

2025 H2 Physics P1 Solutions

- 1 A Units of Q is C = A s
 Units of V is J C⁻¹ = kg m² s⁻² / A s
 Hence units of C = A² s⁴ m⁻² kg⁻¹
- 2 A Average of h
 A - 6.63, B - 6.63, C - 6.65, D - 6.62
 A, B and D are accurate
 Range of variation of h
 A - 0.04, B - 0.02, C - 0.07, D - 0.02
 B and D are precise
- 3 C $\frac{\Delta p}{p} \times 100\% = \frac{1}{2} \left(\frac{0.05}{4.30} + \frac{20}{1450} + 0.05 \right) \times 100\% = 3.8\% \approx 4\%$
- 4 A Initial velocities for both stones, $u = 0$
 $s = ut + \frac{1}{2}gt^2 = \frac{1}{2}gt^2$
 For the same time interval, Δt , both stones fall down by the same distance, s .
 Therefore the distance between them will always remain the same as that at the point of release.
- 5 D $F = N\rho Av^2 = (27)(900)(0.4 \times 10^{-6})(3.0)^2 = 0.087 \text{ N}$
- 6 B The weight of the water converted to ice is the same as that of the ice.
- 7 B Instantaneous power required to drive the escalator
 $= Fv + P_{\text{friction}}$
 $= Mg \sin \theta \times v + P_{\text{friction}}$
 $= \left(62 \times 20 \times 9.81 \times \frac{30}{60} \times 0.75 \right) + 2.5 \times 10^3$
 $= 7.1 \times 10^3 \text{ W}$
 $= 7.1 \text{ kW}$

- 8 C Drag at 21.0 m s⁻¹: $f_b = \frac{110}{21} = 5.24 \text{ kN}$
 Drag at 15.0 m s⁻¹: $\frac{f_b^1}{f_b} = \left(\frac{15.0}{21.0} \right)^2 \Rightarrow f_b^1 = 2.67 \text{ kN}$
 Force of engine at 15.0 m s⁻¹: $F_{\text{engine}} = \frac{110}{15} = 7.33 \text{ kN}$
 Hence resultant force = 7.33 - 2.67 = 4.66 kN

- 9 B Work done = mass x change in potential
 = (1) (final potential - initial potential)
 $= -\frac{3GM}{2R} - \left(-\frac{GM}{R} \right) = -\frac{GM}{2R}$

- 10 C Top: $F_{\text{top}} + mg = m r \omega^2$
 $F_{\text{top}} = 77 [4(2\pi/3.7)^2 - 9.81] = 133 \text{ N}$ (downwards)
 Bottom: $F_{\text{bottom}} = mg + m r \omega^2$
 $F_{\text{bottom}} = 77 [4(2\pi/3.7)^2 + 9.81] = 1640 \text{ N}$ (upwards)

- 11 D Resultant force towards the sun equals to ma_c.

- 12 D GPE of orbiting satellite $E_p = -G \frac{Mm}{r}$
 Gravitational force = centripetal force
 $\Rightarrow G \frac{Mm}{r^2} = m \frac{v^2}{r}$
 $\Rightarrow E_k = \frac{1}{2}mv^2 = \frac{1}{2}G \frac{Mm}{r}$
 $\Rightarrow E_p = -2E_k$
 $E_p = E_p + E$
 $\Rightarrow -2E_k = -2E_k + E$
 $\Rightarrow E_k = E_k - \frac{E}{2}$

- 13 A Total number of moles of gas is constant. Since $PV = nRT$, we take the initial number of moles in the smaller (A) and larger bulb (B) to be n and $8n$ respectively. Total number of moles = $9n$.

At new equilibrium, the pressure will be the same for both.

$$PV = n'RT_A = n'R(80 + 273.15)$$

$$P_1(8)V = (9n - n')RT_B = (9n - n')R(10 + 273.15)$$

Dividing:

$$\frac{V}{8V} = \frac{n'(353.15)}{(9n - n')(283.15)}$$

$$\frac{9n - n'}{8 \times 353.15}$$

$$\frac{n'}{283.15} = \frac{283.15}{8 \times 353.15} + 1$$

$$\frac{9n}{n'} = \frac{8 \times 353.15}{283.15} + 1$$

$$n' = 0.8194n$$

$$\Delta n = n - 0.8194n = 0.18n$$

14 A

$$\frac{x_{sT}}{x_0} = \frac{x_0 \sin\left(\frac{2\pi}{T} \times \frac{5T}{8}\right)}{x_0}$$

