

MHT-CET Physics Sample Paper-6

Duration: 45 Minutes

Maximum Marks: 50

Instructions

- This paper contains a total of **50** Multiple Choice Questions.
- Each correct answer carries **+1 marks**.
- No negative marking for incorrect questions.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.
- No marks will be deducted for questions that are left unattempted.

Q1. A particle of mass m is tied to a string and swung in a vertical circle of radius R . The difference in tension between the highest and lowest points is:

- (A) $3mg$
- (B) $6mg$
- (C) mg
- (D) $2mg$

Q2. In an AM wave, the carrier power is 500 W. If the modulation index is 0.5, the total power of the AM wave is:

- (A) 500 W
- (B) 625 W
- (C) 562.5 W
- (D) 750 W

Q3. The work function of a metal is 2.1 eV. The threshold wavelength for this metal is approximately:

- (A) 5910 Å
- (B) 4000 Å



(C) 7000 \AA

(D) 3000 \AA

Q4. A capacitor of $20 \mu\text{F}$ is charged to 500 V and then connected across a 10 mH inductor. The maximum current in the circuit is:

(A) 10 A

(B) 15.6 A

(C) 22.4 A

(D) 5 A

Q5. A wire of length L and area of cross-section A is made of material of Young's modulus Y . If the wire is stretched by an amount x , the work done is:

(A) $YAx^2/2L$

(B) $YAx/2L$

(C) YAx^2/L

(D) YAx/L

Q6. If the radius of the earth shrinks by 1% , its mass remaining the same, the acceleration due to gravity on the earth's surface would:

(A) Decrease by 2%

(B) Increase by 2%

(C) Decrease by 1%

(D) Increase by 1%

Q7. In a diffraction pattern due to a single slit of width d , the first minimum is observed at an angle of 30° when light of wavelength 5000 \AA is incident. The width of the slit is:

(A) $1.0 \times 10^{-4} \text{ cm}$

(B) $1.0 \times 10^{-5} \text{ cm}$

(C) $0.5 \times 10^{-4} \text{ cm}$



(D) 2.0×10^{-4} cm

Q8. An ideal gas undergoes an isothermal expansion. In this process:

- (A) Internal energy increases
- (B) Internal energy decreases
- (C) Internal energy remains constant
- (D) Heat is not exchanged

Q9. The resistance of a potentiometer wire is 8Ω and its length is 4 m. A resistance of 5Ω and a cell of emf 2 V are connected in series with the wire. The potential gradient is:

- (A) 0.5 V/m
- (B) 0.307 V/m
- (C) 1.23 V/m
- (D) 0.8 V/m

Q10. A p-n junction diode has a reverse saturation current of 10^{-12} A. For a forward bias of 0.6 V, the current is approximately ($e^{23} \approx 9.7 \times 10^9$):

- (A) 9.7 mA
- (B) 0.97 mA
- (C) 97 mA
- (D) 0.097 mA

Q11. The dimensions of $\frac{1}{\mu_0 \epsilon_0}$ are:

- (A) $L^2 T^{-2}$
- (B) LT^{-1}
- (C) $L^{-2} T^2$
- (D) $L^{-1} T$



- Q12.** A car starts from rest and accelerates at 5 m/s^2 . At $t = 4 \text{ s}$, a ball is dropped out of the window. The velocity of the ball at $t = 6 \text{ s}$ is ($g = 10 \text{ m/s}^2$):
- (A) 20 m/s
 - (B) $20\sqrt{2} \text{ m/s}$
 - (C) 28.2 m/s
 - (D) 40 m/s
- Q13.** A charged particle is moving in a circle of radius r in a uniform magnetic field B . The kinetic energy of the particle is doubled. The new radius of the path will be:
- (A) $2r$
 - (B) $r/2$
 - (C) $\sqrt{2}r$
 - (D) $r/\sqrt{2}$
- Q14.** The ratio of the magnetic field at the center of a current-carrying circular loop to its magnetic dipole moment is x . If the current and radius are both doubled, the new ratio will be:
- (A) $x/8$
 - (B) $x/4$
 - (C) $x/16$
 - (D) $8x$
- Q15.** Two spheres of the same material have radii in the ratio 1:2. The ratio of their terminal velocities in a viscous liquid is:
- (A) 1 : 2
 - (B) 1 : 4
 - (C) 2 : 1
 - (D) 4 : 1



- Q16.** In a series LCR circuit, $R = 10 \Omega$, $X_L = 20 \Omega$, and $X_C = 20 \Omega$. The impedance of the circuit is:
- (A) 10Ω
(B) 50Ω
(C) 30Ω
(D) $10\sqrt{2} \Omega$
- Q17.** The de-Broglie wavelength of a neutron at thermal equilibrium with heavy water at temperature T (Kelvin) is:
- (A) $\propto T$
(B) $\propto 1/T$
(C) $\propto 1/\sqrt{T}$
(D) $\propto T^2$
- Q18.** A body of mass 5 kg is moving in a circle of radius 1 m with an angular velocity of 2 rad/s. The centripetal force is:
- (A) 10 N
(B) 20 N
(C) 30 N
(D) 40 N
- Q19.** A transverse wave is represented by $y = A \sin(kx - \omega t)$. The maximum particle velocity is 4 times the wave velocity if:
- (A) $kA = 4$
(B) $kA = 1/4$
(C) $kA = \pi/4$
(D) $kA = 1$
- Q20.** Two point charges Q and $-3Q$ are placed at some distance apart. If the electric field at the location of Q is E , then the electric field at the location of $-3Q$ is:



- (A) $E/3$
- (B) $-E/3$
- (C) $3E$
- (D) $-E$

Q21. A liquid does not wet the solid surface if the angle of contact is:

- (A) 0°
- (B) 45°
- (C) 90°
- (D) 120°

Q22. In a Young's double slit experiment, if the separation between the slits is halved and the distance between the slits and screen is doubled, the fringe width becomes:

- (A) 2 times
- (B) 4 times
- (C) $1/2$ times
- (D) $1/4$ times

Q23. The temperature of a black body is increased from 27°C to 327°C . The ratio of the intensities of radiation emitted will be:

- (A) 1 : 2
- (B) 1 : 8
- (C) 1 : 16
- (D) 1 : 4

Q24. A simple pendulum has a time period T_1 on the surface of the earth and T_2 at a height R above the surface (where R is the radius of the earth). The ratio T_2/T_1 is:

- (A) 1



- (B) 2
- (C) 4
- (D) $1/2$

Q25. For a common emitter transistor amplifier, the current gain is 60. If the emitter current is 6.1 mA, then the base current is:

- (A) 0.1 mA
- (B) 6 mA
- (C) 1 mA
- (D) 2 mA

Q26. The half-life of a radioactive element is 10 hours. The fraction of the initial mass that remains undecayed after 40 hours is:

- (A) $1/4$
- (B) $1/8$
- (C) $1/16$
- (D) $1/32$

Q27. In a Wheatstone bridge, all four arms have equal resistance R . If the resistance of the galvanometer is also R , the equivalent resistance of the combination as seen by the battery is:

- (A) $R/2$
- (B) R
- (C) $2R$
- (D) $R/4$

Q28. A ray of light is incident on a glass plate at an angle of 60° . If the reflected and refracted rays are mutually perpendicular, the refractive index of glass is:

- (A) $\sqrt{3}/2$
- (B) $3/2$



(C) $\sqrt{3}$

(D) $1/2$

Q29. The radius of gyration of a uniform rod of length L about an axis passing through its center and perpendicular to its length is:

(A) $L/\sqrt{12}$

(B) $L/\sqrt{3}$

(C) $L/2$

(D) $L/\sqrt{2}$

Q30. A $100\ \Omega$ resistor is connected to a 220 V, 50 Hz AC supply. The net power consumed over a full cycle is:

(A) 484 W

(B) 242 W

(C) 0 W

(D) 110 W

Q31. The escape velocity from the moon is less than that from the earth because:

(A) Moon has no atmosphere

(B) Moon is less massive than earth

(C) Moon is cooler than earth

(D) Moon's radius is smaller than earth's

Q32. A particle moves in a straight line with a deceleration proportional to the square of its velocity. If the initial velocity is v_0 , the velocity at time t is:

