Exampro GCSE Physics

P2 Radioactivity Self Study Questions Higher tier

Name:

Class:

Author:

Date:

Time: 80

Marks: 80

Comments:

Q1. A beta particle is a high-energy electron.

(i) Which part of an atom emits a beta particle?

.....

(1)

(ii) How does the composition of an atom change when it emits a beta particle?

.....

(1)

(Total 2 marks)

Q2. (a) (i) Describe the structure of alpha particles.

.....

.....

.....

.....

(2)

(ii) What are beta particles?

.....

.....

.....

(1)

(b) Describe how beta radiation is produced by a radioactive isotope.

.....

.....

(1)

(Total 4 marks)

Q3. When atoms of uranium 238 (U^{234}) decay they produce another radionuclide called thorium 234 (Th^{234})

Thorium 234 (Th^{234}) decays by emitting beta radiation.

(i) What does beta radiation consist of?

.....

(1)

(ii) Thorium 234 (Th^{238}) decays to form protactinium 234 (Pa^{234}).

What differences are there between the nucleus of a protactinium 234 (Pa^{234}) atom and the nucleus of a thorium 234 (Th^{234}) atom?

.....

.....

(2)
(Total 3 marks)

Q4. (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

.....

(1)

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

.....

.....

(1)

(ii) Inside which part of a nuclear power station would molybdenum be produced?

.....

(1)

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}Mo \longrightarrow {}^{99}_{43}Tc + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

.....

Give a reason for your answer.

.....

.....

(2)

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term ‘half-life’?

.....

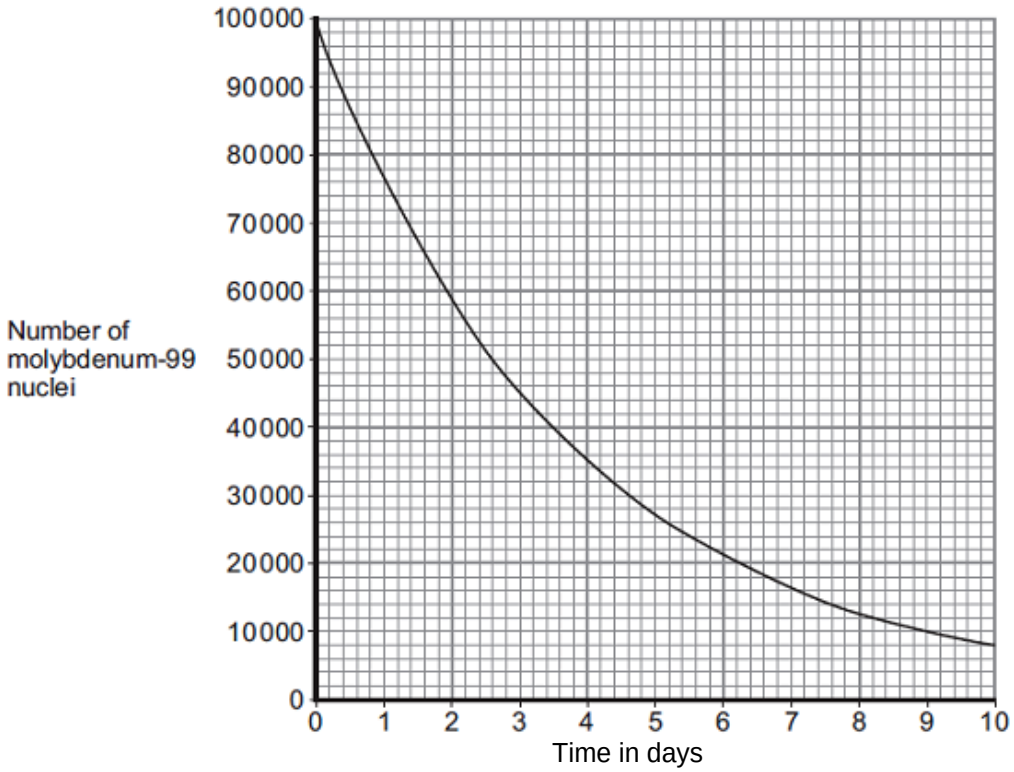
.....

.....

(1)

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.



A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

.....

.....

.....

Number of days = ...

(2)

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

.....

.....

.....

.....

(2)

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

.....

.....

