Radioactivity – 2021/20 GCSE Gateway Physics A

1. Nov/2021/Paper_J249/02/No.4

   A radioactive source has a count rate of 200 counts per minute (cpm).

   The half-life of the radioactive source is 3 minutes.

   What is the count rate of the radioactive source after 3 minutes?

   A   0 cpm

   B   100 cpm

   C   200 cpm

   D   400 cpm

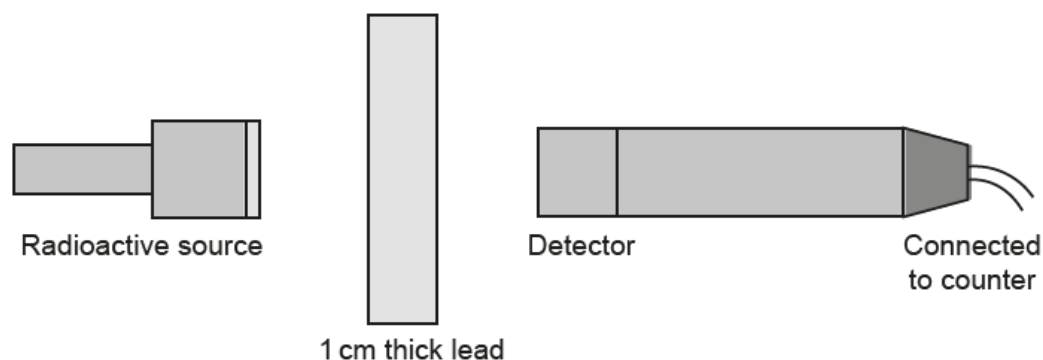   Your answer [ ]   [1]

2. Nov/2021/Paper_J249/02/No.7

   A radioactive source produces gamma rays.

   The diagram shows a detector and a piece of lead placed near the radioactive source.

   Radioactive source   1 cm thick lead   Detector   Connected to counter

   The count rate is 1840 counts per minute (cpm) **without** the lead in place.

   What could the count rate be **with** the lead in place?

   A   0 cpm

   B   160 cpm

   C   1840 cpm

   D   2530 cpm

   Your answer [ ]   [1]
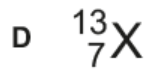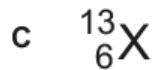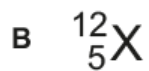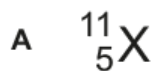
3. Nov/2021/Paper_J249/02/No.14

Carbon-12 is an isotope of carbon.

Carbon-12 contains 6 protons and 6 neutrons.

Which atom **X** is also an isotope of carbon?

A $\quad {}^{11}_{5}X$

B $\quad {}^{12}_{5}X$

C $\quad {}^{13}_{6}X$

D $\quad {}^{13}_{7}X$

Your answer ☐ [1]

4. Nov/2021/Paper_J249/02/No.19

Plutonium-238 (Pu-238) is a radioactive element.

(a) This is the symbol for Pu-238:

$$^{238}_{94}\text{Pu}$$
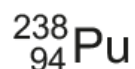
Draw lines to connect each box with the correct answer.

| Mass number |
| Number of protons |
| Number of neutrons |

| 94 |
| 144 |
| 238 |

[2]

(b) (i) A scientist measures the activity of a sample of Pu-238.

The scientist takes five different measurements.

Table 19.1 shows their results:

Measurement	1	2	3	4	5
Activity (GBq)	227	235	234	227	232

Table 19.1

What is the **mode** of the activity?

Mode = ... GBq **[1]**

(ii) An alpha particle is emitted by Pu-238.

Complete the radioactive decay equation for Pu-238 decay.

$$^{238}_{94}\text{Pu} \rightarrow\ ^{234}_{\cdots}\text{U} +\ ^{\cdots}_{2}\text{He}$$

[2]

3

(iii) A student says, 'Alpha radiation is safer than beta.'

Do you agree with this student?

Tick (✓) **one** box.

