The Atomic Model and Nuclear Radiation

1 **Figure 1** shows part of the periodic table which includes the symbol, name and atomic number of different elements.

Figure 1

Symbol: Name: Atomic number:	**K** potassium 19	**Ca** calcium 20	**Sc** scandium 21	**Ti** titanium 22
Symbol: Name: Atomic number:	**Rb** rubidium 37	**Sr** strontium 38	**Y** yttrium 39	**Zr** zirconium 40
Symbol: Name: Atomic number:	**Cs** caesium 55	**Ba** barium 56	**La** lanthanum 57	**Hf** hafnium 72

a) Yttrium-93 can undergo radioactive decay to form zirconium-93.
State the type of radioactive decay that yttrium-93 undergoes.

.....

[1]

b) Write a nuclear equation for this decay of yttrium-93.

.....

[2]

c) Caesium-112 decays by emitting a single particle to form iodine-108.
Explain the changes in the caesium nucleus for this decay.

.....

.....

.....

[2]

d) Using **Figure 1** and your answer to (c), calculate the atomic number of iodine.

Atomic number = ...

[1]

e) Titanium is formed by fusion in stars.
Which element could form titanium by fusion with another element? Tick **one** box.

☐ **A** Calcium ☐ **B** Strontium

☐ **C** Rubidium ☐ **D** Caesium

[1]

f) The part of the periodic table in **Figure 1** doesn't give a value for the mass number of each element. Suggest why this is not usually possible.

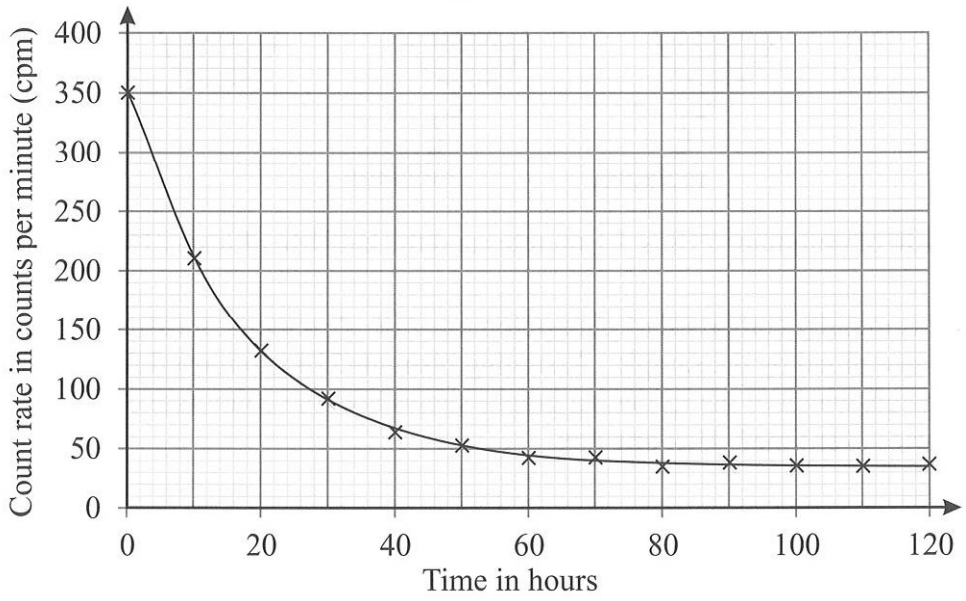
.....

[1]

[Total 8 marks]

2 A village's water supply comes from a nearby lake. The lake has been contaminated with a nuclear material. The graph in **Figure 2** shows how the count rate measured in the lake changes over time.

Figure 2



a) The count rate measured was not corrected for background radiation. Using **Figure 2**, estimate the background radiation count rate.

Background radiation = ... cpm
[1]

b) Draw a line on **Figure 2** showing how the corrected count rate changes over time.
[2]

c) Estimate the half-life of the sample.

Half-life = ... hours
[2]

d) The water is safe to drink when the corrected count rate of the contaminated water falls below 25 counts per minute. The decay curve was produced using data from a radiation detector which is accurate to ± 5 cpm. How many hours after the source of contamination has stopped will the water first become safe to drink? Explain your answer.

.....

.....

.....
[2]

e) The water company won't declare contaminated water safe to drink until it has been below 25 counts per minute for more than 24 hours. Suggest why this is the case.

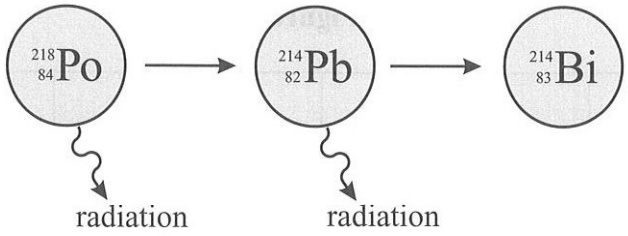
.....

