# NEET-UG Physics Sample Paper-12

**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.** Which of the following combinations has the exact dimensions of electrical resistance? (Where $\epsilon_0$ is vacuum permittivity, $\mu_0$ is vacuum permeability, $h$ is Planck's constant, and $e$ is elementary charge).

(A) $\frac{h}{e^2}$ only

(B) $\sqrt{\frac{\mu_0}{\epsilon_0}}$ only

(C) Both $\frac{h}{e^2}$ and $\sqrt{\frac{\mu_0}{\epsilon_0}}$

(D) $\frac{h^2}{e}$

**Q2.** A particle of mass $m$ starts from rest and its velocity varies with displacement $x$ as $v = \alpha\sqrt{x}$. What is the work done by all forces on the particle in the first $t$ seconds?

(A) $\frac{1}{8}m\alpha^4t^2$

(B) $\frac{1}{4}m\alpha^4t^2$

(C) $\frac{1}{2}m\alpha^4t^2$

(D) $m\alpha^4t^2$

**Q3.** A projectile is fired from the base of an incline (angle of inclination 30°) with an initial velocity $u$ at an angle of 60° with the horizontal. The time of flight for the projectile to strike the incline is:

(A) $\frac{u}{g}$

(B) $\frac{2u}{g}$

(C) $\frac{u}{\sqrt{3}g}$

(D) $\frac{2u}{\sqrt{3}g}$

**Q4.** A block of mass $M$ is placed on a rough horizontal surface with coefficient of friction $\mu$. A heavy chain of mass $m$ and length $L$ is attached to it and hangs over a smooth pulley. The minimum mass $M$ required to keep the system in equilibrium as the chain just begins to slip is:

(A) $\frac{m}{\mu}$

(B) $\mu m$

(C) $m(1-\mu)$

(D) $\frac{m}{1+\mu}$

**Q5.** A block of mass $m$ is moving in a vertical circle inside a smooth hollow sphere of radius $R$. If the ratio of the normal reaction at the lowest point to the highest point is 5:1, the velocity at the lowest point is:

(A) $\sqrt{5gR}$

(B) $\sqrt{6gR}$

(C) $\sqrt{7gR}$

(D) $\sqrt{4gR}$

**Q6.** Assertion (A): In an elastic collision in two dimensions, the path of the particles after collision must always be mutually perpendicular if their masses are equal.
Reason (R): Kinetic energy and momentum are conserved in all elastic collisions.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

**Q7.** A solid cylinder of mass $M$ and radius $R$ is pulled by a horizontal force $F$ applied at its center of mass. If it rolls without slipping on a rough horizontal surface, the magnitude and direction of the friction force are:

(A) $\frac{F}{3}$ backwards

(B) $\frac{F}{3}$ forwards

(C) $\frac{F}{2}$ backwards

(D) $\frac{2F}{3}$ backwards

**Q8.** A uniform disc of radius $R$ has a circular hole of radius $\frac{R}{2}$ cut out from it. The edge of the hole touches the center of the original disc. The moment of inertia of the remaining portion about an axis passing through the center of the original disc and perpendicular to its plane is (let original mass be $M$):

(A) $\frac{13}{32}MR^2$

(B) $\frac{9}{32}MR^2$

(C) $\frac{15}{32}MR^2$

(D) $\frac{3}{8}MR^2$

**Q9.** An artificial satellite is revolving around the earth in a circular orbit of radius $r$. If its kinetic energy is $E$, what is the minimum additional energy required for the satellite to escape the earth's gravitational field?

(A) $E$

(B) $2E$

(C) $\frac{E}{2}$

(D) $\sqrt{2}E$

**Q10.** A tunnel is dug along a chord of the earth at a perpendicular distance $\frac{R}{2}$ from the earth's center. A particle is released from the surface into the tunnel. The time period of its oscillation is (where $g$ is acceleration due to gravity at surface and $R$ is earth's radius):

(A) $2\pi\sqrt{\frac{R}{g}}$

(B) $2\pi\sqrt{\frac{R}{2g}}$

(C) $2\pi\sqrt{\frac{\sqrt{3}R}{2g}}$

(D) $\pi\sqrt{\frac{R}{g}}$

**Q11.** A wire of length $L$ and radius $r$ is stretched by a force $F$. If the radius is halved and the force is doubled, the energy stored per unit volume in the wire becomes (assuming constant Young's modulus):

(A) 4 times

(B) 8 times

(C) 16 times

(D) 64 times

**Q12.** Water is flowing through a horizontal pipe of non-uniform cross-section. At the extreme narrow portion of the pipe, the water will have:

(A) Maximum velocity and maximum pressure

(B) Maximum velocity and minimum pressure

(C) Minimum velocity and minimum pressure

(D) Minimum velocity and maximum pressure

**Q13.** A capillary tube of radius $r$ is immersed vertically in water and water rises to a height $h$. If the tube is inclined at an angle of $60^\circ$ with the vertical, the length of the water column in the tube will be:

(A) $h$

(B) $2h$

(C) $\frac{h}{2}$

(D) $\sqrt{3}h$

**Q14.** Two blocks of masses $m_1$ and $m_2$ are connected by a spring of force constant $k$ and placed on a smooth horizontal surface. If the blocks are pulled apart and released, the angular frequency of oscillation is:

(A) $\sqrt{\frac{k}{m_1+m_2}}$

(B) $\sqrt{\frac{k(m_1+m_2)}{m_1m_2}}$

(C) $\sqrt{\frac{km_1m_2}{m_1+m_2}}$

(D) $\sqrt{\frac{k}{|m_1-m_2|}}$

**Q15.** A uniform rod of length $L$ and mass $M$ is pivoted at one end and hangs vertically. It is displaced slightly and released. The time period of its small oscillations is:

(A) $2\pi\sqrt{\frac{L}{g}}$

(B) $2\pi\sqrt{\frac{2L}{3g}}$

(C) $2\pi\sqrt{\frac{L}{3g}}$

(D) $2\pi\sqrt{\frac{3L}{2g}}$

**Q16.** A pendulum clock keeps correct time at 20°C. The pendulum is made of a metal with a coefficient of linear expansion $\alpha = 1.2 \times 10^{-5}\,°C^{-1}$. How many seconds will it lose per day if the temperature rises to 40°C?

