SAAT Physics

Sample Paper – 9

Duration: 40 Minutes **Maximum Marks: 40**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Physics section of the **SAAT** (Siksha 'O' Anusandhan Admission Test).
- Each correct answer carries **+1 mark**. There is **no negative marking** for incorrect or unattempted answers.
- Only **one** option is correct. Attempt every question, since wrong answers are not penalised.
- Use of mobile phones, calculators, or other electronic gadgets is strictly prohibited.

Q1. The dimensional formula of the permittivity of free space ε_0 is

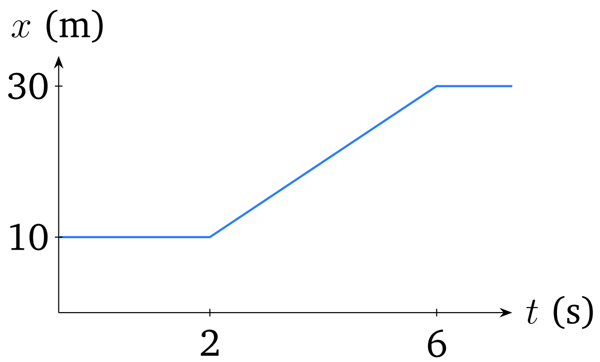
(A) $M^{-1}L^{-3}T^4A^2$

(B) $M^{-1}L^{-2}T^3A^2$

(C) $MLT^{-2}A^{-2}$

(D) $M^{-1}L^{-3}T^2A^2$

Q2. The position–time graph of a particle moving along a straight line is shown. The velocity of the particle during the interval from $t = 2$ s to $t = 6$ s is



(A) 2.5 m/s

(B) 5 m/s

(C) 10 m/s

(D) 0 m/s

Q3. A projectile is thrown with a speed of 30 m/s at an angle of 30° above the horizontal. Its horizontal range is $(g = 10 \text{ m/s}^2)$

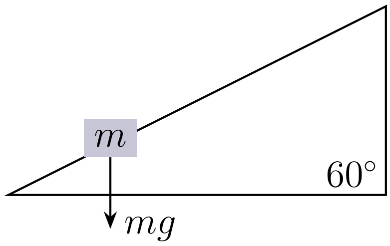
(A) 90 m

(B) 45 m

(C) $45\sqrt{3}$ m

(D) $30\sqrt{3}$ m

Q4. A block of mass 4 kg rests on a smooth inclined plane of inclination 60° as shown. The normal reaction exerted by the surface on the block is $(g = 10 \text{ m/s}^2)$



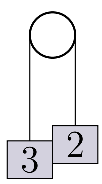
(A) 40 N

(B) 34.6 N

(C) 30 N

(D) 20 N

Q5. Two masses of 3 kg and 2 kg are connected by a light inextensible string over a frictionless pulley, as shown. The acceleration of the system is $(g = 10 \text{ m/s}^2)$



(A) 2 m/s^2

(B) 5 m/s^2

(C) 1 m/s^2

(D) 10 m/s^2

Q6. A force of 20 N pulls a body through a displacement of 5 m, the force making an angle of 60° with the displacement. The work done by the force is

(A) 100 J

(B) 50 J

(C) 86.6 J

(D) 25 J

Q7. A body of mass 2 kg is dropped from rest from a height of 20 m. Its kinetic energy just before striking the ground is $(g = 10 \text{ m/s}^2)$

(A) 200 J

(B) 800 J

(C) 400 J

(D) 40 J

Q8. The moment of inertia of a uniform solid sphere of mass M and radius R about an axis passing through its centre is

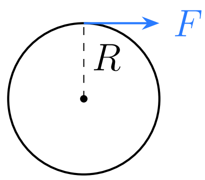
(A) $\frac{1}{2}MR^2$

(B) MR^2

(C) $\frac{2}{3}MR^2$

(D) $\frac{2}{5}MR^2$

Q9. A force of 10 N is applied tangentially at the rim of a wheel of radius 0.5 m, as shown. The torque produced about the axle is



(A) 10 N m

(B) 5 N m

(C) 20 N m

(D) 2.5 N m

Q10. The orbital speed of a satellite revolving close to the surface of the Earth (radius $R = 6.4 \times 10^6$ m, $g = 10\ \mathrm{m/s^2}$) is approximately

(A) 11.2 km/s

(B) 4 km/s

(C) 8 km/s

(D) 16 km/s

Q11. A wire is stretched so that the stress in it is $2 \times 10^8\ \mathrm{N/m^2}$ and the corresponding strain is 1×10^{-3}. The elastic potential energy stored per unit volume of the wire is

