UPCATET UG Physics Sample Paper-9

Duration: 45 Minutes **Maximum Marks: 200**

Instructions

- This paper contains **50** Multiple Choice Questions.
- Each correct answer carries **+4** marks. Incorrect answer: **−1** mark. Only **one** correct option is correct for each question.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. In a farm produce lift, a crate of mass 40 kg is carried upward by a vertical elevator. The lift starts accelerating upward at 2 m/s^2. What normal reaction does the floor of the lift exert on the crate? Take $g = 10$ m/s^2.

(A) 320 N

(B) 400 N

(C) 480 N

(D) 520 N

Q2. Two positive charges $+9q$ and $+q$ are fixed 40 cm apart in air. At what distance from the charge $+9q$ on the line joining the charges should a test charge be placed so that the net electrostatic force on it is zero?

(A) 10 cm

(B) 30 cm

(C) 20 cm

(D) 35 cm

Q3. A concave mirror of focal length 15 cm is used to inspect a small seed. The seed is placed 30 cm in front of the mirror. What is the nature and position of the image?

(A) Virtual and erect at 30 cm behind the mirror

(B) Real, inverted and at 30 cm in front of the mirror

(C) Real and enlarged at 45 cm

(D) Virtual and enlarged at 15 cm

Q4. A fixed-volume storage cylinder contains an ideal gas at 1.5 atm and 300 K. If the gas is heated to 450 K without changing its volume, the final pressure is:

(A) 1.0 atm

(B) 2.0 atm

(C) 2.25 atm

(D) 3.0 atm

Q5. An electron beam is produced by accelerating electrons through a potential difference. If the accelerating potential is changed from 100 V to 400 V, what is the ratio of the de Broglie wavelength at 100 V to that at 400 V?

(A) 1 : 2

(B) 2 : 1

(C) 4 : 1

(D) 1 : 4

Q6. A soap bubble used in a surface tension demonstration has radius 2 cm. If the surface tension of the soap solution is 0.03 N/m, the excess pressure inside the bubble is:

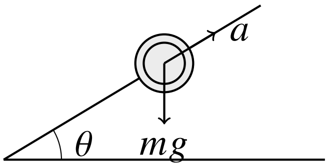
(A) 3 Pa

(B) 6 Pa

(C) 1.5 Pa

(D) 12 Pa

Q7. A hollow sphere rolls without slipping down a rough inclined track of angle θ as shown. If its moment of inertia about its centre is $I = \frac{2}{3}mR^2$, what is the acceleration of its centre of mass?



(A) $g \sin\theta$

(B) $\frac{3}{5} g \sin\theta$

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

(D) $\frac{2}{3} g \sin\theta$

Q8. A galvanometer has resistance 20 Ω and gives full-scale deflection at 5 mA. What shunt resistance should be connected to convert it into a 1 A ammeter?

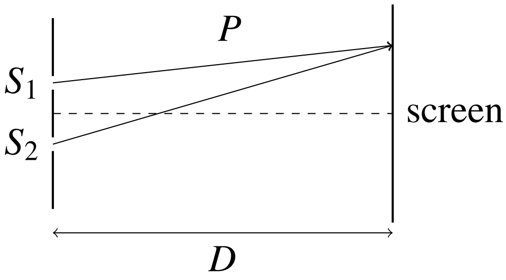
(A) 0.10 Ω approximately

(B) 4 Ω approximately

(C) 20 Ω

(D) 100 Ω

Q9. In a Young's double-slit arrangement, $d = 0.5$ mm, $D = 2$ m and $\lambda = 500$ nm. What is the distance between the second bright fringe and the fifth bright fringe on the screen?



(A) 2 mm

(B) 4 mm

(C) 6 mm

(D) 8 mm

Q10. A 4 kg feed block moving at 10 m/s on a rough horizontal floor comes to rest due to friction. If $\mu_k = 0.25$ and $g = 10$ m/s^2, the stopping distance is:

(A) 10 m

(B) 15 m

(C) 20 m

(D) 25 m

Q11. A composite wall has two slabs in series. Each slab has thickness 0.10 m and area 0.01 m^2. Their thermal conductivities are 200 W m^{-1}K^{-1} and 50 W m^{-1}K^{-1}. If the outer faces differ in temperature by 100 K, the steady heat current is:

(A) 100 W

(B) 200 W

(C) 400 W

(D) 800 W

Q12. A straight wire of length 0.5 m carries a current of 3 A perpendicular to a uniform magnetic field of 0.2 T. The magnetic force on the wire is:

(A) 0.03 N

(B) 0.30 N

(C) 3.0 N

(D) 30 N

Q13. A two-input NAND gate is supplied with inputs $A = 1$ and $B = 1$. What is its output?

(A) 1

(B) 0

(C) A

(D) B

Q14. A projectile is launched from level ground with speed 20 m/s at an angle 30° to the horizontal. Taking $g = 10$ m/s^2, its horizontal range is:

(A) $10\sqrt{3}$ m

(B) $20\sqrt{3}$ m

(C) $40\sqrt{3}$ m

(D) 20 m

Q15. An equilateral prism has refracting angle 60° and refractive index $\sqrt{2}$. At minimum deviation, what is the angle of minimum deviation?

(A) 15°

(B) 30°

(C) 45°

(D) 60°

Q16. A metal wire is stretched within its elastic limit so that the tensile stress in it becomes 2×10^6 N/m^2. If Young's modulus of the metal is 2×10^{11} N/m^2, the elastic energy density stored in the wire is:

(A) 5 J/m^3

(B) 10 J/m^3

(C) 20 J/m^3

(D) 40 J/m^3

Q17. An LCR series circuit has $L = 0.10$ H and $C = 10\ \mu$F. The resonance frequency is approximately:

(A) 50 Hz

(B) 159 Hz

(C) 314 Hz

(D) 1000 Hz

Q18. The temperature of 2 moles of a monoatomic ideal gas is raised by 30 K. The increase in its internal energy is closest to: take $R = 8.31$ J mol^{-1}K^{-1}.

(A) 249 J

(B) 499 J

(C) 748 J

(D) 997 J

Q19. A tractor moving on a level circular track of radius 50 m is just about to skid when the coefficient of friction is 0.20. What is the maximum safe speed? Take $g = 10$ m/s^2.

(A) 5 m/s

(B) 10 m/s

(C) 15 m/s

(D) 20 m/s

Q20. A metal has threshold wavelength 600 nm. Light of wavelength 400 nm falls on it. Taking $hc = 1240$ eV nm, the maximum kinetic energy of emitted photoelectrons is approximately:

(A) 0.52 eV

(B) 1.03 eV

(C) 2.07 eV

(D) 3.10 eV

Q21. An electric dipole of moment 4×10^{-8} C m is placed in a uniform electric field of magnitude 2×10^5 N/C. If the dipole makes an angle 30° with the field, the torque magnitude is:

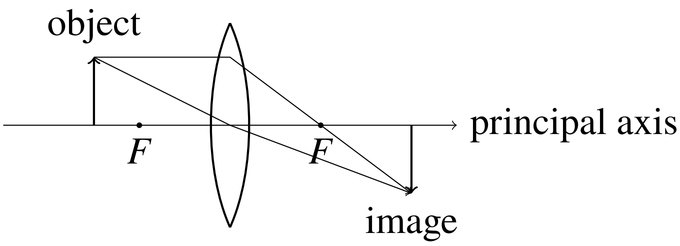
(A) 2×10^{-3} N m

(B) 4×10^{-3} N m

(C) 8×10^{-3} N m

(D) 1.6×10^{-2} N m

Q22. A convex lens of focal length 20 cm forms the image of a crop leaf placed 30 cm in front of it. Which option correctly describes the image?



