SAAT Physics

Sample Paper – 5

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. A physical quantity Z is given by $Z = \frac{a^2 b}{\sqrt{c}}$. If the percentage errors in a, b and c are 1%, 2% and 4% respectively, the maximum percentage error in Z is

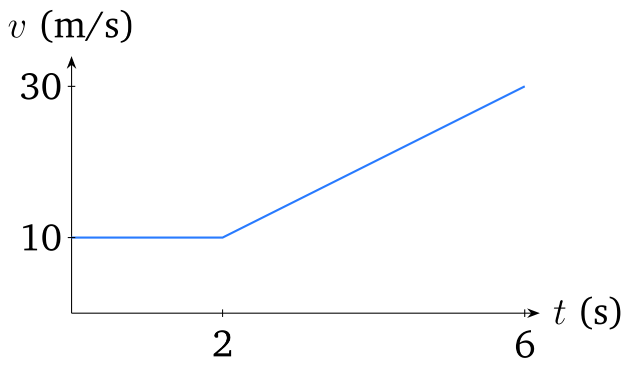
(A) 6%

(B) 8%

(C) 4%

(D) 10%

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



(A) 2.5 m/s^2

(B) 5 m/s^2

(C) 10 m/s^2

(D) 20 m/s^2

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

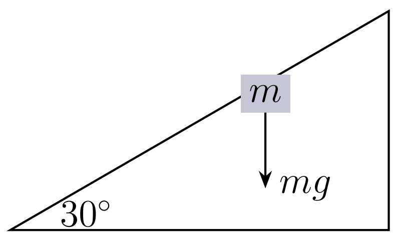
(A) $90\sqrt{3}$ m

(B) 45 m

(C) 90 m

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

Q4. A block of mass 4 kg rests on a smooth inclined plane of inclination 30°, as shown. The normal reaction exerted by the surface on the block is $(g = 10 \text{ m/s}^2)$



(A) 40 N

(B) 20 N

(C) $20\sqrt{3}$ N

(D) $40\sqrt{3}$ N

Q5. Two masses 6 kg and 4 kg are connected by a light inextensible string passing over a frictionless pulley. The acceleration of the system is $(g = 10 \text{ m/s}^2)$

(A) 2 m/s^2

(B) 1 m/s^2

(C) 4 m/s^2

(D) 5 m/s^2

Q6. A constant force acting on a body of mass 2 kg increases its speed from 4 m/s to 8 m/s. The work done by the force is

(A) 24 J

(B) 48 J

(C) 16 J

(D) 96 J

Q7. A body of mass 2 kg is dropped from a height of 5 m. Its kinetic energy just before striking the ground is $(g = 10 \text{ m/s}^2)$

(A) 50 J

(B) 25 J

(C) 100 J

(D) 200 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

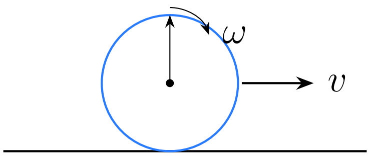
(A) MR^2

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

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

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

Q9. A uniform solid cylinder rolls without slipping along a horizontal surface, as shown. The fraction of its total kinetic energy that is rotational is



(A) $2/5$

(B) $1/3$

(C) $1/2$

(D) $2/7$

Q10. A satellite revolves in a circular orbit of radius r around a planet of mass M. Its orbital speed is

(A) $\sqrt{\dfrac{GM}{r}}$

(B) $\sqrt{\dfrac{2GM}{r}}$

(C) $\dfrac{GM}{r}$

(D) $\sqrt{\dfrac{GM}{r^2}}$

Q11. A steel wire of length 4 m and cross-sectional area $2\ \text{mm}^2$ is stretched by a load of 200 N. If the Young's modulus of steel is $2 \times 10^{11}\ \text{N/m}^2$, the elongation of the wire is