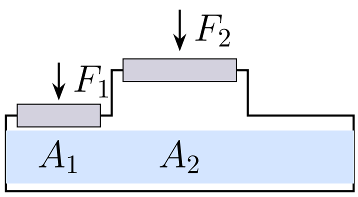
(A) $1 \times 10^5\ \mathrm{J/m^3}$

(B) $2 \times 10^5\ \mathrm{J/m^3}$

(C) $2 \times 10^8\ \mathrm{J/m^3}$

(D) $1 \times 10^3\ \mathrm{J/m^3}$

Q12. In a hydraulic press, a force of 50 N is applied on a piston of area $0.01\ \mathrm{m^2}$. The force transmitted to a second piston of area $0.05\ \mathrm{m^2}$ is



(A) 50 N

(B) 10 N

(C) 25 N

(D) 250 N

Q13. In a thermodynamic process, the internal energy of a gas increases by 120 J while 80 J of work is done *by* the gas on its surroundings. The heat supplied to the gas is

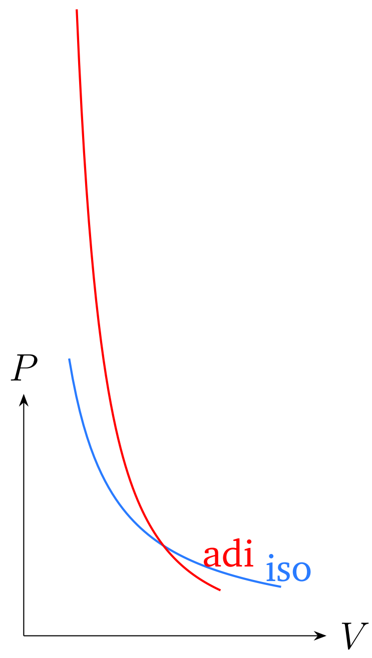
(A) 40 J

(B) 200 J

(C) 120 J

(D) 80 J

Q14. On a pressure–volume (P–V) diagram, an adiabatic curve and an isothermal curve are drawn through the same point, as shown. Compared with the isothermal, the adiabatic curve is



(A) steeper (greater magnitude of slope)

(B) less steep (smaller magnitude of slope)

(C) of exactly the same slope

(D) horizontal

Q15. The internal energy of 2 moles of an ideal monatomic gas at a temperature of 300 K is $(R = 8.31\ \mathrm{J\,mol^{-1}K^{-1}})$

(A) 3739 J

(B) 4986 J

(C) 7479 J

(D) 2493 J

Q16. The absolute temperature of a black body is increased from T to $2T$. The power it radiates per unit area becomes

(A) 2 times

(B) 4 times

(C) 8 times

(D) 16 times

Q17. A particle executes SHM described by $x = 0.05\sin(10\,t)$ (SI units). Its maximum speed is

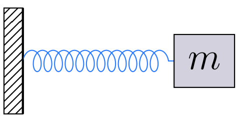
(A) 0.05 m/s

(B) 0.5 m/s

(C) 5 m/s

(D) 10 m/s

Q18. A spring of force constant $200\ \mathrm{N/m}$ carries a block of mass 0.5 kg, as shown. The period of oscillation of the block is



(A) $\dfrac{\pi}{10}$ s

(B) $\dfrac{\pi}{20}$ s

(C) $\dfrac{\pi}{5}$ s

(D) $\dfrac{\pi}{40}$ s

Q19. Two tuning forks of frequencies 256 Hz and 260 Hz are sounded together. The number of beats heard per second is

(A) 8

(B) 2

(C) 4

(D) 516

Q20. Two point charges of $+3\ \mu\text{C}$ and $+4\ \mu\text{C}$ are placed 0.3 m apart in air. The electrostatic force between them is $\left(\dfrac{1}{4\pi\varepsilon_0} = 9\times 10^9\ \text{N m}^2/\text{C}^2\right)$

(A) 0.6 N

(B) 0.3 N

(C) 2.4 N

(D) 1.2 N

Q21. Two equal and opposite point charges $+q$ and $-q$ are separated by a distance $2a$. The magnitude of the electric field at the midpoint of the line joining them, due to a single charge q at distance a, is

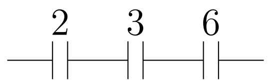
(A) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{a^2}$

