Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

9476674854

PHYSICS **9702/21**

Paper 2 AS Structured Questions **October/November 2015**

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **15** printed pages and **1** blank page.

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Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{m F}^{-1})$
elementary charge,	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant,	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
acceleration of free fall,	$g = 9.81\ \text{m s}^{-2}$

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Formulae

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

work done on/by a gas, $W = p\Delta V$

gravitational potential, $\phi = -\frac{Gm}{r}$

hydrostatic pressure, $p = \rho gh$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

simple harmonic motion, $a = -\omega^2 x$

velocity of particle in s.h.m., $v = v_0 \cos \omega t$
$v = \pm \omega\sqrt{(x_0^2 - x^2)}$

electric potential, $V = \frac{Q}{4\pi\varepsilon_0 r}$

capacitors in series, $1/C = 1/C_1 + 1/C_2 + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

energy of charged capacitor, $W = \frac{1}{2}QV$

resistors in series, $R = R_1 + R_2 + \ldots$

resistors in parallel, $1/R = 1/R_1 + 1/R_2 + \ldots$

alternating current/voltage, $x = x_0 \sin \omega t$

radioactive decay, $x = x_0 \exp(-\lambda t)$

decay constant, $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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

1 **(a)** State two SI base quantities other than mass, length and time.

1. .....

2. .....
[2]

(b) A beam is clamped at one end and an object X is attached to the other end of the beam, as shown in Fig. 1.1.

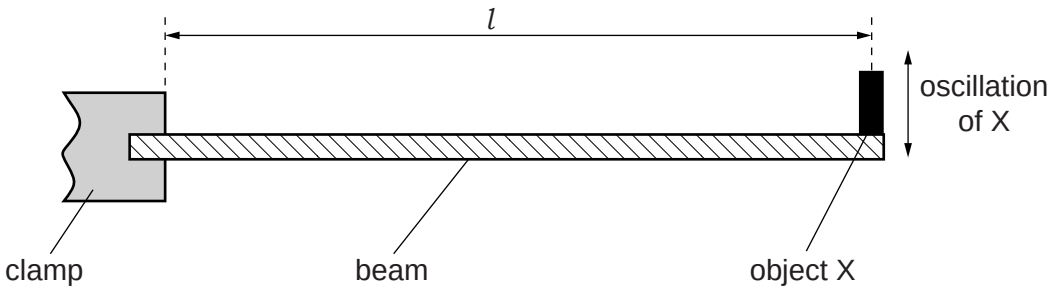


Fig. 1.1

The object X is made to oscillate vertically.

The time period T of the oscillations is given by

$$T = K\sqrt{\frac{Ml^3}{E}}$$

where M is the mass of X,
l is the length between the clamp and X,
E is the Young modulus of the material of the beam
and K is a constant.

(i) **1.** Show that the SI base units of the Young modulus are $kg\,m^{-1}\,s^{-2}$.

[1]

2. Determine the SI base units of K.

SI base units of K ..... [2]

(ii) Data in SI units for the oscillations of X are shown in Fig. 1.2.

quantity	value	uncertainty
T	0.45	± 2.0%
l	0.892	± 0.2%
M	0.2068	± 0.1%
K	1.48×10^5	± 1.5%

Fig. 1.2

Calculate E and its actual uncertainty.

E = ... ± ..... kg m^{-1} s^{-2} [4]

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2 The signal from a microwave detector is recorded on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 2.1.

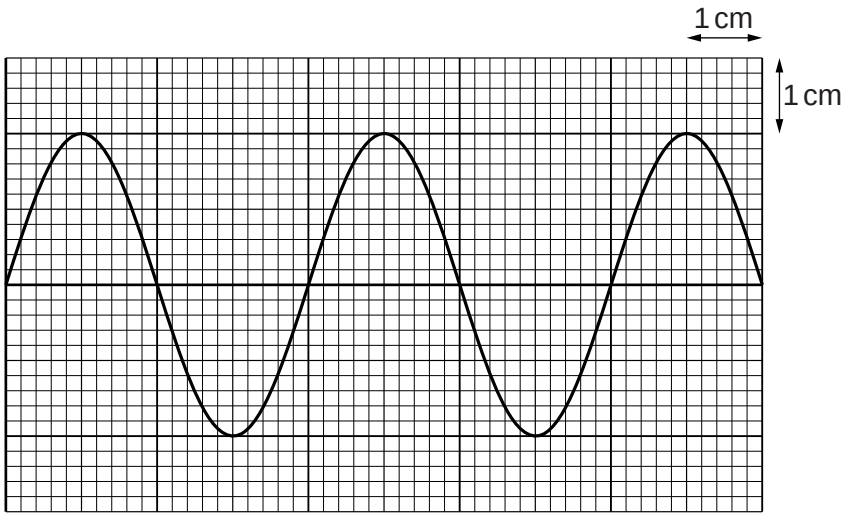


Fig. 2.1

The time-base setting on the c.r.o. is 50 ps cm^{-1}.

