

Name: _____

Atomic Structure part 3 AQA Triple Physics

Class: _____

Date: _____

Time: **70 minutes**

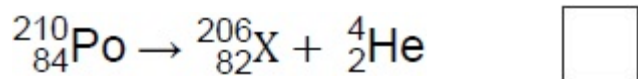
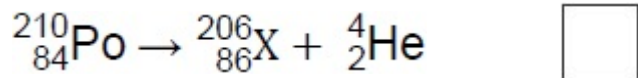
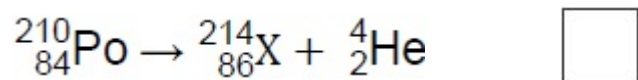
Marks: **69 marks**

Comments:

1. Polonium-210 (${}^{210}_{84}\text{Po}$) is a radioactive isotope that decays by emitting alpha radiation.

(a) Which is the correct decay equation for polonium-210?

Tick (✓) **one** box.



(1)

(b) Why is alpha radiation dangerous inside the human body?

Tick (✓) **one** box.

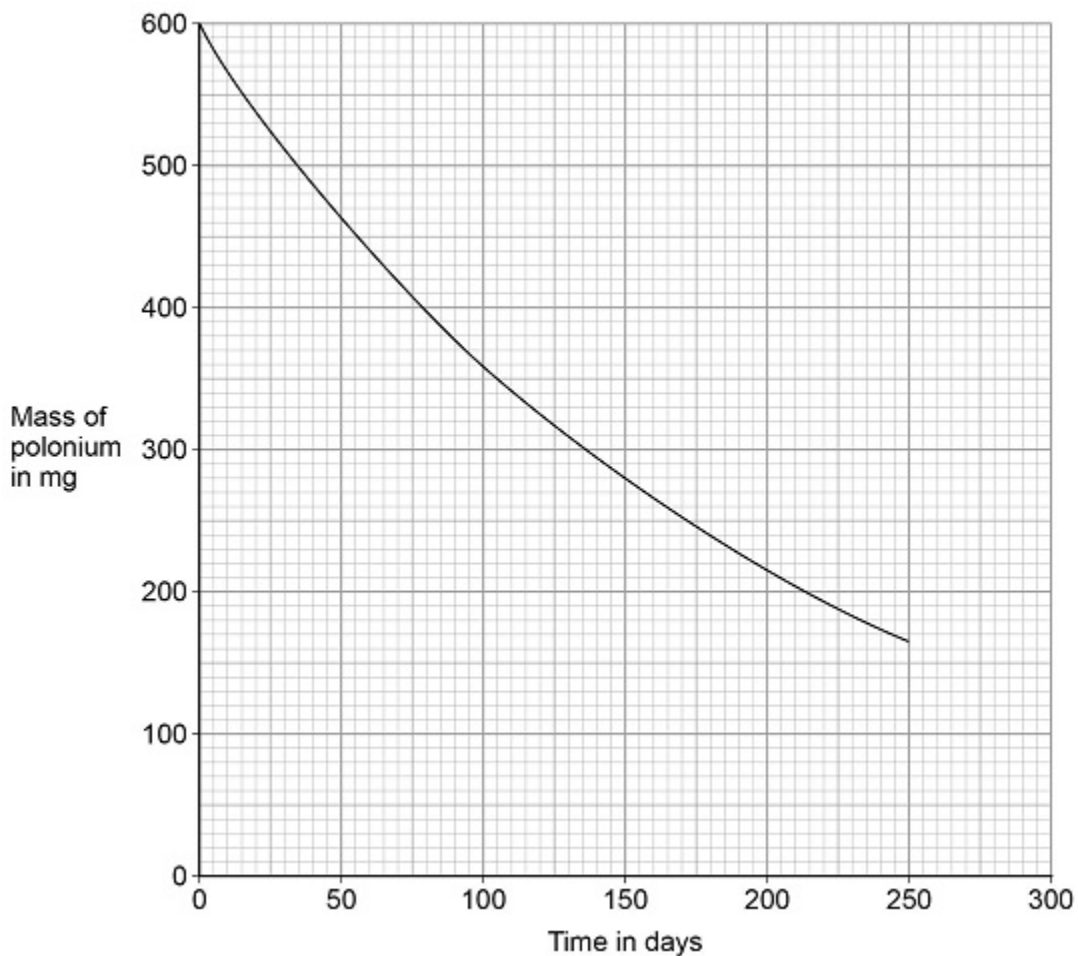
Alpha radiation is electromagnetic radiation.

