Q1. There are many different isotopes of gold. The isotope, gold-198, is radioactive.
An atom of gold-198 decays by emitting a beta particle.

(a) Complete the following sentences.

All atoms of gold have the same number of .....

and the same number of ..... .

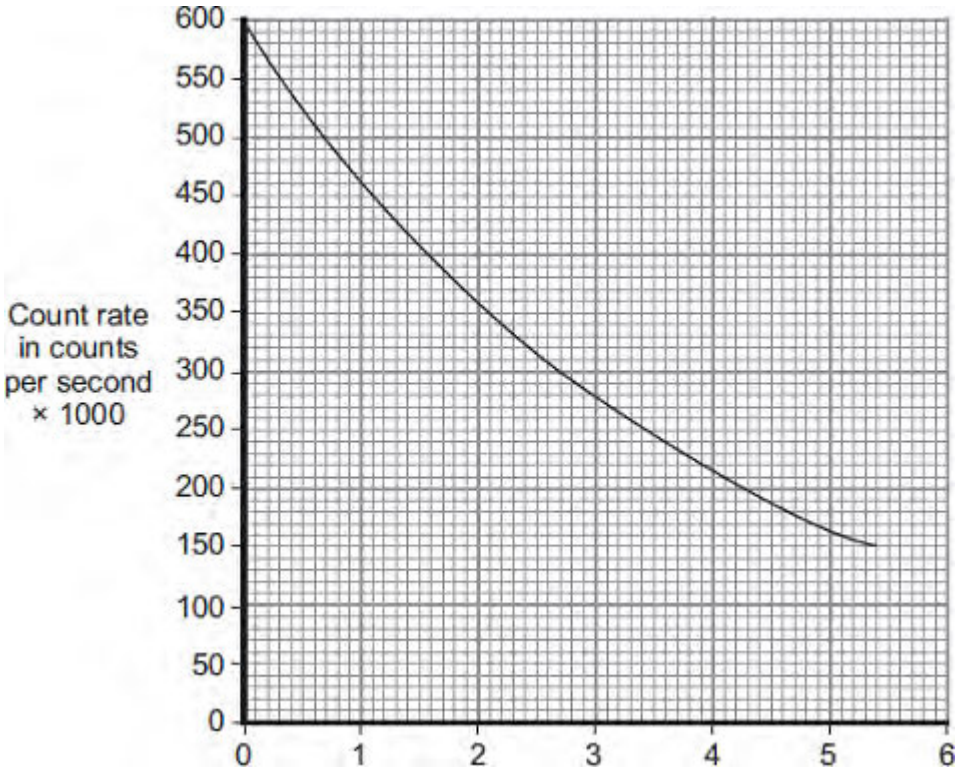
The atoms from different isotopes of gold have different numbers of ..... .

A beta particle is an ..... emitted

from the ..... of an atom.

(3)

(b) The graph shows how the count rate from a sample of gold-198 changes with time.



Use the graph to calculate the half-life of gold-198.

Show clearly on the graph how you obtain your answer.

.....

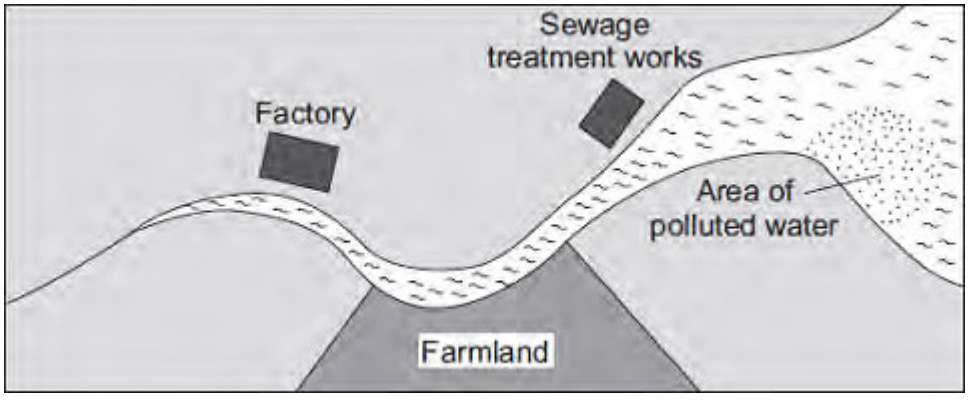
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Half-life = ... days

(2)

(c) The diagram shows a map of a river and the river estuary.

