Radioactivity – 2019 Nov IGCSE

1. 0625/31/O/N/19/No.12

A teacher carries out two experiments at the same time.

(a) In the first experiment the count rate for a sample of a radioactive isotope is measured every 30 seconds for 6 minutes.

The results are shown in Table 12.1.

Table 12.1

time / minutes	count rate counts / second
0.0	1246
0.5	1036
1.0	941
1.5	810
2.0	686
2.5	621
3.0	550
3.5	468
4.0	421
4.5	368
5.0	318
5.5	280
6.0	242

Estimate the half-life of the radioactive isotope. Use the information in the table.

half-life = ... minutes [1]

(b) In the second experiment the teacher repeats the procedure with another sample of the same radioactive isotope. The mass of the second sample is greater than that of the first sample.

Suggest a value for the count rate for this sample at the start of the experiment.

count rate = ...counts / second [1]

(c) One type of particle emitted during radioactive decay is an α-particle (alpha particle).

Describe:

(i) the nature of an α-particle

..... [1]

(ii) the ionising ability of an α-particle

..... [1]

(iii) the penetrating ability of an α-particle.

..... [1]

[Total: 5]

2. 0625/32/O/N/19/No.12

A radioactive substance decays by emitting an α-particle.

(a) The nuclide notation for an α-particle is

$$^{4}_{2}\alpha$$

(i) State the term given to the number 4, written in the nuclide notation.

..... [1]

(ii) State the term given to the number 2, written in the nuclide notation.

..... [1]

(b) Fig. 12.1 shows the decay curve for a radioactive material.

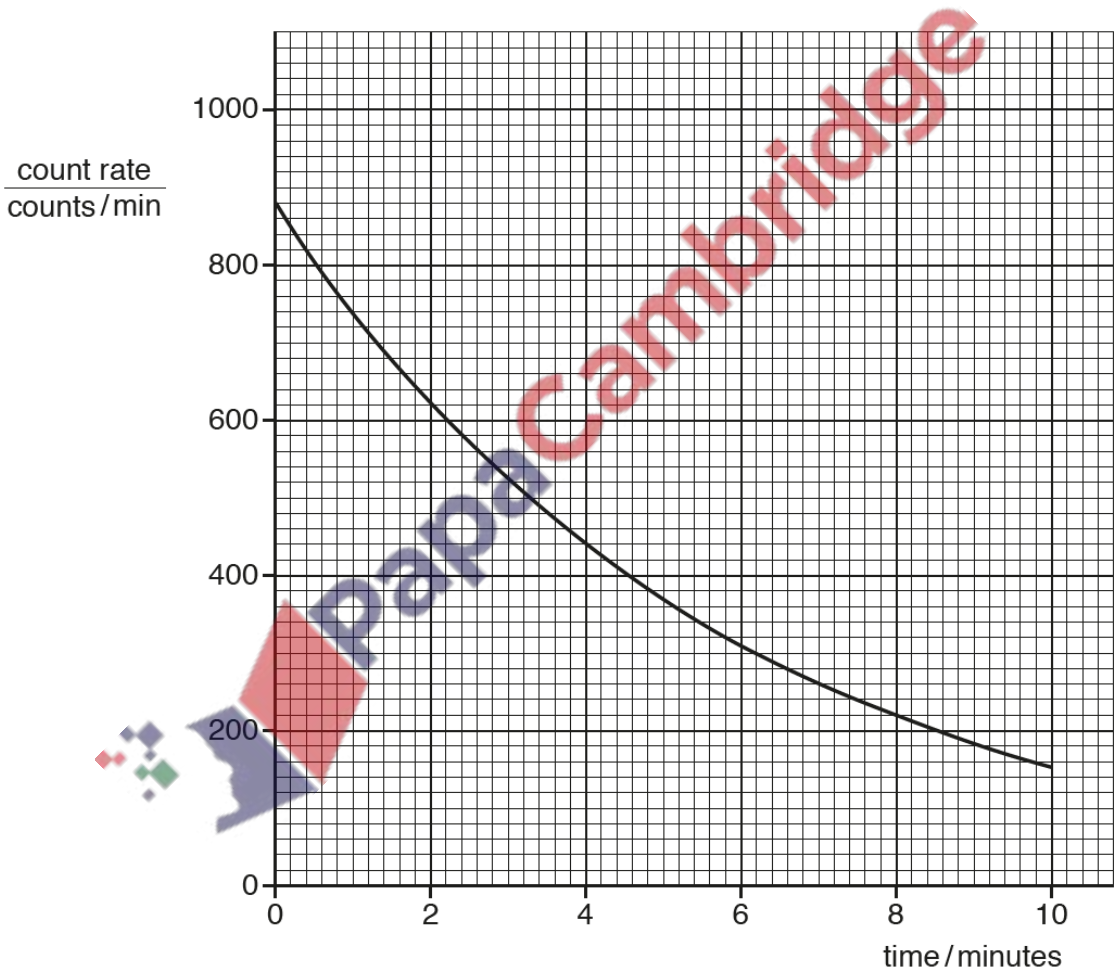

Fig. 12.1

(i) Use information from the graph in Fig. 12.1 to determine the half-life of the material. Clearly show how you used the graph to obtain your answer.

half-life = ... minutes [3]

(ii) Another radioactive material with the same half-life has an initial count rate of 600 counts/min. On Fig. 12.1 sketch the decay curve for this material. [1]

[Total: 6]

3. 0625/33/O/N/19/No.12

Fig. 12.1 shows the nuclide notation for three isotopes of an element.

$$\begin{matrix} {}^{1}_{1}\mathrm{X} & {}^{2}_{1}\mathrm{Y} & {}^{3}_{1}\mathrm{Z} \end{matrix}$$

Fig. 12.1

(a) **(i)** Describe how the nuclide notation shows that each isotope is of the same element.

