

AQA GCSE PHYSICS (HIGHER) • 8463

PHYSICS



EXAM QUESTION PACK

4.4.1 ATOMS AND ISOTOPES (PACK 2)

SCORE

/106

PERCENTAGE

%

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Q1.

- (a) The table gives information about five radioactive isotopes.

Isotope	Type of radiation emitted	Half-life
Californium-241	alpha (α)	4 minutes
Cobalt-60	gamma (γ)	5 years
Hydrogen-3	beta (β)	12 years
Strontium-90	beta (β)	28 years
Technetium-99	gamma (γ)	6 hours

- (i) What is an alpha (α) particle?

(1)

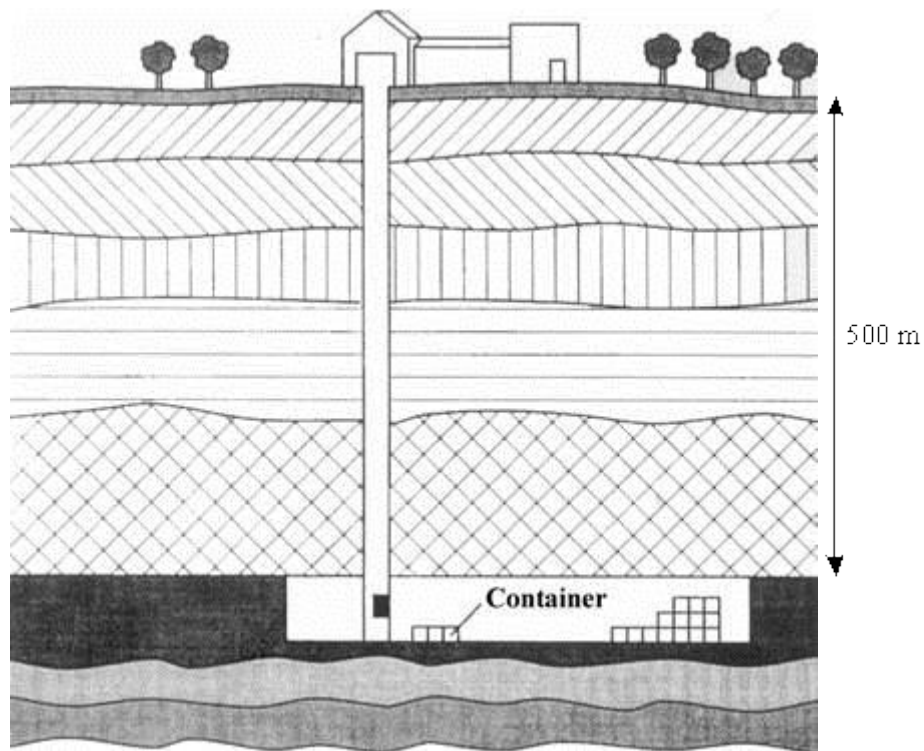
- (ii) What is meant by the term half-life?

(1)

- (iii) Which **one** of the isotopes could be used as a tracer in medicine? Explain the reason for your choice.

(3)

- (b) The increased use of radioactive isotopes is leading to an increase in the amount of radioactive waste. One method for storing the waste is to seal it in containers which are then placed deep underground.



Some people may be worried about having such a storage site close to the area in which they live. Explain why.

(3)

(Total 8 marks)

Q2.

Radon is a radioactive gas. Radon makes a major contribution to background radiation levels. Radon atoms decay by the emission of *alpha particles*.

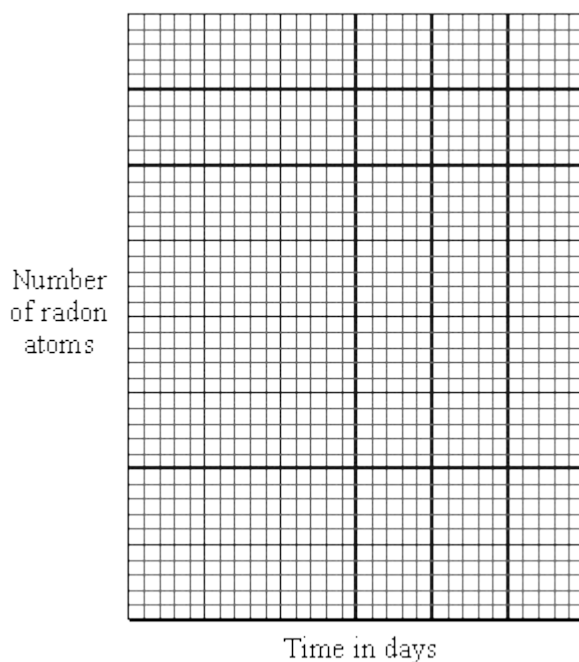
- (a) (i) What is an *alpha particle*?