$$= x_0 \sin\left(\frac{5\pi}{4}\right)$$

$$= -0.71$$

15 C

$$E = \frac{1}{2}m(2\pi f)^2 x^2$$

$$\frac{1}{2}(0.5m)(2\pi)^2(3.0f)^2(0.40x)^2 = (0.72) \left(\frac{1}{2}m(2\pi f)^2 x^2 \right)$$

$$= 0.72E$$

16 D

$$I = \frac{P}{2\pi r d} \propto \frac{1}{r}$$

$$I \propto A^2$$

$$\therefore A \propto \frac{1}{\sqrt{I}}$$

$$\frac{A'}{2.0} = \frac{\sqrt{150}}{\sqrt{1200}}$$

$$A' = 0.71 \text{ mm}$$

17 C

Unpolarised light after passing through a polarizer, its intensity is halved (therefore we eliminate options A/B).

Amplitude remains at A. (The component of E field perpendicular to the polariser axis is absorbed (e.g. A_y is absorbed), leaving the transmitted light having amplitude A_x)

Since the polarization angle is 75° (or 105°), by resolving the electric field,

$$A' = A \cos 75^\circ = A \sin 15^\circ$$

18 A First minima position:

$$b \sin \theta = \lambda$$

$$0.010 \times 10^3 \times 0.05 = \lambda$$

$$5.0 \times 10^2 \text{ m} = \lambda$$

19 D Electric potential energy $U = qV$

Since charge of electron is -ve, and potential at X is +ve while that at Y is -ve,

$$\Rightarrow U_Y > U_X$$

Magnitude of electric force $F = qE$. Since the E field strength at Y > E field strength at X

$$\Rightarrow F_Y > F_X$$

20 D Break in +ve wire of cable \Rightarrow voltmeter reading = 0 when connected to X or Y

Break in connection within motor \Rightarrow voltmeter reading = 24 V when connected to X and 0 V when connected to Y

Break in -ve wire of cable \Rightarrow voltmeter reading = 24 V when connected to X or Y

21 A In dark condition:

$$V = \frac{5 \times 10^3}{5 \times 10^3 + 5 \times 10^6} \times 6 = 0.0060 \text{ V}$$

In bright condition:

$$V = \frac{5 \times 10^3}{5 \times 10^3 + 1 \times 10^9} \times 6 = 5.0 \text{ V}$$

22 C

$$P = I^2 R = I_{ms}^2 \frac{R}{4}$$

$$I_{ms} = 2I \Rightarrow I_0 = 2\sqrt{2}I$$

23 A The point charge's velocity is parallel to resultant magnetic flux density at the centre of the two wires. Thus magnetic force is zero.

24 A

25 A By Fleming's left hand rule (to find force on an electron in the rod), the electrons in the rod will accumulate at P, causing Q to be of higher electrical potential.

26 C If the magnetic flux linkage is a sine function, the induced e.m.f. will be a cosine function, and vice-versa. Hence, the phase difference between them is $\pi/2$ rad.

27 D Option A is incorrect because photoelectric effect can occur even for very low intensity but sufficiently high frequency radiation (above the threshold frequency f_0).

Option B is incorrect because photoelectrons are emitted only if the frequency of radiation is greater than a minimum frequency known as threshold frequency f_0 ; since $\lambda_0 = \frac{c}{f_0}$, the wavelength of the radiation must be smaller than the threshold wavelength, which is instead a maximum value.

Option C is incorrect because the maximum kinetic energy and thus speed of the photoelectrons is independent of intensity but depends on the frequency of radiation and work function of the metal, as given by $hf = \phi + E_{k,max}$.

Option D is correct since $I = \frac{N_e hf}{t A}$, at constant intensity and increased frequency, the rate of photons incident on the metal decreases, the lesser the rate of emission of photoelectrons.

28 D proton with the same v but bigger m than electron will have a much larger momentum p (more than 1000 times)

Rings will not be observable.