Alpha radiation is highly ionising.

Alpha radiation is very penetrating.

(1)

The figure below shows how the mass of a sample of polonium-210 changes with time.



(c) Determine the change in mass of the sample of polonium-210 between 50 and 150 days.

Change in mass = _____ mg

(2)

(d) Estimate the mass of polonium-210 remaining after 300 days.

Mass = _____ mg

(1)

(e) Nuclear radiation can cause ionisation.

Complete the sentences.

Choose answers from the box.

a negative an electron a neutron a positive a proton a zero

An atom becomes an ion when it loses _____.

The resulting ion has _____ charge.

(2)

(Total 7 marks)

2.

The ancient Greeks thought that atoms were tiny spheres that could not be divided into anything smaller.

Since then, different discoveries have led to the model of the atom changing.

Some of the discoveries are given in the table below.

The mass of an atom is concentrated in the nucleus.	A
Electrons orbit the nucleus at specific distances.	B
The nucleus contains neutrons.	C
The nucleus contains positively charged protons.	D

(a) Which discovery was the earliest?

Tick (✓) **one** box.

A **B** **C** **D**

(1)

(b) Which discovery was the most recent?

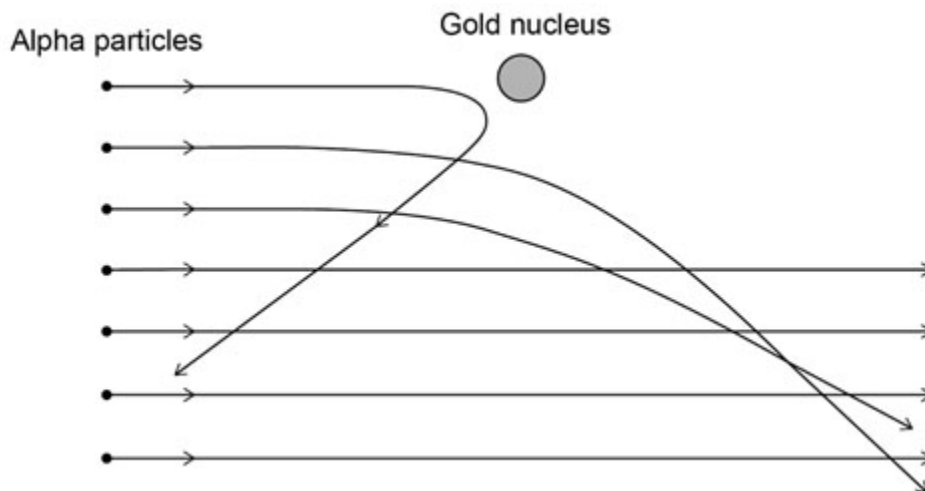
Tick (✓) **one** box.

A **B** **C** **D**

(1)

(c) The alpha particle scattering experiment led to the nuclear model of the atom.

The figure below shows the paths of alpha particles travelling close to a gold nucleus.



Complete the sentences.

Choose answers from the box.

Each answer may be used once, more than once or not at all.

attracts	decreases	does not change
increases	reflects	repels

Alpha particles and gold nuclei are both positively charged.

The gold nucleus _____ the alpha particles.

As the alpha particle approaches the gold nucleus, the electric field strength experienced by the alpha particle _____.

As an alpha particle approaches the gold nucleus, the force experienced by the alpha particle _____.

(3)

(d) The results of the alpha particle scattering experiment were reproducible.

What does reproducible mean?

Tick (✓) **one** box.

Another scientist repeats the experiment and gets the same results.

Another scientist repeats the experiment and gets different results.

The same scientist repeats the experiment and gets the same results.

The same scientist repeats the experiment and gets different results.

(1)

(Total 6 marks)

3.

Polonium-210 (${}^{210}_{84}\text{Po}$) is a radioactive isotope that decays by emitting alpha radiation.

(a) Complete the decay equation for polonium-210



(2)

(b) Explain why contamination of the inside of the human body by a radioactive material that emits alpha radiation is highly dangerous.

(3)

(c) A sample of polonium-210 was left for 414 days.