(1)

- (ii) From which part of the radon atom does the alpha particle come?

(1)

- (b) (i) A sample of air contains 40 000 radon atoms. The half-life of radon is four days. Draw a graph to show how the number of radon atoms present in a sample of air will change over a period of 12 days.



(3)

- (ii) After 20 days, how many of the radon atoms from the original sample of air will have decayed? Show clearly how you work out your answer.

Number of radon atoms decayed = _____

(3)

- (c) Fairly constant concentrations of radon gas have been found in some deep mine shafts.

- (i) Suggest why the concentration of radon gas remains fairly constant although the radon gas decays.

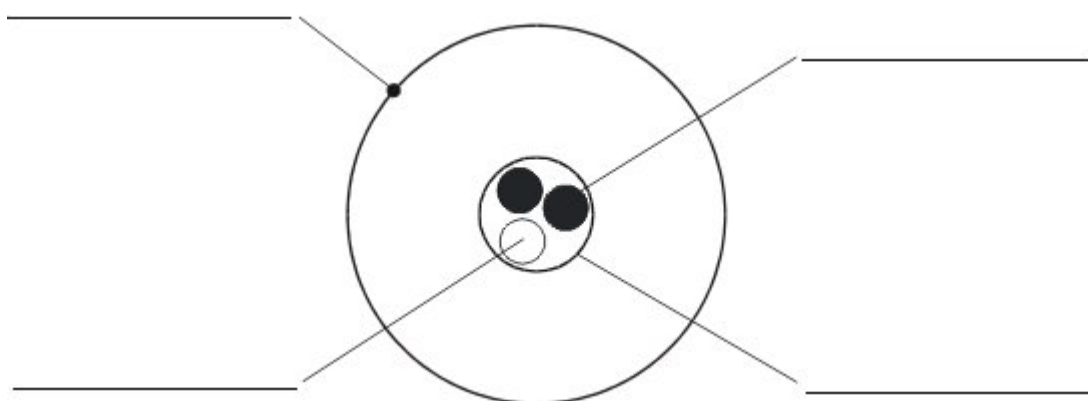
(1)

- (ii) Explain why the long term exposure to large concentrations of radon gas could be a danger to health.

Q3.

- (a) Tritium (${}^3_1\text{H}$) is an isotope of hydrogen. Tritium has a proton number of 1 and a mass number of 3.

- (i) The diagram below shows a simple model of a tritium atom. Complete the diagram by adding the names of the particles indicated by the labels.



(4)

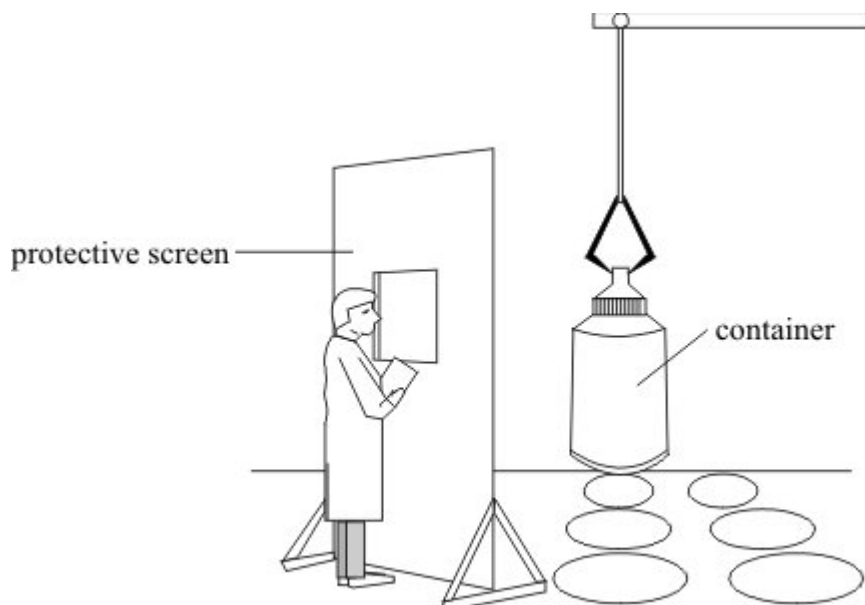
- (ii) Explain how the nucleus of an ordinary hydrogen atom is different from the nucleus of a tritium atom. Ordinary hydrogen atoms (${}^1_1\text{H}$) have a mass number of 1.