(1)

(Total 11 marks)

Q5. In 2011 an earthquake caused severe damage to a nuclear power station in Japan.

The damage led to the release of large amounts of radioactive iodine-131 ($^{131}_{53}I$) into the atmosphere.

(a) The table gives some information about an atom of iodine-131 ($^{131}_{53}I$).

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1)

(b) Complete the sentence.

The number of protons in an atom is called the proton number or

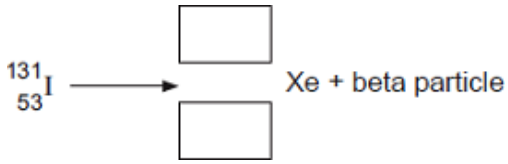
the ..... number.

(1)

(c) An atom of iodine-131 decays into an atom of xenon (Xe) by emitting a beta particle.

(i) The decay of iodine-131 can be represented by the equation below.

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



(2)

(ii) A sample of rainwater contaminated with iodine-131 gives a count rate of 1200 counts per second.

Calculate how many days it will take for the count rate from the sample of rainwater to fall to 75 counts per second.

Half-life of iodine-131 = 8 days

Show clearly how you work out your answer.

.....

.....

..... days

(2)

(iii) If people drink water contaminated with iodine-131, the iodine-131 builds up in the thyroid gland. This continues until the thyroid is saturated with iodine-131 and cannot absorb any more. The radiation emitted from the iodine-131 could cause cancer of the thyroid.

In Japan, people likely to be drinking water contaminated with iodine-131 were advised to take tablets containing a non-radioactive isotope of iodine.

Suggest why this advice was given.

.....

.....

.....

.....

(2)
(Total 8 marks)

Q6. (a) A radioactive source emits alpha (α), beta (β) and gamma (γ) radiation.

(i) Which **two** types of radiation will pass through a sheet of card?

.....

(1)

(ii) Which **two** types of radiation would be deflected by an electric field?

.....

(1)

(iii) Which type of radiation has the greatest range in air?

.....

(1)

(b) A student suggests that the radioactive source should be stored in a freezer at – 20 °C. The student thinks that this would reduce the radiation emitted from the source.

Suggest why the student is wrong.

.....

.....

(1)

(c) Phosphorus-32 is a radioactive isotope that emits beta radiation.

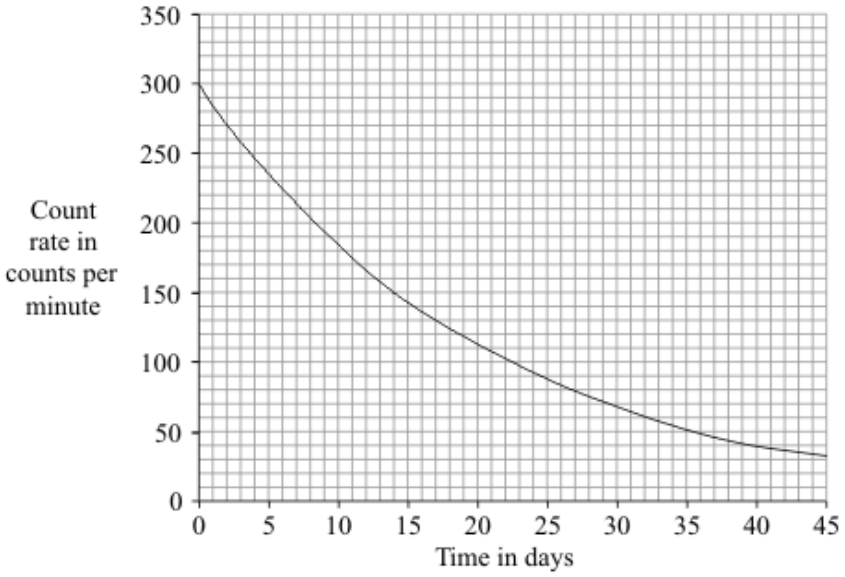
(i) How is an atom of phosphorus-32 different from an atom of the stable isotope phosphorus-31?

.....

.....

(1)

(ii) The graph shows how the count rate of a sample of phosphorus-32 changes with time.



Use the graph to calculate the half-life of phosphorus-32.

Show clearly how you used the graph to obtain your answer.

