



P4 ATOMIC STRUCTURE

Question Practice

Name: _____

Class: _____

Date: _____

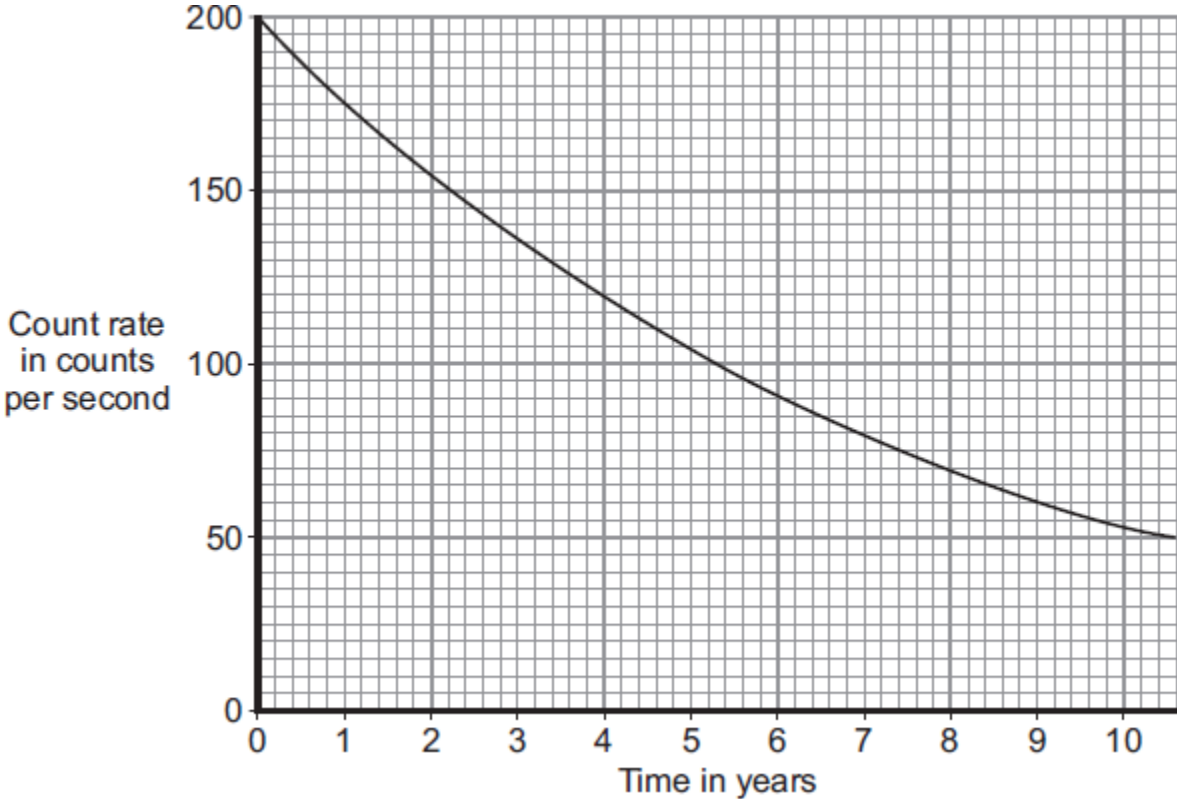
Time: **132 minutes**

Marks: **129 marks**

Comments: **HIGHER TIER**

1

(a) The graph shows how the count rate from a sample containing the radioactive substance cobalt-60 changes with time.



(i) What is the range of the count rate shown on the graph?

From _____ counts per second to _____ counts per second.

(1)

(ii) How many years does it take for the count rate to fall from 200 counts per second to 100 counts per second?

Time = _____ years

(1)

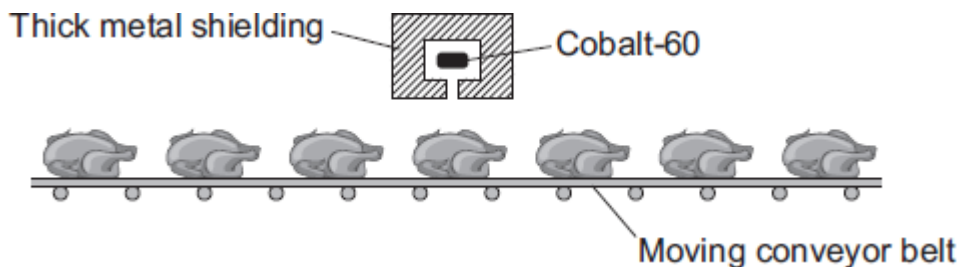
(iii) What is the half-life of cobalt-60?

Half-life = _____ years

(1)

- (b) The gamma radiation emitted from a source of cobalt-60 can be used to kill the bacteria on fresh, cooked and frozen foods. Killing the bacteria reduces the risk of food poisoning.

The diagram shows how a conveyor belt can be used to move food past a cobalt-60 source.



- (i) Which **one** of the following gives a way of increasing the amount of gamma radiation the food receives?

Put a tick (✓) in the box next to your answer.

Increase the temperature of the cobalt-60 source.

Make the conveyor belt move more slowly.

Move the cobalt-60 source away from the conveyor belt.

(1)

- (ii) To protect people from the harmful effects of the gamma radiation, the cobalt-60 source has thick metal shielding.

Which **one** of the following metals should be used?

Draw a ring around your answer.

aluminium

copper

lead

(1)

- (c) A scientist has compared the vitamin content of food exposed to gamma radiation with food that has not been exposed.

The table gives the data the scientist obtained when she tested 1 kg of cooked chicken.

Vitamin	Food not exposed to gamma radiation	Food exposed to gamma radiation
	Mass in milligrams	Mass in milligrams
B6	1.22	1.35
B12	21.00	28.00
E	3.30	2.15
Niacin	58.00	55.50
Riboflavin	2.10	2.25

Considering only this data, which **one** of the following is a correct conclusion?

Put a tick (✓) in the box next to your answer.

Vitamin content is not affected by gamma radiation.

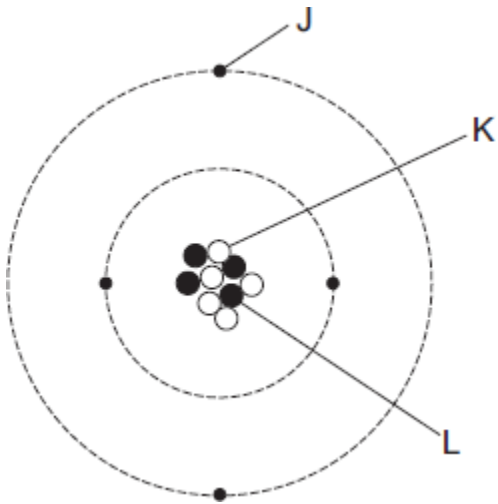
Gamma radiation completely destroys some types of vitamin.

