

- 4 The numbers of protons, neutrons and nucleons in three nuclei are shown.

9702/1/O/N/02/Q38

nucleus	number of protons	number of neutrons	number of nucleons
X	15	16	31
Y	15	17	32
Z	16	16	32

Which nuclei are isotopes of the same element?

- A** X and Y **B** X and Z **C** Y and Z **D** none of them

- 5 In an experiment to investigate the nature of the atom, a very thin gold film was bombarded with α -particles.

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What pattern of deflection of the α -particles was observed?

- A** A few α -particles were deflected through angles greater than a right angle.
B All α -particles were deflected from their original path.
C Most α -particles were deflected through angles greater than a right angle.
D No α -particle was deflected through an angle greater than a right angle.

- 6 When a nucleus of $^{238}_{92}\text{U}$ absorbs a slow neutron it subsequently emits two β -particles.

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What is the resulting nucleus?

- A** $^{240}_{93}\text{Np}$ **B** $^{240}_{91}\text{Pa}$ **C** $^{239}_{94}\text{Pu}$ **D** $^{239}_{90}\text{Th}$

- 7 In what way do the atoms of the isotopes $^{12}_6\text{C}$, $^{13}_6\text{C}$ and $^{14}_6\text{C}$ differ?

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- A** different charge
B different numbers of electrons
C different numbers of neutrons
D different numbers of protons

- 8 A nickel nucleus $^{59}_{28}\text{Ni}$ can be transformed by a process termed K-capture. In this process the nucleus absorbs an orbital electron.

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If no other process is involved, what is the resulting nucleus?

- A** $^{58}_{28}\text{Ni}$ **B** $^{58}_{27}\text{Co}$ **C** $^{59}_{27}\text{Co}$ **D** $^{59}_{29}\text{Cu}$

- 9 Strontium- 90 ($^{90}_{38}\text{Sr}$) is radioactive and emits β -particles.

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Which equation could represent this nuclear decay?

- A** $^{90}_{38}\text{Sr} \rightarrow ^{90}_{39}\text{Sr} + ^0_{-1}\beta$
B $^{90}_{38}\text{Sr} \rightarrow ^{90}_{39}\text{Y} + ^0_{-1}\beta$
C $^{90}_{38}\text{Sr} \rightarrow ^{90}_{37}\text{Rb} + ^0_{+1}\beta$
D $^{90}_{38}\text{Sr} \rightarrow ^{90}_{37}\text{Sr} + ^0_{+1}\beta$

- 10 Protons and neutrons are thought to consist of smaller particles called quarks.

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The 'up' quark has a charge of $\frac{2}{3}e$: a 'down' quark has a charge of $-\frac{1}{3}e$, where e is the elementary charge ($+1.6 \times 10^{-19}\text{C}$).

How many up quarks and down quarks must a proton contain?

	up quarks	down quarks
A	0	3
B	1	1
C	1	2
D	2	1

- 11 Which are the correct descriptions of a γ -ray and a β -particle?

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	γ -ray	β -particle
A	high-speed electron	electromagnetic radiation
B	electromagnetic radiation	Helium-4 nucleus
C	electromagnetic radiation	high-speed electron
D	high-speed electron	Helium-4 nucleus

- 12 A certain nuclide, Uranium-235, has nucleon number 235, proton number 92 and neutron number 143. Data on four other nuclides are given below.

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Which is an isotope of Uranium-235?

	nucleon number	proton number	neutron number
A	235	91	144
B	236	92	144
C	237	94	143
D	238	95	143

- 13 A nucleus of the nuclide ${}^{241}_{94}\text{Pu}$ undergoes α particle emission. The emission of an α particle

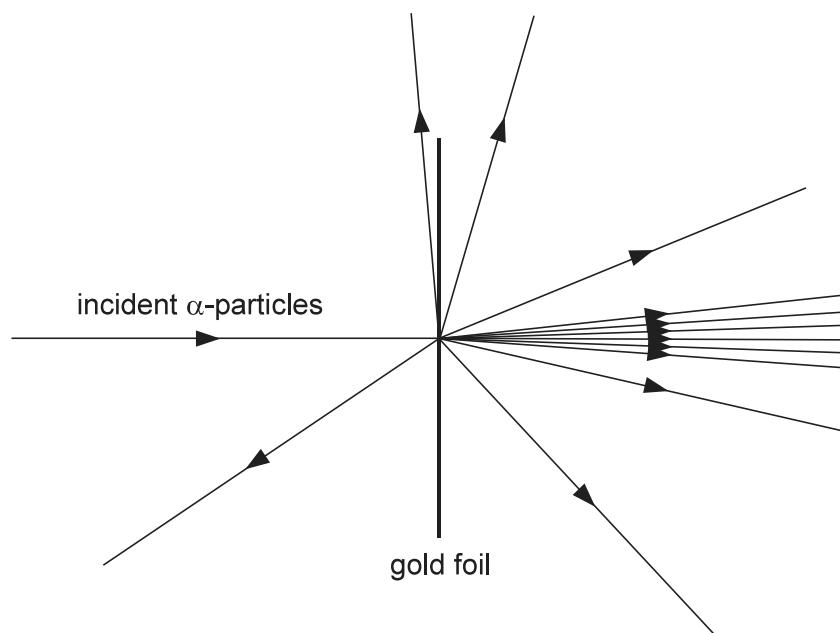
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results in the formation of