After this time it had a mass of 1.45×10^{-4} g

The half-life of polonium-210 is 138 days.

Calculate the initial mass of the sample.

Initial mass = _____ g

(3)

(Total 8 marks)

4.

Americium-241 (${}_{95}^{241}\text{Am}$) is an isotope of americium.

(a) Which of the isotopes given in the table below is **not** an isotope of americium?

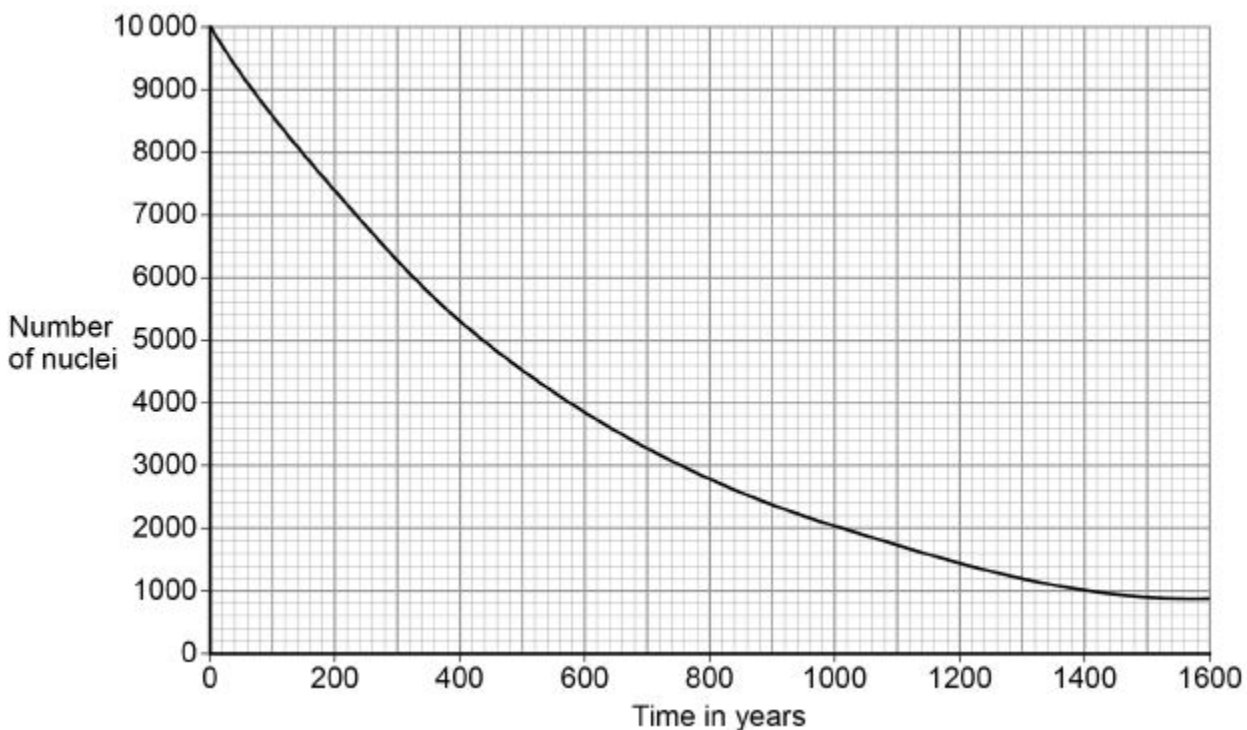
Isotope	Mass number	Atomic number
A	243	95
B	243	94
C	242	95

Isotope _____

Give a reason for your answer.

(2)

The graph below shows how the number of americium-241 nuclei in a sample changes with time.



(b) How many years does it take for the number of americium-241 nuclei to decrease from 10 000 to 5000?

Time = _____ years

(1)

(c) What is the half-life of americium-241?

Half-life = _____ years

(1)

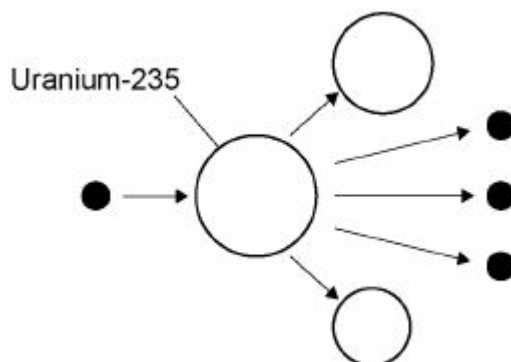
(Total 4 marks)

5.

