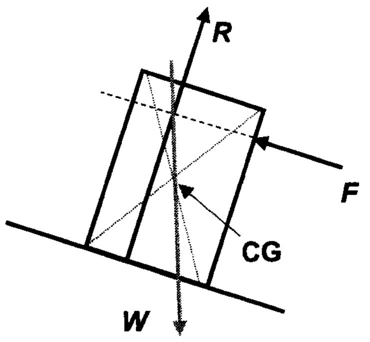
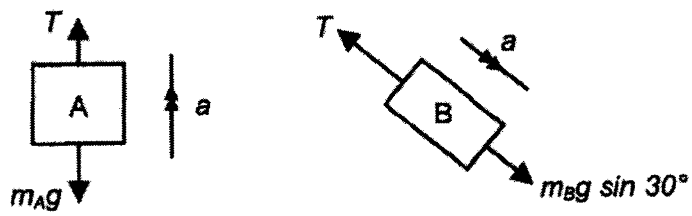
2025 JC2 Preliminary Examinations

H2 Physics Paper 1 Solutions

Qn	Answer	Explanation
1	**B**	Mass of an average male adult ~ 80 kg Average height ~170 cm Average width ~40 cm Average "thickness" ~20 cm $\text{density} = \frac{80 \times 1000}{(170)(50)(20)} = 0.6 \text{ g cm}^{-3} \approx 1 \text{ g cm}^{-3}$ OR The human body is mainly made up of water. And density of water is 1 g cm^{-3}. A human float just barely on water. So it is about the same density as water.
2	**D**	$s = ut + \frac{1}{2}at^2$ $560 = 0 + \frac{1}{2}a(35)^2$ $a = 0.91 \text{ m s}^{-2}$ $v = u + at$ $= 0 + (0.914)(35)$ $= 32 \text{ m s}^{-1}$
3	**D**	Option A is incorrect because at highest point, it has zero velocity vertically but still has non-zero horizontally. Option B is incorrect because the ball has non-zero vertical acceleration throughout the whole motion. In fact, the value of this vertical acceleration is g and is pointing downwards. Option C is incorrect as it is accelerating vertically throughout the whole motion including the highest point. The value of this vertical acceleration is g. But it has non-zero horizontal velocity. Option D is correct as it is accelerating vertically throughout the whole motion including the highest point. It has non-zero horizontal velocity throughout the whole motion, including the highest point.

4	B	There are three forces acting concurrently on the block. Besides *R* and *F*, the weight *W* of the block acts at the CG. The CG is determined by the intersection of the diagonals. By extending the lines of action of the three forces, they must intersect at the same point. The other options do not satisfy this. 
5	D	Let the tension in the cord be *T* and the acceleration of both blocks be *a*.  For A: $F_{net} = T - m_A g = m_A a$ $T = 3.0(a + g)$ For B: $F_{net} = T - m_B g \sin 30° = m_B a$ $T = 6.0(a + 0.5g)$ Combining both equations $3.0(a+g) = 6.0(a+0.5g)$ $3a + 3g = 6a + 3g$ $a = 0$
6	C	$F_{engine} = F_{drag} = kv^2$ $P_{engine} = F_{engine} v = kv^3$ $\frac{P_{40}}{P_{25}} = \frac{40^3}{25^3} = \frac{P_{40}}{30 \text{ kW}}$ $P_{40} = 120 \text{ kW}$

7	**B**	Energy transferred to turbine per unit time = Loss of KE per unit time $P_{in} = \frac{\frac{1}{2}m(u^2 - v^2)}{t} = \frac{\frac{1}{2}(10.7)(5.0^2 - 2.5^2)}{1.0} = 100.3 \text{ W}$ $P_{out} = 0.70P_{in} = 70 \text{ W}$ $P_{out} = IV = 2.8(25) = 70 \text{ W}$
8	**B**	Angular velocity (ω = 3.0 rad s^{-1}) at any point of the circle is constant. Hence options C and D are wrong. $\because r_P = 2r_Q$ $a_c = r\omega^2$ $\therefore a_{cP} = 2a_{cQ} = 54 \text{ cm s}^{-2}$
9	**A**	According to conservation of energy: $GPE_P + KE_P = GPE_S + KE_S$ $-\frac{GMm}{3R} + 0 = -\frac{GMm}{R} + \frac{1}{2}mv^2$ $v = \sqrt{\frac{4GM}{3R}}$
10	**B**	$g = \frac{GM}{r^2} = \frac{G(\rho V)}{r^2} = \frac{G\rho}{r^2}\left(\frac{4}{3}\pi r^3\right)$ $= \frac{4}{3}G\pi\rho r$ $\Rightarrow r \propto \frac{g}{\rho}$ $\frac{r_E}{r_M} = \left(\frac{g_E}{g_M}\right)\left(\frac{\rho_M}{\rho_E}\right)$ $= (6)\left(\frac{3}{5}\right)$ $= 3.6$
11	**A**	$U = \frac{3}{2}kT = \frac{1}{2}m\langle c^2 \rangle$ $c_{rms} \propto \sqrt{T}$ $\frac{c_{rms}}{350} = \sqrt{\frac{200 + 273.15}{100 + 273.15}}$ $c_{rms} = 394 \text{ m s}^{-1}$ B – didn't square root the temperature C – didn't convert to K D – assumed doubled temperature results in doubled rms speed.

12 | **D**

No work done in processes Q → R and S → P.

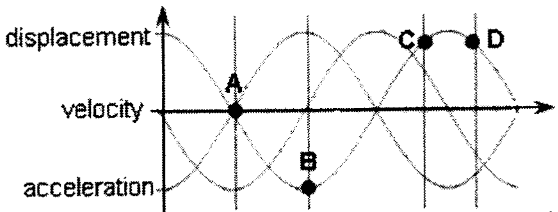
Work done on gas $R \rightarrow S = p\Delta V = 120000(0.30 - 0.05) = 30000$ J

For cyclic process, no change in internal energy.

$$\Delta U = Q + W$$
$$0 = Q + (-120000 + 30000)$$
$$Q = 90000 \text{ J}$$
$$= 90 \text{ kJ}$$

13 | **D**

Since the displacement – time graph is a cosine function, the related velocity – time and acceleration – time graph are negative sine and negative cosine graph.



	v	a	Remark
A	negative	zero	-
B	zero	positive	-
C	positive	negative	opposite direction
D	negative	negative	same direction

14 | **D**

Option A: Incorrect, the phase angle of X (0°) and Y (270°)) is different.

Option B: Incorrect, both the period and frequency of X and Y are the same.

Option C: Incorrect, the phase difference is 270 – 0 = 270°, or 1.5 π rad.

Option D: Correct. Period and frequency at points X and Y are the same.

15 | **B**

Fact from question: Since the width of gap is equal to wavelength of ripple, there should be significant diffraction after passing through the gap.

Option A: Wrong, as there is limited diffraction of the waves.

Option B: Correct, since the width of the gap is equal to the wavelength of the ripple, diffraction occurs and the waves spread out with wavelength the same as before.

Option C: Wrong, as there is a break (or zero displacement) in the diffracted wavefronts

Option D: Wrong, as there are breaks (or zero displacement) in the diffracted wavefronts