(A) $v_0/(1 + v_0kt)$

(B) v_0e^{-kt}

(C) $v_0 - kt$

(D) $v_0/(1 + kt)$



- Q33.** The molar specific heat of an ideal gas at constant pressure is $C_P = 5R/2$. The gas is:
- (A) Monoatomic
 - (B) Diatomic
 - (C) Polyatomic
 - (D) Mixture
- Q34.** Two tuning forks A and B produce 4 beats per second. When A is loaded with wax, the beats decrease to 2 per second. If the frequency of B is 512 Hz, the frequency of A is:
- (A) 508 Hz
 - (B) 516 Hz
 - (C) 510 Hz
 - (D) 514 Hz
- Q35.** A current of 2 A flows through a conductor of resistance 10Ω for 1 minute. The heat produced is:
- (A) 1200 J
 - (B) 2400 J
 - (C) 200 J
 - (D) 600 J
- Q36.** A satellite is revolving around the earth in a circular orbit of radius r . Its total energy is E . Its potential energy is:
- (A) E
 - (B) $2E$
 - (C) $-E$
 - (D) $E/2$



- Q37.** The electric potential at a point (x, y, z) is $V = -x^2y - xz^3 + 4$. The electric field E at that point is:
- (A) $(2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$
 - (B) $2xy\hat{i} + x^2\hat{j} + z^3\hat{k}$
 - (C) $(x^2y)\hat{i} + (xz^3)\hat{j}$
 - (D) $x^2\hat{i} + y^2\hat{j} + z^2\hat{k}$
- Q38.** The magnetic flux linked with a coil is given by $\phi = 5t^2 + 3t + 16$. The induced emf in the coil at $t = 2$ s is:
- (A) 23 V
 - (B) 20 V
 - (C) 10 V
 - (D) 16 V
- Q39.** A bubble of air is underwater. As it rises, its size:
- (A) Increases
 - (B) Decreases
 - (C) Remains same
 - (D) First increases then decreases
- Q40.** A long solenoid has 1000 turns. When a current of 4 A flows through it, the magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self-inductance of the solenoid is:
- (A) 4 H
 - (B) 1 H
 - (C) 2 H
 - (D) 0.4 H
- Q41.** In the Bohr model of a hydrogen atom, the ratio of the kinetic energy to the total energy of the electron in a quantum state n is:



- (A) 1 : 1
- (B) 1 : -1
- (C) 2 : 1
- (D) 1 : -2

Q42. The displacement of a particle is given by $x = a \sin(\omega t) + b \cos(\omega t)$. The amplitude of its SHM is:

- (A) $a + b$
- (B) $a^2 + b^2$
- (C) $\sqrt{a^2 + b^2}$
- (D) ab

Q43. The work done in moving a unit positive charge from one point to another on an equipotential surface is:

- (A) Positive
- (B) Negative
- (C) Zero
- (D) Infinite

Q44. A body weighs 72 N on the surface of the earth. What is its weight at a height $R/2$ from the surface?

- (A) 32 N
- (B) 48 N
- (C) 16 N
- (D) 36 N

Q45. The unit of Stefan's constant is:

- (A) $\text{W m}^{-2} \text{K}^{-4}$
- (B) $\text{W m}^2 \text{K}^4$



- (C) $\text{J m}^{-2} \text{K}^{-4}$
- (D) $\text{W m}^{-2} \text{K}^{-2}$

- Q46.** For a metallic wire, the ratio V/I where V is applied potential difference and I is current:
- (A) Is independent of temperature
 - (B) Increases as temperature rises
 - (C) Decreases as temperature rises
 - (D) Increases as temperature decreases
- Q47.** A telescope has an objective lens of focal length 150 cm and an eyepiece of focal length 5 cm. If it is focused for distinct vision (25 cm), the magnifying power is:
- (A) 30
 - (B) 36
 - (C) 60
 - (D) 45
- Q48.** Which of the following is not a property of ultrasonic waves?
- (A) They are longitudinal waves
 - (B) They can travel through vacuum
 - (C) They have high frequency
 - (D) They can undergo reflection
- Q49.** The value of current gain α of a transistor is 0.98. The value of current gain β is:
- (A) 49
 - (B) 50
 - (C) 98



(D) 100

Q50. An engine has an efficiency of $1/6$. When the temperature of the sink is reduced by 62°C , its efficiency is doubled. The temperature of the source is:

(A) 124°C

(B) 37°C

(C) 62°C

(D) 99°C



Detailed Solutions

Q1.

Solution

Concept:

When a particle tied to a string moves in a vertical circle, the tension in the string changes with position because the component of weight along the radius changes.

At the lowest point, both tension and weight act along the vertical line, but tension acts upward toward the centre and weight acts downward.

At the highest point, both tension and weight act toward the centre of the circle.

The radial force equation is applied separately at the lowest and highest points.

Solution:

At the lowest point, the centripetal force is directed upward toward the centre.

$$\text{Therefore: } T_L - mg = \frac{mv_L^2}{R}$$

$$\text{So: } T_L = \frac{mv_L^2}{R} + mg$$

At the highest point, both tension and weight act toward the centre.

$$\text{Therefore: } T_H + mg = \frac{mv_H^2}{R}$$

$$\text{So: } T_H = \frac{mv_H^2}{R} - mg$$

Now subtract the tension at the highest point from the tension at the lowest point: $T_L - T_H =$

$$\left(\frac{mv_L^2}{R} + mg\right) - \left(\frac{mv_H^2}{R} - mg\right)$$

$$T_L - T_H = \frac{m}{R}(v_L^2 - v_H^2) + 2mg$$

Using conservation of mechanical energy between lowest and highest points, the height difference is $2R$.

Loss of kinetic energy from bottom to top is equal to gain in potential energy: $\frac{1}{2}m(v_L^2 - v_H^2) = mg(2R)$

$$\text{Therefore: } v_L^2 - v_H^2 = 4gR$$

Substitute this in the tension difference: $T_L - T_H = \frac{m}{R}(4gR) + 2mg$

$$T_L - T_H = 4mg + 2mg$$

$$T_L - T_H = 6mg$$

Final Answer: The difference in tension between the lowest and highest points is $6mg$.

Answer: (B)



Q2.

Solution**Concept:**

For an amplitude modulated wave, the total transmitted power is related to carrier power by: $P_T = P_C \left(1 + \frac{\mu^2}{2}\right)$

where P_T is total power, P_C is carrier power, and μ is modulation index.

The sidebands carry extra power, so the total power is greater than the carrier power.

Solution:

Given carrier power is: $P_C = 500 \text{ W}$

Modulation index is: $\mu = 0.5$

Total power of AM wave is: $P_T = P_C \left(1 + \frac{\mu^2}{2}\right)$

Substitute the values: $P_T = 500 \left(1 + \frac{(0.5)^2}{2}\right)$

Now: $(0.5)^2 = 0.25$

Therefore: $P_T = 500 \left(1 + \frac{0.25}{2}\right)$

$P_T = 500(1 + 0.125)$

$P_T = 500(1.125)$

$P_T = 562.5 \text{ W}$

Hence, the total power of the AM wave is 562.5 W.

Final Answer: The total power of the AM wave is 562.5 W.

Answer: (C)

Q3.

Solution**Concept:**

Threshold wavelength is the maximum wavelength of light that can just eject electrons from a metal surface.

At threshold frequency, the kinetic energy of photoelectrons is zero, so: $\phi = \frac{hc}{\lambda_0}$

Therefore: $\lambda_0 = \frac{hc}{\phi}$

In electron-volt and Angstrom units, a useful relation is: $hc = 12400 \text{ eV } \text{\AA}$

Solution:

Work function of the metal is: $\phi = 2.1 \text{ eV}$

Threshold wavelength is: $\lambda_0 = \frac{hc}{\phi}$

Using: $hc = 12400 \text{ eV } \text{\AA}$

Substitute the values: $\lambda_0 = \frac{12400}{2.1} \text{\AA}$

Now calculate: $\lambda_0 \approx 5904.76 \text{\AA}$

Therefore, threshold wavelength is approximately: $\lambda_0 \approx 5910 \text{\AA}$

This means that light of wavelength greater than this value will not be able to eject electrons from the metal surface.