(A) Virtual, erect and at 60 cm

(B) Real, inverted and at 60 cm

(C) Real, inverted and at 30 cm

(D) Virtual, erect and at 20 cm

Q23. Two particles of masses 2 kg and 3 kg lie on the x-axis at $x = 0$ and $x = 10$ m respectively. The position of their centre of mass is:

(A) 4 m

(B) 5 m

(C) 6 m

(D) 8 m

Q24. A heat engine absorbs 1200 J of heat from a hot reservoir and rejects 800 J to a cold reservoir in each cycle. Its efficiency is:

(A) 25%

(B) 33.3%

(C) 50%

(D) 66.7%

Q25. A uniform wire has resistance 5 Ω. It is stretched uniformly to double its original length without changing its volume. Its new resistance is:

(A) 2.5 Ω

(B) 10 Ω

(C) 20 Ω

(D) 40 Ω

Q26. A small metal sphere of mass 0.10 kg falls through a liquid and experiences a viscous drag force $F = kv$ with $k = 0.20$ N s/m. Neglecting buoyancy, its terminal speed is: take $g = 10$ m/s^2.

(A) 2 m/s

(B) 5 m/s

(C) 10 m/s

(D) 20 m/s

Q27. In the Bohr model of hydrogen, the energy of the electron in the $n = 2$ orbit is -3.4 eV. The minimum energy required to ionize the atom from this orbit is:

(A) 1.51 eV

(B) 3.4 eV

(C) 10.2 eV

(D) 13.6 eV

Q28. A block slides down a rough plane inclined at 30° to the horizontal. If $\mu = \dfrac{1}{2\sqrt{3}}$ and $g = 10$ m/s^2, the acceleration of the block is:

(A) 1.25 m/s^2

(B) 2.5 m/s^2

(C) 5 m/s^2

(D) 7.5 m/s^2

Q29. Unpolarized light of intensity I_0 passes through a polarizer and then through an analyser whose axis is at 45° to the polarizer. The final transmitted intensity is:

(A) $\frac{I_0}{2}$

(B) $\frac{I_0}{4}$

(C) $\frac{I_0}{8}$

(D) $\frac{3I_0}{4}$

Q30. A coil of 50 turns and area 0.02 m^2 rotates in a uniform magnetic field of 0.10 T with angular speed 100 rad/s. The peak induced emf is:

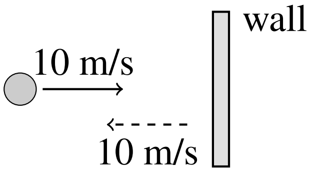
(A) 1 V

(B) 5 V

(C) 10 V

(D) 20 V

Q31. A rubber ball of mass 0.20 kg moving horizontally at 10 m/s strikes a rigid wall normally and rebounds with the same speed. What is the magnitude of change in its momentum?



(A) 0

(B) 2 kg m/s

(C) 4 kg m/s

(D) 8 kg m/s

Q32. Equal masses of water are not used in a mixing experiment: 100 g of water at 60°C is mixed with 200 g of water at 30°C in an insulated vessel. The final temperature is:

(A) 35°C

(B) 40°C

(C) 45°C

(D) 50°C

Q33. A radioactive sample is observed for three half-lives. What percentage of the original number of nuclei remains undecayed?

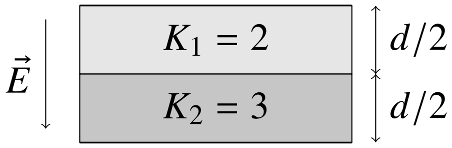
(A) 50%

(B) 25%

(C) 12.5%

(D) 6.25%

Q34. A parallel-plate capacitor of vacuum capacitance $C_0 = \varepsilon_0 A/d$ is completely filled with two dielectric slabs in series along the field direction, each of thickness $d/2$. Their dielectric constants are 2 and 3. The equivalent capacitance is:



(A) $\dfrac{5}{12}C_0$

(B) $\dfrac{12}{5}C_0$

(C) $5C_0$

(D) $6C_0$

Q35. Light travels from glass of refractive index 1.5 to air. The critical angle for the glass-air interface is:

(A) $\sin^{-1}\left(\dfrac{1}{3}\right)$

(B) $\sin^{-1}\left(\dfrac{2}{3}\right)$

(C) $\sin^{-1}\left(\dfrac{3}{2}\right)$

(D) 45° exactly

Q36. The length of a simple pendulum is increased to four times its original length. Its time period becomes:

(A) Half

(B) Double

(C) Four times

(D) Unchanged

Q37. Water rises to a height h in a capillary tube of radius r. If another tube of the same material has radius $r/2$, the height of rise will be:

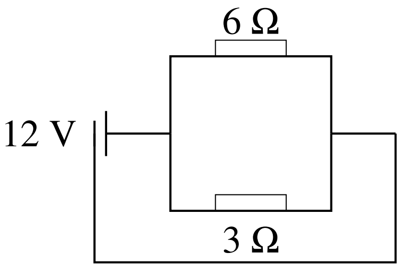
(A) $h/2$

(B) h

(C) $2h$

(D) $4h$

Q38. In the circuit shown, a 6 Ω resistor and a 3 Ω resistor are connected in parallel across a 12 V battery. What current flows through the 3 Ω resistor?



(A) 2 A

(B) 3 A

(C) 4 A

(D) 6 A

Q39. A Zener diode is normally used in reverse breakdown region because it can:

(A) Amplify alternating current signals

(B) Act as a voltage regulator

(C) Convert light into electric current only

(D) Store magnetic energy

Q40. The rms speed of gas molecules in a container is to be doubled. By what factor must the absolute temperature of the gas be increased?

(A) 2

(B) 4

(C) $\sqrt{2}$

(D) 8

Q41. A satellite of mass m moves in a circular orbit of radius r around Earth of mass M. The minimum energy that must be supplied to move it to a circular orbit of radius $2r$ is:

(A) $\dfrac{GMm}{4r}$

(B) $\dfrac{GMm}{2r}$

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

(D) $\dfrac{3GMm}{4r}$

Q42. In single-slit diffraction, light of wavelength 600 nm passes through a slit of width 0.30 mm. The angular position of the first minimum is approximately:

(A) 1×10^{-3} rad

(B) 2×10^{-3} rad

(C) 4×10^{-3} rad

(D) 6×10^{-3} rad

Q43. A capacitor of capacitance 100 μF is connected to a 50 Hz AC source. Its capacitive reactance is approximately:

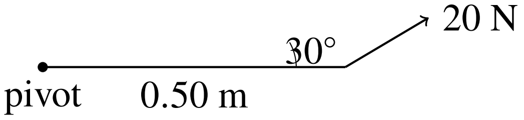
(A) 15.9 Ω

(B) 31.8 Ω

(C) 62.8 Ω

(D) 100 Ω

Q44. A force of 20 N is applied at the end of a 0.50 m light lever making an angle 30° with the lever. The torque about the pivot is:



(A) 2.5 N m

(B) 5 N m

(C) 10 N m

(D) 20 N m

Q45. The mass defect of a nucleus is 0.030 u. Taking 1 u = 931 MeV$/c^2$, its binding energy is approximately:

(A) 9.31 MeV

(B) 18.6 MeV

(C) 27.9 MeV

(D) 31.0 MeV

Q46. One mole of an ideal gas expands isothermally at 300 K from volume V to eV. The work done by the gas is approximately: take $R = 8.31$ J mol^{-1}K^{-1}.