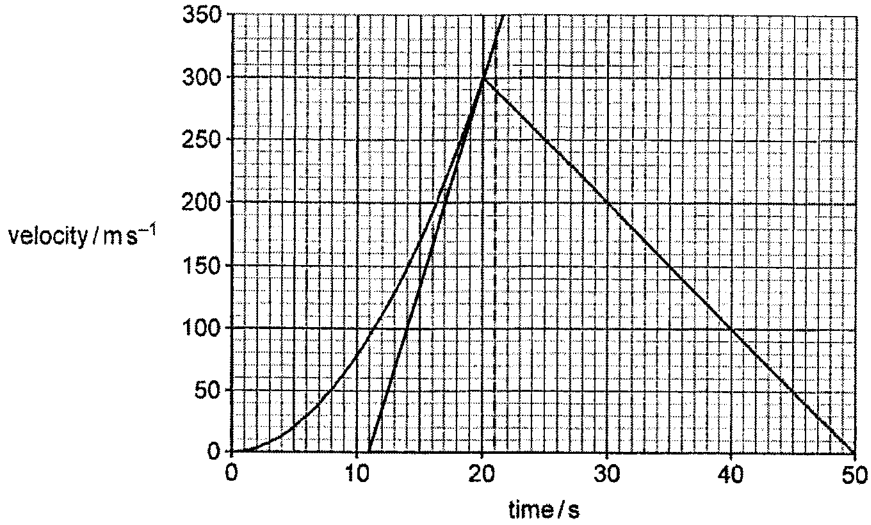
16	**C**	$$d \sin\theta_n = n\lambda$$ $$\frac{1}{(3.0\times10^3)\times10^2}\sin 90^\circ = n(600\times10^{-9})$$ $$n = 5.5$$ The total images produced = 5 + 1 + 5 = 11 A – did not account for both sides of the central bright fringe B – did not account for the central bright fringe (0^{th} order) D – counted 6 fringes on both sides (n = 6).
17	**C**	PQ is a stationary wave with two loops. The nodes are at the ends P, Q and in the middle. The antinodes are at the middle of each loop. Within the loop, the phase difference is zero. Between adjacent loops, the phase difference is π radian
18	**A**	The test charge needs to be small so that it does not distort the electric field. The test charge itself should not alter the field that it is attempting to measure.
19	**D**	Work done against electrical force is the work done in moving the charge by an external force where the external force is equal in magnitude but opposite in direction to the electric force. Since the electrical field is acting downwards, the electric force and external force F_{ext} is acting downwards and upwards respectively. *$W = F_{ext}\, s \cos\theta = qEs \cos\theta$ where θ is the angle between external force and displacement* For X to Y: The angle between the F_{ext} and s is 90°. $W = 0$ For Y to Z: The angle between the F_{ext} and s is 150°. $W = qEs \cos 150^\circ = -Es \sin 60^\circ$ For Z to X: The angle between the F_{ext} and s is 30°. $W = qEs \cos 30^\circ = +Es \sin 60^\circ$
20	**B**	$$P = I^2R$$ $$0.300 = 0.030^2R$$ $$R = 333\ \Omega$$ $$R = \frac{\rho L}{A}$$ $$333 = \frac{\rho(1.8\times10^{-2})}{1.2\times10^{-3}(1.5\times10^{-2})}$$ $$\rho = 0.33\ \Omega\ \text{m}$$
21	**A**	To have smallest reading, both devices must have the lowest possible p.d. values across them. Hence, the lower their individual resistances, the lower their p.d. will be. For NTC thermistor, high temperature leads to lower resistance. For LDR, high brightness leads to lower resistance.

22	D	$\because R_P = R_{Voltmeter}$ $R_{P+Voltmeter} = 0.5R_V$ Voltmeter reading, $V = \frac{R_{P+Voltmeter}}{R_{P+Voltmeter} + R_Q}(9.0)$ $6.0 = \frac{0.5R_V}{0.5R_V + R_Q}(9.0)$ $\frac{2}{3} = \frac{0.5R_V}{0.5R_V + R_Q}$ $R_V + 2R_Q = 1.5R_V$ $2R_Q = 0.5R_V$ $\frac{R_V}{R_Q} = 4.0$
23	C	A: When the currents in both wires flow in the same direction, the wires attract each other. B: When the currents are vertical and slanted respectively, each wire still produces a magnetic field that affects the other. Accordingly to Flemings' Left Hand Rule, the magnetic force has a component that is attractive. C: When the currents are vertical and horizontal respectively, each wire still produces a magnetic field that affects the other. However, the magnetic force acting on the wire is neither attractive nor repulsive. D: When the currents in both wires flow in opposite directions, the wires repel each other.
24	A	When the velocity of the second beam of electrons doubles, the downwards magnetic force acting on the electrons doubles. With the upwards electric force remains unchanged, the resultant force is acting downwards, deflecting the electrons downwards.
25	A	When the coil is moving without rotating in a uniform magnetic field, there is no change in magnetic flux linkage. Hence, according to Faraday's law, there is no e.m.f. induced.
26	B	$P_{half-wave} = \frac{1}{2}P_{full-wave}$ $\frac{(V_{rms,half-wave})^2}{R} = \frac{1}{2}\frac{(V_{rms,full-wave})^2}{R}$ $= \frac{\left(\frac{1}{\sqrt{2}}V_{rms,full-wave}\right)^2}{R}$ $V_{rms,half-wave} = \frac{1}{\sqrt{2}}V_{rms,full-wave}$ $= \frac{1}{\sqrt{2}}\frac{V_0}{\sqrt{2}} = \frac{200}{2} = 100\text{ V}$

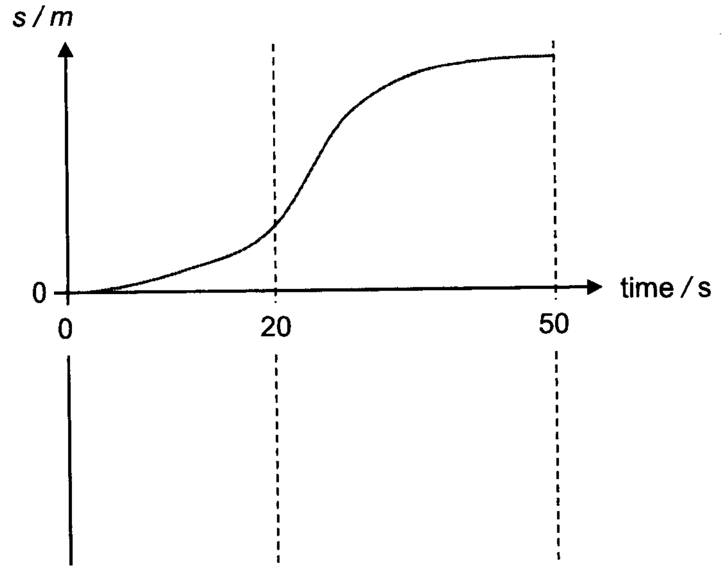
27	**A**	Intensity $= \dfrac{\text{Rate of EM radiation energy transferred}}{\text{Normal Area}}$ $I = \left(\dfrac{E_{total}}{t}\right)\left(\dfrac{1}{A}\right)$ $= \left(\dfrac{Nhf}{t}\right)\left(\dfrac{1}{A}\right)$ $= \left(\dfrac{N}{t}\right)\left(\dfrac{hc}{\lambda}\right)\left(\dfrac{1}{A}\right)$ The rate of photon flow is constant (*N/t* is constant). Since the wavelength increases, the intensity of the radiation decreases.
28	**B**	Based on loss of EPE of e to KE just before hitting target, de Broglie's wavelength of incident electron $\lambda_{dB} = \dfrac{h}{p} = \dfrac{h}{\sqrt{2meV}}$ Cut-off (minimum) wavelength of X-ray produced $\lambda_{cut-off} = \dfrac{hc}{eV}$ $\dfrac{\lambda_{dB}}{\lambda_{cut-off}} = \dfrac{1}{c}\sqrt{\dfrac{eV}{2m}} = \dfrac{1}{3.0\times10^{8}}\sqrt{\dfrac{(1.60\times10^{-19})(20\times10^{3})}{2(9.11\times10^{-31})}} = 0.14$ Option A : 0.0044 , Did not convert 20 kV to 20 000 V. Option C : 7.1, Inverse of ratio (1/0.14) Option D : 230, Inverse of ratio (1/0.0044)
29	**C**	$\dfrac{N_{tin}}{N_{anti}} = 5$ $\dfrac{N_{\text{anti remaining}}}{N_{total}} = \dfrac{N_{anti}}{N_{tin} + N_{anti}} = \dfrac{1}{5+1} = \dfrac{1}{6}$ after 2 half lives (120 days), $\dfrac{N_{anti}}{N_{total}} = \dfrac{1}{4}$ after 3 half lives (180 days), $\dfrac{N_{anti}}{N_{total}} = \dfrac{1}{8}$ Hence, for the ratio to be 1/6, the time that has passed is between 2 half-lives (120 days) and 3 half-lives (180 days).