- A ${}^{239}_{93}\text{Pa}$ B ${}^{239}_{91}\text{Pa}$ C ${}^{237}_{93}\text{Pu}$ D ${}^{237}_{92}\text{Pu}$

- 14 The diagram shows the results of an experiment to determine the structure of an atom.

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The results of this experiment provide information about the

- A internal energy of a gold nucleus
B energy levels of electrons in gold atoms
C size of a gold nucleus
D structure of a gold nucleus

- 15 The following are properties of isotopes of the same element.

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- A charge to mass ratio
B neutron number
C nucleon number
D proton number

- 16 Which is a correct order of magnitude estimate for the diameter of a typical atomic nucleus?

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- A 10^{-14}m B 10^{-18}m C 10^{-22}m D 10^{-2}m

- 17 The sample $^{77}_{32}\text{Ge}$ represents a nuclide of germanium that decays to a nuclide of arsenic. As emitting a β^- particle

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What is the sample of arsenic nuclide

- A $^{77}_{32}\text{As}$ B $^{78}_{32}\text{As}$ C $^{78}_{31}\text{As}$ D $^{77}_{33}\text{As}$

- 18 The following are the properties of different types of ionising radiation

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charge	0	$1e$	$2e$
mass	0	$\frac{1}{1840}u$	$4u$
speed	c	$0.9c$	$0.1c$

What are the radiations and

A	alpha	gamma	alpha
B	gamma	alpha	gamma
C	gamma	gamma	alpha
D	alpha	alpha	gamma

- 19 Which conclusion can be drawn from the results of the experiments on the scattering of α particles? Go on

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- A Electrons orbit the atomic nucleus in discrete orbits
 B Nuclides of different isotopes contain different numbers of neutrons
 C The atomic nucleus contains protons and neutrons
 D The nucleus is very small compared to the size of the atom

- 20 Which two nuclei contain the same number of neutrons

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- A $^{12}_6\text{C}$ and $^{14}_6\text{C}$
 B ^1_7N and ^1_8O
 C $^{23}_{11}\text{Na}$ and $^{24}_{12}\text{Mg}$
 D $^{32}_{14}\text{Si}$ and $^{32}_{16}\text{S}$

21 A student conducts an experiment using an α particle source

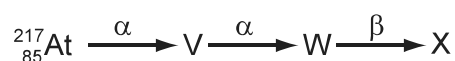
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When considering safety precautions that can be assumed to be the maximum range of α particles in air

- A between 0 and 1 mm
- B between 1 mm and 200 mm
- C between 200 mm and 500 mm
- D between 500 mm and 1000 mm

22 The following represents a sequence of radioactive decays in which the α particles are β particles

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What is the nucleus

- A ${}_{8}^{213}\text{At}$
- B ${}_{77}^{21}\text{Fr}$
- C ${}_{82}^{209}$
- D ${}_{81}^{217}$

23 An atomic nucleus emits a β particle

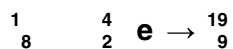
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What change does this cause to the proton and nucleon numbers of the nucleus