Final Answer: The threshold wavelength is approximately 5910 \AA .

Answer: (A)



Q4.

Solution**Concept:**

When a charged capacitor is connected to an inductor, electrical energy stored in the capacitor is converted into magnetic energy stored in the inductor.

At maximum current, the entire initial energy of the capacitor becomes magnetic energy in the inductor.

Energy stored in capacitor is: $U_C = \frac{1}{2}CV^2$

Energy stored in inductor is: $U_L = \frac{1}{2}LI_{max}^2$

By conservation of energy: $\frac{1}{2}CV^2 = \frac{1}{2}LI_{max}^2$

Solution:

Capacitance is: $C = 20 \mu\text{F} = 20 \times 10^{-6} \text{ F}$

Voltage is: $V = 500 \text{ V}$

Inductance is: $L = 10 \text{ mH} = 10 \times 10^{-3} \text{ H}$

Using conservation of energy: $\frac{1}{2}CV^2 = \frac{1}{2}LI_{max}^2$

Cancel $\frac{1}{2}$ from both sides: $CV^2 = LI_{max}^2$

Therefore: $I_{max} = V\sqrt{\frac{C}{L}}$

Substitute the values: $I_{max} = 500\sqrt{\frac{20 \times 10^{-6}}{10 \times 10^{-3}}}$

Simplify inside square root: $\frac{20 \times 10^{-6}}{10 \times 10^{-3}} = 2 \times 10^{-3}$

So: $I_{max} = 500\sqrt{2 \times 10^{-3}}$

$\sqrt{2 \times 10^{-3}} \approx 0.0447$

Therefore: $I_{max} = 500 \times 0.0447$

$I_{max} \approx 22.35 \text{ A}$

Thus, the maximum current is approximately 22.4 A.

Final Answer: The maximum current in the circuit is 22.4 A.

Answer: (C)



Q5.

Solution**Concept:**

When a wire is stretched, elastic potential energy is stored in it.

Young's modulus is defined as: $Y = \frac{\text{stress}}{\text{strain}}$

For a wire of length L , area of cross-section A , and extension x , the force required is: $F = \frac{YAx}{L}$

Since the force increases gradually from zero to F , the work done is: $W = \frac{1}{2}Fx$

Solution:

Length of wire is: L

Area of cross-section is: A

Young's modulus is: Y

Extension produced is: x

Using Young's modulus: $Y = \frac{F/A}{x/L}$

Rearrange this equation: $Y = \frac{FL}{Ax}$

Therefore, force at extension x is: $F = \frac{YAx}{L}$

Since stretching is gradual, the average force during stretching is: $F_{avg} = \frac{F}{2}$

Work done is: $W = F_{avg} \times x$

$$W = \frac{F}{2} \times x$$

Substitute $F = \frac{YAx}{L}$: $W = \frac{1}{2} \left(\frac{YAx}{L} \right) x$

$$W = \frac{YAx^2}{2L}$$

This work is stored as elastic potential energy in the stretched wire.

Final Answer: The work done is $\frac{YAx^2}{2L}$.

Answer: (A)



Q6.

Solution**Concept:**

Acceleration due to gravity on the surface of Earth is: $g = \frac{GM}{R^2}$

If mass remains constant, then: $g \propto \frac{1}{R^2}$

For small percentage changes: $\frac{\Delta g}{g} = -2 \frac{\Delta R}{R}$

Solution:

The radius of Earth shrinks by 1%.

So, percentage change in radius is: $\frac{\Delta R}{R} = -1\%$

Since: $g \propto R^{-2}$

Percentage change in g is: $\frac{\Delta g}{g} \times 100 = -2 \left(\frac{\Delta R}{R} \times 100 \right)$

Substitute the value: $\frac{\Delta g}{g} \times 100 = -2(-1\%)$

$\frac{\Delta g}{g} \times 100 = +2\%$

The positive sign indicates that acceleration due to gravity increases.

This happens because the same mass is now concentrated in a smaller radius, so the gravitational field at the surface becomes stronger.

Final Answer: The acceleration due to gravity would increase by 2%.

Answer: (B)

Q7.

Solution**Concept:**

For single slit diffraction, the condition for minima is: $d \sin \theta = n\lambda$

For the first minimum: $n = 1$

Therefore: $d \sin \theta = \lambda$

So: $d = \frac{\lambda}{\sin \theta}$

Solution:

Wavelength of incident light is: $\lambda = 5000 \text{ \AA}$

Convert Angstrom into centimetre: $1 \text{ \AA} = 10^{-8} \text{ cm}$

Therefore: $\lambda = 5000 \times 10^{-8} \text{ cm}$

$\lambda = 5 \times 10^{-5} \text{ cm}$

The first minimum is observed at: $\theta = 30^\circ$

For the first minimum: $d \sin \theta = \lambda$

So: $d = \frac{\lambda}{\sin \theta}$

Substitute the values: $d = \frac{5 \times 10^{-5}}{\sin 30^\circ}$

Since: $\sin 30^\circ = \frac{1}{2}$

Therefore: $d = \frac{5 \times 10^{-5}}{1/2}$

$d = 10 \times 10^{-5} \text{ cm}$

$d = 1.0 \times 10^{-4} \text{ cm}$

Final Answer: The width of the slit is $1.0 \times 10^{-4} \text{ cm}$.

Answer: (A)



Q8.

Solution**Concept:**

For an ideal gas, internal energy depends only on temperature.

In an isothermal process, temperature remains constant: $T = \text{constant}$

Therefore, the change in internal energy is zero: $\Delta U = 0$

Solution:

The process given is an isothermal expansion.

In an isothermal process, the temperature of the gas remains constant throughout the process.

For an ideal gas, internal energy is a function of temperature only.

Since temperature does not change, internal energy also does not change.

Therefore: $\Delta U = 0$

So, internal energy remains constant.

However, heat is exchanged in an isothermal expansion. The heat absorbed by the gas is converted into work done by the gas.

From the first law of thermodynamics: $Q = \Delta U + W$

Since $\Delta U = 0$: $Q = W$

Thus, the statement that heat is not exchanged is not correct for isothermal expansion.

Final Answer: Internal energy remains constant.

Answer: (C)



Q9.

Solution**Concept:**

Potential gradient of a potentiometer wire is the potential drop per unit length of the wire.

If current through the potentiometer wire is I , resistance of wire is R_w , and length is L , then: $k =$

$$\frac{IR_w}{L}$$

Current in the circuit is found from total resistance: $I = \frac{E}{R_{total}}$

Solution:

Resistance of potentiometer wire is: $R_w = 8 \Omega$

Length of potentiometer wire is: $L = 4 \text{ m}$

External series resistance is: $R = 5 \Omega$

EMF of the cell is: $E = 2 \text{ V}$

Total resistance in series is: $R_{total} = 8 + 5 = 13 \Omega$

Current through the circuit is: $I = \frac{E}{R_{total}}$

$$I = \frac{2}{13} \text{ A}$$

Potential drop across potentiometer wire is: $V_w = IR_w$

$$V_w = \frac{2}{13} \times 8$$

$$V_w = \frac{16}{13} \text{ V}$$

Potential gradient is: $k = \frac{V_w}{L}$

$$k = \frac{16/13}{4}$$

$$k = \frac{16}{52}$$

$$k \approx 0.307 \text{ V/m}$$

Final Answer: The potential gradient is 0.307 V/m.

Answer: (B)



Q10.

Solution**Concept:**

For a p-n junction diode, the diode current is given by: $I = I_s \left(e^{\frac{eV}{kT}} - 1 \right)$

In the given question, the exponential term is already provided as: $e^{23} \approx 9.7 \times 10^9$

Since this value is very large, subtracting 1 is negligible.

Therefore: $I \approx I_s e^{23}$

Solution:

Reverse saturation current is: $I_s = 10^{-12}$ A

For the given forward bias, exponential factor is: $e^{23} \approx 9.7 \times 10^9$

Using diode equation: $I = I_s (e^{23} - 1)$

Since: $e^{23} \gg 1$

Therefore: $I \approx I_s e^{23}$

Substitute the values: $I \approx 10^{-12} \times 9.7 \times 10^9$

$I = 9.7 \times 10^{-3}$ A

Convert ampere into milliampere: 1 A = 1000 mA

$I = 9.7$ mA

Thus, the forward current is approximately 9.7 mA.