(A) 831 J

(B) 1247 J

(C) 2493 J

(D) 4986 J

Q47. Four charges are placed at the corners of a square: $+q$ at two opposite corners and $-q$ at the other two opposite corners. The electric potential at the centre of the square is:

(A) Positive

(B) Negative

(C) Zero

(D) Infinite

Q48. A pond appears 67.5 cm deep when viewed normally from air. If the refractive index of water is $4/3$, the actual depth is:

(A) 50.6 cm

(B) 67.5 cm

(C) 90 cm

(D) 120 cm

Q49. A block attached to a spring of force constant k executes SHM with amplitude A on a frictionless surface. The magnitude of acceleration when its displacement is $A/2$ from equilibrium is:

(A) $\dfrac{kA}{2m}$

(B) $\dfrac{kA}{m}$

(C) $\dfrac{2kA}{m}$

(D) 0

Q50. A 2 kg trolley moving at 6 m/s collides with a stationary 1 kg trolley and they stick together. The loss of kinetic energy in the collision is:

(A) 6 J

(B) 12 J

(C) 18 J

(D) 24 J

Detailed Solutions

Q1.

Solution

Concept:
Apparent weight in an accelerating lift is the normal reaction exerted by the floor. When the lift accelerates upward, the floor must support the weight and also provide an upward net force. Newton's second law in the vertical direction gives $N - mg = ma$.

Solution:

(a) The given mass is $m = 40$ kg and the upward acceleration is $a = 2$ m/s^2.

(b) For upward acceleration, take upward as positive. The forces on the crate are normal reaction N upward and weight mg downward.

(c) Applying Newton's second law gives $N - mg = ma$.

(d) Hence $N = m(g + a) = 40(10 + 2) = 40 \times 12 = 480$ N.

(e) The option 400 N would be the reading only when the lift is not accelerating, so it is not valid here.

Final Answer: $\boxed{480 \text{ N}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 1

Q2.

Solution

Concept:
For two like charges, the zero-field point lies between them because the electric fields due to the two charges are in opposite directions there. The magnitudes of the two Coulomb fields must be equal at the required point.

Solution:

(a) Let the point be at a distance x from $+9q$. Its distance from $+q$ is then $(40 - x)$ cm.

(b) Equate the magnitudes of the two electric fields: $\dfrac{k(9q)}{x^2} = \dfrac{kq}{(40 - x)^2}$.

(c) Canceling kq gives $\dfrac{9}{x^2} = \dfrac{1}{(40 - x)^2}$.

(d) Taking the positive square root, because distances are positive, $\dfrac{3}{x} = \dfrac{1}{40 - x}$.

(e) Thus $3(40 - x) = x$, so $120 - 3x = x$ and $x = 30$ cm.

(f) This point is closer to the smaller charge, which is physically expected.

Final Answer: $\boxed{30 \text{ cm from } + 9q}$

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:

For a spherical mirror, the mirror formula relates object distance, image distance and focal length. With the Cartesian sign convention, distances in front of a concave mirror are negative, and a real image has negative image distance.

Solution:

(a) For a concave mirror, $f = -15$ cm and the object distance is $u = -30$ cm.

(b) Use the mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$.

(c) Substitute the values: $\frac{1}{-15} = \frac{1}{v} + \frac{1}{-30}$.

(d) Therefore $\frac{1}{v} = -\frac{1}{15} + \frac{1}{30} = -\frac{1}{30}$, so $v = -30$ cm.

(e) The negative image distance shows that the image is formed in front of the mirror. The magnification is $m = -v/u = -(-30)/(-30) = -1$, so it is real, inverted and same size.

Final Answer: $\boxed{\text{real, inverted, at 30 cm in front}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 3

Q4.

Solution

Concept:

For a fixed mass of ideal gas at constant volume, pressure is directly proportional to absolute temperature. This is Gay-Lussac's law, obtained from $PV = nRT$ by keeping V and n constant.

Solution:

(a) The initial pressure and temperature are $P_1 = 1.5$ atm and $T_1 = 300$ K.

(b) The final temperature is $T_2 = 450$ K, and volume remains fixed.

(c) Use $\frac{P_1}{T_1} = \frac{P_2}{T_2}$.

(d) Thus $P_2 = P_1\frac{T_2}{T_1} = 1.5 \times \frac{450}{300}$.

(e) Since $450/300 = 1.5$, $P_2 = 2.25$ atm.

(f) The temperature must be used in kelvin; here it is already given in kelvin.

Final Answer: $\boxed{2.25 \text{ atm}}$

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept:
For a non-relativistic charged particle accelerated through a potential difference V, the de Broglie wavelength is inversely proportional to the square root of the accelerating voltage: $\lambda = h/\sqrt{2meV}$.

Solution:

(a) Let λ_1 correspond to 100 V and λ_2 correspond to 400 V.

(b) Since $\lambda \propto \dfrac{1}{\sqrt{V}}$, the ratio is $\dfrac{\lambda_1}{\lambda_2} = \sqrt{\dfrac{V_2}{V_1}}$.

(c) Substitute $V_1 = 100$ V and $V_2 = 400$ V.

(d) This gives $\dfrac{\lambda_1}{\lambda_2} = \sqrt{\dfrac{400}{100}} = \sqrt{4} = 2$.

(e) Increasing the accelerating voltage makes momentum larger, so the wavelength must decrease. The ratio 2 : 1 matches this expectation.

Final Answer: $\boxed{2:1}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 5

Q6.

Solution

Concept:

A soap bubble has two liquid-air surfaces, one inside and one outside. Therefore the excess pressure across a soap bubble is $\Delta P = 4T/r$, unlike a single liquid drop where the factor is $2T/r$.

Solution:

(a) The radius is $r = 2$ cm $= 0.02$ m and surface tension is $T = 0.03$ N/m.

(b) For a soap bubble, use $\Delta P = \dfrac{4T}{r}$.

(c) Substitute the values: $\Delta P = \dfrac{4 \times 0.03}{0.02}$.

(d) The numerator is 0.12, and $0.12/0.02 = 6$.

(e) The correct unit is pascal because N/m divided by metre gives N/m^2.

(f) Using $2T/r$ would give 3 Pa, which is the common trap for a bubble.

Final Answer: $\boxed{6 \text{ Pa}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 6

Q7.