	proton number	nucleon number
A	1	1
B	0	1
C	1	1
D	1	0

24 A nuclear reaction is represented by the equation

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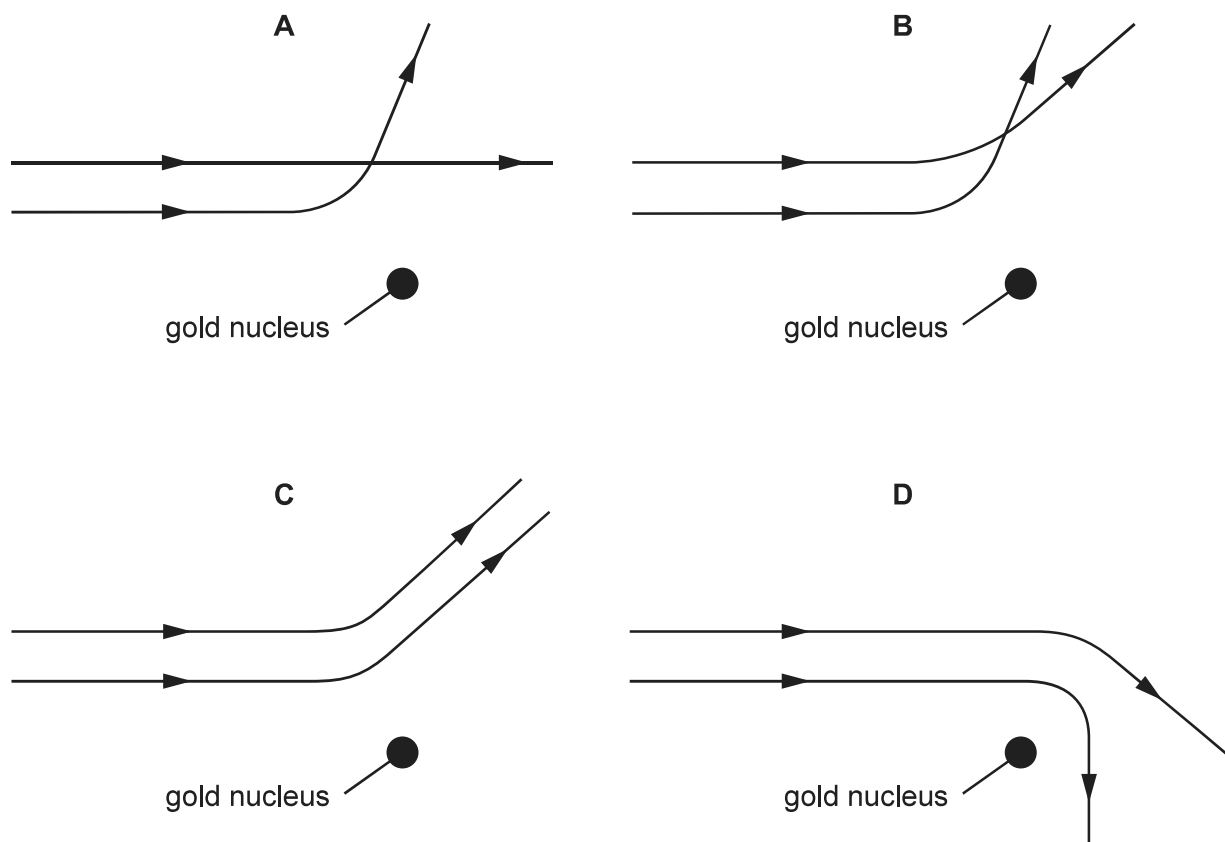


What is the particle

- A an α particle
- B a β particle
- C a neutron
- D a proton

25 α particles of high energies are fired towards the nucleus of a gold atom 9702 01 0 /Q39

The diagram represents their paths



26 The decay of a nucleus of neptunium is accompanied by the emission of a β particle and γ radiation 9702 01 0 /Q39

What effect does this decay have on the proton number and the nucleon number of the nucleus?

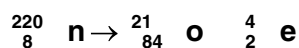
	proton number	nucleon number
A	increases	decreases
B	decreases	increases
C	unchanged	decreases
D	increases	unchanged

27 The symbol ${}^{77}_{32}\text{Ge}$ represents a nucleus of germanium that decays to a nucleus of arsenic emitting a β particle 9702 01 07/Q39

What is the symbol of the arsenic nucleus?

- A ${}^{77}_{32}\text{As}$ B ${}^{78}_{32}\text{As}$ C ${}^{78}_{31}\text{As}$ D ${}^{77}_{33}\text{As}$

- 28 A nuclide of thorium with mass number 220 emits an α -particle. The mass number of the daughter nuclide is
- 9702 01 0 /Q40



How many neutrons are in the daughter nuclide?

	neutrons	protons
A	8	84
B	134	132
C	220	212
D	220	21

- 29 Which statement concerning α -particles is correct?
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- A An α -particle has a charge of $+4e$
- B An α -particle is a helium atom
- C In α -decay, the emitted particles cause ionisation
- D In α -decay, the emitted particles are stopped by a sheet of paper

- 30 Which of the following are found in the nucleus of an atom?
- 9702 01 0 /Q39

	electrons	neutrons	protons
A	in the nucleus	in the nucleus	orbiting the nucleus
B	in the nucleus	orbiting the nucleus	in the nucleus
C	orbiting the nucleus	in the nucleus	orbiting the nucleus
D	orbiting the nucleus	in the nucleus	in the nucleus