30	**C**	Energy released per event $= \Delta mc^2 = (0.231)(1.66\times10^{-27})(3.0\times10^{8})^2$ $= 3.45114\times10^{-11}$ J Nuclear power generated $= \dfrac{\text{electric power}}{\text{effeciency}} = \dfrac{900\times10^{6}}{0.25}$ $= 3.6\times10^{9}$ J s^{-1} Number of events per unit time $= \dfrac{\text{nuclear power}}{\text{energy per event}} = \dfrac{3.6\times10^{9}}{3.45144\times10^{-11}}$ $= 1.0\times10^{20}$ s^{-1}

2025 YIJC JC2 Preliminary Examination
H2 Physics Paper 2 Solution

1	**(a)**	**(i)**	 Tangent line drawn correctly at time = 20 s Correct read off for 2 points - coordinates (11, 0) & (21, 330) $a = \frac{330-0}{21-11}$ $= 33 \text{ m s}^{-2}$ (allowed accuracy range: $30 \text{ m s}^{-2} \le a \le 36 \text{ m s}^{-2}$)	**M1** **A1**
			Most were able to link the gradient to the acceleration. However, the common mistake lies in the accuracy of determining the maximum acceleration by drawing the tangent line at the point of greatest slope.	
		(ii)	$F_{net} = ma$ $\text{thrust} - mg = ma$ $\text{thrust} = mg + ma = 150(9.81) + 150(33)$ $= 6421 \approx 6400 \text{ N } (2sf)$ Allow ECF	**C1** **A1**
			Some assumed the maximum thrust is the maximum net force. Some confused upthrust (aka buoyant force) with thrust (forward push) of the rocket.	
	(b)		(Taking upwards as positive, from the convention of the velocity-time graph) The engine of the rocket is turned off / The fuel has been used up. The upward moving rocket is now subjected to (constant) weight downwards, causing the rocket to slow down (decelerate) at a constant rate (due to free fall)	**B1** **B1**
			Some did not explain the cause for the velocity decreasing. Some attributed it to the rocket attaining terminal velocity. *Some thought that the rocket stops at t = 20s (max height here) and immediately starts to fall after that.*	

(c)



Correct shape: Increasing gradient from 0 to 20s and decreasing gradient from 20 s to 50 s. **B1**

Increasing displacement throughout motion. Zero gradient at t = 0s and 50 s. **B1**

Common mistakes

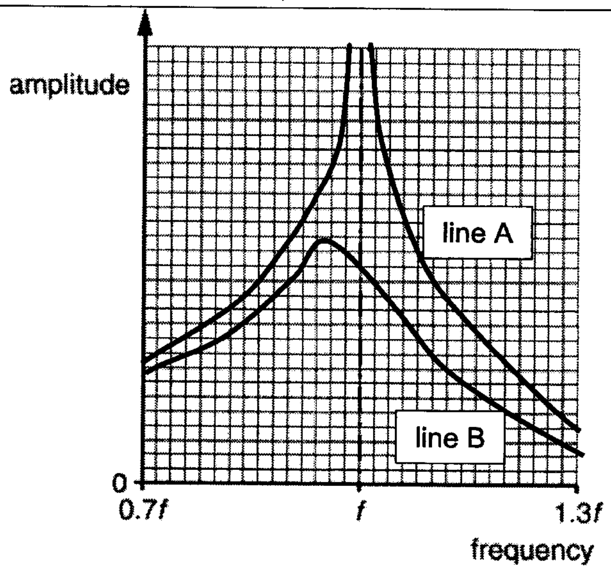
- *stating that the turning point was at t = 20s. (the velocity is always positive)*
- *the graph between t = 0 to 20 s is not parabolic (ie initial gradient is zero)*
- *the graph between t = 20 to 50 s is a straight line (velocity is not constant).*

2	**(a)**		The origin of the upthrust acting on a body in a fluid is the pressure difference between the top and bottom surface of the body.	**B1**
			Many students quoted Archimedes' principle instead of stating how upthrust comes about.	
	(b)	**(i)**	Upthrust = $\rho_{air}Vg=(1.29)\left[\frac{4}{3}\pi(0.15)^3\right](9.81)$ = 0.179 N Weight of helium = $\rho_{helium}Vg=(0.18)\left[\frac{4}{3}\pi(0.15)^3\right](9.81)$ = 0.0250 N The net force on the balloon is zero. Weight of balloon material + Weight of helium + Tension = Upthrust (0.012)(9.81) + 0.0250 + T = 0.179 T = 0.036 N	**C1** **C1** **A1**
			Many students are unsure of which density is to be used to determine upthrust or weight of helium. Some forgot to include the weight of the balloon material.	
		(ii)	Water is denser than air so the upthrust will increase. Hence, the tension will increase.	**M1** **A1**
			Generally well done although some students did not know/state that water is denser than air.	

3	(a)	(i)	$F_{net} = F_C$ $N + W = \frac{mv^2}{r}$ $N + 60(9.81) = \frac{60 \times 12^2}{7.0}$ $N = 646$ N	 C1 A1
			Many know that the normal contact force is related to the centripetal force. However, some wrongly think that the centripetal force is equal to the normal contact force, or to the normal contact force minus the weight.	
		(ii)	$KE_{top} + GPE_{top} = KE_{bot} + GPE_{bot}$ $\Delta GPE = KE_{bot} - KE_{top}$ $mg(14.0) = \frac{1}{2}m\left(v_{bot}{}^2 - 12^2\right)$ $v_{bot} = 20.46 \approx 20$ m s^{-1}	 C1 A1
			Some wrongly thought that the normal contact force calculated in (a)(i) could be used here, without recognising that the normal contact force must be greater than the weight in order to provide the required centripetal force towards the centre of the circular motion. Those who correctly applied conservation of energy needed to account for all forms of energy involved, especially the kinetic energy at the top of the circular motion.	
	(b)		If the speed is too slow, the centripetal (or net) force required to complete the loop is reduced. Since the net force is equal to the sum of the weight and normal reaction force from the cart, and weight is fixed, reducing the centripetal (or net) force required will reduce the normal contact force until it is zero, and the rider will lose contact with the cart. OR Speed must be large enough so that weight alone is insufficient to provide the centripetal force. Hence, contact force experienced by the man will be greater than zero and remain in contact with the loop when travelling above the minimum speed. Accept explanation based on equations.	B1 B1 (B1) (B1)
			Challenging. Some wrongly tried to use conservation of energy to explain that falling off the loop is due to a lack of kinetic energy. Many simply stated that a minimum speed is needed for the man and the cart to continue moving in circular motion or not fall off the loop, without further elaboration. Others correctly noted that falling off the loop occurs when the normal contact force becomes zero, but they needed to relate this back to the minimum speed required.	

4	(a)	(i)	An ideal gas is defined as a gas that has zero internal / microscopic potential energy and all its internal energy is only contributed by the microscopic kinetic energy of its molecules.	B1 B1
			Many candidates were careless with their phrasing, most commonly missing out on 'internal' or 'microscopic' and not providing evidence that they understand that that this is talking about energy at molecule level. Candidates can score a max of 1 mark if they miss out on this. *Answers also lack precision due to usage of words like 'mostly' or 'close to'.*	
		(ii)	$pV = NkT$ $4.4\times10^5\times1.5\times10^{-2} = N\times1.38\times10^{-23}\times(65+273.15)$ $N = 1.4139\times10^{24}\approx1.4\times10^{24}$	C1 A1
			Most common error is mixing up moles and the number of molecules.	
		(iii)	$E_K = \frac{3}{2}kT$ $U = NE_K = 1.4\times10^{24}\left[\frac{3}{2}(1.38\times10^{-23})(65+273.15)\right]$ $U = 9897 = 9900$ J	C1 A1
			Generally ok, but common errors include forgetting N or 3/2.	
	(b)	(i)	$W = p\Delta V$ $W = 4.4\times10^5(1.9-1.5)\times10^{-2}$ $W = 1760$ J Deduct A1 if work done calculated is negative	C1 A1
			Generally well done, but some candidates attempted to calculate new volume using change in temperature. They do not understand the concepts of change in U and work done.	
		(ii)	$\Delta U = \frac{3}{2}Nk(\Delta T)$ $= \frac{3}{2}(1.41\times10^{24})(1.38\times10^{-23})(150-65) = 2480$ J **Change in internal energy** $n = \frac{N}{N_A}$ $= \frac{1.41\times10^{24}}{6.02\times10^{23}}$ $n = 2.342$ mol **Find Q** **Q = (2.342)C(150-65)** **Applying the first law of thermodnamics** $\Delta U = W_{on} + Q_{in}$ $Q_{in} = \Delta U - W_{on}$ $nC(\Delta T) = \Delta U - W_{on}$ $2480 + 1760 = (2.342)C(150-65)$ $C = 21$ J mol^{-1} K^{-1}	C1 C1 C1 A1

			Generally poorly done *Most candidates did not find change in U, and instead used U directly.* *They also assumed Q to be same value as W or U, or sub W wrongly into first law equation.* *There was also some confusion with the term molar heat capacity, with some candidates finding molecular heat capacity or mass-specific heat capacity.*	

5	**(a)**	**(i)**	$\omega = \frac{2\pi}{T}$ $\omega = \frac{2\pi}{0.60}$ ω = 10.47 ≈ 10 rad s^{-1}	**C1** **A1**
			Well done by most students.	
		(ii)	Energy $= \frac{1}{2} m\omega^2 x_0^2$ $= \frac{1}{2} \times 0.120 \times 10.5^2 \times 0.020^2$ $= 2.63 \times 10^{-3} \approx 2.6 \times 10^{-3}$ J	**C1** **A1**
			Well done by most students.	
	(b)		Resonance is the phenomenon that occurs when the driving frequency of the driver is the same as (very close to) the natural frequency of the driven system, resulting in maximum transfer of energy from the driver to the driven system.	**B1**
			Most students indicated natural frequency and driving frequency in their answers. *To score the full marks, students need to mention energy transfer.*	
	(c)		 smooth curve with correct shape and amplitude never zero and line extends from 0.7*f* to 1.3*f* asymptote or peak at *f*	**B1** **B1**
			Only some students manage to score full marks. *You will need to recall the shape of the graph correctly.*	
	(d)		Correct shape: peaked line always below a peaked line A peak not as sharp and slightly less than frequency of peak in line A	**B1** **B1**
			Only some students manage to score full marks.	