Exposure increased the content of some types of vitamin.

(1)
(Total 6 marks)

2

The diagram represents an atom of beryllium.



(a) Complete the following statements by writing one of the letters, **J**, **K** or **L**, in each box.

Each letter should be used only **once**.

The particle with a positive charge is

The particle with the smallest mass is

The particle with no charge is

(2)

(b) Give the reason why all atoms have a total charge of zero.

(1)

(c) Complete the following sentence.

There are several isotopes of beryllium. Atoms of different beryllium

isotopes will have different numbers of _____

(1)

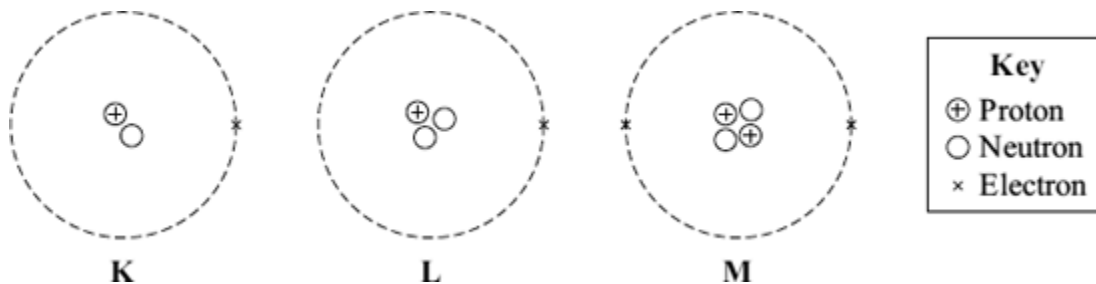
(d) What happens to the structure of an atom to change it into an ion?

(1)

(Total 5 marks)

3

(a) The diagram represents 3 atoms, **K**, **L** and **M**.



(i) Which **two** of the atoms are isotopes of the same element?

_____ and _____

(1)

(ii) Give a reason why the **two** atoms that you chose in part (a)(i) are:

(1) atoms of the same element _____

(2) different isotopes of the same element. _____

(2)

(b) The table gives some information about the radioactive isotope thorium-230.

mass number	230
atomic number	90

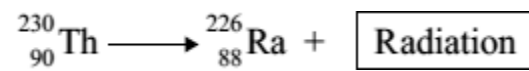
(i) How many electrons are there in an atom of thorium-230?

(1)

(ii) How many neutrons are there in an atom of thorium-230?

(1)

(c) When a thorium-230 nucleus decays, it emits radiation and changes into radium-226.



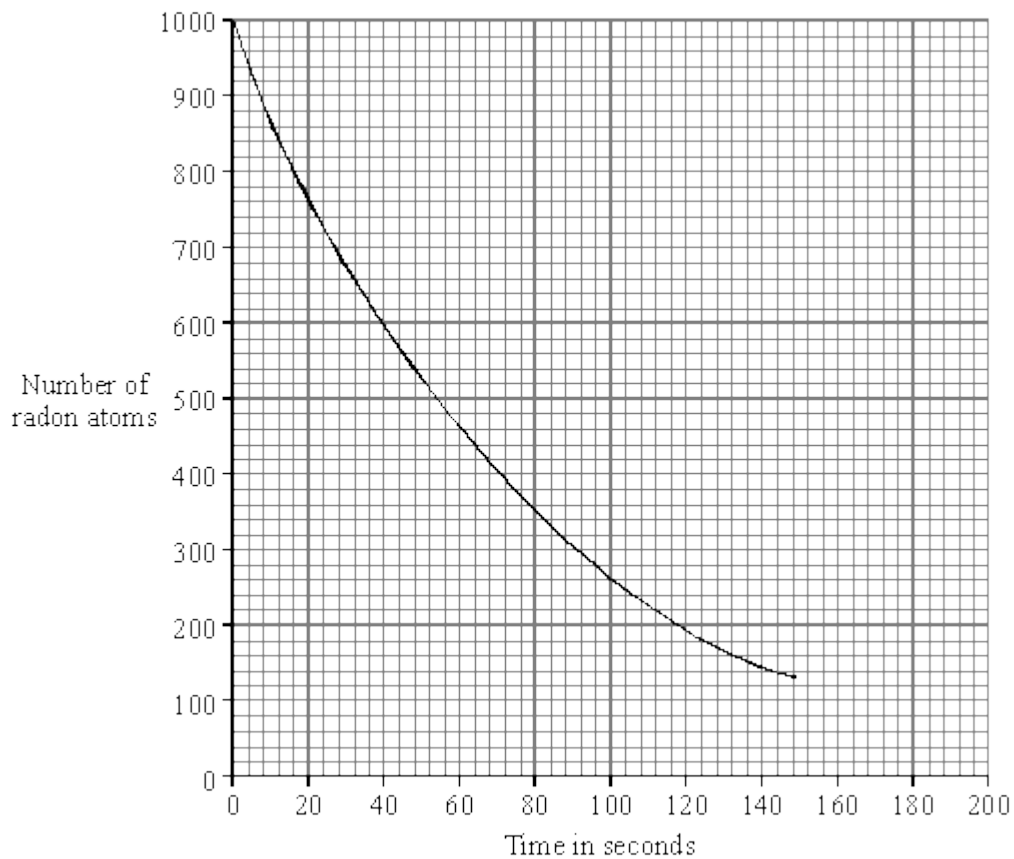
What type of radiation, alpha, beta or gamma, is emitted by thorium-230?

Explain the reason for your answer.

(3)

(Total 8 marks)

4 Radon is a radioactive element. The graph shows how the number of radon atoms in a sample of air changes with time.



- (i) How long did it take the number of radon atoms in the sample of air to fall from 1000 to 500?

Time = _____ seconds

(1)

- (ii) How long is the half-life of radon?

Half-life = _____ seconds

(1)

- (iii) Complete this sentence by crossing out the **two** lines in the box that are wrong.

As a radioactive material gets older, it emits

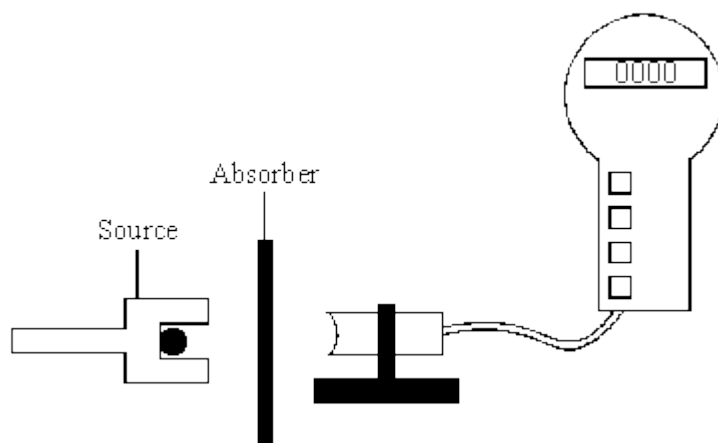
less
a constant level of
more

radiation per second.

