GCE PHYSICS

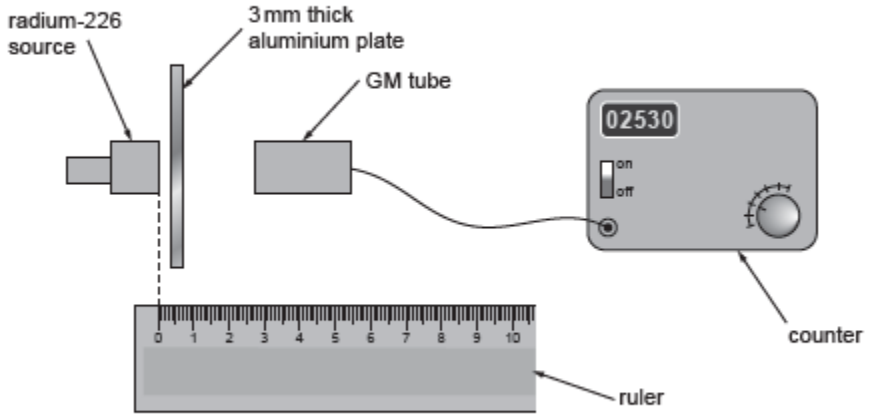
S21-A420QS

Assessment Resource number 26

Light and Nuclei Resource H

1

Bronwen carries out an experiment to investigate the relationship between count rate and distance from a gamma emitting radioactive source (radium-226).

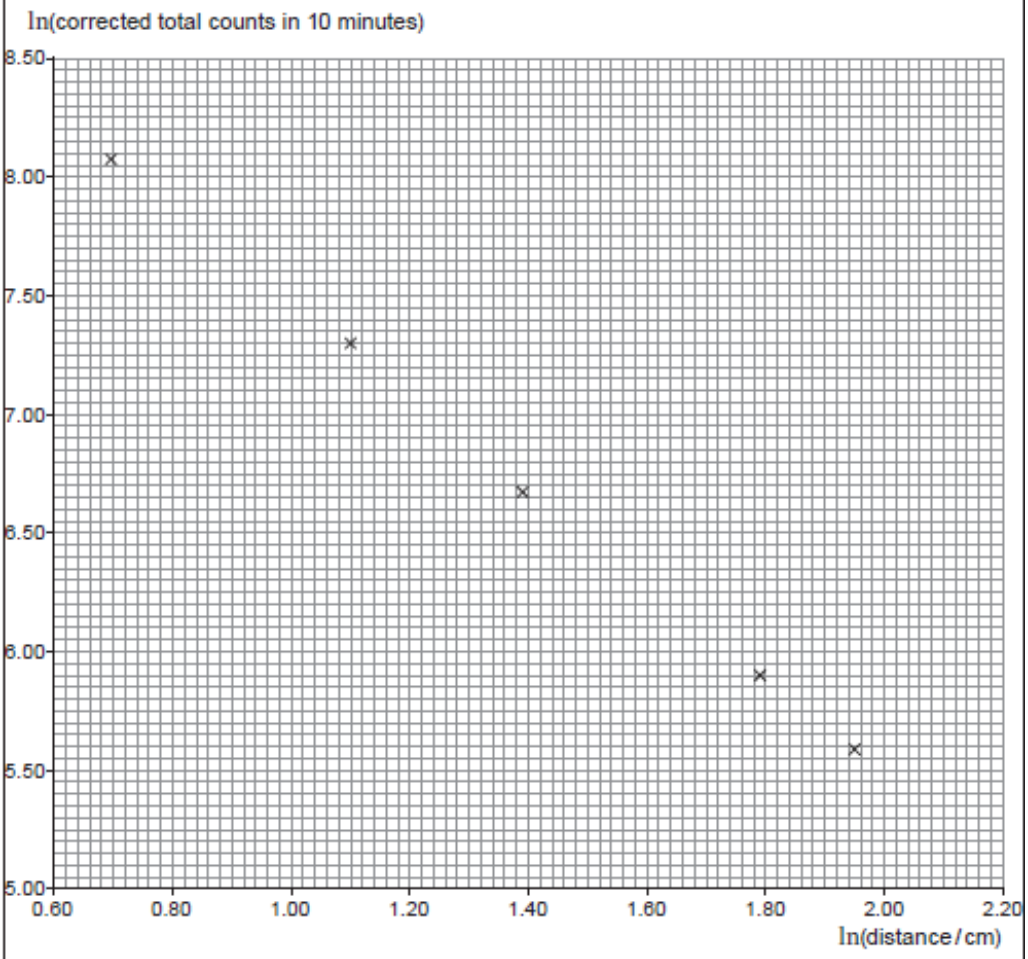


Her results are shown in the table.

Distance / cm	Total counts in 10 minutes	ln(distance / cm)	ln(corrected total counts in 10 minutes) **{corrected for background radiation}**
2.0	3 466	0.69	8.08
3.0	1 697	1.10	7.28
4.0	1 028	1.39	6.67
5.0	762	.....	.....
6.0	609	1.79	5.91
7.0	507	1.95	5.59
8.0	447	.....	.....