6	**(a)**		An alternating voltage applied to the primary coil produces a changing magnetic flux in the core. An e.m.f. is only induced in the secondary coil when this magnetic flux linking it is changing.	**B1** **B1**

<table>
<tr><td></td><td></td><td></td><td colspan="3">Many answers lacked details e.g. did not state where the changing flux is created/experienced and the location where is e.m.f. is induced.</td></tr>
<tr><td></td><td>(b)</td><td></td><td>Either
$(V_p)_0 = 220$

$(V_p)_{rms} = \frac{220}{\sqrt{2}}$
$= 155.6$
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$
$\frac{155.6}{V_s} = \frac{2700}{450}$
$V_s = 25.9 \approx 26$ V</td><td>Or
$(V_p)_0 = 220$
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$
$\frac{220}{V_s} = \frac{2700}{450}$
$V_s = 36.67$

$(V_p)_{rms} = \frac{36.67}{\sqrt{2}}$
$= 25.9 \approx 26$ V</td><td>C1

C1
A1</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Generally well done. A minority of students included the trigonometric function in the working which made the calculation confusing and usually inconclusive.</td></tr>
<tr><td></td><td>(c)</td><td></td><td colspan="2">The power dissipated as heat in the heating coil is given by $P = I^2R$.
Hence, the power dissipated (heating power) in the coil is directly proportional to the square of instantaneous current.
This means that regardless of whether current is flowing in either direction, there will still be power dissipated in the heating coil, cause heating.

OR

The average current is zero because the current flows one direction for half a cycle and in the opposite direction for the second half of the cycle.

The heating effect directly proportional to the square of the non-zero current in each half cycle.

Instantaneous current not zero (most of the time). OR rms current is not zero.
Average power is thus not zero.</td><td>B1

B1

(B1)

(B1)

(B1)
(B1)</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Poorly done in general. Many answers did not reconcile how the average current being zero can still lead to power being dissipated in the resistor.</td></tr>
</table>

7	(a)		The emission line spectrum consists of bright coloured lines against a black / dark background. The absorption line spectrum consists of dark lines on a continuous coloured background. Do not accept "rainbow" in replacement of coloured background/coloured lines. *Award marks only when the two spectral lines are compared as the question asked for the difference rather than for their individual description.*	B1
			Some mixed up the descriptions distinguishing between the two different line spectra. *Some stated black lines against white background and vice-versa (probably due to the notes printed in black and white).*	
	(b)	(i)	The energy transition between levels is related to the emission of photon by $\Delta E = \frac{hc}{\lambda}$. $\Delta E = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{(400\times10^{-9})}$ $= 4.97\times10^{-19}$ J $= 3.11$ eV In the case of the 400 nm violet light which is the smallest wavelength (most energetic photon) in the visible spectrum, a minimum energy transition of 3.11 eV is required for visible light emission. This is less than the smallest energy transition involving the energy level -13.6 eV (that is from n=2 and n=1) which is -3.40 – (-13.6) = 10.2 eV. Therefore, transition to the energy level -13.6 eV cannot emit wavelength in the visible spectrum. Alternative explanation: The smallest energy transition involving the energy level -13.6 eV is 10.2 eV. Since the wavelength emitted is inversely proportional to the energy transition, the corresponding wavelength released from transitions to -13.6 eV would be shorter than 400nm.	C1 A1 B1 B1 (B1) (B1)
			Most were able to derive the energy of the violet light photon (3.1 eV). *However, the explanation to the visible light waves not being emitted with respect to the ground state (-13.6 eV) was not clear.* *Rather than comparing violet light photon energy (3.1 eV) to the energy transition 10.2 eV as being too large, many merely stated that 3.11 eV does not match any transitions between the energy levels.*	
		(ii) 1.	Based on **(b)(i)**, the range of the energies of photons in the visible spectrum is between a minimum of 1.6 eV and a maximum of 3.11 eV. Thus, based on Fig. 7.1 only, there are 3 lines in the visible spectrum (transitions ending with n = 2).	B1
			Most were able to get the value.	
		(ii) 2.	The longest wavelength emitted by the hydrogen atom in the visible spectrum corresponds to the smallest energy transition from -1.51 eV to -3.40 eV $[(-1.51)-(-3.40)]\times(1.60\times10^{-19}) = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{\lambda}$ $\lambda = 6.58\times10^{-7}$m	C1 A1
			Some obtained wavelengths that were outside of the visible light range.	

	(c)	From Einstein's photoelectric equation Energy of incident photon = Work function + Max KE of electron emitted -3.40 – (-13.6) = 4.5 + Max KE Max KE = 5.69 eV	C1 A1
		Mostly well done. However, some mixed up the signs. Example : 4.5 + 10.2 = 14.7 eV	
	(d)	The <u>largest energy transition</u> for the hydrogen atom <u>is 13.6eV</u> which <u>will release radiation up to the ultraviolet range only</u>. The hydrogen atom is too small in size (energy transition is insufficient) to release radiation in the X-ray region (typically 10keV) Must compare X-ray photons to hydrogen transition within the eV range.	B1
		The wavelength of X-ray is typically 10^{-10} m and the required energy transition is $\Delta E = \frac{hc}{\lambda}$ $\Delta E = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{(1\times10^{-10})}$ $= 2.0\times10^{-15}$ J $= 12.4$ keV	

8	(a)	(i)1.	$\text{total energy stored} = 0.055\times34$ $= 1.87$ GJ	C1 A1
		(i)2.	$\text{useful energy used to propel the car} = 1.870\times25\%(=0.4675\text{ GJ})$ $\text{range} = 0.4675\times\left(\frac{100}{0.086}\right)$ $= 544$ km OR $\text{energy required to travel 100 km} = \frac{0.086}{25\%}(=0.0344\text{ GJ})$ $\text{range} = \frac{1.87}{0.0344}\times100$ $= 544$ km OR $\text{range if car is 100\% efficient} = \frac{1.87}{0.086}\times100(=2174\text{ km})$ $\text{actual range} = 2174\times25\%$ $= 544$ km Allow for range = 543 m (rounded down), as this is the max distance.	C1 C1 A1 (C1) (C1) (A1) (C1) (C1) (A1)
		(i)3.	$\text{fuel efficiency} = \frac{544}{0.055}$ $= 9890\text{ km m}^{-3}$	C1 A1
			(a)(i) is mostly done well.	

		(ii)	required stored energy in battery $= \frac{0.4675}{77\%} (= 0.607\text{ GJ})$ required volume of battery $= \frac{0.607}{2.63}$ $= 0.23\text{ m}^3$ (*shown*) OR required energy per 100 km $= \frac{0.086}{77\%} (= 0.1117\text{ GJ})$ required volume of battery $= \frac{0.1117 \times \frac{544}{100}}{2.63}$ $= 0.23\text{ m}^3$ (*shown*) OR useful max energy density $= 2.63 \times 77\% (= 2.0251\text{ GJ kg}^{-1})$ required volume of battery $= \frac{0.4675}{2.0251}$ $= 0.23\text{ m}^3$ (*shown*)	**M1** **M1** **A0** **(M1)** **(M1)** **(A0)** **(M1)** **(M1)** **(A0)**
			Some students forgot to take into account the efficiency of the battery (77%).	
		(iii)	Volume of battery required is about/more than 4x that of petroleum for the same range. Electric cars would need to carry more volume/mass than ICE cars over the same distance for the same capacity of energy. OR For the same volume of battery and petroleum, the electric car battery can power the electric car for a smaller range. OR To travel the same distance, the volume/mass of battery must be larger than the volume/mass of fuel.	**B1** **(B1)**
			Poorly attempted. The term "Hence" requires students to talk about the volume as shown in previous part. Many just commented on energy density. Some mentioned the lower volume, but did not mentioned this was for the same range as that of the ICE car carrying same volume of fuel.	
	(b)	(i)	Li-NMC: average change in OCV $= \frac{4.00 - 3.45}{90 - 10} = 6.88 \times 10^{-3}$ V per 1% LFP: average change in OCV $= \frac{3.35 - 3.25}{90 - 10} = 1.88 \times 10^{-3}$ V per 1% Correct read off for all 4 data points (to ½ smallest division) (minimum read off correctly for 3 points) Correct answer for Li-NMC Correct answer for LFP	**C1** **A1** **A1**
			Mostly well done. Some mistakenly read values for the whole 100% range.	