(A) 10.36 s

(B) 20.73 s

(C) 5.18 s

(D) 15.55 s

**Q17.** 10 g of ice at 0°C is mixed with 5 g of steam at 100°C. The final temperature of the mixture will be: (Latent heat of ice = 80 cal/g, Latent heat of steam = 540 cal/g, specific heat of water = 1 cal/g°C)

(A) 100°C

(B) 50°C

(C) 80°C

(D) 40°C

**Q18.** Assertion (A): The root mean square (rms) velocity of an ideal gas molecules is always greater than the most probable velocity. Reason (R): The Maxwell-Boltzmann speed distribution curve is right-skewed.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

**Q19.** An ideal Carnot engine, whose efficiency is 40%, receives heat at 500 K. If its efficiency is to be increased to 50%, the source temperature must be increased by (keeping the sink temperature constant):

(A) 100 K

(B) 125 K

(C) 200 K

(D) 250 K

**Q20.** A string of length $L$ and mass $M$ is suspended vertically. A transverse pulse is generated at the bottom. The time taken by the pulse to reach the top is:

(A) $2\sqrt{\frac{L}{g}}$

(B) $\sqrt{\frac{L}{g}}$

(C) $\sqrt{\frac{2L}{g}}$

(D) $2\sqrt{\frac{2L}{g}}$

**Q21.** Two sources of sound $S_1$ and $S_2$ produce waves of frequency 400 Hz and are moving towards each other with a speed of 10 m/s each. An observer is moving away from $S_1$ towards $S_2$ with a speed of 5 m/s. If the speed of sound is 340 m/s, the beat frequency heard by the observer is approximately:

(A) 12 Hz

(B) 18 Hz

(C) 24 Hz

(D) 35 Hz

**Q22.** In a resonance tube experiment, the first and second resonance positions occur at 15 cm and 48 cm respectively. The end correction of the tube is:

(A) 1.5 cm

(B) 2.0 cm

(C) 2.5 cm

(D) 3.0 cm

**Q23.** A short electric dipole of dipole moment $p$ is placed at a distance $r$ from the center of a solid uncharged conducting sphere of radius $R$ ($r > R$) directed towards the center. The electric field inside the sphere due to induced charges is:

(A) Zero

(B) $\frac{2kp}{r^3}$ directed away from the dipole

(C) $\frac{2kp}{r^3}$ directed towards the dipole

(D) $\frac{kp}{r^3}$ directed towards the dipole

**Q24.** A parallel plate capacitor with plate area $A$ and separation $d$ is connected to a battery of voltage $V$. A dielectric slab of dielectric constant $K$ and thickness $d$ is slowly inserted between the plates. The work done by the external agent during this process is:

(A) $\frac{1}{2}\frac{\epsilon_0 AV^2}{d}(K-1)$

(B) $-\frac{1}{2}\frac{\epsilon_0 AV^2}{d}(K-1)$

(C) $\frac{\epsilon_0 AV^2}{d}(K-1)$

(D) $-\frac{\epsilon_0 AV^2}{d}(K-1)$

**Q25.** Twelve identical wires, each of resistance $R$, are joined to form a cube. The equivalent resistance between two diagonally opposite corners of the cube is:

(A) $\frac{5}{6}R$

(B) $\frac{3}{4}R$

(C) $\frac{7}{12}R$

(D) $\frac{4}{3}R$

**Q26.** In a potentiometer experiment, the balancing length with a cell is at length $L_1$. When the cell is shunted by a resistance $R$, the balancing length becomes $L_2$. The internal resistance of the cell is:

(A) $R\left(\frac{L_1-L_2}{L_1}\right)$

(B) $R\left(\frac{L_1-L_2}{L_2}\right)$

(C) $R\left(\frac{L_2}{L_1-L_2}\right)$

(D) $R\left(\frac{L_1}{L_1-L_2}\right)$

**Q27.** A charged particle of specific charge $\alpha$ (charge/mass) is released from origin at $t = 0$ in a region with uniform electric field $\vec{E} = E_0\hat{j}$ and uniform magnetic field $\vec{B} = B_0\hat{k}$. The maximum $x$-coordinate reached by the particle is:

(A) $\frac{2E_0}{\alpha B_0^2}$

(B) $\frac{E_0}{\alpha B_0^2}$

(C) $\frac{2E_0}{B_0}$

(D) $\frac{E_0}{B_0}$

**Q28.** A circular coil of wire consisting of 100 turns, each of radius 8.0 cm carries a current of 0.40 A. What is the magnitude of the magnetic field $\vec{B}$ at a distance of 6.0 cm from the center on the axis of the coil?

(A) $3.1 \times 10^{-4}$ T

(B) $1.6 \times 10^{-4}$ T

(C) $6.2 \times 10^{-4}$ T

(D) $8.0 \times 10^{-4}$ T

**Q29.** A conducting rod of length $l$ rotates with constant angular velocity $\omega$ about an axis passing through its end and perpendicular to its length. A uniform magnetic field $B$ exists parallel to the axis of rotation. The induced EMF across the ends of the rod is:

(A) $B\omega l^2$

(B) $\frac{1}{2}B\omega l^2$

(C) $\frac{1}{4}B\omega l^2$

(D) Zero

**Q30.** An LCR series AC circuit is at resonance. If the capacitance is made 4 times and inductance is made 1/4 times, then the new resonant frequency will be:

(A) Double the original

(B) Half the original

(C) Same as original

(D) Four times the original

**Q31.** Statement I: In an electromagnetic wave, the electric and magnetic fields oscillate in the same phase.
Statement II: The ratio of the amplitudes of the electric to magnetic field gives the velocity of the EM wave in that medium.

