MHT-CET Physics Sample Paper-9

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 uniform solid disc of mass 2 kg and radius 0.20 m rotates about its central axis with angular speed 30 rad s^{-1}. Its rotational kinetic energy is:

(A) 18 J

(B) 9 J

(C) 36 J

(D) 4.5 J

Q2. A wheel starts from rest and reaches angular speed 40 rad s^{-1} in 8 s under uniform angular acceleration. The angular displacement covered in this time is:

(A) 80 rad

(B) 160 rad

(C) 320 rad

(D) 40 rad

Q3. A solid sphere rolls without slipping down an inclined plane of angle θ. Its acceleration along the plane is:

(A) $g \sin\theta$

(B) $\frac{5}{7} g \sin\theta$

(C) $\frac{2}{5}g\sin\theta$

(D) $\frac{7}{5}g\sin\theta$

Q4. A constant torque of $12\,\text{N m}$ acts on a body of moment of inertia $3\,\text{kg m}^2$. The angular acceleration produced is:

(A) $2\,\text{rad s}^{-2}$

(B) $3\,\text{rad s}^{-2}$

(C) $4\,\text{rad s}^{-2}$

(D) $36\,\text{rad s}^{-2}$

Q5. A particle executes SHM with amplitude $5\,\text{cm}$ and angular frequency $4\,\text{rad s}^{-1}$. Its maximum acceleration is:

(A) $20\,\text{cm s}^{-2}$

(B) $40\,\text{cm s}^{-2}$

(C) $80\,\text{cm s}^{-2}$

(D) $100\,\text{cm s}^{-2}$

Q6. If the length of a simple pendulum is made four times its original length, its time period becomes:

(A) Half

(B) Two times

(C) Four times

(D) Unchanged

Q7. Two tuning forks produce 6 beats per second. If one tuning fork has frequency 512 Hz, the possible frequency of the other tuning fork is:

(A) 506 Hz only

(B) 518 Hz only

(C) 506 Hz or 518 Hz

(D) 512 Hz

Q8. The speed of a transverse wave on a stretched string is doubled when:

(A) Tension is doubled

(B) Tension is made four times

(C) Linear density is doubled

(D) Linear density is made four times

Q9. Two charges $+4\,\mu$C and $-4\,\mu$C are separated by 2 cm. The magnitude of electric dipole moment is:

(A) 8×10^{-8} C m

(B) 4×10^{-8} C m

(C) 2×10^{-8} C m

(D) 8×10^{-6} C m

Q10. A point charge produces electric potential V at distance r. At distance $2r$, the potential becomes:

(A) $V/4$

(B) $V/2$

(C) $2V$

(D) $4V$

Q11. Two capacitors of capacitances $3\,\mu$F and $6\,\mu$F are connected in series. Their equivalent capacitance is:

(A) $2\,\mu$F

(B) $4\,\mu$F

(C) $9\,\mu$F

(D) $18\,\mu$F

Q12. The electric field inside a charged conducting sphere in electrostatic equilibrium is:

(A) Maximum at centre

(B) Zero everywhere inside

(C) Inversely proportional to distance

(D) Same as field at surface

Q13. A wire carries current 2 A for 5 min. The charge flowing through the wire is:

(A) 10 C

(B) 100 C

(C) 300 C

(D) 600 C

Q14. Three resistors of 6 Ω each are connected in parallel. The equivalent resistance is:

(A) 18 Ω

(B) 6 Ω

(C) 3 Ω

(D) 2 Ω

Q15. A heater rated 1000 W is used for 2 h. The electrical energy consumed is:

(A) 0.5 kWh

(B) 1 kWh

(C) 2 kWh

(D) 4 kWh

Q16. A cell of emf 12 V and internal resistance 1 Ω is connected to an external resistance 5 Ω. The terminal voltage is:

(A) 10 V

(B) 12 V

(C) 2 V

(D) 11 V

Q17. A charge q moves with speed v perpendicular to a uniform magnetic field B. The magnitude of magnetic force acting on it is:

(A) qvB

(B) qv/B

(C) qB/v

(D) Zero

Q18. A moving coil galvanometer is converted into an ammeter by connecting:

(A) High resistance in series

(B) Low resistance in parallel

(C) High resistance in parallel

(D) Low resistance in series

Q19. The magnetic field at the centre of a circular coil of radius R carrying current I is B. If current is doubled and radius is halved, the new magnetic field is:

(A) B

(B) $2B$

(C) $4B$

(D) $B/2$

Q20. A magnetic needle is placed in a uniform magnetic field. It experiences maximum torque when its magnetic moment makes an angle of:

(A) $0°$

(B) $30°$

(C) $90°$

(D) 180°

Q21. Magnetic flux through a coil changes from 0.20 Wb to 0.05 Wb in 0.03 s. The magnitude of induced emf is:

(A) 2 V

(B) 5 V

(C) 10 V

(D) 15 V

Q22. In an AC circuit, rms current is 5 A. The peak current is:

(A) 5 A

(B) $5/\sqrt{2}$ A

(C) $5\sqrt{2}$ A

(D) 10 A

Q23. An ideal transformer has $N_p = 1000$ turns and $N_s = 250$ turns. If input voltage is 240 V, output voltage is:

(A) 60 V

(B) 120 V

(C) 480 V

(D) 960 V

Q24. A concave mirror forms an image at its centre of curvature when the object is placed:

(A) At focus

(B) At centre of curvature

(C) Between focus and pole

(D) At infinity

Q25. A ray of light is incident normally on a glass slab. The angle of refraction is:

(A) 0°

(B) 30°

(C) 45°

(D) 90°

Q26. In Young's double slit experiment, if wavelength of light is doubled while slit separation and screen distance remain unchanged, the fringe width becomes:

(A) Half

(B) Double

(C) Four times

(D) Unchanged

Q27. A convex lens has focal length 25 cm. Its power is:

(A) +2 D

(B) +4 D

(C) −4 D

(D) −2 D

Q28. For single slit diffraction, the angular width of the central maximum is approximately proportional to:

(A) a/λ

(B) λ/a

(C) $a\lambda$

(D) $1/(a\lambda)$

Q29. For an ideal gas heated at constant volume, the heat supplied is used to:

