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Radioactivity: 16

TOPIC-Alpha-particle scattering experiment, fundamental particles, radioactivity

CLASSIFIED

International Examinations Papers

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Radioactivity: 16

TOPIC- Fundamental particles, radioactivity

For Examiner's Use

01 The radioactive decay of nuclei is both spontaneous and random.

Explain what is meant by

(a) *radioactive decay* of a nucleus,

....

....

.... [2]

(b) *spontaneous* decay,

....

....

.... [2]

(c) *random* decay.

....

....

.... [2]

For Examiner's Use

02 **(a)** Explain what is meant by *radioactive decay*.

....

....

.... [2]

(b) **(i)** State how the random nature of radioactive decay may be inferred from observations of the count rate.

....

.... [1]

(ii) A radioactive source has a long half-life so that, over a period of several days, its rate of decay remains constant.
State the effect, if any, of a rise in temperature on this decay rate.

.... [1]

(iii) Suggest why some radioactive sources are found to contain traces of helium gas.

....

....

.... [2]

0 3 The spontaneous and random decay of a radioactive substance involves the emission of either α-radiation or β-radiation and/or γ-radiation.

For Examiner's Use

(a) Explain what is meant by *spontaneous* decay.

....

....

.... [2]

(b) State the type of emission, one in each case, that

(i) is not affected by electric and magnetic fields,

.... [1]

(ii) produces the greatest density of ionisation in a medium,

.... [1]

(iii) does not directly result in a change in the proton number of the nucleus,

.... [1]

(iv) has a range of energies, rather than discrete values.

.... [1]

04 (a) State what is meant by

α-particle: ....

β-particle: ....

γ-radiation: .... [2]

(b) Describe the changes to the proton number and the nucleon number of a nucleus when emission occurs of

(i) an α-particle,

....

.... [1]

(ii) a β-particle,

....

.... [1]

(iii) γ-radiation.

....

.... [1]

05 (a) State the experimental observations that show radioactive decay is

For Examiner's Use

(i) spontaneous,

....

....[1]

(ii) random.

....

....[1]

(b) On Fig. 7.1, complete the charge and mass of α-particles, β-particles and γ-radiation. Give example speeds of α-particles and γ-radiation emitted by a laboratory source.

	α-particle	β-particle	γ-radiation
charge			0
mass	4u		
speed		up to 0.99c	

Fig. 7.1

[3]

(c) Explain the process by which α-particles lose energy when they pass through air.

....

....

....[2]

06 A uranium-235 nucleus absorbs a neutron and then splits into two nuclei. A possible nuclear reaction is given by

$$^{235}_{92}\text{U} + {}^{a}_{b}\text{n} \rightarrow {}^{93}_{37}\text{Rb} + {}^{c}_{d}\text{X} + 2\,{}^{a}_{b}\text{n} + \text{energy.}$$

(a) State the constituent particles of the uranium-235 nucleus.

.... [1]

(b) Complete Fig. 7.1 for this reaction.

	value
a	
b	
c	
d	

[3]

Fig. 7.1

(c) Suggest a possible form of energy released in this reaction.

.... [1]

(d) Explain, using the law of mass-energy conservation, how energy is released in this reaction.

....

....

.... [2]

For Examiner's Use

7 (a) The spontaneous decay of polonium is shown by the nuclear equation

$$^{210}_{84}Po \rightarrow ^{206}_{82}Pb + X.$$

(i) State the composition of the nucleus of X.

....

.... [1]

(ii) The nuclei X are emitted as radiation. State two properties of this radiation.

1. ....

....

2. ....

....

[2]

(b) The mass of the polonium (Po) nucleus is greater than the combined mass of the nuclei of lead (Pb) and X. Use a conservation law to explain qualitatively how this decay is possible.

....

....

.... [3]

0 8 The equation represents the spontaneous radioactive decay of a nucleus of bismuth-212.

$$^{212}_{83}\text{Bi} \longrightarrow \text{X} + {}^{208}_{81}\text{T}l + 6.2\,\text{MeV}$$

(a) (i) Explain the meaning of *spontaneous* radioactive decay.

....

....[1]

(ii) State the constituent particles of X.

....[1]

(b) (i) Use the conservation of mass-energy to explain the release of 6.2 MeV of energy in this reaction.

....

....

....[2]

(ii) Calculate the energy, in joules, released in this reaction.

energy = ... J [1]

For Examiner's Use

0 9 (a) Two isotopes of the element uranium are $^{235}_{92}U$ and $^{238}_{92}U$.

Explain the term *isotope*.

....

....

.... [2]

(b) (i) In a nuclear reaction, proton number and neutron number are conserved. Other than proton number and neutron number, state a quantity that is conserved in a nuclear reaction.

.... [1]

(ii) When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

$$^{235}_{92}U + ^{a}_{b}n \longrightarrow ^{141}_{x}Ba + ^{y}_{36}Kr + 3\,^{a}_{b}n$$

State the values of *a*, *b*, *x* and *y*.

a = ...

b = ...

x = ...

y = ... [3]

(c) When the nucleus of $^{238}_{92}U$ absorbs a neutron, the nucleus decays, emitting an α-particle. State the proton number and nucleon number of the nucleus that is formed as a result of the emission of the α-particle.

proton number = ...

nucleon number = ... [2]

For Examiner's Use

10 **(a)** Uranium (U) has at least fourteen isotopes.
Explain what is meant by *isotopes*.

....

....

.... [2]

(b) One possible nuclear reaction involving uranium is

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{Z}Kr + x\,^{1}_{0}n + \text{energy.}$$

(i) State three quantities that are conserved in a nuclear reaction.

1. ....

....

2. ....

....

3. ....

.... [3]

(ii) For this reaction, determine the value of

1. *Z*,

Z = ... [1]

2. *x*.

x = ... [1]

For Examiner's Use

11 (a) Two isotopes of uranium are uranium-235 ($^{235}_{92}U$) and uranium-238 ($^{238}_{92}U$).

(i) Describe in detail an atom of uranium-235.

....

....

....

....

.... [4]

(ii) With reference to the two forms of uranium, explain the term *isotopes*.

....

....

.... [2]

(b) When a uranium-235 nucleus absorbs a neutron, the following reaction may occur:

$$^{235}_{92}U + {}^{W}_{X}n \rightarrow {}^{148}_{57}La + {}^{Z}_{Y}Q + 3\,{}^{W}_{X}n$$

(i) Determine the values of *Y* and *Z*.

Y = ...

Z = ... [2]

(ii) Explain why the sum of the masses of the uranium nucleus and of the neutron does not equal the total mass of the products of the reaction.

....

....

