Questions are for both separate science and combined science students

Q1.

Some isotopes emit nuclear radiation.

(a) Carbon-14 and carbon-12 are isotopes of carbon.

Compare the structure of an atom of carbon-14 with the structure of an atom of carbon-12.

Similarities:

C-12 and C-14 have same number of protons thus, same number of electrons and same Atomic Number

Differences:

C-12 and C-14 have different number of neutrons and hence masses

(3)

(b) Carbon-14 is a radioactive isotope.

Carbon-14 has a half-life of 5700 years.

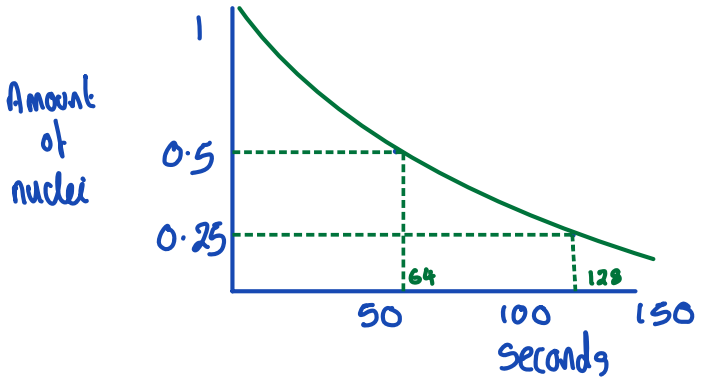
What does 'a half-life of 5700 years' mean?

The time it takes for the number of nuclei in a radioactive sample to halve (5700 years for C-14)

(1)

The table below gives the half-life of some other radioactive isotopes.

Isotope	Half-life in seconds
Nitrogen-18	0.62
Nitrogen-17	4.17
Fluorine-17	64.37
Fluorine-18	6584.34



(c) A sample of fluorine-17 has an activity that is one quarter of its original activity.

Calculate the age of the sample of fluorine-17.

1 $\xrightarrow{t_{1/2}}$ ½ $\xrightarrow{t_{1/2}}$ ¼ = 2 halflives.

t½ for F-17 = 64.37 s

time to decay to ¼ original = 64.37 × 2 = 128.74

Age = 128.74 s

(2)

(d) All of the isotopes in the table above emit beta radiation.

Explain which isotope would cause the biggest risk to a person's health based only on the half-life of each isotope.

The shorter the half-life, the greater the activity. The greater the activity, the more radiation emitted per second.

So greatest dose of radiation absorbed, per second and greatest risk.

Nitrogen-18 has the shortest half-life of 0.62 s

(3)

(e) People who work in the nuclear power industry need to be aware of irradiation and contamination.

Describe the difference between irradiation and contamination.

Irradiation: Exposure of a person or object to radiation.

Contamination: Unwanted presence of radioactive material on a person or object.

(2)

(f) Give **one** health risk to a person working close to a source of nuclear radiation.

Cancer (radiation poisoning etc.)

(1)

(g) Workers in nuclear power stations are monitored to check the radiation they emit.

A worker stands 1 cm away from a radiation detector.

The amount of radiation the worker emits is recorded.

Explain why the worker needs to stand close to the radiation detector.

Some radioactive materials emit alpha (α) radiation which has a very short range in air. Needs to stand close so any α is recorded.

(2)

(h) Workers in the nuclear power industry are exposed to nuclear radiation.

Pilots on aircraft are exposed to cosmic radiation from space.

daily dose caused by working in a nuclear power station = 0.00050 mSv

hourly dose from cosmic rays to a pilot while flying = 0.0030 mSv

Calculate the number of days it takes for a nuclear power station worker to receive the same dose as a pilot flying for 24 hours.

Pilot's dose = 0·003 mSv per hour

= 0·003 mSv × 24

= 0·072 mSv.