(1)

(Total 3 marks)

- 5** The detector and counter are used in an experiment to show that a radioactive source gives out alpha and beta radiation only.



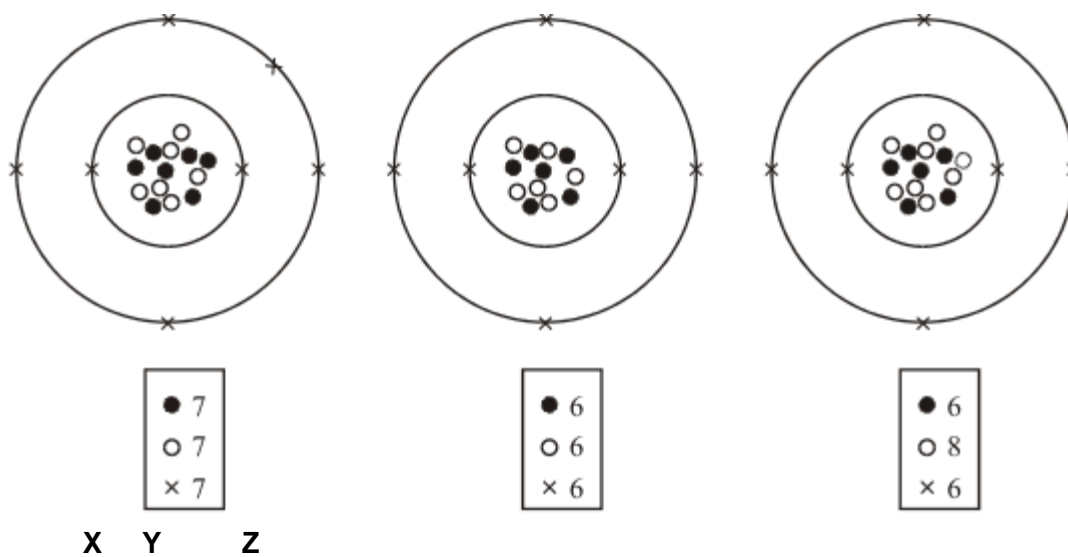
Two different types of absorber are placed one at a time between the detector and the source. For each absorber, a count is taken over ten minutes and the average number of counts per second worked out. The results are shown in the table.

Absorber used	Average counts per second
No absorber	33
Card 1 mm thick	20
Metal 3 mm thick	2

Explain how these results show that alpha and beta radiation is being given out, but gamma radiation is **not** being given out.

(Total 3 marks)

6 (a) The diagrams represent three atoms **X**, **Y** and **Z**.

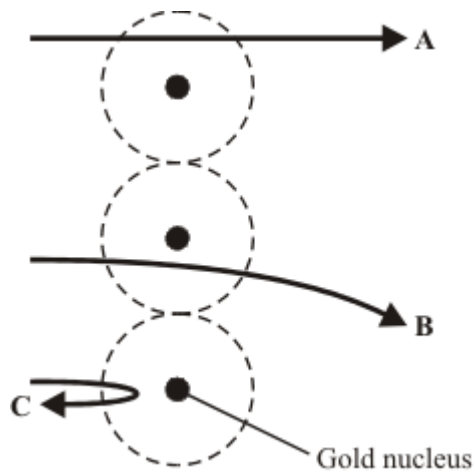


Which **two** of the atoms are from the same element?

Give a reason for your answer.

(2)

- (b) In the early part of the 20th century some scientists investigated the paths taken by positively charged alpha particles into and out of a very thin piece of gold foil. The diagram shows the paths of three alpha particles.



Explain the different paths **A**, **B** and **C** of the alpha particles.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

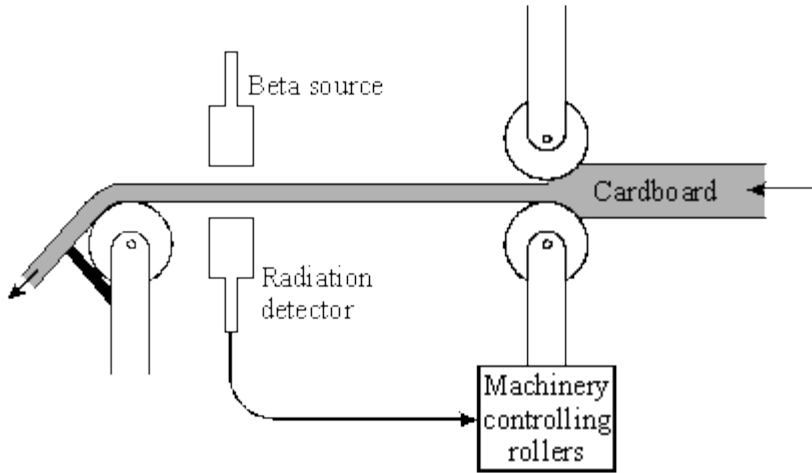
(3)
(Total 5 marks)

7

(a) Two sources of radiation look identical. One source emits only alpha radiation, the other only beta radiation. Describe **one** way to find out which source emits the alpha radiation. You can assume a radiation detector and counter are available. You may wish to draw a diagram to help with your answer.

(3)

(b) The diagram shows a beta radiation source and detector used to measure the thickness of cardboard as it is made. The table gives the detected count rate at different times.



Time	Count rate in counts/minute
09:00	120
09:30	122
10:00	119
10:30	165
11:00	118

- (i) Between 09:00 and 10:00 the cardboard is produced at the correct constant thickness. Give a reason for the small variation in count rate.

(1)

- (ii) What can you say about the thickness of the cardboard being made at 10:30?

Explain the reason for your answer.

(3)

- (iii) Explain why gamma radiation is not suitable for detecting changes to the thickness of the cardboard.