.....
[1]

[Total 8 marks]

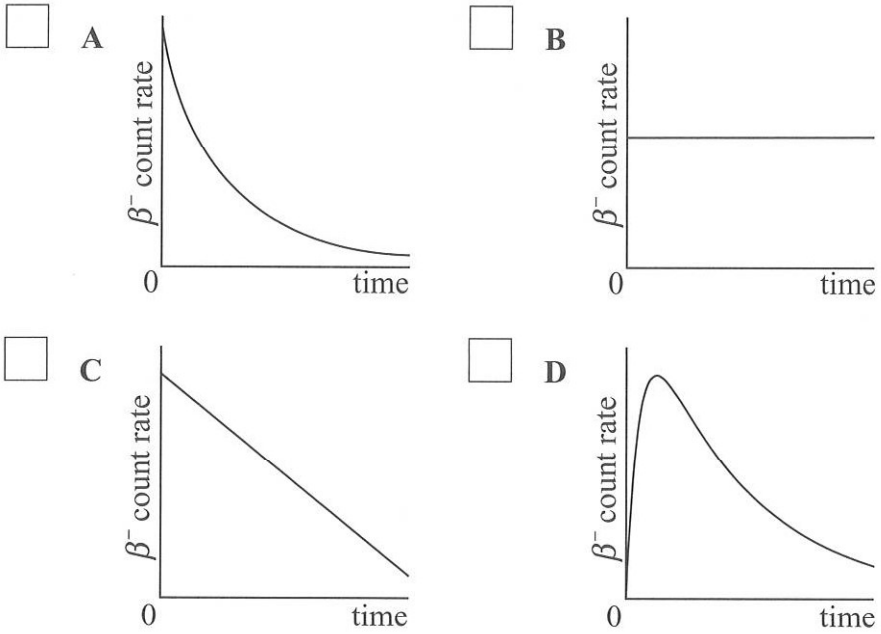
3 Polonium-218 undergoes radioactive decay producing lead-214. In turn, lead-214 decays radioactively, producing bismuth-214. This decay chain is shown in **Figure 3**.

Figure 3



The half-life of polonium-218 is 3.1 minutes and the half-life of lead-214 is 26.8 minutes.

a) A sample is initially composed of pure polonium-218. A scientist measures the count rate of β^- radiation emitted by the sample. Assuming bismuth-214 is removed from the sample as soon as it is created, which of the following graphs shows how the count rate of β^- emissions from the sample varies over time? Tick **one** box.



[1]

b) Explain your answer to part (a).

.....

.....

.....

.....

.....

[3]

[Total 4 marks]

Exam Practice Tip

Pretty much every topic you will cover for your GCSE exams will feature graphs of some sort or another. So being able to interpret all sorts of graphs is a really useful skill to have. Get used to using graphs to work out how two variables are linked or how a system changes over time.

Score: ____ / **20**

Uses and Dangers of Nuclear Radiation

1 Radioactive isotopes are used as tracers in medical imaging.

a) The radioactive isotope iodine-131 has a half-life of 8.0 days and an atomic number of 53. It is used as a medical tracer. It is taken into the body and a detector outside the body traces its position. Iodine-131 undergoes beta decay and then gamma decay to form stable xenon. The chemical symbols for iodine and xenon and I and Xe respectively. Write **two** nuclear decay equations to show these processes.

1. .....

2. .....

[4]

b) Describe how a nucleus changes as a result of emitting gamma radiation.

.....

.....

[2]

c) Give **two** reasons why iodine-131 is a suitable radioactive isotope to be used as a medical tracer.

1. .....

.....

2. .....

.....

[2]

d) Iodine-131 can be used in radioiodine therapy to treat thyroid cancer. Iodine-131 capsules are taken by the patient and the isotope travels to the thyroid where it kills cancer cells with radiation. Suggest why patients receiving this treatment often have to stay in hospital and why there are strict limitations on visitors.

.....

.....

.....

[2]

e) Iodine-131 does not occur in nature, but it can be produced in a laboratory by bombarding naturally occurring tellurium nuclei with neutrons. A significant fraction of the neutrons fired at a tellurium target will pass through without interacting with the tellurium nuclei. Suggest **two** explanations for why this happens.

1. .....

.....

2. .....