(2)

- (iii) Tritium is a radioactive substance which emits beta (β) radiation. Why do the atoms of some substances give out radiation?

(2)

- (b) Tritium is one of the elements found in the waste material of the nuclear power industry. The diagram below shows a worker behind a protective screen. The container holds a mixture of different waste materials which emit alpha (α), beta (β) and gamma (γ) radiation.



Suggest a suitable material for the protective screen. The material should prevent radiation from the container reaching the worker. Explain your answer.

(2)

(Total 10 marks)

Q4.

- (a) Complete the table about atomic particles.

ATOMIC PARTICLE	RELATIVE MASS	RELATIVE CHARGE
proton		+1
neutron	1	0
electron	negligible	

(2)

- (b) Use the Data Sheet to help you to answer some parts of this question.

Read the following passage about potassium.

Potassium is a metallic element in Group 1 of the Periodic Table. It has a proton (atomic) number of 19.

Its most common isotope is potassium-39, ($^{39}_{19}\text{K}$).

Another isotope, potassium-40, ($^{40}_{19}\text{K}$), is a radioisotope.

- (i) State the number of protons, neutrons and electrons in potassium-39.

Number of protons _____

Number of neutrons _____

Number of electrons _____

(2)

- (ii) Explain why potassium-40 has a different mass number from potassium-39.

(1)

- (iii) What is meant by a *radioisotope*?

(1)

- (iv) Atoms of potassium-40 change into atoms of a different element. This element has a proton (atomic) number of 20 and a mass number of 40.

Name, or give the symbol of, this new element.

(1)

- (v) Explain in terms of atomic structure, why potassium-39 and potassium-40 have the same chemical reactions.

(1)

- (c) (i) Name a suitable detector that could be used to show that potassium-40 gives out radiation.

(1)

- (ii) Name a disease which can be caused by too much exposure to a radioactive substance such as potassium-40.

(1)

(Total 10 marks)

Q5.

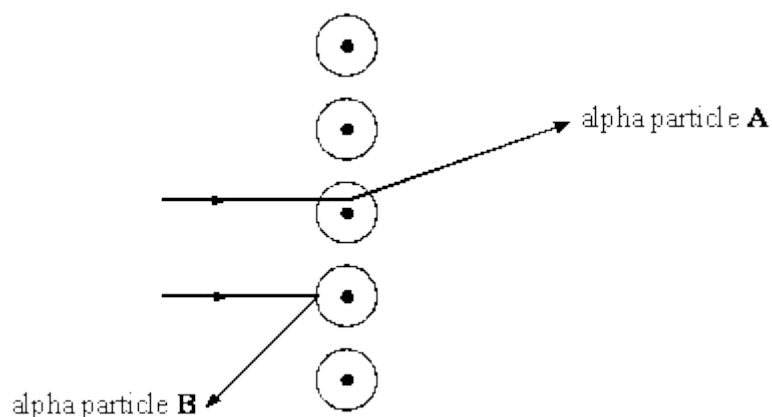
- (a) Atoms are made up of three types of particle called protons, neutrons and electrons. Complete the table below to show the relative mass and charge of a neutron and an electron. The relative mass and charge of a proton has already been done for you.

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.



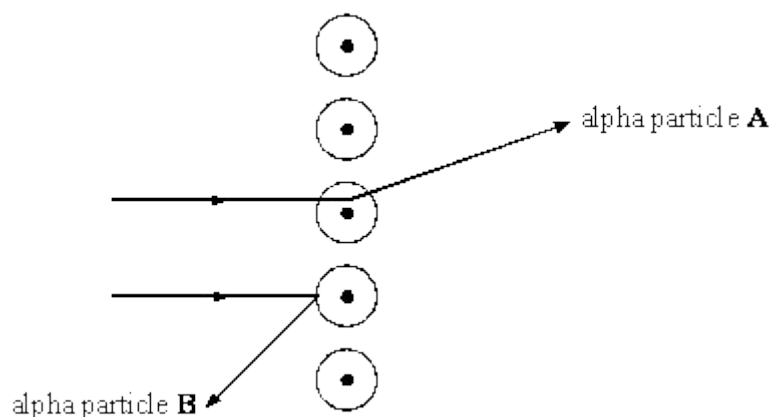
The paths of the alpha particles depend on the forces on them in the metal. Describe the model of the atom which is used to explain the paths of alpha particles aimed at thin sheets of metal foil.

