Answers to 2023 JC2 Preliminary Examination Paper 1 (H2 Physics)

Answer:

1 B	**2 B**	**3 C**	**4 C**	**5 A**	**6 A**	**7 D**	**8 B**	**9 C**	**10 B**
11 C	**12 A**	**13 D**	**14 C**	**15 D**	**16 B**	**17 A**	**18 D**	**19 A**	**20 A**
21 C	**22 A**	**23 C**	**24 D**	**25 B**	**26 D**	**27 B**	**28 B**	**29 D**	**30 A**

Suggested Solutions:

Qn	Ans	Solution
1	**B**	$R = \sigma T^4$ → $\sigma = \dfrac{R}{T^4}$ Unit of $\sigma = \dfrac{\text{J s}^{-1}\text{ m}^{-2}}{\text{K}^4}$ = (kg m^2 s^{-2}) s^{-1} m^{-2} K^{-4} = kg s^{-3} K^{-4}
2	**B**	Z = X – Y → X = Z + Y
3	**C**	By conservation of energy, $\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 + mg\Delta h$ Since, the magnitude of the loss in gravitational potential energy is the same for stones P and Q, with the same initial kinetic energy, the stones will end up with the same magnitude of kinetic energy, implying they will hit the ground with the same speed.
4	**C**	Using $s = ut + \frac{1}{2}at^2$, distance travelled in first 10 s is 24 m, $24 = \frac{1}{2}a(10)^2$ $\therefore a = 0.48 \text{ m s}^{-2}$ Distance travelled in the first 25 s, $s = \frac{1}{2}(0.48)(25)^2$ $= 150 \text{ m}$ Distance travelled from $t = 10$ s to $t = 25$ s $= 150 - 24$ $= 126 \text{ m}$
5	**A**	For A: $T = (2.0)a$ .... (1) For B: $(5.0)(9.81) - T = (5.0)a$ .... (2) Sub (1) into (2): $49.05 - 2a = 5a$ $a = 7.0 \text{ m s}^{-2}$

Qn	Ans	Solution
6	A	By principle of conservation of linear momentum, $m(2v)+3m(-v)=(m+3m)V$ $V=-\frac{1}{4}v$ The speed of mass *m* is $\frac{1}{4}v$ after the collision.
7	D	Weight of boat = upthrust = weight of fresh water displaced = 35.6 kN Weight of boat = weight of salt water displaced = mg = ρVg = 35.6 kN $V=\frac{35.6\times10^3}{\rho g}=\frac{35.6\times10^3}{(1024)(9.81)}$ $=3.54\text{ m}^3$
8	B	Extension for spring X, $x_1=\frac{F}{k_1}=\frac{1.5}{5.0}=0.30\text{ m}$ Extension for spring Y, $x_2=\frac{F}{k_2}=\frac{1.5}{10.0}=0.15\text{ m}$ Elastic P.E. stored = $\frac{1}{2}kx^2$ Total elastic P.E. stored = $\frac{1}{2}(5)(0.3)^2+\frac{1}{2}(10)(0.15)^2$ J = 0.34 J
9	C	Loss in G.P.E. by Y = gain in G.P.E. by X + gain in K.E. by X and Y $3.0\times9.81\times3.0\sin40^\circ=2.0\times9.81\times3.0\sin30^\circ+\frac{1}{2}(2.0+3.0)v^2$ $v\approx3.3\text{ m s}^{-1}$
10	B	For mass m_1: $\frac{m_1v^2}{L+e}=ke$ $v^2=\frac{ke(L+e)}{m_1}$ For mass m_2: $\frac{m_2v^2}{2(L+e)}=k(2L+2e-L)$ $\frac{m_2v^2}{2(L+e)}=k(L+2e)$ $m_2=\frac{2k(L+2e)(L+e)}{v^2}$ $=\frac{2k(L+2e)(L+e)m_1}{ke(L+e)}$ $=\frac{2m_1(L+2e)}{e}$