(a) (i) **The background radiation is 0.40 counts per second. Complete the table.** [3]
Space for calculations.

(ii) **Complete the graph** by plotting the two missing data points. [1]



(iii) Draw a line of best fit and calculate its gradient. [3]

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(iv) Theory suggests that:

$$\text{count rate} \propto \frac{1}{\text{distance}^2}$$

I. Show that the gradient of the graph should be –2. [2]

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II. Explain to what extent the results obtained in this experiment agree with theory. [3]

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(b) Radium-226 also emits other radiation. Suggest a reason for using a 3 mm aluminium plate between the source and the GM tube. [1]

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(c) In 1896, G. Brandes reported that large intensities of high energy X-rays produced a "blue-grey" glow within the eye. This was later confirmed by Willhelm Röntgen and other scientists. The mechanism for this "blue-grey" glow is still not fully understood. Discuss the ethics of reproducing this experiment to understand it better. [3]

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2 Discuss the make-up and properties of the following particles e^-, e^+, n, $\overline{p}$, π^-. [6 QER]

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3

(a) The bismuth isotope ($^{209}_{83}$Bi) decays by alpha decay to an isotope of thallium (Tl). Fill in the missing numbers for this decay. [2]

$$^{209}_{83}\text{Bi} \longrightarrow \text{.....}^{\text{.....}}_{\text{.....}}\text{Tl} + \text{.....}^{\text{.....}}_{\text{.....}}\text{He}$$

(b) Determine whether or not a kinetic energy of 3.6 MeV for the alpha particle in the above reaction is consistent with the data in the table below (you may assume that the kinetic energies of the bismuth and thallium nuclei are negligible). [5]

Nuclear mass of thallium isotope	204.9300 u
Nuclear mass of alpha particle	4.0015 u
Binding energy per nucleon of $^{209}_{83}$Bi nucleus	7.87 MeV / nucleon
Mass of proton, m_p	1.0073 u
Mass of neutron, m_n	1.0087 u
Energy equivalent of 1 u	931 MeV

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(c) (i) The half-life of $^{209}_{83}\text{Bi}$ is 1.9×10^{19} year. Calculate the activity of 1.00 gram of $^{209}_{83}\text{Bi}$. [4]

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(ii) Determine the number of nuclei in 1.00 gram of $^{209}_{83}\text{Bi}$ which will decay in 5 years. [2]

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4

(a) (i) A long solenoid has 12 000 turns per metre and carries a current of 3.8 A. Calculate the magnetic flux density at its centre. [1]

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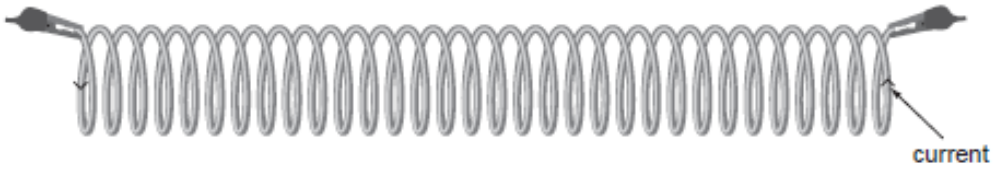
(ii) **Sketch the magnetic field lines** due to this long solenoid. [2]



(iii) State how the strength of the magnetic field produced by **this solenoid** can be increased greatly without increasing the current or changing the dimensions of the solenoid. [1]

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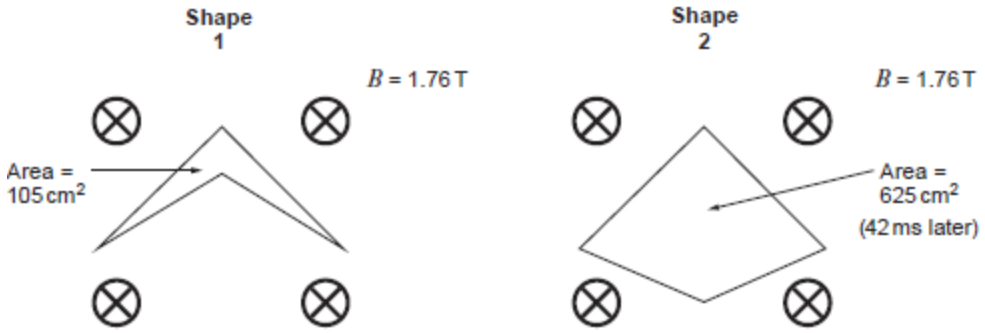
(b) Maria carries out an experiment inside an extremely large magnetic field of uniform density 1.76 T. She uses a copper wire and deforms it from shape 1 to shape 2 in a time of 42 ms.



(i) Explain why a large current flows in the copper wire during this deformation. [3]

(ii) Explain how you can deduce that this current flows anticlockwise. [2]

(iii) Calculate the mean current flowing in the copper wire given that its resistance is $6.75 \times 10^{-3}\,\Omega$. [3]

(iv) Halfway through the deformation of the copper wire it is in the position shown below. Maria claims that in this position, a "motor effect" force of approximately 200 N will act upwards on the length of copper wire shown. Determine whether or not Maria is correct. [3]