H

TEMASEK JUNIOR COLLEGE
2024 JC2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CG

PHYSICS 9749/03

Paper 3 Longer Structured Questions

9 September 2024

2 hours

Candidates answer on the Question Paper.

No additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, CG and subject tutor's name on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only

You are advised to spend one and a half hour on Section A and half an hour on Section B.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
Section B	
7	
8	
s.f.	
Total	

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1} or $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} Js
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\,\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin\omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos\omega t$
		=	$\pm\,\omega\sqrt{(x_o{}^2 - x^2)}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + ...$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + ...$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	x	=	$x_o \sin\omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$

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Section A

Answer **all** the questions in the spaces provided.

1 The Earth may be assumed to be a uniform sphere of radius 6400 km and mass 6.02×10^{24} kg.

(a) A 50.0 kg boy is standing still on a flat ground located at latitude 35.6° north of the Equator, somewhere in Japan, as shown in Fig 1.1.

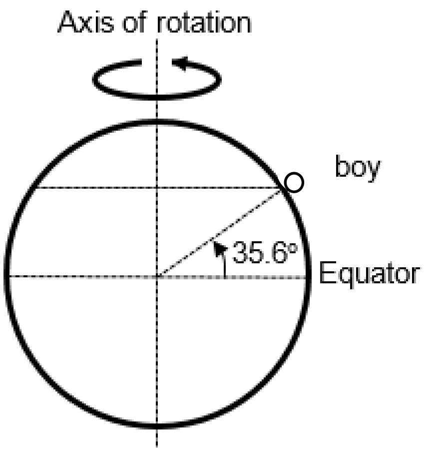

Fig. 1.1

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(i) Draw and label all the forces acting on the boy on Fig. 1.2.

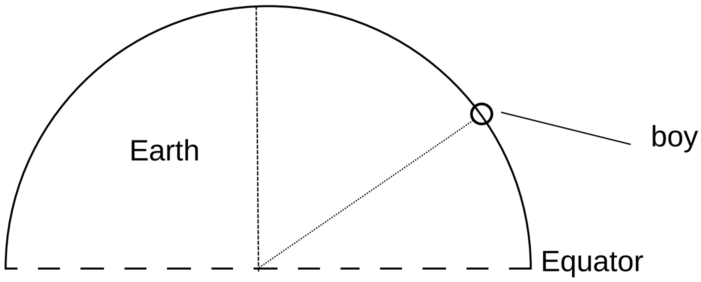

Fig. 1.2

[2]

(ii) The boy now puts a weighing scale under him to read his weight from the scale.

Explain whether there is a difference in the readings on the weighing scale if the boy stands on the same weighing scale at the North pole.

....

....

....

.... [2]

(b) A satellite orbiting the Earth with a period of 24 hours and flew directly above the boy from west to east. The satellite is under the influence of gravitational force alone.

(i) Determine the height of the satellite above the boy.

height = ... m [3]

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(ii) Explain whether it is a geostationary satellite above the boy.

....

....

.... [1]

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2 **(a)** The first law of thermodynamics may be given by the expression

$$\Delta U = Q + W$$

State the meaning of positive values for each of the symbols in this equation.

....

.... [1]

(b) The specific latent heat of vaporization of water at atmospheric pressure of 1.0×10^5 Pa is 2.3×10^6 J kg^{-1}. A mass of 0.37 kg of liquid water at 100 °C is provided with thermal energy needed to vaporize all of the water at atmospheric pressure.

(i) Calculate the thermal energy Q supplied to the water.

Q = ... J [1]

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(ii) The mass of 1 mole of water is 18 g. Assume that water vapour can be considered to behave as an ideal gas.
Show that the volume of water vapour produced is 0.64 m^3. [2]

(iii) Assume that the initial volume of liquid water is negligible compared with the volume of water vapour produced.
Determine the magnitude of the work done by the water in expanding against the atmosphere when it vaporizes.

work done = ... J [2]

(iv) Use your answers in **(b)(i)** and **(b)(iii)** to determine the increase in internal energy of the water when it vaporizes at 100 °C. Explain your reasoning.

Increase in internal energy = ... J [2]

(v) State and explain at the molecular level what contributes to this increase in internal energy of the water when it vaporizes at 100 °C.

....

....

.... [2]

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3 Fig. 3.1 shows a mass-spring system placed on a frictionless slope. The slope has an angle of θ from the horizontal. When a block of mass m is hung, the spring stretches by an extension of e and the mass remains in equilibrium. The spring is further extended by x downwards, along the slope, and released for the mass-spring system to oscillate. The spring constant is k.

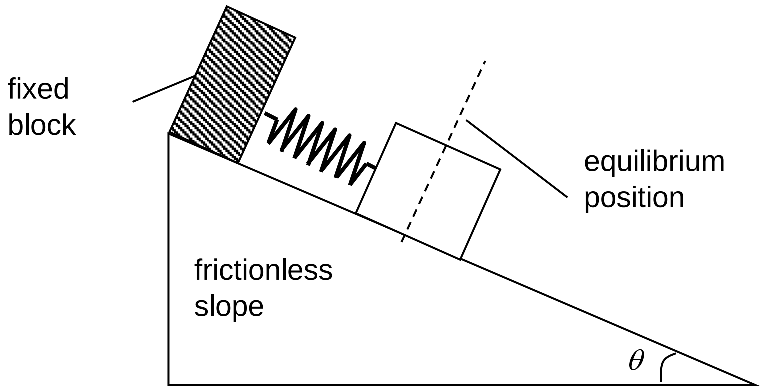

Fig. 3.1

(a) By using Newton's second law, show that the acceleration a of the block at the lowest point is given by $a = -\frac{k}{m}x$.

[2]

(b) The amplitude of oscillation of the mass-spring system is 3.0 cm. Calculate the position of the mass from equilibrium when the speed of the mass is 25 % of the maximum speed.

position = ... cm [2]

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(c) A student removes the fixed block and attaches a variable frequency oscillator to the mass-spring system, as shown in Fig. 3.2.

Fig. 3.3 shows the variation of the amplitude of mass with the frequency of the oscillator.