(A) Do external work only

(B) Increase internal energy only

(C) Decrease internal energy

(D) Keep temperature constant

Q30. The average translational kinetic energy of one molecule of an ideal gas at absolute temperature T is:

(A) kT

(B) $\frac{1}{2}kT$

(C) $\frac{3}{2}kT$

(D) $3kT$

Q31. A heat engine absorbs 600 J heat and rejects 450 J heat. Its efficiency is:

(A) 15%

(B) 20%

(C) 25%

(D) 75%

Q32. A photon has energy 3.3×10^{-19} J. If $h = 6.6 \times 10^{-34}$ J s, its frequency is:

(A) 5×10^{14} Hz

(B) 2×10^{14} Hz

(C) 1×10^{15} Hz

(D) 3.3×10^{14} Hz

Q33. In the hydrogen atom, the energy of the electron in the $n = 2$ orbit is:

(A) -13.6 eV

(B) -6.8 eV

(C) -3.4 eV

(D) -1.51 eV

Q34. The half-life of a radioactive sample is 10 days. The fraction of sample remaining after 30 days is:

(A) 1/2

(B) 1/4

(C) 1/8

(D) 1/16

Q35. The de Broglie wavelength of a particle is inversely proportional to its:

(A) Mass only

(B) Momentum

(C) Velocity only

(D) Kinetic energy

Q36. In beta-minus decay, the atomic number of the nucleus:

(A) Decreases by 1

(B) Increases by 1

(C) Decreases by 2

(D) Remains unchanged

Q37. A body starts from rest and moves with uniform acceleration $2\,\text{m s}^{-2}$. Distance covered in 5 s is:

(A) 10 m

(B) 25 m

(C) 50 m

(D) 5 m

Q38. A force of 20 N acts on a body of mass 4 kg. The acceleration produced is:

(A) $2\,\text{m s}^{-2}$

(B) $4\,\text{m s}^{-2}$

(C) $5\,\text{m s}^{-2}$

(D) $80\,\text{m s}^{-2}$

Q39. For a projectile fired with fixed speed, horizontal range is maximum when angle of projection is:

(A) 30°

(B) 45°

(C) 60°

(D) 90°

Q40. A body of mass 2 kg moves with speed $3\,\text{m s}^{-1}$. Its kinetic energy is:

(A) 3 J

(B) 6 J

(C) 9 J

(D) 18 J

Q41. A pump lifts 100 kg of water through height 5 m in 10 s. Taking $g = 10\,\text{m s}^{-2}$, the power of the pump is:

(A) 50 W

(B) 500 W

(C) 1000 W

(D) 5000 W

Q42. Acceleration due to gravity at a height equal to Earth's radius above Earth's surface is:

(A) g

(B) $g/2$

(C) $g/4$

(D) $2g$

Q43. The orbital speed of a satellite very close to Earth's surface is approximately:

(A) $\sqrt{gR}$

(B) $\sqrt{2gR}$

(C) gR

(D) $2\sqrt{gR}$

Q44. A wire of length 2 m extends by 1 mm under a load. The longitudinal strain is:

(A) 5×10^{-4}

(B) 2×10^{-3}

(C) 1×10^{-3}

(D) 5×10^{-3}

Q45. The excess pressure inside a soap bubble of radius r and surface tension T is:

(A) $2T/r$

(B) $4T/r$

(C) T/r

(D) $8T/r$

Q46. The dimensional formula of Planck's constant is:

(A) ML^2T^{-1}

(B) MLT^{-2}

(C) ML^2T^{-2}

(D) $M^0L^0T^0$

Q47. If percentage errors in measuring A and B are 2% and 3% respectively, the percentage error in $Q = A^2B$ is:

(A) 5%

(B) 7%

(C) 8%

(D) 12%

Q48. In an intrinsic semiconductor at room temperature, the number of electrons and holes are:

(A) Equal

(B) Electrons more than holes

(C) Holes more than electrons

(D) Both zero

Q49. A p-type semiconductor is obtained by doping silicon with:

(A) Phosphorus

(B) Arsenic

(C) Boron

(D) Antimony

Q50. In amplitude modulation, if the modulating signal frequency is 4 kHz, the bandwidth required is:

(A) 2 kHz

(B) 4 kHz

(C) 8 kHz

(D) 16 kHz

Detailed Solutions

Q1.

Solution

Concept:
Rotational kinetic energy and moment of inertia of a disc.

Solution:

Step 1: Rotational kinetic energy is the energy possessed by a rotating rigid body. The formula is $K = \frac{1}{2}I\omega^2$, where I is moment of inertia and ω is angular speed.

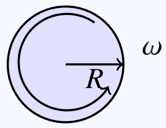
Step 2: For a uniform solid disc rotating about its own central axis, $I = \frac{1}{2}MR^2$. This is important because many students wrongly use MR^2, which is for a ring.

Step 3: Substitute $M = 2$ kg and $R = 0.20$ m: $I = \frac{1}{2} \times 2 \times (0.20)^2 = 0.04$ kg m^2.

Step 4: Now $K = \frac{1}{2} \times 0.04 \times (30)^2 = 0.02 \times 900 = 18$ J.

Step 5: Option B would result if another extra factor of $\frac{1}{2}$ is mistakenly applied. Option C comes from forgetting the $\frac{1}{2}$ in kinetic energy. Hence option A is correct.

Exam Insight:
CET often checks whether you remember the correct moment of inertia for disc, ring, sphere, and rod.



Uniform disc rotating about central axis

Final Answer:

$$\boxed{18\,\text{J}}$$

Answer: (A)

Q2.

Solution

Concept:
Angular kinematics under uniform angular acceleration.

Solution:

Step 1: The motion is rotational with constant angular acceleration, so rotational equations are exactly analogous to linear kinematics.

Step 2: Initial angular velocity is $\omega_0 = 0$ because the wheel starts from rest, and final angular velocity is $\omega = 40\,\text{rad s}^{-1}$.

Step 3: For uniform angular acceleration, average angular speed is $\omega_{avg} = \frac{\omega_0+\omega}{2} = \frac{0+40}{2} = 20\,\text{rad s}^{-1}$.