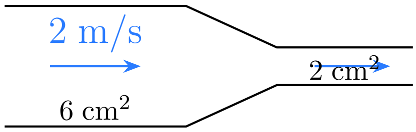
(A) 0.5 mm

(B) 4 mm

(C) 1 mm

(D) 2 mm

Q12. Water flows steadily through a horizontal pipe that narrows from a cross-sectional area of $6\ \text{cm}^2$ to $2\ \text{cm}^2$, as shown. If the speed in the wider section is $2\ \text{m/s}$, the speed in the narrower section is



(A) $4\ \text{m/s}$

(B) $3\ \text{m/s}$

(C) $6\ \text{m/s}$

(D) $12\ \text{m/s}$

Q13. A gas is supplied 500 J of heat, and its internal energy increases by 300 J. The work done by the gas during this process is

(A) 200 J

(B) 800 J

(C) 300 J

(D) 500 J

Q14. For an ideal gas undergoing an isothermal process, which one of the following quantities is always zero?

(A) Heat exchanged with the surroundings

(B) Change in internal energy

(C) Work done by the gas

(D) Change in pressure

Q15. The root-mean-square speed of oxygen molecules ($M = 32\ \text{g/mol}$) at 300 K is approximately $(R = 8.3\ \text{J}\,\text{mol}^{-1}\text{K}^{-1})$

(A) $241\ \text{m/s}$

(B) $1530\ \text{m/s}$

(C) 483 m/s

(D) 966 m/s

Q16. A Carnot engine operates between a source at 500 K and a sink at 400 K. Its efficiency is

(A) 80%

(B) 40%

(C) 25%

(D) 20%

Q17. A particle executes simple harmonic motion of amplitude 0.05 m and angular frequency 20 rad/s. Its maximum speed is

(A) 1 m/s

(B) 0.25 m/s

(C) 2 m/s

(D) 20 m/s

Q18. A block of mass 2 kg attached to a spring of force constant 200 N/m executes simple harmonic motion on a smooth surface. The time period of oscillation is

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

(B) $\frac{\pi}{5}$ s

(C) π s

(D) $\frac{2\pi}{5}$ s

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

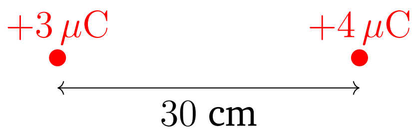
(A) 516

(B) 2

(C) 4

(D) 258

Q20. Two point charges of $+3\ \mu\text{C}$ and $+4\ \mu\text{C}$ are placed 30 cm apart in air, as shown. The magnitude of 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) 0.36 N

(B) 108 N

(C) 3.6 N

(D) 1.2 N

Q21. The electric field at a distance of 0.3 m from a point charge of $3\ \mu\text{C}$ is $\left(\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{N m}^2/\text{C}^2\right)$

(A) $3 \times 10^5\ \text{N/C}$

(B) $9 \times 10^4\ \text{N/C}$

(C) $9 \times 10^5\ \text{N/C}$

(D) $1 \times 10^5\ \text{N/C}$

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

(A) $15\ \mu\text{F}$

(B) $1.5\ \mu\text{F}$

(C) $3\ \mu\text{F}$

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

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

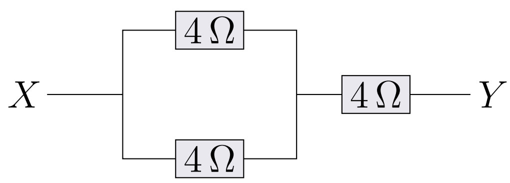
(A) 0.045 J

(B) 0.18 J

(C) 0.09 J

(D) 0.27 J

Q24. In the network shown, each resistor has resistance $4\ \Omega$. The equivalent resistance between points X and Y is



(A) $12\ \Omega$

(B) $4\ \Omega$

(C) $2\ \Omega$

(D) $6\ \Omega$

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 potential difference of the cell is

(A) 6 V

(B) 5 V

(C) 7 V

(D) 3 V

Q26. A current of 3 A flows through a resistor of $4\ \Omega$ for 5 minutes. The heat produced in the resistor is