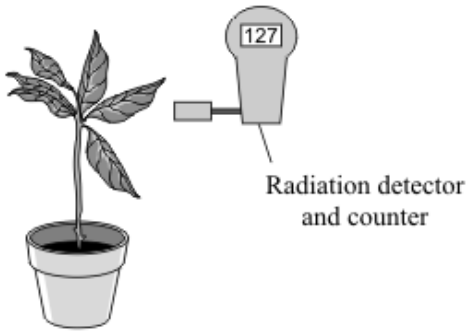
.....

.....

Half-life = ... days

(2)

(iii) Plants use phosphorus compounds to grow. Watering the root system of a plant with a solution containing a phosphorus-32 compound can help scientists to understand the growth process.



Explain why phosphorus-32 is suitable for use as a tracer in this situation.

.....

.....

.....

.....

(2)

(Total 9 marks)

Q7. (a) Alpha particles (α), beta particles (β) and gamma rays (γ) are types of nuclear radiation.

(i) Which of the three types of radiation is the most strongly ionising?

.....

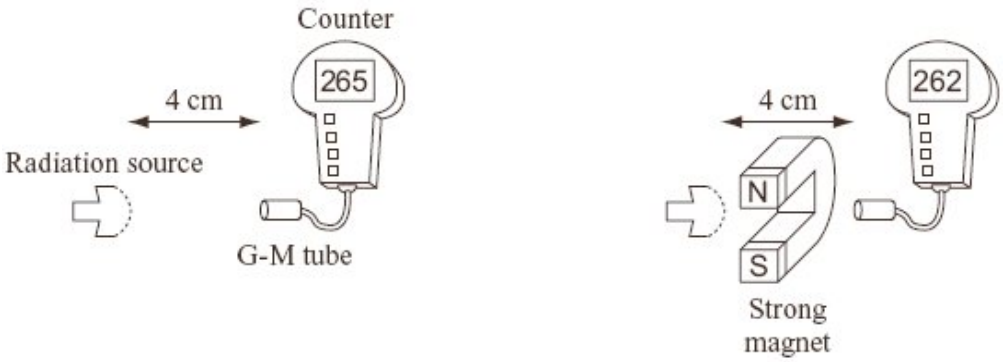
(1)

(ii) What effect does nuclear radiation have on living cells?

.....

(1)

(b) The diagrams show a G-M tube and counter used to measure the radiation emitted from a source. Both diagrams show the reading on the counter one minute after it was switched on.



Explain why the counter readings show that the source is giving out only gamma radiation.

.....

.....

.....

.....

(2)

(c) The box gives information about the radioactive isotope technetium-99.

Type of radiation emitted: gamma
Half-life: 6 hours
Used as a medical tracer

What is meant by the term *half-life*?

.....

.....

(1)

(d) To study the blood flow in a patient's lungs, a doctor injects a small quantity of a technetium-99 compound into the patient. The radiation emitted by the technetium-99 atoms is detected outside the patient's body.

Explain why a doctor would not use a radioactive isotope with a very short half-life, such as 2 seconds, as a medical tracer.

.....

.....

.....

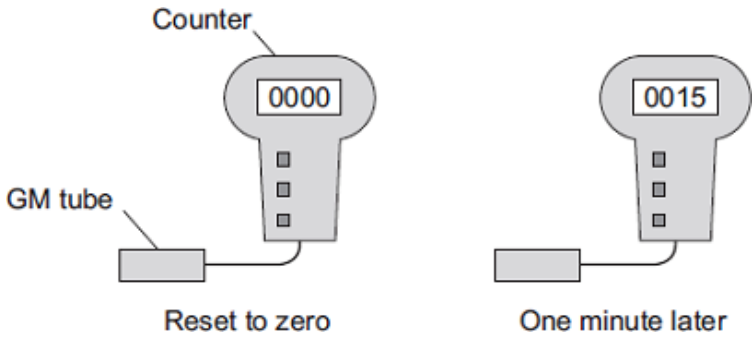
.....

(2)

(Total 7 marks)

Q8. (a) A teacher used a Geiger-Műller (GM) tube and counter to measure the *background radiation* in her laboratory.

The teacher reset the counter to zero, waited one minute and then took the count reading. The teacher repeated the procedure two more times.



(i) Background radiation can be either from natural sources or from man-made sources.

Name **one man-made** source of background radiation.

.....

(1)

(ii) The three readings taken by the teacher are given in the table.