Yes ☐

No ☐

Explain your answer.

....

....

.... **[2]**

(c) A scientist is using a radioactive element. The scientist accidently touches the radioactive element and becomes **contaminated**.

The scientist stops using the radioactive element.

Explain why the scientist is still at risk.

....

....

....

.... **[2]**

4

(d) Pu-238 can be used to generate electricity.

    (i)   The power output generated increases with the mass of Pu-238.

        This is a graph of power output against mass of Pu-238:
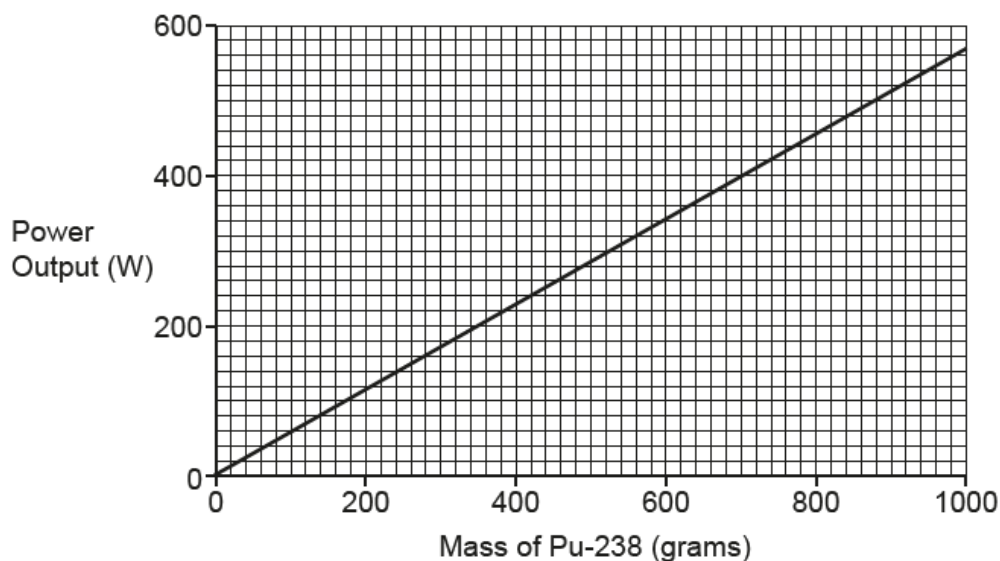
        Use the graph to find the mass of Pu-238 needed for a power output of 460 W.

Mass = ... grams **[1]**

    (ii) Pu-238 was used to generate electricity on a probe that went to Neptune.

        The half-life of Pu-238 is 88 years.

        Suggest why Pu-238 was used on the probe that went to Neptune.

        ....

        ....

        ....

        .... **[2]**

5. Nov/2020/Paper_J249/02/No.2

Which statement about alpha particles is correct?

A They are fast moving electrons.

B They are less penetrating than beta particles.

C They can pass through lead.

D They have less mass than beta particles.

Your answer ☐ [1]

6. Nov/2020/Paper_J249/02/No.10

Which statement about nuclear **fission** is correct?

A An example is when hydrogen is converted to helium.

B It may happen when a nucleus absorbs a neutron.

C The Sun uses fission to generate its energy.

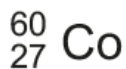**D** Two nuclei join to make a heavier nucleus.

Your answer ☐ [1]

7. Nov/2020/Paper_J249/02/No.18

(a) Some isotopes of cobalt are radioactive.

The isotope cobalt-60 (Co-60) has the symbol:

$$^{60}_{27}\text{Co}$$

The isotope cobalt-57 (Co-57) has the symbol:

$$^{57}_{27}\text{Co}$$
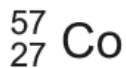
(i) State the number of protons in a nucleus of Co-60.

Number of protons = ... [1]

(ii) Give **one** similarity and **one** difference between the nucleus of Co-57 and the nucleus of Co-60.

Similarity ....