		(ii)	The variation of OCV per 1% change in SOC is very low for LFP batteries compared to Li-NMC batteries. Hence it is more accurate to monitor the capacity of an Li-NMC battery using this method. OR A small change in OCV will have a larger change in SOC for Li-NMC batteries compared to LFP batteries. Hence it is more accurate to monitor the capacity of an Li-NMC battery using this method. OR A more precise scale is required to observe changes in OCV for an LFP battery than for an Li-NMC battery. Hence it is more accurate to monitor the capacity of an Li-NMC battery using this method.	B1 (B1) (B1)
			Many students understood wrongly. If the change OCV per 1% is lower, it is harder to read. The percentage error in reading the change is bigger for smaller changes in OCV.	
			LHS: base unit of $F_D = \text{kg m s}^{-2}$ RHS: base units of $\frac{1}{2}\rho v^2 CA = (\text{kg m}^{-3})(\text{m s}^{-1})^2(\text{m}^2)$ $= \text{kg m s}^{-2}$ Since units of left side of the equation are equal to the units of right side of the equation, the equation is homogeneous. Correct expression of base units of F_D. Correct base unit substitution for each quantity of $\frac{1}{2}\rho v^2 CA$	 B1 B1
			Most students presented their answer poorly. Some assumed LHS and RHS are already equal at the get go (e.g., starting off with $\text{kg m s}^{-2} = (\text{kg m}^{-3})(\text{m s}^{-1})^2(\text{m}^2)$) *Some incorrectly wrote that the quantity = units (e.g., $F = \text{kg m s}^{-2}$)*	
		(ii)	At max power, the drag force = driving force (no net force/acceleration) $F_{drive} = F_{drag} = \frac{1}{2}(1.29)v^2(0.29)(1.62 \times 1.88)$ $P_{drive} = F_{drive} \times v$ $100 \times 10^3 = \frac{1}{2}(1.29)v^2(0.29)(1.62 \times 1.88) \times v$ $v^3 = \frac{2(100 \times 10^3)}{(1.29)(0.29)(1.62 \times 1.88)}$ $v = 56.0 \text{ m s}^{-1}$	 C1 C1 A1
			Many students could not tell that at max velocity, there is no net force, so driving force = drag force. *Some identified the wrong dimension for the car's cross-sectional area, which should be perpendicular to the direction of motion (hence, breadth x width).*	

		(iii)	The driving force needs to be more than the drag force to accelerate. As it approaches the top speed, the drag force (viscous force) increases. Hence, the acceleration will be very low and it will take very long for the car to accelerate up to this top speed. OR Hence, the energy loss is higher at higher speeds and it will take very long for the car to reach the top speed (gain kinetic energy). OR Hence, at high speeds almost all of the power is used to overcome drag, so it will take a long time for the car to gain kinetic energy.	**B1** **B1** **(B1)** **(B1)**
			Poorly done. Most students gave general knowledge type answers (e.g., there are no roads long enough to attain the speed), which did not reference any physics concepts.	

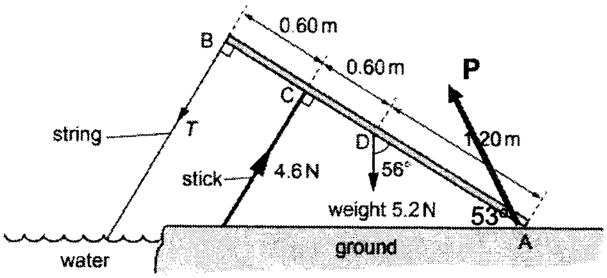
2025 YIJC JC2 Preliminary Examination
H2 Physics Paper 3 Solution

1			$\pm\frac{\Delta\sigma}{\sigma} = \pm\left[\frac{\Delta F}{F} + \frac{2\Delta d}{d}\right]$ $= \pm\left[\frac{0.5}{25.0} + \frac{2(0.02)}{0.4}\right]$ $(= \pm 0.12)$	**C1**
			$\sigma = \frac{4(25)}{\pi(0.40\times10^{-3})^2}$ $(= 1.98\times10^8\ \text{N m}^{-2})$	**C1**
			$\pm\Delta\sigma = \pm 0.12\times(1.98\times10^6)$ $= 0.2\times10^8\ \text{N m}^{-2}\ (1sf)$	**C1**
			$\sigma \pm \Delta\sigma = (2.0 \pm 0.2)\times10^8\ \text{N m}^{-2}$	**A1**
			Many students did not convert d's value from mm to m. *An even larger majority did not leave the absolute uncertainty to 1 s.f. and the value of σ was not expressed to the same d.p. as its uncertainty.*	

2	**(a)**	**(i)**	Taking rightwards as positive, $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ $5u(2000) + 32u(-500) = 5uv_A + 32u(56)$ $v_A = -1560\ \text{m s}^{-1}\ (3sf)$ <u>Leftwards</u> (Simply stating 'leftwards' or 'rightwards' without justification by way of using a sign convention and the proper working will not be given credit. It must be based on a sign convention in the working and final answer's sign.)	**C1** **A1** **A1**
			Most candidates were able to write the COM equation correctly with the normal sign convention. However, a significant number of candidates were careless with the signs. Some even use the alternative form in terms of the change of momentum for A and B (eg loss of momentum of A = gain in momentum of B which is ($\Delta P_A = -\Delta P_B$). But in most cases, the signs were inserted wrong (eg ($\Delta P_A = \Delta P_B$).	
	(b)	**(i)**	The initial <u>net momentum of the system is non-zero (Left hand side = -6000u)</u> In a closed system, COM applies and hence the <u>net momentum during the collision is non-zero</u>. Hence it is <u>impossible for both trolleys to be stationary (as its total momentum would be zero)</u>	**M1** **A1**

			Those who got it right were few. There was confusion on the use of the sign convention again. *The main misconception was the notion that prior to the collision there was momentum or motion for each individual particle and therefore during the collision it cannot result in a zero momentum or zero motion. It is possible to have a zero momentum if the momentum of both approaching particles are equal and opposite.* *Some tried to justify for it using the rule of conservation of kinetic energy. Initially there was KE. But during collision, KE is zero. Thus, the two particles cannot be stationary at the same time.* *Candidates should determine the total initial momentum for this question in order to justify the case.*	
		(ii)	$F=\frac{\Delta p_B}{\Delta t}=\frac{32(1.66\times10^{-27})[-500-56]}{2.5\times10^{-12}}$ Magnitude of $F=1.18\times10^{-11}$ N	C1 A1
			This was poorly done. The force of impact applies to the change of momentum happening on either particle (not on both). Due to N3L, the force of impact on A by B is the same and opposite to the force on B by A. Confusion arises again with the wrong signs (eg 500-56). Instead of the change of momentum for either A or B, the total momentum of the system was used. *Some arrived at F= 7.1 x 1015 N which is a huge value for such a microscopic collision. This should be a red flag. They forgot to consider the unified atomic mass u in the calculation.*	
	(c)		Relative speed of approach: $u_B-u_A=-500-2000=-2500$ m s^{-1} Relative speed of approach: $v_A-v_B=-1560-56=-1616$ m s^{-1} Both workings for the relative speeds are correct Since the relative speeds of approach and separation are **not** equal, it is an <u>inelastic collision.</u> (Proof by calculating the difference in the initial and final KE of the system is not accepted as the question specifically asked for proof using the above step).	 M1 A1
			This was poorly done mainly due to the wrong application of the sign convention for vector quantities (eg relative speed of approach = 2000 – 500 = 1500 m s^{-1}). *Some did not follow the question and instead use the differences in KE method instead.* *In the end, this question was not so much on the concept of COM but the wrong application of the same convention.*	

3	(a)		The moment of a force about a point is the <u>product of the force and the perpendicular distance between the line of action of the force to the point.</u>	B1
			Most students managed to recall the definition correctly, though some students still confuse with the principle of moments definition.	
	(b)	(i)	Taking moments about point A Total anticlockwise moments = Total clockwise moments (T × 2.4) + (5.2sin56° × 1.2) = (4.6 × 1.8) T = 1.3 N	 C1 A1
			Most students managed to calculate tension correctly.	