Solution

Concept:

In rolling without slipping, translational and rotational motions are linked by $a = R\alpha$. The acceleration down an incline depends on both gravitational component and rotational inertia according to $a = g\sin\theta/(1 + I/mR^2)$.

Solution:

(a) The force component pulling the sphere down the plane is $mg\sin\theta$.

(b) Static friction supplies the torque needed for rotation, but it does no work because the contact point is instantaneously at rest.

(c) Use the standard rolling result $a = \dfrac{g\sin\theta}{1 + I/(mR^2)}$.

(d) For a hollow sphere, $I = \dfrac{2}{3}mR^2$, so $I/(mR^2) = 2/3$.

(e) Therefore $a = \dfrac{g\sin\theta}{1 + 2/3} = \dfrac{g\sin\theta}{5/3} = \dfrac{3}{5}g\sin\theta$.

(f) The value is less than $g\sin\theta$ because some gravitational energy goes into rotation.

Final Answer: $\boxed{\dfrac{3}{5}g\sin\theta}$

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept:
To convert a galvanometer into an ammeter, a small shunt resistance is connected in parallel so that most of the current bypasses the delicate galvanometer coil. The potential difference across the galvanometer and shunt must be equal.

Solution:

(a) The galvanometer resistance is $G = 20\ \Omega$ and full-scale current is $I_g = 5$ mA $= 0.005$ A.

(b) For a 1 A ammeter, the shunt current is $I_s = I - I_g = 1 - 0.005 = 0.995$ A.

(c) Equal voltage across parallel branches gives $I_g G = I_s S$, where S is the shunt resistance.

(d) Thus $S = \dfrac{I_g G}{I_s} = \dfrac{0.005 \times 20}{0.995}$.

(e) This equals $0.1005\ \Omega$, which is approximately $0.10\ \Omega$.

(f) A shunt must be very small compared with the galvanometer resistance, so this value is physically reasonable.

Final Answer: $\boxed{0.10\ \Omega \text{ approximately}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 8

Q9.

Solution

Concept:

In YDSE, successive bright fringes are separated by the fringe width $\beta = \lambda D/d$. The distance between two bright fringes equals the difference in their order numbers multiplied by β.

Solution:

(a) Convert the data into SI units: $d = 0.5$ mm $= 5 \times 10^{-4}$ m and $\lambda = 500$ nm $= 5 \times 10^{-7}$ m.

(b) The fringe width is $\beta = \dfrac{\lambda D}{d}$.

(c) Substitute values: $\beta = \dfrac{(5 \times 10^{-7})(2)}{5 \times 10^{-4}} = 2 \times 10^{-3}$ m $= 2$ mm.

(d) The fifth and second bright fringes differ by $5 - 2 = 3$ fringe intervals.

(e) Therefore the required distance is $3\beta = 3 \times 2$ mm $= 6$ mm.

(f) The distance is not measured from the central fringe here; it is between two specified bright fringes.

Final Answer: $\boxed{6 \text{ mm}}$

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept:

On a horizontal rough surface, kinetic friction provides a constant retarding force $\mu_k mg$. The corresponding deceleration is $\mu_k g$, and the stopping distance can be found from the kinematic equation $v^2 = u^2 + 2as$.

Solution:

(a) The initial speed is $u = 10$ m/s and the final speed is $v = 0$.

(b) The frictional retardation is $a_r = \mu_k g = 0.25 \times 10 = 2.5$ m/s^2.

(c) Taking the direction of motion as positive, acceleration is $a = -2.5$ m/s^2.

(d) Use $v^2 = u^2 + 2as$: $0 = 10^2 + 2(-2.5)s$.

(e) This gives $5s = 100$, hence $s = 20$ m.

(f) The mass cancels because both friction and inertia are proportional to mass.

Final Answer: $\boxed{20 \text{ m}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 10

Q11.

Solution

Concept:

For heat conduction through slabs in series, the same heat current passes through each slab. Thermal resistances add, where a slab has resistance $R_{th} = L/(kA)$. The heat current is $H = \Delta T/R_{th,total}$.

Solution:

(a) For the first slab, $R_1 = \dfrac{0.10}{200 \times 0.01} = 0.05$ K/W.

(b) For the second slab, $R_2 = \dfrac{0.10}{50 \times 0.01} = 0.20$ K/W.

(c) The total thermal resistance is $R_1 + R_2 = 0.25$ K/W.

(d) The temperature difference across the composite wall is $\Delta T = 100$ K.

(e) Therefore $H = \dfrac{\Delta T}{R_{total}} = \dfrac{100}{0.25} = 400$ W.

(f) Adding conductivities directly would be wrong because the slabs are in series, not parallel.

Final Answer: $\boxed{\text{400 W}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 11

Q12.

Solution

Concept:
A current-carrying conductor in a magnetic field experiences a force $F = BIL\sin\theta$. The angle θ is between the direction of current and the magnetic field.
Solution:

(a) Here $B = 0.2$ T, $I = 3$ A, and $L = 0.5$ m.

(b) The wire is perpendicular to the magnetic field, so $\theta = 90^\circ$ and $\sin\theta = 1$.

(c) Use $F = BIL\sin\theta$.

(d) Substitution gives $F = 0.2 \times 3 \times 0.5 \times 1$.

(e) Thus $F = 0.30$ N.

(f) If the wire were parallel to the field, the force would be zero, but that is not the given condition.

Final Answer: $\boxed{0.30 \text{ N}}$

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:
A NAND gate is an AND gate followed by a NOT operation. Its Boolean expression is $Y = \overline{A \cdot B}$. It gives zero only when both inputs are one.
Solution:

(a) The given binary inputs are $A = 1$ and $B = 1$.

(b) First evaluate the AND part: $A \cdot B = 1 \cdot 1 = 1$.

(c) Now apply the NOT operation to the AND output.

(d) Thus $Y = \overline{1} = 0$.

(e) This is the only input combination for which a NAND gate gives zero.

Final Answer: $\boxed{0}$

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept:
For projectile motion over level ground, the range is $R = u^2 \sin 2\theta / g$. This formula assumes launch and landing occur at the same vertical level and air resistance is neglected.

Solution:

(a) The launch speed is $u = 20$ m/s and angle is $\theta = 30°$.

(b) Use $R = \dfrac{u^2 \sin 2\theta}{g}$.

(c) Here $2\theta = 60°$ and $\sin 60° = \sqrt{3}/2$.

(d) So $R = \dfrac{20^2 \times (\sqrt{3}/2)}{10}$.

(e) This simplifies to $R = \dfrac{400\sqrt{3}}{20} = 20\sqrt{3}$ m.

(f) The formula would not apply directly if the projectile landed at a different height.

Final Answer: $\boxed{20\sqrt{3}\ \text{m}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 14

Q15.

Solution

Concept:
At minimum deviation through a prism, the path of the ray is symmetric and the prism formula is $\mu = \sin[(A+\delta_m)/2]/\sin(A/2)$. This connects refractive index, prism angle and minimum deviation.

Solution:

(a) The prism angle is $A = 60^\circ$ and $\mu = \sqrt{2}$.

