Oxford Cambridge and RSA

A level Physics A

H556/03 Unified physics

Question Set 14

1

$^{60}_{27}Co$ is produced by irradiating the stable isotope $^{59}_{27}Co$ with neutrons.

Each nucleus of $^{60}_{27}Co$ then decays into a nucleus of nickel (Ni) by the emission of a low energy beta-minus particle, one other particle and two gamma photons.

(a) Complete the nuclear equations for these two processes.

$$^{59}_{27}Co + {}^{\cdots\cdots}_{\cdots\cdots}n \longrightarrow {}^{60}_{27}Co \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}Ni + {}^{\cdots\cdots}_{\cdots\cdots}e + \cdots\cdots + 2\gamma$$ **[3]**

(b) Students want to carry out an investigation into gamma photon absorption using a source of $^{60}_{27}Co$.

They add sheets of lead between the source **S** and a radiation detector **T**, to give a total thickness *d* of lead. **S** and **T** remain in fixed positions, as shown in Fig. 2.1.

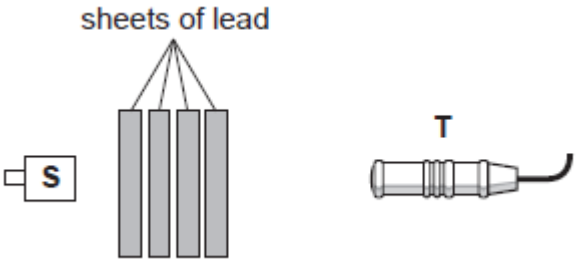

Fig. 2.1

(i) The $^{60}_{27}Co$ source emits beta radiation as well as gamma radiation.

Explain why this would not affect the experiment.

[1]

(ii) The students record the number N of gamma photons detected by **T** in 10 minutes for each different thickness d of lead. The background count is negligible.

The results are shown in a table. The table includes values of ln N, including the absolute uncertainties.

N	d / mm	ln N
4300 ± 440	0	8.37 ± 0.10
2500 ± 250	10	7.82 ± 0.10
1400 ± 150	20	7.24 ± 0.11
800 ± 90	30	6.68 ± 0.11
500 ± 60	40	6.21 ± 0.12
300 ± 40	50	

N and d are related by the equation $N = N_0 e^{-\mu d}$ where N_0 and μ are constants.

1. The students decide to plot a graph of ln N against d.

Show that this should give a straight line with gradient = $-\mu$ and y-intercept = ln N_0.

[1]

2. Complete the missing value of ln N in the table, including the absolute uncertainty.

Show your calculation of the absolute uncertainty in the space below.

[2]

3. I

3. In Fig. 2.2, five of the data points have been plotted, including error bars for ln *N*.
   - Plot the missing data point and error bar.
   - Draw a straight line of best fit and one of worst fit. **[2]**

Fig.

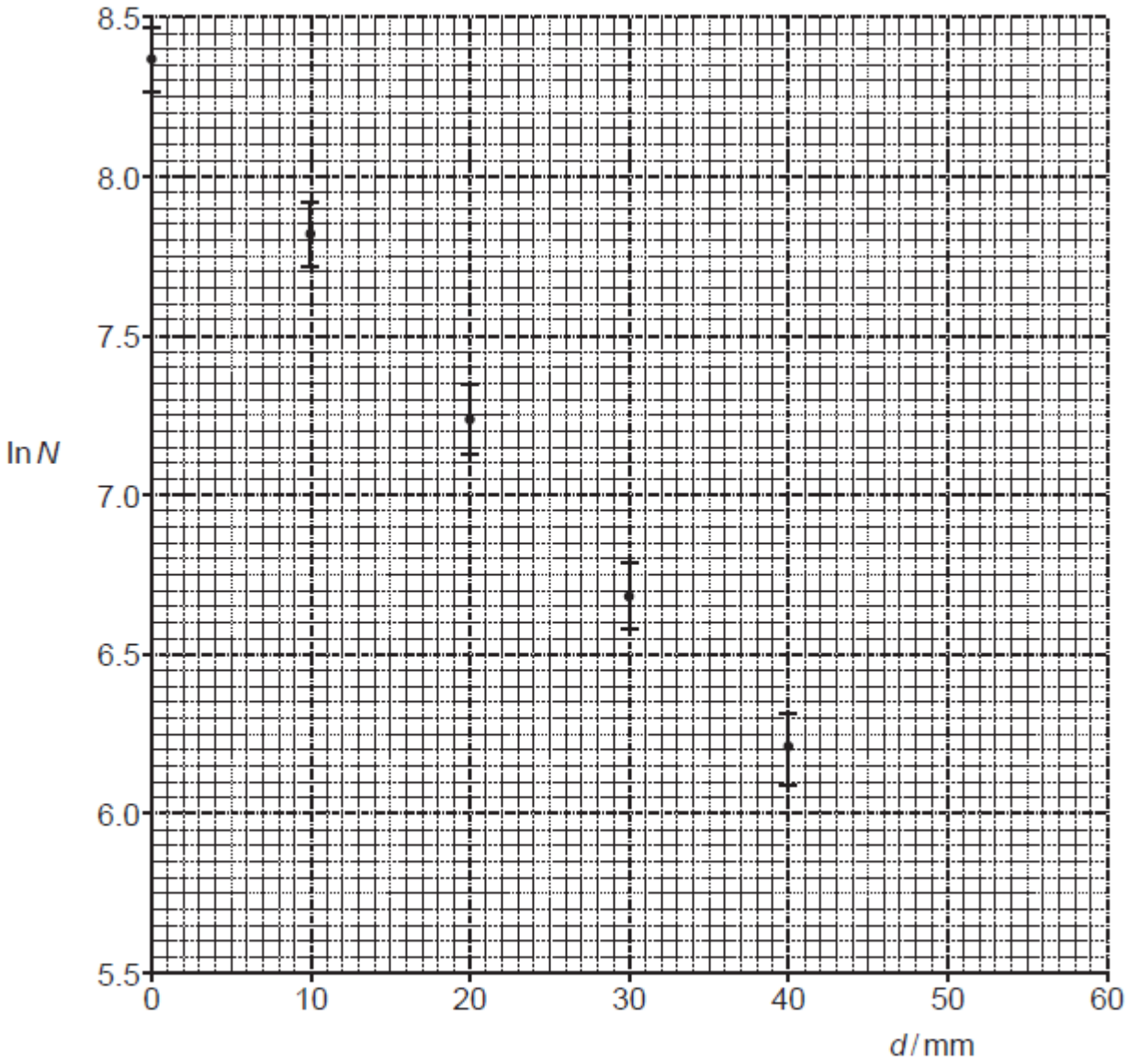

Fig. 2.2

4. Use Fig. 2.2 to determine the value of μ in m^{-1}, including the absolute uncertainty.

μ = ... ± ..... m^{-1} **[4]**

5. Determine the thickness, $d_{½}$, of lead which halves the number of gamma photons reaching **T**.

$d_{½}$ = ... m **[2]**

Total Marks for Question Set 14: 15

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