.... [2]

12 A polonium nucleus $^{210}_{84}Po$ is radioactive and decays with the emission of an α-particle. The nuclear reaction for this decay is given by

For Examiner's Use

$$^{210}_{84}Po \rightarrow {}^{W}_{X}Q + {}^{Y}_{Z}\alpha.$$

(a) **(i)** State the values of *W* ....

X ....

Y ....

Z ....

[2]

(ii) Explain why mass seems not to be conserved in the reaction.

....

....[2]

(b) The reaction is spontaneous. Explain the meaning of *spontaneous*.

....

....[1]

13 **(a)** A nuclear reaction occurs when a uranium-235 nucleus absorbs a neutron. The reaction may be represented by the equation:

$$^{235}_{92}\text{U} + ^{W}_{X}\text{n} \rightarrow ^{93}_{37}\text{Rb} + ^{141}_{Z}\text{Cs} + Y^{W}_{X}\text{n}$$

State the number represented by the letter

W ....

X ....

Y ....

Z ....

[3]

(b) The sum of the masses on the left-hand side of the equation in **(a)** is not the same as the sum of the masses on the right-hand side.

Explain why mass seems not to be conserved.

....

....

.... [2]

14 Thoron is a radioactive gas. The variation with time t of the detected count rate C from a sample of the gas is shown in Fig. 8.1.

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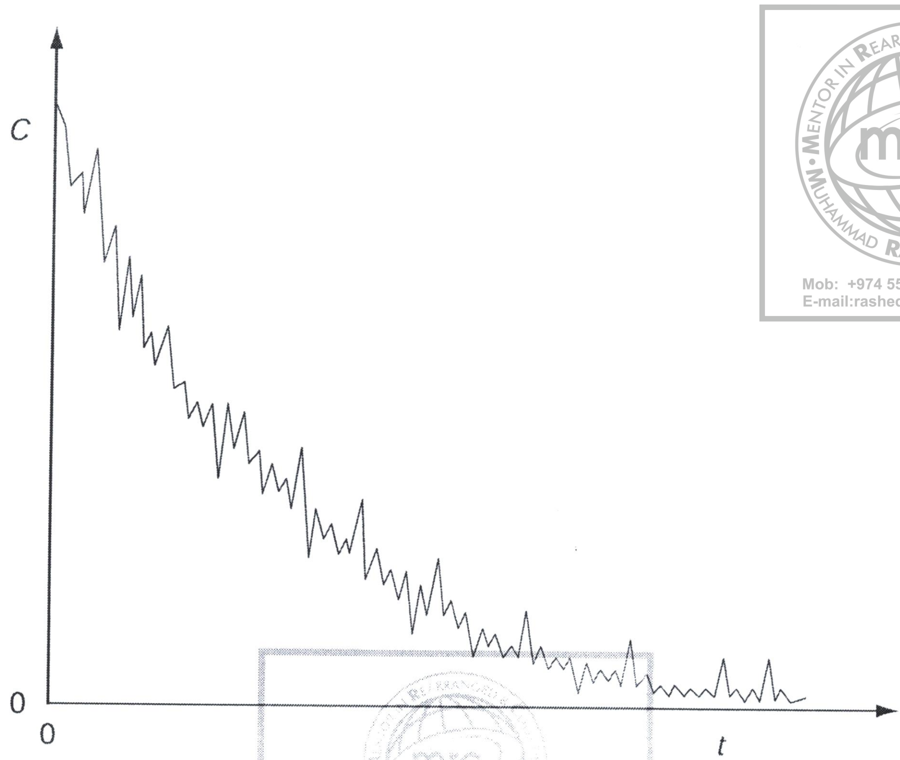

Fig. 8.1

Radioactive decay is said to be a random and spontaneous process.

(a) Explain, by reference to radioactive decay, what is meant by a *random* process.

....

....

.... [2]

(b) State the feature of Fig. 8.1 which indicates that the process is

(i) a decay process,

.... [1]

(ii) random.

.... [1]

(c) A second similar sample of thoron is prepared but it is at a much higher temperature. The variation with time of the count rate for this second sample is determined. State the feature of the decay curves for the two samples that suggests that radioactive decay is a spontaneous process.

....

.... [1]

For Examiner's Use

Radioactivity: 16

TOPIC- α particle scattering experiment

0 1 **(a)** Evidence for the nuclear atom was provided by the α-particle scattering experiment. State the results of this experiment.

....

....

....

.... [2]

(b) Give estimates for the diameter of

(i) an atom,

.... [1]

(ii) a nucleus.

.... [1]

02 The α-particle scattering experiment provided evidence for the existence of a nuclear atom.

For Examiner's Use

(a) State what could be deduced from the fact that

(i) most α-particles were deviated through angles of less than 10°,

....

....

.... [2]

(ii) a very small proportion of the α-particles was deviated through angles greater than 90°.

....

....

.... [2]

3 The results of the α-particle scattering experiment provided evidence for the existence and small size of the nucleus.

For Examiner's Use

(a) State the result that provided evidence for

(i) the small size of the nucleus, compared with the atom,

....

....

.... [2]

(ii) the nucleus being charged and containing the majority of the mass of the atom.

....

....

.... [2]

(b) The α-particles in this experiment originated from the decay of a radioactive nuclide. Suggest two reasons why β-particles from a radioactive source would be inappropriate for this type of scattering experiment.

1. ....

....

2. ....

....

[2]

04 **(a)** Describe the two main results of the α-particle scattering experiment.

For Examiner's Use

result 1: ....

....

result 2: ....

....

[3]

(b) Relate each of the results in **(a)** with the conclusions that were made about the nature of atoms.

result 1: ....

....

result 2: ....

....

[3]

05 **(a)** State **one** difference between a hadron and a lepton.

....

....[1]

(b) **(i)** State the quark composition of a proton and of a neutron.

proton: ....

neutron: ....
[2]

(ii) Use your answer in **(i)** to determine the quark composition of an α-particle.

quark composition: ....[1]

(c) The results of the α-particle scattering experiment provide evidence for the structure of the atom.

result 1: The vast majority of α-particles pass straight through the metal foil or are deviated by small angles.

result 2: A very small minority of α-particles are scattered through angles greater than 90°.

State what may be inferred from

(i) result 1,

....

....[1]

(ii) result 2.

....

....

....

....[2]

[Total: 7]

06 (a) State **one** difference between a hadron and a lepton.

....

....[1]

(b) (i) State the quark composition of a proton and of a neutron.

proton: ....

neutron: ....
[2]

(ii) Use your answer in **(i)** to determine the quark composition of an α-particle.

quark composition: ....[1]

(c) The results of the α-particle scattering experiment provide evidence for the structure of the atom.

result 1: The vast majority of α-particles pass straight through the metal foil or are deviated by small angles.

result 2: A very small minority of α-particles are scattered through angles greater than 90°.

State what may be inferred from

(i) result 1,

....

