Radioactivity – 2021/20 GCSE Gateway Physics Combined Science A

1. Nov/2021/Paper_J250/06/No.7

P, Q, R and S are isotopes.

$^{4}_{2}P$ $^{6}_{3}Q$ $^{3}_{2}R$ $^{2}_{1}S$

Which **two** atoms are isotopes of the **same** element?

A $^{4}_{2}P$ and $^{3}_{2}R$

B $^{6}_{3}Q$ and $^{3}_{2}R$

C $^{3}_{2}R$ and $^{2}_{1}S$

D $^{4}_{2}P$ and $^{2}_{1}S$

Your answer ☐ **[1]**

2. Nov/2021/Paper_J250/06/No.11

This question is about two radioactive isotopes, **X** and **Y**.

(a) Draw lines to connect each **part of the atom** with its correct **description**.

Part of the atom	Description
Electrons	Usually found in the nucleus.
Neutrons	Unstable in radioactive isotopes.
Nucleus	Arranged in shells around the nucleus.
Protons	

[3]

(b) Isotope **X** gives out gamma rays.

(i) The charge on the nucleus of isotope **X** stays the same.

What happens to the mass number of the nucleus?

..... **[1]**

(ii) Isotope **X** is stored safely in a container.

Suggest a material for the container.

.....

..... **[1]**

(c) Describe how an object can be **irradiated** using isotope **X**.

.....

.....

.....

..... **[2]**

(d) Equal amounts of isotope **Y** are placed in a plastic box and in a cardboard box.

Table 11.1 gives information about both boxes.

	Plastic box	**Cardboard box**
Waterproof	yes	no
Material breaks easily	no	yes
Secure lid	yes	no

Table 11.1

(i) Which box is best for storing isotope **Y**?

Give **one** reason for your answer using the information in **Table 11.1**.

.....

.....

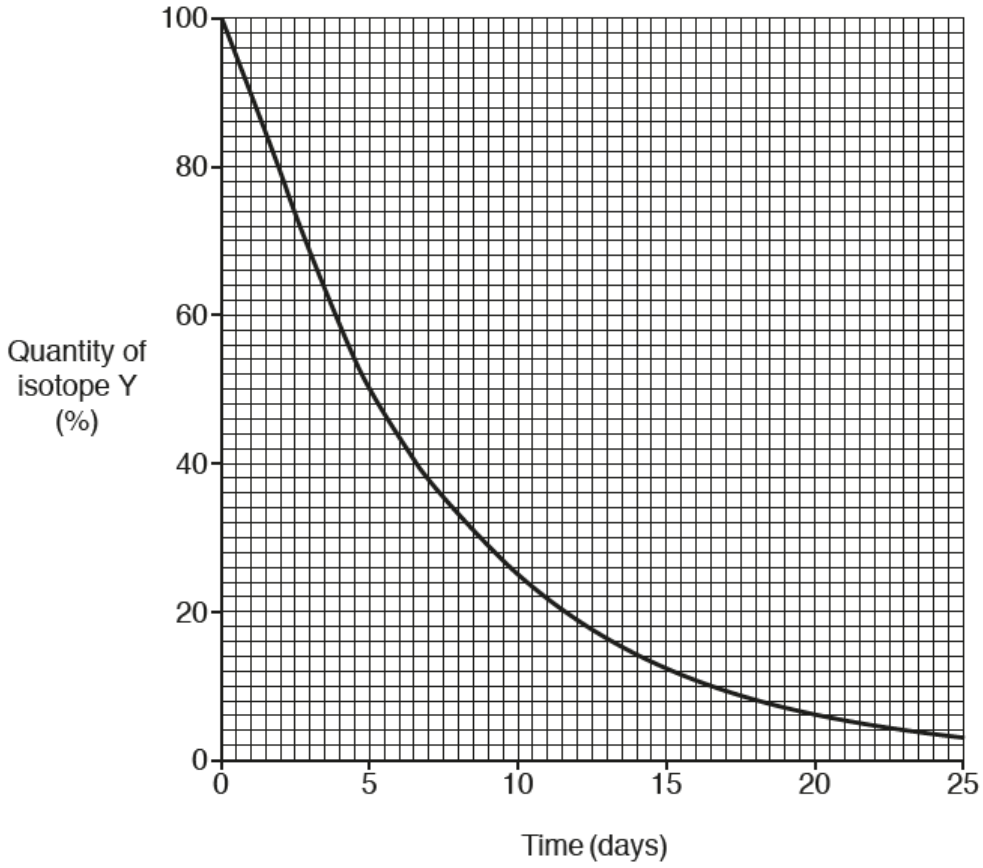
..... **[1]**

(ii) The plastic box does not let any of the radiation emitted by isotope **Y** pass through it.

Which type of radiation does isotope **Y** emit?

..... **[1]**

(e) The graph shows how the quantity of isotope **Y** changes with time.



(i) Complete **Table 11.2** using the graph to help you.

Time (days)	Quantity of isotope Y (%)
5	.....
10	.....