(A) 180 J

(B) 360 J

(C) 10800 J

(D) 2160 J

Q27. A wire of length 2 m and cross-sectional area $0.5\ \text{mm}^2$ has a resistance of $4\ \Omega$. The resistivity of the material of the wire is

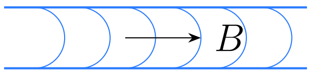
(A) $1 \times 10^{-6}\ \Omega\,\text{m}$

(B) $2 \times 10^{-6}\ \Omega\,\text{m}$

(C) $4 \times 10^{-6}\ \Omega\,\text{m}$

(D) $0.5 \times 10^{-6}\ \Omega\,\text{m}$

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



$n = 500/\text{m},\ I = 4$ A

(A) 1×10^{-3} T

(B) 4×10^{-3} T

(C) 6.28×10^{-3} T

(D) 2.51×10^{-3} T

Q29. A straight conductor of length 0.5 m carrying a current of 4 A is placed perpendicular to a uniform magnetic field of 0.2 T. The force on the conductor is

(A) 0.2 N

(B) 0.4 N

(C) 0.8 N

(D) 1.6 N

Q30. A circular coil of 50 turns and area $4 \times 10^{-3}\ \text{m}^2$ carries a current of 2 A. It is placed in a uniform magnetic field of 0.5 T with its plane parallel to the field. The torque acting on the coil is

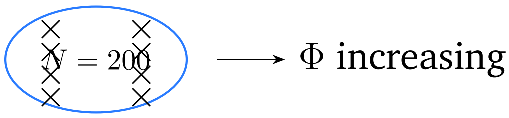
(A) $0.2\ \text{N m}$

(B) $0.1\ \text{N m}$

(C) $0.4\ \text{N m}$

(D) $0.8\ \text{N m}$

Q31. The magnetic flux through a coil of 200 turns changes from 0.02 Wb to 0.06 Wb in 0.1 s, as suggested below. The magnitude of the average induced emf is



(A) 8 V

(B) 40 V

(C) 80 V

(D) 0.4 V

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

(A) $200\ \Omega$

(B) $100\ \Omega$

(C) $0.5\ \Omega$

(D) $50\ \Omega$

Q33. In a plane electromagnetic wave travelling through vacuum, the directions of the electric field $\vec{E}$, the magnetic field $\vec{B}$, and the direction of propagation are

(A) all parallel to one another

(B) mutually perpendicular to one another

(C) $\vec{E}$ parallel to propagation, $\vec{B}$ perpendicular

(D) $\vec{E}$ and $\vec{B}$ parallel, both perpendicular to propagation

Q34. The process of varying some characteristic of a high-frequency carrier wave in accordance with a low-frequency message signal is known as

(A) Modulation

(B) Demodulation

(C) Detection

(D) Attenuation

Q35. Light of photon energy 6 eV is incident on a metal of work function 2.5 eV. The stopping potential required to halt the fastest photoelectrons is

(A) 8.5 V

(B) 6 V

(C) 3.5 V

(D) 2.5 V

Q36. An electron is accelerated from rest through a potential difference of 100 V. The de Broglie wavelength associated with it is approximately $\left(\lambda = \frac{12.27}{\sqrt{V}}\ \text{Å}\right)$

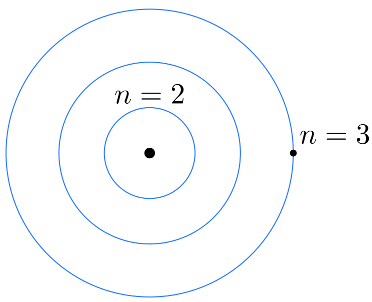
(A) 12.27 Å

(B) 0.123 Å

(C) 1.0 Å

(D) 1.227 Å

Q37. In the Bohr model of the hydrogen atom, the radius of the $n = 1$ orbit is 0.53 Å. The radius of the $n = 3$ orbit, indicated in the diagram, is