....[1]

(ii) result 2.

....

....

....

....[2]

[Total: 7]

07 (a) The results of the α-particle scattering experiment gave evidence for the structure of the atom.

State two results and the associated conclusions.

result 1: ....

....

conclusion 1: ....

....

result 2: ....

....

conclusion 2: ....

....
[4]

(b) In a model of a copper atom of the isotope $^{63}_{29}Cu$, the atom and its nucleus are assumed to be spherical.

The diameter of the nucleus is 2.8×10^{-14} m. The diameter of the atom is 2.3×10^{-10} m.

Calculate the ratio

$$\frac{\text{density of the nucleus}}{\text{density of the atom}}.$$

ratio = ... [3]

8 (a) State the quantities, other than momentum, that are conserved in a nuclear reaction.

....

.... [2]

(b) A stationary nucleus of uranium-238 decays to a nucleus of thorium-234 by emitting an α-particle. The kinetic energy of the α-particle is 6.69×10^{-13} J.

(i) Show that the kinetic energy E_k of a mass m is related to its momentum p by the equation

$$E_k = \frac{p^2}{2m}.$$

[1]

(ii) Use the conservation of momentum to determine the kinetic energy, in keV, of the thorium nucleus.

kinetic energy = ... keV [3]

0 9 An arrangement for producing stationary waves in air in a tube that is closed at one end is shown in Fig. 6.1.

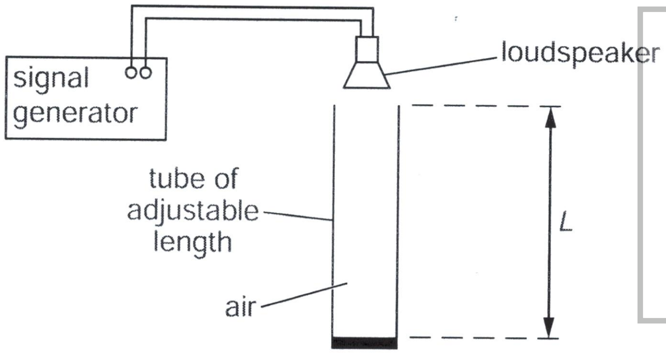

Fig. 6.1

A loudspeaker produces sound waves of wavelength 0.680 m in the tube.
For some values of the length L of the tube, stationary waves are formed.

(a) Explain how stationary waves are formed in the tube.

....

....

.... [2]

(b) The length L is adjusted between 0.200 m and 1.00 m.

(i) Calculate two values of L for which stationary waves are formed.

L = ... m and L = ... m [2]

(ii) On Fig. 6.2, label the positions of the antinodes with an **A** and the nodes with an **N** for the least value of L for which a stationary wave is formed.

Fig. 6.2

[1]

10 Two parallel, vertical metal plates in a vacuum are connected to a power supply and a switch, as shown in Fig. 7.1.

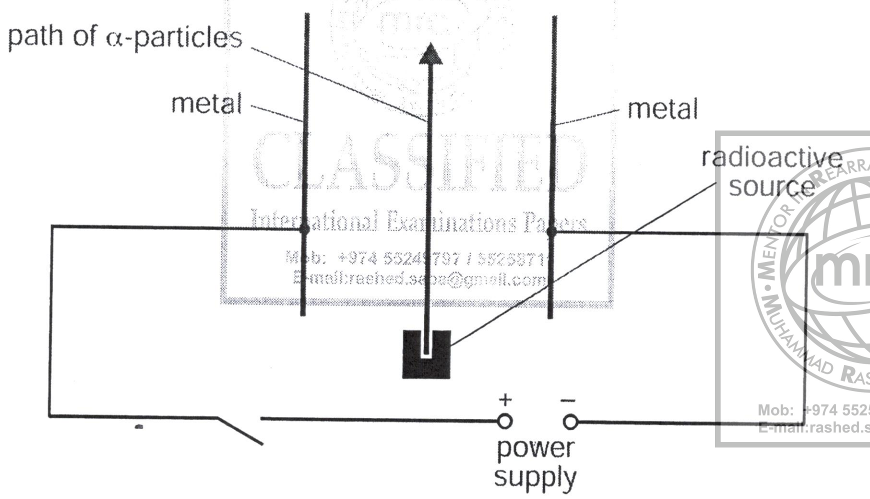

Fig. 7.1

A radioactive source emitting α-particles is placed below the plates. The path of the α-particles is shown on Fig. 7.1. The switch is closed producing a potential difference (p.d.) across the plates. This gives rise to a uniform electric field between the plates.

The separation of the plates is 12 mm.

(a) **(i)** On Fig. 7.1, draw the path of the α-particles. [1]

(ii) Explain why the metal plates are placed in a vacuum.

....

.... [1]

(iii) Calculate the p.d. required to produce an electric field of $140\,\text{MV}\,\text{m}^{-1}$.

p.d. = ... MV [2]

(b) The α-particle source is replaced by a β-particle source. By reference to the properties of α-radiation and β-radiation, suggest three possible differences in the deflection observed with β-particles.

1. ....

....

2. ....

....

3. ....

....

[3]

(c) Complete Fig. 7.2 to show the changes in the proton number Z and the nucleon number A of different radioactive nuclei when either an α-particle or a β-particle is emitted.

emitted particle	change in Z	change in A
α-particle		
β-particle		

Fig. 7.2

[1]

1 (a) An electric field is set up between two parallel metal plates in a vacuum. The deflection of α-particles as they pass between the plates is shown in Fig. 7.1.

For Examiner's Use

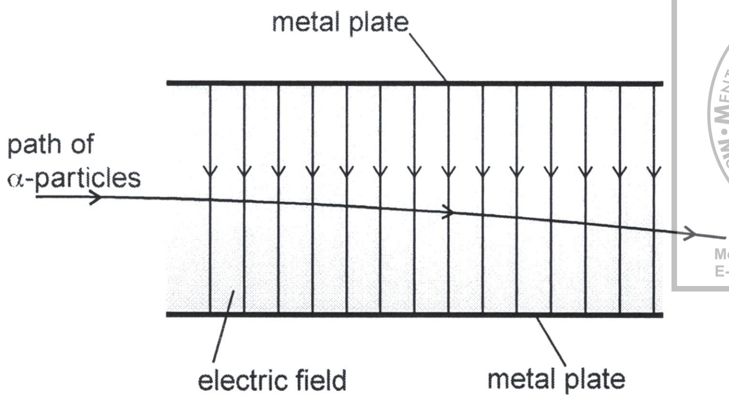

Fig. 7.1

The electric field strength between the plates is reduced. The α-particles are replaced by β-particles. The deflection of β-particles is shown in Fig. 7.2.