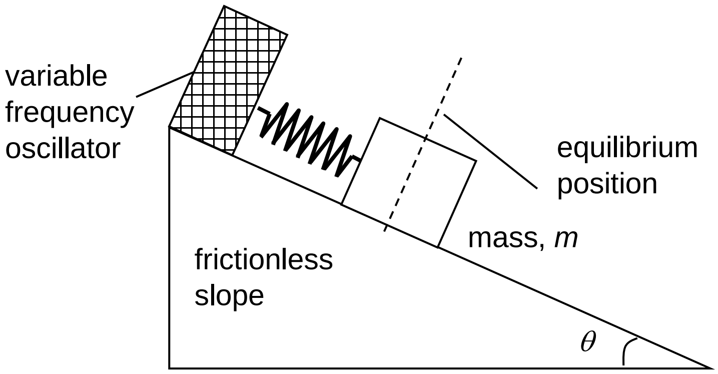

Fig. 3.2

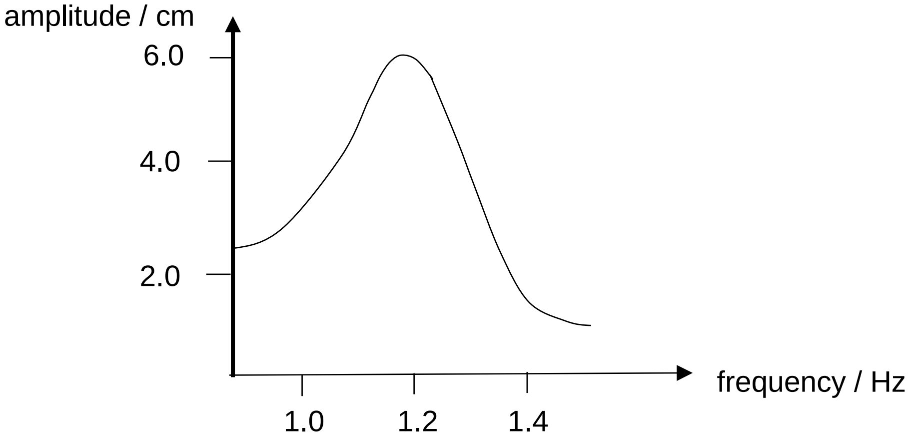

Fig. 3.3

(i) Explain the phenomenon illustrated in Fig. 3.3.

....

....

....

....

.... [2]

(ii) Using Fig. 3.3 calculate the magnitude of maximum acceleration of the mass.

acceleration = ... $m\ s^{-2}$ [2]

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4 **(a)** State Coulomb's law between 2 point charges.

....

....

.... [1]

(b) A positive point charge +*Q* is positioned at a fixed point X and an identical positive point charge is positioned at a fixed point Y, as shown in Fig. 4.1.

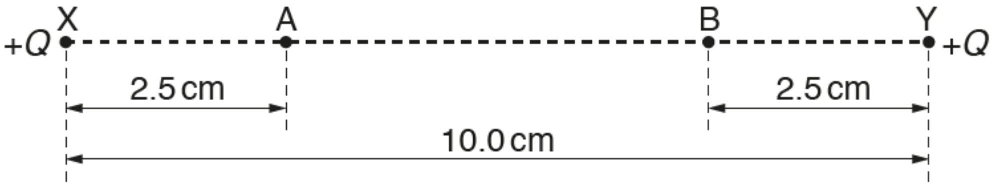

Fig. 4.1

The charges are separated in a vacuum by a distance of 10.0 cm.

Point A and B are on the line XY. Point A is a distance of 2.5 cm from X and point B is at a distance of 2.5 cm from Y. The electric field strength at point A is 4.1×10^{-5} V m^{-1}.

(i) Calculate charge +*Q*.

+*Q* = ... C [3]

(ii) On Fig. 4.2, sketch the variation of the electric field strength E with distance d from A, along the line AB, up to B. [2]

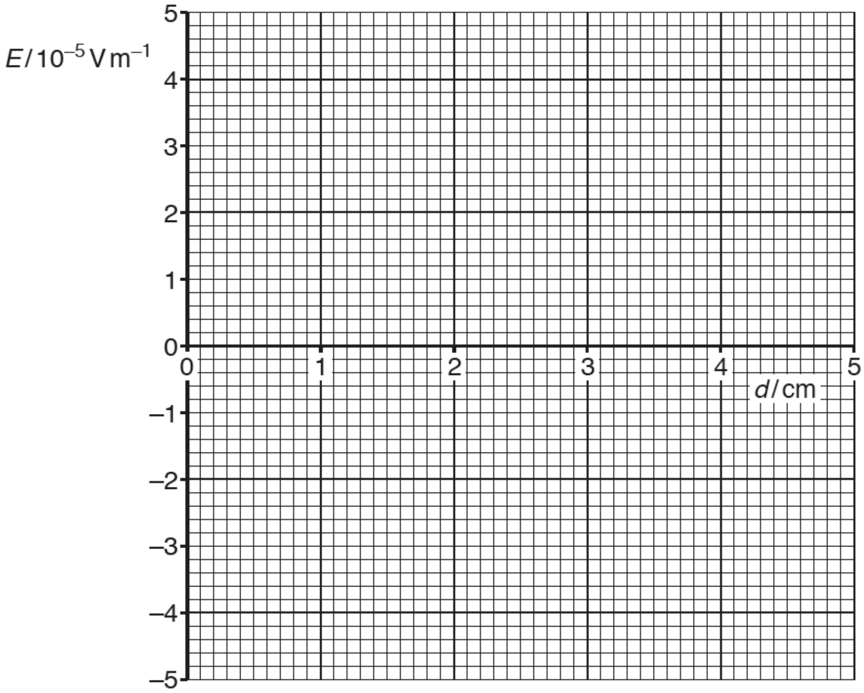

Fig. 4.2

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(iii) What quantity is represented by the area between the line drawn **(b)(ii)** and the d-axis?

.... [1]

(iv) **1.** A small positive charge is placed at A. The electric field causes this charge to move from rest along the line AB.
Describe the acceleration of the charge as it moves from A to B.

....

....

....

.... [2]

2. Hence, state the type of motion it has along the line AB.

.... [1]

5 **(a)** The mean value of an alternating current is zero.
Explain

(i) Why an alternating current gives rise to a heating effect in a resistor,

....

....