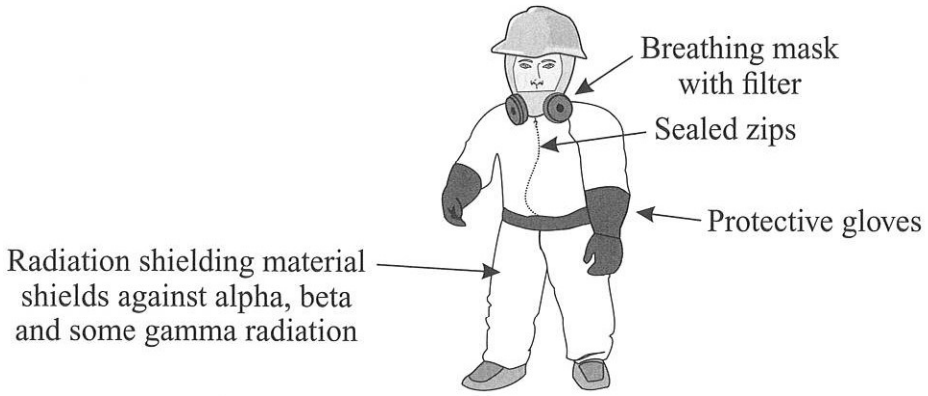
.....

[2]

[Total 12 marks]

2 Uranium-235 is a radioactive material used as fuel in fission reactors. It releases both gamma rays and alpha particles as part of the decay process. Workers at nuclear power stations wear protective suits, as shown in **Figure 1**, when working with uranium-235.

Figure 1



a)* Evaluate the risks of contamination and irradiation from the different types of radiation emitted by uranium-235. Include an explanation of how the design of the protective suit in **Figure 1** protects the user from these risks.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[6]

b) Uranium-235 undergoes nuclear fission in a nuclear reactor. Which equation shows the nuclear fission of uranium-235 in a nuclear chain reaction? Tick **one** box.

☐ **A** $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + {}^{144}_{56}Ba$

☐ **B** $^{235}_{92}U \rightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + 2{}^{1}_{0}n$

☐ **C** $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + 3{}^{1}_{0}n$

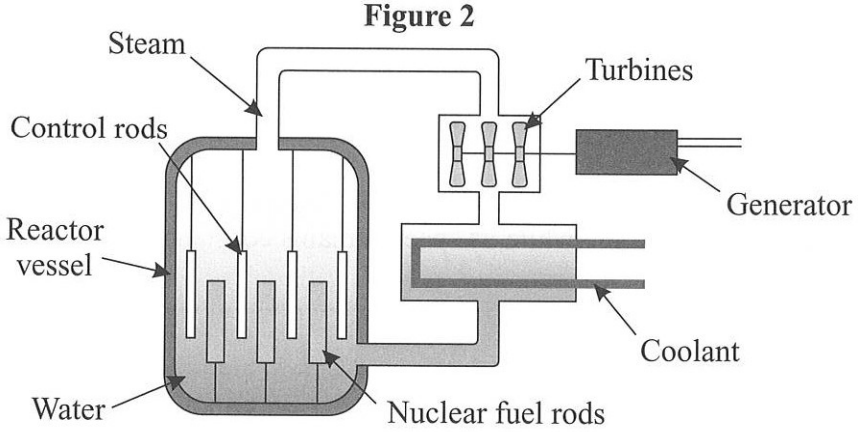
☐ **D** $^{235}_{92}U + 3{}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + {}^{1}_{0}n$

[1]

[Total 7 marks]

3 **Figure 2** shows a boiling water nuclear reactor.

Figure 2



a) In a nuclear reactor, the nuclear fuel rods generate huge amounts of energy which heat the water surrounding the fuel rods. As the water is heated it boils and turns into steam. The steam rushes from the reactor vessel and turns the turbines, generating electricity in the generator.
Which of the following increases the energy produced by a nuclear reactor? Tick **one** box.

- ☐ **A** Cooling the steam before it reaches the turbines.
- ☐ **B** Increasing the boiling point of the water in the reactor.
- ☐ **C** Increasing the number of secondary fissions caused by each fission in the chain reaction.
- ☐ **D** Adding more neutron-absorbing control rods.

[1]

b) A beta-emitting radioactive isotope called iodine-131 is often released into the air during nuclear accidents. It can settle on skin and clothing and can be inhaled or ingested. Iodine is absorbed in the body by the thyroid gland, where it is used to make molecules that travel throughout the body. When the thyroid gland has enough iodine, any excess iodine is removed by the body. If a nuclear accident occurs at a power plant, workers are asked to ingest potassium iodide tablets which contain a stable isotope of iodine. Explain how this minimises the risk of damage to their bodies.

.....

.....

.....

.....

.....

.....

[4]

[Total 5 marks]

Exam Practice Tip

Multiple choice questions — you'd be forgiven for thinking they're a gift from the examiner. I mean, the answer's right there in front of you on the page. But they can be trickier than you might think. Before you commit to an answer, quickly check you can eliminate all the other possibilities.

Score: ☐ / **24**