29 A $A_{p0} + A_{\alpha0} = 800$ (1)

$$A_{p0} \left(\frac{1}{2}\right)^{120/30} + A_{\alpha0} \left(\frac{1}{2}\right)^{120/30} = 80$$

$$\frac{1}{4} A_{p0} + \frac{1}{16} A_{\alpha0} = 80$$

$$\Rightarrow 4A_{p0} + A_{\alpha0} = 1280$$
 (2)

$$(2) - (1) :$$

$$3A_{p0} = 480$$

$$A_{p0} = 160$$

30 B Only α decay results in a change in mass number, and each α decay causes the mass number to decrease by 4. Hence the difference in the mass number of the end product and the parent nuclide must be a multiple of 4.

2025 H2 Physics P2 Solution

- 1 (a) The distribution is not uniform with more mass loaded nearer to the left. B1
 (b) Resultant force on the boat is zero B1
 Resultant moment about any pivot is zero B1
 C1
 $T_1 + T_2 = 15000$
 $15000(0.75) = T_2(2)$
 $T_1 = 9400 \text{ N}$
 $T_2 = 5600 \text{ N}$
 (d) $Wd = 15000(30)$
 $P = 15000(30)/12$
 $= 37500 \text{ W}$

- 2 (a) The cube undergoes resonance when the driving frequency of the water wave equals the natural frequency of the oscillating system/cube. B1
 There is maximum transfer of energy from the water wave to the cube/ The energy of the system/cube becomes a maximum and the system/cube oscillates with maximum amplitude. B1

- (b) $v = f\lambda$
 $f = 2.0 \text{ Hz}$
 Substitute $f = 2.0 \text{ Hz}$ into $f = \frac{1}{2\pi} \sqrt{\frac{g}{l}}$
 $l = 0.0621 \text{ m}$

- (c) (i) Increase in wavelength results in decrease in driving frequency, thus driving frequency is not equal to natural frequency, Amplitude decreases. M1
 A1
 (ii) Increase in mass results in an increase in l , and an decrease in natural frequency. Thus, driving frequency is not equal to natural frequency, Amplitude decreases. M1
 A1

- (d) Drag force due to water on the cube causes damping. B1
 Thus, maximum amplitude of oscillation occurs at a driving frequency 2 Hz, which is smaller than the natural frequency.
 Since $f = \frac{1}{2\pi} \sqrt{\frac{g}{l}}$, a smaller value of f used in calculation results in a larger value of l calculated. B1
 As such, the value determined in (b) is larger than actual measurement.

- 3(a) Using $v = f\lambda$

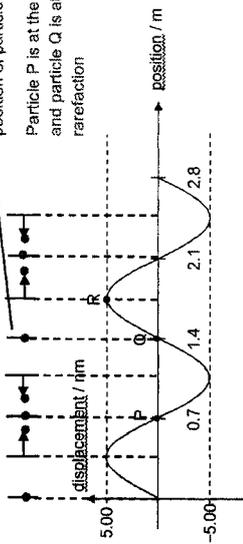
$$v = \frac{1}{4.0 \times 10^{-3}} \times 1.4$$

$$= 350 \text{ m s}^{-1}$$

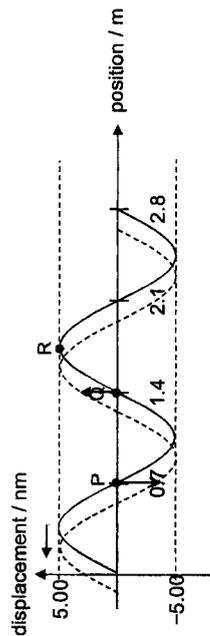
M1
 A1

- (b)(i) Particle R
 (As the particle is undergoing SHM, at the amplitude, the instantaneous velocity of the particle is zero). A1

- (b)(ii) Particle Q.
 Vertical lines represent equilibrium position of particle along the wave. A1
 Particle P is at the centre of compression and particle Q is at the centre of rarefaction

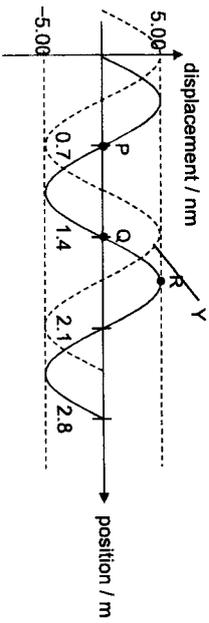


- (b)(iii) Displacement of article Q will be positive next instant. A1



(c)(i) Distance travelled by wave in $t = 1 \text{ ms} = vt = (350)(1 \times 10^{-3}) = 0.35 \text{ m}$

The graph should have shifted to the left by 0.35 m.