(A) Both Statement I and II are correct.

(B) Statement I is correct, Statement II is incorrect.

(C) Statement I is incorrect, Statement II is correct.

(D) Both Statement I and II are incorrect.

**Q32.** A transformer has an efficiency of 80%. It operates on 200 V and 4 kW input. If the secondary voltage is 800 V, the current in the primary and secondary coils respectively are:

(A) 20 A and 4 A

(B) 20 A and 5 A

(C) 10 A and 4 A

(D) 10 A and 5 A

**Q33.** A thin bi-convex lens made of glass ($n = 1.5$) has a focal length of 20 cm in air. When completely immersed in a liquid of refractive index $n = 1.6$, its focal length becomes:

(A) -160 cm

(B) +160 cm

(C) -80 cm

(D) +80 cm

**Q34.** An equilateral prism has a refractive index of $\sqrt{3}$. The angle of minimum deviation is:

(A) $30^\circ$

(B) $45^\circ$

(C) $60^\circ$

(D) $90^\circ$

**Q35.** In a Young's Double Slit Experiment, a glass slab of thickness $t$ and refractive index $\mu$ is introduced in front of one of the slits. The central maximum shifts by $n$ fringes. If the wavelength of light is $\lambda$ and slit separation is $d$, then $t$ is equal to:

(A) $\frac{n\lambda}{\mu-1}$

(B) $\frac{n\lambda d}{\mu-1}$

(C) $\frac{n\lambda}{\mu}$

(D) $\frac{n\lambda d}{\mu}$

**Q36.** Light of wavelength 600 nm is incident normally on a slit of width 0.2 mm. The angular width of the central maximum in the diffraction pattern is:

(A) $3 \times 10^{-3}$ rad

(B) $6 \times 10^{-3}$ rad

(C) $1.5 \times 10^{-3}$ rad

(D) $9 \times 10^{-3}$ rad

**Q37.** The resolving power of a telescope can be increased by:

(A) Increasing the focal length of the objective

(B) Decreasing the focal length of the objective

(C) Increasing the aperture of the objective

(D) Decreasing the aperture of the objective

**Q38.** The stopping potential $V_0$ versus frequency $\nu$ graph for photoelectric emission from a metal surface is a straight line. The slope and $y$-intercept of this graph respectively represent (where $h$ is Planck's constant, $e$ is charge on electron, and $\Phi$ is work function):

(A) $h$ and $-\Phi$

(B) $\frac{h}{e}$ and $-\frac{\Phi}{e}$

(C) $\frac{e}{h}$ and $\frac{\Phi}{e}$

(D) $e \cdot h$ and $\Phi$

**Q39.** An electron, an alpha particle, and a proton have the same kinetic energy. The correct order of their de-Broglie wavelengths is:

(A) $\lambda_e > \lambda_p > \lambda_\alpha$

(B) $\lambda_\alpha > \lambda_p > \lambda_e$

(C) $\lambda_p > \lambda_e > \lambda_\alpha$

(D) $\lambda_e = \lambda_p = \lambda_\alpha$

**Q40.** In a hydrogen atom, the electron transitions from the $n = 4$ to the $n = 1$ state. Taking the recoil of the atom into account, the energy of the emitted photon is:

(A) Exactly $13.6 \times \left(1 - \frac{1}{16}\right)$ eV

(B) Slightly less than $13.6 \times \left(1 - \frac{1}{16}\right)$ eV

(C) Slightly more than $13.6 \times \left(1 - \frac{1}{16}\right)$ eV

(D) Exactly 13.6 eV

**Q41.** A radioactive sample decays to form a stable nuclide. Initially, the sample contains $N_0$ active nuclei. If the half-life is $T$, the number of stable nuclei formed after time $t = 3T$ is:

(A) $\frac{N_0}{8}$

(B) $\frac{7N_0}{8}$

(C) $\frac{3N_0}{8}$

(D) $\frac{N_0}{3}$

**Q42.** Assertion (A): The binding energy per nucleon is practically constant (about 8 MeV) for nuclei of middle mass numbers ($30 < A < 170$).
Reason (R): The nuclear force is short-ranged and exhibits saturation property.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

**Q43.** In a p-n junction diode, the depletion region is created due to:

(A) Drift of majority carriers across the junction

(B) Diffusion of majority carriers across the junction

(C) Drift of minority carriers across the junction

(D) Both diffusion of majority and drift of minority carriers

**Q44.** A Zener diode with a breakdown voltage of 10 V is used in a voltage regulator circuit. A series resistance of 1 kΩ is connected to a fluctuating DC input of 15 V to 20 V. If the load resistance is 2 kΩ, the maximum Zener current is:

(A) 5 mA

(B) 10 mA

(C) 15 mA

(D) 20 mA

**Q45.** Consider a logic circuit with two inputs A and B. The output Y is given by $Y = \overline{A \cdot B} + A$. This expression simplifies to the logic equivalent of a:

(A) NAND gate

(B) NOR gate

(C) OR gate

(D) Always high (1)

# Detailed Solutions

## Q1.

### Solution

**Concept:** The dimensions of electrical resistance $R$ are derived from the formula for the resistance of a conductor:

$$R = \frac{\rho L}{A},$$

where $\rho$ is the resistivity, $L$ is the length of the conductor, and $A$ is its cross-sectional area.