(a) Using Fig. 2.1, determine the wavelength of the microwaves.

wavelength = ... m [4]

(b) The signal from a radio wave detector is recorded on the same c.r.o.
The wavelength of the radio waves is 1.5×10^3 m.

Determine the time-base setting required to display the same number of oscillations on the c.r.o. as shown in Fig. 2.1.

time-base setting = ... unit..... [2]

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3 **(a)** An object is moved from point P to point R either by a direct path or by the path P to Q to R, as shown in Fig. 3.1.

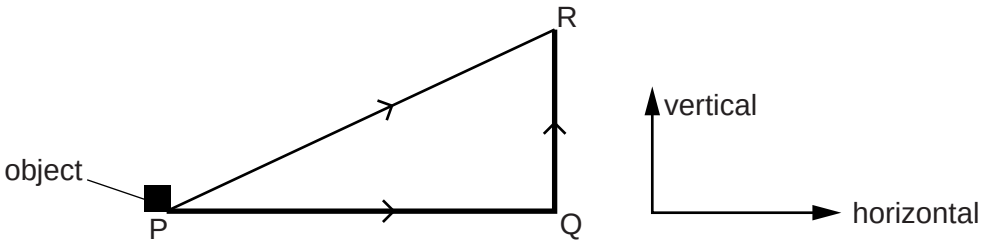


Fig. 3.1

P and Q are on the same horizontal level. R is vertically above Q.

Explain whether the work done moving the object against the gravitational field is the same or different along paths PR and PQR.

.....

.....

.....

.....[2]

(b) A ball is thrown with an initial velocity V at an angle θ to the horizontal, as shown in Fig. 3.2.

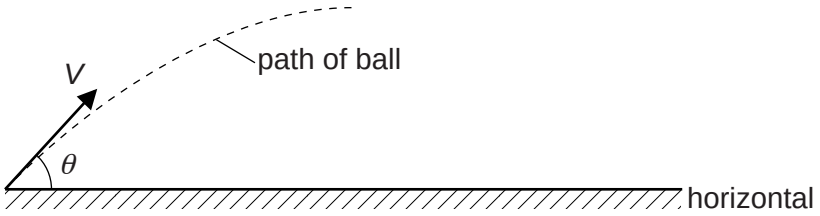


Fig. 3.2 (not to scale)

The variation with time t of the height h of the ball is shown in Fig. 3.3.

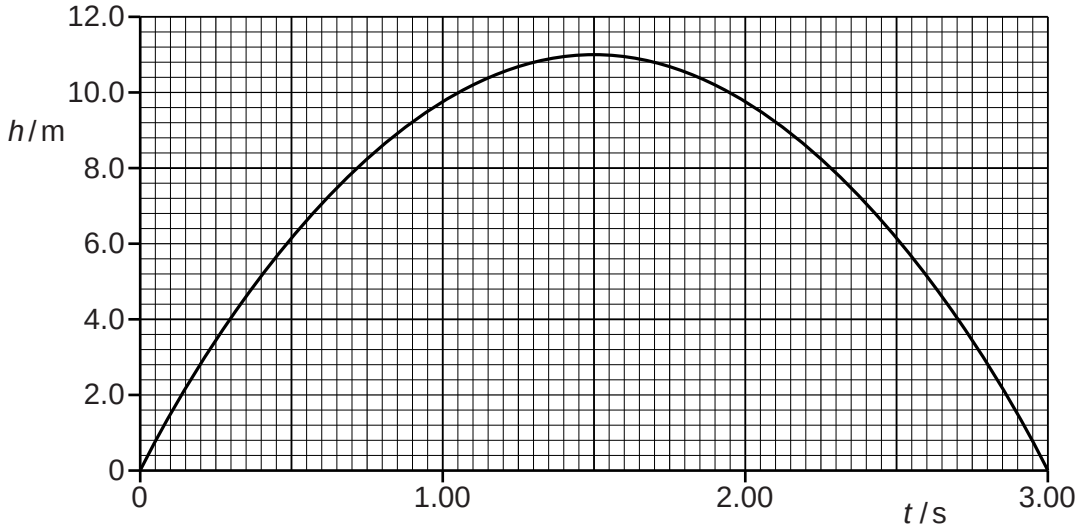


Fig. 3.3

Air resistance is negligible.