.... [2]

(ii) by reference to heating effect, what is meant by the root-mean-square (r.m.s.) value of an alternating current.

....

....

.... [1]

(b) The variation with time t of the output V of an alternating voltage supply of frequency 50 Hz is shown in Fig. 5.1.

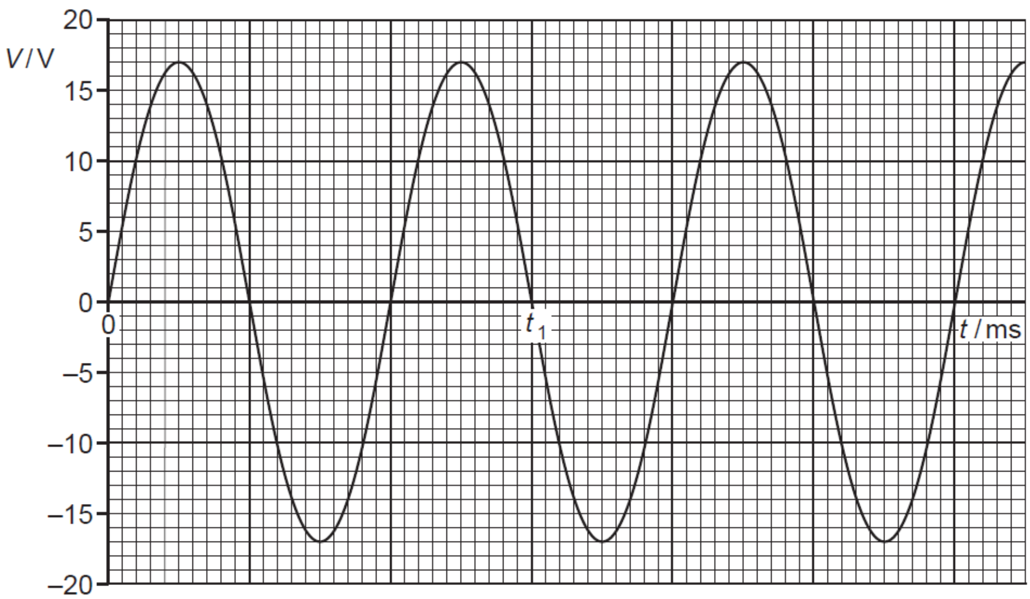

Fig. 5.1

Use Fig. 5.1 to determine

(i) the time t_1 ,

t_1 = ... s [2]

(ii) the root-mean-square voltage V_{rms}

V_{rms} = ... V [2]

(iii) The alternating supply is connected in series with a diode and a load resistor of resistance 2.4 Ω. On Fig. 5.2, sketch the variation with time t of the power P dissipated in the load resistor for time t = 0 to t = 40 ms.
Assume that P = 0 when t = 0. [3]

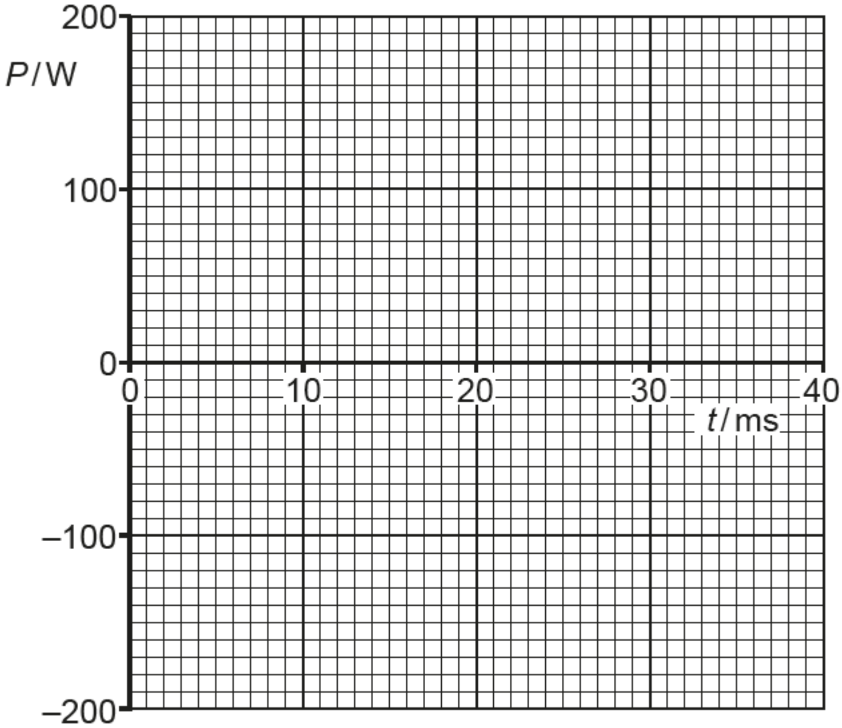

Fig. 5.2

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6 **(a)** Electromagnetic radiation of frequency f is incident on a metal surface. The variation with frequency f of the maximum kinetic energy E_{MAX} of electrons emitted from the surface is shown in Fig. 6.1