C1

A1

Award mark as long as one full wavelength is drawn with displacement at 5.00 mm at initial position.

(c)(ii) Phase difference between particle R and S

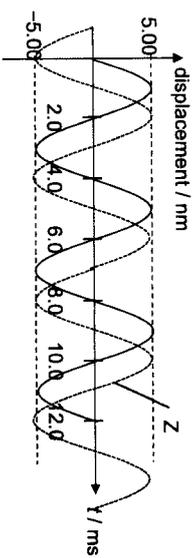
$$\Delta\phi = \frac{\Delta x}{\lambda} \times 360^\circ = \frac{0.7}{1.4} \times 360^\circ = 180^\circ$$

C1

OR

Phase difference between particle Q and S is 90° .

A1



4 (a) 1. Waves must meet π rad out of phase.

A1

2. Waves must have equal amplitude.

A1

(b) (i) Wavefrains from S_1 and S_2 are coherent and superpose at points along YZ.

C1

When path difference is an integral multiple of λ , the waves meet in phase, constructive Interference takes place to give a series of maxima.

C1

(ii) It decreased to one quarter of the original x (since $x = \lambda D/a$)

A1

(iii) The line YZ is not parallel to the slits
or the slits not normal to the (incident) microwaves

A1

(iv) Place a polariser in front of the transmitter and rotate through 90° OR rotate transmitter/detector through 90° .

M1

If this causes minimal/zero signal at some angles, the wave is plane polarized.

A1

(c) Distance between two nodes = $\frac{1}{2}\lambda$ = speed of detector / frequency of detection

C1

= $10 / 1.5 = 6.7 \text{ mm}$

C1

Hence, wavelength = 13 mm

(d) (i) $f = c/\lambda = 3.00 \times 10^8 / 13 \times 10^{-3} = 2.3 \times 10^{10} \text{ Hz}$

A1

(ii) White light diffracts after passing through the slits in the grating. For zeroth order maxima, each of the wavelengths in the white light travels the same path length/ zero path difference.

B1

The amplitudes add up vectorially to produce a resultant white colour maxima

A1

wavelength λ of red light $>$ wavelength blue light ($\lambda_{red} > \lambda_{blue}$)

B1

For waves from any two adjacent slits, path difference is $d \sin \theta$, where d is the separation between the slits.

A0

To produce a maxima for 1st order, path difference, $d \sin \theta = 1 \lambda$.

B1

Hence, maxima for different colors occurs at different angle θ , with red light at a larger angle

B1

5 (a) (ai) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{170}{\sqrt{2}} = 120 \text{ V}$

A1

(aii) $\omega = 2\pi/T = 314$

A1

$T = 0.0200 \text{ s}$

A1

(b) (i)

C1

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$\frac{170}{2000} = \frac{3500}{N_P}$$

$$V_S = 298 \text{ V}$$

A1

(ii) Using points (0.070, 1.500) and (3.80, 0.550) on the line in Fig. 5.2,

$$\frac{dI}{dt} = \frac{0.380 - 0.070}{3.80 - 1.500} = -3.0645 = -3.06$$

According to Faraday's law,

$$\text{e.m.f.} = -\frac{d\Phi}{dt} = -\frac{d}{dt}(N_c B_s A_s)$$

$$= -N_c A_s \frac{d}{dt}(\mu_0 n I)$$

$$= -N_c A_s \mu_0 n \frac{dI}{dt}$$

$$= -1500 \times 2.5 \times 10^{-4} \times 4\pi \times 10^{-7} \times 20000 \times (-3.0645)$$

$$= 2.8882 \times 10^{-2} = 2.89 \times 10^{-2} \text{ V}$$

A1

C1

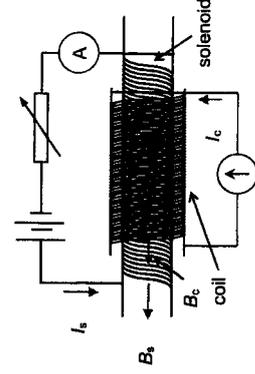
(ii)

$$\begin{aligned} V_s &= I_s R \\ 298 &= I_s (130) \\ I_s &= 2.288 \text{ A} \\ I_p &= \frac{N_s}{N_p} \times 3500 \\ \frac{I_s}{I_p} &= \frac{N_p}{N_s} = \frac{2000}{3500} \\ I_p &= 4.00 \text{ A} \end{aligned}$$

b iii

$$\begin{aligned} V_s &= I_s R \\ 298 &= I_s (130) \\ I_s &= 2.288 \text{ A} \\ I_p &= \frac{N_s}{N_p} \times 3500 \\ \frac{I_s}{I_p} &= \frac{N_p}{N_s} = \frac{2000}{3500} \\ I_p &= 4.00 \text{ A} \end{aligned}$$