Difference ....
[2]

(b) A teacher measures the radiation emitted by Co-60.

She uses this equipment:

The teacher's results are shown in **Table 18.1**.

	Count-rate (counts per minute)
Measurement 1	191
Measurement 2	224
Measurement 3	212

Table 18.1

(i) Explain why the teacher's three measurements are **not** the same.

....
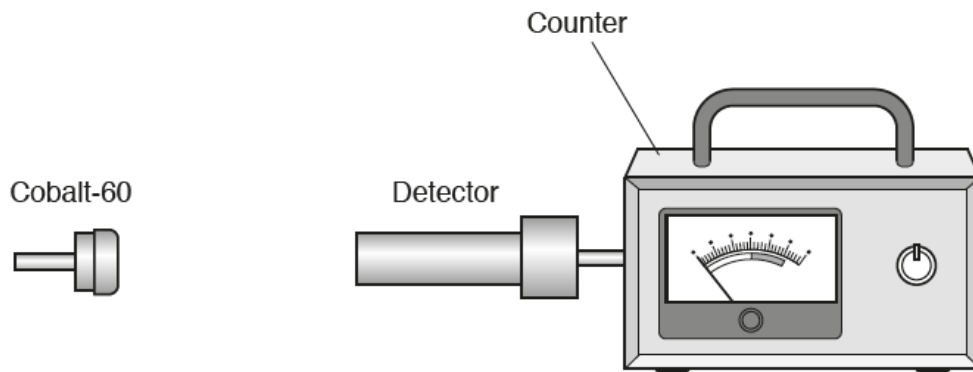
.... [1]

(ii) Use the teacher's results in **Table 18.1** to calculate the mean count-rate for Co-60.

Count-rate = ... counts per minute **[2]**

(iii) Co-60 emits gamma radiation.

The teacher puts thin aluminium foil between Co-60 and the detector.

State what happens to the count-rate.

.... **[1]**

(c) (i) Explain what is meant by the half-life of a radioactive isotope.

....

.... **[1]**

(ii) The half-life of Co-60 is 5 years.

The count-rate of a sample of Co-60 is 160 counts per minute.

Calculate the count-rate of the Co-60 after 10 years.

Count-rate = ... counts per minute **[3]**

(d) A radioactive isotope can be used as a tracer in a patient's body. It is monitored by a radiation detector outside the body.

Four possible radioactive isotopes are shown in **Table 18.2**.

Radioactive isotope	Type of radiation emitted	Half-life
Radon-222	Alpha	4 days
Iodine-131	Gamma	8 days
Cobalt-60	Gamma	5 years
Plutonium-238	Alpha	88 years

Table 18.2

(i) Doctors wear a lead apron when they use radioactive isotopes.

Explain why.

....

....

.... **[2]**

(ii) Which radioactive isotope from **Table 18.2** is best to use as a radioactive tracer in a patient's body?

Tick (✓) **one** box.

Radon-222 ☐

Iodine-131 ☐

Cobalt-60 ☐

Plutonium-238 ☐

Explain your answer.

....

....

....

....
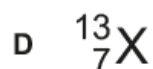
[3]

9

8. Nov/2021/Paper_J249/04/No.1

Carbon-12 is an isotope of carbon.

Carbon-12 contains 6 protons and 6 neutrons.

Which atom **X** is also an isotope of carbon?

A $\ _{5}^{11}X$

B $\ _{5}^{12}X$

C $\ _{6}^{13}X$

D $\ _{7}^{13}X$
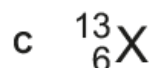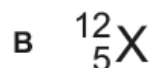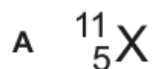
Your answer [ ] [1]

9. Nov/2021/Paper_J249/04/No.11

A teacher measures the activity of a radioactive source. They place different materials between the radioactive source and detector.

The results are shown in the table:

Material	Activity (counts per minute)
Air only	325
Sheet of paper	337
Aluminium, 5 mm thick	26
Lead, 15 mm thick	24

Which type of radiation is emitted by the radioactive source?