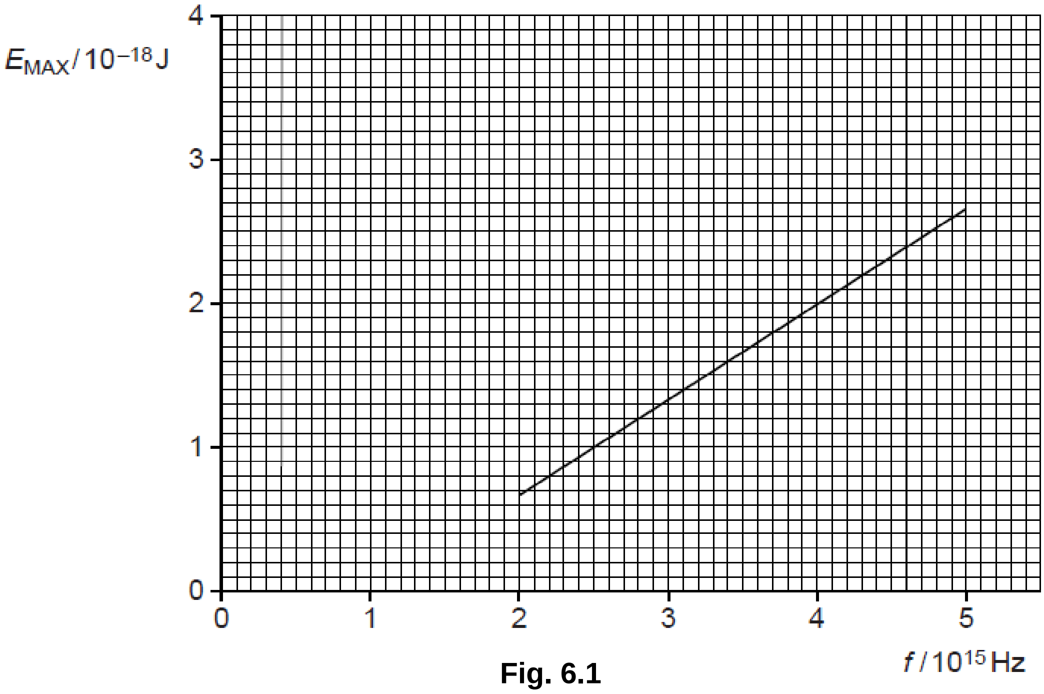

Fig. 6.1

(i) Use Fig. 6.1 to determine the work function energy of the metal surface.

work function energy = ... J [3]

(ii) A second metal has a greater work function energy than that in **(i)**.

On Fig. 6.1, draw a line to show the variation with f of E_{MAX} for this metal. [2]

(iii) Explain why E_{MAX} does not depend on the intensity of the incident radiation.

....

....

.... [2]

(b) Some electron energy levels in atomic hydrogen are illustrated in Fig 6.2.

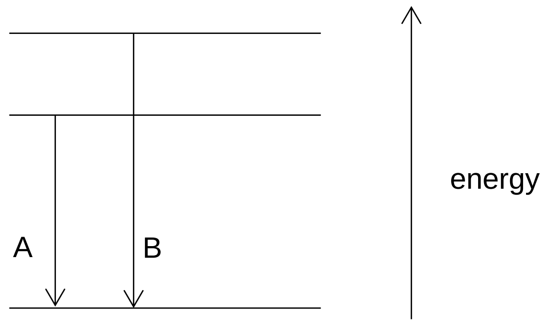

Fig. 6.2

Two possible electron transitions A and B giving rise to an emission spectrum are shown. These electron transitions cause light of wavelengths 654 nm and 488 nm to be emitted.

(i) On Fig 6.2, draw an arrow to show a third possible transition. [1]

(ii) Calculate the wavelength of the emitted light for the transition in part **(i)**.

wavelength = ... m [3]

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(c) The Heisenberg Uncertainty principle for position and momentum can be written as

$$\Delta p \, \Delta x \geq h$$

where Δp is the uncertainty in momentum, Δx is the uncertainty in the position of a particle and h is the Planck constant.

Calculate the percentage uncertainty in its momentum when an electron travelling at 3.00×10^{7} m s^{-1} passes through a narrow slit of width 1.00×10^{-10} m.

percentage uncertainty = ... % [3]

Section B

Answer **one** question from this Section in the spaces provided.

7 A cannon is placed flat on top of a hill. A ball is fired from the stationary cannon at a velocity of 20 m s^{-1} at an angle 50° to the horizontal as shown in Fig. 7.1. The ball lands on a horizontal ground 52 m below the point of projection of cannon on the hill.

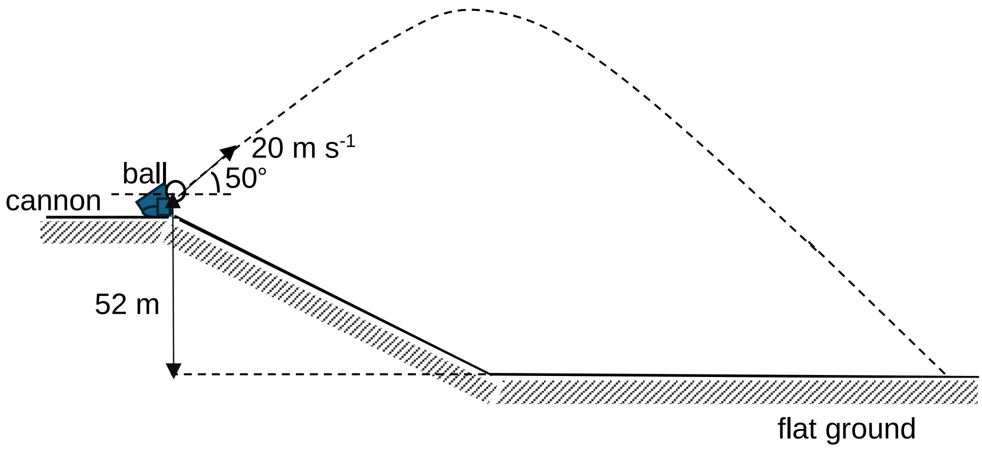

Fig. 7.1

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(a) **(i)** Show that the time taken for the ball to reach the ground after being fired is 5.2 s. Assume air resistance is negligible.

[3]

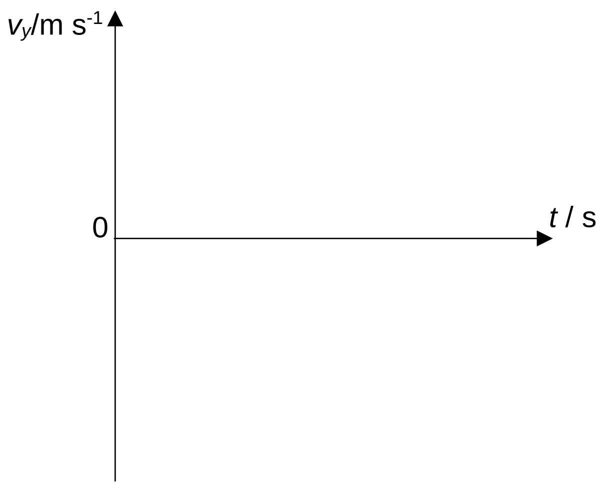
(ii) Hence calculate the horizontal displacement of the ball where it lands.

displacement = ... m [2]

(iii) Determine the vertical component of the ball's velocity just before it hits the ground.

velocity = ... m s^{-1} [2]

(iv) On Fig. 7.2, sketch the variation with time t of the vertical component of the ball's velocity v_y after it has been fired up to the time it reaches the ground at t = 5.2 s. Label in your sketch, the velocity of the ball at the start and at t = 5.2 s, and the point where it reaches maximum height as H. Assume air resistance is negligible.