Table 11.2

[1]

(ii) Explain why the half-life of isotope **Y** is 5 days.

.....

..... **[1]**

3. Nov/2020/Paper_J250/06/No.3

Atoms contain protons, neutrons and electrons.

Which row in the table describes the **nucleus**?

	Nucleus contains	Charge on the nucleus
A	Electrons and neutrons	Negative
B	Protons and electrons	Neutral
C	Protons and neutrons	Neutral
D	Protons and neutrons	Positive

Your answer ☐ **[1]**

4. Nov/2020/Paper_J250/06/No.12

(a) A scientist measures the activity of a radioactive isotope. She uses a Geiger-Muller tube connected to a counter.

Table 12.1 shows her results.

Measurement	Activity (Bq)
1	701
2	708
3	704
4	707

Table 12.1

(i) What is the **mean** activity of the isotope?

Mean activity = ... Bq **[1]**

(ii) Is there a pattern in the results in **Table 12.1**?

Explain your answer using ideas about radioactivity.

.....

.....

..... **[2]**

(b) **(i)** Carbon-12 is a stable isotope. Carbon-14 is an unstable radioactive isotope.

Table 12.2 shows the contents of each nucleus.

	Carbon-12	Carbon-14
Number of protons	6	6
Number of neutrons	6	8

Table 12.2

Explain why carbon-12 and carbon-14 are isotopes.

.....

..... **[1]**

(ii) This is the equation for the radioactive decay of carbon-14:

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

What happens to the **nuclear mass** (mass number) when carbon-14 decays?

.....

..... **[1]**

(c) Americium-241 is a radioactive isotope used in smoke alarms.

Table 12.3 shows how the activity of americium-241 changes.

Time (years)	Activity (Bq)
458	36000
916	18000
1374	9000

Table 12.3

(i) What is meant by the half-life of an isotope?

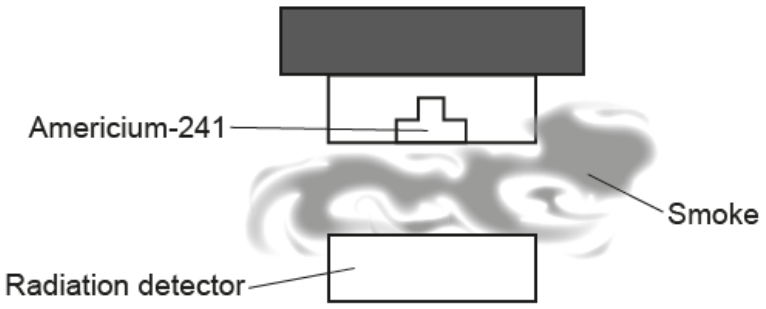
.....

..... **[1]**

(ii) Use the data in **Table 12.3** to calculate the half-life of americium-241.

Half-life = ... years **[1]**

(iii) This is a diagram of a smoke alarm.



Smoke enters the smoke alarm, which blocks the radiation emitted by the americium-241.

A smoke alarm company decides to use a different isotope.

Table 12.4 shows the three choices of isotope.

Isotope	Radiation emitted	Half-life (years)
A	Alpha	2
B	Beta	400
C	Alpha	350

Table 12.4

Which isotope, **A**, **B** or **C**, is the best to use in a smoke alarm?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

Explain your answer using the information in **Table 12.4**.

.....

.....

.....

.....

..... **[3]**

5. Nov/2021/Paper_J250/12/No.4

An atom of element **X** can be written like this:

$$^{20}_{11}\mathbf{X}$$

What does an atom of element **X** contain?

A 11 protons, 9 neutrons and 11 electrons

B 11 protons, 11 neutrons and 11 electrons

C 20 protons, 11 neutrons and 9 electrons

D 20 protons, 11 neutrons and 20 electrons

Your answer ☐ **[1]**

6. Nov/2021/Paper_J250/12/No.14

X and **Y** are radioactive isotopes. They emit either alpha particles or beta particles.

(a) Complete **Table 14.1** to show what happens to a **nucleus** of an atom when an alpha particle or a beta particle is emitted.

	Alpha particle emitted	**Beta particle emitted**
Change in mass of nucleus	.....	0
Change in charge on nucleus	−2	.....

Table 14.1

[2]

(b) A scientist measures the half-life of isotope **X**.

They measure the half-life **three** times.

Why do they get a slightly different result each time?

.....

..... **[1]**

(c) After 18 days, the ratio of the activity of **X** to the initial activity of **X** is 1:4.

Calculate the half-life of isotope **X**.

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

(d) Isotope **X** only gives out beta particles. Isotope **Y** only gives out alpha particles.

The scientist measures the activity of **one** of the isotopes using a Geiger counter.

They then place a material between the isotope and the Geiger counter and record the reading.

Table 14.2 shows their results:

Material between isotope and Geiger counter	Reading on Geiger counter (Bq)
Paper	No change
Aluminium sheet	Decreases

Table 14.2

Which isotope are they using?

Give **two** reasons for your answer.