- 31 A nuclide of bismuth with mass number 222 undergoes α - and β -decay to form ${}_{83}^{214}\text{Bi}$.
- 9702 01 0 /Q40

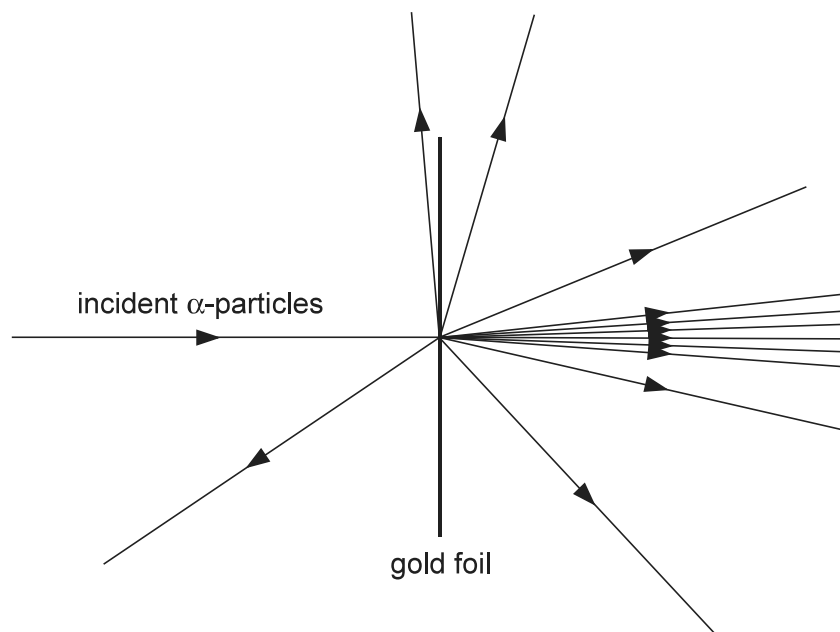
How many α - and β -particles are emitted in the decay of the original nuclide?

	α -particles	β -particles
A	1	1
B	2	1
C	1	2
D	2	2

- 32 A detector is exposed to a radioactive source. Fluctuations in the count rate are observed. What do these fluctuations indicate about the radioactive decay?
- 9702 01 07/Q38
- A It is random
B It is spontaneous
C It is exponential
D It is nonlinear
- 33 A α particle is accelerated from rest through the same potential difference. Which one completes the acceleration with the greatest speed?
- 9702 01 07/Q40
- A ${}^1_1\text{H}$ B ${}^4_2\text{He}$ C ${}^7_3\text{Li}$ D ${}^9_4\text{Be}$
- 34 Which is it possible to distinguish between two isotopes of uranium?
- 9702 01 07/Q36
- A Their nuclei have different charge and different mass and they emit different particles in the decay
B Their nuclei have different charge but the same mass
C Their nuclei have the same charge but different mass
D Their nuclei have the same charge and mass but they emit different particles in the decay
- 35 What is not conserved in nuclear processes?
- 9702 01 07/Q37
- A Energy and mass together
B Nucleon number
C Neutron number
D Charge
- 36 α particles are each accelerated from rest through the same potential difference. Which one completes the acceleration with the greatest momentum?
- 9702 01 07/Q40
- A α particle
B Electron
C Neutron
D Proton

37 At in go oi is om ar e it α artices ass o n

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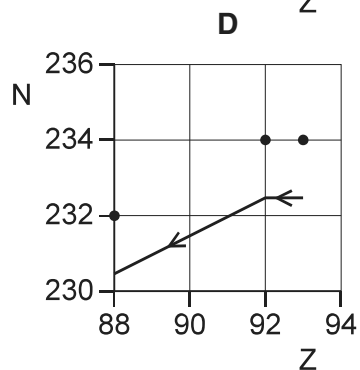
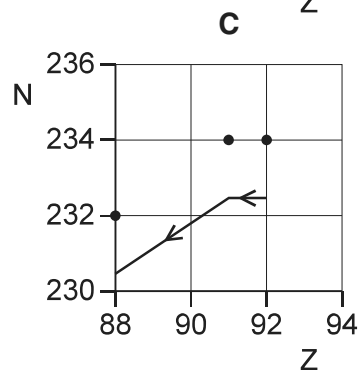
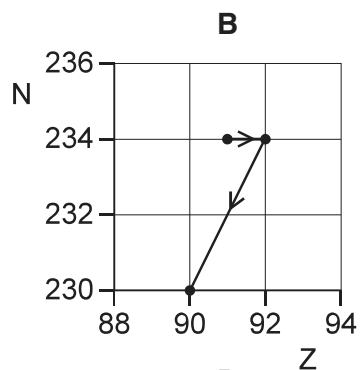
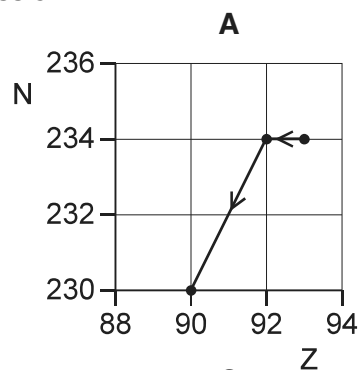


at can e e uce rom t is e eriment

- A t e in ing energ o a go nucleus
- B t e energ e es o e electrons in go atoms
- C t e sma si e o a go nucleus
- D t e structure o a go nucleus