C1
A1

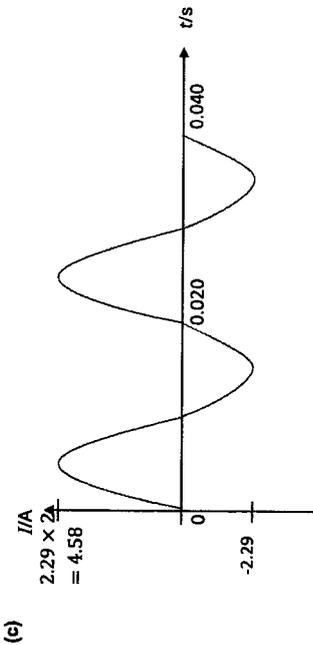


(iii)

A1

B1

Power loss due to
Induced Eddy currents
Hysteresis loss
Any possible causes



(c)

The current I_s in the solenoid flows from the positive terminal of the battery. By right-hand-grip rule, the magnetic flux density B_s produced points to the left.

Since I_s decreases, B_s also decreases so by Lenz's law, the induced magnetic flux density B_c in the coil must point to the left.

By right-hand-grip rule, the induced current I_c in the coil flows from left to right through the galvanometer.

7 (a)

gravitational force exerted by Sun on Earth provides the centripetal force

$$m r \omega^2 = GMm / r^2$$

$$r^3 = GM \times (T / 2\pi)^2$$

$$r^3 = 6.67 \times 10^{-11} \times 2.0 \times 10^{30} \times (365 \times 24 \times 3600 / 2\pi)^2$$

$$1 \text{ AU} = r = 1.498 \times 10^{11} \text{ m}$$

$$= 1.50 \times 10^{11} \text{ m}$$

7

(a)

B1

M1

M1

A0

6 (a) (i) From Fig. 6.2, the current at $t = 0.070 \text{ s}$ is 1.500 A .

$$n = \frac{3000}{0.15} = 20000$$

$$B = \mu_0 n I = 4\pi \times 10^{-7} \times 20000 \times 1.500 = 3.77 \times 10^{-2} \text{ T}$$

- (b)(i) The mass of the Sun is much bigger compared to the total mass of all the planets, and so their gravitational influence is small.
 To escape to infinity, initial KE of object at Jupiter \geq gain in GPE from Jupiter to infinity
 $(1/2)mv^2 \geq 0 - (-GMm/r)$

$$(1/2)v^2 \geq GM/r$$

$$v^2 \geq (2 \times 6.67 \times 10^{-11} \times 2.0 \times 10^{30}) / (5.2 \times 1.50 \times 10^{11})$$

$$v_{\min} = 1.85 \times 10^4 \text{ m s}^{-1}$$

- (b)(iii) According to Fig 7.3, the speed of Voyager 2 at Jupiter on 9 July 1979 was $10.5 \text{ km s}^{-1} = 1.05 \times 10^4 \text{ m s}^{-1}$, which is less than the escape speed of $1.85 \times 10^4 \text{ m s}^{-1}$ needed at that distance from the Sun. Hence, it was not travelling fast enough to escape to infinity.

- (b)(iv) From Fig. 3, the speed of Voyager 2 increased from 10.5 km s^{-1} to 28.0 km s^{-1} during its interaction with Jupiter.