Count after one minute
15
24
18

The readings given in the table are correct.

Why are the readings different?

.....

.....

(1)

(b) Some scientists say they have found evidence to show that people living in areas of high natural background radiation are less likely to develop cancer than people living in similar areas with lower background radiation.

The evidence these scientists found does not definitely mean that the level of background radiation determines whether a person will develop cancer.

Suggest a reason why.

.....

.....

(1)

(c) An atom of the isotope radon-222 emits an alpha particle and decays into an atom of polonium.

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

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

(i) How many protons and how many neutrons are there in an alpha particle?

Number of protons = ...

Number of neutrons = ...

(2)

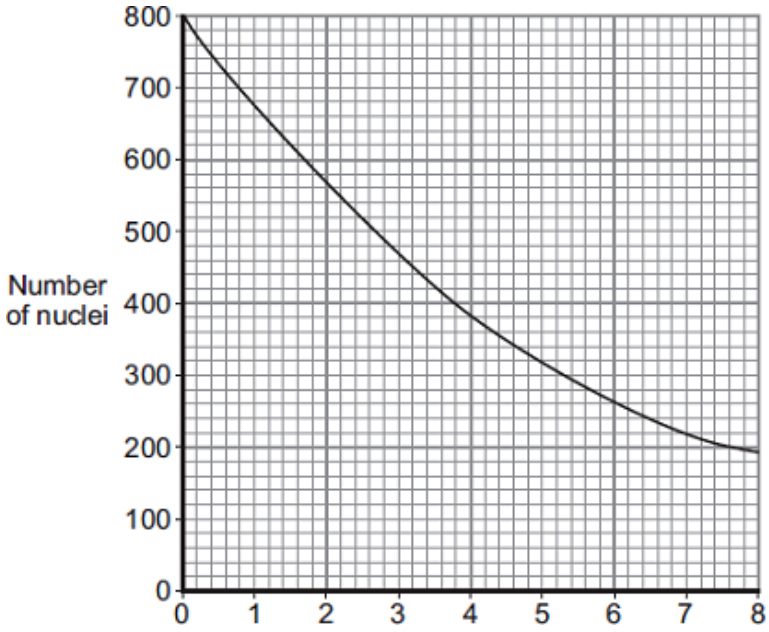
(ii) The decay of radon-222 can be represented by the equation below.

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

$$^{222}_{86}\text{Rn} \longrightarrow \square \quad \square + \text{Po} + \text{alpha particle}$$

(2)

(d) The graph shows how, in a sample of air, the number of radon-222 nuclei changes with time.



Use the graph to find the half-life of radon-222.

Show clearly on the graph how you obtain your answer.

Half-life = ... days

(2)

(Total 9 marks)

Q9. 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 ..... .

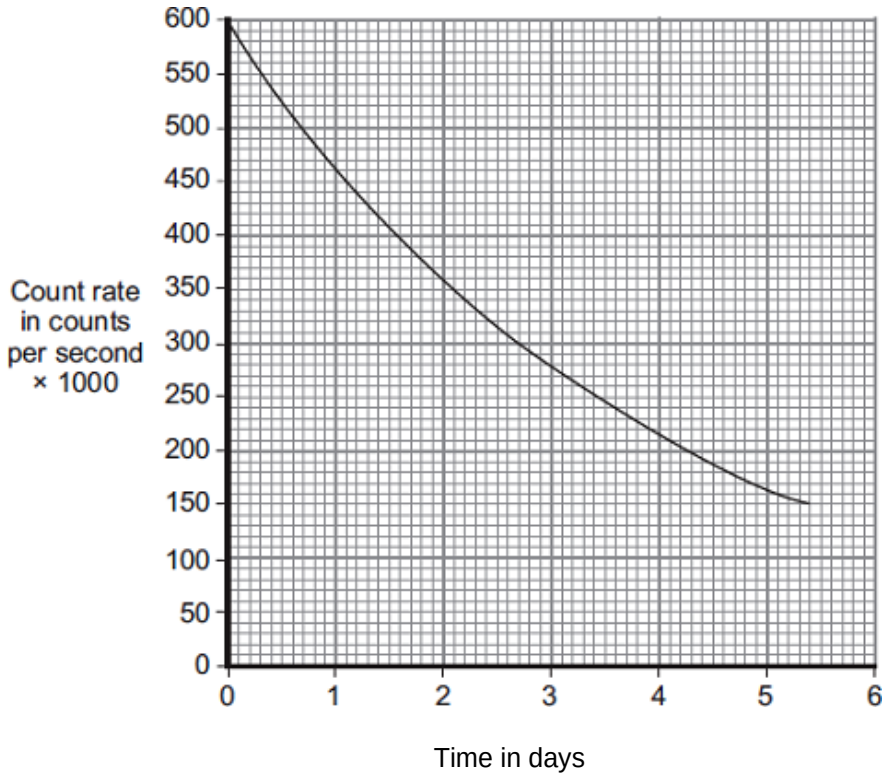
The atoms from different isotopes of gold have different numbers of ..... .

