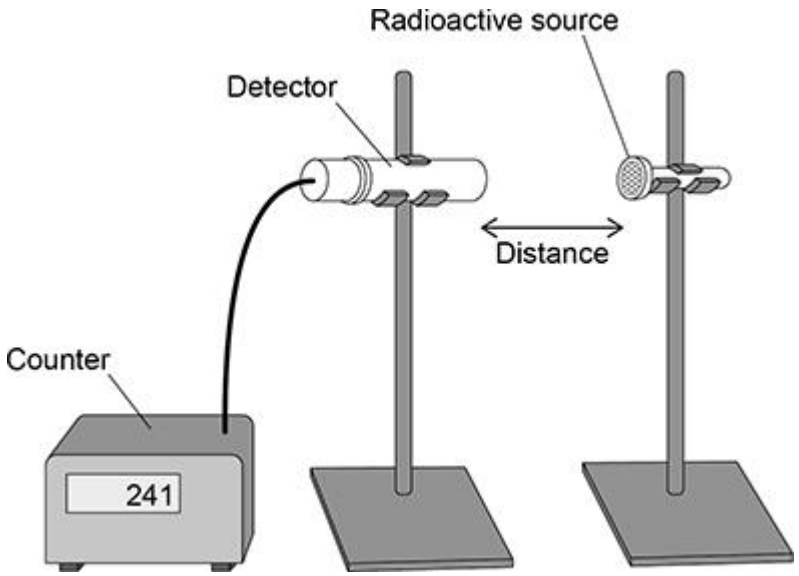
**Questions are for separate science students only**

## Q1.

A teacher investigated the radiation emitted by two different radioactive sources, **A** and **B**.

**Figure 1** shows a radiation detector positioned near one of the radioactive sources. **(Physics only)**

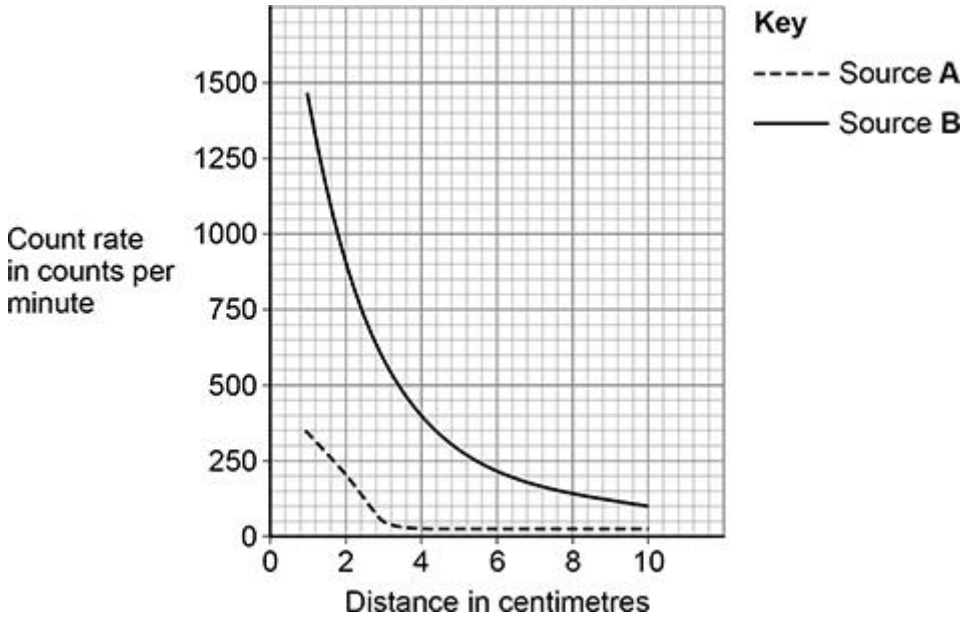
**Figure 1**




The teacher measured the count rate at different distances for each radioactive source.

**Figure 2** shows the results.

**Figure 2**



(a) Explain how **Figure 2** shows that Source **A** only emits alpha radiation. **(HT only)**

Radiation from Source A travels ~ 3 cm in air, after which the count rate decreases to background radiation, because alpha (α) radiation has a short range in air

**(3)**

(b) **Figure 2** can **not** be used to determine if Source **B** emits beta radiation or gamma radiation.

Explain how an absorbing material could be used to show which type of radiation is emitted by Source **B**. **(HT only)**

Use an aluminium sheet, which beta (β) radiation will not penetrate, but gamma (γ) will.

**(2)**

The teacher took safety precautions during the experiment.

(c) Suggest **one** safety precaution the teacher would have taken to reduce the radiation dose the teacher received.

Increase distance between source and teacher.