(i) Use the time to reach maximum height to determine the vertical component V_v of the velocity of the ball for time $t = 0$.

V_v = ... $m\,s^{-1}$ [2]

(ii) The horizontal displacement of the ball at $t = 3.00\,s$ is $25.5\,m$.
On Fig. 3.4, draw the variation with t of the horizontal displacement x of the ball.

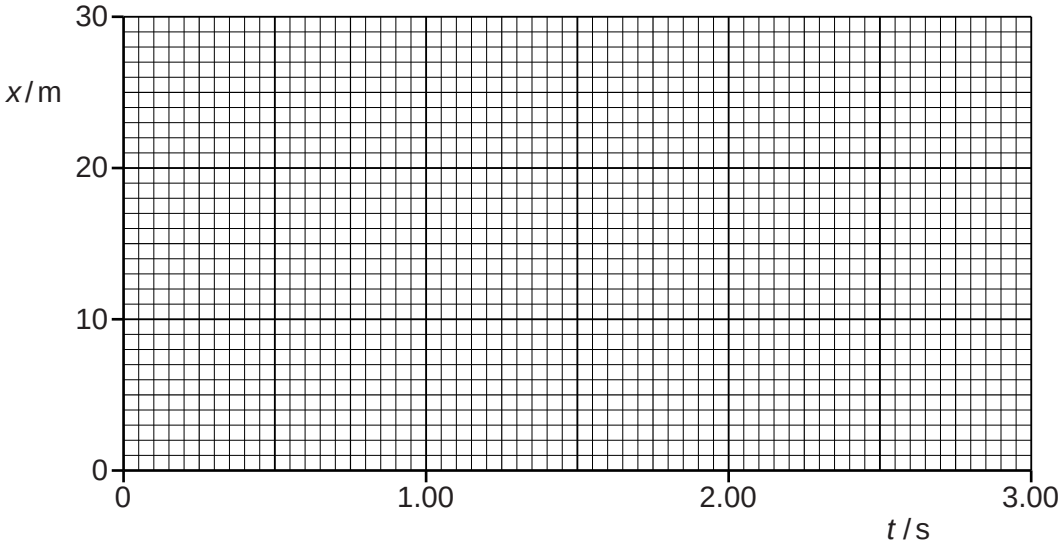


Fig. 3.4

[1]

(iii) For the ball at maximum height, calculate the ratio

$$\frac{\text{potential energy of the ball}}{\text{kinetic energy of the ball}}.$$

ratio = ... [3]

(iv) In practice, air resistance is not negligible. State and explain the effect of air resistance on the time taken for the ball to reach maximum height.

.....

.....

.....

.....[2]

4 Fig. 4.1 shows a metal cylinder of height 4.5 cm and base area 24 cm^2.

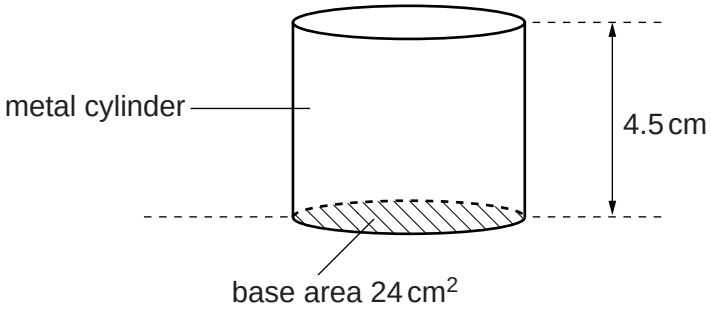


Fig. 4.1

The density of the metal is 7900 kg m^{-3}.

(a) Show that the mass of the cylinder is 0.85 kg.

[2]

(b) The cylinder is placed on a plank, as shown in Fig. 4.2.

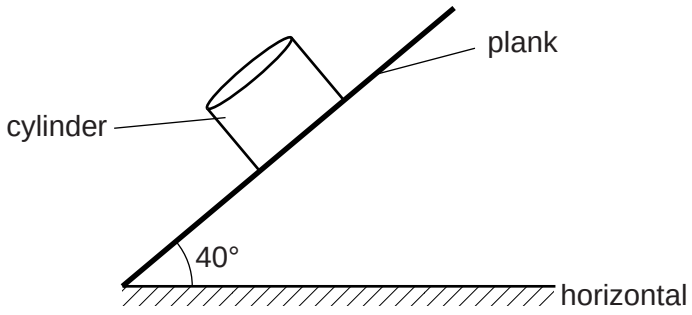


Fig. 4.2

The plank is at an angle of 40° to the horizontal.