[2]

Fig. 7.2

(v) Sketch in Fig. 7.2 the variation with time t of velocity v_y if air resistance is **not** negligible. Label your graph **R**. [2]

(b) The total mass of the same ball and the cannon together before it was fired is 1550 kg. Upon the canon being fired, the ball in Fig. 7.1 leaves the cannon within 0.35 s. The cannon can only recoil horizontally with a speed of 0.45 m s^{-1} as the ball leaves.

(i) State the principle of conservation of momentum.

....

.... [1]

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(ii) By considering momentum in horizontal direction, show that the mass of the ball is 52 kg.

mass = ... kg [2]

(iii) Determine whether the firing of the cannon and ball, is an elastic or inelastic collision. Show any calculations if any clearly.

[2]

(iv) Determine the magnitude of the average force on the cannon. Explain your answer clearly.

force = ... N [3]

(v) The vertical momentum of the cannon becomes zero after firing. Explain if this violates the principle of conservation of momentum.

[1]

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8 **(a)** In an α-particle scattering experiment, an α-particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 8.1.

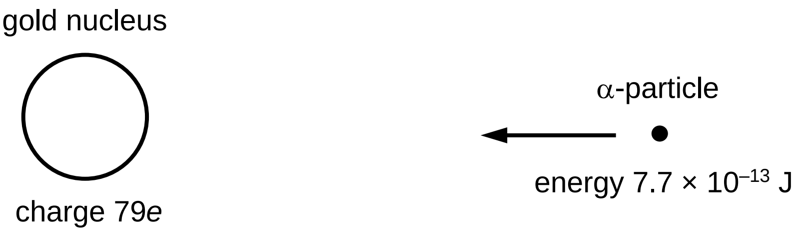

Fig. 8.1

The gold nucleus has a charge 79*e*. At a large distance from the gold nucleus, the α-particle has energy 7.7×10^{-13} J.

(i) The α-particle does not collide with the gold nucleus.

Show that the radius of the gold nucleus must be less than 4.7×10^{-14} m.

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[2]

(ii) Fig. 8.2 shows three α-particles, all with the same kinetic energy and travelling in the same initial direction, as they approach a stationary gold nucleus.
The path followed by one of the α-particles is shown.

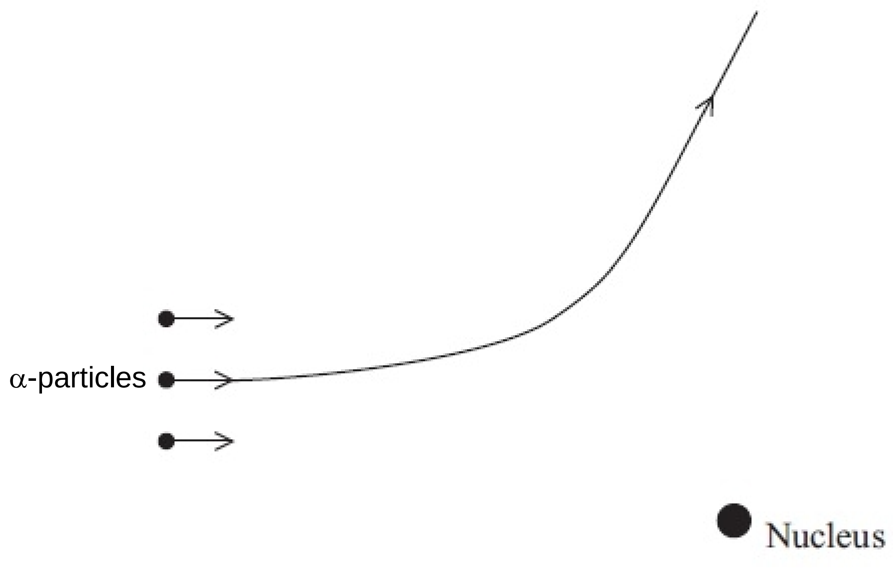

Fig. 8.2 (not to scale)

On Fig. 8.2, complete the paths of the other two α-particles as they approach and pass by the nucleus. [2]

(b) Some data for nuclei are given in Fig. 8.3.

Particle/ Nuclide	**Name**	**Mass / u**	**Binding energy per nucleon / MeV**
$^{1}_{1}H$	Proton	1.00728	-
$^{1}_{0}n$	Neutron	1.00866	-
$^{4}_{2}He$	Helium		7.07470
$^{14}_{7}N$	Nitrogen		7.47724
$^{17}_{8}O$	Oxygen		7.75224

Fig. 8.3

(i) Explain what is meant by *binding energy per nucleon* for the helium nucleus.

....

....

.... [2]

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(ii) Use data from Fig. 8.3 to determine the mass of helium nucleus.

mass = ... u [2]

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(iii) In a particular nuclear reaction, a slow moving alpha particle bombards a stationary nitrogen nucleus ${}^{14}_{7}\text{N}$, transmuting it to an oxygen nucleus ${}^{17}_{8}\text{O}$ and a proton.

The nuclear reaction is shown below.

$$ {}^{14}_{7}\text{N} + {}^{4}_{2}\text{He} \rightarrow {}^{17}_{8}\text{O} + {}^{1}_{1}\text{H} $$

Use data from Fig. 8.3 to determine whether the reaction can occur spontaneously. Explain your working.

[3]

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(c) A radiation detector is placed close to a radioactive source.

The variation with time t of the measured count rate is shown in Fig. 8.4.