Nuclear power can be used to generate electricity through nuclear fission.

Figure 1 shows the process of nuclear fission.

Figure 1



(a) Complete the sentences.

Choose answers from the box.

gamma rays	light rays	proton	neutron	nucleus	X-rays
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During the process of nuclear fission, a uranium _____

absorbs a _____ .

Electromagnetic radiation is released in the form of _____ .

(3)

(b) The UK needs at least 25 000 000 kW of electrical power at any time.

A nuclear power station has an electrical power output of 2 400 000 kW

Calculate how many nuclear power stations are needed to provide 25 000 000 kW of electrical power.

Number of nuclear power stations = _____

(2)

(c) State **two** environmental issues caused by generating electricity using nuclear power stations.

1. _____

2. _____

(2)

- (d) The UK currently generates a lot of electricity by burning natural gas. This process releases carbon dioxide into the atmosphere.

Figure 2 shows how the concentration of carbon dioxide in the atmosphere has changed over the past 115 years.

Figure 2

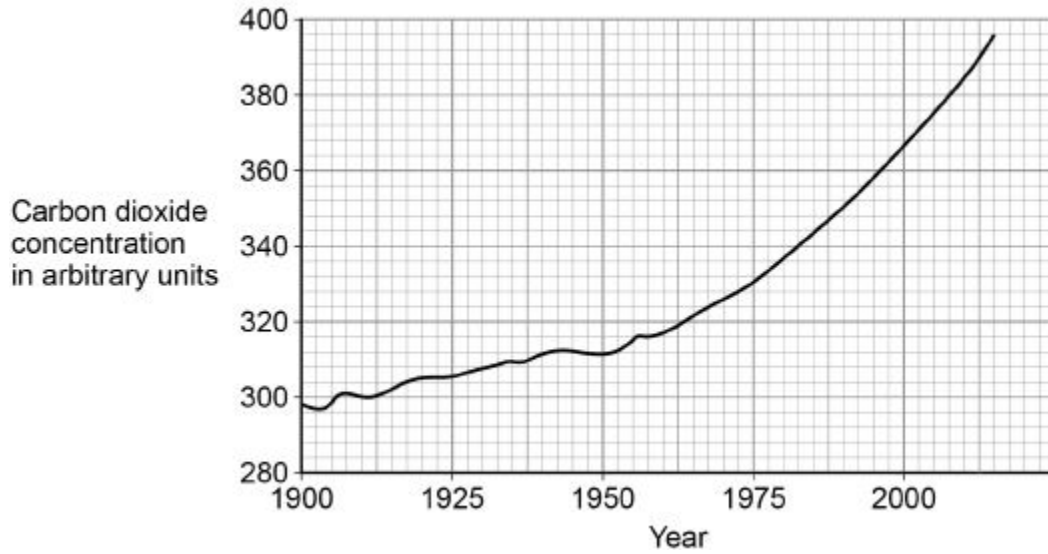
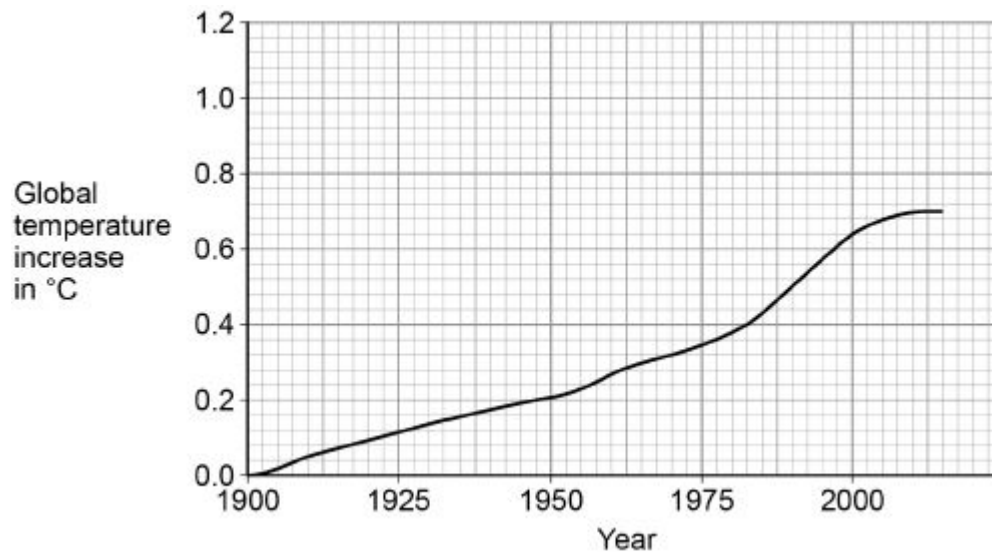


Figure 3 shows how the global temperature has changed over the past 115 years.