(1)

(Total 8 marks)

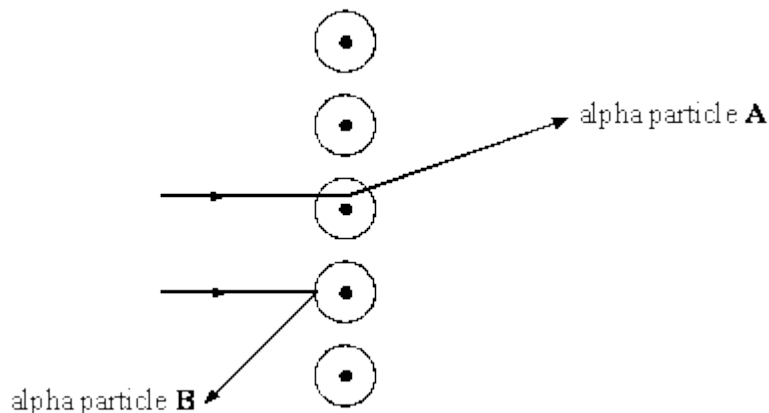
8

- (a) Atoms are made up of three types of particle called protons, neutrons and electrons. Complete the table below to show the relative mass and charge of a neutron and an electron. The relative mass and charge of a proton has already been done for you.

PARTICLE	RELATIVE MASS	RELATIVE CHARGE
proton	1	+1
neutron		
electron		

(2)

- (b) The diagram below shows the paths of two alpha particles **A** and **B**, into and out of a thin piece of metal foil.



The paths of the alpha particles depend on the forces on them in the metal. Describe the model of the atom which is used to explain the paths of alpha particles aimed at thin sheets of metal foil.

(3)

(Total 5 marks)

9

- (a) A radioactive isotope has a half-life of 10 minutes. At the start of an experiment, the activity of a sample of this isotope was 800 counts per second after allowing for background radiation.

Calculate how long it would be before the activity fell from 800 counts per second to 200 counts per second.

Time _____ min.

(2)

- (b) A physicist investigates a solid radioactive material. It emits alpha particles, beta particles and gamma rays.

The physicist does not touch the material.

Explain why the alpha particles are less dangerous than the beta particles and gamma rays.

(2)

(Total 4 marks)

10

Use the Data Sheet to help you answer this question.

This question is about elements and atoms.

- (a) About how many different elements are found on Earth?

Draw a **ring** around the correct number.

40 50 60 70 80 90

(1)

- (b) The following are parts of an atom:

electron **neutron** **nucleus** **proton**

Choose from the list the one which:

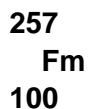
(i) has no electrical charge; _____

(ii) contains two of the other particles; _____

(iii) has very little (negligible) mass. _____

(3)

- (c) Scientists have been able to make new elements in nuclear reactors. One of these new elements is fermium. An atom of fermium is represented by the symbol below.



(i) How many protons does this atom contain? _____

(ii) How many neutrons does this atom contain? _____

(2)

(Total 6 marks)

11

Some small fractures do not show up on an X-ray image.

To see the fracture doctors inject the patient with a radioactive isotope.

The image is formed by detecting radiation as it leaves the body.

The figure below shows an image of a foot after the patient was injected with the radioactive isotope technetium-99.



© Ni Qin/ Getty Images

Technetium-99 emits gamma radiation.

(a) What is gamma radiation?

(1)

(b) Explain why a gamma emitter is used.

(2)

(c) Technetium-99 has a **half-life** of 6 hours.

Give the meaning of the term **half-life**.

(1)

(d) After treatment, hospital equipment may become contaminated.

Describe the level of the hazard associated with contamination with technetium-99.

You should include in your answer a description of how the level of hazard changes over time.

(3)

(e) Some of the hospital equipment may also be irradiated during treatment.

Describe how equipment becomes irradiated.

(1)

(f) Why is irradiated equipment not hazardous?

(1)

(Total 9 marks)

12

Atoms are very small and most of their mass is concentrated in the nucleus.

Electrons orbit at different distances from the nucleus.

(a) A nucleus is much smaller than an atom.

Approximately how many times smaller is a nucleus than an atom?

Tick **one** box.

100

1000

10 000

100 000

(1)

(b) The electrons in an atom can only orbit at specific distances from the nucleus.

State what causes an electron's distance from the nucleus to increase or decrease.

Increase _____

Decrease _____

(2)

(c) Atoms have different atomic numbers and mass numbers.

In terms of sub-atomic particles, describe the difference between an atom's atomic number and its mass number.

(2)

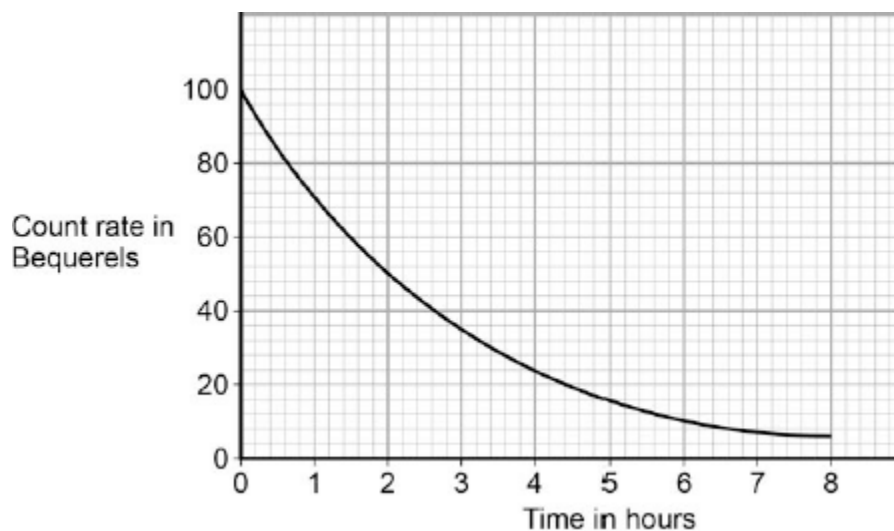
(d) Transmutation is the name given to a process where one element changes into another.

Explain and compare how two different types of radioactive decay can cause transmutation.

(4)
(Total 9 marks)

13

The figure below shows how the activity of a radioactive isotope changes over an 8 hour period of time.



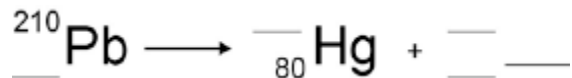
(a) Predict how long it will take for the count rate to fall from 100 to 1.56 Bequerels.

Time = _____ hours

(2)

(b) Lead-210 is a radioactive isotope that decays to an isotope of mercury by alpha decay.

Complete the nuclear equation to show the alpha decay of lead-210.



(3)

(c) Explain how ionising radiation can have hazardous effects on the human body.

(5)

(Total 10 marks)

14

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 ($^{131}_{53}\text{I}$) into the atmosphere.

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

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1)

(b) Complete the sentence.

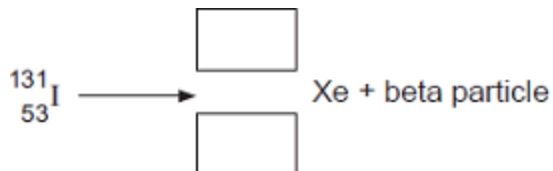
The number of protons in an atom is called the proton number or the _____ number.