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Calculate the pressure on the plank due to the cylinder.

pressure = ... Pa [3]

(c) The cylinder then slides down the plank with a constant acceleration of $3.8\,m\,s^{-2}$.
A constant frictional force f acts on the cylinder.

Calculate the frictional force f.

f = ... N [3]

5 **(a)** A progressive wave transfers energy. A stationary wave does not transfer energy. State two other differences between progressive waves and stationary waves.

1. .....

.....

2. .....

.....

[2]

(b) A stationary wave is formed on a stretched string between two fixed points A and B.
The variation of the displacement y of particles of the string with distance x along the string for the wave at time $t = 0$ is shown on Fig. 5.1.

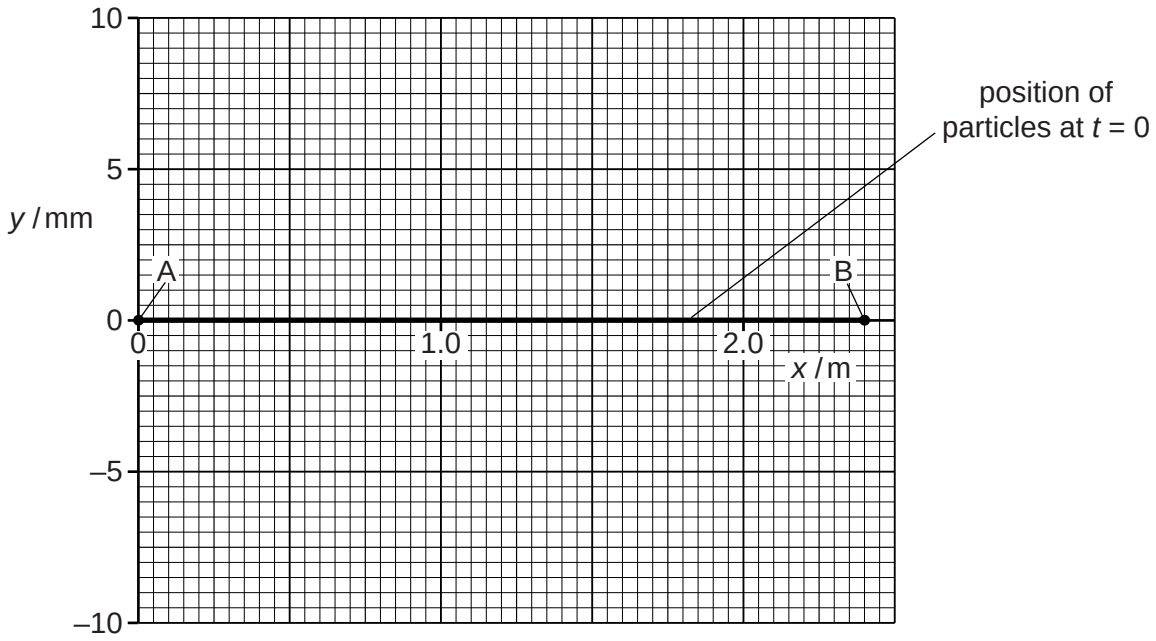


Fig. 5.1

The wave has a period of 20 ms and a wavelength of 1.2 m. The maximum amplitude of the particles of the string is 5.0 mm.

(i) On Fig. 5.1, draw a line to represent the position of the string at $t = 5.0$ ms. [2]

(ii) State the phase difference between the particles of the string at $x = 0.40$ m and at $x = 0.80$ m.

phase difference = ... unit ..... [1]

(iii) State and explain the change in the kinetic energy of a particle at an antinode between $t = 0$ and $t = 5.0$ ms. A numerical value is not required.

.....

.....

.....

.....[2]

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6 **(a)** Define electromotive force (e.m.f.) for a battery.

.....

..... [1]

(b) A battery of e.m.f. 6.0 V and internal resistance 0.50 Ω is connected in series with two resistors X and Y, as shown in Fig. 6.1.

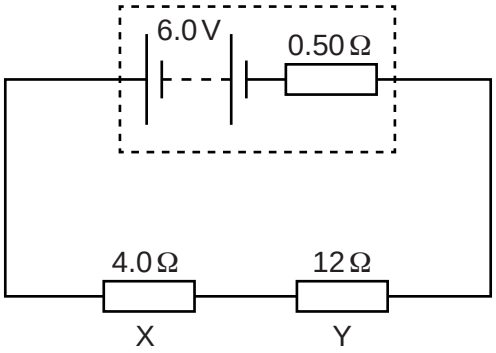


Fig. 6.1

The resistance of X is 4.0 Ω and the resistance of Y is 12 Ω.