(B) 0

(C) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{2q}{a^2}$

(D) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{4a^2}$

Q22. Three capacitors of $2\ \mu\text{F}$, $3\ \mu\text{F}$ and $6\ \mu\text{F}$ are connected in series, as shown. The equivalent capacitance of the combination is



(A) $11\ \mu\text{F}$

(B) $1\ \mu\text{F}$

(C) $0.5\ \mu\text{F}$

(D) $6\ \mu\text{F}$

Q23. Two point charges $+2\ \mu\text{C}$ and $+3\ \mu\text{C}$ are placed 0.6 m apart. The electrostatic potential energy of this pair of charges is $\left(\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{N m}^2/\text{C}^2\right)$

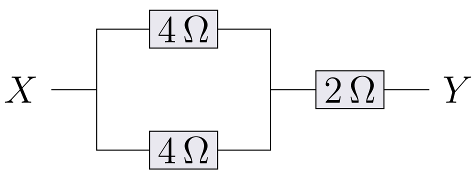
(A) 4.5×10^{-2} J

(B) 1.8×10^{-1} J

(C) 9×10^{-2} J

(D) 9×10^{-3} J

Q24. Three resistors of $4\ \Omega$, $4\ \Omega$ and $2\ \Omega$ are connected as shown, with the two $4\ \Omega$ resistors in parallel and the result in series with the $2\ \Omega$. The equivalent resistance between X and Y is



(A) $10\ \Omega$

(B) $6\ \Omega$

(C) $2\ \Omega$

(D) $4\ \Omega$

Q25. A cell of emf 6 V and internal resistance $0.5\ \Omega$ delivers a current of 2 A to an external circuit. The terminal voltage of the cell is

(A) 5 V

(B) 7 V

(C) 6 V

(D) 1 V

Q26. A heater of resistance $20\ \Omega$ is connected to a 200 V supply. The heat produced by it in 1 minute is

(A) 2000 J

(B) 120000 J

(C) 20000 J

(D) 200 J

Q27. A wire of length 4 m and uniform cross-sectional area $2 \times 10^{-6}\ \mathrm{m}^2$ has a resistance of $0.1\ \Omega$. The resistivity of its material is

(A) $2 \times 10^{-7}\ \Omega\,\mathrm{m}$

(B) $1 \times 10^{-8}\ \Omega\,\mathrm{m}$

(C) $2.5 \times 10^{-8}\ \Omega\,\mathrm{m}$

(D) $5 \times 10^{-8}\ \Omega\,\mathrm{m}$

Q28. A long solenoid has 500 turns per metre and carries a current of 4 A. The magnetic field inside the solenoid is $(\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T\,m/A})$

(A) 1.26×10^{-2} T

(B) 1.26×10^{-3} T

(C) 2.51×10^{-3} T

(D) 6.28×10^{-3} T

Q29. A straight conductor of length 0.4 m carrying a current of 5 A is placed perpendicular to a uniform magnetic field of 0.6 T. The force on the conductor is

(A) 1.2 N

(B) 0.6 N

(C) 2.4 N

(D) 3 N

Q30. A circular coil of 50 turns and radius 0.1 m carries a current of 2 A. Its magnetic dipole moment is

(A) 2π A m^2

(B) π A m^2

(C) 4π A m^2

(D) 0.5π A m^2

Q31. The magnetic flux through a coil of 200 turns changes from 0.02 Wb to 0.05 Wb in 0.1 s. The magnitude of the average emf induced in the coil is

(A) 6 V

(B) 30 V

(C) 60 V

(D) 0.3 V

Q32. An inductor of inductance 0.5 H is connected to an AC source of angular frequency 100 rad/s. The inductive reactance is

(A) 100 Ω

(B) 200 Ω

(C) 25 Ω

(D) 50 Ω

Q33. Which part of the electromagnetic spectrum is used in a household microwave oven and in RADAR systems?

(A) X-rays

(B) Microwaves

(C) Infrared waves

(D) Ultraviolet waves

Q34. For long-distance transmission of television and satellite signals, which mode of propagation of electromagnetic waves is used?