(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)

15

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 _____ .

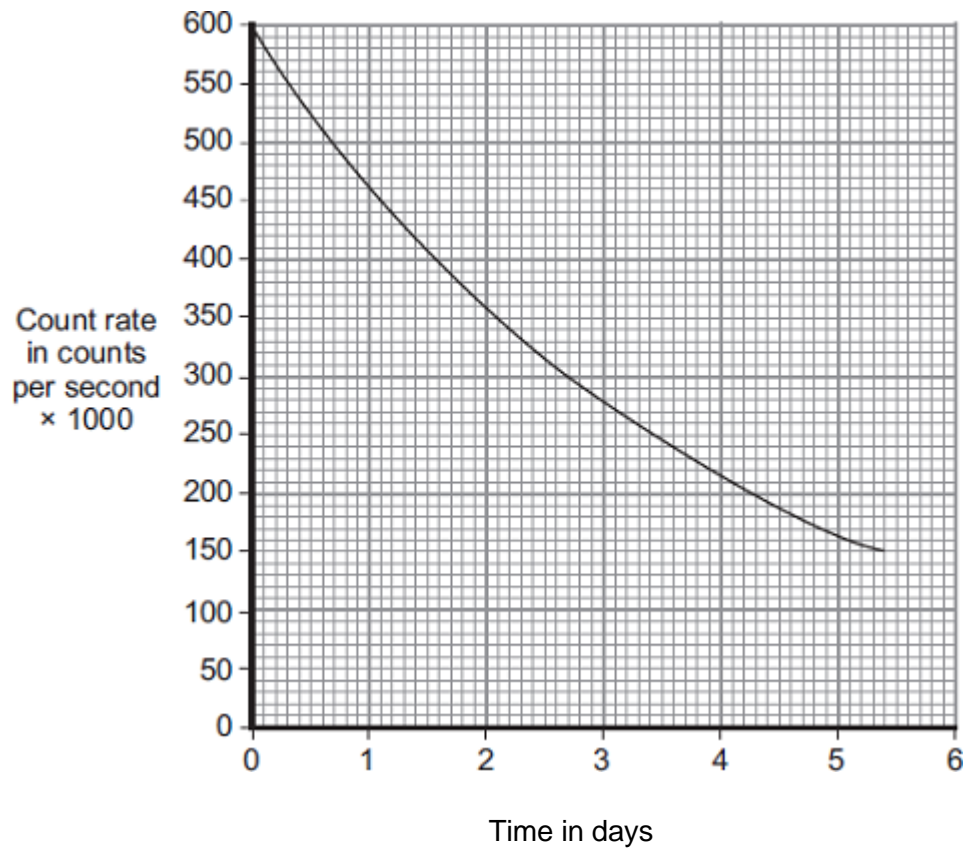
The atoms from different isotopes of gold have different numbers of _____ .

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.

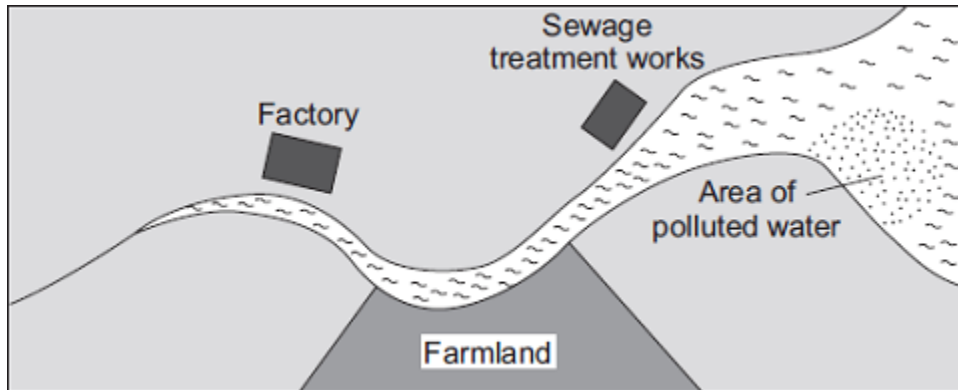
Show clearly on the graph how you obtain your answer.

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.



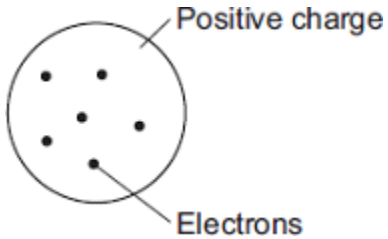
The gold-198 is used to find where the pollution is coming from.

Explain how.

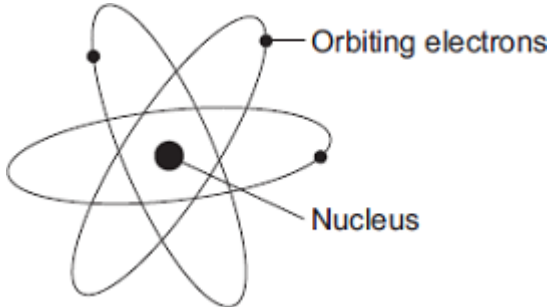
(2)
(Total 7 marks)

16

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.

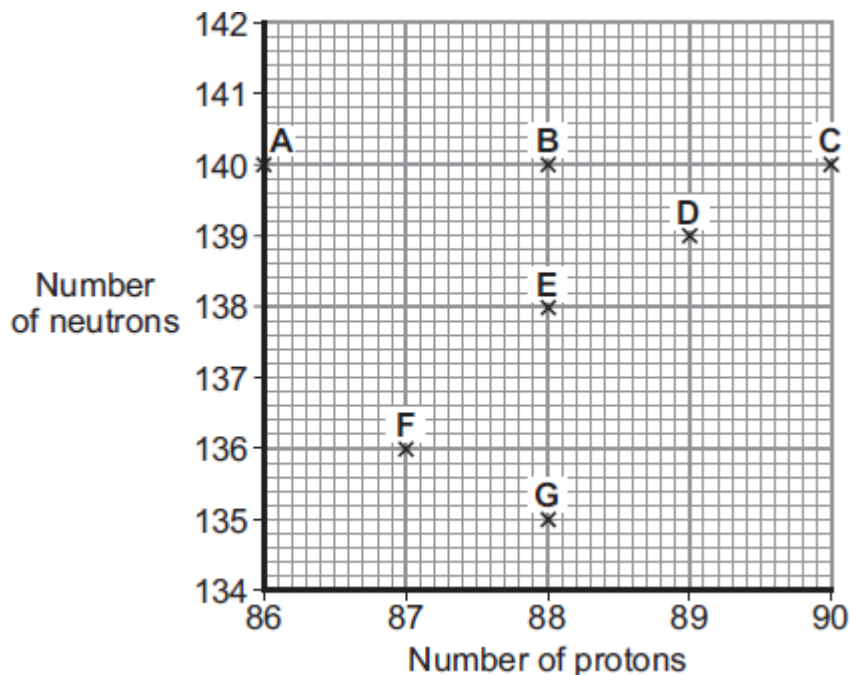


Describe the differences between the two models of the atom.