		(ii)	Let the force on point A be P **Resolving forces in x-direction,** $\Sigma F_x = 0$ $P_x + 4.6\cos56° - (1.29)\cos56° = 0$ $P_x = -1.85$ N **Resolving forces in y-direction,** $\Sigma F_y = 0$ $P_y + 4.6\sin56° - (1.29)\sin56° - 5.2 = 0$ $P_y = 2.46$ N Resultant force $P = \sqrt{P_y^2 + P_x^2} = \sqrt{2.46^2 + 1.85^2} = 3.1$ N $\tan\theta = \frac{P_y}{P_x} = \frac{2.46}{1.85} = 1.33$ $\theta = 53°$ above the negative x-direction  If one of the components calculated wrongly, max 2m awarded if resultant force **AND** θ is correctly calculated based on the wrong component value.	C1 C1 A1 A1
			Most students get at least one mark. *Less than half the number of students managed to get full credit for this question.* *Students are reminded to be careful in their calculations and present their answers systematically.* *Less than 5 students are able to solve using vector triangle method and get the correct answers.*	

4	(a)	(i)	(According to Newton's third law), the gravitational force acting on star A by star B has the same magnitude as the gravitational force acting on star B by star A. Since the gravitational forces acting on each star provides its centripetal force, the centripetal forces acting on both stars have the same magnitude.	B1 B1
			This part was marked quite leniently. Answers that lacked details and given BOD included "gravitational force on both stars was equal". *Many still did not get the full score. Some included equations in their answers without defining the terms. Some stated Newton's 3rd Law without applying to the context (i.e., the gravitational force or A on B is equal to the gravitational force of B on A.) Other common mistake was to state that the higher mass of B is outweighed by the larger distance from P. This was inconclusive as no quantity analysis was given.* *The most problematic answers applied N3L to the centripetal force which is conceptually wrong. N3L should be applied to actual forces, and not resultant (or centripetal) force.*	

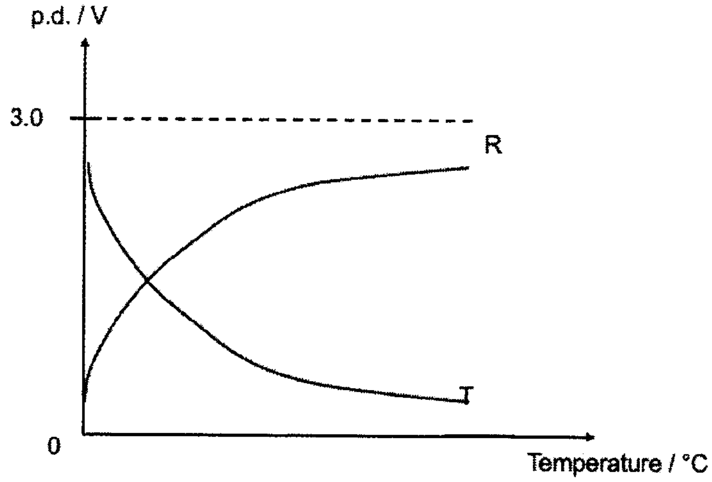
		(ii)	$\omega = \frac{2\pi}{T}$ $= \frac{2\pi}{4 \times 265 \times 24 \times 60 \times 60}$ $= 4.98 \times 10^{-8} = 5.0 \times 10^{-8}$ (2sf)	C1 A1
			Mostly well done. Some careless mistakes in calculating the final answer even though the substitution was correct.	
	(b)	(i)	$F_{c\ of\ A} = M_A d\omega^2$ $F_{c\ on\ B} = M_B(2.8 \times 10^8 - d)\omega^2$ *(Correct expression for either F_c.)* Since $F_{c\ of\ A} = F_{c\ on\ B}$, $M_A d\omega^2 = M_B(2.8 \times 10^8 - d)\omega^2$ $\frac{d}{2.8 \times 10^8 - d} = \frac{M_A}{M_B} = 3$ $d = 7.0 \times 10^7$ km	C1 C1 A1
			A lot of students wrongly assumed that the gravitational potential at P of both planets are the same magnitude. Some unnecessarily equated the gravitational force but substituted the wrong value of distance between the planets' centres.	
		(ii)	$F_{c\ of\ A} = M_A d\omega^2$ $= M_A(7.0 \times 10^7 \times 10^3)(4.98 \times 10^{-8})^2$ $F_{G\ on\ A} = \frac{GM_AM_B}{r^2}$ $= \frac{GM_AM_B}{(2.8 \times 10^8 \times 10^3)^2}$ gravitational force provides the centripetal force $F_G = F_c$ $\frac{GM_AM_B}{(2.8 \times 10^8 \times 10^3)^2} = M_A(7.0 \times 10^7 \times 10^3)(4.98 \times 10^{-8})^2$ $M_B = 2.04 \times 10^{29}$ kg $= 2.0 \times 10^{29}$ kg (2sf)	C1 C1 A1

			OR $F_{c\text{ of B}} = M_B\left(2.8\times10^8\times10^3 - d\right)\omega^2$ $= M_B\left(2.8\times10^8\times10^3 - 7.0\times10^7\times10^3\right)\left(4.98\times10^{-8}\right)^2$ $F_{G\text{ on B}} = \dfrac{GM_AM_B}{r^2}$ $= \dfrac{G\left(\frac{1}{3}M_B\right)M_B}{\left(2.8\times10^8\times10^3\right)^2}$ gravitational force provides the centripetal force $F_G = F_c$ $\dfrac{G\left(\frac{1}{3}M_B\right)M_B}{\left(2.8\times10^8\times10^3\right)^2} = M_B\left(2.8\times10^8\times10^3 - 7.0\times10^7\times10^3\right)\left(4.98\times10^{-8}\right)^2$ $M_B = 2.04\times10^{29}\text{ kg} = 2.0\times10^{29}\text{ kg (2sf)}$	**(C1)** **(C1)** **(A1)**
			A good number of students could not solve this question. The most common mistake for those that attempted was to assume (wrongly) the distance r in the equation $\frac{GMm}{r^2} = mr\omega^2$ was the same for both sides. ***The distance r in the gravitational force is the distance between centres of the masses, but the distance r is the distance between the mass and the centre of the orbit, which is P.***	

5	**(a)**		Electric field strength is the electric force per unit positive charge.	**B1**
			Most students who lose the mark did not mention "positive". *Students are reminded to review their definitions prior to the examinations.*	
	(b)	**(i)**	The mobile charges (in the metal sphere) would move in an electric field. The charges would move until the net electric force or net electric field is zero.	**B1** **B1**
			More than half the number of students misunderstood the question. *The question is about why the electric field in (within) each sphere is zero, not between the 2 spheres.*	
		(ii)	At P, $E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$ $E_A = \frac{1}{4\pi\epsilon_0}\frac{3.0\times10^{-12}}{(5.0\times10^{-2})^2} = 10.79\ \text{N C}^{-1}$ $E_B = \frac{1}{4\pi\epsilon_0}\frac{12.0\times10^{-12}}{(10.0\times10^{-2})^2} = 10.79\ \text{N C}^{-1}$ Since E_A and E_B have the equal magnitude and opposite in direction, (the net electric field strength at point P is zero.) (Final A1 can BOD if mathematical equation is used in lieu and there is evidence that the candidate understands that *E* is a vector.)	**M1** **M1** **A1**
			Some students lost marks due to power of ten (POT) calculation in the working such as 5 cm or 3.0 x 10⁻⁹ C in the substitution. *Most students who scored 2 marks did not mention why the 2 values must subtract/cancel each other. A short explanation such as the 2 fields are in opposite direction, or electric field is a vector quantity is expected.*	

		(iii)	$V_{net} = V_A + V_B$ $V_{net} = \frac{1}{4\pi\epsilon_0}\left[\frac{3.0 \times 10^{-12}}{5.0 \times 10^{-2}} + \frac{12.0 \times 10^{-12}}{10.0 \times 10^{-2}}\right]$ $V_{net} = 1.618 \approx 1.6$ V	C1 A1
			The most common wrong answer is 0.54 V as students subtract the 2 values instead of add.	
		(iv)	Using conservation of energy, $EPE_1 + KE_1 = EPE_2 + KE_2$ For the minimum speed so that the nucleus can reach point P, the final KE is 0. Since the nucleus starts at a long distance from point P, its initial EPE is zero. $0 + ½ mv^2 = qV + 0$ $½ \times 107 \times 1.66 \times 10^{-27} \times v^2 = 47 \times 1.60 \times 10^{-19} \times 1.62$ $v = 1.17 \times 10^4 \approx 1.2 \times 10^4$ m s^{-1}	C1 C1 A1
			It is satisfying to see some students to get full credit for this question. *About half the number of students get at least one mark for the conservation of energy statement.*	