(A) Space wave (line-of-sight / satellite) propagation

(B) Sky wave propagation

(C) Surface wave propagation

(D) Ground wave propagation

Q35. When light of energy 6 eV falls on a metal of work function 2 eV, the stopping potential required to halt the fastest photoelectrons is

(A) 8 V

(B) 6 V

(C) 2 V

(D) 4 V

Q36. The wave nature of electrons was experimentally established by the diffraction of an electron beam from a nickel crystal. This historic experiment is the

(A) Millikan oil-drop experiment

(B) Rutherford scattering experiment

(C) Davisson–Germer experiment

(D) Stern–Gerlach experiment

Q37. In the Bohr model of the hydrogen atom, the radius of the first orbit $(n = 1)$ is 0.53 Å. The radius of the third orbit $(n = 3)$ is

(A) 4.77 Å

(B) 0.53 Å

(C) 2.12 Å

(D) 1.59 Å

Q38. In a nuclear reaction the mass defect is 0.02 u. The energy released is (take 1 u $= 931$ MeV)

(A) 9.31 MeV

(B) 18.62 MeV

(C) 46.55 MeV

(D) 93.1 MeV

Q39. When a pure silicon crystal is doped with a small amount of a pentavalent impurity such as phosphorus, the resulting semiconductor is

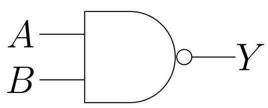
(A) p-type, with holes as majority carriers

(B) intrinsic, with equal electrons and holes

(C) n-type, with electrons as majority carriers

(D) an insulator at all temperatures

Q40. For the two-input NAND gate shown, the output Y when both inputs are set to $A = 1$ and $B = 1$ is



(A) undefined

(B) $A \cdot B = 1$

(C) floating

(D) 0

Detailed Solutions

Q1.

Solution

Concept — Dimensions of ε_0: From Coulomb's law $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$, so $\varepsilon_0 = \frac{q_1q_2}{4\pi F r^2}$.

Step 1 — Charge dimension: $[q] = [I\,t] = AT$, so $[q^2] = A^2T^2$.

Step 2 — Substitute: $[\varepsilon_0] = \dfrac{A^2T^2}{(MLT^{-2})(L^2)} = M^{-1}L^{-3}T^4A^2$.

Why other options are wrong: $M^{-1}L^{-2}T^3A^2$ and $M^{-1}L^{-3}T^2A^2$ mis-count the powers of T; $MLT^{-2}A^{-2}$ is the dimension of μ_0, not ε_0.

Final Answer: $[\varepsilon_0] = M^{-1}L^{-3}T^4A^2 \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q1**

Q2.

Solution

Concept — Slope of an x–t graph: The velocity equals the slope of the position–time graph.

Step 1 — Read the sloped portion: Between $t = 2$ s and $t = 6$ s the position rises from 10 m to 30 m.

Step 2 — Compute: $v = \dfrac{30-10}{6-2} = \dfrac{20}{4} = 5$ m/s.

Why other options are wrong: 2.5 m/s uses the wrong time interval; 10 m/s reads a position as a velocity; 0 applies to the flat segments only.

Final Answer: $v = 5$ m/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q2**

Q3.

Solution

Concept — Range of a projectile: $R = \dfrac{u^2\sin 2\theta}{g}$.

Step 1 — Find $\sin 2\theta$: For $\theta = 30°$, $2\theta = 60°$ and $\sin 60° = \dfrac{\sqrt{3}}{2}$.

Step 2 — Substitute: $R = \frac{(30)^2}{10} \times \frac{\sqrt{3}}{2} = 90 \times \frac{\sqrt{3}}{2} = 45\sqrt{3}$ m.

Why other options are wrong: 90 m uses $\sin 2\theta = 1$ (45°); 45 m drops the $\sqrt{3}$; $30\sqrt{3}$ uses a wrong factor.

Final Answer: $R = 45\sqrt{3}$ m $\Rightarrow$ C

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Normal reaction on an incline: On a smooth incline, $N = mg\cos\theta$.

Step 1 — Substitute: $N = 4 \times 10 \times \cos 60° = 40 \times 0.5$.

Step 2 — Compute: $N = 20$ N.

Why other options are wrong: 40 N ignores the $\cos\theta$ factor; 34.6 N uses $\cos 30°$; 30 N has no consistent basis.

Final Answer: $N = 20$ N $\Rightarrow$ D

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Atwood machine: For two masses over a frictionless pulley, $a = \frac{(m_1 - m_2)g}{m_1 + m_2}$.

Step 1 — Substitute: $a = \frac{(3-2)(10)}{3+2} = \frac{10}{5}$.

Step 2 — Compute: $a = 2\ \text{m/s}^2$.

Why other options are wrong: 5 uses only the difference of masses; 1 and 10 mis-handle the denominator.

Final Answer: $a = 2\ \text{m/s}^2 \Rightarrow$ A

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Work with an angle: $W = Fd\cos\theta$.

