Examiner only

Data Analysis Task

A student investigates whether the measured count rate due to a radioactive source follows an inverse square relationship with distance of the detector from the source.

(a) Describe another physical example where an inverse square relationship is followed. [1]

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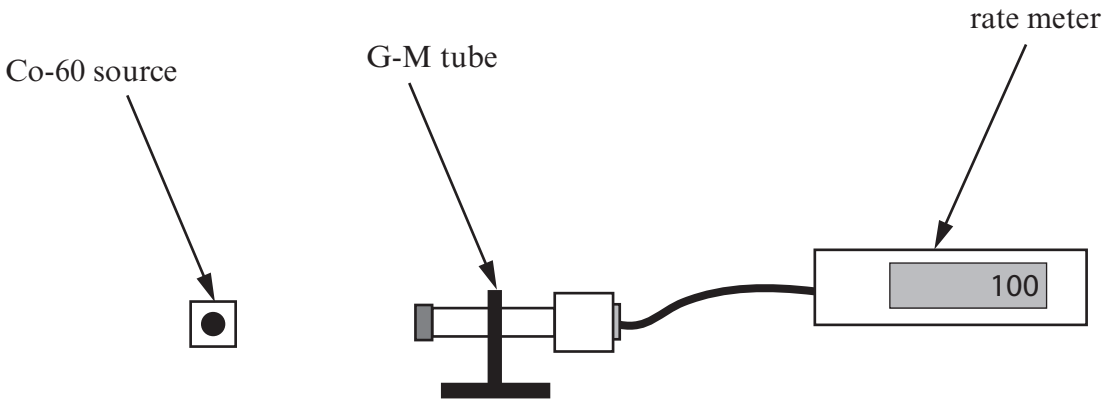
(b) The student uses a cobalt-60 source and a Geiger-Muller tube to measure the count rate due to the source.



(i) Describe **one** safety precaution when using radioactive sources. [1]

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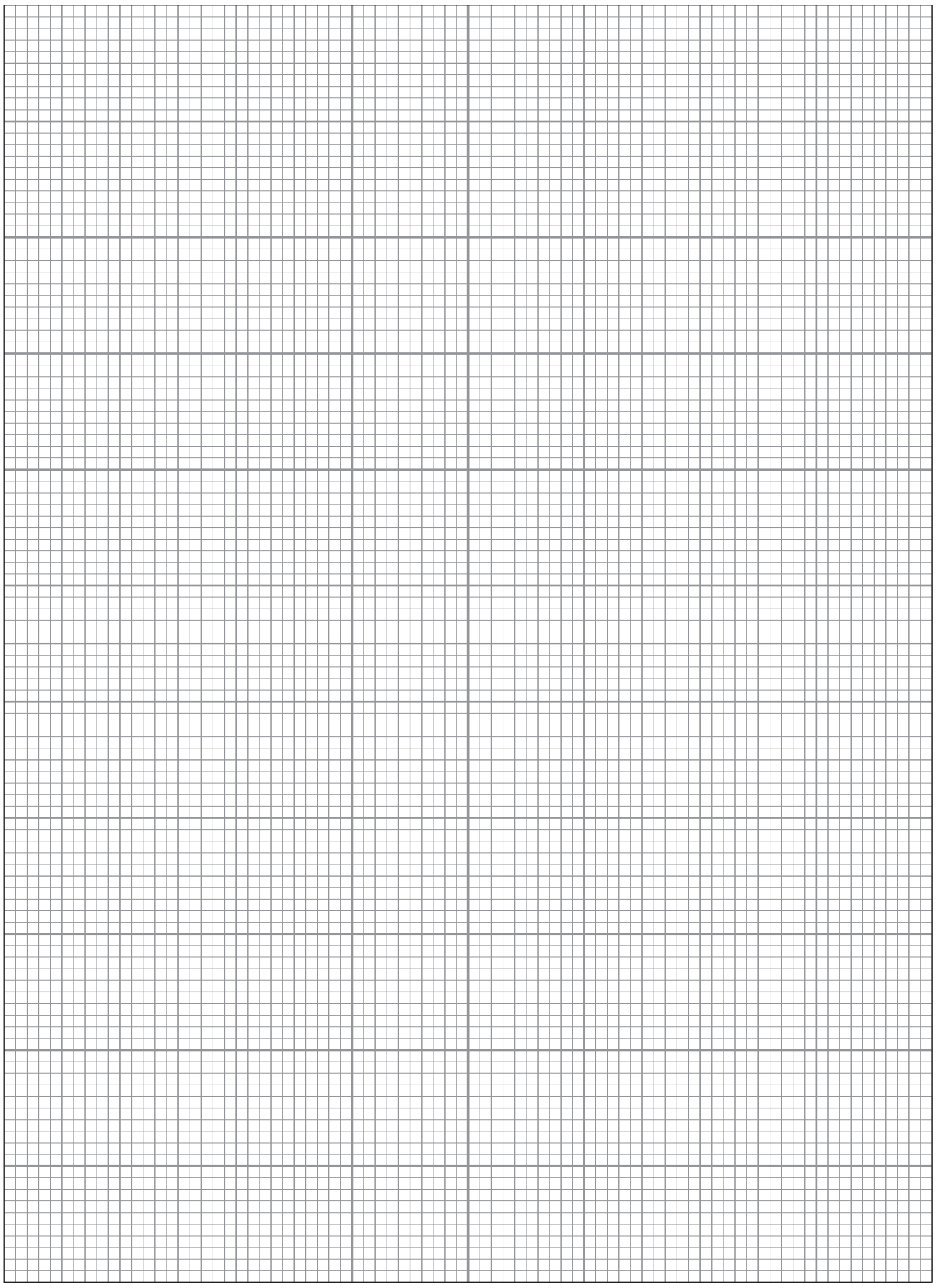
(ii) The following table shows the count rate of the source at various distances as measured by the student.