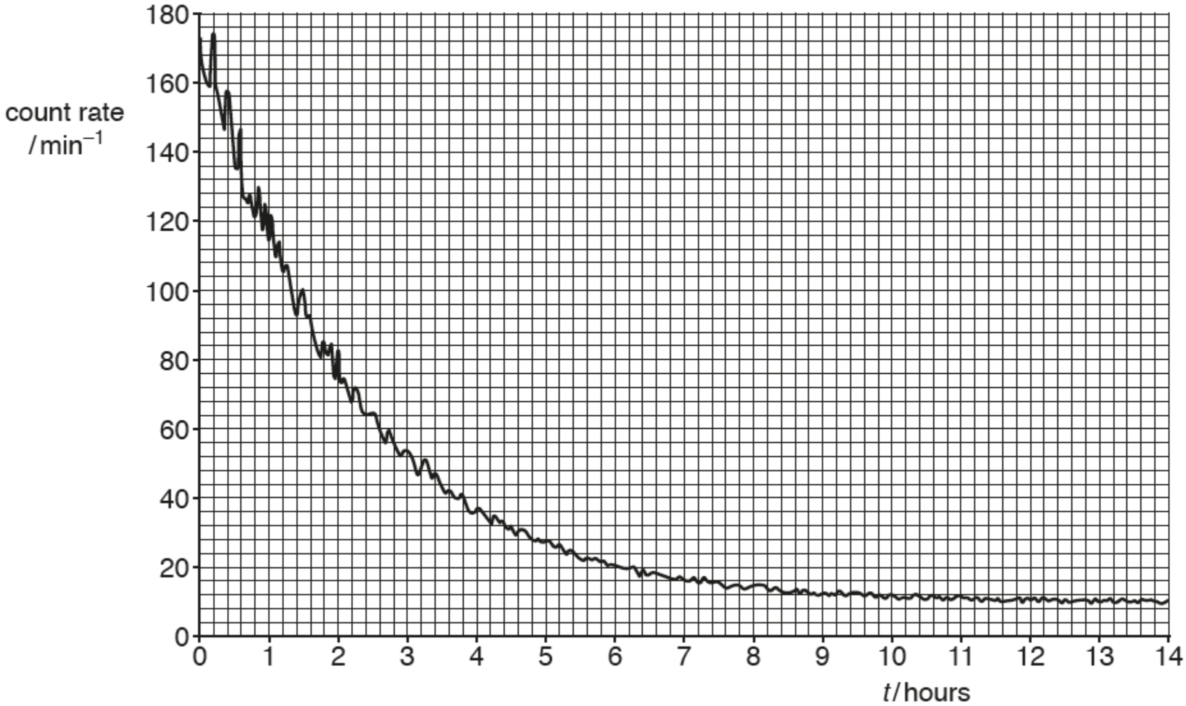

Fig. 8.4

The graph is used to determine the half-life of the radioactive source.

(i) With reference to the graph, explain how we can deal with the problem of the random nature of count rate.

....

.... [1]

(ii) With reference to the graph, explain how we can deal with the problem of background radiation.

....

.... [1]

(iii) Hence use Fig. 8.4 to determine the half-life of the radioactive source.

half-life = ... hours [2]

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(iv) The readings in Fig. 8.4 were obtained at room temperature.

A second sample of this radioactive source is heated to a temperature of 500 °C.
The initial count rate at time $t = 0$ *is* the same as that in Fig. 8.4.
The variation with time t of the measured count rate from the heated source is determined.

State and explain if there are any differences for the 2 samples in

1. the half-life,

....

.... [1]

2. the measured count rate at any time *t*.

....

.... [1]

(d) A small volume of solution containing the radioactive isotope sodium-24 ($^{24}_{11}Na$) has an initial activity of 3.8×10^4 Bq.

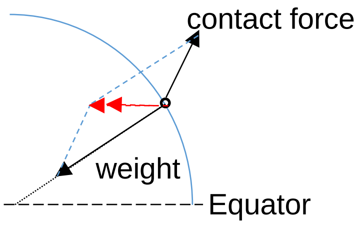
Sodium-24 has a half-life of 15 hours and decays to form a stable daughter isotope.

All of the solution is poured into a container of water. After 36 hours, a sample of water of volume 5.0 cm^3, taken from the container, is found to have an activity of 1.2 Bq.

Assuming that the solution of the radioactive isotope is distributed uniformly throughout the container of water, calculate the volume of water in the container initially.

volume = ... cm^3 [3]

Answers and Marking Scheme

1	**(a)**	**(i)**	 • Weight pointing towards the centre of the Earth • Contact force by ground on person comprises of normal contact force and friction. Accept if normal contact force and friction force are drawn separately. • Resultant force parallel to the plane of equator and pointing towards the axis of rotation. • Wrong labelling -1	B1 B1
		(ii)	• At the poles there is no rotation, hence the centripetal force required is zero. • The weighing scale reads the normal contact force which is equal to the true weight of the boy at the North pole. Thus scale reading is larger than the reading at the current location.	B1 B1
	(b)	**(i)**	Gravitational force provides the centripetal force for circular motion $\frac{GMm}{r^2} = m\omega^2 r = m\left(\frac{4\pi^2}{T^2}\right)r$ $r^3 = GM\frac{T^2}{4\pi^2} = \left(6.67\times10^{-11}\right)\left(6.02\times10^{24}\right)\frac{\left(24\times3600\right)^2}{4\pi^2}$ $r = 4.23\times10^7$ m Height above the boy or surface of Earth (boy's height is negligible) $h = 4.23\times10^7 - 6400\times10^3 = 3.59\times10^7$ m	C1 A1 A1
		(iii)	It is not a geostationary satellite as it does not orbit in the same plane as the equator.	B1

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2	**(a)**	ΔU : Increase in internal energy Q : heat supplied to the system W : Work done on system	B1
	(b)(i)	$Q = ml_v = 0.37 \times 2.3 \times 10^6 = 8.51 \times 10^5$ J	A1
	(b)(ii)	No of moles $n = \frac{M}{M_R} = \frac{370}{18} = 20.6$ Using $PV = nRT$ $\Rightarrow 1.0 \times 10^5 V = 20.6 \times 8.31 \times (273 + 100)$ $\Rightarrow V = 0.64$ m^3	C1 M1 A0
	(b)(iii)	Work done by water = $P\Delta V = 1.0 \times 10^5 \times 0.64$ = 6.4×10^4 J	C1 A1
	(b)(iv)	Work done on water, W = - 6.4×10^4 J By 1st law, $\Delta U = Q + W$ = 8.51×10^5 - 6.4×10^4 = 7.9×10^5 J	C1 A1
	(b)(iv)	Increase in internal energy is due to the increase in potential energy of the molecules when the separation between the molecules increases as it vaporizes. There is no increase in the kinetic energy of the molecules since kinetic energy of molecules is proportional to thermodynamic temperature and there is no change in temperature.	B1 B1

