7 Radon-222 is an isotope of radon which undergoes a series of radioactive decays.

Fig. 7.1 is a diagram showing the proton number (atomic number) and nucleon number (mass number) of nuclei involved in the series of decays.

The point P represents a nucleus of radon-222.

Starting at P, a nucleus of radon-222 decays to Q; then from Q to R; then from R to S; then from S to T; and finally from T to U.

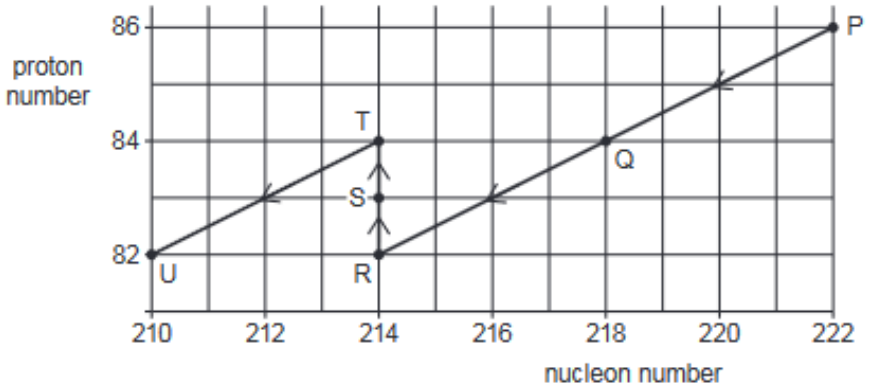

Fig. 7.1

(a) (i) State two points on Fig. 7.1 which represent isotopes of the same element.

..... [1]

(ii) Different isotopes of the same element have different atomic compositions.

State how the composition of their atoms is different.

.....

..... [1]

(b) A nucleus of radon-222 emits an alpha-particle as it decays.

(i) The radioactive decay of a single nucleus is random.

Explain what is meant by the *random* radioactive decay of a nucleus.

.....

.....

..... [1]

(ii) In nuclide notation, radon-222 is written as $^{222}_{86}Rn$.

When a nucleus of radon-222 emits an alpha-particle (α), it decays to an isotope of polonium (Po).

Complete the decay equation below for this decay.

$$^{222}_{86}Rn \rightarrow \begin{matrix}\cdots\cdots\\ \cdots\cdots\end{matrix} Po + \begin{matrix}\cdots\cdots\\ \cdots\cdots\end{matrix} \alpha$$

[2]

(c) (i) State the name of the particle emitted as a nucleus of R decays to a nucleus of S.

..... [1]

(ii) Describe the change in the composition of a nucleus of R as it decays to a nucleus of S.

.....

.....

..... [2]

[Total: 8]

7 Two isotopes of carbon are carbon-12 and carbon-14.

One of these isotopes, carbon-14, undergoes radioactive decay.

(a) Describe what is meant by *radioactive decay*.

.....

..... [2]

(b) Carbon-12 has a proton number (atomic number) of 6 and a nucleon number (mass number) of 12.

Complete Table 7.1 for a neutral atom of each of these two isotopes.

Table 7.1

	carbon-12	carbon-14
number of protons	6	
number of neutrons		
number of electrons		

[2]

(c) A sample of carbon-14 is contained in a thin aluminium container of thickness 0.2 mm.

Radiation from the sample is detected outside the container.

When the thickness of the aluminium is increased to 6 mm, no radiation from the sample is detected outside the container.

(i) State the type of radiation which is stopped by increasing the thickness of the aluminium.

..... [1]

(ii) Explain how you know that the sample does **not** emit one other type of radiation.

.....

.....

.....

..... [2]

[Total: 7]

9 Protactinium-234 ($^{234}_{91}$Pa) is a radioactive isotope of protactinium that decays to uranium-234 ($^{234}_{92}$U).

(a) Compare the nuclide notation $^{234}_{91}$Pa with the nuclide notation $^{234}_{92}$U and deduce what this shows about what is emitted from a nucleus of protactinium-234 as it decays to uranium-234.

Place a tick (✓) in the appropriate boxes of Table 9.1 to show what is deduced from comparing the nuclide notations.

Table 9.1

	yes	no	it is not possible to tell
an alpha-particle is emitted			
a beta-particle is emitted			
a gamma ray is emitted			

[2]

(b) The most abundant isotope of protactinium is protactinium-231.

(i) Explain, by referring to their nuclear compositions, why protactinium-231 and protactinium-234 are both isotopes of the same element.

.....

..... [1]

(ii) Explain, by referring to their nuclear compositions, why protactinium-231 and protactinium-234 are different isotopes of that element.

.....

..... [1]

(c) A teacher places a radiation detector on a bench in a school laboratory and switches it on.

(i) The teacher measures and records the background radiation count rate.

Describe what is meant by 'background radiation' and state **two** significant sources of the count rate recorded by the teacher.

background radiation .....

.....

source 1 .....

source 2 .....

[3]

(ii) The teacher moves a sample of protactinium-234 so that it is next to the detector.

Suggest **one** precaution that ensures that the sample is moved in a safe way.

.....

..... [1]

(iii) The count rate is measured every 20 s with the sample present, and then corrected for background radiation.

Fig. 9.1 shows a graph of the corrected count rate against time for the protactinium-234 sample.

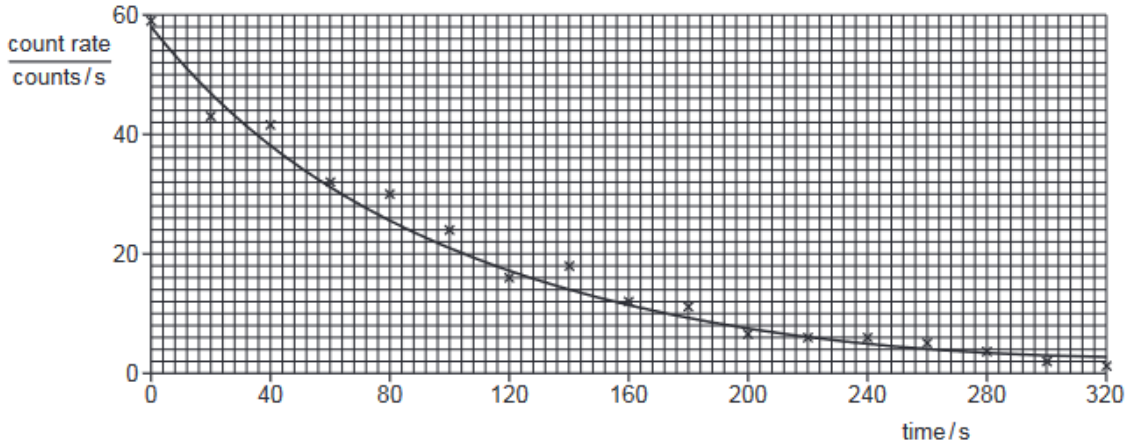

Fig. 9.1

The curve is the best-fit line.

Explain why many of the crosses do not lie on the curve.

.....

.....

..... [2]

(iv) Using Fig. 9.1, determine the half-life of protactinium-234.

Show your working.

half-life = ... [3]

(v) The uranium-234 formed from the protactinium-234 is also radioactive. Its half-life is many thousands of years.

Explain why the radiation from uranium-234 does **not** affect the count rates measured in this experiment.

.....

.....

..... [2]

[Total: 15]