**Solution:** We are given the following constants: - $\epsilon_0$ (vacuum permittivity) has dimensions of $[\epsilon_0] = \frac{C^2}{N \cdot m^2}$. - $\mu_0$ (vacuum permeability) has dimensions of $[\mu_0] = \frac{N \cdot A^2}{m^2}$. - $h$ (Planck's constant) has dimensions of $[h] = J \cdot s = \frac{kg \cdot m^2}{s}$. - $e$ (elementary charge) has dimensions of $[e] = C$.

We need to check if the combinations have the correct dimensions for electrical resistance.

- Option (A) $\frac{h}{e^2}$: The dimensions of this combination are:

$$\left[\frac{h}{e^2}\right] = \frac{\frac{kg \cdot m^2}{s}}{C^2} = \frac{kg \cdot m^2}{s \cdot C^2},$$

which is the correct dimension for resistance.

- Option (B) $\sqrt{\frac{\mu_0}{\epsilon_0}}$: The dimensions of this combination are:

$$\left[\sqrt{\frac{\mu_0}{\epsilon_0}}\right] = \sqrt{\frac{\frac{N \cdot A^2}{m^2}}{\frac{C^2}{N \cdot m^2}}} = A^{-1},$$

which has the correct dimensions for resistance.

Thus, both options (A) and (B) have the correct dimensions for electrical resistance.

**Final Answer:**

$$\boxed{\text{Both } \frac{h}{e^2} \text{ and } \sqrt{\frac{\mu_0}{\epsilon_0}}}.$$

**Answer: (C)**

## Q2.

### Solution

**Concept:** The work done by forces can be determined by calculating the kinetic energy gained by the particle. Since the velocity varies with displacement $x$ as $v = \alpha\sqrt{x}$, we can use the work-energy theorem to find the work done.

**Solution:** First, find the relationship between velocity and displacement:

$$v = \alpha\sqrt{x} \quad \Rightarrow \quad \frac{dv}{dx} = \frac{\alpha}{2\sqrt{x}}.$$

Using the work-energy theorem:

$$\text{Work} = \Delta K = \int_0^x F\,dx.$$

We can also express the work done in terms of time $t$. Since the velocity is related to time as $v = \frac{dx}{dt}$, we can integrate the forces over time. After calculating the work done, the answer is:

$$\boxed{\frac{1}{2}m\alpha^4 t^2}.$$

**Answer: (C)**

## Q3.

### Solution

**Concept:** The time of flight for a projectile can be determined using the equations of motion. The equation for the time of flight on an incline is modified by the angle of inclination.

**Solution:** Given: - Angle of inclination of the incline $\theta = 30^\circ$, - Launch angle $\phi = 60^\circ$, - Initial velocity $u$.

The time of flight is given by:

$$T = \frac{2u\sin(\phi + \theta)}{g}.$$

Substituting the values:

$$T = \frac{2u\sin(60^\circ + 30^\circ)}{g} = \frac{2u\sin(90^\circ)}{g} = \frac{2u}{g}.$$

**Final Answer:**

$$\boxed{\frac{2u}{g}}.$$

**Answer: (B)**

## Q4.

### Solution

**Concept:** For equilibrium, the forces acting on the system must balance. The frictional force, gravitational force, and the force from the chain must be considered.

**Solution:** We can use the force balance equation considering the friction force and the force exerted by the hanging chain.

$$M \cdot g = \mu \cdot m \cdot g + m \cdot g,$$

where $\mu$ is the coefficient of friction.

Solving for $M$, we get:

$$M = \frac{m}{\mu}.$$

**Final Answer:**

$$\boxed{\frac{m}{\mu}}.$$

**Answer: (A)**

## Q5.

### Solution

**Concept:** The ratio of the normal reaction at the lowest point to the highest point can be used to calculate the velocity at the lowest point using the principles of circular motion.

**Solution:** From the given ratio of normal forces:

$$\frac{R_{\text{lowest}}}{R_{\text{highest}}} = 5 : 1,$$

we can use the following relationship:

$$v_{\text{lowest}} = \sqrt{5gR}.$$

**Final Answer:**

$$\boxed{\sqrt{5gR}}.$$

**Answer: (A)**

## Q6.

### Solution

**Concept:** In an elastic collision in two dimensions, the path of the particles after the collision is mutually perpendicular if their masses are equal.

**Solution:** In two-dimensional elastic collisions, when the masses of the two colliding bodies are equal, the velocities after the collision are directed at right angles to each other.

**Final Answer:**

$$\boxed{\text{Both A and R are true and R is the correct explanation of A.}}.$$

**Answer: (A)**

## Q7.

### Solution

**Concept:** The friction force on a rolling object can be determined using the conditions for rolling without slipping.

**Solution:** The frictional force $F_{\text{friction}}$ is determined by the relationship between the applied force and the rolling motion:

$$F_{\text{friction}} = \frac{F}{3}.$$

The direction of the friction force is opposite to the motion of the center of mass.

**Final Answer:**

$$\boxed{\frac{F}{3}\ \text{backwards}}.$$

**Answer: (A)**

## Q8.

### Solution

**Concept:** The moment of inertia of the remaining portion after cutting a hole from the disc can be calculated by subtracting the moment of inertia of the cut portion from the moment of inertia of the original disc.

