2022 DHS H2 Physics Prelim Paper 2 Suggested Solutions

1 **(a)** $v_x = (6.0^2 - 4.8^2)^{1/2}$ **M1**

$= 3.6\ \text{m s}^{-1}$ **A0**

or

$6.0 \sin \theta = 4.8$, so $\theta = 53.1°$ and $v_x = 6.0 \cos 53.1°$ **M1**

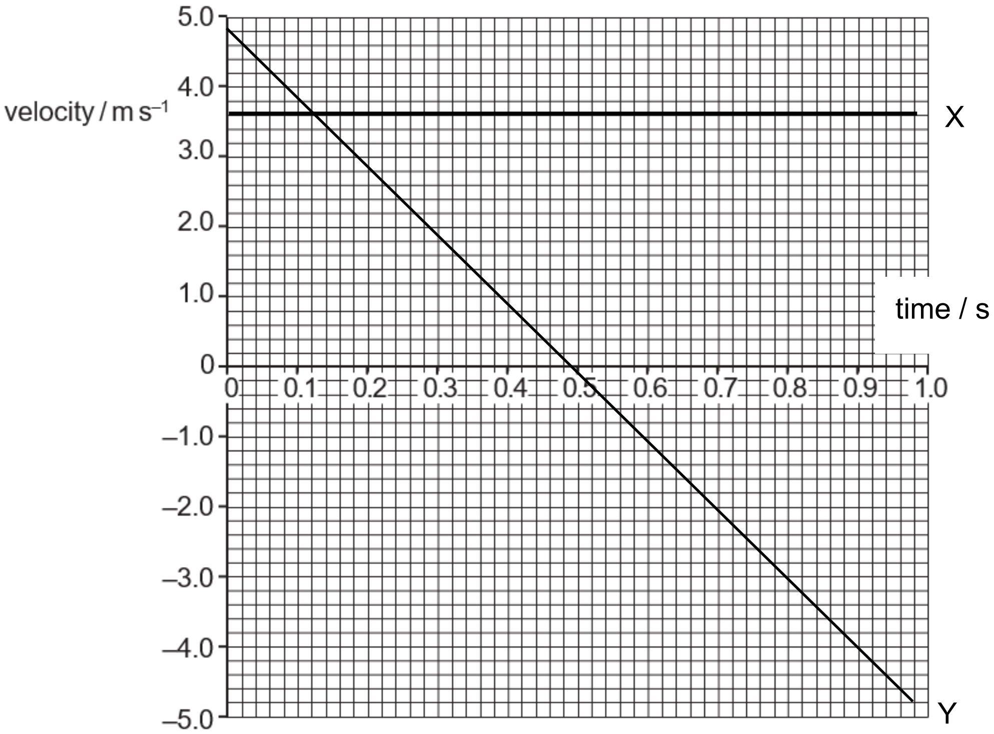
$= 3.6\ \text{m s}^{-1}$ **A0**

(b) **(i)** straight line from (0, 4.8) to (0.49, 0) **A1**

straight line continues with same slope to (0.98, –4.8), labelled Y **A1**

(ii) a horizontal line **A1**

from (0, 3.6) to (0.98, 3.6), labelled X **A1**



(c) $s = ut + ½at^2 = (4.8 \times 0.49) + (½ \times -9.81 \times 0.49^2)$ **C1**

$= 1.2\ \text{m}$ **A1**

or $s = ½(u + v)t = ½ \times (4.8 + 0) \times 0.49$ **C1**

$= 1.2\ \text{m}$ **A1**

or $v^2 = u^2 + 2as$

$s = 4.8^2 / (2 \times 9.81)$ **C1**

$= 1.2\ \text{m}$ **A1**

(d) $\dfrac{\text{kinetic energy at maximum height}}{\text{change in gravitational potential energy}} = \dfrac{{}^1\!/_2(mv_X^2)}{mgh} = \dfrac{{}^1\!/_2(3.6^2)}{9.81(1.2)}$ **C1**

$= 0.56$ **A1**

or

$\dfrac{\text{kinetic energy at maximum height}}{\text{change in gravitational potential energy}} = \dfrac{{}^1\!/_2(mv_X^2)}{{}^1\!/_2(mv_Y^2)} = \dfrac{{}^1\!/_2(3.6^2)}{{}^1\!/_2(4.8^2)}$ **C1**

$= 0.56$ **A1**

(e) With air resistance, the resultant force is larger than weight, resulting in larger deceleration, hence the actual time is shorter. **B1**