Final Answer: The current is approximately 9.7 mA.

Answer: (A)

Q11.

Solution**Concept:**

The quantity $\frac{1}{\mu_0 \epsilon_0}$ is related to the speed of light in vacuum.

From electromagnetic wave theory: $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

Therefore: $\frac{1}{\mu_0 \epsilon_0} = c^2$

The dimensions of speed are: $c = LT^{-1}$

Solution:

We know: $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

Squaring both sides: $c^2 = \frac{1}{\mu_0 \epsilon_0}$

Therefore, the dimensions of $\frac{1}{\mu_0 \epsilon_0}$ are the dimensions of c^2 .

Since speed has dimensions: $c = LT^{-1}$

$c^2 = L^2 T^{-2}$

$c^2 = L^2 T^{-2}$

Hence: $\left(\frac{1}{\mu_0 \epsilon_0} \right) = L^2 T^{-2}$

Final Answer: The dimensions of $\frac{1}{\mu_0 \epsilon_0}$ are $L^2 T^{-2}$.

Answer: (A)



Q12.

Solution**Concept:**

When a ball is dropped from a moving car, it already has the horizontal velocity of the car at the instant of release.

After release, the horizontal velocity remains constant because there is no horizontal acceleration.

The vertical velocity increases due to gravity.

The resultant velocity is: $v = \sqrt{v_x^2 + v_y^2}$

Solution:

The car starts from rest and accelerates at: $a = 5 \text{ m/s}^2$

At $t = 4 \text{ s}$, the speed of the car is: $v_x = u + at$

Since the car starts from rest: $u = 0$

Therefore: $v_x = 0 + 5 \times 4$

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

This becomes the horizontal velocity of the ball at the instant it is dropped.

The ball is dropped at $t = 4 \text{ s}$ and velocity is required at $t = 6 \text{ s}$.

Time of fall is: $\Delta t = 6 - 4 = 2 \text{ s}$

Initial vertical velocity of the ball is zero.

Vertical velocity after 2 seconds is: $v_y = g\Delta t$

$v_y = 10 \times 2$

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

Now the resultant velocity is: $v = \sqrt{v_x^2 + v_y^2}$

Substitute the values: $v = \sqrt{20^2 + 20^2}$

$v = \sqrt{400 + 400}$

$v = \sqrt{800}$

$v = 20\sqrt{2} \text{ m/s}$

Final Answer: The velocity of the ball at $t = 6 \text{ s}$ is $20\sqrt{2} \text{ m/s}$.

Answer: (B)



Q13.

Solution**Concept:**

For a charged particle moving perpendicular to a uniform magnetic field, the radius of circular path is: $r = \frac{mv}{qB}$

The kinetic energy of the particle is: $K = \frac{1}{2}mv^2$

For the same particle in the same magnetic field: $r \propto v$

Also: $v \propto \sqrt{K}$

Therefore: $r \propto \sqrt{K}$

Solution:

Initial radius of the circular path is: r

Initial kinetic energy is: K

The kinetic energy is doubled: $K' = 2K$

Since: $r \propto \sqrt{K}$

The ratio of new radius to original radius is: $\frac{r'}{r} = \sqrt{\frac{K'}{K}}$

Substitute $K' = 2K$: $\frac{r'}{r} = \sqrt{\frac{2K}{K}}$

$\frac{r'}{r} = \sqrt{2}$

Therefore: $r' = \sqrt{2}r$

Thus, when kinetic energy is doubled, the radius increases by a factor of $\sqrt{2}$.

Final Answer: The new radius of the path is $\sqrt{2}r$.

Answer: (C)



Q14.

Solution**Concept:**

Magnetic field at the centre of a circular current-carrying loop is: $B = \frac{\mu_0 I}{2R}$

Magnetic dipole moment of the loop is: $M = IA = I\pi R^2$

Therefore, the ratio is: $\frac{B}{M} = \frac{\mu_0 I / (2R)}{I\pi R^2}$

After cancellation of current: $\frac{B}{M} = \frac{\mu_0}{2\pi R^3}$

So, the ratio depends only on radius as: $\frac{B}{M} \propto \frac{1}{R^3}$

Solution:

Initial ratio of magnetic field at centre to magnetic dipole moment is given as: x

From the concept: $\frac{B}{M} \propto \frac{1}{R^3}$

Now the current is doubled and radius is also doubled.

However, the ratio $\frac{B}{M}$ does not depend on current because current cancels out.

Only the change in radius affects the ratio.

New radius is: $R' = 2R$

Therefore, new ratio is: $x' = x \left(\frac{R}{R'}\right)^3$

Substitute $R' = 2R$: $x' = x \left(\frac{R}{2R}\right)^3$

$$x' = x \left(\frac{1}{2}\right)^3$$

$$x' = \frac{x}{8}$$

Final Answer: The new ratio will be $\frac{x}{8}$.

Answer: (A)

Q15.

Solution**Concept:**

Terminal velocity of a small sphere falling through a viscous liquid is given by Stokes' law: $v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$

For spheres of the same material falling in the same liquid, ρ , σ , g , and η are constant.

Therefore: $v_t \propto r^2$

Solution:

The radii of the two spheres are in the ratio: $r_1 : r_2 = 1 : 2$

Since terminal velocity is proportional to the square of radius: $v_t \propto r^2$

Therefore: $v_1 : v_2 = r_1^2 : r_2^2$

Substitute the ratio of radii: $v_1 : v_2 = 1^2 : 2^2$

$$v_1 : v_2 = 1 : 4$$

Thus, the larger sphere has four times the terminal velocity of the smaller sphere.

Final Answer: The ratio of their terminal velocities is 1 : 4.

Answer: (B)



Q16.

Solution**Concept:**

In a series LCR circuit, impedance is: $Z = \sqrt{R^2 + (X_L - X_C)^2}$

At resonance or when $X_L = X_C$, the inductive and capacitive reactances cancel each other.

Then the impedance becomes purely resistive: $Z = R$

Solution:

Given resistance is: $R = 10 \Omega$

Inductive reactance is: $X_L = 20 \Omega$

Capacitive reactance is: $X_C = 20 \Omega$

Net reactance is: $X_L - X_C = 20 - 20 = 0$

Impedance of series LCR circuit is: $Z = \sqrt{R^2 + (X_L - X_C)^2}$

Substitute the values: $Z = \sqrt{10^2 + 0^2}$

$$Z = \sqrt{100}$$

$$Z = 10 \Omega$$

Therefore, the circuit behaves like a pure resistance of 10Ω .

Final Answer: The impedance of the circuit is 10Ω .

Answer: (A)

Q17.

Solution**Concept:**

The de-Broglie wavelength of a particle is: $\lambda = \frac{h}{p}$

For a neutron in thermal equilibrium at temperature T , its average kinetic energy is proportional to temperature: $K \propto T$

Since: $K = \frac{p^2}{2m}$

we get: $p \propto \sqrt{T}$

Therefore: $\lambda \propto \frac{1}{\sqrt{T}}$

Solution:

For a neutron at thermal equilibrium, thermal energy is proportional to absolute temperature: $K \propto T$

Momentum is related to kinetic energy by: $K = \frac{p^2}{2m}$

Thus: $p = \sqrt{2mK}$

Since m is constant and $K \propto T$: $p \propto \sqrt{T}$

The de-Broglie wavelength is: $\lambda = \frac{h}{p}$

Since h is constant: $\lambda \propto \frac{1}{p}$

Therefore: $\lambda \propto \frac{1}{\sqrt{T}}$

Hence, as temperature increases, the de-Broglie wavelength decreases as the inverse square root of temperature.

Final Answer: The de-Broglie wavelength is proportional to $\frac{1}{\sqrt{T}}$.

Answer: (C)



Q18.

Solution**Concept:**

For circular motion, centripetal force is: $F = mr\omega^2$

where m is mass, r is radius, and ω is angular velocity.

This force always acts toward the centre of the circular path.