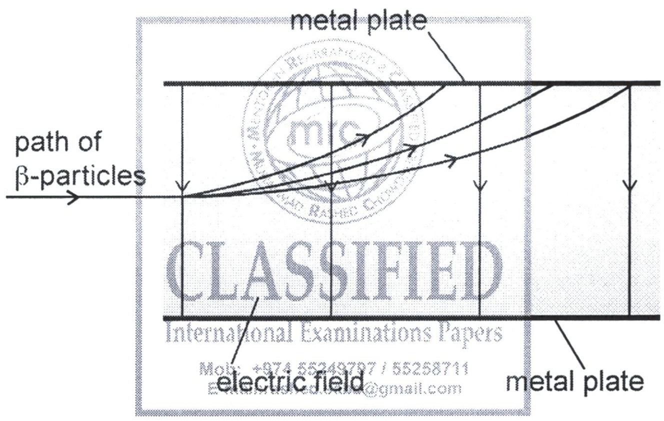

Fig. 7.2

(i) State one similarity of the electric fields shown in Fig. 7.1 and Fig. 7.2.

....

.... [1]

(ii) The electric field strength in Fig. 7.2 is less than that in Fig. 7.1. State two methods of reducing this electric field strength.

1. ....

2. ....

[2]

For Examiner's Use

(iii) By reference to the properties of α-particles and β-particles, suggest three reasons for the differences in the deflections shown in Fig. 7.1 and Fig. 7.2.

1. ....

....

2. ....

....

3. ....

....

[3]

(b) A source of α-particles is uranium-238. The nuclear reaction for the emission of α-particles is represented by

$$^{238}_{92}U \rightarrow {}^{W}_{X}Q + {}^{Y}_{Z}\alpha.$$

State the values of *W*..............

X ....

Y ....

Z ....

[2]

(c) A source of β-particles is phosphorus-32. The nuclear reaction for the emission of β-particles is represented by

$$^{32}_{15}P \rightarrow {}^{A}_{B}R + {}^{C}_{D}\beta.$$

State the values of *A* ....

B ....

C ....

D ....

[1]

12 **(a)** Describe the structure of an atom of the nuclide $^{235}_{92}U$.

For Examiner's Use

....

....

....

.... [2]

(b) The deflection of α-particles by a thin metal foil is investigated with the arrangement shown in Fig. 6.1. All the apparatus is enclosed in a vacuum.

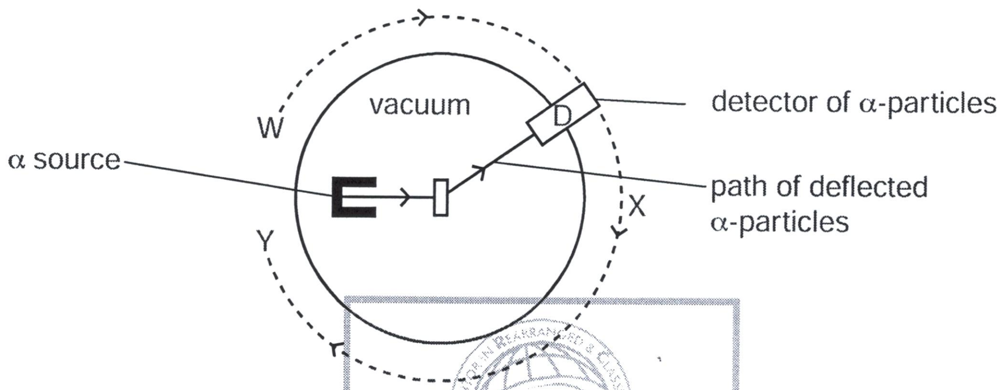

Fig. 6.1

The detector of α-particles, D, is moved around the path labelled WXY.

(i) Explain why the apparatus is enclosed in a vacuum.

....

.... [1]

(ii) State and explain the readings detected by D when it is moved along WXY.

....

....

....

....

....

.... [3]

Question 6 continues on page 16.

(c) A beam of α-particles produces a current of 1.5 pA. Calculate the number of α-particles per second passing a point in the beam.

For Examiner's Use

number = ... s^{-1} [3]

13 An α-particle A approaches and passes by a stationary gold nucleus N. The path is illustrated in Fig. 7.1.

For Examiner's Use

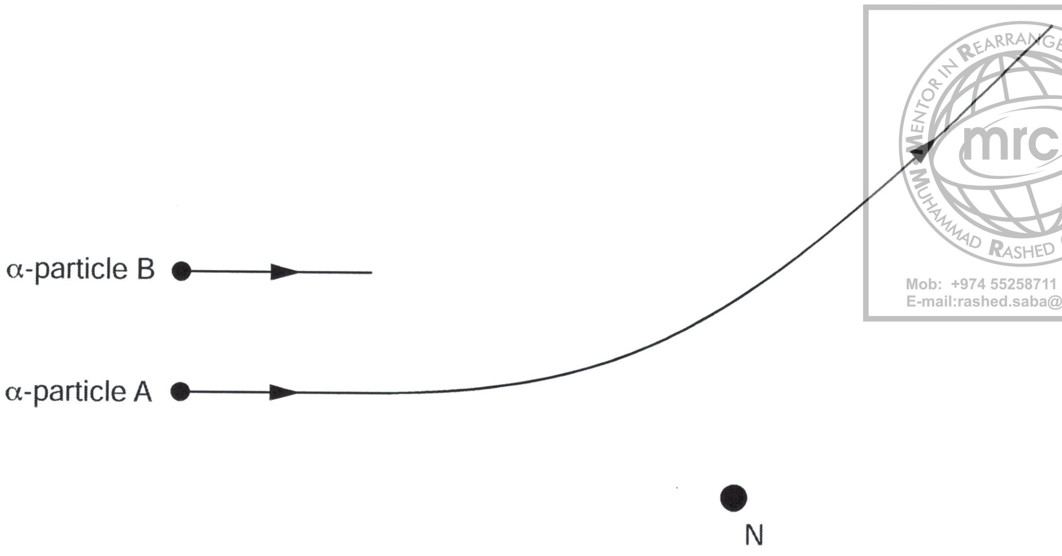

Fig. 7.1

(a) On Fig. 7.1, mark the angle of deviation *D* of this α-particle as a result of passing the nucleus N. [1]

(b) A second α-particle B has the same initial direction and energy as α-particle A.
On Fig. 7.1, complete the path of α-particle B as it approaches and passes by the nucleus N. [2]

(c) State what can be inferred about atoms from the observation that very few α-particles experience large deviations.

....

....

.... [2]

(d) The nucleus N could be one of several different isotopes of gold.

Suggest, with an explanation, whether different isotopes of gold would give rise to different deviations of a particular α-particle.

....

....

.... [2]

(b) Fig. 7.1 shows the path AB of an α-particle as it approaches and passes by a stationary gold nucleus.