Calculate

(i) the current in the circuit,

current = ... A [2]

(ii) the terminal potential difference (p.d.) across the battery.

p.d. = ... V [1]

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(c) A resistor Z is now connected in parallel with resistor Y in the circuit in **(b)**. The new arrangement is shown in Fig. 6.2.

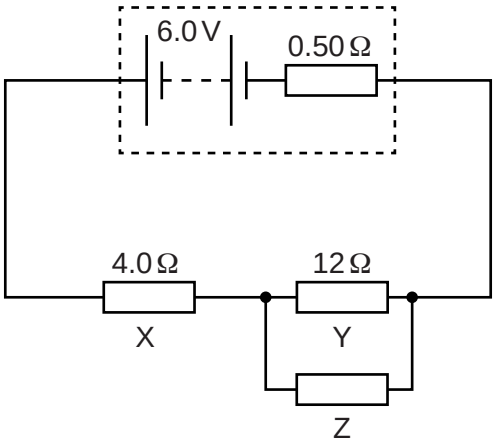


Fig. 6.2

Resistor Y is made from a wire of length l and diameter d. Resistor Z is a wire made from the same material as Y. The length of the wire for Z is $l/2$ and the diameter is $d/2$.

(i) Calculate the resistance R of the combination of resistors Y and Z.

R = ... Ω [3]

(ii) State and explain the effect on the terminal p.d. across the battery.

A numerical value is not required.

.....

.....

.....

..... [2]

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(d) For the circuits given in **(b)** and **(c)**, show that the ratio

$$\frac{\text{power developed in the external circuit in Fig. 6.1}}{\text{power developed in the external circuit in Fig. 6.2}}$$

is approximately 0.8.

[3]

7 Two parallel, vertical metal plates in a vacuum are connected to a power supply and a switch, as shown in Fig. 7.1.

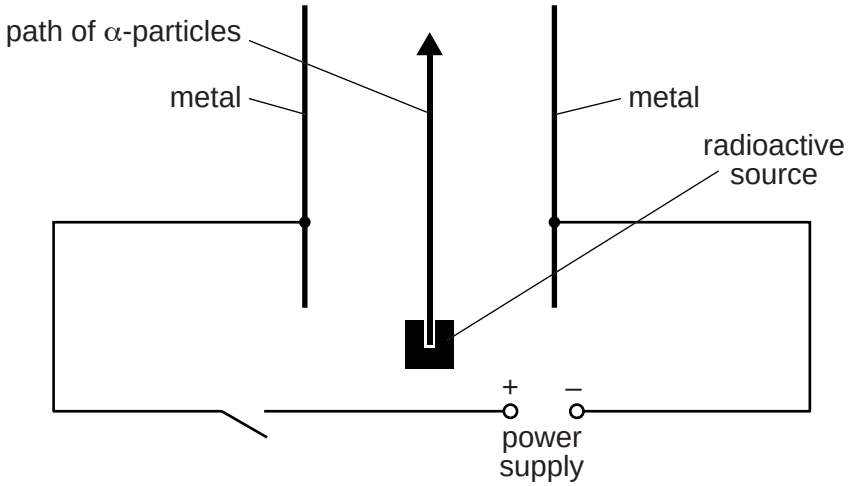


Fig. 7.1

A radioactive source emitting α-particles is placed below the plates. The path of the α-particles is shown on Fig. 7.1. The switch is closed producing a potential difference (p.d.) across the plates. This gives rise to a uniform electric field between the plates.

The separation of the plates is 12 mm.

(a) (i) On Fig. 7.1, draw the path of the α-particles. [1]

(ii) Explain why the metal plates are placed in a vacuum.

.....

..... [1]

(iii) Calculate the p.d. required to produce an electric field of 140 MV m^{-1}.

p.d. = ... MV [2]

(b) The α-particle source is replaced by a β-particle source. By reference to the properties of α-radiation and β-radiation, suggest three possible differences in the deflection observed with β-particles.

1. .....

.....

2. .....

.....

3. .....

.....

[3]

(c) Complete Fig. 7.2 to show the changes in the proton number *Z* and the nucleon number *A* of different radioactive nuclei when either an α-particle or a β-particle is emitted.

emitted particle	change in *Z*	change in *A*
α-particle		
β-particle		

Fig. 7.2

[1]

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