Step 4: Angular displacement is $\theta = \omega_{avg}t = 20 \times 8 = 160\,\text{rad}$.

Step 5: Option C is obtained if final angular speed is multiplied directly by time, which ignores that the wheel starts from rest. Option A comes from taking half of the correct time effect.

Exam Insight:
When motion starts from rest and acceleration is uniform, average speed is half the final speed.

Final Answer:

$$\boxed{160\,\text{rad}}$$

Answer: (B)

Q3.

Solution

Concept:
Rolling acceleration of a rigid body on an inclined plane.

Solution:

Step 1: For a body rolling without slipping, part of gravitational potential energy goes into translational kinetic energy and part into rotational kinetic energy. Hence acceleration is less than pure sliding acceleration.

Step 2: The general formula is $a = \frac{g\sin\theta}{1+I/(MR^2)}$.

Step 3: For a solid sphere, moment of inertia about its centre is $I = \frac{2}{5}MR^2$. Therefore $I/(MR^2) = 2/5$.

Step 4: Substituting this value gives $a = \frac{g\sin\theta}{1+2/5} = \frac{g\sin\theta}{7/5} = \frac{5}{7}g\sin\theta$.

Step 5: Option A is for frictionless sliding, not rolling. Option D is greater than $g\sin\theta$, which is physically impossible for rolling down an incline without an external push.

Exam Insight:
For rolling objects, smaller $I/(MR^2)$ means larger acceleration.

Final Answer:

$$\boxed{\frac{5}{7}g\sin\theta}$$

Answer: (B)

Q4.

Solution

Concept:

Rotational form of Newton's second law.

Solution:

Step 1: In rotational dynamics, torque plays the role of force and moment of inertia plays the role of mass.

Step 2: The relation is $\tau = I\alpha$, where α is angular acceleration.

Step 3: Given $\tau = 12\,\text{N m}$ and $I = 3\,\text{kg m}^2$.

Step 4: Therefore $\alpha = \frac{\tau}{I} = \frac{12}{3} = 4\,\text{rad s}^{-2}$.

Step 5: Option D is obtained by multiplying torque and moment of inertia, but the law requires division. The unit rad s^{-2} confirms that option C is correct.

Exam Insight:

Remember: $F = ma$ corresponds to $\tau = I\alpha$.

Final Answer:

$$\boxed{4\,\text{rad s}^{-2}}$$

Answer: (C)

Q5.

Solution

Concept:

Maximum acceleration in simple harmonic motion.

Solution:

Step 1: In SHM, acceleration is directly proportional to displacement from mean position and opposite in direction: $a = -\omega^2 x$.

Step 2: The magnitude of acceleration is maximum at extreme position because displacement is maximum there.

Step 3: Given amplitude $A = 5\,\text{cm}$ and angular frequency $\omega = 4\,\text{rad s}^{-1}$.

Step 4: So $a_{max} = \omega^2 A = 4^2 \times 5 = 16 \times 5 = 80\,\text{cm s}^{-2}$.

Step 5: Option A represents $A\omega$, which is maximum velocity, not maximum acceleration. This is a common SHM trap.

Exam Insight:

In SHM, $v_{max} = A\omega$ but $a_{max} = A\omega^2$.

Final Answer:

$$\boxed{80\,\text{cm s}^{-2}}$$

Answer: (C)

Q6.

Solution

Concept:

Dependence of pendulum time period on length.

Solution:

Step 1: The time period of a simple pendulum for small oscillations is $T = 2\pi\sqrt{l/g}$.

Step 2: This formula shows that T is proportional to $\sqrt{l}$, not directly proportional to l.

Step 3: If the new length is $l' = 4l$, then $T' = 2\pi\sqrt{4l/g}$.

Step 4: Taking square root gives $T' = 2 \times 2\pi\sqrt{l/g} = 2T$.

Step 5: Option C is a common mistake caused by assuming $T \propto l$. Correct relation is $T \propto \sqrt{l}$.

Exam Insight:

Whenever a quantity is inside square root, its multiplication effect becomes square-rooted.

Final Answer:

$$\boxed{2T}$$

Answer: (B)

Q7.

Solution

Concept:

Beat frequency produced by two close frequencies.

Solution:

Step 1: Beats are produced when two sound waves of slightly different frequencies superpose.

Step 2: The beat frequency is equal to the absolute difference of the two frequencies: $f_b = |f_1 - f_2|$.

Step 3: Here $f_b = 6\,\text{Hz}$ and one fork has frequency $512\,\text{Hz}$, so $|f - 512| = 6$.

Step 4: This gives two possible values: $f = 512 + 6 = 518\,\text{Hz}$ or $f = 512 - 6 = 506\,\text{Hz}$.

Step 5: Without extra information such as loading wax on one fork, both frequencies are possible. Therefore option C is correct.

Exam Insight:

Beat problems usually have two possible answers unless a frequency-increase/decrease condition is given.

Final Answer:

$$\boxed{506\,\text{Hz or } 518\,\text{Hz}}$$

Answer: (C)

Q8.

Solution

Concept:

Wave speed on a stretched string.

Solution:

Step 1: The speed of transverse wave on a stretched string is $v = \sqrt{T/\mu}$, where T is tension and μ is linear mass density.

Step 2: If only tension changes, then $v \propto \sqrt{T}$.

Step 3: To double the speed, we need $v' = 2v$.

Step 4: Since speed depends on square root of tension, $2v = \sqrt{T'/T}\, v$, so $T'/T = 4$.

Step 5: Thus tension must be made four times. Doubling tension gives only $\sqrt{2}$ times speed, not double.

Exam Insight:

Square-root relations are common in waves, pendulum, and kinetic theory.

Final Answer:

$$\boxed{T' = 4T}$$

Answer: (B)

Q9.

Solution

Concept:

Electric dipole moment.

Solution:

Step 1: An electric dipole consists of two equal and opposite charges separated by a small distance.

Step 2: The magnitude of dipole moment is $p = q \times d$, where d is the separation between the two charges.

Step 3: Here $q = 4 \times 10^{-6}\,\text{C}$ and $d = 2\,\text{cm} = 2 \times 10^{-2}\,\text{m}$.