**(1)**

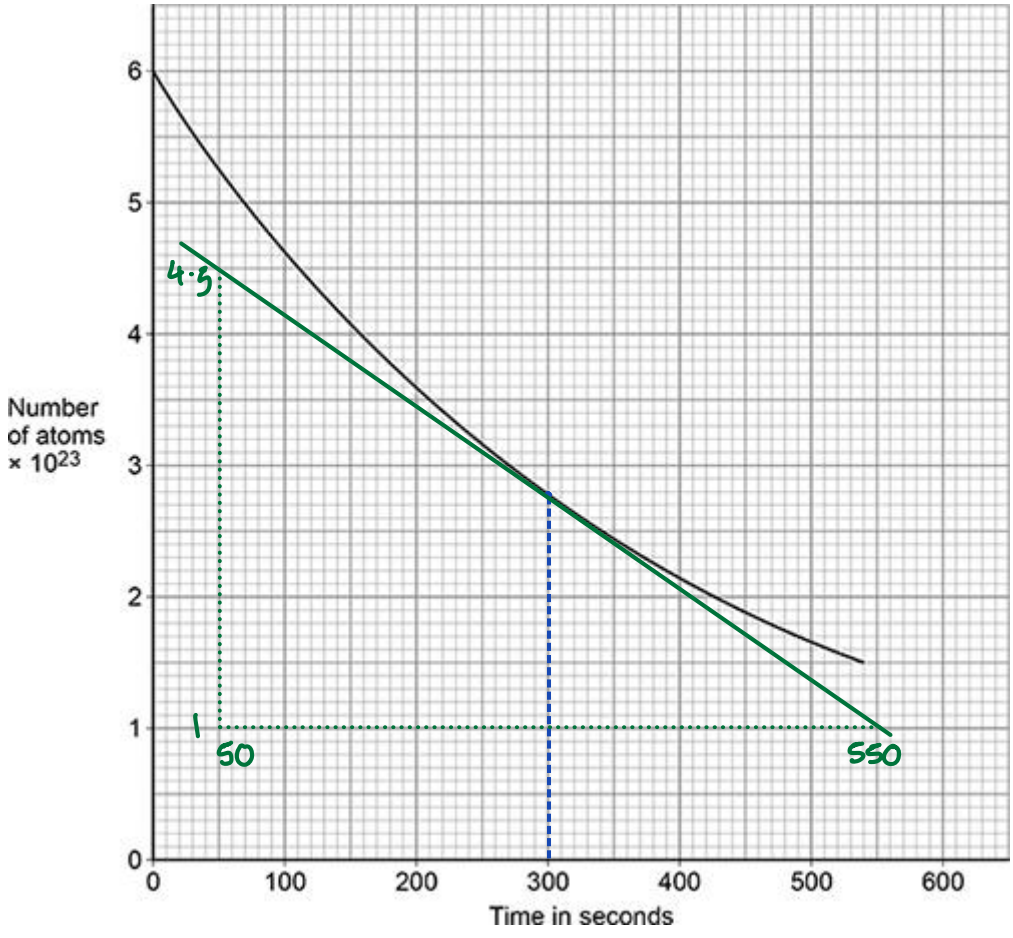
(d) Suggest **one** safety precaution that the teacher would have taken to avoid becoming contaminated.

Wear a lab coat and gloves.

**(1)**

(e) **Figure 3** shows how the number of atoms of a radioactive element in a sample varied with time.

**Figure 3**



Activity is the rate at which a source of unstable nuclei decays.

Determine the activity of the radioactive sample at 300 seconds.

Give the unit.

Rate = Gradient of tangent at 300 s:

Gradient = $\frac{\text{change in } y}{\text{change in } x} = \frac{(1 - 4.5)\times10^{23}}{550 - 50}$

$= -7\times10^{20}$ rate $= 7\times10^{20}$ atoms per sec.

Activity = $7\times10^{20}$ Unit Bq

**(4)**

**(Total 11 marks)**

Activity measured in: decays per second or Becquerel (Bq)

N.B. Even though the gradient slopes down and is negative, the rate at which the nuclei are decaying is positive.

## Q2.

(a) Carbon-14 is a radioactive isotope. **(Physics only)**

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

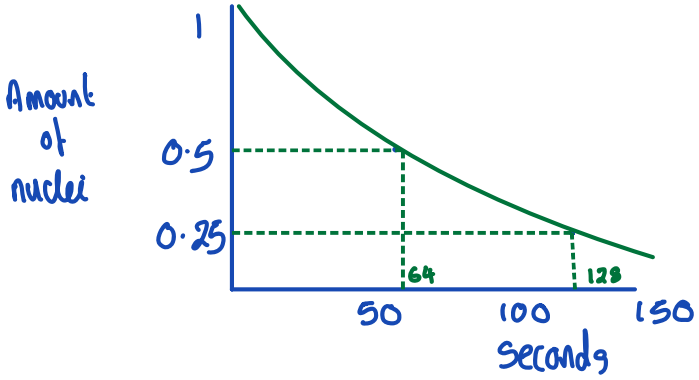
What does 'a half-life of 5700 years' mean?

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 |




(b) 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. **(HT only)**

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

$t_{1/2}$ for F-17 = 64.37 s

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

Age = 128.74 s

**(2)**

(c) 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. **(HT only)**

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)**

(d) 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)**

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

Cancer (radiation poisoning etc.)

**(1)**

(f) 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 ($\alpha$) radiation which has a very short range in air.

Needs to stand close so any $\alpha$ is recorded.

**(2)**

(g) 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 = $\frac{0·072}{0·0005}$ = 144 days

days

Number of days = 144

**(3)**

**(Total 14 marks)**