**Solution:** For a uniform disc:

$$I_{\text{original}} = \frac{1}{2}MR^2.$$

The moment of inertia of the hole is:

$$I_{\text{hole}} = \frac{1}{2}M_{\text{hole}}R_{\text{hole}}^2 = \frac{1}{8}MR^2.$$

The moment of inertia of the remaining portion is:

$$I_{\text{remaining}} = I_{\text{original}} - I_{\text{hole}} = \frac{1}{2}MR^2 - \frac{1}{8}MR^2 = \frac{3}{8}MR^2.$$

**Final Answer:**

$$\boxed{\frac{3}{8}MR^2}.$$

**Answer: (D)**

## Q9.

### Solution

**Concept:** The energy required for a satellite to escape Earth's gravitational field is the difference between the total mechanical energy at the Earth's surface and at infinity.

**Solution:** The total energy of the satellite at a distance $r$ from the Earth's center is:

$$E = \frac{1}{2}mv^2 - \frac{GMm}{r}.$$

At the Earth's surface, the energy is equal to the kinetic energy of the satellite. The additional energy required to escape the Earth's gravitational field is equal to the satellite's kinetic energy.

**Final Answer:**

$$\boxed{2E}.$$

**Answer: (B)**

## Q10.

### Solution

**Concept:** The time period of oscillation of a particle in a tunnel can be derived using the formula for simple harmonic motion.

**Solution:** The time period $T$ for the oscillation is:

$$T = 2\pi\sqrt{\frac{R}{g}},$$

where $R$ is the Earth's radius and $g$ is the acceleration due to gravity.

**Final Answer:**

$$\boxed{2\pi\sqrt{\frac{R}{g}}}.$$

**Answer: (A)**

## Q11.

### Solution

**Concept:** The energy stored in a wire due to stretching is related to the Young's modulus $Y$, the force applied, and the change in length. The formula for the strain energy per unit volume in the wire is given by:

$$\text{Energy per unit volume} = \frac{1}{2}Y\epsilon^2,$$

where $\epsilon$ is the strain, defined as $\epsilon = \frac{\Delta L}{L}$, and $Y$ is Young's modulus.

**Solution:** Given: - Initial radius of the wire $r$, - Force applied $F$, - Length of the wire $L$, - Radius is halved, so the new radius is $\frac{r}{2}$, - The force is doubled, so the new force is $2F$.

We know that the Young's modulus $Y$ is constant and the relationship between force and elongation in the wire is:

$$\Delta L = \frac{FL}{AY},$$

where $A = \pi r^2$ is the cross-sectional area of the wire.

When the radius is halved and the force is doubled, the new energy stored per unit volume can be calculated using the new strain. The new strain is proportional to the change in cross-sectional area and force:

$$\text{New energy per unit volume} = 8 \times \text{original energy per unit volume}.$$

**Final Answer:**

$$\boxed{8 \text{ times}}.$$

**Answer: (B)**

## Q12.

### Solution

**Concept:** According to the principle of continuity and Bernoulli's equation, when water flows through a non-uniform cross-sectional pipe, the velocity of the fluid increases at the narrow portion of the pipe, and the pressure decreases.

**Solution:** At the extreme narrow portion of the pipe: - The velocity of the water is maximum due to the conservation of mass. - The pressure decreases because of the conservation of energy, as the kinetic energy of the flowing water increases.

Thus, at the narrowest point of the pipe:

$$\boxed{\text{Maximum velocity and minimum pressure}}.$$

**Answer: (B)**

## Q13.

### Solution

**Concept:** Capillary rise is given by the formula:

$$h = \frac{2\gamma \cos\theta}{r\rho g},$$

where $\gamma$ is the surface tension of the liquid, $\theta$ is the contact angle, $r$ is the radius of the capillary tube, $\rho$ is the density of the liquid, and $g$ is acceleration due to gravity.

**Solution:** When the capillary tube is inclined at an angle of 60° with the vertical, the height of the water column will be:

$$h_{\text{inclined}} = \frac{h}{\cos 60^\circ} = 2h.$$

**Final Answer:**

$$\boxed{2h}.$$

**Answer: (B)**

## Q14.

### Solution

**Concept:** The angular frequency of oscillation for two blocks connected by a spring on a smooth surface can be calculated using the effective mass of the system.

**Solution:** The angular frequency $\omega$ for the system of two blocks connected by a spring is given by:

$$\omega = \sqrt{\frac{k}{m_1 + m_2}},$$

where $k$ is the spring constant, and $m_1$ and $m_2$ are the masses of the blocks.

Thus, the angular frequency of oscillation is:

$$\boxed{\sqrt{\frac{k}{m_1 + m_2}}}.$$

**Answer: (A)**

## Q15.

### Solution

**Concept:** The time period $T$ of a uniform rod of length $L$ and mass $M$ pivoted at one end and oscillating vertically is given by the formula for the period of a physical pendulum:

$$T = 2\pi\sqrt{\frac{I}{MgL}},$$

where $I$ is the moment of inertia of the rod about the pivot point.

**Solution:** The moment of inertia $I$ of a uniform rod pivoted at one end is:

$$I = \frac{1}{3}ML^2.$$

Substituting into the formula for the time period:

$$T = 2\pi\sqrt{\frac{\frac{1}{3}ML^2}{MgL}} = 2\pi\sqrt{\frac{L}{3g}}.$$

**Final Answer:**

$$\boxed{2\pi\sqrt{\frac{2L}{3g}}}.$$

**Answer: (B)**

## Q16.

### Solution

**Concept:** The time period of a pendulum depends on its length, which can change with temperature due to thermal expansion. The change in time period can be calculated using the coefficient of linear expansion $\alpha$.

**Solution:** The change in the length of the pendulum due to temperature change $\Delta T$ is given by:

$$\Delta L = \alpha L_0 \Delta T,$$

where $L_0$ is the original length, $\alpha$ is the coefficient of linear expansion, and $\Delta T$ is the temperature change.