Environmental scientists have found that water flowing into one part of the river estuary is polluted. To find where the pollution is coming from, the scientists use a radioactive isotope, gold-198.



The gold-198 is used to find where the pollution is coming from.

Explain how.

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(2)

(Total 7 marks)

Q2. (a) Complete the following table for an atom of uranium-238 ($^{238}_{92}U$)

mass number	238
number of protons	92
number of neutrons	

(1)

(b) Complete the following sentence.

The name given to the number of protons in an atom is the proton number or the

..... .

(1)

(c) An atom of uranium-238 ($^{238}_{92}U$) decays to form an atom of thorium-234 ($^{234}_{90}Th$).

(i) What type of radiation, alpha, beta or gamma, is emitted by uranium-238?

.....

(1)

(ii) Why does an atom that decays by emitting alpha or beta radiation become an atom of a different element?

.....

.....

(1)

(Total 4 marks)

Q3. Most elements have some *isotopes* which are *radioactive*.

(a) What is meant by the terms:

(i) *isotopes*

.....

.....

(1)

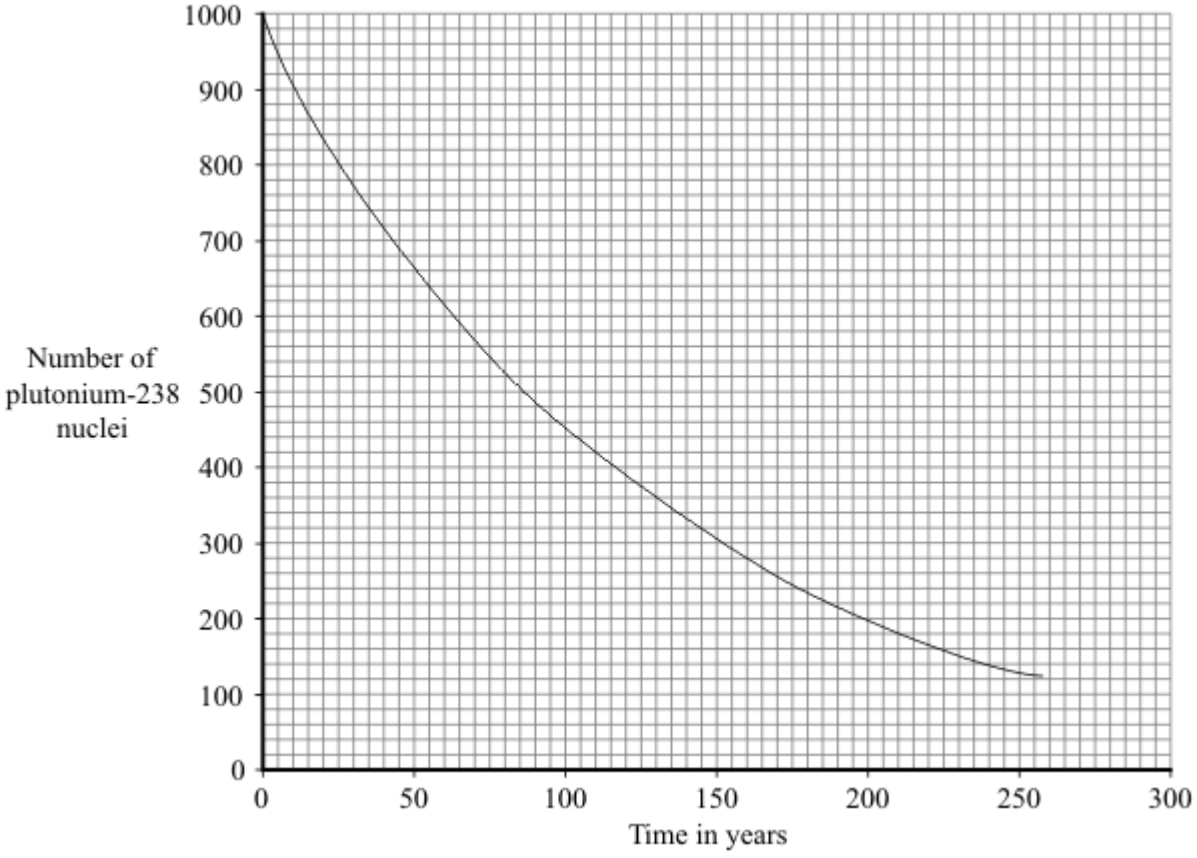
(ii) *radioactive*?