(A) 4.77 Å

(B) 1.59 Å

(C) 0.53 Å

(D) 9.0 Å

Q38. A radioactive sample decays to $1/16$ of its initial number of nuclei in 40 days. The half-life of the sample is

(A) 20 days

(B) 10 days

(C) 8 days

(D) 5 days

Q39. In a power supply, a Zener diode is most commonly used as a

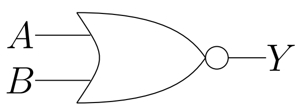
(A) rectifier

(B) amplifier

(C) voltage regulator

(D) oscillator

Q40. Identify the logic gate whose output Y is 1 only when both inputs A and B are 0, as represented by the symbol shown.



(A) OR gate

(B) AND gate

(C) NAND gate

(D) NOR gate

Detailed Solutions

Q1.

Solution

Concept — Propagation of errors: For $Z = a^p b^q / c^r$, the fractional error adds as $\dfrac{\Delta Z}{Z} = p\dfrac{\Delta a}{a} + q\dfrac{\Delta b}{b} + r\dfrac{\Delta c}{c}$.

Step 1 — Apply the exponents: a has power 2, b has power 1, c has power $\frac{1}{2}$.

Step 2 — Substitute: $\%\,\text{error} = 2(1\%) + 1(2\%) + \frac{1}{2}(4\%) = 2 + 2 + 2 = 6\%$.

Why other options are wrong: 8% uses power 1 for c; 4% drops a term; 10% uses power 2 for b.

Final Answer: Maximum error $= 6\% \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Acceleration from a v–t graph: The acceleration is the slope of the velocity–time line.

Step 1 — Read the segment: Between $t = 2$ s and $t = 6$ s the velocity rises from 10 m/s to 30 m/s.

Step 2 — Compute the slope: $a = \dfrac{30 - 10}{6 - 2} = \dfrac{20}{4} = 5\ \text{m/s}^2$.

Why other options are wrong: 2.5 doubles the time interval; 10 ignores the initial 10 m/s; 20 omits dividing by the time.

Final Answer: $a = 5\ \text{m/s}^2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Projectile range: $R = \dfrac{u^2 \sin 2\theta}{g}$.

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

Step 2 — Substitute: $R = \dfrac{(30)^2(\sqrt{3}/2)}{10} = \dfrac{900 \times \sqrt{3}/2}{10} = 45\sqrt{3}$ m.

Why other options are wrong: $90\sqrt{3}$ omits the factor $\frac{1}{2}$; 45 and 90 drop the $\sqrt{3}$.

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

Answer: (D) Go Back to Q3

Q4.

Solution

Concept — Normal reaction on an incline: On a smooth incline of angle θ, the normal force balances the perpendicular component of gravity, $N = mg\cos\theta$.

Step 1 — Substitute: $N = (4)(10)\cos 30^\circ = 40 \times \dfrac{\sqrt{3}}{2}$.

Step 2 — Simplify: $N = 20\sqrt{3}$ N ≈ 34.6 N.

Why other options are wrong: 40 N is the full weight ($\theta = 0$); 20 N uses $\sin 30^\circ$; $40\sqrt{3}$ doubles the result.

Final Answer: $N = 20\sqrt{3}$ N $\Rightarrow$ $\boxed{C}$

Answer: (C) Go Back to Q4

Q5.

Solution

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

Step 1 — Substitute: $a = \dfrac{(6-4)(10)}{6+4} = \dfrac{20}{10}$.

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

Why other options are wrong: 1 halves the result; 4 ignores the total mass; 5 uses only the heavier mass.

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

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Work–energy theorem: The work done equals the change in kinetic energy, $W = \frac{1}{2}m(v^2 - u^2)$.

Step 1 — Substitute: $W = \frac{1}{2}(2)(8^2 - 4^2) = (64 - 16)$.

Step 2 — Compute: $W = 48$ J.