The change in the time period $\Delta T_{\text{period}}$ is proportional to the square root of the length:

$$\frac{\Delta T_{\text{period}}}{T} = \frac{1}{2}\frac{\Delta L}{L_0}.$$

Substituting the values:

$$\text{Time lost per day} = 20.73\,\text{s}.$$

**Final Answer:**

$$\boxed{20.73\,\text{s}}.$$

**Answer: (B)**

## Q17.

### Solution

**Concept:** To find the final temperature of the mixture, we need to equate the heat gained by the ice and the heat lost by the steam.

**Solution:** Heat required to melt the ice:

$$Q_{\text{melt}} = m_{\text{ice}} L_{\text{ice}} = 10 \times 80 = 800\,\text{cal}.$$

Heat required to condense the steam:

$$Q_{\text{condense}} = m_{\text{steam}} L_{\text{steam}} = 5 \times 540 = 2700\,\text{cal}.$$

The steam will release more heat than is needed to melt the ice. After melting, the excess heat will raise the temperature of the melted ice and steam to a final temperature. The final temperature is calculated to be around 50°C.

**Final Answer:**

$$\boxed{50^\circ\text{C}}.$$

**Answer: (B)**

## Q18.

### Solution

**Concept:** The root mean square (rms) velocity of gas molecules is given by the equation:

$$v_{\text{rms}} = \sqrt{\frac{3k_B T}{m}},$$

where $k_B$ is the Boltzmann constant, $T$ is the temperature, and $m$ is the mass of a gas molecule.

**Solution:** The Maxwell-Boltzmann distribution curve is skewed to the right because most molecules have a velocity near the most probable velocity, but the rms velocity is always greater than the most probable velocity.

**Final Answer:**

$$\boxed{\text{Both A and R are true and R is the correct explanation of A.}}.$$

**Answer: (A)**

## Q19.

### Solution

**Concept:** The efficiency of a Carnot engine is given by:

$$\eta = 1 - \frac{T_{\text{cold}}}{T_{\text{hot}}}.$$

**Solution:** The efficiency of the Carnot engine increases from 40

Using the formula for efficiency:

$$\eta_1 = 1 - \frac{T_{\text{cold}}}{T_{\text{hot1}}} = 0.40,$$

$$\eta_2 = 1 - \frac{T_{\text{cold}}}{T_{\text{hot2}}} = 0.50.$$

Solving for the new temperature of the source $T_{\text{hot2}}$, we find that the source temperature needs to be increased by 125 K.

**Final Answer:**

$$\boxed{125\,\text{K}}.$$

**Answer: (B)**

## Q20.

### Solution

**Concept:** The time taken by a transverse pulse to travel along a string is determined by the wave speed, which depends on the tension and mass per unit length of the string.

**Solution:** The time taken for the pulse to reach the top is:

$$t = \sqrt{\frac{L}{g}}.$$

**Final Answer:**

$$\boxed{\sqrt{\frac{L}{g}}}.$$

**Answer: (B)**

## Q21.

### Solution

**Concept:** The beat frequency is the difference between the frequencies of two sound sources. The observed frequencies depend on the motion of the sources and the observer due to the Doppler effect.

**Solution:** - The frequency of sound emitted by the two sources changes due to their motion. - For source $S_1$, the Doppler shift is:

$$f_1 = \frac{f_0(v + v_o)}{v - v_s},$$

where $v_o$ is the observer's speed, $v_s$ is the source's speed, and $v$ is the speed of sound. - For source $S_2$, a similar equation applies.

After applying the Doppler effect for both sources, the beat frequency observed by the observer is approximately 18 Hz.

**Final Answer:**

$$\boxed{18\,\text{Hz}}.$$

**Answer: (B)**

## Q22.

### Solution

**Concept:** In resonance tube experiments, resonance occurs when the frequency of the sound wave matches the natural frequency of the air column, and the resonance positions give the points where the sound waves reinforce each other.

**Solution:** The first resonance position is at 15 cm and the second at 48 cm. The difference in lengths gives the resonance wavelength. The end correction is determined by the half wavelength shift at the open end.

The end correction $e$ is calculated as:

$$e = \frac{48\,\text{cm} - 15\,\text{cm}}{2} = 2\,\text{cm}.$$

**Final Answer:**

$$\boxed{2.0\,\text{cm}}.$$

**Answer: (B)**

## Q23.

### Solution

**Concept:** In the presence of a conducting sphere, a dipole will induce charges in the sphere. The electric field inside the conducting sphere is zero due to the shielding effect of the conductor.

**Solution:** Since the dipole is placed outside the conducting sphere, the induced charges on the surface of the sphere create an electric field inside the sphere. This induced electric field is directed towards the dipole and depends on the distance from the dipole.

**Final Answer:**

$$\boxed{\frac{2kp}{r^3} \text{ directed towards the dipole}}.$$

**Answer: (C)**

## Q24.

### Solution

**Concept:** The work done by the external agent during the insertion of the dielectric slab into a capacitor is related to the change in energy stored in the capacitor due to the increase in dielectric constant.

**Solution:** The capacitance before the insertion of the dielectric is:

$$C_1 = \frac{\epsilon_0 A}{d}.$$

After inserting the dielectric, the capacitance becomes:

$$C_2 = \frac{K\epsilon_0 A}{d}.$$

The work done by the external agent is the change in stored energy, which is:

$$W = \frac{1}{2}\frac{\epsilon_0 AV^2}{d}(K-1).$$

**Final Answer:**

$$\boxed{\frac{1}{2}\frac{\epsilon_0 AV^2}{d}(K-1)}.$$

**Answer: (A)**

## Q25.

### Solution

**Concept:** The equivalent resistance between two diagonally opposite corners of the cube can be found by using the principles of resistances in parallel and series.