2 **(a)** energy (stored) / work done represented by area under graph **B1**

energy = ½ (180) (4.0 x 10^{-2}) **C1**

= 3.6 J **A1**

(b) **(i)** *either* momentum before release is zero **M1**

so sum of momenta of trolleys after release is zero **A1**

or force = rate of change of momentum **M1**

force on trolleys equal and opposite **A1**

or impulse = change in momentum **M1**

impulse on each trolley is equal and opposite **A1**

(ii) **1.** $M_1V_1 = M_2V_2$ **B1**

2. $E = ½\, M_1V_1^2 + ½\, M_2V_2^2$ **B1**

(iii) **1.**

$$E_K = \frac{1}{2}mv^2$$

$$= \frac{1}{2}\left(\frac{m}{m}\right)mv^2$$ **M1**

$$= \frac{(mv)^2}{2m}$$

$$= \frac{p^2}{2m}$$ **A0**

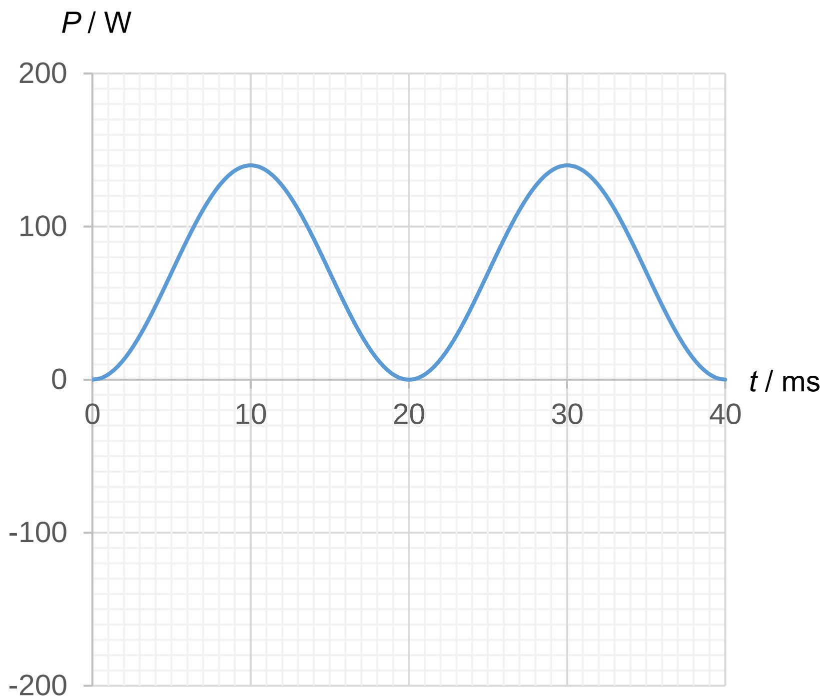
2. As trolley B has a smaller mass, it has a larger kinetic energy <u>because momentum is the same/ constant for both trolleys</u>. **B1**

3	**(a)**	Phase difference = $\frac{2\pi t}{T} = \frac{2\pi(2.5-1.5)}{3} = \frac{2\pi}{3} = 120^\circ$	**A1**
	(b)	At t = 0.75 ms, resultant displacement = $s_Y + s_Z$ = 4.0 – 1.0 = 3.0 μm	**A1**
	(c)	$I \propto A^2$	**C1**
		Thus $I = k\,(4)^2$	
		and $I_Z = k\,(2)^2 = 0.25I$	**A1**
	(d)	$v = f\lambda = \frac{\lambda}{T}$	**C1**
		so $\lambda = vT = 330\,(3.0 \times 10^{-3}) = 0.99$ m	**A1**

4	**(a)**	**(i)** Current in R_4 or R_1 = 0.30 + 0.30 = 0.60 A	**C1**
		$R = V / I$	**M1**
		= 2.4 / 0.60	
		= 4.0 Ω	**A0**
		or	
		p.d. across R_3 or R_2 = 2.4 / 2 = 1.2 V	**C1**
		$R = V / I$	**M1**
		= 1.2 / 0.30	
		= 4.0 Ω	**A0**
		(ii) E = 2.4 + 2.4 + 1.2	**C1**
		= 6.0 V	**A1**
		or	
		total resistance = 10 Ω	**C1**
		E = 10 × 0.60	
		= 6.0 V	**A1**
	(b)	total resistance increases	**B1**
		current decreases (in battery) so total power decreases	**B1**

5	**(a)**	**(i)** It is to increase the magnetic flux linkage between the coils	**B1**
		Comments: Most candidates answered correctly.	
		(ii) It is to reduce energy losses	**B1**
		by reducing induced currents	**B1**
	(b)	**(i)** maximum $V_{OUT} = (N_s / N_p)\, V_p$	
		= (625 / 25 000) 12 000	
		= 300 V	**A1**
		(ii) r.m.s. current = peak current /√2	
		= 300 / (640 × √2)	
		= 0.33 A	**A1**

(iii)



positive sinusoidal squared shape, with $P = 0$ at $t = 20$, 40 ms
and maximum P shown as 140 W **B1**
two complete cycles, with period = 20 ms **B1**