3(a) At equilibrium,

$T_1 = ke = mg\sin\vartheta$

$T - mg\sin\vartheta = ma$ M1

$T - T_1 = ma$ A1

$k(x+e) - ke = ma$ (Newton's Second Law)

Since x is measured downwards from equilibrium, A0

$$a = -\frac{kx}{m}$$

(b)

$v = \pm\omega\sqrt{x_o^2 - x^2}$

$v_o = \omega x_o$

$\frac{v}{v_o} = \frac{\sqrt{x_o^2 - x^2}}{x_o}$ M1

$0.25 = \frac{\sqrt{3^2 - x^2}}{3}$

$x = 2.9$ cm A1

Or

v = $\pm\omega\sqrt{(x_o^2 - x^2)}$ = 0.25 ω x_o

$x_o^2 - x^2 = 0.0625\, x_o^2$

x = 2.9 cm

(c)(i) Resonance is illustrated. The driving frequency of the oscillator is equal to the natural frequency of the mass-spring system, maximum energy is transferred to the system and the mass-spring system oscillates with maximum amplitude. B1 B1

(c)(ii) Magnitude of acceleration = $\omega^2 x_0$

$= [2\pi(1.2)]^2(0.06)$ M1

$= 3.4\ \text{ms}^{-1}$ A1

4 **(a)** It states that the electrostatic force of interaction between 2 point charges is proportional to the product of the 2 charges and inversely proportional to the square of the distance between them. B1

(b)(i)

$$E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$$

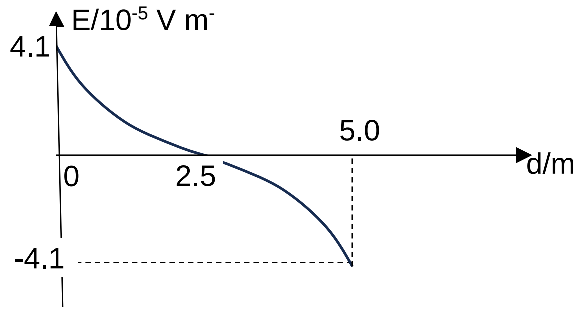
$$E_A = E_X - E_Y \qquad \text{C1}$$

$$4.1\times10^{-5} = \frac{Q}{4\pi\times8.85\times10^{-12}\times0.025^2} - \frac{Q}{4\pi\times8.85\times10^{-12}\times0.075^2} \qquad \text{M1}$$

$\Rightarrow$ Q = 3.2×10^{-18} C A1

(b)(ii) Smooth curve with gradient decreasing starting at (0, 4.1×10^{-5}) to d-axis at (2.5, 0). B1

Smooth curve with gradient increasing from (2.5, 0) ending at (5, - 4.1×10^{-5}). B1



(b)(iii) Change in potential / potential difference between AB B1

(b)(iv) Acceleration decreases to zero at midpoint; B1

1. Then acceleration decreases in the opposite direction/ increasing negative acceleration B1

2. Oscillation / oscillatory motion B1

5 **(a)(i)** Heating effect in a resistor $\propto$ (current)^2 B1

so square of value of alternating current is always positive B1

OR (current moves in opposite direction in resistor during half-cycles. (B1)

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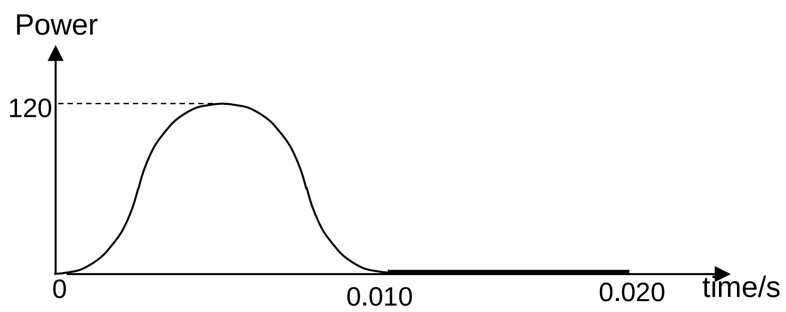
	But heating effect is independent of direction)	(B1)
(a)(ii)	The value of the direct current that produces the same heating effect or power (as the alternating current) in a resistor	B1
(b)(i)	Period $T = \frac{1}{f} = \frac{1}{50} = 0.020$ s	C1
	Hence, t = 0.030 s	A1
(b)(ii)	Peak voltage, $V_o = 17.0$ V	C1
	$V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{17.0}{\sqrt{2}} = 12.0$ V	A1
(b)(iii)	Sine square curve for half a cycle with maximum power of ≈120 W and a horizontal straight line in the 2nd half cycle or vice-versa	
	correct shape	B1
	maximum at ≈120 W	B1
	initial zero gradient for sine square graph	B1



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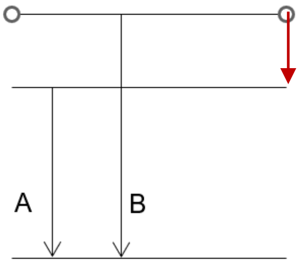
6	**(a)**	**(i)**	threshold frequency = 1.00×10^{15} Hz (allow $\pm 0.05 \times 10^{15}$ Hz)	C1
			work function energy = hf_0	
			$= 6.63 \times 10^{-34} \times 1.00 \times 10^{15}$	C1
			$= 6.63 \times 10^{-19}$ J	A1
		(ii)	straight line with same gradient	M1
			displaced to right	A1
		(iii)	For the same incident frequency and work function,	B1
			intensity determines number of photons arriving per unit time but	
			not the energy of the photon OR	B1
			it affects number of electrons emitted per unit time	
			and not maximum kinetic energy of electrons.	