38 A ra ioacti e nucleus is orme β eca is nucleus t en eca s α emission 9702 01 08/Q40

ic gra o roton num er otte against nucleon num er s o s t e β eca o o e t e α emission



39 The approximate mass of a nucleus of uranium

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- A 10^{-1} g B 10^{-20} g C 10^{-2} g D 10^{-30} g

40 An irconium nucleus $^{100}_{40}\text{Ir}$ is a β emitter. The product nucleus is also a β emitter. 9702 01 07/Q39

What is the resulting nucleus of these two decays

- A $^{100}_{38}\text{r}$ B $^{100}_{42}\text{o}$ C $^{98}_{40}\text{r}$ D $^{102}_{40}\text{r}$

41 Which conclusion can be drawn from the results of the experiment showing the scattering of α particles? 9702 01 08/Q38

- A Electrons orbit the atomic nucleus in discrete orbits
B Nuclei of different isotopes contain different numbers of neutrons
C The atomic nucleus contains protons and neutrons
D The nucleus is very small compared to the size of the atom

42 A nucleus has the notation

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What is the meaning of the superscript 1?

- A 1 B 1 C 1 D $\frac{1}{1}$

43 A $^{238}_{92}\text{Po}$ nucleus decays in two stages to a $^{234}_{91}\text{Po}$ nucleus. 9702 01 08/Q40

What particles are emitted in these two stages?

- A α β B α γ C β β D β γ

44 What is the ratio of the nucleon mass number to the proton atomic number for isotopes of an element? 9702 01 09/Q36

	nucleon number	proton number
A	different	different
B	different	same
C	same	different
D	same	same

45 ucear eca is ot s ontaneous an ran om

9702 01 09/Q37

en t e count rate o a ra ioacti e isoto e is measure t e rea ings uctuate

ic ro escri es at t e uctuations emonstrate

	s ontaneous nature	ran om nature
A	no	no
B	no	es
C	es	no
D	es	es

46 ic t o nucei contain t e same num er o neutrons

9702 01 09/Q38

A $^{12}_{6}\text{C}$ an $^{14}_{6}\text{C}$

B 1_7 an 1_8

C $^{23}_{11}\text{a}$ an $^{24}_{12}\text{g}$

D $^{32}_{14}\text{i}$ an $^{32}_1$

47 e ca cium nuci e $^{42}_{20}\text{Ca}$ is orme eta eca

9702 01 09/Q39

at are t e nuceon mass num er an roton atomic num er o t e unsta e nuci e t at un er ent eta eca to orm t e ca cium nuci e

	nuceon num er	roton num er
A	41	19
B	41	21
C	42	19
D	42	21

48 en oron 11 ^{11}B is om ar e it α artices a ne nuceus is orme an a neutron is re ease

9702 01 09/Q40

ic nucear e uation cou re resent t is reaction

A $^{11}\text{B} + ^1_1\text{e} \rightarrow ^{11}\text{C} + ^1_0\text{n}$

B $^{11}\text{B} + ^2_2\text{e} \rightarrow ^{12}_7 + ^1_0\text{n}$

C $^{11}\text{B} + ^4_2\text{e} \rightarrow ^{14}\text{C} + ^1_1\text{n}$

D $^{11}\text{B} + ^4_2\text{e} \rightarrow ^{14}_7 + ^1_0\text{n}$

49 The nucleus $^{18}_{79}\text{Au}$ undergoes a decay

9702 11 09/Q37

What are the nucleon mass number and proton atomic number of the nucleus formed?