Step 4: Therefore $p = 4 \times 10^{-6} \times 2 \times 10^{-2} = 8 \times 10^{-8}\,\text{C m}$.

Step 5: Option D comes from not converting centimetre into metre. Unit conversion is the key trap in this CET-type numerical.

Exam Insight:

Always convert microcoulomb and centimetre into SI units before multiplying.

Final Answer:

$$\boxed{8 \times 10^{-8}\,\text{C m}}$$

Answer: (A)

Q10.

Solution

Concept:

Electric potential due to a point charge.

Solution:

Step 1: Electric potential due to a point charge is $V = \frac{kq}{r}$.

Step 2: Potential is inversely proportional to distance r, unlike electric field which is inversely proportional to r^2.

Step 3: When the distance becomes $2r$, new potential is $V' = \frac{kq}{2r}$.

Step 4: So $V' = \frac{1}{2}\frac{kq}{r} = V/2$.

Step 5: Option A confuses potential with electric field. This distinction is frequently tested in MHT-CET.

Exam Insight:

Potential varies as $1/r$; electric field varies as $1/r^2$.

Final Answer:

$$\boxed{\frac{V}{2}}$$

Answer: (B)

Q11.

Solution

Concept:

Series combination of capacitors.

Solution:

Step 1: For capacitors in series, charge on each capacitor is the same but potential difference divides.

Step 2: The reciprocal formula is $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$.

Step 3: Substitute $C_1 = 3\,\mu$F and $C_2 = 6\,\mu$F: $\frac{1}{C_{eq}} = \frac{1}{3} + \frac{1}{6} = \frac{1}{2}$.

Step 4: Thus $C_{eq} = 2\,\mu$F.

Step 5: In series, equivalent capacitance must be less than the smallest capacitor. Since $2 < 3$, the answer is physically reasonable.

Exam Insight:

For two capacitors in series, use $C = \frac{C_1C_2}{C_1+C_2}$ for speed.

Final Answer:

$$\boxed{2\,\mu\text{F}}$$

Answer: (A)

Q12.

Solution

Concept:

Electrostatic shielding and conductors.

Solution:

Step 1: In a conductor, free charges can move easily under the influence of electric field.

Step 2: In electrostatic equilibrium, charges must be at rest. Therefore the electric field inside the conducting material must be zero.

Step 3: Any excess charge given to a conductor resides on its outer surface.

Step 4: Hence the electric field inside a charged conducting sphere is zero everywhere inside.

Step 5: Options A, C and D would be possible for non-conducting charge distributions, but not for a conductor in electrostatic equilibrium.

Exam Insight:

Inside a conductor at electrostatic equilibrium, $E = 0$ is a standard one-line CET concept.

Final Answer:

$$\boxed{0}$$

Answer: (B)

Q13.

Solution

Concept:

Current as rate of flow of charge.

Solution:

Step 1: Current is defined as charge flowing per unit time: $I = Q/t$.

Step 2: Rearranging, total charge is $Q = It$.

Step 3: Given current is 2 A and time is 5 min $= 5 \times 60 = 300$ s.

Step 4: Therefore $Q = 2 \times 300 = 600$ C.

Step 5: Option A comes from multiplying 2 by 5 without converting minutes into seconds, which is the common error.

Exam Insight:

Ampere means coulomb per second, so time must be in seconds.

Final Answer:

$$\boxed{600\,\text{C}}$$

Answer: (D)

Q14.

Solution

Concept:

Parallel combination of equal resistors.

Solution:

Step 1: When resistors are connected in parallel, voltage across each resistor is the same, but current divides.

Step 2: For n identical resistors each of resistance R, equivalent resistance is R/n.

Step 3: Here $R = 6\,\Omega$ and $n = 3$, so $R_{eq} = 6/3 = 2\,\Omega$.

Step 4: Equivalent resistance in parallel is always less than the smallest individual resistance, so $2\,\Omega$ is sensible.

Step 5: Option A is the value for series combination, not parallel combination.

Exam Insight:

Equal resistors in parallel: directly divide resistance by number of resistors.

Final Answer:

$$\boxed{2\,\Omega}$$

Answer: (D)

Q15.

Solution

Concept:

Electrical power and commercial energy unit.

Solution:

Step 1: Electrical energy consumed is the product of power and time: $E = Pt$.

Step 2: Power rating 1000 W means 1 kW.

Step 3: The appliance is used for 2 h.

Step 4: So $E = 1\,\text{kW} \times 2\,\text{h} = 2\,\text{kWh}$.

Step 5: In electricity billing, 1 kWh is called one unit. Hence the heater consumes 2 units.

Exam Insight:

For domestic energy questions, convert watt into kilowatt and keep time in hours.

Final Answer:

$$\boxed{2\,\text{kWh}}$$

Answer: (C)

Q16.

Solution

Concept:
Terminal voltage of a cell with internal resistance.

Solution:

Step 1: When current is drawn from a cell, some voltage is lost across internal resistance. Hence terminal voltage is less than emf.

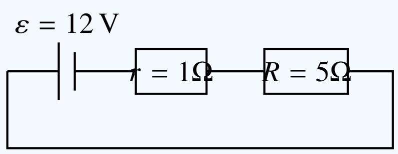
Step 2: Total resistance in the circuit is $R + r = 5 + 1 = 6\,\Omega$.

Step 3: Current supplied by the cell is $I = \frac{\varepsilon}{R+r} = \frac{12}{6} = 2\,\text{A}$.

Step 4: Terminal voltage across external resistance is $V = IR = 2 \times 5 = 10\,\text{V}$. It also equals $\varepsilon - Ir = 12 - 2 = 10\,\text{V}$.

Step 5: Option B is emf, not terminal voltage. The difference appears because internal resistance is present.

Exam Insight:
Terminal voltage during discharge is $V = \varepsilon - Ir$.



Terminal voltage is across external resistance

Final Answer:

$$\boxed{10\,\text{V}}$$

Answer: (A)

Q17.

Solution

Concept:
Magnetic Lorentz force.

Solution:

Step 1: The magnetic force on a moving charge is given by $F = qvB\sin\theta$.

Step 2: Here the velocity is perpendicular to the magnetic field, so $\theta = 90^\circ$.