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.

.....

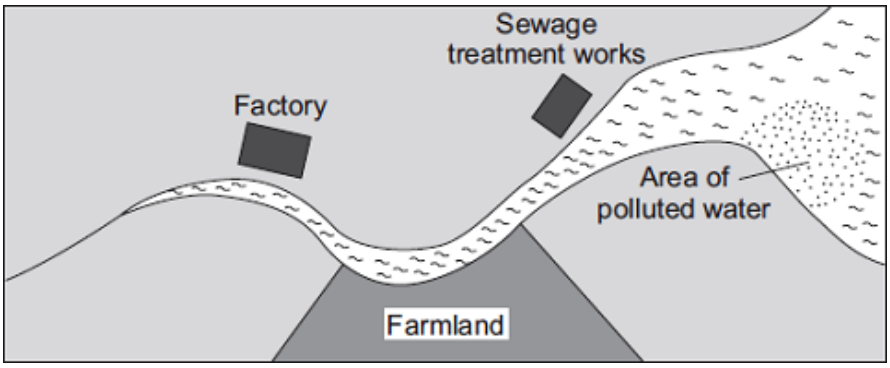
.....

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.

.....

.....

.....

.....

(2)

(Total 7 marks)

Q10. (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?

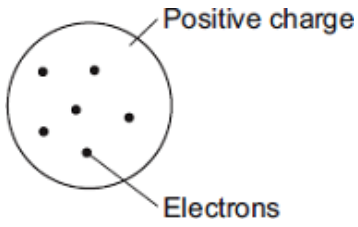
.....

.....

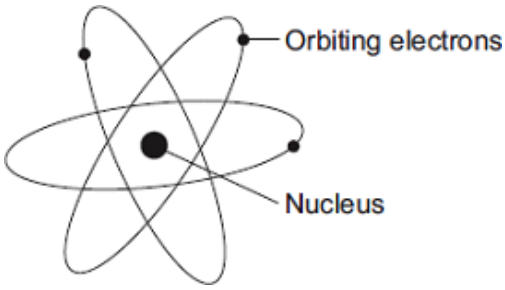
(1)

(Total 4 marks)

Q11. 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.

.....

.....

.....

.....

.....

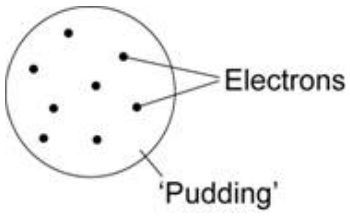
.....

.....

.....

(Total 4 marks)

Q12. In the early part of the 20th century scientists used the 'plum pudding' model to explain the structure of the atom.

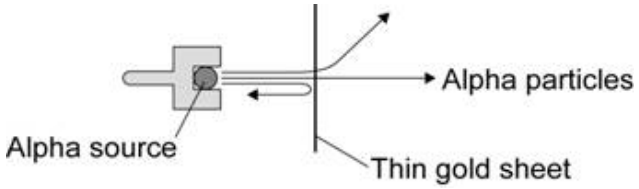


(a) What did scientists think that the 'pudding' part of the atom was?

.....

(1)

(b) The scientists Geiger and Marsden devised an experiment to test the 'plum pudding' model. They fired positively charged alpha particles at a very thin sheet of gold foil. They then measured the different paths taken by the alpha particles.



List A gives some of the observations from the experiment. **List B** gives the conclusions reached from the observations.

Draw **one** line from each observation in **List A** to the conclusion reached in **List B**.