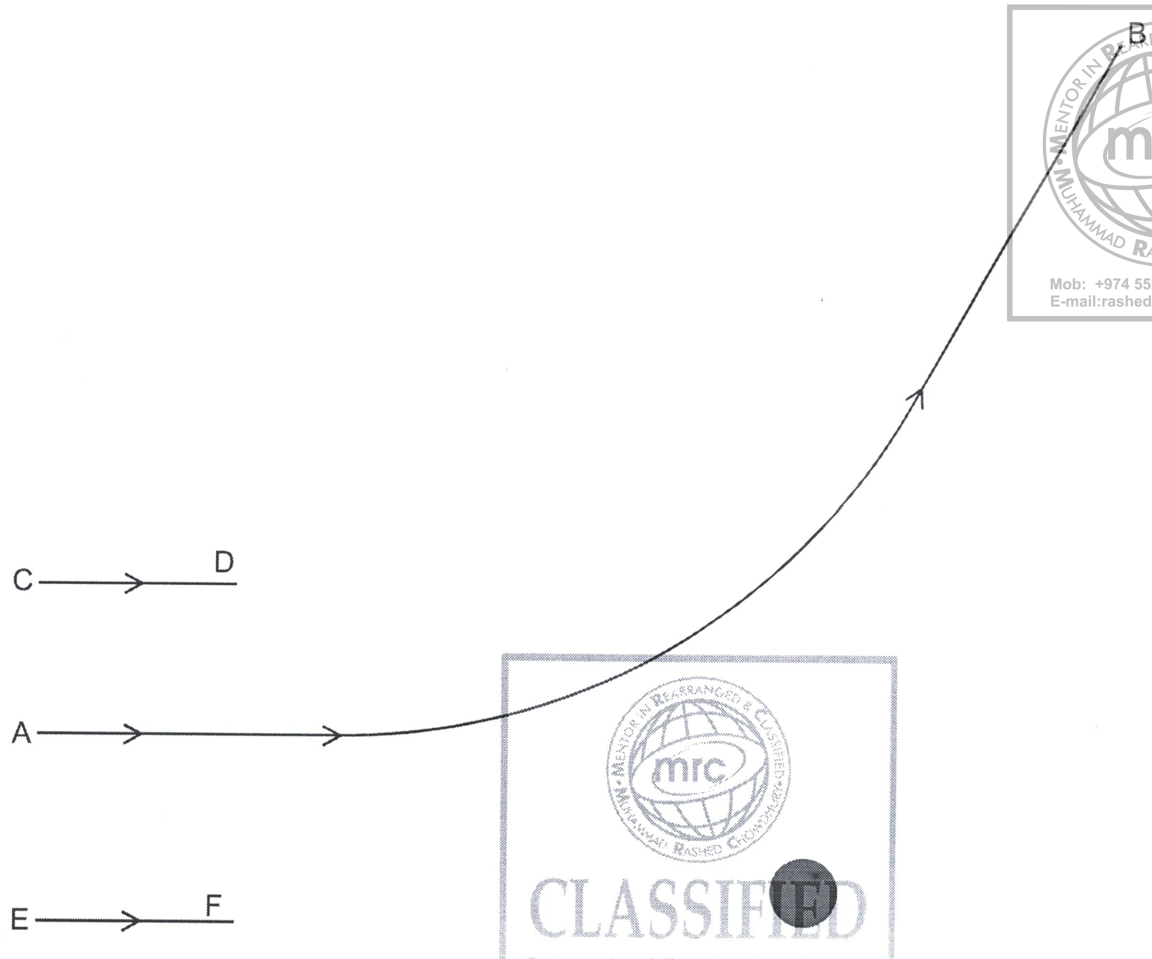

Fig. 7.1

On Fig. 7.1, draw lines (one in each case) to complete the paths of the α-particles passing by the gold nucleus when the initial direction of approach is

(i) along line CD,

(ii) along line EF.

[3]

For Examiner's Use

14 The radioactive decay of a strontium (Sr) nucleus is represented in Fig. 7.1.

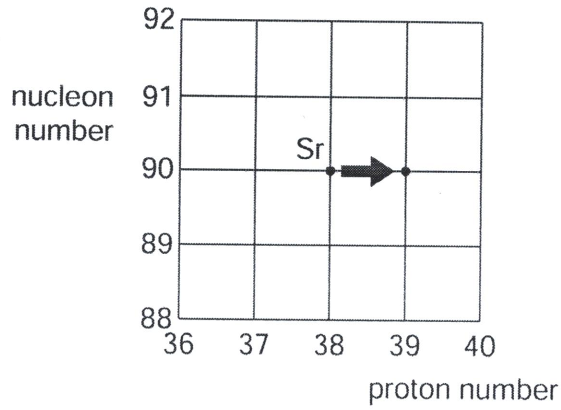

Fig. 7.1

(a) State whether Fig. 7.1 represents α-decay, β-decay or γ-decay.

....[1]

(b) One type of radioactive decay cannot be represented on Fig. 7.1.
Identify this decay and explain why it cannot be represented.

....

....

....[2]

15 7 Uranium-236 ($^{236}_{92}U$) and Uranium-237 ($^{237}_{92}U$) are both radioactive.
Uranium-236 is an α-emitter and Uranium-237 is a β-emitter.

For Examiner's Use

(a) Distinguish between an α-particle and a β-particle.

....

....

....

....

....

.... [4]

(b) The grid of Fig. 7.1 shows some proton numbers Z on the x-axis and the number N of neutrons in the nucleus on the y-axis.