(b) Use $\mu = \dfrac{\sin[(A+\delta_m)/2]}{\sin(A/2)}$.

(c) Since $A/2 = 30^\circ$, $\sin(A/2) = \sin 30^\circ = 1/2$.

(d) Therefore $\sin\left(\dfrac{60^\circ + \delta_m}{2}\right) = \sqrt{2} \times \dfrac{1}{2} = \dfrac{1}{\sqrt{2}}$.

(e) The relevant acute angle is 45°, so $\dfrac{60^\circ + \delta_m}{2} = 45^\circ$.

(f) Hence $60^\circ + \delta_m = 90^\circ$ and $\delta_m = 30^\circ$.

Final Answer: $\boxed{30^\circ}$

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:

Elastic energy density in a stretched wire is $u = \frac{1}{2} \times \text{stress} \times \text{strain}$. Since $Y = \text{stress}/\text{strain}$, it can also be written as $u = \sigma^2/(2Y)$.

Solution:

(a) The tensile stress is $\sigma = 2 \times 10^6$ N/m^2.

(b) Young's modulus is $Y = 2 \times 10^{11}$ N/m^2.

(c) Use the formula $u = \dfrac{\sigma^2}{2Y}$.

(d) Substitute the values: $u = \dfrac{(2 \times 10^6)^2}{2(2 \times 10^{11})}$.

(e) The numerator is 4×10^{12} and the denominator is 4×10^{11}.

(f) Thus $u = 10$ J/m^3.

Final Answer: $\boxed{10 \text{ J/m}^3}$

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept:
In a series LCR circuit, resonance occurs when inductive reactance and capacitive reactance are equal. The resonance frequency is $f_0 = 1/(2\pi\sqrt{LC})$.
Solution:

(a) Convert the capacitance: $C = 10\ \mu\text{F} = 10 \times 10^{-6}\ \text{F} = 10^{-5}\ \text{F}$.

(b) The inductance is $L = 0.10$ H.

(c) Compute $LC = 0.10 \times 10^{-5} = 10^{-6}$.

(d) Therefore $\sqrt{LC} = 10^{-3}$.

(e) Now $f_0 = \dfrac{1}{2\pi \times 10^{-3}} \approx \dfrac{1000}{6.28} \approx 159$ Hz.

(f) At this frequency the impedance is minimum and current is maximum.

Final Answer: $\boxed{159\ \text{Hz}}$

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept:

For an ideal gas, internal energy depends only on temperature. A monoatomic ideal gas has molar heat capacity at constant volume $C_V = 3R/2$, so $\Delta U = nC_V\Delta T$.

Solution:

(a) The number of moles is $n = 2$ and the temperature rise is $\Delta T = 30$ K.

(b) For a monoatomic ideal gas, $C_V = \dfrac{3R}{2}$.

(c) Thus $\Delta U = n\dfrac{3R}{2}\Delta T$.

(d) Substitute values: $\Delta U = 2 \times \dfrac{3}{2} \times 8.31 \times 30$.

(e) The factor 2 cancels the denominator 2, giving $\Delta U = 3 \times 8.31 \times 30 = 747.9$ J.

(f) Rounded to the nearest option, this is 748 J.

Final Answer: $\boxed{748 \text{ J}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 18

Q19.

Solution

Concept:
On a level circular road, static friction provides the centripetal force. At the limiting safe speed, the maximum available friction μmg equals mv^2/r.
Solution:

(a) The track radius is $r = 50$ m and the coefficient of friction is $\mu = 0.20$.

(b) At the limiting condition, $\mu mg = \dfrac{mv^2}{r}$.

(c) The mass cancels, giving $v = \sqrt{\mu g r}$.

(d) Substitute the values: $v = \sqrt{0.20 \times 10 \times 50}$.

(e) The quantity inside the square root is 100, so $v = 10$ m/s.

(f) At speeds larger than this, available friction is insufficient for the required centripetal force.

Final Answer: $\boxed{10 \text{ m/s}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 19

Q20.

Solution

Concept:

Einstein's photoelectric equation is $K_{\text{max}} = h\nu - \phi$. If threshold wavelength is λ_0, then $\phi = hc/\lambda_0$, so $K_{\text{max}} = hc(1/\lambda - 1/\lambda_0)$.

Solution:

(a) The incident wavelength is $\lambda = 400$ nm and the threshold wavelength is $\lambda_0 = 600$ nm.

(b) Use $K_{\text{max}} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$.

(c) Substitute $hc = 1240$ eV nm: $K_{\text{max}} = 1240\left(\frac{1}{400} - \frac{1}{600}\right)$.

(d) The bracket is $\frac{3-2}{1200} = \frac{1}{1200}$.

(e) Thus $K_{\text{max}} = \frac{1240}{1200} = 1.03$ eV approximately.

(f) Because 400 nm $<$ 600 nm, emission is possible; a shorter wavelength means higher photon energy.

Final Answer: $\boxed{1.03 \text{ eV}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 20

Q21.

Solution

Concept:

A dipole in a uniform electric field experiences no net force, but it experiences a torque that tends to align it with the field. The magnitude is $\tau = pE\sin\theta$.

Solution:

(a) The dipole moment is $p = 4 \times 10^{-8}$ C m.

(b) The electric field strength is $E = 2 \times 10^5$ N/C and the angle is 30°.

(c) Use $\tau = pE\sin\theta$.

(d) First compute $pE = (4 \times 10^{-8})(2 \times 10^5) = 8 \times 10^{-3}$.

(e) Since $\sin 30^\circ = 1/2$, $\tau = 8 \times 10^{-3} \times 1/2 = 4 \times 10^{-3}$ N m.

(f) The torque becomes zero only when the dipole is exactly parallel or anti-parallel to the field.

Final Answer: $\boxed{4 \times 10^{-3}\ \text{N m}}$

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:

A convex lens forms a real image when the object is placed beyond its focal length. The lens formula $1/f = 1/v - 1/u$ with Cartesian signs gives the image position and magnification.

Solution:

(a) For a convex lens, $f = +20$ cm. The object is in front of the lens, so $u = -30$ cm.

(b) Use $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$.

(c) Substitute values: $\frac{1}{20} = \frac{1}{v} - \frac{1}{-30} = \frac{1}{v} + \frac{1}{30}$.

(d) Thus $\frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{3-2}{60} = \frac{1}{60}$, so $v = 60$ cm.

(e) The positive image distance means the image is real and formed on the other side of the lens. The magnification $v/u = 60/(-30) = -2$ shows it is inverted and enlarged.

(f) Therefore the correct description is real, inverted and at 60 cm.

Final Answer: $\boxed{\text{real, inverted and at 60 cm}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 22

Q23.

Solution

Concept:
The centre of mass of point masses on a line is the mass-weighted average of their positions. It lies closer to the heavier mass.

Solution:

(a) The masses are $m_1 = 2$ kg at $x_1 = 0$ and $m_2 = 3$ kg at $x_2 = 10$ m.

(b) Use $x_{cm} = \dfrac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$.

(c) Substitute the values: $x_{cm} = \dfrac{2(0) + 3(10)}{2 + 3}$.