Hence, its gain in momentum $= \Delta p = p_f - p_i = mv_f - mv_i$

$$= 773 (28.0 - 10.5) \times 10^3$$

$$= 1.35 \times 10^7 \text{ kg m s}^{-1}$$

- (b)(v) Voyager 2 gains kinetic energy/momentum from Jupiter's orbital kinetic energy about the Sun. In a gravity assist, the spacecraft exchanges momentum/energy with the moving planet, the craft gains a tiny amount of the planet's orbital energy
 Half-life, $t_{1/2} = 87.74$ years
 $A = A_0 \exp(-\lambda t)$ or $A = A_0 \exp(-\ln 2 \times t / t_{1/2})$

$$A = A_0 \exp(-\ln 2 \times 1/87.74)$$

$$A = A_0 \exp(-0.00790)$$

Activity remaining after one year is $A = 0.992 A_0$

Hence, fractional decrease in activity in one year $= 1 - 0.992 = 0.0079 = 0.79 \%$

- (c)(iii) $A = 0.623 A_0$
 Power output is proportional to the activity, so
 $P = 0.623 P_0$
 $P = 0.623 \times 470 = 290 \text{ W}$

- (c)(iii) As spacecraft moved farther away, the intensity of the received radio waves had decreased, power received decreases (since power received \propto Intensity at that point \times area of receiver.)
 Hence, the total area of the receiving parabolic dish antenna needed to be increased so that the total power of the received waves will be large enough to be detected.

(d) In 1990, distance of Earth from Voyager 1 = 40.47 AU
 Angular diameter of Earth $= \theta = d / D$

$$= (2 \times 6.4 \times 10^6) / (40.47 \times 1.50 \times 10^{11}) = 2.1 \times 10^{-4} \text{ rad}$$

C1

A1

A1

C1

C1

C1

A1

B1

A1

B1

B1

2025 Physics Prelim P3 Solutions

1 (a) (i) $v_y^2 = u_y^2 + 2as_y$
 $= 0 + 2(9.81)(32)$

M1

(ii) $v_y = 25.1 \text{ m s}^{-1}$
 $\sin \theta = \frac{25.1}{34}$
 $\theta = 47.6^\circ$

A1

M1

A1

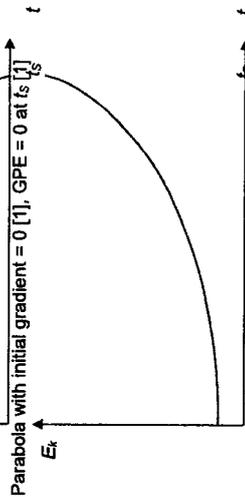
(b) With splashing, there is a transfer of KE of stone to KE of water.
 Less KE of stone available to do work against resistive forces in the water.

B1

(c) (i) E_p

B1

B1



(ii)

B1

2 (a) Net force on body proportional to rate of change of momentum of the body
 (allow eqn with symbols if defined?)

(b) (i) $\Delta p = 140 \times 10^{-3} \times [(5.5 - (-4.0))] = 1.33 \text{ kg m s}^{-1}$

(ii) $F_{\text{net}} = 1.33 / 0.04$
 $= 33.3 \text{ N}$

Average force on ball due to bar
 $= F_{\text{net}} + W_{\text{ball}}$
 $= (1.33 / 0.04) + (9.81 \times 140 \times 10^{-3})$
 $= 34.6 \text{ N}$

By N3 $F_{\text{bar}} = F_{\text{ball}}$
 $= 34.6 \text{ N} = 35 \text{ N}$

(iii) Taking moments about B
 $(35 \times 0.75) + (0.450 \times 9.81 \times 0.25) = F_A \times 0.20$
 $F_A = 137 \text{ N}$

(iv) loss = $\frac{1}{2} (0.140) [5.5^2 - 4.0^2] = 0.998 \text{ J}$

(c) Since initial and final velocities remain the same, the change in momentum of the ball on hitting the bar is unchanged.
 However the duration of contact increases, average contact force on bar at point D decreases, leading to lower average contact force at D
 And hence a lower exerted force at A

3 (a)(i) An ideal gas is one that obeys the ideal gas equation, $pV = nRT$ at all pressures, volumes and temperatures.

(ii) $pV = nRT$
 $(1.00 \times 10^5) (750 \times 10^{-6}) = n (8.31) (300)$
 $n = 0.030$

M1

A1

(b)

	work done on gas / J	heat supplied to gas / J	increase in internal energy of gas / J
A to B	+360	0	+360
B to C	0	+670	+670
C to D	-810	0	-810
D to A	0	-220	-220

Minus 1 per mistake.

(c) the gas molecules bounce off the receding piston at lower speeds
 And hence lower kinetic energy.

B1

For an ideal gas, the temperature is proportional to the average kinetic energy of the molecules.