List A **Observation**	**List B** **Conclusion**
Most of the alpha particles go straight through the gold foil	Most of the atom is empty space
Some alpha particles are deflected through a big angle	The nucleus of the atom is very small
Only a very small number of alpha particles rebound backwards	The nucleus has a large positive charge

(2)

(c) Following the work of Geiger and Marsden, the 'plum pudding' model of the atom was replaced by the 'nuclear model' of the atom.

Explain why it is sometimes necessary for scientists to replace a scientific model.

.....

.....

.....

.....

(2)
(Total 5 marks)

Q13. (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.

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

(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.

.....

.....

.....

.....

(2)
(Total 7 marks)

M1. (i) nucleus / neutron

*do **not** accept shells or orbits*

1

(ii) neutron changes to a proton **or** number of neutrons goes down 1 and the number of protons goes up by 1

*do **not** accept becomes positive*

1

[2]

M2. (a) (i) two protons

1

2 neutrons

if neither point gained allow 1 mark for helium nucleus

1

(ii) electron

1

(b) neutron splits (to form proton and electron)

1

[4]

M3. (i) (fast moving) electrons (from the nucleus)
(*allow* negatively charged particles)

for 1 mark

1

(ii) protactinium has one neutron fewer
protactinium has one proton more
(*credit* has different numbers of neutrons / protons *with one mark*)

for 1 mark each

2

[3]

M4. (a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) reactor

1

(c) beta

1

any **one** from:

- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve
or
(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive
*allow **1** mark for correctly calculating number remaining as 20 000*
or
*allow **1** mark for number of*
80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

M5. (a) 78

1

(b) atomic

1

(c) (i) 131

correct order only

1

54

1

(ii) 32 (days)

*allow **1** mark for showing 4 half-lives provided no subsequent step*

2

(iii) limits amount of iodine-131 / radioactive iodine that can be absorbed

accept increases level of non-radioactive iodine in thyroid

*do **not** accept cancels out iodine-131*

1

so reducing risk of cancer (of the thyroid)

accept stops risk of cancer (of the thyroid)

1

[8]

M6. (a) (i) beta and gamma

both answers required

accept correct symbols

1

(ii) alpha and beta

both answers required

accept correct symbols

1

(iii) gamma

accept correct symbol

1

(b) nothing *(*you do to a radioactive substance / source*)* changes the count rate / activity / rate of decay / radiation (emitted)

accept it = radiation emitted

or *(*reducing*)* the temperature does not change the activity / count rate / rate of decay / radiation (emitted)

1

(c) (i) has <u>one</u> more neutron

correct answer only

1

(ii) 14 days

no tolerance

*allow **1** mark for showing a correct method on the graph*

2

(iii) any **two** from:

- beta particles / radiation can be detected externally
- beta particles / radiation can pass out of / through the plant
- long half-life gives time for phosphorus to move through the plant / be detected / get results
- phosphorus-32 is chemically identical to phosphorus-31
- phosphorus-32 is used in the same way by a plant as phosphorus-31

2

[9]

M7. (a) (i) alpha

1

(ii) damages them / changes DNA

accept kills them / destroys

accept causes cancer

accept causes cell mutations

*do **not** accept they ionise cells on its own*

1

(b) count is (roughly) the same

1

gamma is not affected by magnetic field

accept magnet for magnetic field

1

or

alpha and beta are deflected by a magnetic field (1)
count would go down significantly (1)

(c) time taken for number of nuclei to halve

*do **not** accept time for radioactivity to halve*

or

time taken for count rate to fall to half
(its initial value)

*do **not** accept time for nuclei to halve*

1

(d) not enough time to take measurements / make observations

1

before level of radiation became insignificant

1

[7]

M8. (a) (i) any **one** from:

- nuclear power (stations)
  accept nuclear waste
  accept coal power stations
- nuclear weapons (testing)
  accept nuclear bombs / fallout
- nuclear accidents
  accept named accident, eg Chernobyl or Fukushima
  accept named medical procedure which involves a radioactive source
  accept radiotherapy
  accept X-rays
  accept specific industrial examples that involve a radioactive source
  nuclear activity / radiation is insufficient
  smoke detectors is insufficient

1

(ii) (radioactive decay) is a random process
accept an answer in terms of background / radiation varies (from one point in time to another)

1

(b) any **one** from:

- (maybe) other factors involved
  accept a named 'sensible' factor, eg smoking
- evidence may not be valid
  accept not enough data
- may not have (a complete) understanding of the process (involved)