(b) **(i)** B1 [1]



(ii) $\Delta E = \frac{hc}{\lambda}$

EB = hc/488 x 10^{-9} = 4.07 x 10^{-19}
EA = hc/3.04 x 10^{-9} = 3.04 x 10^{-19} C1
ΔE = 1.03 x 10^{-19} C1

$\lambda = \frac{hc}{\Delta E} = 1.9 \times 10^{-6}$ m A1 [3]

(c) (i) Use $\Delta p\, \Delta x \geq h$
Δp = 6.63 x 10^{-34}/ 1.00 x 10^{-10} = 6.63 × 10^{-24} kg m s^{-1} for electron C1

%Δp/p = (6.63 × 10^{-24}/9.11 × 10^{-31} x 3.00 × 10^{7}) x 100 % = 24.3 % A1

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7(ai)	u_y = 20 sin 50° = 15.3 taking upwards as positive, $s_y = u_y t + ½ gt^2$ -52 = 20 sin 50° t + ½(-9.1)t^2 -52 = 15.3 t – 4.91 t^2 $t = \frac{15.3 \pm \sqrt{15.3^2 - 4 \times 4.91 \times (-52.0)}}{2 \times 4.91}$ = 5.17 s - First B1: vertical component correctly resolved - C1: use of equation for vertical direction. - Second B1: correct substition	[B1] [C1] [B1]
(aii)	Horizontal displacement = 5.17 x 20 cos 50 = 66.5 m	[M1] [A1]
(aiii)	vy = uy + at v_y = 15.3 + (-9.81)(5.17) = -35 .42 = - 35.4	[M1] [A1]

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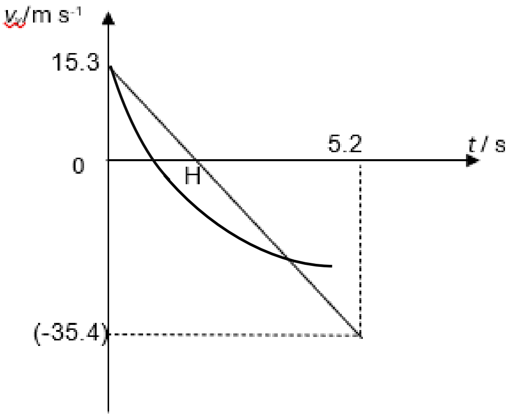
(aiv)	 B1- Straight line with negative gradient B1- correct labels of H and values of vertical velocities (with ECF), area under graph of first triangle smaller.	
(av)	B1: curve with gradient of curve before H steeper than (iv), max height reached at shorter time. B1: curve with gradient less steep than graph of (iv) and area under graph smaller	[B1] [B1]
(bi)	The momentum of a system of objects remains constant if no resultant external force acts on the system.	[B1]
(bii)	0 = (- (1550 – m) 0.45) + m (20 cos 50) 697.5 – 0.45 m = 12.86 m 697.5 =13.31 m m = 52 kg	[M1] [A1]
(biii)	Explanation or evidence of working of total KE before and after. Total KE before firing = 0 Final KE after firing = ½ (52)$(20)^2$ + ½ (1550 -52)$(0.45)^2$ Total KE not conserved Not elastic.	[B1] [B1]
(biv)	On the ball ; <F>t = m∆v <F> = (52) (20-0)/0.35 = 2971 N = 3000 N By Newton's Third Law Force on ball = force on cannon (statement required, otherwise minus 1 mark) = 3000 N	[M1] [M1] [A1]
(c)	No, the vertical momentum of the cannon is transferred to the ground vertically. / there is external force present.	[B1]

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8	**(a) (i)**	$KE_i + PE_i = KE_f + PE_f$ $7.7 \times 10^{-13} + 0 = 0 + \frac{Qq}{4\pi\varepsilon_o r}$ $7.7 \times 10^{-13} = \frac{(79 \times 1.60 \times 10^{-19})(2 \times 1.60 \times 10^{-19})}{4\pi(8.85 \times 10^{-12})r}$ $r = 4.72 \times 10^{-14}$ m Since *r* is the distance of closest approach, the radius of gold must be less than this. Or Loss in KE = Gain in Electric PE	M1 M1 A0
	(a) (ii)	Top particle: smaller deviation (not zero deviation) Bottom particle: bigger deviation 	M1 M1
	(b) (i)	The binding energy per nucleon of the helium nucleus is defined as the <u>average energy per nucleon</u> needed to separate completely the nucleus into <u>its individual 2 protons and 2 neutrons.</u>	B1 B1
	(b) (ii)	BE = (mass defect) c^2 (BE in MeV) x 10^6 x *e* = ($2m_p$ + $2m_n$ – m_{helium}) x *u* x c^2 4 x 7.07470 x 10^6 x *e* = [2 (1.00728 + 1.00866) – m_{helium})] x *u* x c^2 m_{helium} = 4.00157 u	 C1 A1
	(b) (iii)	Total B.E of reactants = 14(7.47724) + 4(7.07470) = 132.980 MeV Total B.E of products = 131.788 MeV Since total B.E of reactants is greater than total B.E of products, this implies energy needs to be supplied for reaction to happen or Comparison of total mass. i.e. Mass of products > Mass of reactants Reaction cannot be spontaneous.	 B1 M1 A1

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	(c) (i)	To deal with the random nature of the count rate, draw a smooth curve to even out the fluctuations.	B1
	(c) (ii)	To deal with the background radiation, at larger timings where the curve tapers off, draw a horizontal line to obtain the background count rate. Then deduct this background count rate from the observed count rate to obtain the actual count rate.	B1
	(c) (iii)	From the graph, background CR ~ 10.0 min^{-1}. CR on graph = 170 min^{-1} , CR due to source only = 170 – 10 = 160 min^{-1}. After $t_{1/2}$, CR on graph CR due to source only = 80 min^{-1}, CR on graph = 80 + 10 = 90 min^{-1} , For CR on graph to reduce from 170 to 90 min^{-1} < $t_{1/2}$ > ~ 1.6 hours	B1 A1
	(c) (iv) 1.	half-life: no change because decay is spontaneous which means it is independent of environment and external factors like temperature.	B1
	(c) (iv) 2.	likely to be different as radioactive decay is random (and cannot be predicted).	B1
	(d)	A = $(3.8 \times 10^4)\, e^{(-\ln 2\,/\,15)(36)}$ = 7200 Bq $A \propto N \propto \text{volume}$ $\frac{A'}{A} = \frac{V'}{V}$ $\frac{1.2}{7200} = \frac{5}{V}$ $V = 3.0 \times 10^4 \text{ m}^3$	C1 C1 A1

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