(Total 4 marks)

17

- (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.



- (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.

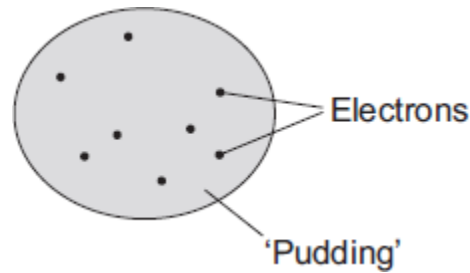
Suggest a reason why the evidence suggesting that radium was harmful was generally ignored.

(1)

(Total 9 marks)

18

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

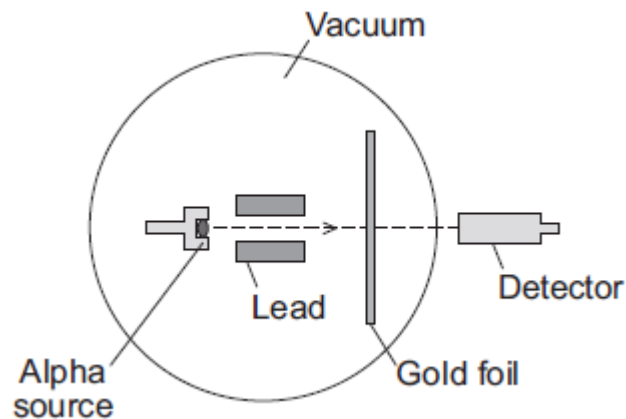


- (a) Those scientists knew that atoms contained electrons and that the electrons had a negative charge. They also knew that an atom was electrically neutral overall.

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.



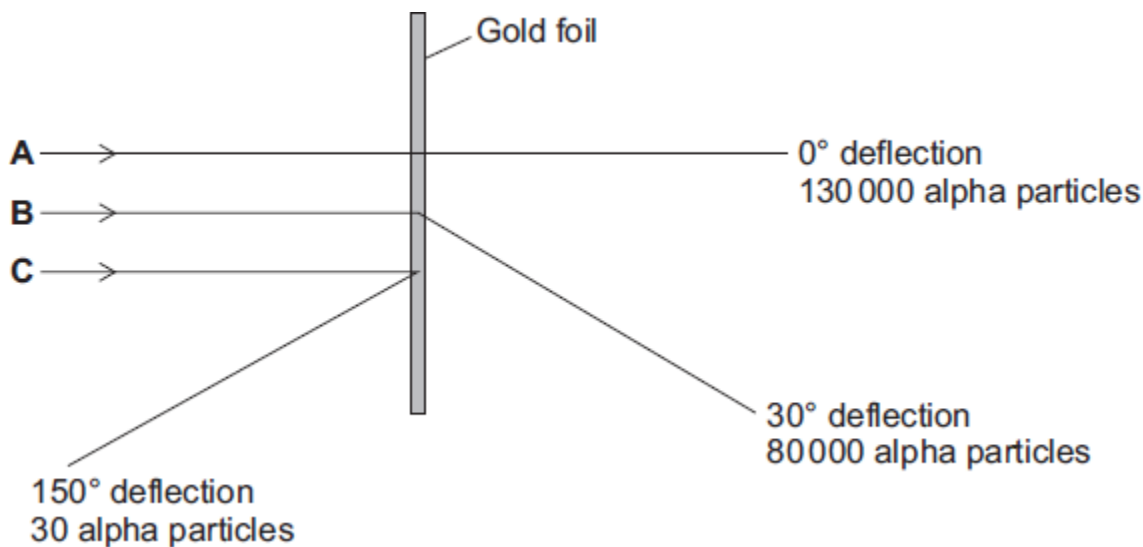
If the 'plum pudding' model was correct, then most of the alpha particles would go straight through the gold foil. A few would be deflected, but by less than 4° .

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?

(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?

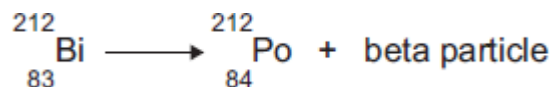
(1)

(Total 6 marks)

19

- (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.



- (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.

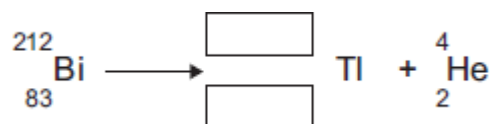
An alpha particle is the same as a helium nucleus.

The symbol below represents an alpha particle.



- (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.

**(2)**

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

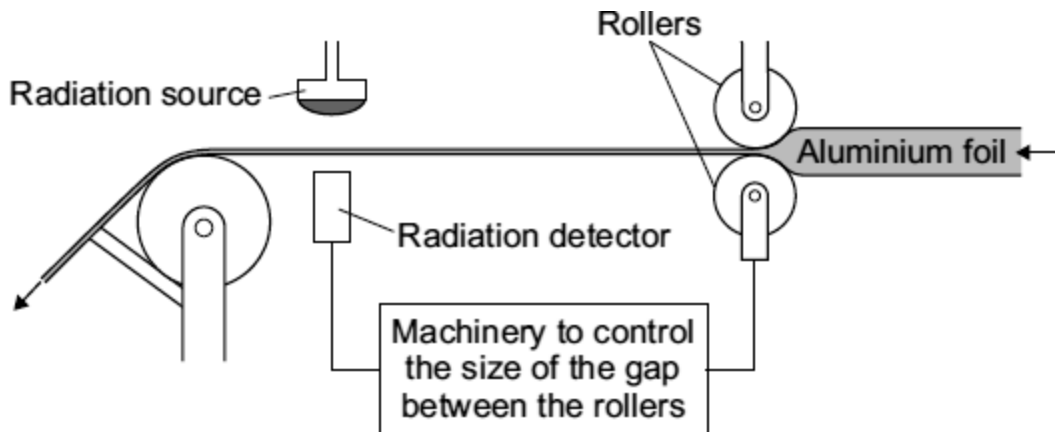
Explain why.

(2)

(Total 7 marks)

20

The diagram shows a system used to control the thickness of aluminium foil as it is being rolled. A radiation source and detector are used to monitor the thickness of the foil.