Solution:

Mass of the body is: $m = 5$ kg

Radius of circular path is: $r = 1$ m

Angular velocity is: $\omega = 2$ rad/s

Centripetal force is: $F = mr\omega^2$

Substitute the values: $F = 5 \times 1 \times (2)^2$

$$F = 5 \times 4$$

$$F = 20 \text{ N}$$

Therefore, the required centripetal force is 20 N.

Final Answer: The centripetal force is 20 N.

Answer: (B)

Q19.

Solution**Concept:**

For a transverse wave: $y = A \sin(kx - \omega t)$

The maximum particle velocity is: $v_p^{max} = A\omega$

The wave velocity is: $v_w = \frac{\omega}{k}$

Given condition is: $v_p^{max} = 4v_w$

Solution:

Maximum particle velocity is: $v_p^{max} = A\omega$

Wave velocity is: $v_w = \frac{\omega}{k}$

According to the question: $A\omega = 4 \left(\frac{\omega}{k} \right)$

Cancel ω from both sides: $A = \frac{4}{k}$

Multiply both sides by k : $kA = 4$

Thus, the maximum particle velocity is four times the wave velocity when $kA = 4$.

Final Answer: The required condition is $kA = 4$.

Answer: (A)



Q20.

Solution**Concept:**

The electric field due to a point charge is: $E = \frac{kq}{r^2}$

The electric field at the location of one charge is due to the other charge only, not due to the charge itself.

For two charges separated by the same distance, the field magnitude is proportional to the source charge.

Solution:

Two point charges are Q and $-3Q$.

The electric field at the location of Q is due to charge $-3Q$.

Magnitude of this electric field is: $E = \frac{k(3Q)}{r^2}$

Now, the electric field at the location of $-3Q$ is due to charge Q .

Its magnitude is: $E' = \frac{kQ}{r^2}$

Compare E' with E : $E = \frac{3kQ}{r^2}$

Therefore: $E' = \frac{1}{3}E$

Now consider direction.

The electric field at Q due to $-3Q$ is directed toward $-3Q$.

The electric field at $-3Q$ due to Q is directed away from Q .

Both directions are along the same line and in the same direction from Q toward $-3Q$.

Therefore, if the electric field at the location of Q is represented as E , then the electric field at the location of $-3Q$ is: $\frac{E}{3}$

Final Answer: The electric field at the location of $-3Q$ is $\frac{E}{3}$.

Answer: (A)



Q21.

Solution**Concept:**

The angle of contact determines whether a liquid wets a solid surface or not.

If the angle of contact is acute, the liquid wets the surface.

If the angle of contact is obtuse, the liquid does not wet the surface.

For a non-wetting liquid, the adhesive force between liquid and solid is weaker than the cohesive force between liquid molecules.

Solution:

A liquid wets a solid surface when it spreads over the surface.

This happens when the angle of contact is less than 90° .

For example, water on clean glass has a small angle of contact and wets the glass surface.

A liquid does not wet the solid surface when it forms droplets instead of spreading.

This happens when the angle of contact is greater than 90° .

Among the given options, 120° is greater than 90° .

Therefore, for angle of contact 120° , the liquid does not wet the solid surface.

Final Answer: A liquid does not wet the solid surface if the angle of contact is 120° .

Answer: (D)

Q22.

Solution**Concept:**

In Young's double slit experiment, fringe width is given by: $\beta = \frac{\lambda D}{d}$

where λ is wavelength of light, D is the distance between slits and screen, and d is the separation between the slits.

Thus, fringe width is directly proportional to D and inversely proportional to d .

Solution:

Initial fringe width is: $\beta = \frac{\lambda D}{d}$

According to the question, the slit separation is halved: $d' = \frac{d}{2}$

The distance between slits and screen is doubled: $D' = 2D$

New fringe width is: $\beta' = \frac{\lambda D'}{d'}$

Substitute $D' = 2D$ and $d' = \frac{d}{2}$: $\beta' = \frac{\lambda(2D)}{d/2}$

$$\beta' = \frac{2\lambda D}{d/2}$$

$$\beta' = 4 \frac{\lambda D}{d}$$

Since: $\beta = \frac{\lambda D}{d}$

Therefore: $\beta' = 4\beta$

Thus, the fringe width becomes 4 times the original value.

Final Answer: The fringe width becomes 4 times.

Answer: (B)



Q23.

Solution**Concept:**

According to Stefan-Boltzmann law, the intensity or energy radiated per unit area per unit time by a black body is proportional to the fourth power of its absolute temperature: $I \propto T^4$

Temperature must be expressed in Kelvin.

Solution:

Initial temperature is: $T_1 = 27^\circ\text{C}$

Convert into Kelvin: $T_1 = 27 + 273 = 300\text{ K}$

Final temperature is: $T_2 = 327^\circ\text{C}$

Convert into Kelvin: $T_2 = 327 + 273 = 600\text{ K}$

Using Stefan-Boltzmann law: $I \propto T^4$

Therefore: $\frac{I_1}{I_2} = \left(\frac{T_1}{T_2}\right)^4$

Substitute the values: $\frac{I_1}{I_2} = \left(\frac{300}{600}\right)^4$

$$\frac{I_1}{I_2} = \left(\frac{1}{2}\right)^4$$

$$\frac{I_1}{I_2} = \frac{1}{16}$$

Therefore: $I_1 : I_2 = 1 : 16$

So, when the temperature increases from 27°C to 327°C , the intensity becomes 16 times.

Final Answer: The ratio of intensities of radiation emitted is 1 : 16.

Answer: (C)



Q24.

Solution**Concept:**

The time period of a simple pendulum is: $T = 2\pi\sqrt{\frac{l}{g}}$

Thus, for the same pendulum: $T \propto \frac{1}{\sqrt{g}}$

Acceleration due to gravity at height h above Earth's surface is: $g_h = g \left(\frac{R}{R+h}\right)^2$

Solution:

At the surface of Earth, acceleration due to gravity is: g

The time period on the surface is: $T_1 = 2\pi\sqrt{\frac{l}{g}}$

At height: $h = R$

Acceleration due to gravity becomes: $g_h = g \left(\frac{R}{R+R}\right)^2$

$$g_h = g \left(\frac{R}{2R}\right)^2$$

$$g_h = g \left(\frac{1}{2}\right)^2$$

$$g_h = \frac{g}{4}$$

Time period at height R is: $T_2 = 2\pi\sqrt{\frac{l}{g_h}}$

Substitute $g_h = \frac{g}{4}$: $T_2 = 2\pi\sqrt{\frac{l}{g/4}}$

$$T_2 = 2\pi\sqrt{\frac{4l}{g}}$$

$$T_2 = 2 \left(2\pi\sqrt{\frac{l}{g}}\right)$$

Since: $T_1 = 2\pi\sqrt{\frac{l}{g}}$

Therefore: $T_2 = 2T_1$

Hence: $\frac{T_2}{T_1} = 2$

Final Answer: The ratio $\frac{T_2}{T_1}$ is 2.

Answer: (B)



Q25.

Solution**Concept:**

For a transistor in common emitter configuration, current gain is: $\beta = \frac{I_C}{I_B}$

The emitter current is the sum of collector current and base current: $I_E = I_C + I_B$

Using $I_C = \beta I_B$, we get: $I_E = (\beta + 1)I_B$

Therefore: $I_B = \frac{I_E}{\beta + 1}$

Solution:

Current gain is: $\beta = 60$

Emitter current is: $I_E = 6.1 \text{ mA}$

Using the relation: $I_E = (\beta + 1)I_B$

Substitute $\beta = 60$: $I_E = 61I_B$

Therefore: $I_B = \frac{I_E}{61}$

Substitute $I_E = 6.1 \text{ mA}$: $I_B = \frac{6.1}{61} \text{ mA}$

$I_B = 0.1 \text{ mA}$

Thus, the base current is much smaller than the emitter current, as expected in a transistor.

Final Answer: The base current is 0.1 mA.

Answer: (A)

Q26.

Solution**Concept:**

After each half-life, the remaining quantity of a radioactive substance becomes half of the previous quantity.