(3)

(Total 5 marks)

Q6.

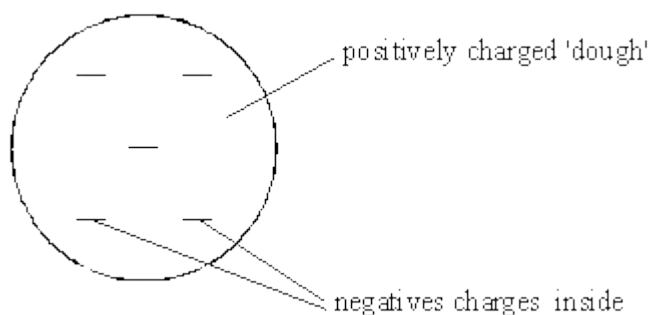
The diagram below shows the paths of two alpha particles A and B into and out of a thin piece of metal foil.



- (a) 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)

- (b) Scientists used to believe that atoms were made up of negative charges embedded in a positive 'dough'. This is called the 'plum pudding' model of the atom. The diagram below shows a model of such an atom.



- (i) Explain how the 'plum pudding' model of the atom can explain why alpha particle **A** is deflected through a very small angle.

(2)

- (ii) Explain why the 'plum pudding' model of the atom can not explain the large deflection of alpha particle **B**.

(3)

- (c) We now believe that atoms are made up of three types of particles 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 have already been done for you.

PARTICLE	RELATIVE MASS	RELATIVE CHARGE
proton	1	+1
neutron		
electron		

(2)

- (d) The diagrams below show the nuclei of four different atoms **A**, **B**, **C** and **D**.

Key: ○ – proton ● – neutron



nucleus **A**



nucleus **B**



nucleus **C**



nucleus **D**

- (i) State the mass number of C.

- (ii) Which two are isotopes of the same element?

_____ and _____

Explain your answer.

(4)

(Total 14 marks)

Q7.

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.

(1)

(b) The following are parts of an atom:

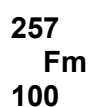
electron neutron nucleus proton

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.



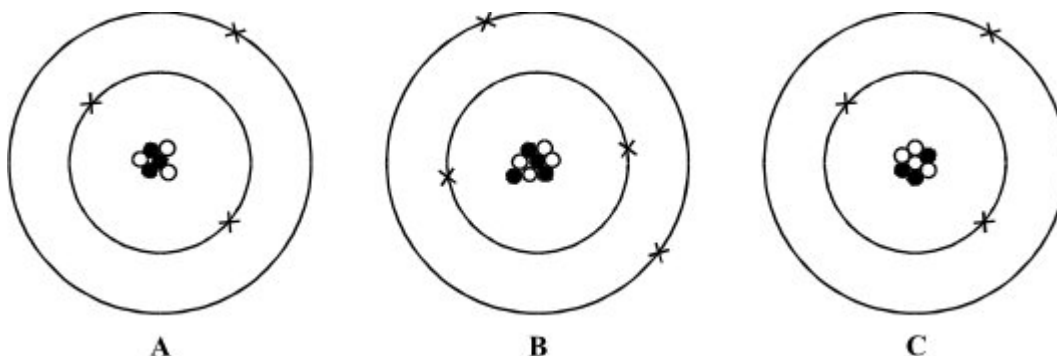
- (i) How many protons does this atom contain? _____
- (ii) How many neutrons does this atom contain? _____

(2)

(Total 6 marks)

Q8.

The diagrams below represent three atoms, **A**, **B** and **C**.



(a) Two of the atoms are from the **same** element.

- (i) Which of **A**, **B** and **C** is an atom of a different element? _____
- (ii) Give **one** reason for your answer.

(2)

(b) Two of these atoms are isotopes of the same element.