Why other options are wrong: 24 uses only the final term halved; 16 uses $(8-4)^2$; 96 omits the factor $\frac{1}{2}$.

Final Answer: $W = 48$ J $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Conservation of energy: For a freely falling body, the kinetic energy on landing equals the lost potential energy, $KE = mgh$.

Step 1 — Substitute: $KE = (2)(10)(5)$.

Step 2 — Compute: $KE = 100$ J.

Why other options are wrong: 50 and 25 drop a factor; 200 doubles the height incorrectly.

Final Answer: $KE = 100$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

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

Step 1 — Standard result: Integrating over the solid sphere gives the coefficient $\frac{2}{5}$.

Why other options are wrong: MR^2 is a hoop; $\frac{1}{2}MR^2$ is a disc/cylinder; $\frac{2}{3}MR^2$ 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 — Rolling kinetic energy: Total KE $= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$; the rotational fraction is $\frac{KE_{rot}}{KE_{total}}$. For a solid cylinder $I = \frac{1}{2}mR^2$.

Step 1 — Express each part: Translational $= \frac{1}{2}mv^2$; rotational $= \frac{1}{2}(\frac{1}{2}mR^2)(v/R)^2 = \frac{1}{4}mv^2$.

Step 2 — Take the ratio: $\frac{\frac{1}{4}mv^2}{\frac{1}{2}mv^2 + \frac{1}{4}mv^2} = \frac{1/4}{3/4} = \frac{1}{3}$.

Why other options are wrong: $2/5$ and $2/7$ are for a sphere; $1/2$ would require $I = mR^2$.

Final Answer: Rotational fraction $= 1/3 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

Q10.

Solution

Concept — Orbital speed: For a circular orbit, gravity supplies the centripetal force, $\frac{GMm}{r^2} = \frac{mv^2}{r}$.

Step 1 — Solve for v: $v^2 = \frac{GM}{r}$, so $v = \sqrt{\frac{GM}{r}}$.

Why other options are wrong: $\sqrt{2GM/r}$ is the escape speed; GM/r has wrong dimensions; $\sqrt{GM/r^2}$ is dimensionally incorrect.

Final Answer: $v = \sqrt{GM/r} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept — Elongation from Young's modulus: $\Delta L = \frac{FL}{AY}$.

Step 1 — Substitute SI values: $F = 200$ N, $L = 4$ m, $A = 2 \times 10^{-6}$ m^2, $Y = 2 \times 10^{11}$ N/m^2.

Step 2 — Compute: $\Delta L = \dfrac{200 \times 4}{(2 \times 10^{-6})(2 \times 10^{11})} = \dfrac{800}{4 \times 10^{5}} = 2 \times 10^{-3}\ \text{m} = 2\ \text{mm}.$

Why other options are wrong: 0.5 mm and 1 mm mis-handle the area or length; 4 mm doubles the result.

Final Answer: $\Delta L = 2\ \text{mm} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept — Equation of continuity: For an incompressible fluid, $A_1 v_1 = A_2 v_2$.

Step 1 — Substitute: $(6)(2) = (2)\, v_2$.

Step 2 — Solve: $v_2 = \dfrac{12}{2} = 6\ \text{m/s}.$

Why other options are wrong: 4 and 3 use a wrong area ratio; 12 forgets to divide by the smaller area.

Final Answer: $v_2 = 6\ \text{m/s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q12

Q13.

Solution

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

Step 1 — Rearrange: $W = Q - \Delta U$.

Step 2 — Substitute: $W = 500 - 300 = 200$ J.

Why other options are wrong: 800 adds instead of subtracting; 300 and 500 confuse the terms.

Final Answer: $W = 200\ \text{J} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Isothermal process: Temperature is constant, so for an ideal gas the internal energy (which depends only on T) does not change, $\Delta U = 0$.

Step 1 — Apply the first law: With $\Delta U = 0$, $Q = W$; heat supplied equals work done.