B1

(d) The net work by the engine is positive and can be used to move the car (turn the wheels)

B1

3

4 (a) $\frac{R}{0.75 + R + 5.5} \times 4.0 = 1.3$ C1
 $R = 3.0 \Omega$

p.d. across AB = $\frac{5.5}{0.75 + 3.0 + 5.5} \times 4.0$ C1
 $= 2.4 \text{ V}$ A0

(b)(i) $E = \frac{1.50 - 0.56}{1.50} \times 2.4$ C1

(b)(ii) As C is shifted closer to A, the potential at C increases, thus increasing the potential difference between BC. M1

(c)(i) Since the potential between BC will become larger than the terminal p.d. of cell Q, current will now flow from C to B through cell Q. A1

$R = 5.5 / 150 = 0.0367 \Omega \text{ cm}^{-1}$ C1

$R = 2 \times 15 \times 0.0367 + \frac{1}{5} \left(\frac{150 - 2 \times 15}{5} \times 0.0367 \right)$ C1
 $= 1.28 \Omega$

(c)(ii) $= 1.3 \Omega$ A0

Since $I = n A v q$, number density n , cross-sectional area A and charge q are the same in both sections XY (consider a single wire) and AX, $v \propto I/A$.
 the current through a single wire in XY is 1/5 of the current through AX.
 OR
 Since the same current flows through sections AX and XY (consider XY as a whole), $v \propto 1/A$.
 the cross-sectional area of XY is 5 times the cross-sectional area of AX.
 drift velocity v is greater in AX than in XY A1

5 (a) (i) Charged particles moving perpendicular to a magnetic field will experience a resultant magnetic force perpendicular to its motion. Hence no work is done. By Newton's 2nd Law, the acceleration of the particles is in the same direction as the resultant force. The direction of the particles changes but not its speed. By Newton's 1st law, upon exit, the particles will move in a straight line with a speed of 4500 ms⁻¹. B1

(ii) Magnetic force provides centripetal force for particle's circular motion B1
 $F = Bqv = \frac{mv^2}{r}$

4

$r = \frac{mv}{Bq}$ C1
 $= \frac{(2.66 \times 10^{-26})(4500)}{(2 \times 10^{-3})(1.6 \times 10^{-19})}$
 $= 0.374 \text{ m}$ A1

(b) $r = \frac{mv}{Bq} = \frac{P}{Bq}$ M1
 $P = rBq = (0.2)(2 \times 10^{-3})(1.6 \times 10^{-19})$
 $= 6.4 \times 10^{-23} \text{ kg m s}^{-1}$ A1

6 (a) (i) 10 A1
 (ii) $\Delta E = E_4 - E_1 = \frac{hc}{\lambda}$
 $= \frac{(6.63 \times 10^{-34} \times 3.00 \times 10^8)}{97.5 \times 10^{-9}}$
 $= 2.04 \times 10^{-18} \text{ J}$ B1
 $= 2.04 \times 10^{-18}$
 $= \frac{1.60 \times 10^{-19}}{12.75} \text{ eV}$
 $= 12.75 \text{ eV}$

$E_4 = E_1 + \Delta E = -0.85 \text{ eV}$ A1
 (b) (i) 13.6 eV = work function + eV_0 M1
 work function = 13.6 - 8.13 A1
 $= 5.47 \text{ eV}$ A1

(ii) max kinetic energy of photoelectrons = 8.13 eV B1
 $8.13 \times 1.60 \times 10^{-19} = \frac{p^2}{2 \times 9.11 \times 10^{-31}}$
 $p = 1.5395 \times 10^{-24} = 1.54 \times 10^{-24} \text{ N s}$ A1

(iii) $p = \frac{h}{\lambda}$ B1
 $1.5395 \times 10^{-24} = \frac{6.63 \times 10^{-34}}{\lambda}$
 $\lambda = 4.31 \times 10^{-10} \text{ m}$ A1

(iv) $\Delta p \Delta x \geq h$ B1
 $9.11 \times 10^{-31} \times (1.2 \times 10^6 \times \frac{0.0025}{100}) \times \Delta x \geq 6.63 \times 10^{-34}$
 $\Delta x \geq 2.43 \times 10^{-5} \text{ m}$ B1
 $\Delta x_{\text{min}} = 2.2 \times 10^5 \text{ m (1 or 2 sf)}$ A1

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- (v) Electrons are accelerated to high kinetic energy in a strong electric field.
 - When a stream of high energy electrons are rapidly brought to rest (decelerated) by collisions with the atoms of tungsten, radiation in the form of X-rays are emitted.
 - If the electron loses only part of its initial kinetic energy during the collision with the target atom, the photon emitted has energy equal to the loss in kinetic energy of the bombarding electrons.
 - Since the loss in kinetic energy can take any value, through the multiple stages of deceleration of electrons in a metal target, a continuous X-ray spectrum is obtained.