.....

.....

(1)

(b) The graph shows how the number of nuclei in a sample of the radioactive isotope plutonium-238 changes with time.



Use the graph to find the half-life of plutonium-238.

Show clearly on the graph how you obtain your answer.

Half-life = ... years

(2)

(c) The Cassini spacecraft launched in 1997 took seven years to reach Saturn.

The electricity to power the instruments on board the spacecraft is generated using the heat produced from the decay of plutonium-238.

(i) Plutonium-238 decays by emitting alpha particles.

What is an alpha particle?

.....

(1)

(ii) During the 11 years that Cassini will orbit Saturn, the output from the generators will decrease.

Explain why.

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.....

(2)

(d) Plutonium-238 is highly dangerous. A tiny amount taken into the body is enough to kill a human.

(i) Plutonium-238 is unlikely to cause any harm if it is outside the body but is likely to kill if it is inside the body.

Explain why.

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.....

.....

.....

(2)

(ii) In 1964, a satellite powered by plutonium-238 was destroyed, causing the release of radioactive material into the atmosphere.

Suggest why some environmental groups protested about the launch of Cassini.

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.....

(1)

(Total 10 marks)

Q4.(a) Atoms of the isotope bismuth-212 decay by emitting either an alpha particle or a beta particle.
The equation represents what happens when an atom of bismuth-212 decays by beta emission into an atom of polonium-212.

$$^{212}_{83}\text{Bi} \longrightarrow {}^{212}_{84}\text{Po} + \text{beta particle}$$

(i) The bismuth atom and the polonium atom have the same mass number (212).

What is the *mass number* of an atom?

.....

(1)

(ii) Beta decay does **not** cause the mass number of an atom to change.

Explain why not.

.....

.....

.....

.....

(2)

(b) When an atom of bismuth-212 emits an alpha particle, the atom decays into an atom of thallium.

An alpha particle is the same as a helium nucleus.
The symbol below represents an alpha particle.

$$^{4}_{2}\text{He}$$

(i) The equation below represents the alpha decay of bismuth-212.

Complete the equation by writing the correct number in each of the two boxes.

$$^{212}_{83}\text{Bi} \longrightarrow \square \quad \square \quad \text{Tl} + {}^{4}_{2}\text{He}$$

(2)

(ii) It is impossible for the alpha decay of bismuth-212 to produce the same element as the beta decay of bismuth-212.

Explain why.

.....

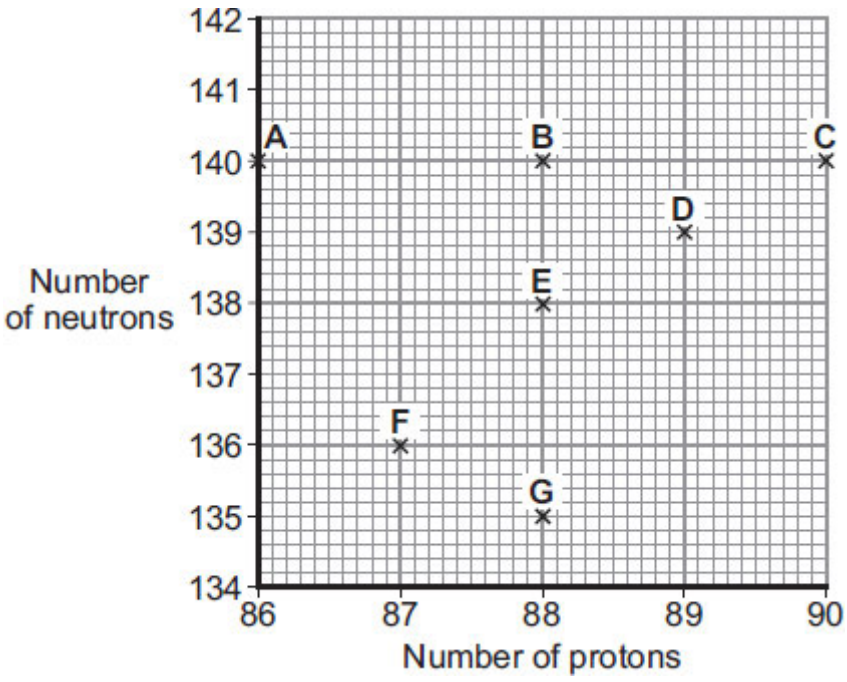
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(2)
(Total 7 marks)