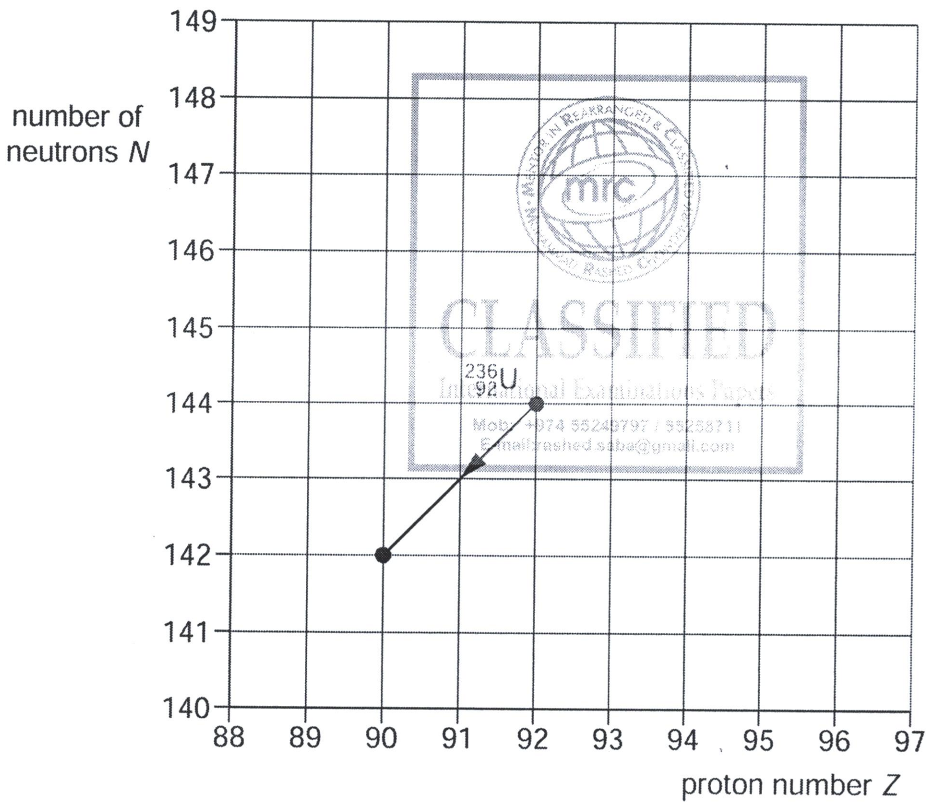

Fig. 7.1

The α-decay of Uranium-236 ($^{236}_{92}U$) is represented on the grid. This decay produces a nucleus of thorium (Th).

For Examiner's Use

(i) Write down the nuclear equation for this α-decay.

.... [2]

(ii) On Fig. 7.1, mark the position for a nucleus of

1. Uranium-237 (mark this position with the letter U),

2. Neptunium, the nucleus produced by the β-decay of Uranium-237 (mark this position with the letters Np). [2]

16 One property of α-particles is that they produce a high density of ionisation of air at atmospheric pressure. In this ionisation process, a neutral atom becomes an ion pair. The ion pair is a positively-charged particle and an electron.

For Examiner's Use

(a) State

(i) what is meant by an α-particle,

....

.... [1]

(ii) an approximate value for the range of α-particles in air at atmospheric pressure.

range = ... cm [1]

(b) The energy required to produce an ion pair in air at atmospheric pressure is 31 eV. An α-particle has an initial kinetic energy of 8.5×10^{-13} J.

(i) Show that 8.5×10^{-13} J is equivalent to 5.3 MeV.

[1]

(ii) Calculate, to two significant figures, the number of ion pairs produced as the α-particle is stopped in air at atmospheric pressure.

number = ... [2]

(iii) Using your answer in **(a)(ii)**, estimate the average number of ion pairs produced per unit length of the track of the α-particle as it is brought to rest in air.

For Examiner's Use

number per unit length = ... [2]

17 (a) The radioactive decay of some nuclei gives rise to the emission of α-particles. State

For Examiner's Use

(i) what is meant by an α-particle,

.... [1]

(ii) two properties of α-particles.

1. ....

....

2. ....

....

[2]

(b) One possible nuclear reaction involves the bombardment of a stationary nitrogen-14 nucleus by an α-particle to form oxygen-17 and another particle.

(i) Complete the nuclear equation for this reaction.

$$^{14}_{7}\text{N} + \,^{\cdots\cdots}_{\cdots\cdots}\alpha \rightarrow \,^{17}_{8}\text{O} + \cdots\cdots\cdots\cdots$$ [2]

(ii) The total mass-energy of the nitrogen-14 nucleus and the α-particle is less than that of the particles resulting from the reaction. This mass-energy difference is 1.1 MeV.

1. Suggest how it is possible for mass-energy to be conserved in this reaction.

....

.... [1]

2. Calculate the speed of an α-particle having kinetic energy of 1.1 MeV.

speed = ... $m\,s^{-1}$ [4]

For Examiner's Use

8 A nuclear reaction between two helium nuclei produces a second isotope of helium, two protons and 13.8 MeV of energy. The reaction is represented by the following equation.

$$^{3}_{2}He + ^{3}_{2}He \rightarrow ^{\dots}_{\dots}He + 2 ^{\dots}_{\dots}p + 13.8\,MeV$$

(a) Complete the nuclear equation. [2]

(b) By reference to this reaction, explain the meaning of the term *isotope*.

....

....

.... [2]

(c) State the quantities that are conserved in this nuclear reaction.

....

....

....

....

.... [2]

(d) Radiation is produced in this nuclear reaction.

State

(i) a possible type of radiation that may be produced,

.... [1]

(ii) why the energy of this radiation is less than the 13.8 MeV given in the equation.

.... [1]

(e) Calculate the minimum number of these reactions needed per second to produce power of 60 W.

number = ... s^{-1} [2]

19 In the decay of a nucleus of ${}^{210}_{84}\text{Po}$, an α-particle is emitted with energy 5.3 MeV.

The emission is represented by the nuclear equation

$$ {}^{210}_{84}\text{Po} \rightarrow {}^{A}_{B}\text{X} + \alpha + \text{energy} $$

(a) **(i)** On Fig. 7.1, complete the number and name of the particle, or particles, represented by A and B in the nuclear equation.

	number	name of particle or particles
A		
B		

Fig. 7.1

[1]

(ii) State the form of energy given to the α-particle in the decay of ${}^{210}_{84}\text{Po}$.

....[1]

(b) A sample of polonium ${}^{210}_{84}\text{Po}$ emits 7.1×10^{18} α-particles in one day.

Calculate the mean power output from the energy of the α-particles.

power = ... W [2]

2 0 A nucleus of bismuth-212 ($^{212}_{83}Bi$) decays by the emission of an α-particle and γ-radiation.

(a) State the number of protons and the number of neutrons in the nucleus of bismuth-212.

number of protons = ...

number of neutrons = ... [1]

(b) The γ-radiation emitted from the nucleus has a wavelength of 3.8 pm.

Calculate the frequency of this radiation.

frequency = ... Hz [3]

(c) Explain how a single beam of α-particles and γ-radiation may be separated into a beam of α-particles and a beam of γ-radiation.

....

....

....

....[2]

(d) The α-particle emitted from the bismuth nucleus has an initial kinetic energy of 9.3×10^{-13} J. As the α-particle moves through air it causes the removal of electrons from atoms. The α-particle loses energy and is stopped after removing 1.8×10^{5} electrons as it moved through the air.

Determine the energy, in eV, needed to remove one electron.

energy = ... eV [2]

[Total: 8]

2 1 (a) Explain the difference in densities in solids, liquids and gases using ideas of the spacing between molecules.

For Examiner's Use

....

....

....

....

....

....