Step 3: Since $\sin 90^\circ = 1$, the force becomes $F = qvB$.

Step 4: The force is maximum in this case because velocity and magnetic field are perpendicular.

Step 5: Option D would be correct only if velocity were parallel or antiparallel to the magnetic field.

Exam Insight:
Magnetic force is zero for parallel motion and maximum for perpendicular motion.

Final Answer:

$$\boxed{qvB}$$

Answer: (A)

Q18.

Solution

Concept:
Conversion of galvanometer into ammeter.

Solution:

Step 1: An ammeter is connected in series in a circuit, so it must have very low resistance.

Step 2: A galvanometer is sensitive and cannot allow large current through it directly.

Step 3: To convert it into an ammeter, a low resistance called shunt is connected in parallel with the galvanometer.

Step 4: Most of the current passes through the shunt and only a small safe current passes through the galvanometer.

Step 5: High resistance in series is used to convert a galvanometer into a voltmeter, not an ammeter.

Exam Insight:
Ammeter needs low resistance; voltmeter needs high resistance.

Final Answer:

$$\boxed{\text{Low resistance in parallel}}$$

Answer: (B)

Q19.

Solution

Concept:
Magnetic field at centre of a circular current loop.

Solution:

Step 1: Magnetic field at the centre of a circular coil is $B = \frac{\mu_0 I}{2R}$ for one turn.

Step 2: This shows $B \propto I$ and $B \propto \frac{1}{R}$.

Step 3: When current is doubled, magnetic field becomes twice.

Step 4: When radius is halved, magnetic field again becomes twice because it is inversely proportional to radius.

Step 5: Combined effect is $2 \times 2 = 4$, so new field is $4B$.

Exam Insight:
For proportionality questions, treat each change separately and multiply the factors.

Final Answer:

$$\boxed{4B}$$

Answer: (C)

Q20.

Solution

Concept:
Torque on a magnetic dipole in uniform magnetic field.

Solution:

Step 1: A magnetic dipole in a uniform magnetic field experiences torque given by $\tau = MB\sin\theta$.

Step 2: Here M is magnetic moment and θ is angle between magnetic moment and magnetic field.

Step 3: Torque is maximum when $\sin\theta$ has maximum value.

Step 4: The maximum value of sine is 1, which occurs at $\theta = 90^\circ$.

Step 5: At 0° and 180°, torque is zero because the dipole is aligned or anti-aligned with the field.

Exam Insight:
Maximum torque on dipole occurs when dipole moment is perpendicular to field.

Final Answer:

$$\boxed{90^\circ}$$

Answer: (C)

Q21.

Solution

Concept:
Faraday's law of electromagnetic induction.
Solution:
Step 1: According to Faraday's law, induced emf is equal to rate of change of magnetic flux.
Step 2: For magnitude, $e = \left|\frac{\Delta\Phi}{\Delta t}\right|$.
Step 3: Change in flux is $|0.05 - 0.20| = 0.15\,\text{Wb}$.
Step 4: Time interval is $0.03\,\text{s}$, so $e = 0.15/0.03 = 5\,\text{V}$.
Step 5: The negative sign in Faraday's law represents Lenz's law direction; since magnitude is asked, we take positive value.
Exam Insight:
In EMI numericals, first calculate magnitude of flux change.
Final Answer:

$$\boxed{5\,\text{V}}$$

Answer: (B)

Q22.

Solution

Concept:
Relation between rms and peak value of AC.
Solution:
Step 1: For sinusoidal alternating current, rms current is related to peak current by $I_{rms} = \frac{I_0}{\sqrt{2}}$.
Step 2: RMS value is the effective DC-equivalent value that produces the same heating effect.
Step 3: Given $I_{rms} = 5\,\text{A}$.
Step 4: Therefore $I_0 = I_{rms}\sqrt{2} = 5\sqrt{2}\,\text{A}$.
Step 5: Option B reverses the relation. Peak value must be larger than rms value.
Exam Insight:
Peak value = rms value $\times\sqrt{2}$ for sinusoidal AC.
Final Answer:

$$\boxed{5\sqrt{2}\,\text{A}}$$

Answer: (C)

Q23.

Solution

Concept:
Voltage transformation in an ideal transformer.

Solution:

Step 1: For an ideal transformer, voltage ratio equals turns ratio: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$.

Step 2: Given $N_p = 1000$ and $N_s = 250$, so $\frac{N_s}{N_p} = \frac{250}{1000} = \frac{1}{4}$.

Step 3: Input voltage is $V_p = 240$ V.

Step 4: Thus $V_s = 240 \times \frac{1}{4} = 60$ V.

Step 5: Since secondary turns are fewer than primary turns, it is a step-down transformer.

Exam Insight:
In ideal transformers, fewer secondary turns means lower secondary voltage.

Final Answer:

$$\boxed{60\text{ V}}$$

Answer: (A)

Q24.

Solution

Concept:
Image formation by a concave mirror.

Solution:

Step 1: For a concave mirror, the centre of curvature is at a distance $2f$ from the pole.

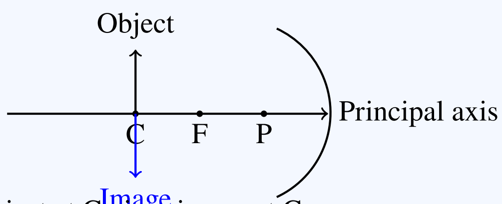
Step 2: When an object is placed at the centre of curvature, reflected rays meet again at the centre of curvature.

Step 3: The image formed is real, inverted, and of the same size as the object.

Step 4: If the object were at focus, the image would form at infinity. If at infinity, image would form at focus.

Step 5: Therefore the object must be placed at the centre of curvature.

Exam Insight:
For concave mirror: object at C gives image at C, same size.



Object at C gives image at C

Final Answer:

$$\boxed{\text{At centre of curvature}}$$

Answer: (B)

Q25.

Solution

Concept:

Refraction at normal incidence.

Solution:

Step 1: Normal incidence means that the incident ray travels along the normal to the surface.

Step 2: Therefore the angle of incidence is $i = 0^\circ$.