	nucleon number	proton number
A	183	79
B	183	77
C	181	77
D	181	7

50 The nucleon number of an element is the same for all its isotopes.

9702 11 09/Q38

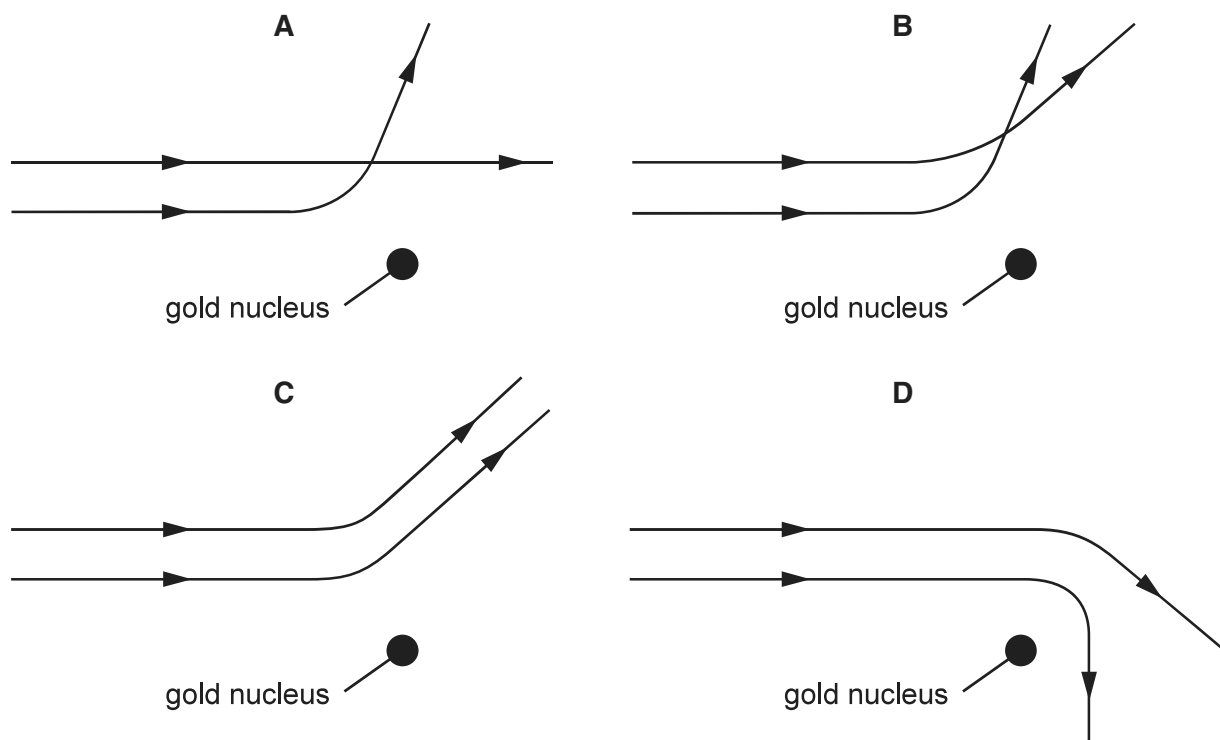
What is this particle?

- A electron
- B neutron
- C nucleon
- D proton

51 α particles have high energies and are used to treat cancer.

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The diagram represents their paths.



52 **A** a eta an gamma ra iations

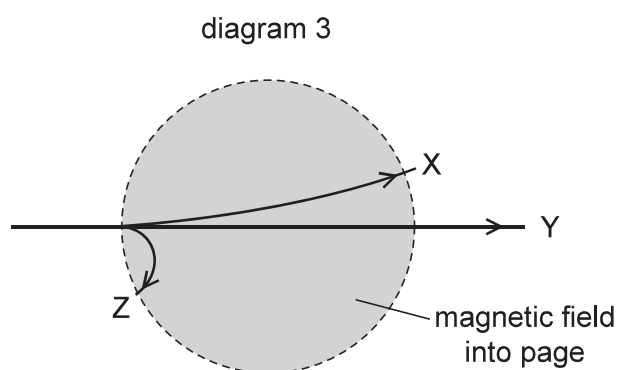
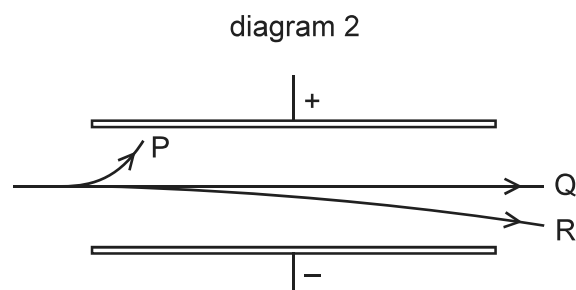
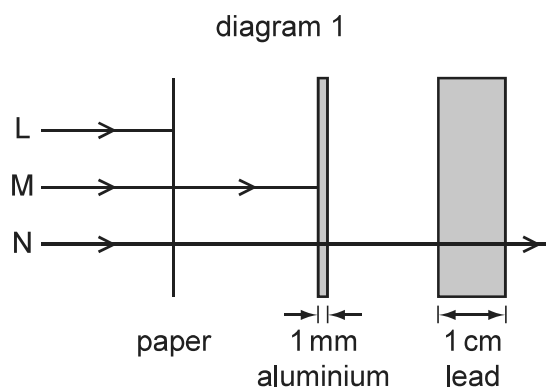
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1 are a sor e to i erent e tents in so i s