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

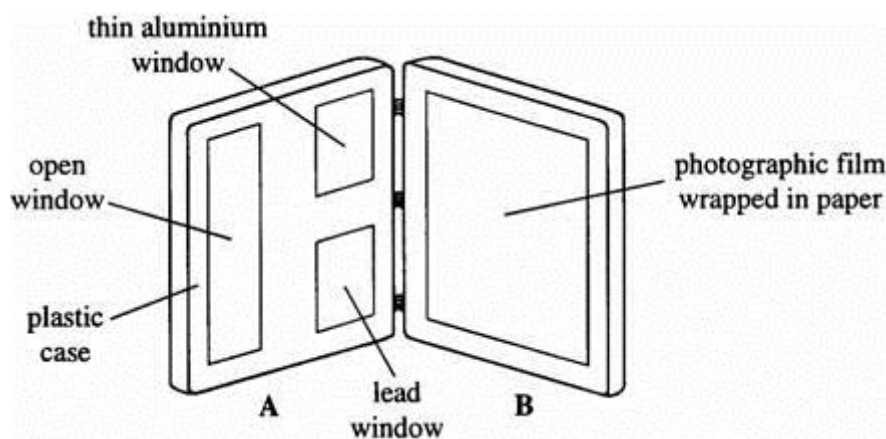
(ii) Explain your answer.

(3)

(Total 5 marks)

Q9.

The diagram shows a film badge worn by people who work with radioactive materials. The badge has been opened. The badge is used to measure the amount of radiation to which the workers have been exposed.



(a) The detector is a piece of photographic film wrapped in paper inside part **B** of the badge.

Part **A** has “windows” as shown.

Complete the sentences below.

When the badge is closed

(i) _____ radiation and _____ radiation can pass through the open window and affect the film.

(1)

(ii) Most of the _____ radiation will pass through the lead window and affect the film.

(1)

(b) Other detectors of radiation use a gas which is ionised by the radiation.

(i) Explain what is meant by *ionised*.

_____ (1)

- (ii) Write down **one** use of ionising radiation.

_____ (1)

- (c) Uranium-238 has a very long half-life. It decays via a series of short-lived radioisotopes to produce the stable isotope lead-204.

Explain, in detail, what is meant by:

- (i) *half-life*,

(1)

- (ii) *radioisotopes*.

(2)

- (d) The relative proportions of uranium-238 and lead-204 in a sample of igneous rock can be used to date the rock.

A rock sample contains three times as many lead atoms as uranium atoms.

- (i) What fraction of the original uranium is left in the rock?

(Assume that there was no lead in the original rock.)

(1)

- (ii) The half-life of uranium-238 is 4500 million years.

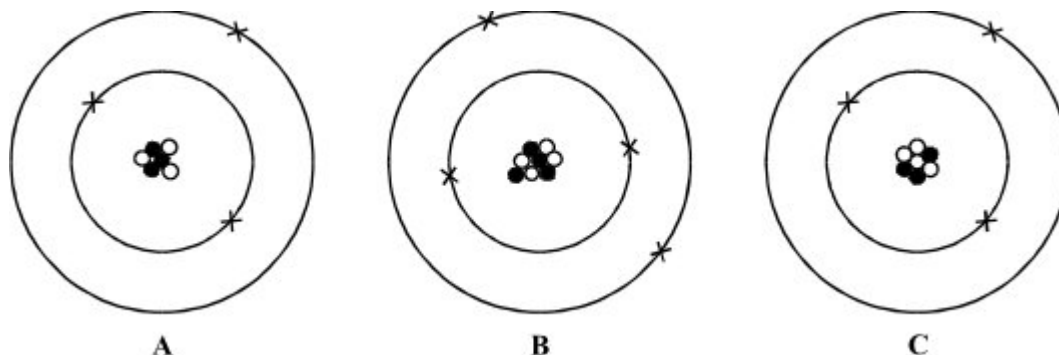
Calculate the age of the rock.

Age _____ million years

(2)
(Total 10 marks)

Q10.

The diagrams below represent three atoms, **A**, **B** and **C**.



(a) Two of these atoms are from the **same** element.

(i) Which of **A**, **B** and **C** is an atom of a different element? _____

(ii) Give **one** reason for your answer.

(2)

(b) Two of these atoms are isotopes of the same element.

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

(ii) Explain your answer.

(3)

(c) Which of the particles $\bigcirc$, $\bullet$ and **X**, shown in the diagrams:

(i) has a positive charge; _____

(ii) has no charge; _____

(iii) has the smallest mass? _____

(3)

- (d) Using the same symbols as those in the atom diagrams, draw an alpha particle.

(1)
(Total 9 marks)

Q11.

In some areas of the U.K. people are worried because their houses are built on rocks that release radon.

Read the information about radon.