6	(a)	(i)	$I = \frac{E}{R+r}$ $I = \frac{1.5}{6.0+0.25}$ $I = 0.24$ A	C1 A1
			Mostly done correctly. Some ignored the internal resistance.	
		(ii)	$E = I^2Rt$ $E = 0.24^2(6.0)(5 \times 60)$ $E = 104$ J Allowed for ECF	C1 A1
			Mostly done correctly. Some used VIt but substituted 1.5V instead of the terminal p.d. *Curiously, a significant number of candidates used Q = It to find the energy transferred.*	
		(iii)	Higher current (due to increased emf) causes the wire to heat up, increasing the lattice ions vibration resulting in more frequent collisions with electrons. This scattering effect causes the current flow to be impeded (impede does not mean that the current decreases) hence increasing the resistance of the wire.	B1
			There are still many lingering misconceptions when explaining the rise in resistance of the wire as a result of the voltage increase. The following are the errors. • *Wrong: Current decreases due to the frequent collisions. They justified it by using Ohm's law, R increase , I decrease. The current actually increases but not as much as the corresponding increase in the voltage. The ratio of V/I is increased and so R increased* • *Wrong:With increased p.d. or current, there will be more electrons generated or flowing. The number density of the free electrons is the same. It is the rate of flow of electrons that is changed not the number.* • *Wrong: The drift velocity decreases. The drift velocity increases because the current increases.* • *The explanation fell short of the full treatment. Most mentioned the lattice ions vibration is increased but did not explain how this will affect the electron flow due to the frequent collisions made. A scattering effect on the electrons will impede their flow – overall the resistance of the wire increases.*	

	(b)	**(i)**	The potential difference (p.d.) *V* between two points of a circuit is the electrical **energy converted per unit charge** into other forms of energy when charges move between the two points. *No mark awarded for stating 'energy transferred to a unit charge'.*	**B1**
			The explanation for the definition of the potential difference was mostly correct. However, some fell short of using the phrase 'per unit charge'. Some were not very specific about the energy transferred. Some simply stated V is defined as the product of the current and the resistance.	
		(ii)	 B1: Trend of T (exponential decrease with temperature) B1: Trend of R should mirror T If any of the graphs touch 0V or 3V, award maximum of 1 mark	**B1** **B1**
			Many were able to interpret the NTC thermistor as a semiconductor that has decreasing R with increasing temperature. Using the principle of potential divider, they were able to deduce that the potetial difference across it follow the same trend. However, the relationship between the p.d. for R and T was unclear.	

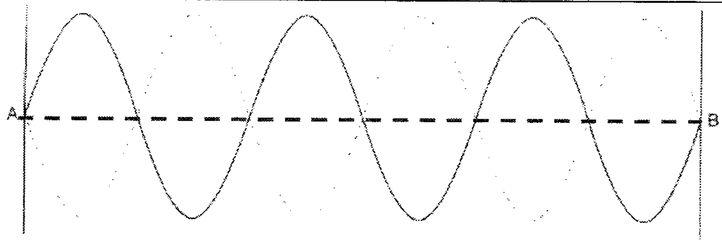
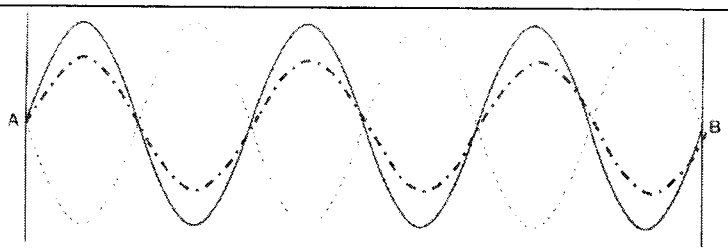
		(iii)	For V across fixed resistor to be 1.2 V at 0 °C, we assume it to have a resistance of *X*. $\frac{X}{X+10000}(3.0)=1.2$ $X=6700\ \Omega$ Using the same value of *X* at 150 °C: $V=\frac{X}{X+100}(3.0)$ $V=\frac{6700}{6700+100}(3.0)$ $V=2.96\text{ V}\quad(\neq 2.4\text{ V})$ Hence, there is no single fixed resistance value that allows for the requirement to work.	**Alternative** For V across fixed resistor to be 1.2 V at 0 °C, we assume it to have a resistance of *X*. $\frac{X}{X+10000}(3.0)=1.2$ $X=6700\ \Omega$ Finding new *X'* at 150 °C where V across fixed resistance is 2.4 V $\frac{X'}{X'+100}(3.0)=2.4$ $X'=400\Omega$ Hence, there is no single fixed resistance value that allows for the requirement to work.	**C1** **C1** **A1**
			Poorly done. The potential divider principle was not properly used leading to confusion on the quantity to be determined.		

7	(a)	(i)	smoke <u>absorbs / stops / block α-particles</u> as it has <u>weak penetrating ability</u>	**B1** **B1**
			When describing the effect smoke particles had on the alpha-particles, many students used vague words such as collide/hamper/hinder or incorrect words such as deflect. *There was hardly any mention of the weak penetrating ability of the alpha-particles.*	
		(ii)	The <u>count-rate detected</u> by the detector <u>is constant</u> over a long duration. The source should have a <u>long half-life</u>. OR The <u>count-rate does not drop to low levels in a short period of time</u>. The source should have a <u>long half-life</u>. No marks if no attempt of explaining long half-life. No marks if wrong physics in the explanation of long half-life.	**B1** **B1** **(B1)** **(B1)**
			Some students stated that long half-life is preferred because the alarm can be used for a longer time. Students are reminded to provide physics reasons as far as possible before discussing economical or functional reasons.	
	(b)	(i)	$^{\underline{239}}_{\underline{94}}\text{U} \rightarrow ^{\underline{235}}_{92}\text{U} + ^{\underline{4}}_{\underline{2}}\alpha$ **All correct: 2** **One wrong: 1** **≥2 wrong: 0**	**B2**

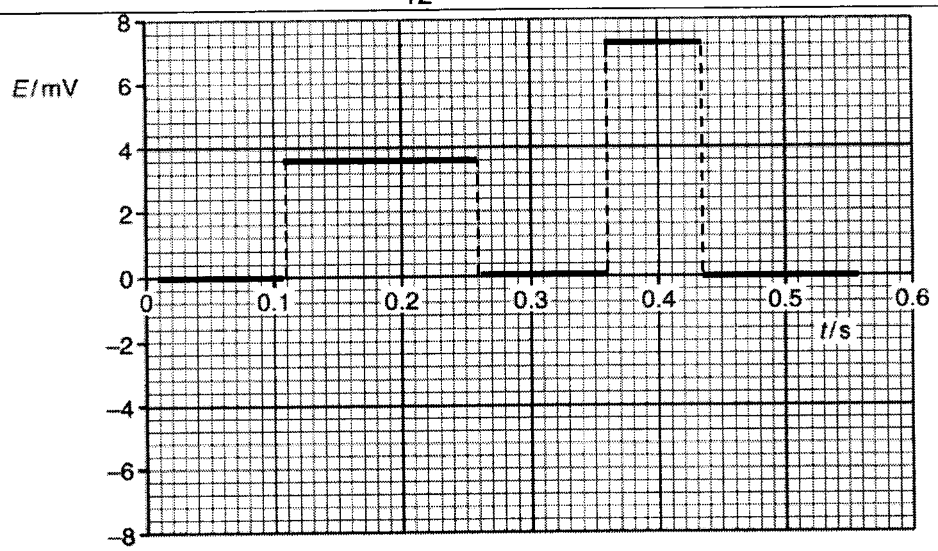
			Generally well-done. A minority of students did not know the A and Z value for an alpha-particle.	
		(ii)	Net energy released = (7.591 × 235) + (7.062 × 4) – (7.560 × 239) = 5.293 MeV (accept 2, 3 or 4 sf here)	 **C1** **A1**
			Although this was generally well-done, there was still a substantial number of students who incorrectly thought that they had to multiply c2 or u to the difference in BE. Some students also wrongly calculated the difference in BE/A.	