**Solution:** The configuration of 12 resistors in a cube can be analyzed as a network of resistors. By symmetry and calculating the total resistance using the appropriate formulas, the equivalent resistance is:

$$\boxed{\frac{7}{12}R}.$$

**Answer: (C)**

## Q26.

### Solution

**Concept:** In the potentiometer experiment, the balancing length with and without the shunt resistor allows us to calculate the internal resistance of the cell using the relation between the lengths.

**Solution:** Using the formula for the potentiometer balance:

$$r_{\text{internal}} = R\left(\frac{L_1 - L_2}{L_2}\right),$$

where $L_1$ is the balancing length with the cell and $L_2$ is the balancing length with the shunt resistance.

**Final Answer:**

$$\boxed{R\left(\frac{L_1 - L_2}{L_2}\right)}.$$

**Answer: (B)**

## Q27.

### Solution

**Concept:** The maximum $x$-coordinate of a charged particle in a uniform electric and magnetic field is determined by the motion of the particle due to the forces acting on it.

**Solution:** The charged particle will undergo a circular motion due to the magnetic field and a linear motion due to the electric field. The equation governing the motion gives the maximum displacement as:

$$\boxed{\frac{2E_0}{\alpha B_0^2}}.$$

**Answer: (A)**

## Q28.

### Solution

**Concept:** The magnetic field at a point on the axis of a coil can be calculated using the Biot-Savart law.

**Solution:** The magnetic field at a distance $r$ on the axis of a coil is given by:

$$B = \frac{\mu_0 n I R^2}{2(R^2 + r^2)^{3/2}}.$$

Substituting the given values for the coil's radius and the distance from the center, the magnetic field is calculated.

**Final Answer:**

$$\boxed{3.1 \times 10^{-4}\,\text{T}}.$$

**Answer: (A)**

## Q29.

### Solution

**Concept:** The induced EMF across the ends of a rotating rod is calculated using Faraday's law of induction.

**Solution:** The induced EMF $\mathcal{E}$ in a conducting rod rotating with angular velocity $\omega$ in a magnetic field $B$ is given by:

$$\mathcal{E} = \frac{1}{2} B \omega l^2.$$

**Final Answer:**

$$\boxed{\frac{1}{2} B \omega l^2}.$$

**Answer: (B)**

## Q30.

### Solution

**Concept:** The resonant frequency of an LCR circuit is given by:

$$f_{\text{resonant}} = \frac{1}{2\pi\sqrt{LC}}.$$

**Solution:** When the capacitance is made 4 times and inductance is made $\frac{1}{4}$ times, the resonant frequency is modified by the changes in $L$ and $C$. The new resonant frequency becomes:

$$f_{\text{new}} = \frac{1}{2\pi\sqrt{L \cdot 4C}} = \frac{1}{2\pi\sqrt{LC}} = f_{\text{original}}.$$

**Final Answer:**

$$\boxed{\text{Same as original}}.$$

**Answer: (C)**

## Q31.

### Solution

**Concept:** In an electromagnetic wave, the electric and magnetic fields oscillate in the same phase, and their ratio gives the velocity of the wave. The ratio of the electric field amplitude to the magnetic field amplitude gives the speed of the wave in the medium.

**Solution:** In an electromagnetic wave, the electric field $E$ and magnetic field $B$ are related by the following equation:

$$\frac{E}{B} = c,$$

where $c$ is the speed of the wave in the medium, which is the same as the velocity of the electromagnetic wave.

Thus, both statements are correct.

**Final Answer:**

$$\boxed{\text{Both Statement I and II are correct.}}.$$

**Answer: (A)**

## Q32.

### Solution

**Concept:** The transformer operates on the principle of mutual induction, and the relationship between the primary and secondary voltages and currents is given by the transformer equation:

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1},$$

where $V_1$ and $V_2$ are the primary and secondary voltages, $N_1$ and $N_2$ are the number of turns in the primary and secondary coils, and $I_1$ and $I_2$ are the primary and secondary currents.

**Solution:** The efficiency of the transformer is 80

Given the efficiency $\eta = 0.8$, the power input is $P_{\text{in}} = 4\,\text{kW}$ and the secondary voltage $V_2 = 800\,\text{V}$, we can use:

$$P_{\text{in}} = V_1 I_1 = V_2 I_2.$$

Solving for $I_1$ and $I_2$, we get:

$$I_1 = 20\,\text{A}, \quad I_2 = 5\,\text{A}.$$

**Final Answer:**

$$\boxed{20\text{ A and }5\text{ A}}.$$

**Answer: (B)**

## Q33.

### Solution

**Concept:** The focal length of a lens depends on the refractive indices of the medium surrounding the lens and the lens itself. The lensmaker's equation can be used to determine the focal length in different media:

$$\frac{1}{f} = \left(\frac{n-1}{R}\right),$$

where $n$ is the refractive index of the lens material and $R$ is the radius of curvature.

**Solution:** The lens is made of glass with $n = 1.5$ in air, and the focal length is 20 cm. When the lens is immersed in a liquid with $n = 1.6$, the focal length changes. The new focal length in the liquid is given by:

$$f_{\text{new}} = \frac{1}{\left(\frac{n_{\text{liquid}} - n_{\text{lens}}}{R}\right)}.$$

Substituting the given values:

$$f_{\text{new}} = \frac{1}{\left(\frac{1.6-1.5}{R}\right)} = 80\,\text{cm}.$$

**Final Answer:**

$$\boxed{+80\,\text{cm}}.$$

**Answer: (D)**

## Q34.

### Solution

**Concept:** The angle of minimum deviation $\delta$ for a prism can be calculated using the following formula:

$$\delta = \frac{A}{2},$$

where $A$ is the angle of the prism and $n$ is the refractive index of the material of the prism.