.... [3]

(b) A hydrogen nucleus (proton) may be assumed to be a sphere of radius $1 \square 10^{-15}$ m. Calculate the density of a hydrogen nucleus.

density = ... $kg\,m^{-3}$ [3]

(c) The density of hydrogen gas in a pressurised cylinder is $4\,kg\,m^{-3}$. Suggest a reason why this density is much less than your answer in **(b)**.

....

....

.... [1]

2 2 One of the isotopes of uranium is uranium-238 ($^{238}_{92}U$).

For Examiner's Use

(a) State what is meant by *isotopes*.

....

....

.... [2]

(b) For a nucleus of uranium-238, state

(i) the number of protons,

number = ... [1]

(ii) the number of neutrons.

number = ... [1]

(c) A uranium-238 nucleus has a radius of 8.9×10^{-15} m.

Calculate, for a uranium-238 nucleus,

(i) its mass,

mass = ... kg [2]

(ii) its mean density.

density = ... $kg\,m^{-3}$ [2]

(d) The density of a lump of uranium is $1.9 \times 10^4\,kg\,m^{-3}$.
Using your answer to **(c)(ii)**, suggest what can be inferred about the structure of the atom.

....

....

....[2]

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International Examinations Papers

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Radioactivity: 16

TOPIC- β- particles

01 (a) Distinguish between an α-particle and a β^+-particle.

....

....

....

....

....[3]

(b) State the equation that shows the decay of a particle in a nucleus that results in β^+ emission. All particles in the equation should be shown in the notation that is usually used for the representation of nuclides.

[2]

(c) (i) State the quark composition of

1. a proton,

....

2. a neutron.

....

[2]

(ii) Use the quark model to explain the charge on a proton.

....

....

....[1]

[Total: 8]

0 2 (a) Give one example of

a hadron: ....

a lepton: .... [1]

(b) Describe, in terms of the simple quark model,

(i) a proton,

.... [1]

(ii) a neutron.

.... [1]

(c) Beta particles may be emitted during the decay of an unstable nucleus of an atom. The emission of a beta particle is due to the decay of a neutron.

(i) Complete the following word equation for the particles produced in this reaction.

neutron → .... + ... + ... [1]

(ii) State the change in quark composition of the particles during this reaction.

.... [1]

[Total: 5]

For Examiner's Use

0 3 (a) β-radiation is emitted during the spontaneous radioactive decay of an unstable nucleus.

(i) State the nature of a β-particle.

.... [1]

(ii) State two properties of β-radiation.

1. ....

2. .... [2]

(iii) Explain the meaning of *spontaneous radioactive decay*.

....

.... [1]

(b) The following equation represents the decay of a nucleus of hydrogen-3 by the emission of a β-particle.

Complete the equation.

$$^{3}_{1}H \longrightarrow \;^{\cdots}_{\cdots}He + \;^{\cdots}_{\cdots}\beta$$ [2]

(c) The β-particle is emitted with an energy of 5.7×10^3 eV.

Calculate the speed of the β-particle.

speed = ... $m s^{-1}$ [3]

(d) A different isotope of hydrogen is hydrogen-2 (deuterium). Describe the similarities and differences between the atoms of hydrogen-2 and hydrogen-3.

....

....

.... [2]

04 Tungsten-184 ($^{184}_{74}W$) and tungsten-185 ($^{185}_{74}W$) are two isotopes of tungsten.

For Examiner's Use

Tungsten-184 is stable but tungsten-185 undergoes β-decay to form rhenium (Re).

(a) Explain what is meant by *isotopes*.

....

....

....

.... [2]

(b) The β-decay of nuclei of tungsten-185 is spontaneous and random.

State what is meant by

(i) *spontaneous* decay,

....

.... [1]

(ii) *random* decay.

....

.... [1]

(c) Complete the nuclear equation for the β-decay of a tungsten-185 nucleus.

$$^{185}_{74}W \rightarrow \text{..............} + \text{.................}$$ [2]

(a) State **one** difference between a hadron and a lepton.

....

....[1]

(b) A proton within a nucleus decays to form a neutron and two other particles. A partial equation to represent this decay is

$$^{1}_{1}\text{p} \rightarrow {}^{1}_{0}\text{n} + {}^{.....}_{.....}\,...... + {}^{.....}_{.....}\,......$$

(i) Complete the equation. [2]

(ii) State the name of the interaction or force that gives rise to this decay.

....[1]

(iii) State three quantities that are conserved in the decay.

1. ....

2. ....

3. ....

[3]

(c) Use the quark composition of a proton to show that it has a charge of +*e*, where *e* is the elementary charge.

Explain your working.

[3]

[Total: 10]

06 A neutron decays by emitting a β^- particle.

(a) Complete the equation below for this decay.

$$^{1}_{0}n \rightarrow \,^{\cdots\cdots}_{\cdots\cdots}\cdots\cdots\cdots + \,^{\cdots\cdots}_{\cdots\cdots}\beta^- + \,^{\cdots\cdots}_{\cdots\cdots}\bar{\nu}$$

[2]

(b) State the name of the particle represented by the symbol $\bar{\nu}$.

.... [1]

(c) State the name of the class (group) of particles that includes β^- and $\bar{\nu}$.

.... [1]

(d) State

(i) the quark structure of the neutron,

.... [1]

(ii) the change to the quark structure when the neutron decays.

....

.... [1]

[Total: 6]

07 (a) The following particles are used to describe the structure of an atom.

electron neutron proton quark

Underline the fundamental particles in the above list. [1]

(b) The following equation represents the decay of a nucleus of $^{60}_{27}$Co to form nucleus Q by β^- emission.

$$^{60}_{27}\text{Co} \rightarrow {}^{A}_{B}\text{Q} + \beta^- + \text{x}$$

(i) Complete Fig. 7.1.

	value
A	
B	

Fig. 7.1

[1]

(ii) State the name of the particle x.

....[1]

[Total: 3]

08 **(a)** Use the quark model to show that

(i) the charge on a proton is +*e*,

....[1]

(ii) the charge on a neutron is zero.

....[1]

(b) A nucleus of $^{90}_{38}Sr$ decays by the emission of a β^- particle. A nucleus of $^{64}_{29}Cu$ decays by the emission of a β^+ particle.

(i) In Fig. 7.1, state the nucleon number and proton number for the nucleus produced in each of these decay processes.

	nucleus formed by β^- decay	nucleus formed by β^+ decay
nucleon number		
proton number		

Fig. 7.1

[1]

(ii) State the name of the force responsible for β decay.

....[1]

(iii) State the names of the leptons produced in each of the decay processes.

β^- decay: ....

β^+ decay: ....

[1]

[Total: 5]

09 Fig. 8.1 shows the position of Neptunium-231 ($^{231}_{93}Np$) on a diagram in which nucleon number (mass number) *A* is plotted against proton number (atomic number) *Z*.