Qn	Ans	Solution
11	**C**	total energy at top of ramp = total energy at lowest point $mgh = \frac{1}{2}mv^2$ → $v^2 = 2gh$ By Newton's second law of motion, at the lowest point, $R - mg = \frac{mv^2}{r}$ $R = \frac{m(2gh)}{r} + mg$ Since $r = h$, $R = 3mg$
12	**A**	Gravitational potential at infinity is zero. Moving from –30 MJ kg^{-1} to –70 MJ kg^{-1} means moving closer to Earth. Potential energy change = 50 [–70 – (–30)] = –2000 MJ
13	**D**	A is true: From $pV = nRT$, at constant pressure, when volume is doubled, temperature is doubled. B is true: work done $W = p\Delta V = 4P_o(2V_o - V_o)$ C is true: $W = 0$ → $\Delta U = Q$. From $pV = nRT$, since there is a decrease in pressure, there must be a decrease in temperature and hence a decrease in internal energy, i.e. ΔU is negative. This means Q is negative, i.e. heat is removed.
14	**C**	From $pV = nRT$, when p and V are tripled, the temperature would be $9T$ New temperature = (200 + 273) × 9 = 4257 K = 4257 – 273 = 3984 = 4000 °C From $\frac{1}{2}m\langle c^2\rangle = \frac{1}{2}mv^2 = \frac{3}{2}kT \rightarrow v^2 = \frac{3kT}{m} \rightarrow v = \sqrt{\frac{3kT}{m}}$, when the new temperature is $9T$, the new r.m.s. speed = $3v$
15	**D**	Option A: The kinetic energy of the oscillator is proportional to **square of the frequency** of its motion. Incorrect. Option B: The potential energy of the oscillator is **maximum** when the oscillator is momentarily at rest. Incorrect. Option C: The kinetic energy of the oscillator is **maximum** when the oscillator is at the equilibrium position. Incorrect. Option D: When the kinetic energy of the oscillator is equal to its potential energy, the oscillator is neither at the rest position nor at the maximum displacement positions. Correct.

Qn	Ans	Solution
16	B	Using $v_0 = x_0\omega$, $x_0 = \frac{v_0}{\omega}$ $= \frac{v_0}{\frac{2\pi}{T}}$ $= \frac{3.0 \times 0.063}{2\pi}$ $= 0.03$ m $a_0 = \omega^2 x_0$ $= \left(\frac{2\pi}{T}\right)^2 x_0$ $= \left(\frac{2\pi}{0.063}\right)^2 \times 0.03$ $= 298$ ≈ 300 m s^{-2}
17	A	Let the speed of the wave be *v*. The wavelength $\lambda = \frac{v}{f} = \frac{v}{12.5} \rightarrow v = 12.5\lambda$ For the displacement to be zero at Q, the wave travels a distance $d = \frac{\lambda}{8} = 0.125\lambda$. The time taken for this $= \frac{d}{v} = \frac{0.125\lambda}{12.5\lambda} = 0.010$ s

Qn	Ans	Solution
18	D	At lowest frequency, $L = \frac{1}{4}\lambda_1$ $\lambda_1 = 4L$ $f_1 = \frac{v}{\lambda_1} = \frac{v}{4L}$ At next highest frequency, $L = \frac{3}{4}\lambda_2$ $\lambda_2 = \frac{4}{3}L$ $f_2 = \frac{v}{\lambda_2} = \frac{3v}{4L} = 3\frac{v}{4L} = 3f_1$ At third highest frequency, $L = \frac{5}{4}\lambda_3$ $\lambda_3 = \frac{4}{5}L$ $f_3 = \frac{v}{\lambda_3} = \frac{5v}{4L} = 5\frac{v}{4L} = 5f_1$ So the frequencies that can be produced by the instrument are $f_1,\ 3f_1,\ 5f_1,\ 7f_1,\ ...$
19	A	Option A: Correct $\theta = \frac{\lambda}{b} \Rightarrow b = \frac{\lambda}{\theta} = \frac{590\times10^{-9}}{2.0\times10^{-6}} = 0.295\ \text{m} \approx 0.30\ \text{m}$ Option B: Incorrect Red stars give out red light of wavelength of 700 nm. $\theta = \frac{\lambda}{b} = \frac{700\times10^{-9}}{0.30} = 2.3\times10^{-6}\ \text{radians}$ which is larger than the angular separation of $2.0\times10^{-6}\ \text{radians}$. Hence, the red stars cannot be resolved. Option C: Incorrect The resolving power of the telescope is dependent of the wavelength of light, according to the expression $\theta = \frac{\lambda}{b}$. Option D: Incorrect The angular separation between the stars is $2.0\times10^{-6}\ \text{radians}$ for the telescope to be able to resolve. Hence, the telescope cannot be used to distinguish the stars.