Step 3: Using Snell's law, $n_1 \sin i = n_2 \sin r$. Since $\sin 0^\circ = 0$, we get $\sin r = 0$.

Step 4: Hence $r = 0^\circ$ and the ray does not bend.

Step 5: The speed and wavelength may change in the slab, but direction does not change at normal incidence.

Exam Insight:

At normal incidence, there is no deviation even though refraction takes place.

Final Answer:

$$\boxed{0^\circ}$$

Answer: (A)

Q26.

Solution

Concept:

Fringe width in Young's double slit experiment.

Solution:

Step 1: In YDSE, fringe width is $\beta = \frac{\lambda D}{d}$.

Step 2: Here D is distance between slits and screen, d is slit separation, and λ is wavelength.

Step 3: Since D and d remain unchanged, fringe width is directly proportional to wavelength.

Step 4: If λ is doubled, then β also becomes doubled.

Step 5: Thus bright and dark fringes become more widely spaced on the screen.

Exam Insight:

YDSE fringe width increases with wavelength and screen distance, decreases with slit separation.

Final Answer:

$$\boxed{2\beta}$$

Answer: (B)

Q27.

Solution

Concept:

Power of a lens.

Solution:

Step 1: Power of a lens is reciprocal of focal length in metre: $P = \frac{1}{f}$.

Step 2: Convex lens is converging, so its focal length is positive.

Step 3: Given $f = 25\,\text{cm} = 0.25\,\text{m}$.

Step 4: Therefore $P = \frac{1}{0.25} = +4\,\text{D}$.

Step 5: Negative power would correspond to a concave lens. Hence option B is correct.

Exam Insight:

Always convert focal length from centimetre to metre before calculating power.

Final Answer:

$$\boxed{+4\,\text{D}}$$

Answer: (B)

Q28.

Solution

Concept:

Single slit diffraction central maximum.

Solution:

Step 1: For a single slit of width a, the first minima are given by $a \sin\theta = \lambda$.

Step 2: For small angles, $\sin\theta \approx \theta$, so $\theta \approx \lambda/a$.

Step 3: The full angular width of the central maximum is approximately $2\theta = 2\lambda/a$.

Step 4: Therefore the angular width is proportional to λ/a.

Step 5: Option A is inverse of the correct dependence. A wider slit gives a narrower central maximum.

Exam Insight:

Diffraction is more prominent when aperture size is comparable to wavelength.

Final Answer:

$$\boxed{\frac{\lambda}{a}}$$

Answer: (B)

Q29.

Solution

Concept:
First law of thermodynamics for isochoric process.

Solution:

Step 1: At constant volume, the gas does not expand or contract, so $\Delta V = 0$.

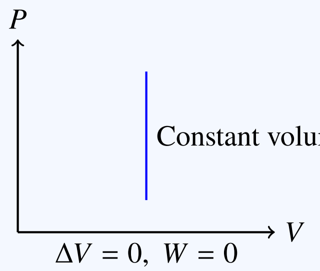
Step 2: Work done by a gas is $W = P\Delta V$, therefore $W = 0$.

Step 3: From first law of thermodynamics, $Q = \Delta U + W$.

Step 4: Since $W = 0$, the supplied heat becomes $Q = \Delta U$ and only increases internal energy.

Step 5: Option A would apply if volume changed. Option D describes isothermal process, not constant-volume heating.

Exam Insight:
Constant volume means no work done by the gas.



Final Answer:

Increase internal energy only

Answer: (B)

Q30.

Solution

Concept:
Kinetic theory of gases.
Solution:
Step 1: According to kinetic theory, temperature measures the average kinetic energy of gas molecules.
Step 2: Each translational degree of freedom contributes $\frac{1}{2}kT$ energy per molecule.
Step 3: A gas molecule moving freely in three dimensions has three translational degrees of freedom.
Step 4: Therefore average translational kinetic energy is $3 \times \frac{1}{2}kT = \frac{3}{2}kT$.
Step 5: This result is independent of the type or mass of the gas molecule.
Exam Insight:
Per molecule use k; per mole use R.
Final Answer:

$$\boxed{\frac{3}{2}kT}$$

Answer: (C)

Q31.

Solution

Concept:
Efficiency of a heat engine.
Solution:
Step 1: Heat engine converts part of absorbed heat into useful work and rejects remaining heat to sink.
Step 2: Work done is $W = Q_H - Q_C = 600 - 450 = 150\,\text{J}$.
Step 3: Efficiency is $\eta = \frac{W}{Q_H} = \frac{150}{600} = 0.25$.
Step 4: Converting into percentage gives $\eta = 25\%$.
Step 5: Option D is rejected heat as a percentage of absorbed heat, not efficiency.
Exam Insight:
Efficiency = useful work output divided by heat input.
Final Answer:

$$\boxed{25\%}$$

Answer: (C)

Q32.

Solution

Concept:

Photon energy relation.

Solution:

Step 1: Energy of a photon is given by Planck's equation $E = hf$.

Step 2: Rearrange the formula to find frequency: $f = E/h$.

Step 3: Substitute the values: $f = \frac{3.3\times10^{-19}}{6.6\times10^{-34}}$.

Step 4: Calculate coefficient and power separately: $3.3/6.6 = 0.5$ and $10^{-19}/10^{-34} = 10^{15}$.

Step 5: So $f = 0.5 \times 10^{15} = 5 \times 10^{14}$ Hz.

Exam Insight:

In scientific notation, divide coefficients and subtract powers of ten.

Final Answer:

$$\boxed{5 \times 10^{14}\,\text{Hz}}$$

Answer: (A)

Q33.

Solution

Concept:

Bohr energy levels of hydrogen atom.

Solution:

Step 1: For hydrogen atom, energy of the electron in the nth orbit is $E_n = -\frac{13.6}{n^2}$ eV.

Step 2: The negative sign indicates that the electron is bound to the nucleus.

Step 3: For $n = 2$, substitute in the formula: $E_2 = -\frac{13.6}{2^2}$.

Step 4: This gives $E_2 = -\frac{13.6}{4} = -3.4$ eV.

Step 5: Option B wrongly divides by 2 instead of $n^2 = 4$.

Exam Insight:

Hydrogen energy varies as $1/n^2$, not $1/n$.

