8 Among the 2500 known *nuclides*, fewer than 300 are stable. Most of them are unstable and will decay to form other nuclides by emitting particles and electromagnetic radiation. The time scale of these processes can range from a small fraction of a microsecond to billions of years. This is due to different nuclides having different *decay constants*.

The measurements of the *activity* from a sample of radioactive substance are given in Fig. 8.1.

time elapsed, t / h	activity, A / s^{-1}	$\log_{10} (A$ / s$^{-1})$
0	7500	3.8751
0.5	4120	3.6149
1.0	2570	3.4099
1.5	1790	3.2529
2.0	1350	3.1303
2.5	1070	3.0294
3.0	872	2.941
4.0	596	2.776
5.0	414	2.617
6.0	288	2.459
7.0	201	2.303
8.0	140	2.146
9.0	98	
10.0	68	
12.0	33	

Fig. 8.1

(a) Define the terms that have been italicised in the passage above.

(i) *nuclides*

…………………………………………………………………………………………………

…………………………………………………………………………………….. [1]

(ii) *activity*

…………………………………………………………………………………………………

…………………………………………………………………………………….. [1]

(iii) *decay constant*

....

.... [1]

(b) **(i)** Complete Fig. 8.1 for t = 9.0 h, 10.0 h and 12.0 h. [2]

(ii) Fig. 8.2 is a graph of some of the data of Fig. 8.1.
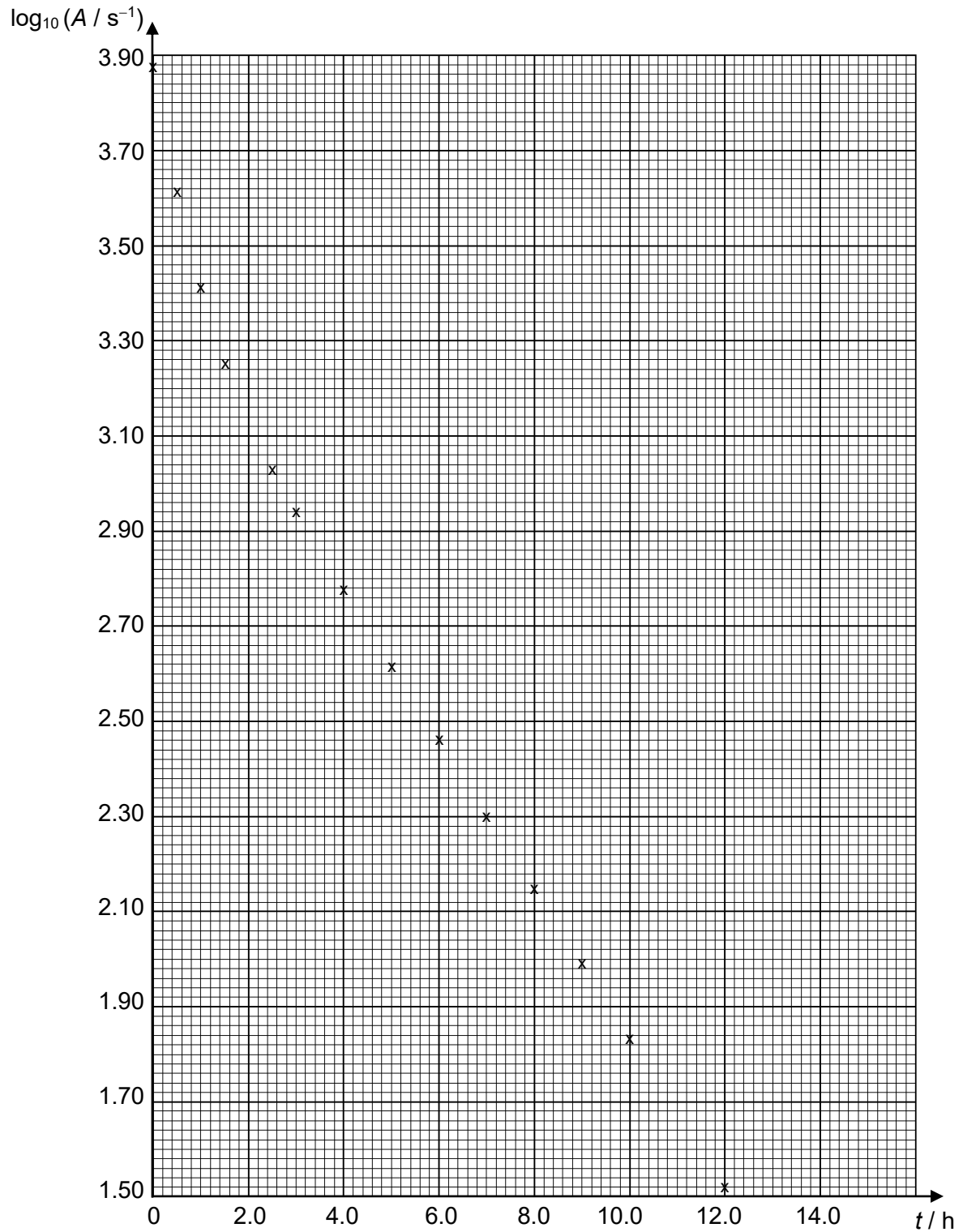
Fig. 8.2

On Fig. 8.2,

1. plot the point corresponding to t = 2.0 h, and

2. draw a line of best fit for the points from t = 4.0 h to 12.0 h and label it R.

[2]

(iii) Suggest the significance of the fact that the trend of the points does not give a straight line with constant gradient.

……………………………………………………………………………………

………………………………………………………………………….. [1]

(iv) Determine the gradient of the line R drawn in Fig. 8.2 and provide the appropriate units.

gradient = ……………………   [2]

(v) Hence explain what the gradient of R found in **(b)(iv)** represents.

………………………………………………………………………….. [1]
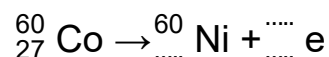
(c) **(i)** Explain why food are sometimes irradiated by exposing them to radioactive substances like cobalt-60 purposefully.

……………………………………………………………………………………

………………………………………………………………………….. [1]

(ii) Cobalt-60 decays via beta decay into stable nickel-60 and releases gamma rays in the process.

Complete the nuclear equation for the reaction

$$^{60}_{27}\text{Co} \rightarrow\ ^{60}_{....}\text{Ni} +\ ^{....}_{....}\text{e}$$

(iii) Radioactive samples like those used in **(c)(i)** have shelf-lives. Just after it has been manufactured in a nuclear reactor, the activity of a sample of cobalt-60 is 50000 Ci. When its activity falls below 35000 Ci, it is considered too weak a source to be used.

One such sample was manufactured on 16th September 2014, it is now 16th September 2019.

Given that 1 Ci = 3.7 × 10¹⁰ Bq and that the half-life of cobalt-60 is 5.271 years, explain quantitatively whether the source is still usable.

………………………………………………………………………………………

………………………………………………………………………………….. [3]

(iv) Determine the initial mass of a sample of cobalt-60.

mass = ……………………… g   [4]

END OF PAPER