Name of the Student:_____
Max. Marks : 19 Marks **Time : 19 Minutes**

Mark Schemes

Q1.

(a) 9.65 mm ✔

1

(b) close jaws using ratchet without pencil (to find zero error) ✔

Condone "close micrometer fully"

add/subtract zero error from each reading

OR

take multiple readings along pencil or around the pencil and find the mean ✔

2

[3]

Q2.

(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';

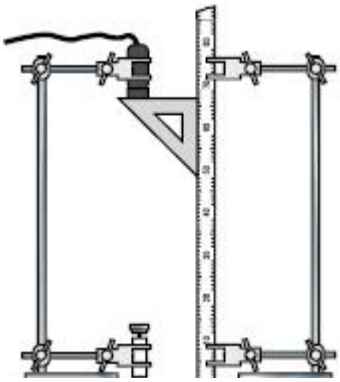
allow 'measures height of the detector and the source and finds difference';

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

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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

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	
$d^2 \times R_C$	$1.1(0)\times10^5$	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)	
$d^2 \times R_C$	$1.1(0)\times10^5$	$8(.43)\times10^4$	29%
$d \times \sqrt{R_C}$	331 / 330	$3.(0)\times10^2$	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*

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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 ∆% 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 $\mathbf{T}_1$✔

*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'

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';

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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)'l
*(**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 ×10^{-4} (s) ✔

minimum 2 sf; accept 196 μs;
calculation should be $\frac{102-100}{102\times100}$ *so only accept*
*2.0 ×10^{-4} (s) / 200 μs only if **rounding up***
($\frac{100-98}{100\times98}$ *gives t_d = 2.04 ×10^{-4} (s))*

1

(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]

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