After n half-lives, the remaining fraction is: $\left(\frac{1}{2}\right)^n$

where: $n = \frac{t}{T_{1/2}}$

Solution:

Half-life of the radioactive element is: $T_{1/2} = 10 \text{ hours}$

Total time elapsed is: $t = 40 \text{ hours}$

Number of half-lives passed is: $n = \frac{t}{T_{1/2}}$

$$n = \frac{40}{10}$$

$$n = 4$$

Remaining fraction after n half-lives is: $\left(\frac{1}{2}\right)^n$

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

$$\left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

Therefore, after 40 hours, $\frac{1}{16}$ of the initial mass remains undecayed.

Final Answer: The fraction of the initial mass remaining undecayed is $\frac{1}{16}$.

Answer: (C)



Q27.

Solution**Concept:**

In a balanced Wheatstone bridge, no current flows through the galvanometer.

If all four arms of a Wheatstone bridge have equal resistance R , the bridge is balanced.

Therefore, the resistance of the galvanometer does not affect the equivalent resistance.

The circuit reduces to two series branches of resistance $2R$ each, connected in parallel.

Solution:

All four arms have equal resistance: R

Since the bridge is balanced, the potential difference across the galvanometer is zero.

Therefore, no current flows through the galvanometer even though its resistance is also R .

Now, the upper branch consists of two resistors in series: $R + R = 2R$

The lower branch also consists of two resistors in series: $R + R = 2R$

These two branches are connected in parallel across the battery.

Equivalent resistance is: $R_{eq} = \frac{(2R)(2R)}{2R+2R}$

$$R_{eq} = \frac{4R^2}{4R}$$

$$R_{eq} = R$$

Thus, the equivalent resistance as seen by the battery is R .

Final Answer: The equivalent resistance of the combination is R .

Answer: (B)

Q28.

Solution**Concept:**

When reflected and refracted rays are mutually perpendicular, the angle of incidence is equal to the polarizing angle or Brewster angle.

According to Brewster's law: $\mu = \tan i_p$

where i_p is the polarizing angle.

Solution:

The angle of incidence is given as: $i = 60^\circ$

Since the reflected and refracted rays are mutually perpendicular, this angle is Brewster angle: $i_p = 60^\circ$

By Brewster's law: $\mu = \tan i_p$

Substitute the value: $\mu = \tan 60^\circ$

We know: $\tan 60^\circ = \sqrt{3}$

Therefore: $\mu = \sqrt{3}$

Hence, the refractive index of glass is $\sqrt{3}$.

Final Answer: The refractive index of glass is $\sqrt{3}$.

Answer: (C)



Q29.

Solution**Concept:**

Radius of gyration K is defined by the relation: $I = MK^2$

For a uniform rod of length L , moment of inertia about an axis passing through its centre and perpendicular to its length is: $I = \frac{1}{12}ML^2$

Solution:

Moment of inertia of the uniform rod about the given axis is: $I = \frac{1}{12}ML^2$

Radius of gyration is defined by: $I = MK^2$

Equating both expressions: $MK^2 = \frac{1}{12}ML^2$

Cancel M from both sides: $K^2 = \frac{L^2}{12}$

Taking square root: $K = \frac{L}{\sqrt{12}}$

Therefore, the radius of gyration of the rod about the given axis is $\frac{L}{\sqrt{12}}$.

Final Answer: The radius of gyration is $\frac{L}{\sqrt{12}}$.

Answer: (A)

Q30.

Solution**Concept:**

For a pure resistor connected to an AC supply, the average power consumed over a full cycle is: $P = \frac{V_{rms}^2}{R}$

The given AC voltage is normally taken as RMS voltage unless otherwise specified.

For a resistor, power factor is 1, so real power is consumed.

Solution:

Resistance is: $R = 100 \Omega$

RMS voltage of AC supply is: $V_{rms} = 220 \text{ V}$

Average power consumed over a full cycle is: $P = \frac{V_{rms}^2}{R}$

Substitute the values: $P = \frac{(220)^2}{100}$

$$P = \frac{48400}{100}$$

$$P = 484 \text{ W}$$

Since the circuit contains only resistance, the current and voltage are in phase, so the net power over a full cycle is not zero.

Final Answer: The net power consumed over a full cycle is 484 W.

Answer: (A)



Q31.

Solution**Concept:**

Escape velocity from the surface of a celestial body is: $v_e = \sqrt{\frac{2GM}{R}}$

where M is the mass of the body and R is its radius.

Escape velocity depends mainly on the ratio $\frac{M}{R}$. A body with smaller mass generally has lower escape velocity if its radius is not proportionally much smaller.

Solution:

The escape velocity from Earth is greater than that from the moon.

The formula is: $v_e = \sqrt{\frac{2GM}{R}}$

The moon has much smaller mass than Earth.

Since escape velocity depends on gravitational pull, a smaller mass produces a weaker gravitational field.

Although the moon also has a smaller radius than Earth, the decrease in mass is much more significant than the decrease in radius.

Therefore, the value of $\frac{M}{R}$ for the moon is less than that for Earth.

Hence, the escape velocity from the moon is less than the escape velocity from Earth.

The absence of atmosphere is not the reason for lower escape velocity. Escape velocity is determined by mass and radius of the celestial body.

Final Answer: The escape velocity from the moon is less because the moon is less massive than Earth.

Answer: (B)



Q32.

Solution**Concept:**

If deceleration is proportional to the square of velocity, then: $\frac{dv}{dt} = -kv^2$
where k is a positive constant.

This differential equation can be solved by separating variables.

Solution:

Given that deceleration is proportional to the square of velocity.

$$\text{So: } \frac{dv}{dt} = -kv^2$$

$$\text{Separate the variables: } \frac{dv}{v^2} = -k dt$$

$$\text{Integrate both sides: } \int v^{-2} dv = \int -k dt$$

$$-\frac{1}{v} = -kt + C$$

$$\text{Multiply by } -1: \frac{1}{v} = kt + C'$$

$$\text{At } t = 0, \text{ velocity is: } v = v_0$$

$$\text{Therefore: } \frac{1}{v_0} = C'$$

$$\text{So: } \frac{1}{v} = kt + \frac{1}{v_0}$$

$$\text{Taking reciprocal: } v = \frac{1}{kt + \frac{1}{v_0}}$$

$$v = \frac{v_0}{1 + v_0 kt}$$

Therefore, the velocity decreases with time according to inverse linear form.

Final Answer: The velocity at time t is $\frac{v_0}{1 + v_0 kt}$.

Answer: (A)



Q33.

Solution**Concept:**

For an ideal gas: $C_P - C_V = R$

For a monoatomic ideal gas: $C_V = \frac{3R}{2}$

Therefore: $C_P = C_V + R = \frac{3R}{2} + R = \frac{5R}{2}$

Solution:

Given molar specific heat at constant pressure is: $C_P = \frac{5R}{2}$

For a monoatomic ideal gas, the number of degrees of freedom is: $f = 3$

The molar specific heat at constant volume is: $C_V = \frac{f}{2}R$

$$C_V = \frac{3R}{2}$$

Using Mayer's relation: $C_P - C_V = R$

Therefore: $C_P = C_V + R$

Substitute $C_V = \frac{3R}{2}$: $C_P = \frac{3R}{2} + R$

$$C_P = \frac{3R}{2} + \frac{2R}{2}$$

$$C_P = \frac{5R}{2}$$

This matches the given value.

Hence, the gas is monoatomic.

Final Answer: The gas is monoatomic.

Answer: (A)



Q34.

Solution**Concept:**

Beat frequency is the absolute difference between the frequencies of two sound sources: $f_b = |f_A - f_B|$

Loading a tuning fork with wax decreases its frequency because the effective mass of the prongs increases.

If beats decrease after loading fork A, the frequency of A must originally have been greater than the frequency of B.

Solution:

Frequency of tuning fork B is: $f_B = 512$ Hz

Initial beat frequency is: 4 beats/s

So: $|f_A - 512| = 4$

This gives two possibilities: $f_A = 516$ Hz or $f_A = 508$ Hz

Now tuning fork A is loaded with wax.

Loading decreases the frequency of fork A.

After loading, beats decrease from 4 per second to 2 per second.

If f_A were initially 508 Hz, loading would decrease it further below 508 Hz, so its difference from 512 Hz would increase, not decrease.

Therefore, f_A cannot be 508 Hz.

If f_A were initially 516 Hz, loading decreases its frequency closer to 512 Hz, so the beat frequency decreases.