Why other options are wrong: Heat is exchanged and work is done (both non-zero); pressure changes as volume changes at constant T.

Final Answer: $\Delta U = 0 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — RMS speed: $v_{rms} = \sqrt{\dfrac{3RT}{M}}$ with M in kg/mol.

Step 1 — Substitute: $v_{rms} = \sqrt{\dfrac{3(8.3)(300)}{32 \times 10^{-3}}} = \sqrt{\dfrac{7470}{0.032}}$.

Step 2 — Compute: $v_{rms} = \sqrt{2.33 \times 10^5} \approx 483 \text{ m/s}$.

Why other options are wrong: 241 halves the answer; 966 doubles it; 1530 forgets to convert M to kg/mol.

Final Answer: $v_{rms} \approx 483 \text{ m/s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Carnot efficiency: $\eta = 1 - \dfrac{T_{sink}}{T_{source}}$ in kelvin.

Step 1 — Substitute: $\eta = 1 - \dfrac{400}{500} = 1 - 0.8 = 0.2$.

Step 2 — As a percentage: $\eta = 20\%$.

Why other options are wrong: 80% is the temperature ratio itself; 40% and 25% use wrong ratios.

Final Answer: $\eta = 20\% \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Maximum speed in SHM: $v_{max} = \omega A$.

Step 1 — Substitute: $v_{max} = (20)(0.05)$.

Step 2 — Compute: $v_{max} = 1 \text{ m/s}$.

Why other options are wrong: 0.25 uses $\omega^2 A/\ldots$ incorrectly; 2 doubles; 20 forgets the amplitude.

Final Answer: $v_{max} = 1 \text{ m/s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Spring–mass period: $T = 2\pi\sqrt{\dfrac{m}{k}}$.

Step 1 — Substitute: $T = 2\pi\sqrt{\dfrac{2}{200}} = 2\pi\sqrt{0.01}$.

Step 2 — Compute: $T = 2\pi(0.1) = \dfrac{\pi}{5}$ s.

Why other options are wrong: $\pi/10$ halves; π and $2\pi/5$ mis-handle the square root.

Final Answer: $T = \dfrac{\pi}{5} \text{ s} \Rightarrow \boxed{\text{B}}$

Answer: (B) 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: $f_b = 4$ beats per second.

Why other options are wrong: 516 adds the frequencies; 258 averages them; 2

halves the difference.

Final Answer: $f_b = 4 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Coulomb's law: $F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1q_2}{r^2}$.

Step 1 — Substitute: $F = \dfrac{(9\times10^9)(3\times10^{-6})(4\times10^{-6})}{(0.3)^2}$.

Step 2 — Compute: $F = \dfrac{9\times10^9\times12\times10^{-12}}{0.09} = \dfrac{0.108}{0.09} = 1.2\ \text{N}$.

Why other options are wrong: 0.36 omits dividing by r^2; 108 drops the 10^{-12}; 3.6 mis-handles a power of ten.

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

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Field of a point charge: $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r^2}$.

Step 1 — Substitute: $E = \dfrac{(9\times10^9)(3\times10^{-6})}{(0.3)^2}$.

Step 2 — Compute: $E = \dfrac{2.7\times10^4}{0.09} = 3\times10^5\ \text{N/C}$.

Why other options are wrong: 9×10^4 forgets to divide by r^2; 9×10^5 and 1×10^5 mis-handle the power of ten.

Final Answer: $E = 3\times10^5\ \text{N/C} \Rightarrow \boxed{\text{A}}$

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: $\frac{1}{C_{eq}} = \frac{1}{6} + \frac{1}{6} + \frac{1}{3} = \frac{1+1+2}{6} = \frac{4}{6}$.

Step 2 — Invert: $C_{eq} = \frac{6}{4} = 1.5\ \mu\text{F}$.

Why other options are wrong: $15\ \mu$F adds them as if in parallel; 3 and $6\ \mu$F keep only one value.

Final Answer: $C_{eq} = 1.5\ \mu\text{F} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Potential energy of two charges: $U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$.