Step 1 — Substitute: $W = 20 \times 5 \times \cos 60° = 100 \times 0.5$.

Step 2 — Compute: $W = 50$ J.

Why other options are wrong: 100 J ignores the angle; 86.6 J uses $\cos 30°$; 25 J halves the result twice.

Final Answer: $W = 50$ J $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Conservation of energy: For a body falling from rest, the kinetic energy at the bottom equals the loss of potential energy, $KE = mgh$.

Step 1 — Substitute: $KE = 2 \times 10 \times 20$.

Step 2 — Compute: $KE = 400$ J.

Why other options are wrong: 200 J drops a factor of 2; 800 J doubles incorrectly; 40 J omits the height.

Final Answer: $KE = 400$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Moment of inertia of a solid sphere: About a diameter (axis through the centre), $I = \frac{2}{5}MR^2$.

Step 1 — Standard result: Integrating $r^2\,dm$ over a uniform solid sphere gives $\frac{2}{5}MR^2$.

Why other options are wrong: $\frac{1}{2}MR^2$ is a disc/cylinder; MR^2 is a thin ring; $\frac{2}{3}MR^2$ is a thin spherical shell.

Final Answer: $I = \frac{2}{5}MR^2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Torque of a tangential force: $\tau = F \times R$ when the force acts tangentially (perpendicular to the radius).

Step 1 — Substitute: $\tau = 10 \times 0.5$.

Step 2 — Compute: $\tau = 5$ N m.

Why other options are wrong: 10 N m ignores the radius; 20 N m doubles it; 2.5 N m halves it.

Final Answer: $\tau = 5$ N m $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

Q10.

Solution

Concept — Orbital speed near the surface: $v_o = \sqrt{gR}$ for an orbit just above the Earth's surface.

Step 1 — Substitute: $v_o = \sqrt{10 \times 6.4 \times 10^6} = \sqrt{6.4 \times 10^7}$.

Step 2 — Compute: $v_o = 8 \times 10^3$ m/s $= 8$ km/s.

Why other options are wrong: 11.2 km/s is the escape speed ($\sqrt{2gR}$); 4 km/s and 16 km/s mis-handle the square root.

Final Answer: $v_o = 8$ km/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept — Elastic energy density: Energy stored per unit volume $= \frac{1}{2} \times$ stress $\times$ strain.

Step 1 — Substitute: $u = \frac{1}{2}(2 \times 10^8)(1 \times 10^{-3})$.

Step 2 — Compute: $u = \frac{1}{2}(2 \times 10^5) = 1 \times 10^5$ J/m^3.

Why other options are wrong: 2×10^5 omits the factor $\frac{1}{2}$; 2×10^8 uses stress alone; 1×10^3 mis-multiplies the powers of ten.

Final Answer: $u = 1 \times 10^5$ J/m^3 $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept — Pascal's law (hydraulic press): Pressure is transmitted equally, so $\frac{F_1}{A_1} = \frac{F_2}{A_2}$.

Step 1 — Rearrange: $F_2 = F_1 \times \frac{A_2}{A_1}$.

Step 2 — Substitute: $F_2 = 50 \times \frac{0.05}{0.01} = 50 \times 5 = 250$ N.

Why other options are wrong: 50 N ignores the area ratio; 10 N and 25 N invert or mishandle it.

Final Answer: $F_2 = 250 \text{ N} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — First law of thermodynamics: $Q = \Delta U + W$, with W the work done by the gas.

Step 1 — Substitute: $Q = 120 + 80$.

Step 2 — Compute: $Q = 200$ J.

Why other options are wrong: 40 J subtracts instead of adding; 120 J and 80 J keep only one term.

Final Answer: $Q = 200 \text{ J} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept — Slopes of isothermal and adiabatic curves: On a P–V diagram, the isothermal slope is $-\frac{P}{V}$ while the adiabatic slope is $-\gamma\frac{P}{V}$.

Step 1 — Compare magnitudes: Since $\gamma > 1$, the adiabatic slope has a larger magnitude at the common point.

Step 2 — Conclusion: The adiabatic curve falls more sharply, i.e. it is steeper than the isothermal.

Why other options are wrong: It is not less steep, not identical, and certainly not horizontal.

Final Answer: The adiabatic is steeper $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q14

Q15.

Solution

Concept — Internal energy of an ideal monatomic gas: $U = \frac{3}{2}nRT$.

Step 1 — Substitute: $U = \frac{3}{2}(2)(8.31)(300)$.