8	**(a)**	**(i)**	It is the <u>rate at which energy</u> is received <u>per unit area perpendicular</u> to the direction of <u>propagation of the energy.</u>	**B1**
			Poorly done. Many wrongly relate the definition of intensity to its amplitude. Some who has some understanding of intensity wrongly use cross-sectional area or did not state that it is per unit surface area.	
		(ii)	Plane polarisation of a wave refers to the <u>limiting of the oscillation</u> or vibration <u>to one direction or on a single plane</u> that is <u>perpendicular to the direction of the energy transfer</u>.	**B1** **B1**
			Poorly done. Many did not indicate that the oscillation is restricted to one plane.	
	(b)		$Int = \frac{P}{A} \rightarrow I = \frac{2.5}{4\pi r^2}$ At distance r = 2.0 m away, $I = \frac{2.5}{4\pi(2)^2} \rightarrow I = 0.0497$ W m^{-2} Using $I = k A^2$, where k is constant and A is the amplitude of the wave, (1): 1.0 = k (4 μm)^2 (2): 0.0497 = k $(A)^2$ $\frac{(2)}{(1)}: \frac{0.0497}{1} = \frac{A^2}{(4\mu m)^2}$ A = 0.892 μm Award C1 for either I = P/4Pi r^2 OR I proportional to A^2.	 **C1** **A1**
			Poorly done. Some manage to find the proportional constant for the relationship between intensity and amplitude. But many didn't use the available data to determine the intensity of the wave at 2 m or did not understand that the area is the surface area of a sphere ($4\pi r^2$).	
	(c)	**(i)**	Either: $\Delta\phi = \frac{\Delta x}{\lambda} \times 360°$ $= \frac{12.5 \text{ small boxes}}{50 \text{ small boxes}} \times 360°$ $= 90°$ (Accept phase difference = 270°) Or: The maximum displacement of the first graph corresponds to the zero displacement of the second graph. The phase difference is 90. (Accept phase difference = 270°)	 **C1** **A1**
			Average. Many could determine or deduce the phase difference from the graph, though some struggled with the calculation method.	

		(ii)	The two waves have the same wavelength / period despite different amplitudes. The two waves have a constant phase difference at all times.	B1 B1
			Average. Many correctly stated that coherent waves require constant phase difference, though some incorrectly believed waves must be "in phase". Many failed to mention the additional requirement of same wavelength/frequency.	
	(d)	(i)	$\lambda = \frac{ax}{D} \rightarrow x = \frac{\lambda D}{a}$ $x = \frac{(546\times10^{-9})(1.25)}{(1.13\times10^{-3})}$ $x = 6.04 \times 10^{-4}$ m OX = 4 x = 0.00242 m = 2.42 mm = 2.42×10^{-3} m	C1 A1
			Average. Many correctly identified this as Young's double slit and calculated OX = 4x. Common errors included using diffraction grating formulae instead, or incorrectly stating OX = x or using wrong multiples of x.	
		(ii) 1.	(When the width of the slits is reduced, the amount of light passing through decreases.) There is an overall decrease in the intensity of the maxima. Or The contrast between the maxima and minima is reduced. The spacing of the bright fringes remains unchanged.	B1
			Poorly done. Many students wrongly stated there would be no change in appearance, failing to consider that reducing slit width decreases brightness of maxima due to less light passing through. Some wrongly thought fringe separation would be affected by slit width.	
		(ii) 2.	For the part of the screen further away from the double slits, the fringe separation increases. For the part of the screen nearer to double slits, the fringe separation decreases.	B1 B1
			Poorly done. Many did not understand what rotating the screen meant and incorrectly concluded that interference would cease entirely. Some recognised that the distance from slits to screen would vary across the rotated screen, but incorrectly explained that this would affect brightness rather than fringe separation.	
	(e)	(i)	$f = \frac{1}{T} \rightarrow f = \frac{1}{40\times10^{-12}}$ = 2.5×10^{10} Hz Since speed of microwave (light) = c = 3.0×10^{8} m s^{-1} $c = f\lambda$ $3.0 \times 10^{8} = 2.5 \times 10^{10}\ \lambda$ λ = 0.0120 m Counting the number of inter-nodal loops, the distance between A and B is 3λ. AB = 3λ = 3 × 0.0120 = 0.0360 m	C1 C1 A1
			Poorly done. Many recognised that distance AB equals 3λ but couldn't calculate it because they failed to realise microwaves travel at the speed of light. Several students left this part unattempt, showing no understanding of the concept.	

		(ii) 1.	 1 mark for the horizontal line joining AB.	B1
			Poorly done. Many students incorrectly treated this as a progressive wave, drawing it shifting horizontally rather than recognising it as a stationary wave.	
		(ii) 2.	 Over the distance of AB, 1 mark for the displacement more than midway between zero and maximum. 1 mark for all the correct nodal points.	B1 B1
			Poorly done. Many students incorrectly treated this as a progressive wave, drawing it shifting horizontally rather than recognising it as a stationary wave. Some who recognised it as a stationary wave failed to show that the displacement at $t = 7T/8$ is greater than at the midway point.	

9	(a)	(i)	*Faraday's law states that the magnitude of the induced e.m.f. is directly proportional to the rate of change of the magnetic flux linkage.*	B1
			Average. Many students recalled this definition correctly, though some omitted the directly proportional relationship and simply stated that changing magnetic flux linkage causes an e.m.f. Another common error was stating "flux" instead of "flux linkage".	
		(ii)	Lenz's law states that the direction/polarity of the induced e.m.f (tends to) causes an effect to oppose the change that produces it.	B1
			Poorly done. Many students failed to mention key concepts of polarity/direction and induced e.m.f. Students need to understand that induced e.m.f. only produces current in a closed circuit. The crucial idea that the induced effect opposes the change that produces it was often missing.	
	(b)	(i)	The direction of the magnetic field inside the solenoid is downward (labelled P).	B1
			Mostly well done.	
		(ii)	As the current in the solenoid is switched off, the magnetic flux linkage experienced by the small coil is decreasing. According to Lenz's Law, the small coil produces a downwards magnetic field (in the opposite direction) to oppose this decrease. On Fig. 9.3, an arrow should be drawn inside (or just above) the small coil pointing in the same direction to P, and labelled Q.	B1 B1 B1
			Challenging. Students struggled to apply Lenz's law correctly and state that the induced e.m.f. creates a downward magnetic field to oppose the decreasing magnetic flux linkage. Many wrongly state that the direction of magnetic field in small coil B is opposite to the direction of the magnetic field in P.	

		(iii)	 Zero for 0 to 0.10 s, 0.25 to 0.35 s and 0.425 to 0.55 s and non-zero outside these ranges two horizontal steps with the same polarity correct values (1st step 3.6 mV and 2nd step 7.2 mV)	**B1** **B1** **B1**
			Challenging. Most students only earned the first mark by recognising that changing magnetic field induces e.m.f., otherwise e.m.f. is zero. Many failed to realise that the magnetic field changes from 0.1-0.25s and 0.35-0.425s have the same gradient, resulting in the same polarity of e.m.f. This could also be deduced using Faraday's law by examining the gradient. Many also missed that the magnitude of induced e.m.f. differs because the gradients of the B-t graph are different.	
	(c)	(i)	$B = 0.72\mu_0 \frac{NI}{r}$ $0.017 = 0.72 \times 4\pi \times 10^{-7} \times \frac{N \times 12}{0.420}$ $N = 657.6 \approx 660$	 **C1** **A1**
			Mostly well done, with a few making the error in the current and the radius of coil.	
		(ii)	magnetic flux = $BA\cos\theta$ $= 0.017 \times \pi \times 0.36^2$ $= 0.00692 \approx 6.9 \times 10^{-3}$ Wb The unit of magnetic flux is Wb (weber).	 **C1** **A1** **B1**
			Average. Most understood the magnetic flux cutting concept and calculated correctly using given values. However, some incorrectly included the number of coil turns, which is unrelated to the rotating disc, while others left this unattempted.	
		(iii)	time for one revolution = 1/25 s e.m.f. = rate of cutting flux or $\Delta\Phi/\Delta t$ $= 0.00692 \times 25$ $= 0.173 \approx 0.17$ V	**C1** **C1** **A1**
			Poorly done. Many didn't know how to proceed even after computing the total magnetic flux cut by the disc. Some incorrectly included the number of coil turns, which is unrelated to the rotating disc.	

		(iv)	Either According to Lenz's law, the induced current produces a braking torque that opposes the rotation of the disc.	Or According to lenz's law, the induced current will be in a direction to oppose the change of flux linkage / reduce the cutting of flux.	B1
			The braking torque is due to the magnetic force acting on the induced current by the magnetic field.	The wire/wheel must experience a braking force/torque that would result in a slower rotation in order to reduce the rate of change of flux linkage.	B1
			Using Fleming's Left-Hand Rule, the force is opposite to the direction of rotation, which indicates that the current flows from the rim to the axle.	Hence, by Fleming's left hand rule, the current must flow from rim to axle.	B1
			No marks awarded if no attempt of explanation even if direction of current is correct. No marks awarded if wrong physics presented in the explanation.		
			Poorly done. Most students failed to recognise that the disc's rotation causes flux cutting. To oppose this change, the induced current must oppose the disc's rotation.		