(c) For sinusoidal squared graph, mean power is half the peak power (140 W)
B1

6 **(a)** electron diffraction/ neutron diffraction **B1**

(b) $\frac{1}{2}mv^2 = eV$
$\frac{1}{2} \times 9.11 \times 10^{-31} \times v^2 = 1.60 \times 10^{-19} \times 4800$
$v = 4.1 \times 10^7$ m s^{-1} **C1**
$\lambda = h / mv$
$= 6.63 \times 10^{-34} / (9.11 \times 10^{-31} \times 4.1 \times 10^7)$ **C1**
$= 1.8 \times 10^{-11}$ m **A1**

(c) **(i)** Any two points, 1 mark each **B2**

- photons are (discrete) packets of energy
- energy of photons depends on frequency (of EM radiation)
- electrons can only absorb a single photon (of energy)
- emission only possible if photon energy is at least the work function

B1

(ii) work function = $hf = 6.63 \times 10^{-34} \times 6.93 \times 10^{14}$ **C1**
$= 4.59 \times 10^{-19}$ J
$= 4.59 \times 10^{-19} / 1.60 \times 10^{-19}$
$= 2.87$ eV **A1**

7 **(a)** Half-life of a radioactive nuclide is defined as the time taken for half of the original number of radioactive nuclides in a sample to decay on average. **B1**

(b) The beta decay is exothermic / releases energy. **B1**

Thus, the total binding energy of ${}^{90}_{39}\text{Y}$ and ${}^{0}_{-1}\text{e}$ is more than that of ${}^{90}_{38}\text{Sr}$.

B1

Since ${}^{0}_{-1}\text{e}$ has no binding energy, ${}^{90}_{39}\text{Y}$ has a greater binding energy. **B1**

(c) **(i)** **1.** $A = \lambda N$

$$3.7 \times 10^6 = \frac{\ln 2}{(27.7)(365)(24)(60)(60)} N$$ **C1**

$N = 4.66 \times 10^{15}$ **A1**

2. 90 g of strontium contains 6.02×10^{23} atoms.

Mass of 4.66×10^{15} atoms = $\frac{4.66\times10^{15}}{6.02\times10^{23}}$ (90/1000) **C1**

$= 6.97 \times 10^{-10}$ kg **A1**

OR

Mass of 4.66×10^{15} atoms = $N(90u)$

= $(4.66 \times 10^{15})(90)(1.66 \times 10^{-27})$ **C1**

$= 6.97 \times 10^{-10}$ kg **A1**

Mass of 4.66×10^{15} atoms

$= N(38\, mass\ of\ electrons + 38\, mass\ of\ protons + 52\, mass\ of\ neutrons)$

= $(4.66 \times 10^{15})(38 \times 9.11 \times 10^{-31} + 38 \times 1.67 \times 10^{-27} + 52 \times 1.67 \times 10^{-27})$

$= 7.01 \times 10^{-10}$ kg

(ii) $A = A_o e^{-\lambda t}$

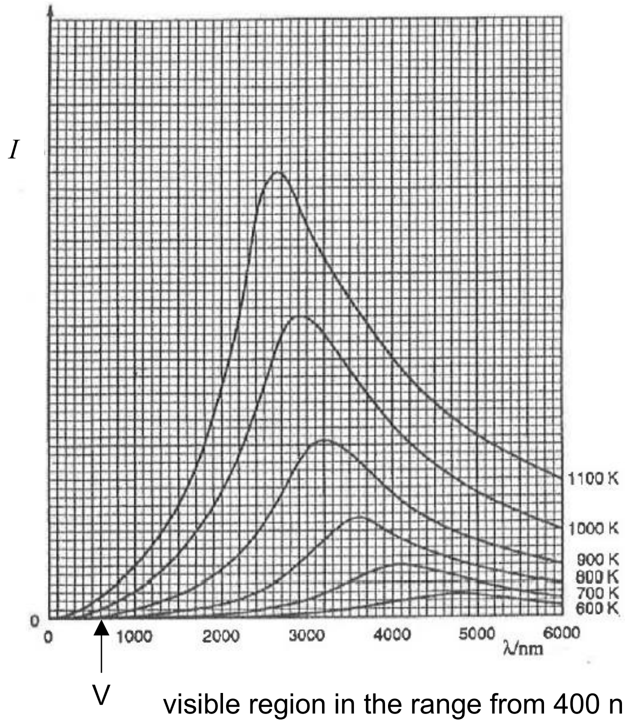
$\frac{A}{A_0} = e^{-\left(\frac{\ln 2}{27.7}\right)(5.0)}$ **C1**

$= 0.882$ **A1**

8 **(a)** Energy has discrete/fixed values. **B1**

Comments: Generally poorly answered. Use of the word packet does not connote quantised.

