3 \times 70 = 210$. Reactant $BE = 210$. (No change)

**Final Answer:** $C \rightarrow A + B$.

**Answer: (A)**

## Q42.

### Solution

**Concept:** Transistor action requires specific physical and doping characteristics of the Emitter, Base, and Collector regions to ensure efficient carrier transport from Emitter to Collector.

**Solution:** 1. **Size:** The regions are not equal in size. The Collector is the largest for heat dissipation, and the Base is the thinnest. 2. **Biasing:** In the active region, the Emitter-Base junction is forward biased, and the Collector-Base junction is reverse biased. 3. **Doping:** The Emitter is heavily doped, the Collector is moderately doped, and the Base is lightly doped. 4. **Base Characteristics:** For transistor action, the base must be thin and lightly doped so that charge carriers from the emitter do not recombine significantly in the base, allowing them to reach the collector.

**Final Answer:** The base region must be very thin and lightly doped. Option (C) is correct.

**Answer: (C)**

## Q43.

### Solution

**Concept:** 1. An **OR gate** produces an output $Y = A + B$. 2. An **AND gate** produces an output $Y = A \cdot B$. 3. The truth table for an OR gate results in '1' if any input is '1'.

**Solution:** 1. The inputs $A$ and $B$ are first processed by an OR gate, yielding the intermediate expression $(A + B)$. 2. If this output is then passed through an AND gate with a third input that is high (or tied), the final logical state remains governed by the OR operation. 3. Comparing the resulting logic with the options provided:

- Option (A) is the AND operation.
- Option (B) is the OR operation.
- Option (C) and (D) often represent inverted logic (NOR/NAND) depending on formatting.

4. For the circuit described as performing an OR function on $A$ and $B$, the output $Y$ is $A + B$.

**Final Answer:** $Y = A + B$. Option (B) is correct.

**Answer: (B)**

## Q44.

### Solution

**Concept:** A universal gate is a gate which can implement any Boolean function without the need to use any other gate type. The two universal gates are NAND and NOR.

**Solution:** 1. Basic gates (AND, OR, NOT) require combinations of each other to fulfill all logic requirements. 2. A NAND gate can be used to create NOT logic (by tying inputs), AND logic (NAND followed by NOT), and OR logic (using De Morgan's theorem). 3. Therefore, NAND is the universal gate among the choices.

**Final Answer:** The NAND gate is a universal gate. Option (C) is correct.

**Answer: (C)**

## Q45.

### Solution

**Concept:** In a common emitter amplifier: 1. Voltage Gain $(A_v) = \beta\left(\frac{R_C}{R_B}\right)$ 2. Power Gain $(A_p) =$ Current Gain $\times$ Voltage Gain $= \beta \cdot A_v$

**Solution:** 1. **Voltage Gain Calculation:** Given $\beta = 100$, $R_C = 3\ \text{k}\Omega$, and $R_B = 2\ \text{k}\Omega$.

$$A_v = 100 \times \frac{3}{2} = 100 \times 1.5 = 150$$

2. **Power Gain Calculation:** Using $A_p = \beta \times A_v$:

$$A_p = 100 \times 150 = 15000$$

3. The values are 150 and 15000.

**Final Answer:** Voltage gain is 150 and power gain is 15000. Option (A) is correct.

**Answer: (A)**

# Answer Key

| Q | Ans | Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|---|---|
| 1 | B | 2 | A | 3 | B | 4 | C | 5 | A |
| 6 | A | 7 | A | 8 | C | 9 | D | 10 | A |
| 11 | B | 12 | A | 13 | B | 14 | D | 15 | B |
| 16 | A | 17 | A | 18 | B | 19 | B | 20 | A |
| 21 | C | 22 | B | 23 | A | 24 | B | 25 | C |
| 26 | C | 27 | A | 28 | A | 29 | B | 30 | A |
| 31 | A | 32 | C | 33 | D | 34 | C | 35 | C |
| 36 | A | 37 | B | 38 | A | 39 | A | 40 | A |
| 41 | A | 42 | C | 43 | B | 44 | C | 45 | A |