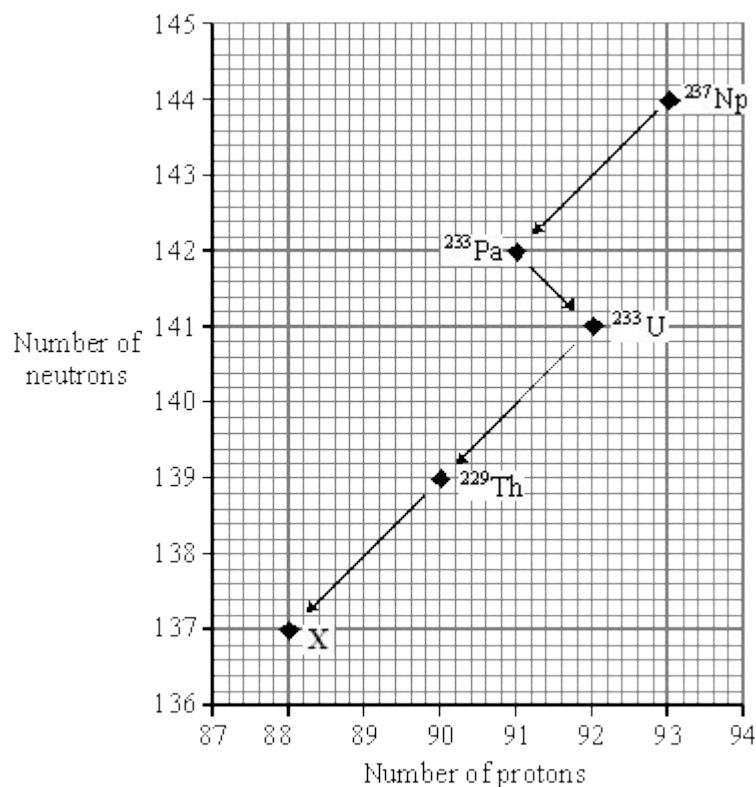
- It is a gas.
- It is formed by the breakdown of radium.
- It emits alpha radiation.
- Each radon atom has 86 protons.
- Each radon atom has 136 neutrons.

- (i) How many electrons has each atom of radon? _____
- (ii) What is the mass (nucleon) number of radon? _____

(Total 2 marks)

Q12.

Neptunium-237 (^{237}Np) is a radioactive element. The graph shows the numbers of neutrons and protons in the nuclei of the elements formed when ^{237}Np decays.



- (a) Use the periodic table on the Data Sheet to identify element X.

 (1)

- (b) Why are ^{233}Pa and ^{233}U considered to be different elements?

 (1)

- (c) What type of radiation is released when ^{237}Np decays to form ^{233}Pa ?

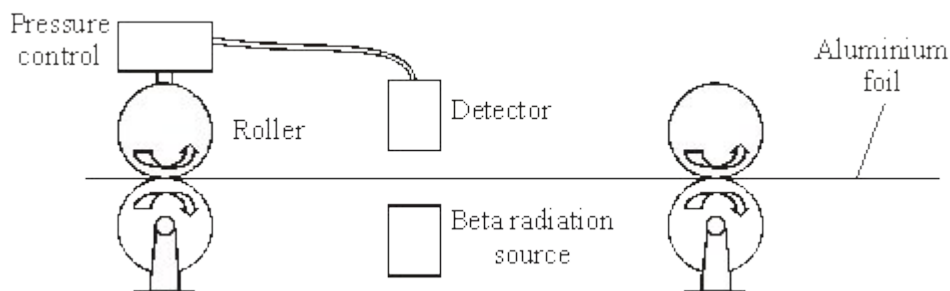
 (1)

- (d) What change takes place in the nucleus when ^{233}Pa changes into ^{233}U ?

 (1)
 (Total 4 marks)

Q13.

The diagram shows how the thickness of aluminium foil is controlled. The thicker the aluminium foil, the more radiation it absorbs.



(a) The designers used a beta radiation source for this control system.

(i) Why would an alpha radiation source be unsuitable in this control system?

(1)

(ii) Why would a gamma radiation source be unsuitable in this control system?

(1)

(b) The substance used in the beta radiation source is radioactive.

(i) Why are some atoms radioactive?

(1)

(ii) Explain why radiation is dangerous to humans.

(2)

(Total 5 marks)

Q14.

(a) Complete the sentences about atoms.

In an atom, the number of electrons is equal to the number of _____.

All atoms of an element have the same number of _____.

Isotopes of the same element have different numbers of _____ .

(3)

(b) Complete the sentence.

When an atom of a radioactive element emits alpha radiation, an atom of a different element is formed. A different element is formed because the radioactive element has lost _____ .