Figure 3



Give **one** similarity and **one** difference between the data in **Figure 2** and **Figure 3**.

Similarity _____

Difference _____

(2)
(Total 9 marks)

6.

A teacher used a Geiger-Muller tube and counter to measure the number of counts in 60 seconds for a radioactive rock.

- (a) The counter recorded 819 counts in 60 seconds. The background radiation count rate was 0.30 counts per second.

Calculate the count rate for the rock.

Count rate = _____ per second

(3)

- (b) A householder is worried about the radiation emitted by the granite worktop in his kitchen.

1 kg of granite has an activity of 1250 Bq. The kitchen worktop has a mass of 180 kg.

Calculate the activity of the kitchen worktop in Bq.

Activity = _____ Bq

(2)

- (c) The average total radiation dose per year in the UK is 2.0 millisieverts.

The table below shows the effects of radiation dose on the human body.

Radiation dose in millisieverts	Effects
10 000	Immediate illness; death within a few weeks
1000	Radiation sickness; unlikely to cause death
100	Lowest dose with evidence of causing cancer

The average radiation dose from the granite worktop is 0.003 millisieverts per day.

Explain why the householder should **not** be concerned about his yearly radiation dose from the granite worktop.

One year is 365 days.

(2)

- (d) Bananas are a source of background radiation. Some people think that the unit of radiation dose should be changed from sieverts to Banana Equivalent Dose.

Suggest **one** reason why the Banana Equivalent Dose may help the public be more aware of radiation risks.

(1)

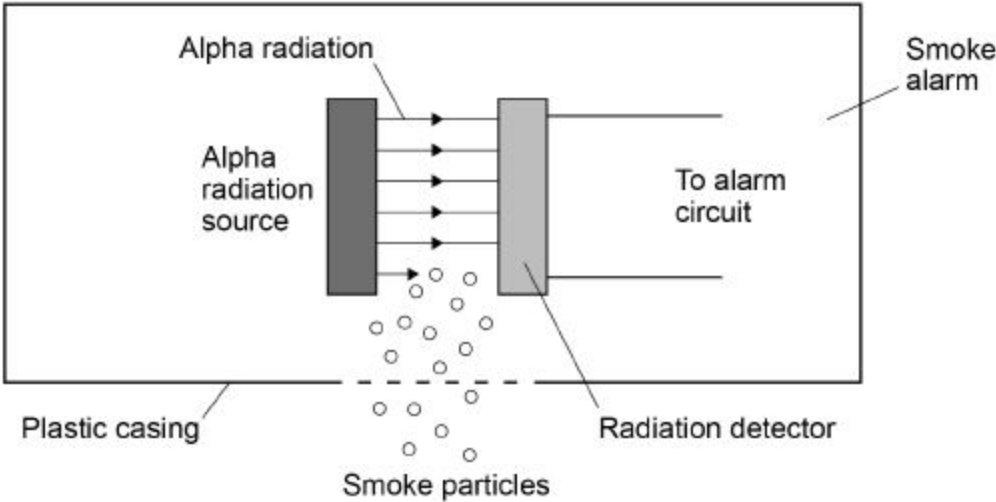
(Total 8 marks)

7.

Smoke alarms contain an alpha radiation source and a radiation detector.

Figure 1 shows part of the inside of a smoke alarm.

Figure 1



(a) The smoke alarm stays off while alpha radiation reaches the detector.

Why does the alarm switch on when smoke particles enter the plastic casing?

(1)

(b) Why is it safe to use a source of alpha radiation in a house?

