Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Mark Schemes

Q1.

(a) finds d by reading position of (lower end of) detector;
subtracts 138 mm or wtte $_1$✔

for $_1$✔ allow 'reads / measures height of detector' / 'distance from detector to bench';

*reject 'measures height of clamp **T**'*

if 'subtracts 138' is not seen; allow

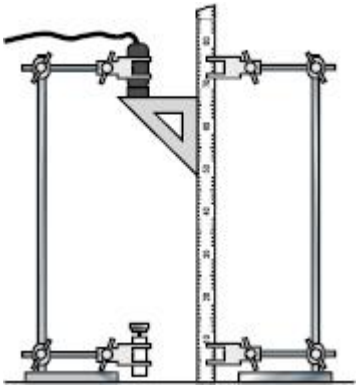
'subtract distance from source to bench' / 'between source and bench' / 'height of source from ground' / 'position of top / open end / mouth of source';

allow 'measures height of the detector and the source and finds difference';

condone 'reversed' subtraction

annotates **Figure 1** to show suitable use of a recognisable set-square $_2$✔

for $_2$✔ expect a <u>triangular</u> 90° set-square in contact with a vertical edge of the ruler, top edge aligned with open end of the detector, eg



condone use of recognisable T-square in contact with vertical edge etc

2

(b) background count rate correct $_1$✔

for $_1$✔ accept any of:

background count rate = 0.7(0) / $\frac{630}{900}\,(s^{-1})$

OR

background count in 100 s = 70

OR

background count in 300 s = 210

1

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working leading to correct Rc_2✔

for $_2$✔ [cao] ≥ 2 sf R_C = 0.33 (s^{-1})

reject R_C = 0.30 if their uncorrected count has been rounded to 1.0

1

(c) attempts two calculations that would lead to a conclusion $_1$✔

for $_1$✔ the result of at least one calculation of $d^2 \times R_C$ or of $d \times \sqrt{R_C}$ must be correct to 2 sf (see table) otherwise withhold both marks;

allow use of d in m but reject POT error;

allow 1 sf $d^2 \times R_C$ for use of R_C = 0.3;

*allow 530^2 × their **(b)** result*

a reasoned judgement that the evidence does not support the prediction $_2$✔

d / mm	380	530	Δ%
R_C / s^{-1}	0.76	0.33	
$d^2 \times R_C$	$1.1(0) \times 10^5$	9.27×10^4	18%
$d \times \sqrt{R_C}$	331 / 330	305 / 310	8.4%

d / mm	380	530	Δ%
R_C / s^{-1}	0.76	0.3 (1 sf)	
$d^2 \times R_C$	$1.1(0) \times 10^5$	$8(.43) \times 10^4$	29%
$d \times \sqrt{R_C}$	331 / 330	$3.(0) \times 10^2$	14%

for $_2$✔ two correct calculations of $d^2 \times R_C$ or $d \times \sqrt{R_C}$, both must be correct to 2 sf

OR

one correct calculation of $d^2 \times R_C$ or of $d \times \sqrt{R_C}$ correct to 2 sf and an appropriate reverse-working calculation;

the statement rejecting the prediction should be supported by a calculation of the percentage difference between the results of their calculations (see Δ% in table);

condone weaker 'large' / 'significant differences' (between calculation results);

reject 'prediction not correct' because 'values are different' / 'not constant' / 'not close enough'

2

(d) lower / adjust the position of the detector / clamp **T**$_1$✔

*for $_1$✔condone 'lower clamp' (this implies clamp **T** since **B** cannot be lowered further)*

*allow 'remove source using tongs while adjusting detector / clamp **T**' otherwise $_2$✘*

1

to maximise distance between the experimenter and the source or wtte

OR

to reduce (limit) exposure (time) of the experimenter to radiation or wtte $_2$✔

for $_2$✔ allow 'not going (too) close (to source)'

reject 'don't touch / make contact with source'

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suggesting using lead shielding is neutral

*allow $_{12}$✔ for 'remove source or wtte using tongs to maximise distance etc before moving **B** upwards'*

*changes to the position of source / clamp **B** without the use of tongs loses both marks*

1

(e) determines $10^a - 10^b$ where a and b are (any) plotted values of log (d / mm) $_1$✔

use of $\Delta d = \frac{10^a - 10^b}{n}$ where n is 1, 2, 3 or 4;