This agrees with the given observation.

Therefore, the original frequency of tuning fork A is: $f_A = 516$ Hz

Final Answer: The frequency of tuning fork A is 516 Hz.

Answer: (B)



Q35.

Solution**Concept:**

Heat produced in a conductor due to electric current is given by Joule's law of heating: $H = I^2 R t$ where I is current, R is resistance, and t is time in seconds.

Solution:

Current through the conductor is: $I = 2$ A

Resistance of the conductor is: $R = 10 \Omega$

Time is: $t = 1$ minute = 60 s

Using Joule's law: $H = I^2 R t$

Substitute the values: $H = (2)^2 \times 10 \times 60$

$$H = 4 \times 10 \times 60$$

$$H = 40 \times 60$$

$$H = 2400 \text{ J}$$

Thus, the heat produced in the conductor is 2400 J.

Final Answer: The heat produced is 2400 J.

Answer: (B)

Q36.

Solution**Concept:**

For a satellite in a circular orbit, kinetic energy is: $K = \frac{GMm}{2r}$

Potential energy is: $U = -\frac{GMm}{r}$

Total energy is: $E = K + U$

Therefore: $E = \frac{GMm}{2r} - \frac{GMm}{r}$

$$E = -\frac{GMm}{2r}$$

Thus, potential energy is twice the total energy: $U = 2E$

Solution:

The total energy of the satellite is given as: E

For a satellite revolving in a circular orbit, total energy is negative: $E = -\frac{GMm}{2r}$

Potential energy is: $U = -\frac{GMm}{r}$

Compare potential energy with total energy.

Since: $E = -\frac{GMm}{2r}$

Multiply both sides by 2: $2E = -\frac{GMm}{r}$

But: $U = -\frac{GMm}{r}$

Therefore: $U = 2E$

Since E is negative, $2E$ is also negative and represents the gravitational potential energy correctly.

Final Answer: The potential energy of the satellite is $2E$.

Answer: (B)



Q37.

Solution**Concept:**

Electric field is related to electric potential by the negative gradient: $\vec{E} = -\nabla V$

In Cartesian coordinates: $\vec{E} = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right)$

Solution:

Given electric potential is: $V = -x^2y - xz^3 + 4$

First find partial derivative with respect to x : $\frac{\partial V}{\partial x} = -2xy - z^3$

Therefore: $E_x = -\frac{\partial V}{\partial x}$

$$E_x = -(-2xy - z^3)$$

$$E_x = 2xy + z^3$$

Now find partial derivative with respect to y : $\frac{\partial V}{\partial y} = -x^2$

Therefore: $E_y = -\frac{\partial V}{\partial y}$

$$E_y = -(-x^2)$$

$$E_y = x^2$$

Now find partial derivative with respect to z : $\frac{\partial V}{\partial z} = -3xz^2$

Therefore: $E_z = -\frac{\partial V}{\partial z}$

$$E_z = -(-3xz^2)$$

$$E_z = 3xz^2$$

Hence, the electric field is: $\vec{E} = (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$

Final Answer: The electric field is $(2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$.

Answer: (A)



Q38.

Solution**Concept:**

According to Faraday's law of electromagnetic induction, induced emf is equal to the negative rate of change of magnetic flux: $e = -\frac{d\phi}{dt}$

The magnitude of induced emf is: $|e| = \left| \frac{d\phi}{dt} \right|$

Solution:

Magnetic flux linked with the coil is given by: $\phi = 5t^2 + 3t + 16$

Induced emf is: $e = -\frac{d\phi}{dt}$

Differentiate flux with respect to time: $\frac{d\phi}{dt} = 10t + 3$

At: $t = 2$ s

$$\frac{d\phi}{dt} = 10(2) + 3$$

$$\frac{d\phi}{dt} = 20 + 3$$

$$\frac{d\phi}{dt} = 23$$

Therefore, induced emf is: $e = -23$ V

The negative sign indicates the direction according to Lenz's law.

The magnitude of induced emf is: $|e| = 23$ V

Final Answer: The induced emf in the coil is 23 V.

Answer: (A)

Q39.

Solution**Concept:**

Pressure inside a liquid increases with depth: $P = P_0 + \rho gh$

As an air bubble rises upward in water, the depth decreases.

Therefore, the external pressure acting on the bubble decreases.

According to Boyle's law, at constant temperature: $PV = \text{constant}$

So, if pressure decreases, volume increases.

Solution:

An air bubble underwater is initially at some depth.

At greater depth, the water pressure is high because: $P = P_0 + \rho gh$

As the bubble rises, the value of h decreases.

Therefore, the external pressure on the bubble decreases.

Assuming temperature remains nearly constant, Boyle's law applies: $PV = \text{constant}$

When pressure decreases, volume increases.

Thus, the bubble expands as it rises.

Since size depends on volume, the size of the air bubble increases while rising.

Final Answer: The size of the air bubble increases as it rises.

Answer: (A)



Q40.

Solution**Concept:**

Self-inductance of a coil is defined by: $N\phi = LI$

where $N\phi$ is total flux linkage, L is self-inductance, and I is current.

Therefore: $L = \frac{N\phi}{I}$

Solution:

Number of turns of the solenoid is: $N = 1000$

Current through the solenoid is: $I = 4$ A

Magnetic flux linked with each turn is: $\phi = 4 \times 10^{-3}$ Wb

Total flux linkage is: $N\phi = 1000 \times 4 \times 10^{-3}$

$N\phi = 4$ Wb-turn

Self-inductance is: $L = \frac{N\phi}{I}$

Substitute the values: $L = \frac{4}{4}$

$L = 1$ H

Therefore, the self-inductance of the solenoid is 1 H.

Final Answer: The self-inductance of the solenoid is 1 H.

Answer: (B)



Q41.

Solution**Concept:**

In the Bohr model of hydrogen atom, the electron moves in a circular orbit under electrostatic attraction.

For an electron in a bound orbit, the total energy is negative.

The kinetic energy and total energy are related as: $K = -E$

Also, for a hydrogen atom: $E = -\frac{K}{1}$

Therefore, the ratio of kinetic energy to total energy is: $K : E = 1 : -1$

Solution:

For an electron revolving around the nucleus in the Bohr model, electrostatic force provides centripetal force.

The potential energy of the electron is: $U = -\frac{ke^2}{r}$

The kinetic energy is: $K = \frac{ke^2}{2r}$

Now compare potential energy and kinetic energy: $U = -2K$

Total energy is: $E = K + U$

Substitute $U = -2K$: $E = K - 2K$

$E = -K$

Therefore: $K = -E$

So, the ratio of kinetic energy to total energy is: $K : E = K : (-K)$

$K : E = 1 : -1$

This relation is valid for every quantum state n in the Bohr model of hydrogen atom.

Final Answer: The ratio of kinetic energy to total energy is $1 : -1$.

Answer: (B)



Q42.

Solution**Concept:**

A displacement of the form: $x = a \sin \omega t + b \cos \omega t$
represents simple harmonic motion.

It can be written as a single sine function: $x = A \sin(\omega t + \phi)$

where A is the amplitude.

For such a combination, the amplitude is: $A = \sqrt{a^2 + b^2}$

Solution:

Given displacement is: $x = a \sin(\omega t) + b \cos(\omega t)$

Let this be written in the form: $x = A \sin(\omega t + \phi)$

Using expansion: $A \sin(\omega t + \phi) = A \sin \omega t \cos \phi + A \cos \omega t \sin \phi$

Compare with: $x = a \sin \omega t + b \cos \omega t$

Therefore: $a = A \cos \phi$

and: $b = A \sin \phi$

Now square and add both equations: $a^2 + b^2 = A^2 \cos^2 \phi + A^2 \sin^2 \phi$

$a^2 + b^2 = A^2(\cos^2 \phi + \sin^2 \phi)$

Since: $\cos^2 \phi + \sin^2 \phi = 1$

we get: $a^2 + b^2 = A^2$

Therefore: $A = \sqrt{a^2 + b^2}$

Final Answer: The amplitude of the SHM is $\sqrt{a^2 + b^2}$.

Answer: (C)



Q43.

Solution**Concept:**

An equipotential surface is a surface on which electric potential is the same at every point.