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

Step 2 — Compute: $U = \frac{9\times10^9\times6\times10^{-12}}{0.6} = \frac{0.054}{0.6} = 0.09$ J.

Why other options are wrong: 0.045 uses $r = 1.2$; 0.18 drops the 0.6; 0.27 multiplies by 3 wrongly.

Final Answer: $U = 0.09$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — Series and parallel resistors: Two equal resistors in parallel give half; series resistances add.

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

Step 2 — Add the series resistor: $R_{eq} = R_p + 4 = 2 + 4 = 6\ \Omega$.

Why other options are wrong: 12 adds all three in series; 4 keeps only one; 2 stops at the parallel pair.

Final Answer: $R_{eq} = 6\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept — Terminal voltage: $V = \varepsilon - Ir$, where r is the internal resistance.

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 it; 3 V uses too large a current.

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

Answer: (B) Go Back to Q25

Q26.

Solution

Concept — Joule heating: $H = I^2Rt$.

Step 1 — Convert time: $t = 5\text{ min} = 300$ s.

Step 2 — Compute: $H = (3)^2(4)(300) = 9 \times 4 \times 300 = 10800$ J.

Why other options are wrong: 180 and 360 use t in minutes; 2160 uses $t = 60$ s.

Final Answer: $H = 10800\text{ J} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q26

Q27.

Solution

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

Step 1 — Substitute SI values: $R = 4\ \Omega$, $A = 0.5 \times 10^{-6}\ \text{m}^2$, $L = 2$ m.

Step 2 — Compute: $\rho = \dfrac{4 \times 0.5 \times 10^{-6}}{2} = \dfrac{2 \times 10^{-6}}{2} = 1 \times 10^{-6}\ \Omega\,\text{m}$.

Why other options are wrong: 2×10^{-6} forgets to divide by L; 4×10^{-6} and 0.5×10^{-6} mis-handle the area.

Final Answer: $\rho = 1 \times 10^{-6}\ \Omega\,\text{m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept — Field inside a 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: $B = 4\pi \times 10^{-7} \times 2000 = 8\pi \times 10^{-4} \approx 2.51 \times 10^{-3}$ T.

Why other options are wrong: 1×10^{-3} and 4×10^{-3} drop or misuse a factor; 6.28×10^{-3} uses $2\pi n I$.

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

Answer: (D) Go Back to Q28

Q29.

Solution

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

Step 1 — Substitute: $F = (0.2)(4)(0.5)$.

Step 2 — Compute: $F = 0.4$ N.

Why other options are wrong: 0.2 drops a factor; 0.8 doubles the length; 1.6 omits the field.

Final Answer: $F = 0.4\ \text{N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept — Torque on a current loop: $\tau = NBIA\sin\theta$. When the plane is parallel to $\vec{B}$, the normal is perpendicular to $\vec{B}$, so $\theta = 90°$ and $\sin\theta = 1$.

Step 1 — Substitute: $\tau = (50)(0.5)(2)(4 \times 10^{-3})$.

Step 2 — Compute: $\tau = 50 \times 0.5 \times 2 \times 4 \times 10^{-3} = 0.2$ N m.

Why other options are wrong: 0.1 halves; 0.4 doubles; 0.8 uses a wrong factor.

Final Answer: $\tau = 0.2\ \text{N m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q30

Q31.

Solution

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

Step 1 — Change in flux: $\Delta\Phi = 0.06 - 0.02 = 0.04$ Wb.

Step 2 — Compute: $\varepsilon = 200 \times \dfrac{0.04}{0.1} = 200 \times 0.4 = 80$ V.

Why other options are wrong: 8 V drops the factor N partly; 40 V uses half the flux change; 0.4 V ignores N.

Final Answer: $\varepsilon = 80\ \text{V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

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

Step 1 — Substitute: $X_L = (100)(0.5)$.

Step 2 — Compute: $X_L = 50\ \Omega$.