(1)

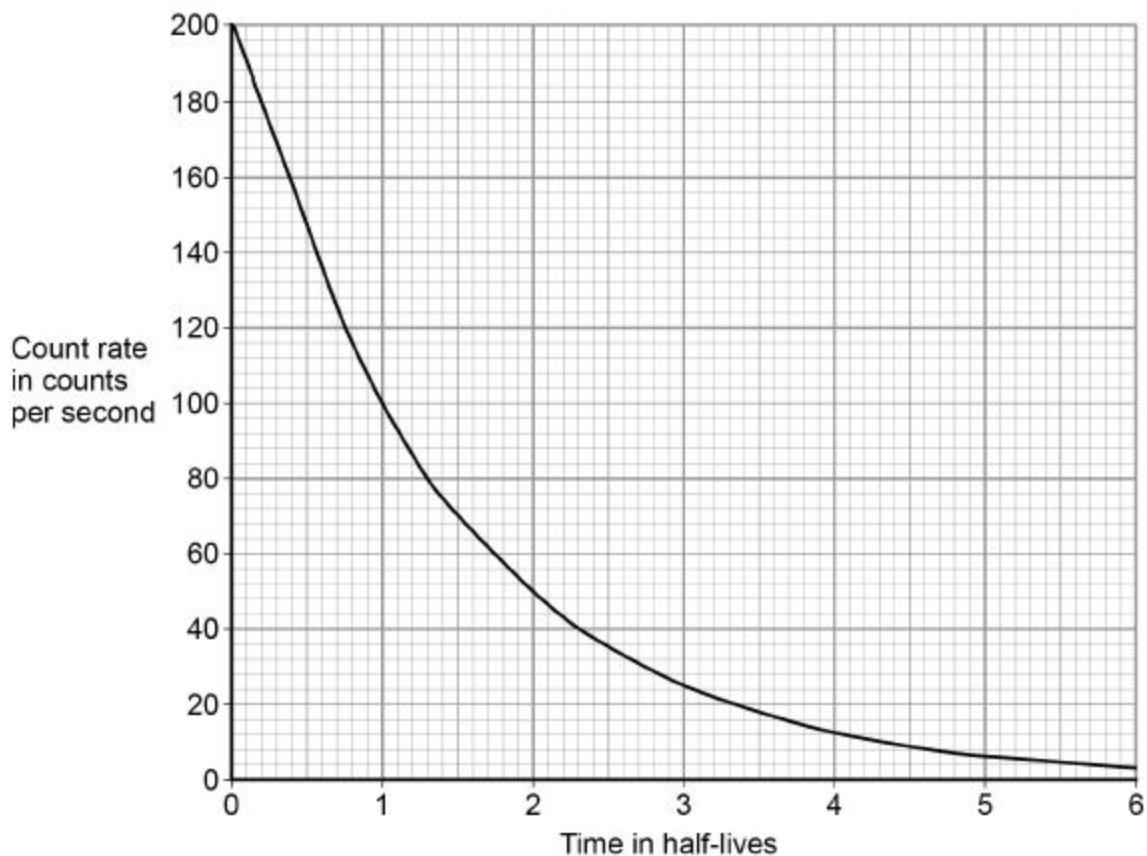
(c) The smoke alarm would not work with a radiation source that emits beta or gamma radiation.

Explain why.

(2)

- (d) **Figure 2** shows how the count rate detected from the radiation source in the smoke alarm changes with time.

Figure 2



The smoke alarm switches on when the count rate falls to 80 counts per second.

Explain why the radiation source inside the smoke alarm should have a long half-life.

(2)

- (e) **Figure 3** shows a patient who has been injected with a radioactive source for medical diagnosis.

Figure 3



Explain the ideal properties of a radioactive source for use in medical diagnosis.

(4)
(Total 10 marks)

8.

Nuclear power stations generate electricity through nuclear fission. Electricity can also be generated by burning shale gas.

- (a) Shale gas is natural gas trapped in rocks. Shale gas can be extracted by a process called fracking. There is some evidence that fracking causes minor earthquakes. Burning shale gas adds carbon dioxide to the atmosphere.

Describe the advantages of nuclear power compared with the use of shale gas to generate electricity.

(3)

- (b) What is the name of **one** fuel used in nuclear power stations?