Work done in moving a charge from one point to another is: $W = q\Delta V$

On an equipotential surface: $\Delta V = 0$

Solution:

The charge being moved is a unit positive charge.

So: $q = 1$

Work done in moving a charge between two points is: $W = q(V_B - V_A)$

On an equipotential surface, both points have the same potential.

Therefore: $V_B = V_A$

Hence: $V_B - V_A = 0$

So: $W = q \times 0$

$W = 0$

Thus, no work is done in moving a charge along an equipotential surface.

This is because the electric field is always perpendicular to an equipotential surface, so the force has no component along the displacement on the surface.

Final Answer: The work done is zero.

Answer: (C)



Q44.

Solution**Concept:**

Weight of a body at height h above the surface of Earth is proportional to acceleration due to gravity at that height.

Acceleration due to gravity at height h is: $g_h = g \left(\frac{R}{R+h}\right)^2$

Therefore, weight at height h is: $W_h = W \left(\frac{R}{R+h}\right)^2$

Solution:

Weight on Earth's surface is: $W = 72 \text{ N}$

Height above surface is: $h = \frac{R}{2}$

Using the formula: $W_h = W \left(\frac{R}{R+h}\right)^2$

Substitute $h = \frac{R}{2}$: $W_h = 72 \left(\frac{R}{R+\frac{R}{2}}\right)^2$

Simplify the denominator: $R + \frac{R}{2} = \frac{3R}{2}$

Therefore: $W_h = 72 \left(\frac{R}{\frac{3R}{2}}\right)^2$

$$W_h = 72 \left(\frac{2}{3}\right)^2$$

$$W_h = 72 \times \frac{4}{9}$$

$$W_h = 8 \times 4$$

$$W_h = 32 \text{ N}$$

Hence, the weight decreases to 32 N at height $\frac{R}{2}$ from the surface.

Final Answer: The weight at height $\frac{R}{2}$ is 32 N.

Answer: (A)

Q45.

Solution**Concept:**

According to Stefan-Boltzmann law, the power radiated per unit area by a black body is: $E = \sigma T^4$ where σ is Stefan's constant.

Here, E has unit of power per unit area: W m^{-2}

Temperature is measured in Kelvin.

Solution:

Stefan-Boltzmann law is: $E = \sigma T^4$

Rearrange for Stefan's constant: $\sigma = \frac{E}{T^4}$

The unit of E is: W m^{-2}

The unit of T^4 is: K^4

Therefore, the unit of σ is: $\frac{\text{W m}^{-2}}{\text{K}^4}$

So: $\sigma = \text{W m}^{-2} \text{K}^{-4}$

Thus, Stefan's constant has unit watt per square metre per fourth power of Kelvin.

Final Answer: The unit of Stefan's constant is $\text{W m}^{-2} \text{K}^{-4}$.

Answer: (A)



Q46.

Solution**Concept:**

For a metallic wire, Ohm's law gives: $\frac{V}{l} = R$

The ratio $\frac{V}{l}$ represents the resistance of the wire.

For metals, resistance increases with increase in temperature because lattice vibrations increase and obstruct the motion of free electrons.

Solution:

The given ratio is: $\frac{V}{l}$

By Ohm's law: $V = IR$

Therefore: $\frac{V}{l} = R$

So, the ratio $\frac{V}{l}$ is the resistance of the metallic wire.

For a metallic conductor, resistance varies with temperature as: $R = R_0(1 + \alpha\Delta T)$

For metals, temperature coefficient of resistance α is positive.

Therefore, when temperature rises, resistance increases.

Hence, the ratio $\frac{V}{l}$ also increases as temperature rises.

Final Answer: The ratio $\frac{V}{l}$ increases as temperature rises.

Answer: (B)

Q47.

Solution**Concept:**

For an astronomical telescope focused for distinct vision, the magnifying power is: $M = \frac{f_o}{f_e} \left(1 + \frac{f_e}{D}\right)$

where f_o is focal length of objective, f_e is focal length of eyepiece, and $D = 25$ cm is the least distance of distinct vision.

Solution:

Focal length of objective is: $f_o = 150$ cm

Focal length of eyepiece is: $f_e = 5$ cm

Least distance of distinct vision is: $D = 25$ cm

Magnifying power for distinct vision is: $M = \frac{f_o}{f_e} \left(1 + \frac{f_e}{D}\right)$

Substitute the values: $M = \frac{150}{5} \left(1 + \frac{5}{25}\right)$

$$M = 30 \left(1 + \frac{1}{5}\right)$$

$$M = 30 \left(\frac{6}{5}\right)$$

$$M = 36$$

Therefore, the magnifying power of the telescope is 36.

Final Answer: The magnifying power is 36.

Answer: (B)



Q48.

Solution**Concept:**

Ultrasonic waves are sound waves having frequency greater than 20,000 Hz.

Sound waves are mechanical waves, so they need a material medium for propagation.

Therefore, ultrasonic waves cannot travel through vacuum.

Solution:

Ultrasonic waves have very high frequency, greater than the audible range of human ears.

In gases and liquids, ultrasonic waves are generally longitudinal waves.

They can undergo reflection, refraction, and absorption, just like ordinary sound waves.

However, ultrasonic waves are mechanical waves.

Mechanical waves require a material medium to travel.

Vacuum has no particles to transmit mechanical vibrations.

Therefore, ultrasonic waves cannot travel through vacuum.

Thus, the statement "They can travel through vacuum" is not a property of ultrasonic waves.

Final Answer: The statement that ultrasonic waves can travel through vacuum is not a property of ultrasonic waves.

Answer: (B)

Q49.

Solution**Concept:**

For a transistor, current gains α and β are related by: $\beta = \frac{\alpha}{1-\alpha}$

where α is common base current gain and β is common emitter current gain.

Solution:

Given current gain is: $\alpha = 0.98$

Using the relation: $\beta = \frac{\alpha}{1-\alpha}$

Substitute the value: $\beta = \frac{0.98}{1-0.98}$

$$\beta = \frac{0.98}{0.02}$$

$$\beta = 49$$

Therefore, the value of common emitter current gain is 49.

Final Answer: The value of β is 49.

Answer: (A)

Q50.

Solution**Concept:**

For a Carnot engine, efficiency is: $\eta = 1 - \frac{T_2}{T_1}$

where T_1 is source temperature and T_2 is sink temperature, both in Kelvin.

If sink temperature is reduced while source temperature remains constant, efficiency increases.

Solution:

Initial efficiency is: $\eta_1 = \frac{1}{6}$

So: $\frac{1}{6} = 1 - \frac{T_2}{T_1}$

Therefore: $\frac{T_2}{T_1} = 1 - \frac{1}{6} = \frac{5}{6}$

So: $T_2 = \frac{5T_1}{6}$

When the sink temperature is reduced by 62°C , the reduction in Kelvin is also 62 K.

New sink temperature is: $T'_2 = T_2 - 62$

Efficiency is doubled: $\eta_2 = \frac{2}{6} = \frac{1}{3}$

Using Carnot efficiency again: $\frac{1}{3} = 1 - \frac{T'_2}{T_1}$

Therefore: $\frac{T'_2}{T_1} = 1 - \frac{1}{3} = \frac{2}{3}$

So: $T'_2 = \frac{2T_1}{3}$

Now: $T_2 - T'_2 = 62$

Substitute values: $\frac{5T_1}{6} - \frac{2T_1}{3} = 62$

Write with common denominator 6: $\frac{5T_1}{6} - \frac{4T_1}{6} = 62$

$\frac{T_1}{6} = 62$

$T_1 = 372 \text{ K}$

Convert source temperature into Celsius: $T_1 = 372 - 273$

$T_1 = 99^\circ\text{C}$

Final Answer: The temperature of the source is 99°C .

Answer: (D)



Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	A	4	C	5	A
6	B	7	A	8	C	9	B	10	A
11	A	12	B	13	C	14	A	15	B
16	A	17	C	18	B	19	A	20	A
21	D	22	B	23	C	24	B	25	A
26	C	27	B	28	C	29	A	30	A
31	B	32	A	33	A	34	B	35	B
36	B	37	A	38	A	39	A	40	B
41	B	42	C	43	C	44	A	45	A
46	B	47	B	48	B	49	A	50	D