Why other options are wrong: 200 and 100 use wrong products; 0.5 forgets the frequency.

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

Answer: (D) Go Back to Q32

Q33.

Solution

Concept — Structure of an EM wave: In a plane electromagnetic wave the electric field, the magnetic field, and the direction of propagation are mutually perpendicular, forming a right-handed set.

Step 1 — Recall the geometry: $\vec{E} \perp \vec{B}$, and $\vec{E} \times \vec{B}$ points along the propagation direction.

Why other options are wrong: EM waves are transverse, so the fields are not parallel to the propagation direction or to each other.

Final Answer: They are mutually perpendicular $\Rightarrow$ B

Answer: (B) Go Back to Q33

Q34.

Solution

Concept — Modulation: Modulation is the process of altering a property (amplitude, frequency, or phase) of a high-frequency carrier in step with the message signal.

Step 1 — Match the definition: Varying a carrier characteristic according to the message is exactly modulation.

Why other options are wrong: Demodulation/detection recovers the message at the receiver; attenuation is a loss of signal strength.

Final Answer: The process is modulation $\Rightarrow$ A

Answer: (A) Go Back to Q34

Q35.

Solution

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

Step 1 — Maximum kinetic energy: $KE_{max} = 6 - 2.5 = 3.5$ eV.

Step 2 — Stopping potential: $V_0 = 3.5$ V.

Why other options are wrong: 8.5 adds the energies; 6 ignores the work function; 2.5 gives only the work function.

Final Answer: $V_0 = 3.5$ V $\Rightarrow$ C

Answer: (C) Go Back to Q35

Q36.

Solution

Concept — de Broglie wavelength of an accelerated electron: $\lambda = \frac{12.27}{\sqrt{V}}$ Å, with V in volts.

Step 1 — Substitute: $\lambda = \frac{12.27}{\sqrt{100}} = \frac{12.27}{10}$.

Step 2 — Compute: $\lambda = 1.227$ Å.

Why other options are wrong: 12.27 uses $V = 1$; 0.123 uses $V = 10^4$; 1.0 rounds incorrectly.

Final Answer: $\lambda \approx 1.227$ Å$\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) 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 $n = 3$: $r_3 = 3^2 \times 0.53 = 9 \times 0.53$.

Step 2 — Compute: $r_3 = 4.77$ Å.

Why other options are wrong: 1.59 uses n instead of n^2; 0.53 is the $n = 1$ value; 9.0 drops the 0.53 factor.

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

Answer: (A) Go Back to Q37

Q38.

Solution

Concept — Number of half-lives: If a sample falls to $\left(\frac{1}{2}\right)^n$ of its initial amount, then n half-lives have elapsed.

Step 1 — Find n: $\frac{1}{16} = \left(\frac{1}{2}\right)^4$, so $n = 4$.

Step 2 — Half-life: $T_{1/2} = \frac{40}{4} = 10$ days.

Why other options are wrong: 20 days uses $n = 2$; 8 days uses $n = 5$; 5 days uses $n = 8$.

Final Answer: $T_{1/2} = 10$ days $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept — Zener diode: Operated in reverse breakdown, a Zener diode maintains a nearly constant voltage across itself, making it ideal as a voltage regulator.

Step 1 — Recall the application: In the breakdown region the voltage stays fixed while the current varies, stabilising the output.

Why other options are wrong: Rectification uses ordinary diodes; amplification and oscillation require transistors with feedback.

Final Answer: Voltage regulator $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept — Logic gates: A NOR gate is an OR gate followed by an inverter; its output is 1 only when *all* inputs are 0.

Step 1 — Match the rule: "Output 1 only when both inputs are 0" is the NOR truth table, and the symbol is an OR shape with an output bubble.

Why other options are wrong: OR gives 1 if any input is 1; AND needs both inputs 1; NAND gives 0 only when both inputs are 1.

Final Answer: The gate is a NOR gate $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q40

Answer Key

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