Step 2 — Compute: $U = 3 \times 8.31 \times 300 = 7479$ J.

Why other options are wrong: 3739 J uses 1 mole; 2493 J uses $\frac{1}{2}nRT$; 4986 J uses nRT without the $\frac{3}{2}$.

Final Answer: $U = 7479$ J $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Stefan–Boltzmann law: The power radiated per unit area is $E = \sigma T^4$, so $E \propto T^4$.

Step 1 — Temperature ratio: Doubling T multiplies E by 2^4.

Step 2 — Compute: $2^4 = 16$, so the radiated power becomes 16 times.

Why other options are wrong: 2 assumes $E \propto T$; 4 assumes $E \propto T^2$; 8 assumes $E \propto T^3$.

Final Answer: Power becomes 16 times $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Maximum speed in SHM: For $x = A\sin(\omega t)$, the maximum speed is $v_{max} = A\omega$.

Step 1 — Identify: $A = 0.05$ m, $\omega = 10$ rad/s.

Step 2 — Compute: $v_{max} = 0.05 \times 10 = 0.5$ m/s.

Why other options are wrong: 0.05 is the amplitude; 10 is ω; 5 misplaces the decimal.

Final Answer: $v_{max} = 0.5$ m/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept — Period of a spring–mass system: $T = 2\pi\sqrt{\dfrac{m}{k}}$.

Step 1 — Substitute: $T = 2\pi\sqrt{\dfrac{0.5}{200}} = 2\pi\sqrt{2.5 \times 10^{-3}}$.

Step 2 — Compute: $\sqrt{2.5 \times 10^{-3}} = 0.05$, so $T = 2\pi(0.05) = \dfrac{\pi}{10}$ s.

Why other options are wrong: $\dfrac{\pi}{20}$ and $\dfrac{\pi}{40}$ mis-handle the square root; $\dfrac{\pi}{5}$ doubles the result.

Final Answer: $T = \dfrac{\pi}{10}$ s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept — Beat frequency: The number of beats per second equals the difference in the two frequencies, $f_b = |f_1 - f_2|$.

Step 1 — Substitute: $f_b = |260 - 256|$.

Step 2 — Compute: $f_b = 4$ Hz, so 4 beats per second.

Why other options are wrong: 8 doubles the difference; 2 halves it; 516 adds the frequencies.

Final Answer: 4 beats per second $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Coulomb's law: $F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{r^2}$.

Step 1 — Substitute: $F = \dfrac{9 \times 10^9 \times 3 \times 10^{-6} \times 4 \times 10^{-6}}{(0.3)^2}$.

Step 2 — Compute: Numerator $= 9 \times 10^9 \times 12 \times 10^{-12} = 0.108$; divide by 0.09 to get 1.2 N.

Why other options are wrong: 0.6 N and 0.3 N mis-handle the r^2 factor; 2.4 N doubles the result.

Final Answer: $F = 1.2$ N $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Field of a single point charge: $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2}$, evaluated at distance $r = a$ from one charge.

Step 1 — Substitute $r = a$: The field due to one charge at the midpoint is $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{a^2}$.

Step 2 — Note: The question asks only for the magnitude due to a single charge q at distance a, which is the standard inverse-square expression with $r = a$.

Why other options are wrong: $\dfrac{q}{4a^2}$ uses $r = 2a$; 0 would be the net field of both equal-sign charges, not this case; $\dfrac{2q}{a^2}$ doubles the charge.

Final Answer: $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{a^2}$ $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Capacitors in series: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$.

Step 1 — Add reciprocals: $\frac{1}{C_{eq}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{3+2+1}{6} = 1$.

Step 2 — Invert: $C_{eq} = 1\ \mu\text{F}$.

Why other options are wrong: $11\ \mu$F adds the values (that is for parallel); 0.5 and 6 mis-handle the reciprocal sum.

Final Answer: $C_{eq} = 1\ \mu\text{F} \Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q22**

Q23.

Solution

Concept — Potential energy of two charges: $U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$.

Step 1 — Substitute: $U = \frac{9\times10^9 \times 2\times10^{-6} \times 3\times10^{-6}}{0.6}$.

Step 2 — Compute: Numerator $= 9\times10^9 \times 6\times10^{-12} = 5.4\times10^{-2}$; divide by 0.6 to get 9×10^{-2} J.

Why other options are wrong: 4.5×10^{-2} uses $r = 1.2$ m; 1.8×10^{-1} doubles; 9×10^{-3} misplaces a power of ten.

Final Answer: $U = 9\times10^{-2}$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q23**

Q24.