(1)

(Total 4 marks)

Q15.

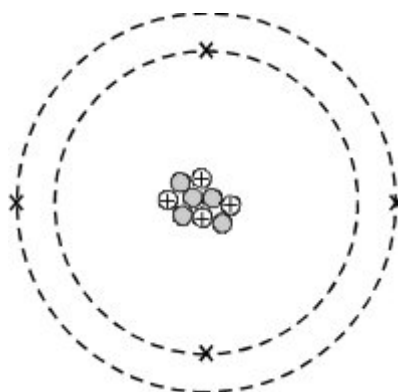
${}_{43}^{99}\text{Tc}$ (technetium) is produced by the radioactive decay of ${}_{42}^{99}\text{Mo}$ (molybdenum).

What change occurs in the nucleus of a molybdenum atom when this happens?

(Total 1 mark)

Q16.

The diagram shows an atom.



How many protons are there in the nucleus of the atom? _____

What is the mass number of the atom? _____

(Total 2 marks)

Mark schemes

Q1.

- (a) (i) helium nuclei

1

or

two protons and two neutrons or $\frac{4}{2}\text{He}$

*do **not** accept it is a particle emitted by an unstable nucleus of Californium -241*

- (ii) time taken for the activity **or** count rate **or** number of nuclei
or number of atoms **or** number of radioactive particles
to decrease to half

1

- (iii) Technetium-99

*this mark **cannot** score without Technetium- 99*

1

any **two** of the following:

- suitable short half-life or activity quickly reduced to a safe level or it doesn't stay in the body long
*this mark **can** score if Cobalt -60 is given*
- (gamma emitter so) it can be detected outside the body
- less (ionising) damage to cells **or** tissue
*this mark **can** score if Cobalt -60 is given*

2

- (b) any **three** of the following:

- transport of waste into the area
- possibility of accident or leakage from transport
- safe levels not reached for hundreds or thousands of years
- Possible leakage **or** contamination of land **or** water **or** increase in background radiation
- increased risk of (radiation linked) illness **or** cancer

3

[8]

Q2.

- (a) (i) a helium nucleus

- accept ${}^4_2\text{He}$
 accept 2 protons + 2 neutrons
 do **not** accept He
 do **not** accept helium atom
- 1
- (ii) nucleus
only answer, no alternative
- 1
- (b) (i) each axis given a linear scale
time axis must go up to 12 days
y-axis must go up to 40 000
- 1
- curve concave to axis drawn
- 1
- curve shows correct half-life of four days
*do **not** accept a straight line must show one half-life*
check first two plotted points correct to $\pm$ half square
a curve drawn dot-to-dot scores a maximum of 1 mark
- 1
- (ii) 38 750
no tolerance
allow 1 mark for 5 half-lives
allow 1 mark for showing that 1 250 are undecayed
- 3
- (c) (i) more radon enters shaft (through cracks in the rock face)
accept radon emitted from surroundings
- 1
- (ii) (alpha) radiation will damage cell structure or ionise cells
accept kill cells
- 1
- causing cancerous growth
*an answer in terms of the daughter product polonium being a solid **or** lodging in the throat and also emitting alpha gains full credit*
- 1

[11]

Q3.

- (a) (i) electron
 neutron
 proton
 nucleus
1 mark for each correct label

4

- (ii) H-1 has no neutrons
H-3 has 2 neutrons
more neutrons gets 1 mark 2
- (iii) nucleus unstable 2
- (b) lead/concrete
lead/concrete needed to stop gamma rays 2
- [10]**

Q4.

- (a) 1.
-1 2
- for 1 mark each*
- (b) (i) 19p,
20n,
19e
all correct for 2 marks
2 correct for 1 mark 2
- (ii) K40 has an extra neutron/different number of neutrons/
it has more neutrons/21 neutrons
for 1 mark
NOT fewer neutrons 1
- (iii) radioactive/unstable nucleus/ nucleus disintegrates/
emits radiation/it has too many neutrons
for 1 mark 1
- (iv) calcium/Ca
for 1 mark 1
- (v) 1 (e) in outer shell/same number of electrons/outer electron
same distance from the nucleus
for 1 mark 1
- (c) (i) Geiger-Muller tube (photographic) film
for 1 mark 1
- (ii) cancer, leukaemia, radiation sickness etc.
for 1 mark 1

[10]

Q5.