1

(c) (i) 2

1

2

1

(ii) 218
correct order only

1

84

1

(d) 3.8 (days)

*allow **1** mark for showing correct method using the graph provided no subsequent steps*

*correct answers obtained using numbers other than 800 and 400 gain **2** marks provided the method is shown*

2

[9]

M9. (a) protons, electrons

both required, either order

1

neutrons

1

electron, nucleus

both required, this order

1

(b) 2.7 (days)

*allow **1** mark for showing correct use of the graph*

2

(c) put source into water at **one** point on bank

accept the idea of testing different parts of the river bank at different times

1

see if radiation is detected in polluted area

accept idea of tracing

or

put source into water at three points on bank (1)
see if radiation is detected downstream of factory **or** farmland **or** sewage treatment works (1)

1

[7]

M10. (a) 146

1

(b) atomic number

1

(c) (i) alpha

1

(ii) number of protons changes

accept atomic number changes

accept <u>loses or gains</u> protons

*do **not** accept protons with any other particle e.g. number of protons and neutrons changes incorrect*

*do **not** accept any reference to mass number*

1

[4]

M11. any **two** pairs from:

to gain credit it must be clear which model is being described

*do **not** accept simple descriptions of the diagram without comparison*

- nuclear model mass is concentrated at the centre / nucleus (1)

  *accept the nuclear model has a nucleus / the plum pudding model does not have a nucleus for **1** mark*

  plum pudding model mass is evenly distributed (1)

- nuclear model positive charge occupies only a small part of the atom (1)

  plum pudding model positive charge spread throughout the atom (1)

- nuclear model electrons orbit some distance from the centre (1)

  accept electrons in shells / orbits provided a valid comparison is made with the plum pudding model

  plum pudding electrons embedded in the (mass) of positive (charge) (1)

  *do **not** accept electrons at edge of plum pudding*

- nuclear model the atom mainly empty space (1)

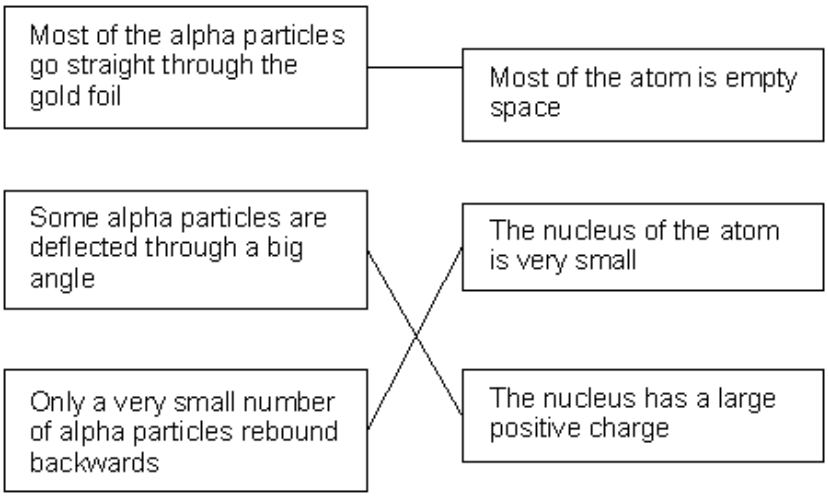
  plum pudding model is a ‘solid’ mass (1)

[4]

M12. (a) (mass of) positive charge

1

(b) three lines correct



*allow **1** mark for 1 correct line*
*if more than 1 line is drawn from a box in **List A** then all those lines are incorrect*

2

(c) new scientific evidence / data is obtained

1

which cannot be explained by the model

1

[5]

M13. (a) (i) (total) number of protons plus neutrons
accept number of nucleons
accept amount for number
do not accept number of particles in the nucleus

1

(ii) number of neutrons decreases by one

1

number of protons increases by one
accept for both marks a neutron changes into a proton

1

(b) (i) $^{208}_{81}Th$

1

correct order only

1

(ii) the number of protons determines the element
accept atomic number for number of protons

1

alpha and beta decay produce different changes to the number of protons

there must be a comparison between alpha and beta which is more than a description of alpha and beta decay alone

or

alpha and beta decay produce different atomic numbers

ignore correct reference to mass number

1

[7]