Q5. (a) The chart gives the number of protons and neutrons within the nuclei of 7 different atoms, **A – G**.



Which of these atoms are isotopes of the same element?

.....

Give a reason for your answer.

.....

.....

(2)

(b) Radium-226 is a radioactive isotope that decays into radon gas by emitting alpha particles.

The decay can be represented by the equation below.

$$^{226}_{88}\text{Ra} \longrightarrow \square\!\!\square + \text{Rn} + \text{alpha particle}$$

(i) Complete the equation by writing the correct number in each of the boxes.

(2)

(ii) A sample of radium-226 has a count rate of 400 counts per second.

The half-life of radium-226 is 1600 years.

How long will it be before the count rate has fallen to 50 counts per second?

Show clearly how you work out your answer.

.....

.....

.....

Length of time = ... years

(2)

(c) In 1927, a group of women who had been employed to paint watch faces with a luminous paint sued their former employer over the illnesses caused by the paint. The women had been told that the paint, which contained radium, was harmless.

The company owners and the scientists working for the company knew that radium was harmful and took precautions to protect themselves from the radiation. The women were given no protection.

What important issue did the treatment of the women by the company owners and scientists raise?

Draw a ring around your answer.

economic **environmental** **ethical** **social**

Give a reason for your answer.

.....

.....

(2)

(d) In the 1920s, many people, including doctors, thought that radium could be used as a treatment for a wide range of illnesses. Medical records that suggested radium could be harmful were generally ignored. When some of the women who had used the luminous paint died, their deaths were not blamed on radium.

Suggest a reason why the evidence suggesting that radium was harmful was generally ignored.

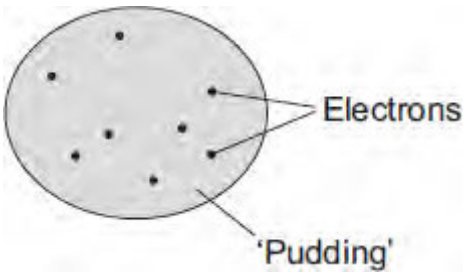
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(1)
(Total 9 marks)

Q6. The 'plum pudding' model of the atom was used by scientists in the early part of the 20th century to explain atomic structure.



(a) Those scientists knew that atoms contained electrons and that the electrons had a negative charge. They also knew that an atom was electrically neutral overall.

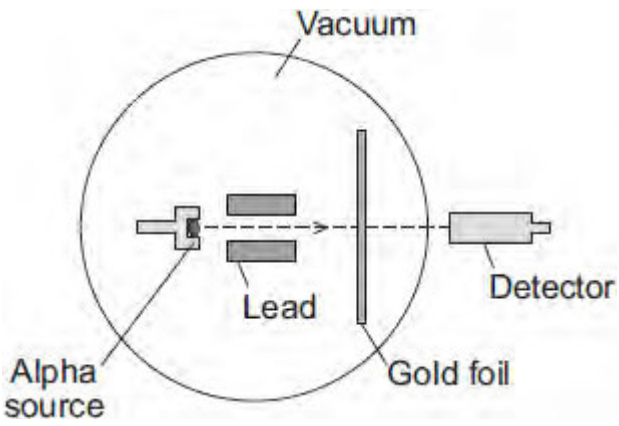
What did this allow the scientists to deduce about the 'pudding' part of the atom?

.....

.....

(1)

(b) An experiment, designed to investigate the 'plum pudding' model, involved firing alpha particles at a thin gold foil.