A Alpha and beta particles only

B Alpha particles only

C Beta particles only

D Gamma rays and beta particles only

Your answer [ ] [1]

10

10. Nov/2021/Paper_J249/04/No.18

This question is about radioactive Plutonium-238 (Pu-238).

(a) Pu-238 can be used to produce electricity:

- The Pu-238 undergoes radioactive decay.
- This causes the temperature of the plutonium to increase.
- Electricity is produced.

Complete the sentences using the words below.

You can use each word once, more than once, or not at all.

chemical   **elastic potential**   **electrostatic**

gravitational potential   **nuclear**   **thermal**

The .... energy store of the plutonium decreases.

The .... energy store of the plutonium increases.

[1]

(b) (i) State why Pu-238 undergoes radioactive decay.

....

.... **[1]**

(ii) A Pu-238 nucleus emits an alpha particle.

$$^{238}_{94}\text{Pu}$$

Determine the value of the mass of the nucleus **and** the number of protons **after** Pu-238 emits an alpha particle.

Mass of the nucleus ....

Number of protons .... **[2]**

(c) **Fig. 18.1** shows how the activity of Pu-238 changes with time.
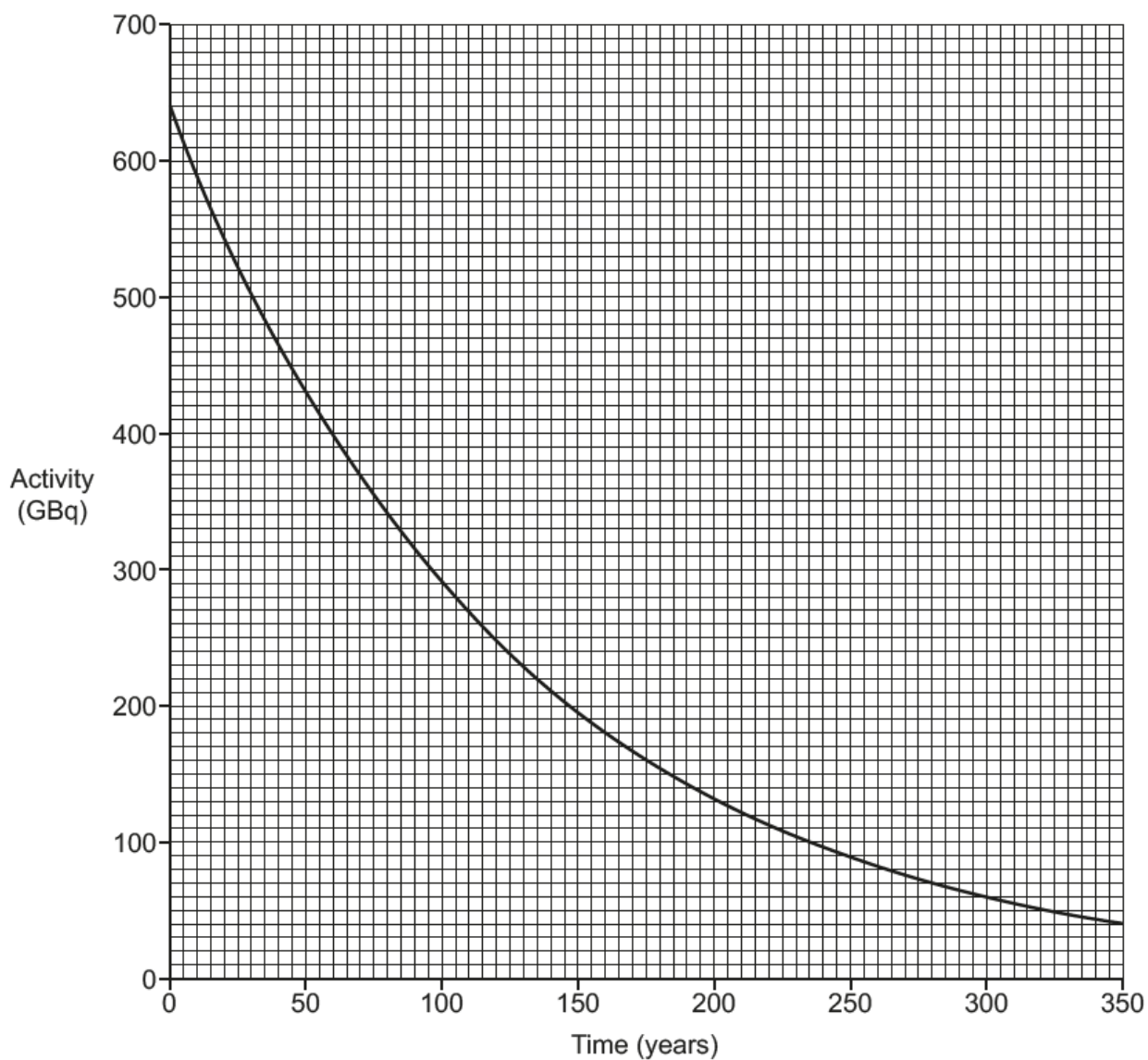
Fig. 18.1