Final Answer:

$$\boxed{-3.4\,\text{eV}}$$

Answer: (C)

Q34.

Solution

Concept:
Radioactive decay using half-life.

Solution:

Step 1: Half-life is the time in which half of the radioactive nuclei decay.

Step 2: Number of half-lives elapsed is total time divided by half-life: $30/10 = 3$.

Step 3: After one half-life, fraction left is $1/2$; after two it is $1/4$; after three it is $1/8$.

Step 4: Mathematically, remaining fraction is $(1/2)^3 = 1/8$.

Step 5: Option B would be correct after two half-lives, not three.

Exam Insight:
Remaining fraction after n half-lives is $(1/2)^n$.

Final Answer:

$$\boxed{\frac{1}{8}}$$

Answer: (C)

Q35.

Solution

Concept:
de Broglie wavelength of matter waves.

Solution:

Step 1: According to de Broglie's hypothesis, every moving particle has an associated wavelength.

Step 2: The wavelength is given by $\lambda = \frac{h}{p}$, where p is momentum.

Step 3: This directly shows that wavelength is inversely proportional to momentum.

Step 4: It is not simply inversely proportional to mass or velocity alone unless the other quantity is constant.

Step 5: For non-relativistic particles, λ is proportional to $1/\sqrt{K}$, not $1/K$.

Exam Insight:
The safest de Broglie formula is always $\lambda = h/p$.

Final Answer:

$$\boxed{\text{Momentum}}$$

Answer: (B)

Q36.

Solution

Concept:
Beta-minus nuclear decay.

Solution:

Step 1: In beta-minus decay, a neutron inside the nucleus converts into a proton, an electron, and an antineutrino.

Step 2: Because one neutron becomes one proton, the number of protons increases by one.

Step 3: Atomic number is equal to number of protons, so atomic number increases by 1.

Step 4: Mass number remains unchanged because total number of nucleons remains the same.

Step 5: Option D would be wrong because atomic identity changes in beta decay.

Exam Insight:
In β^- decay: atomic number increases by 1; mass number remains same.

Final Answer:

$$\boxed{\text{Increases by 1}}$$

Answer: (B)

Q37.

Solution

Concept:
Uniformly accelerated linear motion.

Solution:

Step 1: The body starts from rest, so initial velocity $u = 0$.

Step 2: For uniformly accelerated motion, displacement is $s = ut + \frac{1}{2}at^2$.

Step 3: Substitute $u = 0$, $a = 2\,\text{m s}^{-2}$ and $t = 5\,\text{s}$.

Step 4: So $s = 0 + \frac{1}{2} \times 2 \times 5^2 = 25\,\text{m}$.

Step 5: Option C comes from forgetting the factor $\frac{1}{2}$ in the displacement formula.

Exam Insight:
For motion from rest, $s = \frac{1}{2}at^2$.

Final Answer:

$$\boxed{25\,\text{m}}$$

Answer: (B)

Q38.

Solution

Concept:

Newton's second law of motion.

Solution:

Step 1: Newton's second law states that net force equals mass times acceleration: $F = ma$.

Step 2: To find acceleration, rearrange as $a = F/m$.

Step 3: Given $F = 20\,\text{N}$ and $m = 4\,\text{kg}$.

Step 4: Therefore $a = 20/4 = 5\,\text{m s}^{-2}$.

Step 5: Option D comes from multiplying mass and force, which is not Newton's law.

Exam Insight:

Acceleration is directly proportional to force and inversely proportional to mass.

Final Answer:

$$\boxed{5\,\text{m s}^{-2}}$$

Answer: (C)

Q39.

Solution

Concept:

Range of projectile motion.

Solution:

Step 1: For projectile motion on level ground, range is $R = \frac{u^2 \sin 2\theta}{g}$.

Step 2: If initial speed u is fixed, range depends only on $\sin 2\theta$.

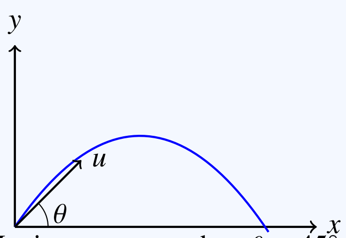
Step 3: Maximum value of sine is 1, so $\sin 2\theta = 1$.

Step 4: This occurs when $2\theta = 90°$, giving $\theta = 45°$.

Step 5: At 90°, the projectile goes vertically upward and has zero horizontal range.

Exam Insight:

Maximum range on level ground occurs at 45°.



Maximum range when $\theta = 45°$

Final Answer:

$$\boxed{45°}$$

Answer: (B)

Q40.

Solution

Concept:

Kinetic energy of a moving body.

Solution:

Step 1: Kinetic energy is the energy possessed by a body due to its motion.

Step 2: The formula is $K = \frac{1}{2}mv^2$.

Step 3: Substitute $m = 2\,\text{kg}$ and $v = 3\,\text{m s}^{-1}$.

Step 4: Thus $K = \frac{1}{2} \times 2 \times 3^2 = 9\,\text{J}$.

Step 5: Option D comes from using mv^2 instead of $\frac{1}{2}mv^2$.

Exam Insight:

Kinetic energy depends on square of velocity.

Final Answer:

$$\boxed{9\,\text{J}}$$

Answer: (C)

Q41.

Solution

Concept:

Power as rate of doing work.

Solution:

Step 1: The work done in lifting water is equal to gain in gravitational potential energy.

Step 2: Work done is $W = mgh = 100 \times 10 \times 5 = 5000\,\text{J}$.

Step 3: Power is the rate of doing work: $P = W/t$.

Step 4: Given time is $10\,\text{s}$, so $P = 5000/10 = 500\,\text{W}$.

Step 5: Option D is work done, not power. The division by time is essential.

Exam Insight:

Power = work/time; lifting problems usually use mgh/t.

Final Answer:

$$\boxed{500\,\text{W}}$$

Answer: (B)

Q42.

Solution

Concept:

Variation of acceleration due to gravity with height.

Solution:

Step 1: Acceleration due to gravity at distance r from Earth's centre varies as $1/r^2$.

Step 2: At Earth's surface, distance from centre is R and gravity is g.