If the 'plum pudding' model was correct, then most of the alpha particles would go straight through the gold foil. A few would be deflected, but by less than 4 °.

The results of the experiment were unexpected. Although most of the alpha particles did go straight through the gold foil, about 1 in every 8 000 was deflected by more than 90 °.

Why did this experiment lead to a new model of the atom, called the nuclear model, replacing the 'plum pudding' model?

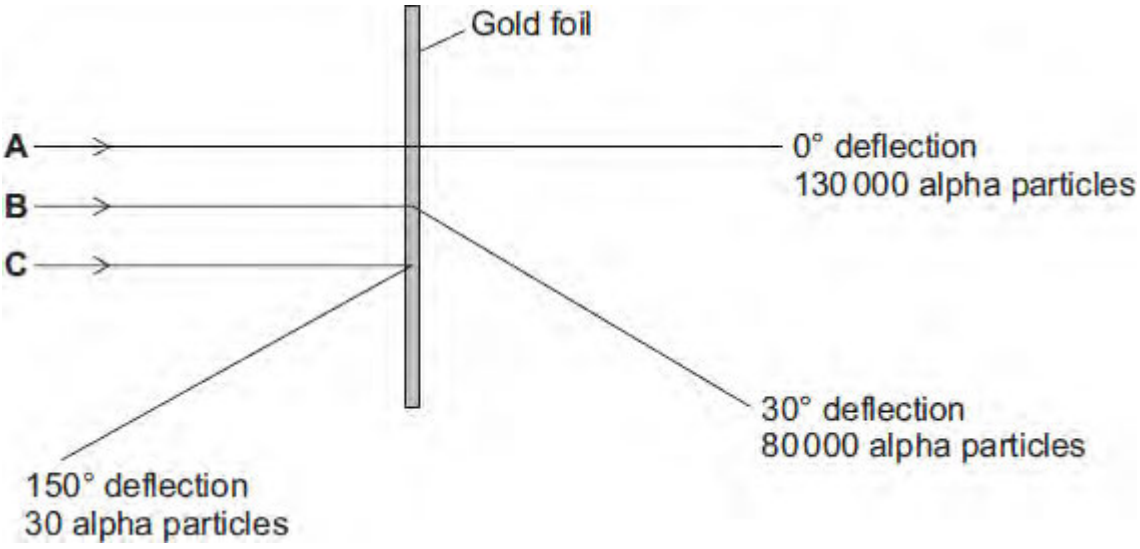
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(1)

(c) The diagram shows the paths, **A**, **B** and **C**, of three alpha particles. The total number of alpha particles deflected through each angle is also given.



(i) Using the nuclear model of the atom, explain the three paths, **A**, **B** and **C**.

A .....

.....

B .....

.....

C .....

.....

(3)

(ii) Using the nuclear model, the scientist E. Rutherford devised an equation to predict the proportion of alpha particles that would be deflected through various angles.

The results of the experiment were the same as the predictions made by Rutherford.

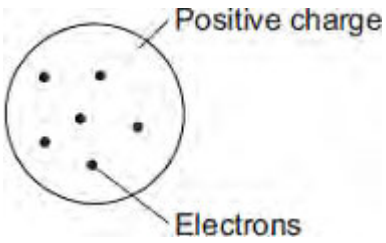
What was the importance of the experimental results and the predictions being the same?

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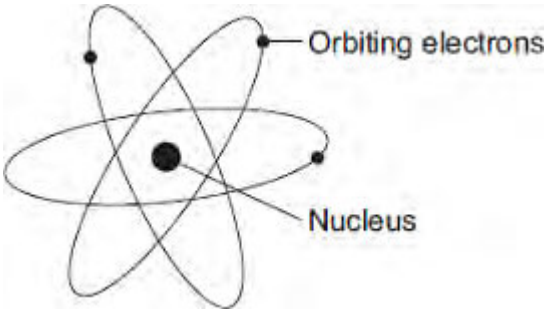
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(1)
(Total 6 marks)

Q7. In the early part of the 20th century, scientists used the 'plum pudding' model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the 'nuclear' model, was suggested.



Describe the differences between the two models of the atom.