Qn	Ans	Solution
20	A	For the first 2.0 m, the movement is along the direction of increasing potential which resulted in positive work done by the electric field. Positive work done by field = $(5.0)(4.0)(2.0) = 40$ J Thus, work done against electric field = −40 J. For the next 3.5 m, movement is along the same potential, hence, there is zero work done. Therefore, total work done against electric field = −40 J.
21	C	By conservation of energy, for the electron to just reach plate AB (that is, $v_y = 0$), work done against electric force = loss in kinetic energy of electron $eV = \frac{1}{2}m_e(v\cos\theta)^2$.
22	A	Effective resistance is made up of copper and iron resistors in parallel. Per unit length, Copper resistance $= \frac{1.7\times10^{-8}}{2.0\times10^{-3}} = 8.5\times10^{-6}\,\Omega$ Iron resistance $= \frac{1.0\times10^{-7}}{1.0\times10^{-3}} = 1.0\times10^{-4}\,\Omega$ Effective resistance per unit length $= \left(\frac{1}{8.5\times10^{-6}} + \frac{1}{1.0\times10^{-4}}\right)^{-1} = 7.8\times10^{-6}\ \Omega\ \text{m}^{-1}$
23	C	The smallest reading on the ammeter means smallest current passing through it. Ammeter has a resistance of 3 Ω. Option A: Incorrect. Current passing through ammeter, $I = \frac{V}{3}$, because ammeter is in parallel connection with the 1 Ω and 2 Ω resistors. Option B: Incorrect. Current passing through ammeter, $I = \frac{V}{3.67}$. Option C: Correct. Current passing through ammeter, $I = \frac{V}{6}$. Option D: Incorrect. Current passing through ammeter, $I = \frac{V}{4}$.
24	D	For zero deflection, magnetic force = electric force $Bqv = qE$ $v = \frac{E}{B}$ perpendicular to both B and E.

Qn	Ans	Solution
25	**B**	The current in the wire will result in a magnetic field coming out of the coil according to the right hand grip rule. As the current in the wire increases, the B-field through coil increases. Applying Lenz Law and right hand grip rule to the coil, the induced B-field must be into the coil. Thus, induced current in the coil is clockwise.
26	**D**	The a.c. is half-wave rectified with a single diode.. Voltmeter reads the r.m.s. voltage, V = 2.5 V So peak voltage across NB = 2(2.5) = 5.0 V By potential divider principle, $\frac{V_{AB}}{V_{NB}} = \frac{L_{AB}}{L_{NB}} = \frac{100}{40} \rightarrow V_{AB} = V_o = \left(\frac{100}{40}\right)V_{NB} = \left(\frac{100}{40}\right)(5.0) = 12.5\text{ V}$ Peak power $= \frac{V_o^2}{R} = \frac{12.5^2}{10} = 15.6 = 16\text{ W}$
27	**B**	By de Broglie's expression, $\lambda = \frac{h}{p}$, Since $E = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mE}$, $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2meV}}$ $\therefore\ \lambda \propto \frac{1}{\sqrt{V}}$
28	**B**	The peaks will remain the same as these are characteristic of the target metal. If the p.d. is increased, the electrons are fired with greater kinetic energy at the target metal, which means that more energetic X-rays can be produced. The cutoff wavelength will decrease, because $eV_{AC} = \frac{hc}{\lambda_{\min}}$.
29	**D**	Original activity is 180 counts s^{-1} after deducting background count. After 10 hours, the radioactive sample decays for 2 half-lives. Hence $\frac{1}{4}$ of its original activity remains giving 45 counts s^{-1}. Adding background counts giving 75 s^{-1}.
30	**A**	${}^{111}_{47}\text{Ag} \rightarrow {}^{111}_{48}\text{Cd} + {}^{0}_{-1}\text{e}$