Step 3: At height $h = R$, distance from centre becomes $R + h = 2R$.

Step 4: So $g' = g\left(\frac{R}{2R}\right)^2 = g/4$.

Step 5: Option B would be a linear-distance assumption, but gravity follows inverse-square law.

Exam Insight:

At height R, distance from centre doubles, so gravity becomes one-fourth.

Final Answer:

$$\boxed{\frac{g}{4}}$$

Answer: (C)

Q43.

Solution

Concept:

Orbital velocity of a near-Earth satellite.

Solution:

Step 1: For a satellite in circular orbit, gravitational force supplies centripetal force.

Step 2: Equate $\frac{GMm}{R^2} = \frac{mv^2}{R}$ for an orbit close to Earth's surface.

Step 3: Cancel m and solve: $v^2 = \frac{GM}{R}$.

Step 4: Since $g = \frac{GM}{R^2}$, we have $GM = gR^2$.

Step 5: Therefore $v = \sqrt{\frac{gR^2}{R}} = \sqrt{gR}$.

Exam Insight:

Near-surface orbital speed is $\sqrt{gR}$; escape speed is $\sqrt{2gR}$.

Final Answer:

$$\boxed{\sqrt{gR}}$$

Answer: (A)

Q44.

Solution

Concept:
Longitudinal strain.

Solution:

Step 1: Longitudinal strain is defined as change in length divided by original length.

Step 2: It has no unit because it is a ratio of two lengths.

Step 3: Given extension $\Delta L = 1\,\text{mm} = 1 \times 10^{-3}$ m and original length $L = 2$ m.

Step 4: Therefore strain $= \frac{\Delta L}{L} = \frac{1\times10^{-3}}{2} = 5 \times 10^{-4}$.

Step 5: Option C would be obtained if original length were incorrectly taken as 1 m.

Exam Insight:
Strain is dimensionless but must be calculated after converting lengths to the same unit.

Final Answer:

$$\boxed{5 \times 10^{-4}}$$

Answer: (A)

Q45.

Solution

Concept:
Excess pressure due to surface tension.

Solution:

Step 1: Excess pressure arises because a curved liquid surface tends to contract due to surface tension.

Step 2: For a liquid drop, there is one free surface and excess pressure is $2T/r$.

Step 3: A soap bubble has two surfaces: inner and outer.

Step 4: Therefore excess pressure inside a soap bubble is double that of a liquid drop: $\Delta P = 4T/r$.

Step 5: Option A is correct for a liquid drop but not for a soap bubble.

Exam Insight:
Liquid drop: $2T/r$; soap bubble: $4T/r$.

Final Answer:

$$\boxed{\frac{4T}{r}}$$

Answer: (B)

Q46.

Solution

Concept:

Dimensional formula using Planck's equation.

Solution:

Step 1: Planck's relation is $E = h\nu$, where E is energy and ν is frequency.

Step 2: Rearranging, $h = E/\nu$.

Step 3: Dimensional formula of energy is $[E] = ML^2T^{-2}$ and frequency is $[\nu] = T^{-1}$.

Step 4: Thus $[h] = \frac{ML^2T^{-2}}{T^{-1}} = ML^2T^{-1}$.

Step 5: Option C is the dimension of energy, not Planck's constant.

Exam Insight:

Planck's constant has the same dimension as angular momentum.

Final Answer:

$$\boxed{ML^2T^{-1}}$$

Answer: (A)

Q47.

Solution

Concept:

Propagation of percentage errors.

Solution:

Step 1: When a measured quantity has powers, percentage errors are multiplied by the powers.

Step 2: For $Q = A^2B$, relative error is $\frac{\Delta Q}{Q} = 2\frac{\Delta A}{A} + \frac{\Delta B}{B}$.

Step 3: Percentage error in A is 2%, so contribution from A^2 is $2 \times 2\% = 4\%$.

Step 4: Percentage error in B is 3%.

Step 5: Total percentage error is $4\% + 3\% = 7\%$.

Exam Insight:

For products and powers, add percentage errors after multiplying by powers.

Final Answer:

$$\boxed{7\%}$$

Answer: (B)

Q48.

Solution

Concept:

Intrinsic semiconductor carrier concentration.

Solution:

Step 1: An intrinsic semiconductor is a pure semiconductor without intentional impurity doping.

Step 2: At room temperature, some covalent bonds break due to thermal energy.

Step 3: Each broken bond creates one free electron and one hole.

Step 4: Therefore the number of electrons is equal to the number of holes.

Step 5: In doped semiconductors, one type of carrier becomes majority, but in intrinsic semiconductor both are equal.

Exam Insight:

Intrinsic means pure: $n = p$.

Final Answer:

$$\boxed{\text{Equal}}$$

Answer: (A)

Q49.

Solution

Concept:

Formation of p-type semiconductor.

Solution:

Step 1: Silicon is tetravalent, meaning each silicon atom has four valence electrons.

Step 2: To create p-type semiconductor, silicon is doped with a trivalent impurity.

Step 3: Boron has three valence electrons, so it creates a deficiency of one electron called a hole.

Step 4: Holes become the majority charge carriers in p-type semiconductor.

Step 5: Phosphorus, arsenic and antimony are pentavalent impurities and form n-type semiconductor.

Exam Insight:

Trivalent impurity gives p-type; pentavalent impurity gives n-type.

Final Answer:

$$\boxed{\text{Boron}}$$

Answer: (C)

Q50.

Solution

Concept:

Bandwidth of amplitude modulated wave.

Solution:

Step 1: In amplitude modulation, a carrier wave is varied according to the message signal.

Step 2: AM produces two sidebands: upper sideband at $f_c + f_m$ and lower sideband at $f_c - f_m$.

Step 3: The bandwidth is the difference between upper and lower sideband frequencies.

Step 4: So bandwidth $= (f_c + f_m) - (f_c - f_m) = 2f_m$.

Step 5: Given $f_m = 4\,\text{kHz}$, required bandwidth is $2 \times 4 = 8\,\text{kHz}$.

Exam Insight:

AM bandwidth is always twice the highest modulating frequency.

Final Answer:

$$\boxed{8\,\text{kHz}}$$

Answer: (C)

Answer Key

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