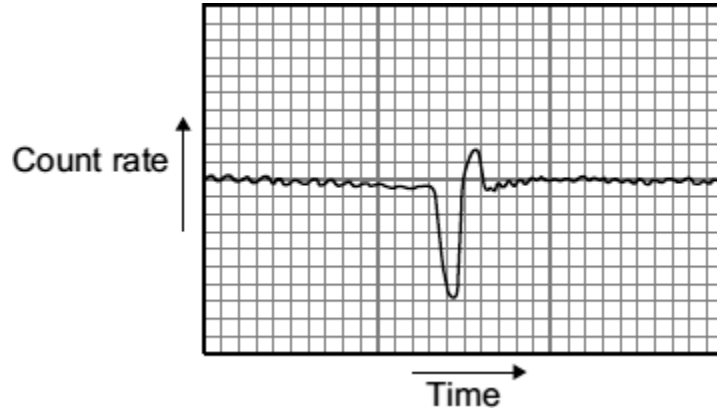


- (a) Which type of source, alpha, beta or gamma, should be used in this control system?

Explain why each of the other two types of source would **not** be suitable.

(3)

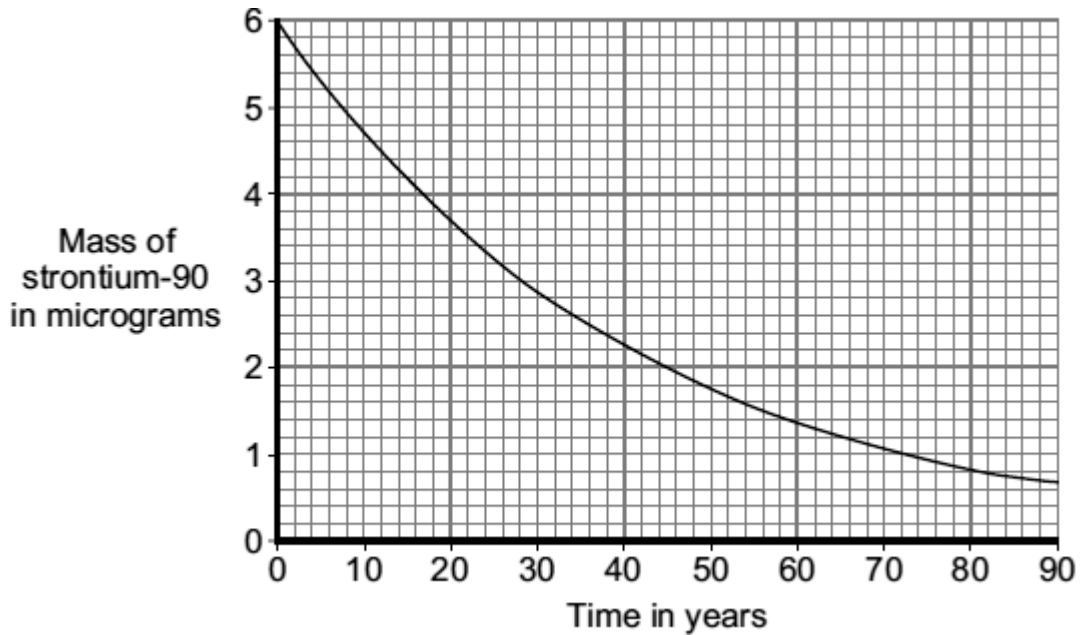
- (b) The chart shows how the count rate recorded by the detector varies over a short period of time.



Use the graph to explain how the thickness of the foil changes, and how the control system responds to this change.

(2)

- (c) When first used, the radiation source contains 6 micrograms of strontium-90. The graph shows how the mass of the strontium-90 will decrease as the nuclei decay.



The control system will continue to work with the same source until 75 % of the original strontium-90 nuclei have decayed.

After how many years will the source need replacing?

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

Number of years = _____

(2)

(Total 7 marks)

Mark schemes

1	(a) (i)	200 to 50 <i>accept either order</i>	1
	(ii)	5.3 <i>accept values between 5.2 and 5.4 inclusive</i>	1
	(iii)	5.3 <i>accept values between 5.2 and 5.4 inclusive</i> or their (a)(ii)	1
	(b) (i)	Make the conveyor belt move more slowly	1
	(ii)	lead	1
	(c)	Exposure increased the content of some types of vitamin.	1
			[6]
2	(a)	L J K <i>all 3 in correct order</i> <i>allow 1 mark for 1 correct</i>	2
	(b)	number of electrons = number of protons <i>accept amount for number</i>	1
	(c)	neutrons <i>this answer only</i>	1
	(d)	loses / gains electron(s)	1
			[5]
3	(a) (i)	K and L <i>both answers required either order</i>	1

(ii) (1) same number of protons
accept same number of electrons
accept same atomic number 1

(2) different numbers of neutrons 1

(b) (i) 90 1

(ii) 140 1

(c) alpha (particle)
reason may score even if beta or gamma is chosen 1

mass number goes down by 4
or
number of protons and neutrons goes down by 4
or
number of neutrons goes down by 2
*candidates that answer correctly in terms of why gamma
and beta decay are not possible gain full credit* 1

atomic / proton number goes down by 2
or
number of protons goes down by 2
*accept an alpha particle consists of 2 neutrons and 2 protons for 1
mark*
accept alpha equals ${}^4_2\text{He}$ or ${}^4_2\alpha$ for 1 mark
an alpha particle is a helium nucleus is insufficient for this mark 1

[8]

4

(i) 50 ± 5 1

(ii) 50 ± 5
accept their (b)(i) 1

(iii) less
accept any way of indicating the correct answer 1

[3]

5

answers must be comparative
accept converse answers throughout

alpha: the count rate is (greatly) reduced
by the card **or** the card absorbs alphas but not betas
accept paper for the card

1

beta: the count rate is (greatly) reduced by the metal **or** the thin metal absorbs
alphas and betas **or** the thin metal absorbs all of the radiation (from the source)
accept aluminium for the metal

1

gamma: would pass through the thin
accept aluminium for the metal

metal but count rate is background **or** no radiation passing through **or** a higher
reading would be recorded **or** to reduce the count to 2 would require much
more than 3 mm of metal
accept lead / aluminium for the metal

1

[3]

6

(a) Y and Z

1

they have the same number of protons **or** same atomic number
*accept they have the same number of electrons **or** same number of
protons **and** electrons*
allow only different in number of neutrons N.B. independent marks

1

(b) **Quality of written communication**

for correct use of terms underlined in B or C

Q ✓ Q ✗

1

A – alpha particle passes straight through the empty space of the atom
or it is a long way from the nucleus

describes 3 tracks correctly for 2 marks

describes 2 or 1 track correctly for 1 mark

B – alpha particle deflected / repelled / repulsed by the (positive) nucleus

C – alpha particle heading straight for the nucleus is deflected / repelled / repulsed backwards