- (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]**Q6.**

- (a) nucleus positive charge / protons in nucleus electrons / negative charges
 orbit nucleus
each for 1 mark

3

- (b) (i) positive dough repels positive alpha particles **or** 2 positive
 charges repel forces small
each for 1 mark

2

- (ii) large force needed + ves in plum pudding spread out – *may appear in (i)*
 positive charge must be concentrated / in nucleus
(ignore references to electrons)
for 1 mark each

3

- (c) 1, 0
 X, -1 (X = negligible / very small / (1/1840) (1/2000), but not nothing)
each row for 1 mark

2

- (d) (i) 4
for 1 mark

1

- (ii) B and C have the same number of protons / atomic number
 but different number of neutrons / mass number
each for 1 mark

3

[14]**Q7.**

- (a) 90
for one mark

1

- (b) (i) neutron
for one mark

1

	(ii)	nucleus <i>for one mark</i>	1	
	(iii)	electron <i>for one mark</i>	1	
(c)	(i)	100 <i>for one mark</i>	1	
	(ii)	157 <i>for one mark</i>	1	
				[6]

Q8.

(a)	(i)	B <i>for one mark</i>	2	
	(ii)	has a different number of electrons (protons) <i>for one mark</i>		
(b)	(i)	A and C <i>for one mark</i>	1	
	(ii)	same number of protons / electrons, same nuclear charge different number of neutrons / nuclear masses different <i>for 1 mark each</i>	2	
				[5]

Q9.

(a)	(i)	beta and gamma (<i>any</i> order) <i>for one mark</i>	1	
	(ii)	gamma <i>for one mark</i>	1	
(b)	(i)	particles / atoms / molecules become charged / gain / lose electrons <i>for one mark</i>	1	
	(ii)	e.g. to kill cancer cells (<i>allow</i> any use of alpha, beta or gamma or X ⁻ radiation) <i>for one mark</i>	1	
(c)	(i)	time taken for no. of atoms / no. of nuclei / mass of U238 / activity to halve – not radioactivity		

or
time taken for count rate to halve
for one mark

1

- (ii) atoms with unstable nuclei which emit radiation
(*not* definition of isotope but isotope which is radioactive gets 1 mark)
for 1 mark each

2

- (d) (i) $1/4$ *accept* 25% or 0.25
for one mark

1

- (ii) $2 \times$ half life or 2×4500 million years (independent of (i))
gains *1 mark*
but

9000 million years ecf only if answer to (i) is $\frac{1}{2}, \frac{1}{8}, \frac{1}{16}$ etc.
gains 2 marks

2

[10]

Q10.

- (a) (i) B
for one mark

1

- (ii) has 4 electrons / protons others only 3; B has a different no. of
electrons / protons - *not* A and C have same no. of protons / electrons
for one mark

1

- (b) (i) A and C
for one mark

1

- (ii) same no. of protons / electrons different no. of neutrons
or
nuclei have the same charge but different mass
for 1 mark each

2

- (c) (i) 

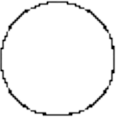
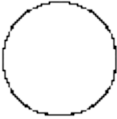
- (ii) 

- (iii) 

for 1 mark each

3

- (d) $2p.2n$ 

allow  but not 
 (i.e. no mark if electrons shown)
 for one mark

1

[9]

Q11.

(i) 86

1

(ii) 222

1

[2]

Q12.

(a) radium

accept Ra

1

(b) different numbers of protons

accept one has 91 protons, one has 92

or Pa has 91 protons, U has 92

do **not** credit they have different atomic numbers

reject different numbers of protons and neutrons

1

(c) alpha

1

(d) neutron changes into proton

accept electron lost / beta radiation

accept singular or plural answers

1

[4]

Q13.

(a) (i) cannot penetrate aluminium

allow can only pass through air / paper too weak is neutral

1

(ii) gamma rays not affected (by aluminium)

allow all / most (gamma rays) to pass through

too strong is neutral

danger is neutral

1

(b) (i) (nuclei) unstable

1

(ii) causes harm / damage to body / cells

allow radiation sickness

1

detail e.g., causes mutations / causes cancer / damages DNA /
damages chromosomes

allow two effects for 2 marks

1

[5]

Q14.

(a) protons

1

protons

accept electrons

1

neutrons

1

(b) protons

reject mass

1

[4]

Q15.

neutron becomes proton / neutron emits electron / neutron emits beta particle

gains proton neutral

[1]

Q16.

• 4

• 9

each for 1 mark

[2]