2 e a e i erent in an e ectric ie

3 e a e i erent in a magnetic ie

e iagrams i ustrate t ese e a iours



ic t ree a e s on t ese iagrams re er to t e same in o ra iation

A**B****C****D**53 **e** go nuc eus $^{18}_{79}\text{Au}$ un ergoes a a eca

9702 12 09/Q36

at are t e nuc eon mass num er an roton atomic num er o t e nuc eus orme t is eca

	nuc eon num er	roton num er
A	183	79
B	183	77
C	181	77
D	181	7

54 **Particle** **isotopes** are elements that contain the same number of protons but a different number of neutrons. This article discusses the properties of isotopes.

9702/12

09/Q37

- A electron
- B neutron
- C nucleon
- D proton

55 **Alpha and gamma rays**

9702/12

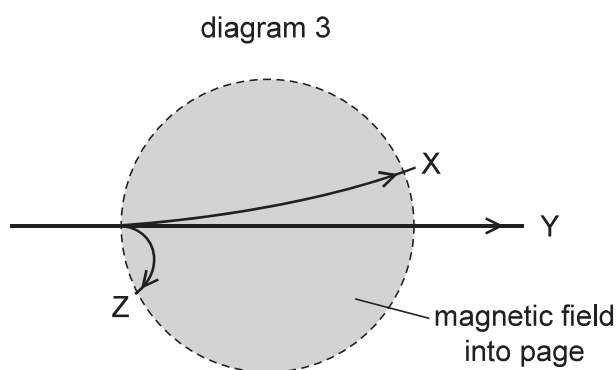
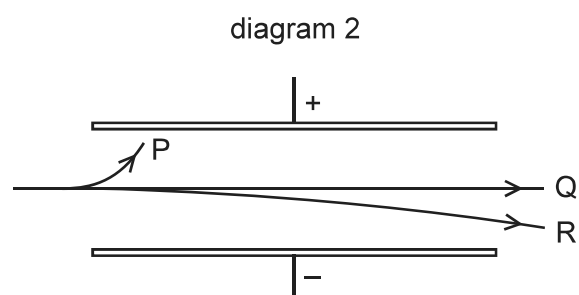
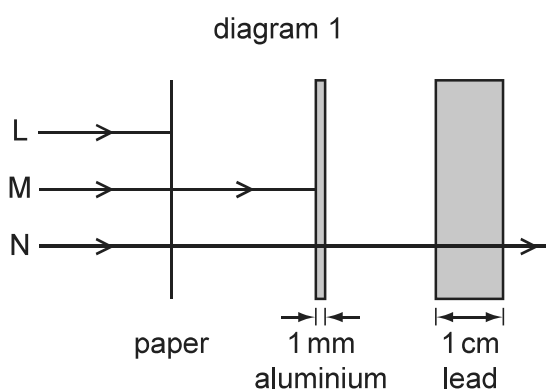
09/Q38

1 They are sources of ionising radiation in soils.

2 They are deflected in an electric field.

3 They are deflected in a magnetic field.

The diagrams illustrate these behaviours.