Isotope: .....

1 .....

.....

2 .....

.....

[2]

(e) The scientist accidentally places isotope **X** close to isotope **Y**.

Explain why isotope **Y** is irradiated, but **not** contaminated, by isotope **X**.

.....

.....

.....

..... **[2]**

(f) Nuclear power is non-renewable and the plants can produce nuclear waste.

Suggest **two** reasons why some countries still use nuclear power.

1 .....

.....

2 .....

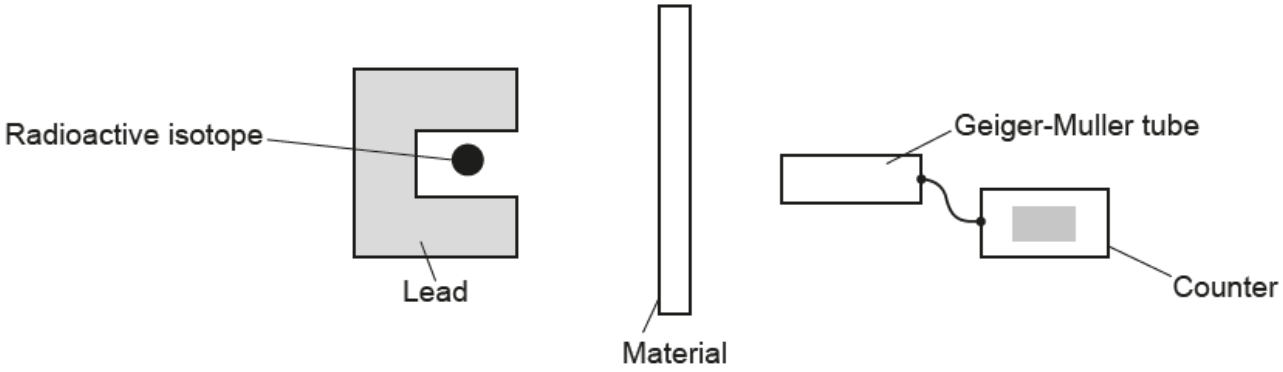
.....

[2]

7. Nov/2020/Paper_J250/12/No.6

A radioactive isotope emits **only** gamma rays.

A teacher places different materials in front of the isotope. She measures the reading on a Geiger-Muller tube connected to a counter.



Which row in the table shows the correct reading on the counter?

	Reading on counter (Bq)			
	No material	**Cardboard**	**5 mm thick aluminium**	**10 cm thick lead**
A	0	20	40	60
B	20	20	19	2
C	20	3	2	2
D	20	20	3	3

Your answer ☐ **[1]**

8. Nov/2020/Paper_J250/12/No.12

Carbon-12 is a stable isotope. Carbon-14 is an unstable radioactive isotope.

(a) Describe what is meant by the term **isotope**.

.....

.....

..... **[1]**

(b) This is the equation for the radioactive decay of carbon-14:

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

(i) Which type of radiation is emitted by carbon-14?

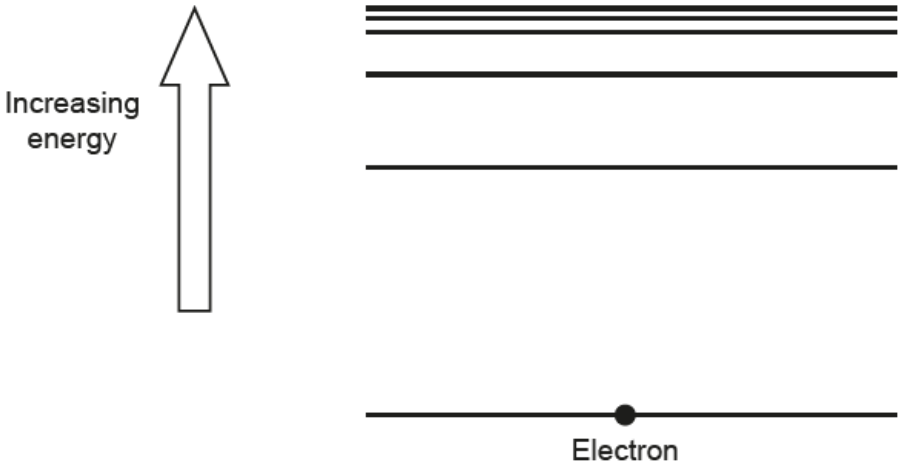
..... **[1]**

(ii) Describe how the mass and charge of the nucleus changes when the carbon-14 decays.

Mass .....

Charge ..... **[2]**

(c) This is a diagram of energy levels inside a hydrogen atom.



Electromagnetic radiation can cause ionisation.

Explain what is meant by the term **ionisation**.

You may add to the diagram to help explain your answer.

.....

.....

..... **[2]**

(d) Carbon-14 can be used to date ancient objects.

An ancient object is 17 100 years old. The half-life of carbon-14 is 5700 years.

For the ancient object, what is the ratio of the original amount of carbon-14 to the amount of carbon-14 left?

Ratio = ... **[3]**