Distance *(d)*/mm	Count rate/Bq	$1/d^2$ ( )
13	215 ± 8	
17	125 ± 6	
20	94 ± 5	
25	59 ± 4	
30	44 ± 3	
50	19 ± 2	

Complete the third column including the correct unit. [3]

(c) Plot a graph of count rate *(vertical axis)* against 1/distance^2 *(horizontal axis)* including count rate error bars. Draw the steepest and least steep lines of fit through the data. [5]



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(d) (i) Calculate the maximum and minimum gradients for your graph. [3]

(ii) Calculate the mean gradient and its uncertainty. [2]

(e) (i) Calculate the mean value of the intercept along with its uncertainty. Express these values to appropriate significant figures. [2]

(ii) The intercept on the count rate axis is the value of background radiation. Explain why this is so. [2]

(f) Explain whether or not the data are consistent with the suggestion that the count rate is inversely proportional to the square of the distance. [4]

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(g) Using your gradient and intercept values, write an equation linking count rate to distance. [2]

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Data analysis task

Marking Scheme

(a) Any suitable example given e.g. gravitational force, light [or em radiation] from star. [1]

(b) (i) Any sensible and practical precaution e.g. use tongs to handle source, source pointed away from body/limit exposure/shielding [not goggles only] [1]

(ii) Table:

Distance (d)/mm	Count rate/Bq	1/distance^2 (mm^{-2} or m^{-2})
13	215 ± 8	0.0059 (5900)
17	125 ± 6	0.0035 (3500)
20	94 ± 5	0.0025 (2500)
25	59 ± 4	0.0016 (1600)
30	44 ± 3	0.0011 (1100)
50	19 ± 2	0.00040 (400)

Correct values in table (1)
2 significant figures used [allow 1sf in bottom cell] (1)
Unit mm^{-2} or m^{-2} (1)
[NB The unit used must be consistent with the values, e.g. mm^{-2} with 5900 in the first box loses the unit mark] [3]

(c) Graph
Titles and units (ecf) on both axes and correctly orientated graph (1)
Sensible scales (over half page used to plot the points, not multiples of 3) (1)
All points plotted correctly to within ½ division (1)
All error bars plotted correctly (1)
Lines of steepest fit and least steep fit consistent with data (not ~ parallel lines) (1) [5]

(d) Gradient

(i) Large triangles used (should be close to the extremities of the lines) or 2 suitable widely separated points on each graph (1)
Both gradients calculated correctly (ignore unit and significant figures) (1 + 1)
[allow e.c.f. for incorrect lines] [3]

(ii) Mean gradient correct (1)
Uncertainty correct (1) [2]

(e) Intercept

(i) Values of intercept correct from graph (1)
Mean intercept expressed to 2-3 significant figures correct (1) [2]

N.B. 1. Zero marks if both candidate's lines drawn through origin.
2. If lines have identical intercept 1 mark max.

(ii) This arises from background radiation [sources] (1)

When distance = ∞ / very large $\left[\frac{1}{d} = 0 \text{ or } \frac{1}{d^2} = 0\right]$ there is a non-zero count rate (1)

[NB for the second mark, the link of background radiation to the intercept must be clear] [2]

(f) Discussion of agreement with inverse-square law:

No agreement [accept: No!] (1)
Straight line (1)
not through origin i.e. reason (1)
If background count rate subtracted then yes! (1)
[NB The 4th marking point implies the 1st marking point] [4]

(g) $C = \frac{m}{d^2}$ with correct value for m [e.c.f.] inserted → 1 mark
$C = \frac{m}{d^2}$ + c with correct values of m and c [e.c.f.] inserted → 2 marks [2]

NB. Accept numerical equation, i.e. units need not be used in the equation.

Illustrative graphs

Specimen graphs illustrating some of the marking points in *(c)-(e)* will be placed on the secure website on Friday 18 March, p.m.