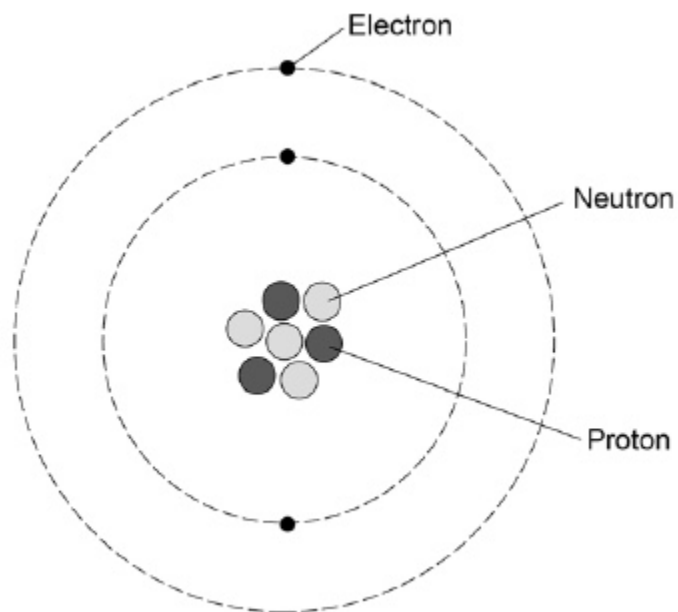
(1)

- (c) Describe the process of nuclear fission.

(4)

(Total 8 marks)

9. The diagram shows a lithium atom.



(a) What is the mass number of this lithium atom?

Tick **one** box.

3

4

7

10

(1)

(b) What is the atomic number of a lithium atom?

Tick **one** box.

3

4

7

10

Give a reason for your answer.

(2)

(c) Complete the sentence.

Choose the answer from the box.

circles	levels	rings
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The electrons in an atom orbit in different energy _____ .

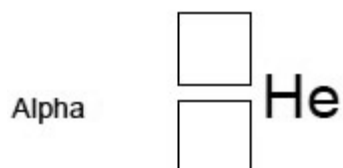
(1)

(d) Some atomic nuclei are unstable and decay by emitting an alpha particle or a beta particle.

Complete the symbols for an alpha particle and a beta particle.

Use answers from the box.

-1	0	1	2	4
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(3)

(e) Doctors may use nuclear radiation to diagnose certain types of illness.

The table below gives data about three radiation sources used.

Each source emits beta radiation.

Radiation source	Half-life in minutes
Carbon-11	20
Nitrogen-13	10
Oxygen-15	2

Explain why oxygen-15 is likely to pose the least risk to a patient.

(2)

(Total 9 marks)

Mark schemes

- 1.** (a) ${}_{84}^{210}\text{Po} \rightarrow {}_{82}^{206}\text{X} + {}_2^4\text{He}$ 1
- (b) Alpha radiation is highly ionising 1
- (c) Change in mass = 460 – 280
allow reading between 460 and 465
allow reading between 278 and 282 1
- Change in mass = 180 (mg)
allow an answer between 178 and 187 inclusive for 2 marks 1
- (d) 130 (mg)
allow an answer between 126 and 150 (mg) inclusive 1
- (e) an electron
in this order only 1
- a positive 1
- [7]**
- 2.** (a) A 1
- (b) C 1
- (c) repels 1
- increases 1
- increases 1
- in this order only* 1
- (d) another scientist repeats the experiment and
gets the same results 1
- [6]**

3. (a) $^{206}_{82}\text{Pb}$ 2
- (b) alpha radiation is highly ionising 1
- causing an increased risk of cancer
or
organ failure
or
radiation sickness / poisoning
or
mutation of genes / DNA
or
damage to cells / tissues / organs
allow kill cells 1
- until the radioactive material is removed / excreted
allow all the alpha radiation is absorbed by the body
or
activity of radioactive material reaches / approaches background radiation levels
ignore references to half-life 1
- (c) *an answer of 1.16×10^{-3} (g) scores 3 marks*
- $\frac{414}{138} = 3$ (half-lives) 1
- $1.45 \times 10^{-4} \times 2 \times 2 \times 2$ 1
- $= 1.16 \times 10^{-3}$ (g)
or
 $= 0.00116$ (g) 1
- [8]**

4. (a) B 1
- reason only scores if B is chosen*
- americium has an atomic number of 95
allow proton number for atomic number
allow B has a different atomic number
allow B has an atomic number of 94 1

(b) 430 (years)
allow an answer between 420 and 440 (years)

1

(c) 430 (years)
or
their answer to part **(b)**
allow an answer between 420 and 440 (years)

1

[4]

5.