Solution

Concept — Parallel then series: Two equal $4\ \Omega$ resistors in parallel give $2\ \Omega$; this adds in series to the $2\ \Omega$ resistor.

Step 1 — Parallel pair: $\frac{1}{R_p} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2} \Rightarrow R_p = 2\ \Omega$.

Step 2 — Add the series resistor: $R_{eq} = 2 + 2 = 4\ \Omega$.

Why other options are wrong: $10\ \Omega$ adds all three in series; $6\ \Omega$ adds one 4 to the 2; $2\ \Omega$ stops at the parallel pair.

Final Answer: $R_{eq} = 4\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept — Terminal voltage: $V = \varepsilon - Ir$ when the cell delivers current.

Step 1 — Substitute: $V = 6 - (2)(0.5)$.

Step 2 — Compute: $V = 6 - 1 = 5$ V.

Why other options are wrong: 6 V ignores the internal drop; 7 V adds instead of subtracting; 1 V is only the internal drop.

Final Answer: $V = 5$ V $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Joule heating: $H = \frac{V^2}{R}t$.

Step 1 — Power: $P = \frac{V^2}{R} = \frac{(200)^2}{20} = \frac{40000}{20} = 2000$ W.

Step 2 — Heat in 60 s: $H = 2000 \times 60 = 120000$ J.

Why other options are wrong: 2000 J is the energy in 1 s; 200 J and 20000 J mis-handle the power or time.

Final Answer: $H = 120000$ J $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Resistivity: $R = \rho\frac{L}{A} \Rightarrow \rho = \frac{RA}{L}$.

Step 1 — Substitute: $\rho = \frac{0.1 \times 2 \times 10^{-6}}{4}$.

Step 2 — Compute: $\rho = \frac{2 \times 10^{-7}}{4} = 5 \times 10^{-8}\ \Omega\,\text{m}$.

Why other options are wrong: 2×10^{-7} omits the division by length; 1×10^{-8} and 2.5×10^{-8} mis-handle the arithmetic.

Final Answer: $\rho = 5 \times 10^{-8}\ \Omega\,\mathrm{m} \Rightarrow \boxed{\mathrm{D}}$

Answer: (D) Go Back to Q27

Q28.

Solution

Concept — Field inside a long solenoid: $B = \mu_0 n I$, where n is turns per metre.

Step 1 — Substitute: $B = (4\pi \times 10^{-7})(500)(4)$.

Step 2 — Compute: $B = (4\pi \times 10^{-7})(2000) = 8\pi \times 10^{-4} \approx 2.51 \times 10^{-3}$ T.

Why other options are wrong: 1.26×10^{-2} and 6.28×10^{-3} misplace a power of ten; 1.26×10^{-3} halves the answer.

Final Answer: $B \approx 2.51 \times 10^{-3}\ \mathrm{T} \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q28

Q29.

Solution

Concept — Force on a current-carrying conductor: $F = BIL \sin\theta$, with $\theta = 90°$.

Step 1 — Substitute: $F = 0.6 \times 5 \times 0.4$.

Step 2 — Compute: $F = 1.2$ N.

Why other options are wrong: 3 N and 2.4 N mis-multiply; 0.6 N drops the length and current factors.

Final Answer: $F = 1.2\ \mathrm{N} \Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Magnetic dipole moment of a coil: $m = NIA = NI\pi R^2$.

Step 1 — Area: $A = \pi R^2 = \pi(0.1)^2 = 0.01\pi\ \mathrm{m}^2$.

Step 2 — Compute: $m = 50 \times 2 \times 0.01\pi = \pi\ \mathrm{A\,m^2} \approx 3.14\ \mathrm{A\,m^2}$.

Why other options are wrong: 2π doubles the result; 4π quadruples it; 0.5π halves it.

Final Answer: $m = \pi\ \mathrm{A\,m^2} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q30

Q31.

Solution

Concept — Faraday's law: $|\varepsilon| = N\dfrac{\Delta\Phi}{\Delta t}$.

Step 1 — Change in flux: $\Delta\Phi = 0.05 - 0.02 = 0.03$ Wb.

Step 2 — Substitute: $|\varepsilon| = 200 \times \dfrac{0.03}{0.1} = 200 \times 0.3 = 60$ V.

Why other options are wrong: 6 V and 0.3 V drop a factor; 30 V uses half the flux change.

Final Answer: $|\varepsilon| = 60\ \mathrm{V} \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept — Inductive reactance: $X_L = \omega L$.