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(Total 4 marks)

Q8.A student models the random nature of radioactive decay using 100 dice.

He rolls the dice and removes any that land with the number 6 facing upwards.

He rolls the remaining dice again.

The student repeats this process a number of times.

The table below shows his results.

Roll number	Number of dice remaining
0	100
1	84
2	70
3	59
4	46
5	40
6	32
7	27
8	23

(a) Give **two** reasons why this is a good model for the random nature of radioactive decay.

1 .....

.....

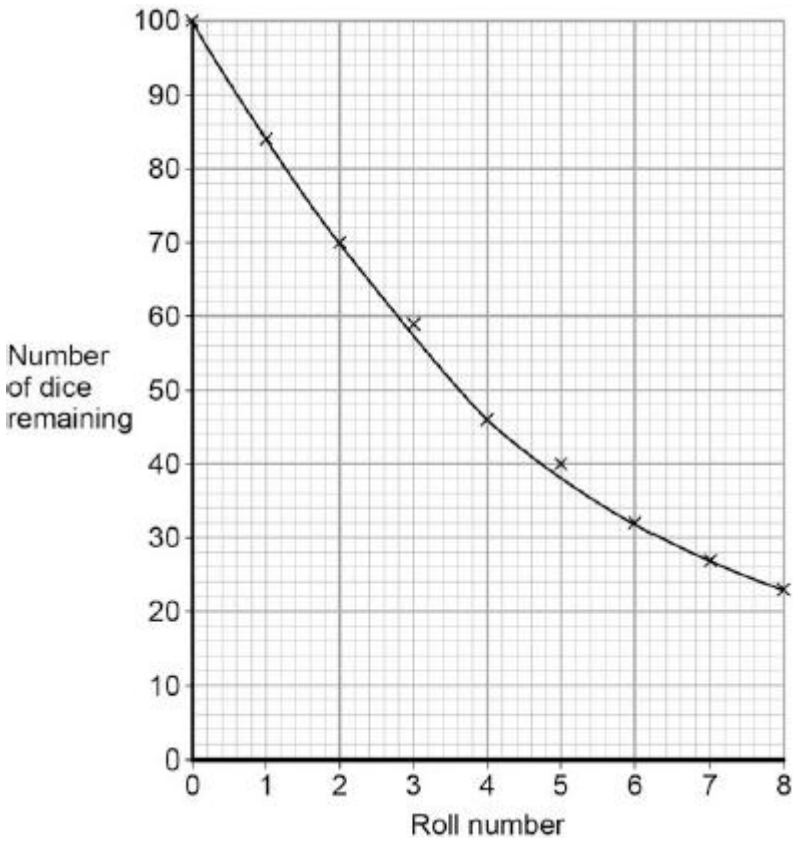
2 .....

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(2)

(b) The student's results are shown in **Figure 1**.

Figure 1



Use **Figure 1** to determine the half-life for these dice using this model.

Show on **Figure 1** how you work out your answer.

Half-life = ... rolls

(2)

(c) A teacher uses a protactinium (Pa) generator to produce a sample of radioactive material that has a half-life of 70 seconds.

In the first stage in the protactinium generator, uranium (U) decays into thorium (Th) and alpha (α) radiation is emitted.

The decay can be represented by the equation shown in **Figure 2**.

Figure 2

$$^{238}_{92}U \longrightarrow \,^{234}_{\square}Th + \alpha$$

Determine the atomic number of thorium (Th) 234.

Atomic number = ...

(1)

(d) When protactinium decays, a new element is formed and radiation is emitted.

The decay can be represented by the equation shown in **Figure 3**.

Figure 3

$$^{234}_{91}Pa \rightarrow {}^{234}_{92}X + radiation$$

When protactinium decays, a new element, **X**, is formed.

Use information from **Figure 2** and **Figure 3** to determine the name of element **X**.

.....

(1)

(e) Determine the type of radiation emitted as protactinium decays into a new element.

Give a reason for your answer.

.....

.....

.....

.....

(2)

(f) The teacher wears polythene gloves as a safety precaution when handling radioactive materials.

The polythene gloves do **not** stop the teacher's hands from being irradiated.

Explain why the teacher wears polythene gloves.

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(2)

(Total 10 marks)