(a) nucleus

1

neutron

1

gamma rays

1

in this order only

(b) $\frac{25\,000\,000}{2\,400\,000}$

1

11

an answer of 10.4 with no working scores 1 mark

1

an answer of 11 scores 2 marks

(c) any **two** from:

- waste is radioactive
allow nuclear waste
- waste has a long half-life
allow waste remains dangerous for a long time
- waste is toxic
- waste needs to be buried
allow waste is difficult to dispose of
- risk of catastrophic accidents
allow named accident e.g. Fukushima, Chernobyl, Three Mile Island
- fuel is non-renewable

2

- (d) **similarity:**
(carbon dioxide concentration and global temperature have) both increased
allow them both show a positive correlation

1

difference:

the carbon dioxide (concentration) continues to increase whereas temperature (increase) levels off

allow carbon dioxide (concentration) increases more quickly than temperature (increase)

1

[9]

6.

(a) $\text{count rate} = \frac{819}{60}$

1

count rate = 13.65

1

corrected count rate = 13.35 (per second)

allow an answer of

background = 0.30 × 60

= 18 (per minute)

corrected count rate

= 819 – 18

corrected count rate

= 801 per minute

1

an answer of 13.35 (per second) scores 3 marks

an answer of 13.95 (per second) scores 2 marks

an answer of 801 (per second) scores 2 marks

(b) activity = 1250 × 180

1

activity = 225 000 (Bq)

1

an answer of 225 000 (Bq) scores 2 marks

(c) yearly dose = 0.003 × 365

allow yearly dose = 1.095 (mSv)

1

which is << 100 (mSv)

or

(well) below the lowest dose with evidence of causing cancer / harm

1

- (d) people are able to compare a radiation risk / dose / hazard to the radiation dose from (eating) bananas

1

[8]

7.

- (a) smoke absorbs / stops alpha radiation

allow alpha particles for alpha radiation

alpha radiation does not reach the detector is insufficient

1

- (b) alpha radiation is not very penetrating

allow alpha particles for alpha radiation

or

alpha radiation does not penetrate skin

allow alpha radiation does not travel very far (in air)

1

- (c) beta and gamma radiation will penetrate smoke

allow beta and gamma radiation will not be stopped by smoke

1

no change (in the count rate) would be detected

allow the change detected (in the count rate) would be too small

1

- (d) (a long half-life means) the count rate is (approximately) constant

allow activity of source is (approximately) constant

or

a short half-life means the count rate decreases quickly

1

until 1.3 half-lives the count rate is above 80 per second

allow after 1.3 half-lives the count rate is below 80 per second

or

until 1.3 half-lives the count rate is above the threshold for the smoke alarm to be activated

or

after 1.3 half-lives the smoke alarm will be activated all the time

so don't have to replace source or smoke detector is insufficient

1

(e) **Level 2:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

3–4

Level 1: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.

1–2

No relevant content

0

Indicative content

- short half-life or half-life of a few hours
- (short half-life means) less damage to cells / tissues / organs / body
- low ionising power
- (low ionising power means) less damage to cells / tissues / organs / body
- highly penetrating
- (highly penetrating means) it can be detected outside the body
- emits gamma radiation

[10]

8.

(a) any **three** from:

- no carbon dioxide emitted (to produce electricity)
no greenhouse gases is insufficient
- doesn't cause global warming
allow climate change or greenhouse effect for global warming
- nuclear power doesn't cause earthquakes
- more energy released per kg of fuel (compared to shale gas)

3

(b) uranium
or
plutonium

ignore any numbers given

1

(c) a neutron is absorbed by a (large) nucleus

a description in terms of only atoms negates first two marking points

1

the nucleus splits into two (smaller) nuclei

1

releasing energy (and gamma rays)

1

and (two / three) neutrons

1

[8]

9.	(a) 7	1
	(b) 3	1
	number of <u>protons</u>	
	<i>reason only scores if 3 chosen</i>	1
	(c) levels	1
	(d) ${}^4_2\text{He}$	
	<i>correct order only</i>	1
		1
	${}^0_{-1}\text{e}$	
	(e) shorter half-life (than the other sources)	1
	exposure time to radiation is shorter	1
		[9]