For Examiner's Use

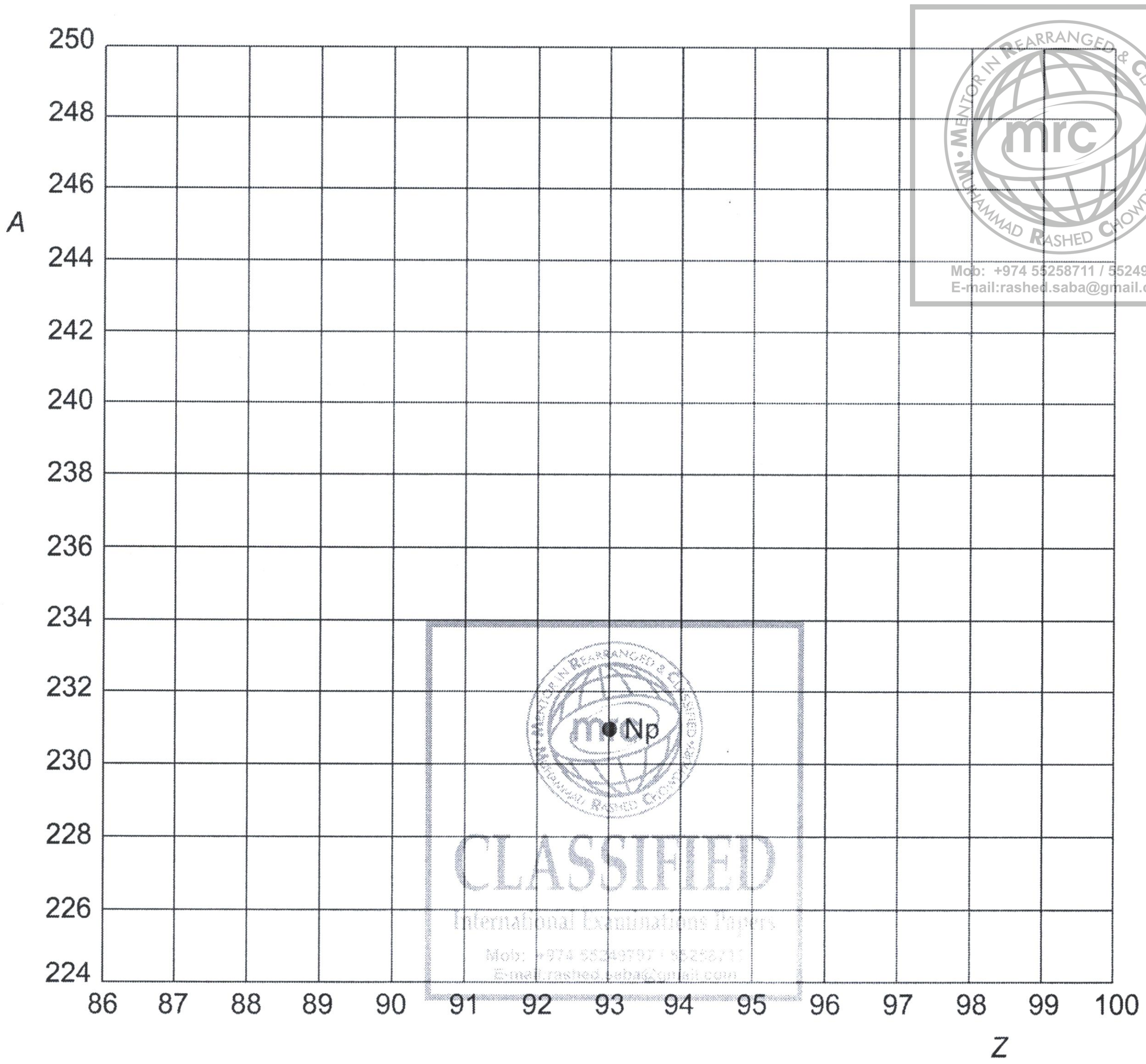

Fig. 8.1

(a) Neptunium-231 decays by the emission of an α-particle to form protactinium.
On Fig. 8.1, mark with the symbol Pa the position of the isotope of protactinium produced in this decay. [1]

(b) Plutonium-243 ($^{243}_{94}Pu$) decays by the emission of a β-particle (an electron).
On Fig. 8.1, show this decay by labelling the position of Plutonium-243 as Pu and the position of the daughter product as D. [2]

10 A stationary nucleus of mass 220u undergoes radioactive decay to produce a nucleus D of mass 216u and an α-particle of mass 4u, as illustrated in Fig. 3.1.

For Examiner's Use

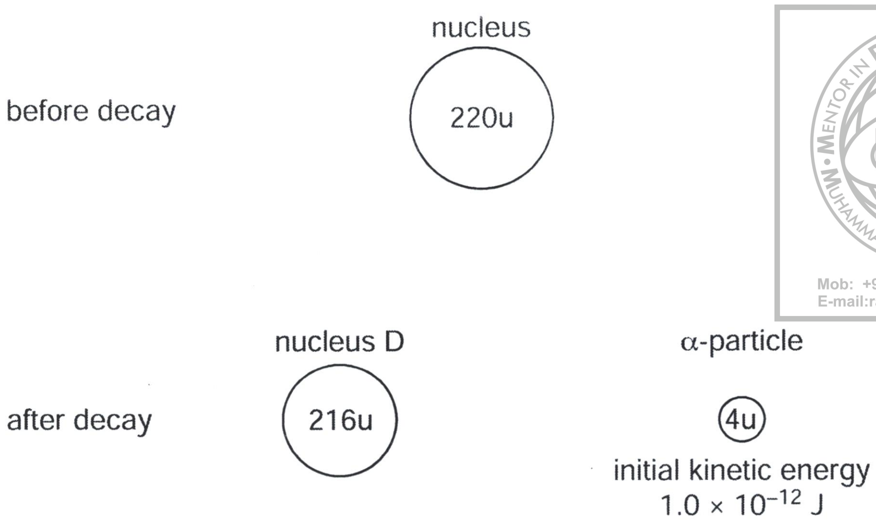

Fig. 3.1

The initial kinetic energy of the α-particle is 1.0×10^{-12} J.

(a) **(i)** State the law of conservation of linear momentum.

....

....

.... [2]

(ii) Explain why the initial velocities of the nucleus D and the α-particle must be in opposite directions.

....

....

.... [2]

(b) **(i)** Show that the initial speed of the α-particle is $1.7 \times 10^{7}\,\mathrm{m\,s^{-1}}$.

[2]

(ii) Calculate the initial speed of nucleus D.

speed = ... $m s^{-1}$ [2]

(c) The range in air of the emitted α-particle is 4.5 cm.
Calculate the average deceleration of the α-particle as it is stopped by the air.

deceleration = ... $m s^{-2}$ [2]