Δd in range 47(.0) to 53(.0) (mm) $_2$✔

insist on a and b ≥ 2 dp; allow read-off errors ± one square;

expect $\frac{10^{2.52} - 10^{2.11}}{4} = 50(.6)\ (\text{mm});$

allow $_{12}$✔for $\frac{e^a - e^b}{n}$ *leading to Δd correct for their values*

$_2$✔is contingent on $_1$✔ie there is no credit for an unsupported answer

2

(f) suitable analysis $_1$✔

for $_1$✔ log R_C = −2 log d + log k seen; minus sign essential

1

appropriate use of **Figure 2** $_2$✔

*for $_2$✔ draw best-fit line **and** measure gradient;*

allow implication that a (linear) best-fit line is drawn and the gradient is being measured, eg 'check gradient of best-fit line';

condone m = gradient

1

processing and conclusion $_3$✔

for $_3$✔ states that the prediction is confirmed if the gradient / m is ≈ −2

OR

*prediction is **not** confirmed if the gradient is ≠ −2*

condone 'the gradient should be −2 (to confirm prediction)'I

*(**no** ECF for m = (+)2 if denied in $_1$✔ for missing − sign)*

*allow $_{123}$✔ prediction is **not** confirmed if the best-fit line is a curve*

reject 'prediction is confirmed if the best-fit line is straight' / 'there is a negative gradient' / 'because 'k is constant'

1

(g) $t_d = 1.96 \times 10^{-4}$ (s) ✔

minimum 2 sf; accept 196 μs;

calculation should be $\frac{102 - 100}{102 \times 100}$ *so only accept*

*2.0 ×10^{-4} (s) / 200 μs only if **rounding up***

($\frac{100 - 98}{100 \times 98}$ *gives t_d = 2.04 ×10^{-4} (s))*

1

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(h) random nature of decay or wtte $_1$✔

for $_1$✔ condone 'the source emits (photons) sporadically' / 'unpredictably';

reject explanation based on exponential decay

reject 'decay occurs by chance' / 'source does not emit photons at a constant rate' / 'photons decay' / 'decay is spontaneous / inconsistent'

1

idea that more than one photon may arrive per 0.01 s interval

OR

idea that no photon may arrive during per 0.01 s interval

OR

photons 'arrive randomly' / 'do not arrive at a steady rate or wtte $_2$✔

$_2$✔ is contingent on $_1$✔

(if no other answer given) allow $_{12}$✔ for:

'only counts 50 since detector still 'dead' at 0.01 s so only 'sees' odd-numbered photons';

use of formula to show R_1 = 50 is neutral

1

[16]

Q2.

(a) Electromagnetic ✔

Reject electrostatic as it is not one of the fundamental forces.

1

(b) Arrow drawn at X in a direction radially away from the centre of the gold nucleus ✔

1

(c) Answer number 5 or 6 plus one consistent justification ✔

First mark must come with at least one justification.

One more consistent justification ✔

List of justifications:
Cannot be 1, 2, or 3 as these s alpha's deflect up. Or must be 5 to 9 as these all alpha's deflect down.

Cannot be 4 as this would backscatter or is scattered at 180^o

Cannot be 7, 8 or 9 as the deflection would be too small. Or must be 2, 3, 5, 6 as these have a greater deflection than alpha1.

The second mark is possible to obtain with two consistent justifications even if the first mark is missed.

E.g. if an answer 7 is given then quoting the first two justifications gains a mark.

2

(d) (Using of potential energy = $\frac{Qq}{4\pi\varepsilon_o r}$

Substituting the values of the two charges multiplied together into an equation

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$(2 \times 1.6 \times 10^{-19})(79 \times 1.6 \times 10^{-19})$✔$_1$

$\text{PE} = \frac{2\times79\times\left(1.6\times10^{-19}\right)^2}{4\pi\times8.9\times10^{-12}\times5.5\times10^{-14}}$ or 6.58×10^{-13} (J) ✓$_2$

$_2$ The substitution may be inferred at the next stage of the calculation that uses

KE = $\frac{1}{2}$ $mv^2 = PE$

(loss of KE = $\frac{1}{2}$ mv^2 = gain in PE}

$$\left(v=\left(\frac{2\times6.58\times10^{-13}}{6.8\times10^{-27}}\right)^{1/2}\right)$$

$v = 1.4 \times 10^7$ (m s^{-1})✔$_3$

3

(e) Using by substitution or rearrangement $R = r_o A^{1/3}$ ✔

$R_{Ag} = 5.7 \times 10^{-15}$ (m) ✔

$$\left(R_{Ag}=R_{Au}\times\left(\frac{A_{Au}}{A_{Ag}}\right)^{1/3}\right)$$

$$\left(R_{Ag}=6.98\times10^{-15}\times\left(\frac{107}{197}\right)^{1/3}\right)$$

The use of the equation must involve both nuclei.

2

(f) Nucleons are incompressible / Nucleons have a constant separation / Neutrons and protons have similar masses / Neutrons and protons have similar volumes ✔

A mark can be given for 'nucleons touch' but it must be implied that this is with all 12 neighbours'.

1

[10]

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