(d) This gives $x_{cm} = \dfrac{30}{5} = 6$ m.

(e) The result is closer to 10 m than to 0, as expected because the 3 kg mass is heavier.

Final Answer: $\boxed{6 \text{ m}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 23

Q24.

Solution

Concept:
The efficiency of a heat engine is the ratio of useful work output to heat absorbed. Over a complete cycle, work output equals heat absorbed minus heat rejected.

Solution:

(a) The heat absorbed is $Q_H = 1200$ J and the heat rejected is $Q_C = 800$ J.

(b) The work done per cycle is $W = Q_H - Q_C = 1200 - 800 = 400$ J.

(c) Efficiency is $\eta = \frac{W}{Q_H}$.

(d) Substitute the values: $\eta = \frac{400}{1200} = \frac{1}{3}$.

(e) In percentage form, $\eta = 33.3\%$ approximately.

(f) Using heat rejected instead of heat absorbed in the denominator would give a wrong efficiency.

Final Answer: $\boxed{33.3\%}$

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:

For a wire of fixed material, $R = \rho L/A$. If volume remains constant, AL is constant, so area is inversely proportional to length. Therefore resistance becomes proportional to L^2.

Solution:

(a) The original resistance is $R = 5\ \Omega$.

(b) The wire is stretched to double its length, so $L' = 2L$.

(c) Because volume is unchanged, $A'L' = AL$, hence $A' = A/2$.

(d) The new resistance is $R' = \rho\dfrac{L'}{A'} = \rho\dfrac{2L}{A/2} = 4\rho\dfrac{L}{A} = 4R$.

(e) Thus $R' = 4 \times 5 = 20\ \Omega$.

(f) The common trap is to assume resistance only doubles; the area change must also be included.

Final Answer: $\boxed{20\ \Omega}$

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept:
Terminal velocity occurs when the net force on the falling object becomes zero. With linear drag and negligible buoyancy, the downward weight is balanced by upward viscous force: $mg = kv_t$.
Solution:

(a) The mass is $m = 0.10$ kg, so its weight is $mg = 0.10 \times 10 = 1.0$ N.

(b) At terminal speed, acceleration is zero, so upward drag equals downward weight.

(c) Thus $kv_t = mg$.

(d) Solving for terminal speed gives $v_t = \dfrac{mg}{k}$.

(e) Substitute $k = 0.20$ N s/m: $v_t = \dfrac{1.0}{0.20} = 5$ m/s.

(f) Before reaching this speed the net force is downward; at terminal speed it becomes zero.

Final Answer: $\boxed{5 \text{ m/s}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 26

Q27.

Solution

Concept:
Ionization from a given Bohr orbit means taking the electron from that negative energy level to the zero-energy free state at infinity. The required energy is the magnitude of the bound-state energy.
Solution:

(a) The energy of the electron in the $n = 2$ orbit is $E_2 = -3.4$ eV.

(b) For ionization, the final energy is $E_\infty = 0$.

(c) The required energy input is $\Delta E = E_\infty - E_2$.

(d) Substitute: $\Delta E = 0 - (-3.4) = 3.4$ eV.

(e) The answer is not 13.6 eV because that value applies to ionization from the ground state $n = 1$.

Final Answer: $\boxed{3.4 \text{ eV}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 27

Q28.

Solution

Concept:

For a block sliding down a rough incline, the component of gravity down the plane is $mg\sin\theta$ and friction acts up the plane with magnitude $\mu mg\cos\theta$. The net acceleration is $g(\sin\theta - \mu\cos\theta)$.

Solution:

(a) Here $\theta = 30^\circ$ and $\mu = 1/(2\sqrt{3})$.

(b) Use $a = g(\sin\theta - \mu\cos\theta)$ for downward sliding.

(c) Substitute $\sin 30^\circ = 1/2$ and $\cos 30^\circ = \sqrt{3}/2$.

(d) Then $\mu\cos 30^\circ = \frac{1}{2\sqrt{3}} \times \frac{\sqrt{3}}{2} = \frac{1}{4}$.

(e) So $a = 10\left(\frac{1}{2} - \frac{1}{4}\right) = 10 \times \frac{1}{4} = 2.5\ \text{m/s}^2$.

(f) Friction reduces but does not stop the downward acceleration.

Final Answer: $\boxed{2.5\ \text{m/s}^2}$

Answer: (B)

Go Back to Question 28

Q29.

Solution

Concept:
An ideal polarizer transmits half the intensity of unpolarized light. The second polarizer follows Malus's law, $I = I_1 \cos^2\theta$, where θ is the angle between transmission axes.

Solution:

(a) After the first polarizer, the intensity becomes $I_1 = I_0/2$.

(b) The analyser makes an angle $\theta = 45^\circ$ with the first polarizer.

(c) Apply Malus's law: $I_2 = I_1 \cos^2 45^\circ$.

(d) Since $\cos 45^\circ = 1/\sqrt{2}$, $\cos^2 45^\circ = 1/2$.

(e) Thus $I_2 = (I_0/2)(1/2) = I_0/4$.

(f) Do not apply Malus's law directly to unpolarized light before accounting for the first half-intensity loss.

Final Answer: $\boxed{\frac{I_0}{4}}$

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept:

For a rotating coil in a uniform magnetic field, the magnetic flux varies sinusoidally. The maximum induced emf is $E_0 = NBA\omega$, where N is turns, B is magnetic field, A is area and ω is angular speed.

Solution:

(a) The number of turns is $N = 50$, area $A = 0.02$ m^2, field $B = 0.10$ T and angular speed $\omega = 100$ rad/s.

(b) Use $E_0 = NBA\omega$.

(c) Substitute the values: $E_0 = 50 \times 0.10 \times 0.02 \times 100$.

(d) First $50 \times 0.10 = 5$, and $0.02 \times 100 = 2$.

(e) Therefore $E_0 = 5 \times 2 = 10$ V.

(f) This is the peak value; the instantaneous emf varies with time.

Final Answer: $\boxed{10 \text{ V}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 30

Q31.

Solution

Concept:

Momentum is a vector quantity. When a ball rebounds with the same speed in the opposite direction, the magnitude of velocity is unchanged but its direction reverses, so the change in momentum is not zero.

Solution:

(a) Take the initial direction toward the wall as positive.

(b) Initial momentum is $p_i = mv = 0.20 \times 10 = 2$ kg m/s.

(c) After rebounding, the velocity is opposite, so $p_f = 0.20 \times (-10) = -2$ kg m/s.

(d) The change in momentum is $\Delta p = p_f - p_i = -2 - 2 = -4$ kg m/s.

(e) The magnitude is therefore $|\Delta p| = 4$ kg m/s.

(f) The common mistake is to subtract speeds instead of velocities.

Final Answer: $\boxed{4 \text{ kg m/s}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 31

Q32.

Solution

Concept:

In calorimetry with no heat loss and the same substance on both sides, heat lost by hot water equals heat gained by cold water. Since the specific heat is the same, it cancels from the equation.

Solution:

(a) Let the final temperature be T.

(b) Heat lost by hot water is $100c(60 - T)$.

(c) Heat gained by cold water is $200c(T - 30)$.