*do **not** accept hits the nucleus*

*do **not** accept answers referring to refraction*

*do **not** accept answers in terms of reflected backwards unless qualified in terms of repulsion*

mention of difference in charge on nucleus negates that track

max 2

[5]

7

(a) suitable arrangement of source and GM tube ie fixed distance apart

accept 'detector' for GM tube and counter

1

suitable test

*eg introduce absorbing material **or** increase distance between source and GM tube*

1

suitable conclusion

*alpha that which gives a greatly reduced count with a paper absorber **or** alpha if count decreases rapidly when distance between source and GM tube exceeds 5cm(approx)*

the first two marks could be scored from a labelled diagram

1

(b) (i) (changes to) background radiation

*do **not** accept the source is decaying if it is their only answer*

or

(beta) decay is random

accept decay is not constant

1

- (ii) thickness decreasing
accept it is thin 1
- increased count rate 1
- (means) less (beta) radiation absorbed
accept more (beta) radiation passes through 1
- (iii) changing thickness will not change count rate (significantly)
accept insufficient absorption of gamma radiation irrespective of thickness
*do **not** accept gamma rays too penetrating*
*do **not** accept answers in terms of speed* 1

[8]

8

- (a) 1, 0
 X, -1 (X = negligible / very small / (1/1840) to (1/2000), but not nothing)
2 for 4 correct
1 for 2/3 correct 2
- (b) has a nucleus which is positive charge
 negative charges (electrons) orbit nucleus
each for 1 mark 3

[5]

9

- (a) two half lives
gains 1 mark
- but**
 20 minutes
gains 2 marks 2
- (b) alphas will be stopped by skin / air **or** do not penetrate betas and gammas
 can reach / damage organs / cells
for 1 mark each 2

[4]

10

- (a) 90
for one mark 1

- (b) (i) neutron
for one mark 1
- (ii) nucleus
for one mark 1
- (iii) electron
for one mark 1
- (c) (i) 100
for one mark 1
- (ii) 157
for one mark 1

[6]

11

- (a) electromagnetic radiation from the nucleus
'electromagnetic radiation' is insufficient 1
- (b) (Gamma is the most penetrating) so a large proportion of the emitted radiation will leave the body 1
- more easily detected outside the body 1
- (c) (average) time it takes for the number of nuclei of the isotope in a sample to halve
or
(average) time it takes for the count rate from a sample containing the isotope to fall to half its initial level 1
- (d) initially there is a high level of hazard. 1
- level of hazard drops to a low level quickly 1
- answer must imply short period of time*
- (activity initially high) due to short half-life
- or**
- (drops to safe level quickly) due to short half-life 1

(e) it is exposed to ionising radiation

1

(f) does not become radioactive

1

[9]

12

(a) 10 000

1

(b) **Increase**

absorb electromagnetic radiation

1

Decrease

emit electromagnetic radiation

1

(c) atomic number is the number of protons

1

mass number is the number of protons and neutrons

1

(d) **Level 2 (3–4 marks):**

A clear comparison, with logical structure.

Level 1 (1–2 marks):

Fragmented points, with no logical structure.

0 marks:

No relevant content

Indicative content

Beta decay

- Atomic number increases by one
- When a neutron decays into a proton

Alpha decay

- Atomic number decreases by two
- When an alpha particle is emitted

Comparison

Both change number of protons (hence new element / transmutation)

Beta decay increases atomic number and alpha decay decreases (explicit)

NB No credit is given for different number of protons = new element.

4

[9]

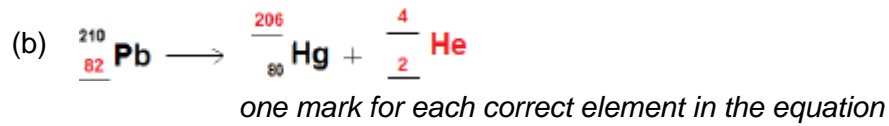
13

(a) half-life read from graph = 2 hours

1

time to fall to 1.56 is six half lives = $6 \times 2 = 12$ (hours)

1



3

(c) ionising radiation turns atoms into ions

1

which can break up molecules

1

this can change DNA

1

causing mutations to genes

1

which can cause cancer

1

[10]

14

(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]

15

(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]

16

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]

17

(a) **B E G**

*all 3 required and no other
any order*

1

same number of / 88 protons (and different numbers of neutrons)
same number of electrons is insufficient

1

(b) (i) 222

1

86

1

(ii) 4800

allow 1 mark for obtaining 3 half-lives

2

(c) ethical

1

deceived / lied to (about safety of working conditions)
*accept (women) not warned of the dangers
given no protection is insufficient*

or

value own / scientists' lives more than women

or

did not treat women humanely

1

(d) accept any sensible suggestion

eg

too many interests in continued use of radium

evidence may cause public unrest

*do **not** accept not enough evidence*

doctors not want to be blamed for illnesses (caused by radium)

*accept doctors not wanting to be sued (for harm caused by using
radium)*

doctors thought (possible) benefits outweighed (possible) risks

*do **not** accept did not know radium could be harmful*

believe radium could treat illnesses is insufficient

1

[9]

18

(a) has an equal amount of positive charge

accept pudding/it is positive

1

(b) (experimental) results could not be explained using 'plum pudding' model
or
 (experimental) results did not support plum pudding model
accept (experimental) results disproved plum pudding model 1

(c) (i) **A** – most of atom is empty space **or** most of atom concentrated at the centre 1

B – nucleus is positive (so repels alpha particles)
accept nucleus has the same charge as alpha 1

C – nucleus is very small
accept nucleus is positive if not scored for B

or
 nucleus is a concentrated mass
accept nucleus has a very concentrated charge 1

(ii) (if predictions correct, this) supports the new model
answers should be in terms of the nuclear model
accept supports his/new/nuclear theory
accept proves for supports
accept shows predictions/ Rutherford was correct 1

[6]

19

(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) ${}_{81}^{208}\text{Th}$ 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]

20

(a) beta

1

alpha: would not pass through (the aluminium / foil)

1

gamma: no change in count rate when thickness changes

must be a connection between detection / count rate / passing through and change in thickness

1

(b) foil thickness increases then decreases (then back to normal / correct thickness)
a description of count rate changes is insufficient

1

gap between rollers decreases, then increases (then back to correct size)

or

pressure from rollers increases then decreases

accept tightness for pressure

answers may link change in thickness and gap width for full credit

ie:

foil thickness increases so gap between rollers decreases (1)

foil thickness decreases so gap between rollers increases (1)

1

(c) 56 (years)

accept any value between 55-57 inclusive

allow 1 mark for correct calculation of mass remaining as 1.5 (micrograms)

allow 1 mark for a mass of 4.5 micrograms plus correct use of graph with an answer of 12

maximum of 1 compensation mark can be awarded

2

[7]