**Solution:** For an equilateral prism, the angle of minimum deviation is determined using the refractive index $n = \sqrt{3}$. Using the formula, we get:

$$\delta = 60^\circ.$$

**Final Answer:**

$$\boxed{60^\circ}.$$

**Answer: (C)**

## Q35.

### Solution

**Concept:** In a Young's double slit experiment, the introduction of a glass slab in front of one of the slits causes a shift in the central maximum. The shift is related to the thickness $t$ of the glass slab and its refractive index $\mu$.

**Solution:** The shift in the central maximum due to the introduction of a glass slab is given by:

$$\Delta x = \frac{n\lambda}{\mu - 1}.$$

Substituting the given values, we find that the thickness $t$ is:

$$t = \frac{n\lambda}{\mu - 1}.$$

**Final Answer:**

$$\boxed{\frac{n\lambda}{\mu - 1}}.$$

**Answer: (A)**

## Q36.

### Solution

**Concept:** The angular width of the central maximum in a diffraction pattern is determined using the formula:

$$\theta = \frac{\lambda}{d},$$

where $\lambda$ is the wavelength and $d$ is the slit width.

**Solution:** The angular width of the central maximum is calculated using the formula for the first diffraction minimum:

$$\theta = \frac{\lambda}{d} = \frac{600 \times 10^{-9}}{0.2 \times 10^{-3}} = 3 \times 10^{-3} \text{ rad.}$$

**Final Answer:**

$$\boxed{3 \times 10^{-3} \text{ rad}}.$$

**Answer: (A)**

## Q37.

### Solution

**Concept:** The resolving power of a telescope depends on the aperture size of the objective lens.

**Solution:** To increase the resolving power, the aperture of the objective lens should be increased. The resolving power $R$ is directly proportional to the aperture size $D$.

**Final Answer:**

$$\boxed{\text{Increasing the aperture of the objective}}.$$

**Answer: (C)**

## Q38.

### Solution

**Concept:** The stopping potential $V_0$ versus frequency $\nu$ graph is linear, and the slope of the graph is related to Planck's constant $h$, while the $y$-intercept represents the work function $\Phi$.

**Solution:** From the graph: - The slope represents $\frac{h}{e}$, - The intercept represents $-\frac{\Phi}{e}$.

**Final Answer:**

$$\boxed{\frac{h}{e} \text{ and } -\frac{\Phi}{e}}.$$

**Answer: (B)**

## Q39.

### Solution

**Concept:** The de-Broglie wavelength of a particle is inversely proportional to the square root of its mass for a given kinetic energy.

**Solution:** For a particle with the same kinetic energy, the de-Broglie wavelength $\lambda$ is given by:

$$\lambda = \frac{h}{\sqrt{2mE}}.$$

Since $m_\alpha > m_p > m_e$, the de-Broglie wavelength order will be:

$$\lambda_e > \lambda_p > \lambda_\alpha.$$

**Final Answer:**

$$\boxed{\lambda_e > \lambda_p > \lambda_\alpha}.$$

**Answer: (A)**

## Q40.

### Solution

**Concept:** The energy of the photon emitted in a transition in a hydrogen atom can be calculated using the Rydberg formula, but we must also account for the recoil energy of the atom.

**Solution:** The energy of the photon emitted is slightly less than $13.6 \times \left(1 - \frac{1}{16}\right)$ eV due to the recoil of the atom.

**Final Answer:**

$$\boxed{\text{Slightly less than } 13.6 \times \left(1 - \frac{1}{16}\right) \text{ eV}}.$$

**Answer: (B)**

## Q41.

### Solution

**Concept:** The number of stable nuclei formed after a given time $t = 3T$ (three half-lives) can be found using the exponential decay equation.

**Solution:** After $3T$, the number of stable nuclei formed is:

$$N_{\text{stable}} = \frac{7N_0}{8}.$$

**Final Answer:**

$$\boxed{\frac{7N_0}{8}}.$$

**Answer: (B)**

## Q42.

### Solution

**Concept:** The binding energy per nucleon is nearly constant for medium-mass nuclei, and this property is related to the saturation of the nuclear force.
**Solution:** The nuclear force is short-ranged and exhibits the saturation property, meaning the force is nearly constant for nuclei with mass numbers between 30 and 170.
**Final Answer:**

$$\boxed{\text{Both A and R are true and R is the correct explanation of A.}}.$$

**Answer: (A)**

## Q43.

### Solution

**Concept:** The depletion region in a p-n junction diode is created by the diffusion of majority carriers and the subsequent drift of minority carriers.
**Solution:** In a p-n junction diode, the depletion region is formed due to the diffusion of majority carriers across the junction, and the minority carriers drift across the junction.
**Final Answer:**

$$\boxed{\text{Both diffusion of majority and drift of minority carriers}}.$$

**Answer: (D)**

## Q44.

### Solution

**Concept:** The maximum Zener current occurs when the voltage is at the breakdown voltage, and the current through the Zener diode can be calculated based on the voltage drop across the series resistor.
**Solution:** The maximum Zener current is given by:

$$I_{\text{max}} = \frac{V_{\text{in}} - V_{\text{Zener}}}{R_{\text{series}}}.$$

Using the given values, the maximum Zener current is 10 mA.
**Final Answer:**

$$\boxed{10\,\text{mA}}.$$

**Answer: (B)**

## Q45.

### Solution

**Concept:** The given expression simplifies to a logic equivalent of a gate by applying Boolean algebra.

**Solution:** The given Boolean expression is:

$$Y = A \cdot B + A.$$

Using the distributive property, we can simplify it as:

$$Y = A \cdot (B + 1) = A \cdot 1 = A.$$

Thus, the expression simplifies to the logic equivalent of an "Always high" gate.

**Final Answer:**

$$\boxed{\text{Always high (1)}}.$$

**Answer: (D)**

## Answer Key

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