(d) Equate them: $100c(60 - T) = 200c(T - 30)$.

(e) Cancel $100c$: $60 - T = 2T - 60$.

(f) Thus $120 = 3T$, giving $T = 40°\text{C}$.

Final Answer: $\boxed{40°\text{C}}$

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept:

After each half-life, the undecayed number of nuclei becomes half of its previous value. After n half-lives, the remaining fraction is $(1/2)^n$.

Solution:

(a) The sample is observed for $n = 3$ half-lives.

(b) The remaining fraction is $\left(\frac{1}{2}\right)^3$.

(c) This equals $1/8$.

(d) Convert to percentage: $\frac{1}{8} \times 100\% = 12.5\%$.

(e) This is the fraction remaining, not the fraction decayed. The decayed percentage would be 87.5%.

Final Answer: $\boxed{12.5\%}$

Answer: (C)

Go Back to Question 33

Q34.

Solution

Concept:

When dielectric layers are stacked along the electric field direction, they behave like capacitors in series. The effective separation becomes the sum of t_i/K_i terms in $C = \varepsilon_0 A/\sum(t_i/K_i)$.

Solution:

(a) The two dielectric thicknesses are $t_1 = d/2$ and $t_2 = d/2$.

(b) Use $C = \dfrac{\varepsilon_0 A}{t_1/K_1 + t_2/K_2}$.

(c) Substitute $K_1 = 2$ and $K_2 = 3$: denominator $= \dfrac{d/2}{2} + \dfrac{d/2}{3} = \dfrac{d}{4} + \dfrac{d}{6}$.

(d) Adding the terms gives $\dfrac{3d + 2d}{12} = \dfrac{5d}{12}$.

(e) Thus $C = \dfrac{\varepsilon_0 A}{5d/12} = \dfrac{12}{5}\dfrac{\varepsilon_0 A}{d} = \dfrac{12}{5}C_0$.

(f) Treating the slabs as parallel would be wrong because they are stacked along the plate separation.

Final Answer: $\boxed{\dfrac{12}{5}C_0}$

Answer: (B)

Go Back to Question 34

Q35.

Solution

Concept:

The critical angle is defined for light going from a denser medium to a rarer medium. It satisfies $\sin C = n_2/n_1$, where n_1 is the refractive index of the denser medium and n_2 that of the rarer medium.

Solution:

(a) Here light travels from glass to air, so $n_1 = 1.5$ and $n_2 = 1$.

(b) Use $\sin C = \frac{n_2}{n_1}$.

(c) Substitute values: $\sin C = \frac{1}{1.5} = \frac{2}{3}$.

(d) Therefore $C = \sin^{-1}(2/3)$.

(e) The expression $\sin^{-1}(3/2)$ is impossible because sine cannot exceed one.

Final Answer: $\boxed{\sin^{-1}\left(\frac{2}{3}\right)}$

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept:
For small oscillations, the time period of a simple pendulum is $T = 2\pi\sqrt{l/g}$. Thus the period is proportional to the square root of its length.
Solution:

(a) Let the original length be l and original period be T.

(b) The new length is $l' = 4l$.

(c) Since $T \propto \sqrt{l}$, $\dfrac{T'}{T} = \sqrt{\dfrac{l'}{l}}$.

(d) Substitute $l' = 4l$: $\dfrac{T'}{T} = \sqrt{4} = 2$.

(e) Hence the time period becomes double.

(f) It does not become four times because the dependence on length is square-root, not linear.

Final Answer: $\boxed{\text{Double}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 36

Q37.

Solution

Concept:
Capillary rise is $h = 2T\cos\theta/(\rho g r)$. For the same liquid and tube material, T, θ, ρ and g remain constant, so height is inversely proportional to radius.
Solution:

(a) For the first tube, height is h with radius r.

(b) For the second tube, radius is $r' = r/2$.

(c) Since $h \propto 1/r$, the new height is $h' = h \times \dfrac{r}{r'}$.

(d) Substitute $r' = r/2$: $h' = h \times \dfrac{r}{r/2} = 2h$.

(e) A narrower capillary gives a larger rise, which agrees with the physical behavior.

Final Answer: $\boxed{2h}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 37

Q38.

Solution

Concept:
In a parallel circuit, each branch has the same potential difference as the source. The current through each resistor is then found independently using Ohm's law $I = V/R$.

Solution:

(a) The 3 Ω resistor is connected directly across the 12 V battery.

(b) Therefore the potential difference across this resistor is 12 V.

(c) Apply Ohm's law to this branch: $I = V/R$.

(d) Substitute $V = 12$ V and $R = 3$ Ω.

(e) This gives $I = 12/3 = 4$ A.

(f) The current through the 6 Ω branch is different, but it is not asked.

Final Answer: $\boxed{4\text{ A}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 38

Q39.

Solution

Concept:
A Zener diode is specially designed to operate safely in reverse breakdown. In that region, the voltage across it remains nearly constant over a range of current, making it useful for regulation.

Solution:

(a) In ordinary forward bias, a diode conducts like a rectifying element.

(b) A Zener diode is different because its reverse breakdown voltage is well-defined and stable.

(c) When connected with a suitable series resistor, changes in supply voltage or load current mainly change the Zener current.

(d) The voltage across the Zener remains approximately constant at the Zener voltage.

(e) Therefore its standard use is voltage regulation, not amplification or magnetic energy storage.

Final Answer: $\boxed{\text{Act as a voltage regulator}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 39

Q40.

Solution

Concept:
For an ideal gas, the rms speed is $v_{rms} = \sqrt{3RT/M}$. For the same gas, molar mass is constant, so v_{rms} is proportional to $\sqrt{T}$.

Solution:

(a) Let the initial rms speed be v at temperature T.

(b) The required final rms speed is $v' = 2v$.

(c) Since $v_{rms} \propto \sqrt{T}$, $\dfrac{v'}{v} = \sqrt{\dfrac{T'}{T}}$.

(d) Substitute $v'/v = 2$: $2 = \sqrt{T'/T}$.

(e) Squaring both sides gives $T'/T = 4$.

(f) Therefore the absolute temperature must be made four times its initial value.

Final Answer: $\boxed{4}$

Answer: (B)

Go Back to Question 40

Q41.

Solution

Concept:

The total energy of a satellite in a circular orbit is $E = -GMm/(2r)$. To shift it to a higher circular orbit, energy must be supplied equal to the increase in total mechanical energy.

Solution:

(a) Initial orbital radius is r, so $E_i = -\dfrac{GMm}{2r}$.

(b) Final orbital radius is $2r$, so $E_f = -\dfrac{GMm}{2(2r)} = -\dfrac{GMm}{4r}$.

(c) Energy supplied is the change $\Delta E = E_f - E_i$.

(d) Thus $\Delta E = -\dfrac{GMm}{4r} - \left(-\dfrac{GMm}{2r}\right)$.

(e) This becomes $\Delta E = \dfrac{GMm}{2r} - \dfrac{GMm}{4r} = \dfrac{GMm}{4r}$.

(f) Although the final energy is still negative, it is less negative, so external energy is required.

Final Answer: $\boxed{\dfrac{GMm}{4r}}$

Answer: (A)

Go Back to Question 41

Q42.