- 7 (a) (i) It is a region of space in which a force acts on a body. B1
 (ii) It is the electric force per unit positive charge acting on a small test charge placed at that point. B1
 (iii) To eliminate the possibility of magnetic force due to its motion in a magnetic field. B1
 b (i) E is the negative of the potential gradient B1
 OR
 The electric field strength E at a point is numerically equal to the potential gradient at that point and the direction of the E field points in the direction of decreasing potential V. B1

- (ii) 1. Potential gradient at P is negative B1
 Electric field $E = -dV/dx$ is positive, hence points in the positive x direction B1
 $E = 0$ B1
 Hence $F = eE = 0$ B1

3. -Any charges placed on an isolated conducting sphere resides entirely on its outer surface because of repulsive forces between them. Since there is no charge within the conductor, the electric field is zero at every point inside the charged conductor.

$-E = -\frac{dV}{dr} = 0$ implies that all points inside the conductor are at constant electric potential B1

x/cm	V/V	VxV/cm
13.0	590	7670
21.0	390	8190

- c (i) Since Vx not constant, student is incorrect B1
 Minimum 2 sets of data needed. x must be read to 1/2 and V square. Unit of Vx must be given B1

(ii) The expression would apply only to a single isolated charge.

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However, Fig 7.2 shows the resultant potential between spheres A and B (which is the scalar sum of the potentials due to A and B).

- d (i) By conservation of energy C1
 $\frac{1}{2}mv_{min}^2 - eV = 0$

$$v_{min} = \sqrt{\frac{2(1.60 \times 10^{-19})295}{9.11 \times 10^{-31}}}$$

$$v_{min} = 1.02 \times 10^7 \text{ m s}^{-1} \quad \text{A1}$$

- (ii) The electron would approach the spheres along line of minimum electric potential B1
 and cross the A-B line at $x = 35.0 \text{ cm}$ B1

- 8 (a) (i) $0 = 4mV + (A - 4)mv$ B1
 $4V = -(a - 4)v$ B1

$$\text{ratio} = \frac{4mV^2}{4(A - 4)mv^2} \quad (1) \quad \text{B1}$$

From (i)

$$V = -\left(\frac{A - 4}{4}\right)v$$

Sub into (1)

$$\text{ratio} = \frac{4\left(\frac{A - 4}{4}\right)^2 v^2}{4(A - 4)v^2}$$

$$\text{ratio} = \frac{A}{4} - 1 \quad \text{B1}$$

- b (i) $E_{released} = [m_{Bi} - (m_{\alpha} + m_{Th})]c^2$ C1
 $= [211.9459 - (4.0015 + 207.9374)](1.66 \times 10^{-27})^2 \frac{(3.00 \times 10^8)^2}{1.60 \times 10^{-23}}$ C1
 $= 654 \text{ MeV}$ A1

- (ii) $\frac{E_{\alpha}}{E_{Th}} = \frac{A}{4} - 1$ C1
 $\frac{E_{\alpha}}{6.54} = \frac{212}{4} - 1 = 52$ C1
 $E_{\alpha} = 6.42 \text{ MeV}$ A1

- c (i) Gamma ray is also emitted in the process. Hence energy of alpha particle is smaller B1

- (ii) Gamma ray is likely to carry off part of the momentum in a direction different from that of thallium nucleus and alpha particle. By conservation of momentum, the 2 particles cannot move in opposite direction B1

(ii) The expression would apply to an isolated charge. But there are two charged objects here.

d (i) 3600s

A1

(ii) Two hours is equivalent to two half lives of bismuth hence number of radioactive bismuth nuclei remaining is approx. $N/4$, forming $3N/4$ thallium nuclei. B1
B1
B1

However, thallium has a much smaller half life and would decay quickly to form other nuclei hence number of thallium nuclei is less than $3N/4$.