.....

..... [1]

(ii) Describe how the nuclide notation shows the differences between the isotopes.

.....

..... [1]

(b) Radioactive sources emit radiation when they decay. State the names of **three** types of radioactive emission.

1 .....

2 .....

3 .....

[2]

(c) Radioactive emissions have differing characteristics. One characteristic is their ionising effect.

Complete the statement about ionisation, using words from the box. The words can be used once, more than once or not at all.

electrons	**negatively**	**neutrons**	**positively**	**neutrally**	**protons**

When atoms are ionised,

..... may be removed, leaving ..... charged atoms (ions), or

..... may be gained, forming ..... charged atoms (ions). [4]

(d) Polonium-210 has a half-life of 140 days. A sample of polonium-210 has 8.0×10^{10} atoms. Calculate the number of polonium-210 atoms remaining in the sample after 280 days.

number of atoms = ... [2]

[Total: 10]

4. 0625/41/O/N/19/No.9

(a) The chemical symbol of the element lithium is Li. The proton number of lithium is 3.

Fig. 9.1 is a representation of a nucleus of a radioactive isotope of lithium that is about to decay.

Fig. 9.1

(i) Write down, using nuclide notation, the symbol that represents this isotope of lithium.

..... [1]

(ii) This isotope of lithium decays by β-particle emission to form another nucleus.

Complete Fig. 9.2 to represent this decay by:

- using the same representation as in Fig. 9.1 and in the space after the arrow, draw a diagram of the nucleus formed by the decay
- writing the name of the particle that is identical to a β-particle on the answer line provided.

+ .....

Fig. 9.2

[3]

(b) A radiation detector is set up in a laboratory where there are no radioactive samples.

On **six** separate occasions, the detector is switched on for 1.0 minute and the background count is recorded. The counts are:

23 27 25 24 20 25

(i) State why the readings are **not** all identical.

..... [1]

(ii) Suggest a possible source for this background radiation.

..... [1]

(iii) A sample containing only one radioactive isotope is brought into the laboratory. The half-life of the isotope is 15 hours.

The sample is placed near to the radiation detector in this laboratory. The detector is switched on and, after 1.0 minute, a count of 440 is recorded.

The sample is left next to the detector and the experiment is repeated 45 hours later.

The detector is switched on for 1.0 minute.

Predict the reading for the count obtained on this occasion.

reading ..... [3]

[Total: 9]

5. 0625/42/O/N/19/No.10

(a) The nucleus of a hydrogen atom is a proton. The mass of a proton is *m* and the size of the charge on a proton is *e*.
Complete Table 10.1. Express your answers in terms of *m* and *e*. Three spaces have already been completed.

Table 10.1

particle or emission	mass	charge
proton	*m*	*e*
neutron	*m*	
γ-ray		
nucleus of helium-4 ($^4_2$He)		

[4]

(b) Many schools and colleges use radioactive isotopes for teaching and research. Describe how these radioactive isotopes are handled, used and stored in a safe way.

.....

.....

.....

.....

.....

..... [3]

[Total: 7]

6. 0625/43/O/N/19/No.11

(a) The circles shown in Fig. 11.1 represent three gold nuclei. Three α-particles are approaching the gold nuclei.

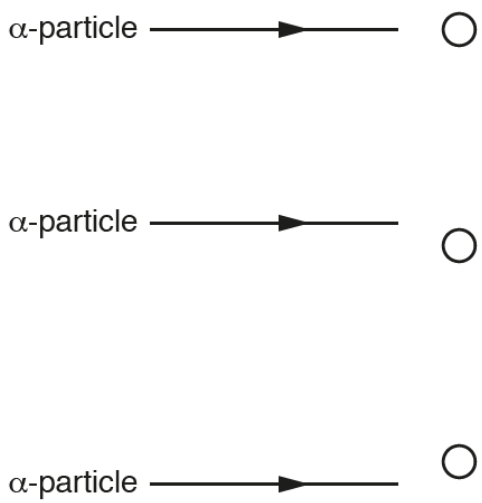

Fig. 11.1

On Fig. 11.1, complete the path of each α-particle. [3]

(b) A detector of radioactivity in a laboratory indicates an average of 16 counts/min when no radioactive samples are present. A radioactive sample of half-life 1.5 days is placed close to the detector, which indicates a count rate of 208 counts/min.

Calculate the count rate that is indicated 6 days later.

count rate = ... counts/min [4]

(c) The waste from nuclear power stations includes the isotopes technetium-99, tin-126 and selenium-79. These isotopes are radioactive with half-lives of many thousands of years.

State **three** economic and environmental consequences of producing this waste.

.....

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.....

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.....

.....

..... [3]

[Total: 10]