Use **Fig. 18.1** to find the half-life for Pu-238.

Show your working on the graph.

Half-life = ... years **[2]**

12

(d) (i) A different isotope of plutonium is used in nuclear **fission**.

Describe how a chain reaction occurs in nuclear **fission**.

....

....

....

.... **[2]**

(ii) Nuclear **fusion** occurs in the Sun.

Describe what is meant by nuclear **fusion**.

....

.... **[1]**

11. Nov/2020/Paper_J249/04/No.15

Which statement about nuclear **fusion** is correct?

A   Energy is released because mass is converted to energy.

B   Helium is converted into hydrogen.

C   It is the main way in which nuclear power generates electricity.

D   It is the splitting of a heavy nucleus into smaller nuclei.

Your answer ☐   [1]

12. Nov/2020/Paper_J249/04/No.20

Americium-241 is a radioactive source that is used in smoke detectors.

(a) This is the symbol for americium-241:

$$^{241}_{95}Am$$

Describe the structure of an americium-241 **nucleus**.

....

....

.... **[2]**

(b) Americium-241 decays by emitting alpha radiation to form neptunium (Np).

Complete the balanced symbol equation for the decay.

$$^{241}_{95}Am \longrightarrow {}^{\cdots}_{\cdots}Np + {}^{4}_{2}\cdots$$

[3]

(c) When smoke enters a detector:

- The smoke particles absorb the emitted alpha radiation.
- The alarm sounds.

Explain why beta and gamma sources are **not** suitable for use in a smoke detector.

....

.... **[1]**

(d) The half-life of americium-241 is 432 years.

   (i) Explain what is meant by **half-life**.

   ....

   .... **[1]**

   (ii) Explain why the half-life of americium-241 is suitable for a smoke detector.

   ....

   .... **[1]**

15

(iii) The table shows some data for two radioactive sources.

Source	Half-life (years)	Radiation emitted
Americium-241 (Am-241)	432	Alpha
Thorium-228 (Th-228)	2	Alpha

Both sources start with the same number of radioactive nuclei.

Which source is a greater health risk? Explain your answer.

....

....

....

.... **[2]**

(e) Read the information below about smoke detectors.

In smoke detectors, fine particles of americium-241 are rolled into a metallic foil. The americium-241 cannot be inhaled or move around.

The amount of radiation emitted is very small compared with the natural radioactivity in $1\,m^3$ of soil.

Americium-241 also emits a small amount of gamma rays.

A scientist says, '**There is no risk from the disposal of smoke detectors in household waste.**'

Do you agree with this statement? Give **two** reasons for your answer.

Yes ☐

No ☐

1 ....

....

2 ....

....

[2]