Solution

Concept:
For single-slit diffraction, minima occur at $a\sin\theta = n\lambda$. For the first minimum, $n = 1$, and for small angles $\sin\theta \approx \theta$ in radians.

Solution:

(a) The wavelength is $\lambda = 600 \text{ nm} = 6 \times 10^{-7}$ m.

(b) The slit width is $a = 0.30 \text{ mm} = 3 \times 10^{-4}$ m.

(c) For the first minimum, $a \sin\theta = \lambda$.

(d) Thus $\sin\theta = \dfrac{6 \times 10^{-7}}{3 \times 10^{-4}} = 2 \times 10^{-3}$.

(e) Since this is a small angle, $\theta \approx 2 \times 10^{-3}$ rad.

(f) The answer is angular position, not the linear width on a screen.

Final Answer: $\boxed{2 \times 10^{-3} \text{ rad}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 42

Q43.

Solution

Concept:
Capacitive reactance is the opposition offered by a capacitor to alternating current. It is given by $X_C = 1/(2\pi f C)$ and decreases as frequency or capacitance increases.

Solution:

(a) The capacitance is $C = 100\ \mu\text{F} = 100 \times 10^{-6}\ \text{F} = 10^{-4}\ \text{F}$.

(b) The frequency is $f = 50$ Hz.

(c) Use $X_C = \dfrac{1}{2\pi f C}$.

(d) Substitute: $X_C = \dfrac{1}{2\pi \times 50 \times 10^{-4}}$.

(e) The denominator is $100\pi \times 10^{-4} = 0.01\pi$, so $X_C = \dfrac{100}{\pi} \approx 31.8\ \Omega$.

(f) The unit of reactance is ohm, same as resistance.

Final Answer: $\boxed{31.8\ \Omega}$

Answer: (B)

Go Back to Question 43

Q44.

Solution

Concept:
Torque magnitude is $\tau = rF\sin\theta$, where θ is the angle between the position vector from pivot to point of application and the applied force. Only the perpendicular component of the force produces torque.

Solution:

(a) The lever arm length is $r = 0.50$ m.

(b) The applied force is $F = 20$ N.

(c) The angle between the lever and the force is 30°.

(d) Use $\tau = rF\sin\theta$.

(e) Substitute values: $\tau = 0.50 \times 20 \times \sin 30^\circ$.

(f) Since $\sin 30^\circ = 1/2$, $\tau = 10 \times 1/2 = 5$ N m.

Final Answer: $\boxed{5\text{ N m}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 44

Q45.

Solution

Concept:

Nuclear binding energy is the energy equivalent of mass defect. Using $E = \Delta mc^2$, a mass defect measured in atomic mass units can be converted with 1 u = 931 MeV$/c^2$.

Solution:

(a) The mass defect is $\Delta m = 0.030$ u.

(b) Binding energy is $E_b = \Delta m \times 931$ MeV.

(c) Substitute the value: $E_b = 0.030 \times 931$.

(d) This gives $E_b = 27.93$ MeV.

(e) Rounded to the nearest option, the binding energy is 27.9 MeV.

(f) The positive binding energy is the energy required to separate the nucleus into free nucleons.

Final Answer: $\boxed{\text{27.9 MeV}}$

$\boxed{\textbf{Answer: (C)}}$

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Q46.

Solution

Concept:
For an isothermal expansion of an ideal gas, the work done is $W = nRT\ln(V_f/V_i)$. Since temperature is constant, internal energy does not change for an ideal gas.
Solution:

(a) Here $n = 1$, $T = 300$ K, $V_i = V$ and $V_f = eV$.

(b) Use $W = nRT\ln\left(\frac{V_f}{V_i}\right)$.

(c) The volume ratio is $\frac{eV}{V} = e$.

(d) Since $\ln e = 1$, the work becomes $W = nRT$.

(e) Substitute values: $W = 1 \times 8.31 \times 300 = 2493$ J.

(f) The work is positive because the gas expands.

Final Answer: $\boxed{2493 \text{ J}}$

Answer: (C)

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Q47.

Solution

Concept:
Electric potential is a scalar quantity, so potentials due to individual charges add algebraically. At the centre of a square, all four corners are at the same distance from the centre.

Solution:

(a) Let the distance from each corner to the centre be r.

(b) Potential due to each $+q$ charge is $+kq/r$, and there are two such charges.

(c) Potential due to each $-q$ charge is $-kq/r$, and there are two such charges.

(d) The total potential is $V = 2(kq/r) + 2(-kq/r)$.

(e) These contributions cancel exactly, giving $V = 0$.

(f) This cancellation is for potential; the electric field would require vector addition and is a different question.

Final Answer: $\boxed{0}$

Answer: (C)

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Q48.

Solution

Concept:
For viewing an object in water from air nearly normally, apparent depth equals real depth divided by refractive index. Thus real depth is refractive index times apparent depth.

Solution:

(a) The apparent depth is $d_a = 67.5$ cm.

(b) The refractive index of water is $\mu = 4/3$.

(c) Use $d_a = \frac{d_r}{\mu}$, where d_r is real depth.

(d) Therefore $d_r = \mu d_a = \frac{4}{3} \times 67.5$.

(e) Since $67.5/3 = 22.5$, $d_r = 4 \times 22.5 = 90$ cm.

(f) The actual depth must be greater than the apparent depth when viewed from air.

Final Answer: $\boxed{90 \text{ cm}}$

$\boxed{\textbf{Answer: (C)}}$

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Q49.

Solution

Concept:

In simple harmonic motion, acceleration is directly proportional to displacement and opposite in direction: $a = -\omega^2 x$. For a spring-mass system, $\omega^2 = k/m$.

Solution:

(a) The displacement from equilibrium is $x = A/2$.

(b) For a spring-mass oscillator, $a = -\frac{k}{m}x$.

(c) The magnitude is $|a| = \frac{k}{m}|x|$.

(d) Substitute $x = A/2$: $|a| = \frac{k}{m} \cdot \frac{A}{2}$.

(e) Thus $|a| = \frac{kA}{2m}$.

(f) At equilibrium acceleration is zero, but at $A/2$ it is not zero.

Final Answer: $\boxed{\frac{kA}{2m}}$

Answer: (A)

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Q50.

Solution

Concept:
In a perfectly inelastic collision, momentum is conserved but kinetic energy is not. The common final speed is found from conservation of linear momentum, and then initial and final kinetic energies are compared.

Solution:

(a) Initial momentum is $p_i = 2 \times 6 + 1 \times 0 = 12$ kg m/s.

(b) The combined mass after sticking is $2 + 1 = 3$ kg.

(c) Final speed is $v = 12/3 = 4$ m/s.

(d) Initial kinetic energy is $K_i = \frac{1}{2}(2)(6^2) = 36$ J.

(e) Final kinetic energy is $K_f = \frac{1}{2}(3)(4^2) = 24$ J.

(f) Loss of kinetic energy is $K_i - K_f = 36 - 24 = 12$ J.

Final Answer: $\boxed{12 \text{ J}}$

$\boxed{\textbf{Answer: (B)}}$

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Answer Key

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