Step 1 — Substitute: $X_L = 100 \times 0.5$.

Step 2 — Compute: $X_L = 50\ \Omega$.

Why other options are wrong: 100 ignores the inductance; 200 and 25 mis-multiply.

Final Answer: $X_L = 50\ \Omega \Rightarrow \boxed{\mathrm{D}}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept — Applications of the EM spectrum: Microwaves (wavelength a few cm) are used both to heat food in microwave ovens and as the radiation in RADAR.

Step 1 — Match the application: Both stated uses fall in the microwave band.

Why other options are wrong: X-rays image bone and probe crystals; infrared is used for heating and remote sensing; ultraviolet sterilises and causes fluorescence; none of these powers RADAR or microwave ovens.

Final Answer: Microwaves $\Rightarrow$ B

Answer: (B) Go Back to Q33

Q34.

Solution

Concept — Modes of wave propagation: Very-high-frequency TV and satellite signals are sent by space-wave (line-of-sight) propagation, often relayed via satellites.

Step 1 — Match the mode: Frequencies above about 40 MHz penetrate the ionosphere and cannot be reflected back, so sky-wave fails; line-of-sight/space-wave (satellite) propagation is used.

Why other options are wrong: Ground/surface waves attenuate quickly and suit only low frequencies; sky-wave reflection works only up to a few tens of MHz.

Final Answer: Space-wave (satellite) propagation $\Rightarrow$ A

Answer: (A) Go Back to Q34

Q35.

Solution

Concept — Stopping potential: $eV_0 = KE_{max} = E_{photon} - \phi$, so V_0 (in volts) equals KE_{max} (in eV).

Step 1 — Maximum KE: $KE_{max} = 6 - 2 = 4$ eV.

Step 2 — Stopping potential: $V_0 = 4$ V.

Why other options are wrong: 8 V adds the energies; 6 V ignores the work function; 2 V uses only the work function.

Final Answer: $V_0 = 4$ V $\Rightarrow$ D

Answer: (D) Go Back to Q35

Q36.

Solution

Concept — Experimental proof of matter waves: The Davisson–Germer experiment scattered low-energy electrons off a nickel crystal and observed a diffraction maximum, confirming the de Broglie wave nature of electrons.

Step 1 — Identify: Diffraction of an electron beam from a crystal demonstrates wave behaviour.

Why other options are wrong: Millikan measured the electron's charge; Rutherford scattering revealed the nucleus; Stern–Gerlach demonstrated spin quantisation.

Final Answer: Davisson–Germer experiment $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q36

Q37.

Solution

Concept — Bohr orbit radius: $r_n = n^2 r_1$, where $r_1 = 0.53$ Å.

Step 1 — Put $n = 3$: $r_3 = 9 \times 0.53$.

Step 2 — Compute: $r_3 = 4.77$ Å.

Why other options are wrong: 1.59 Å uses n (not n^2); 0.53 Å is $n = 1$; 2.12 Å is $n = 2$.

Final Answer: $r_3 = 4.77$ Å $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q37

Q38.

Solution

Concept — Mass–energy equivalence: $E = \Delta m\, c^2$, and 1 u of mass defect releases 931 MeV.

Step 1 — Substitute: $E = 0.02 \times 931$.

Step 2 — Compute: $E = 18.62$ MeV.

Why other options are wrong: 9.31 MeV uses 0.01 u; 46.55 MeV uses 0.05 u; 93.1 MeV uses 0.1 u.

Final Answer: $E = 18.62$ MeV $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept — Doping with a pentavalent impurity: A pentavalent atom (e.g. phosphorus) donates one extra electron per atom to the silicon lattice, producing an n-type semiconductor.

Step 1 — Majority carriers: The donated electrons are the majority charge carriers; holes are the minority carriers.

Why other options are wrong: A trivalent dopant would give p-type (holes); an undoped crystal is intrinsic; doping does not make silicon an insulator.

Final Answer: n-type with electrons as majority carriers $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept — NAND gate truth table: A NAND gate gives output $Y = \overline{A \cdot B}$; its output is 0 only when both inputs are 1.

Step 1 — Apply $A = 1$, $B = 1$: $A \cdot B = 1$, so $Y = \overline{1} = 0$.

Why other options are wrong: The output is well defined, never floating, and it is 0 (not $A \cdot B = 1$, which is the AND result before inversion).

Final Answer: $Y = 0 \Rightarrow \boxed{D}$

Answer: (D) Go Back to Q40

Answer Key

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