(b) **(i)**



visible region in the range from 400 nm to 700 nm. **A1**

(ii) In the visible region, the intensity of the emitted radiation increases with increasing wavelength. **B1**

The red region has the longest wavelength and according to the graph highest intensity at 1100 K **B1**

The hot object is perceived by the eye as glowing red. **A0**

(c) **(i)** The wavelength, λ_{max}, that corresponds to the peak intensity of the emitted radiation. The higher the temperature, the shorter the λ_{max}. **B1**

(ii) advantage: The radiation can be detected at a distance. Hence there is no need for contact between device and the body to measure its temperature. **B1**

disadvantage: At lower temperature, the peak cannot be easily identified. **B1**

(d) **(i)** Electric force of attraction on electron provides the centripetal force for its motion about the nucleus. **B1**

$$\frac{e^2}{4\pi\varepsilon_o r^2} = \frac{mv^2}{r}$$ **C1**

$$v = \sqrt{\frac{e^2}{4\pi\varepsilon_o mr}} = \sqrt{\frac{(1.6 \times 10^{-19})^2}{4\pi(8.85 \times 10^{-12})(9.11 \times 10^{-31})r}}$$ **M1**

$$= \frac{15.9}{\sqrt{r}}$$ **A0**

(ii) $v = \frac{nh}{2\pi mr} = \frac{15.9}{\sqrt{r}}$

$n = 1$ so $\frac{h^2}{4\pi^2 m^2 r^2} = \frac{(15.9)^2}{r}$ **C1**

$r = \frac{h^2}{4\pi^2 m^2 (15.9)^2} = 0.053$ nm **A1**

(iii) Energy = potential energy + kinetic energy

$= -\frac{e^2}{4\pi\varepsilon_o r} + \frac{1}{2}mv^2$

$= -\frac{(1.6 \times 10^{-19})^2}{4\pi(8.85 \times 10^{-12})(5.3 \times 10^{-11})} + \frac{1}{2}(9.11 \times 10^{-31})\frac{(15.9)^2}{(5.3 \times 10^{-11})}$ **C1**

$= -2.17 \times 10^{-18}$ J **M1**

$= -\frac{2.17 \times 10^{-18}}{1.6 \times 10^{-19}}$ eV

$= -13.6$ eV **A0**

(e) **(i)** For minimum wavelength, n is infinity

$\lambda = \frac{1}{1.097 \times 10^7} = 91.2$ nm **A1**

(ii) $E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3.00 \times 10^8)}{\lambda}$ **C1**

$E\lambda = 1.99 \times 10^{-25}$ J m

$= 1.99 \times 10^{-25}$ J ($\times 10^9$) nm **M1**

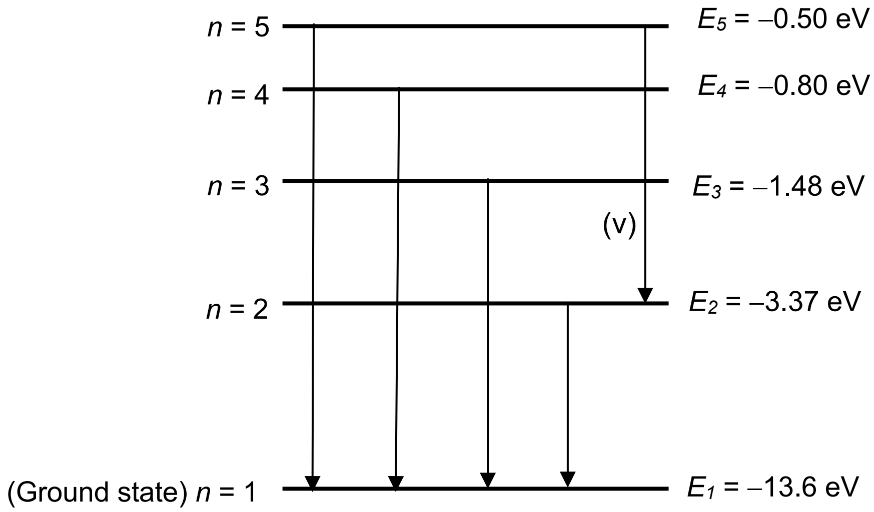
$= 1.99 \times 10^{-16}$ J nm **A0**

(iii)

wavelength λ / nm	$E = \frac{hc}{\lambda}$ / eV
121.6	10.23
102.6	12.12
97.3	12.8
95.0	13.1

energy in eV **A1**

(iv)



5 energy levels shown, with progressively smaller energy difference between higher energy levels **C1**

Correct energy values for each level **C1**

Correct electron transitions from higher to lower energy levels **C1**

(v) For λ = 434.1 nm, $E_h - E_l$ = 2.87 eV.

Hence the transition is from n = 5 to n = 2 **A1**