Worker's dose = 0·0005 mSv per day

No. equivalent days = $\frac{0·072}{0·0005}$ = 144 days

Number of days = 144

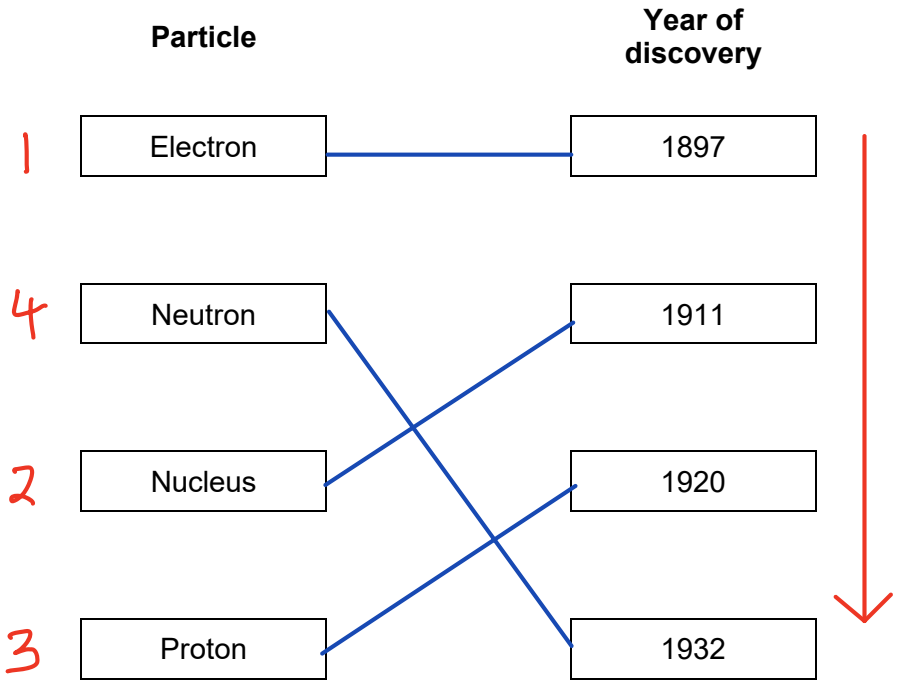
(3)

(Total 17 marks)

Q2.

Scientists developed new models of the atom as new particles were discovered.

(a) Draw **one** line from each particle to the year it was discovered.

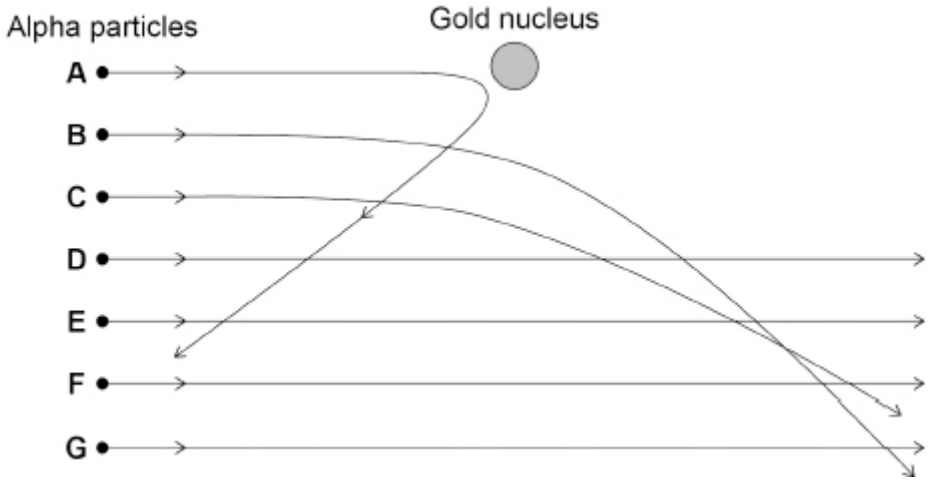


(2)

The nucleus was discovered using an alpha particle scattering experiment.

Alpha particles were directed at a sheet of gold foil.

The figure below shows the paths taken by seven alpha particles, **A**, **B**, **C**, **D**, **E**, **F** and **G**.



(b) Explain why alpha particle **A** takes the path shown in the figure above.

Both the alpha particles and the gold nucleus have +ve charge. Like charges repel, so the alpha particle and the gold nucleus repel each other.

(2)

(c) Explain why the path of alpha particle **B** is more tightly curved than the path of alpha particle **C**.

Particle B passes closer to the nucleus, so experiences a stronger repulsive force.

(2)

(d) What can be deduced about the atom from the paths taken by alpha particles **D**, **E**, **F** and **G** in the figure above?

Tick (✓) **one** box.

The atom contains a nucleus.	☐
The atom contains protons, neutrons and electrons.	☐
The atom is mostly empty space.	✓

(1)

(e) How is the Bohr model of the atom different from the nuclear model of the atom?

In the Bohr model, the electrons orbit the nucleus at specific distances. Unlike the constructed nuclear model.

(1)

(f) Explain how an electron can move up and down between energy levels in an atom.

To move to a higher energy level, an electron absorbs energy from electromagnetic radiation
To move to a lower energy level, an electron emits energy in the form of electromagnetic radiation

(2)

(Total 10 marks)