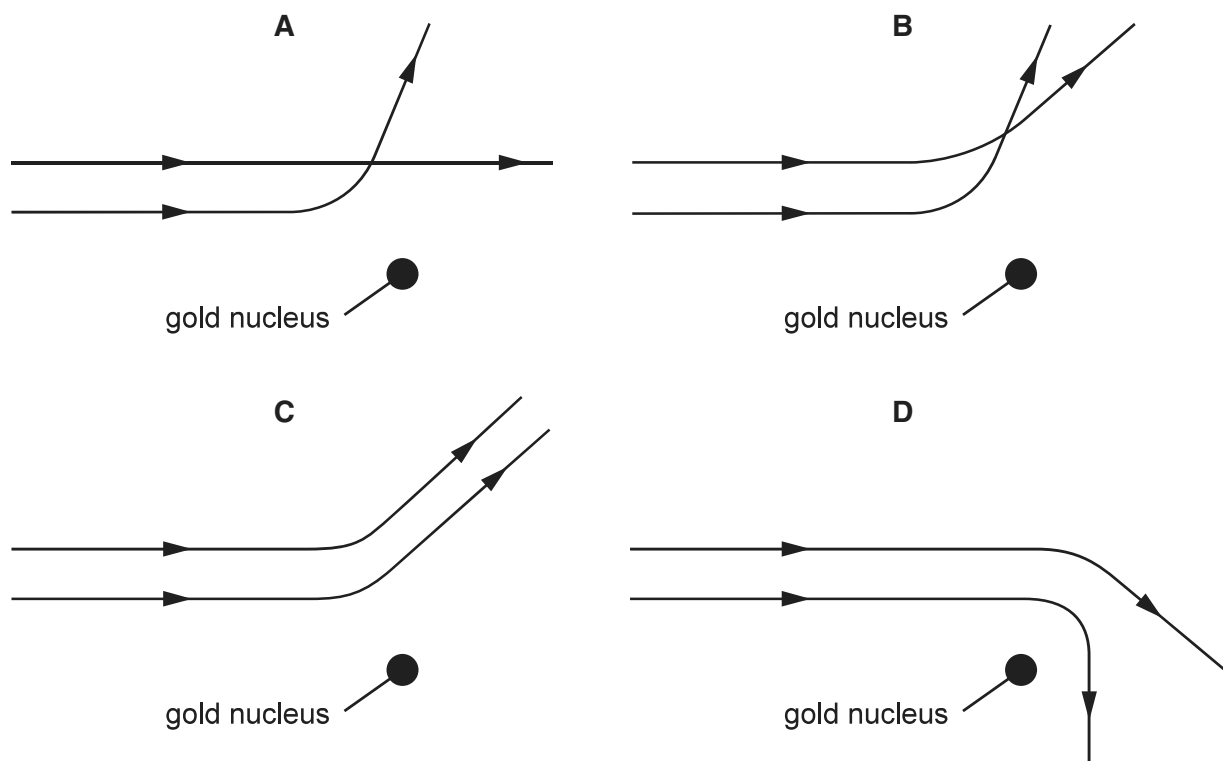


Which two are consistent with the diagrams referring to the same ionisation?

- A
- B
- C
- D

56 α particles have energies are large to approach the nucleus of a gold atom 9702/12 09/Q39

the diagram best represents their paths



57 what are the correct descriptions of a γ ray and a β particle 9702/11 10/Q37

	γ ray	β particle
A	high speed electron	electromagnetic radiation
B	electromagnetic radiation	electron from nucleus
C	electromagnetic radiation	high speed electron
D	high speed electron	electron from nucleus

58 what is not conserved in nuclear processes 9702/11 10/Q39

- A charge
- B momentum
- C the total number of neutrons
- D the total number of nucleons

- 59 The grid shows a number of nuclei arranged according to the number of protons and the number of neutrons in each

9702 11

10/Q38

A nucleus of the nucleus ${}^8_3\text{Li}$ decays emitting a β particle

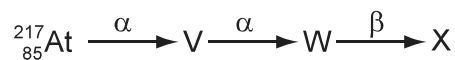
What is the resulting nucleus

number of protons	4					A	B	
3				${}^6_3\text{Li}$	${}^7_3\text{Li}$	${}^8_3\text{Li}$		
2		${}^3_2\text{He}$	${}^4_2\text{He}$			C	D	
1	${}^1_1\text{H}$	${}^2_1\text{H}$						
	0	1	2	3	4	5	6	number of neutrons

- 60 The following represents a sequence of radioactive decays in which α particles and one β particle

9702 11

10/Q40



What is the nucleus

A ${}^{213}_{85}\text{At}$

B ${}^{211}_{77}\text{Fr}$

C ${}^{209}_{82}\text{Pb}$

D ${}^{217}_{81}\text{Po}$

- 61 The grid shows a number of nuclei arranged according to the number of protons and the number of neutrons in each

9702 12

10/Q37

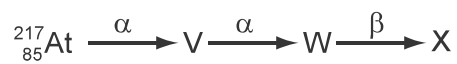
A nucleus of the nucleus ${}^8_3\text{Li}$ decays emitting a β particle

What is the resulting nucleus

number of protons	4					A	B	
3				${}^6_3\text{Li}$	${}^7_3\text{Li}$	${}^8_3\text{Li}$		
2		${}^3_2\text{He}$	${}^4_2\text{He}$			C	D	
1	${}^1_1\text{H}$	${}^2_1\text{H}$						
	0	1	2	3	4	5	6	number of neutrons

- 62 The following represents a sequence of radioactive decays in which the α particles and one β particle

9702 12 10/Q38



What is the nucleon number of X?

- A ${}_{8}^{213}\text{At}$ B ${}_{77}^{21}\text{r}$ C ${}_{82}^{209}$ D ${}_{81}^{217}$

- 63 Which are the correct descriptions of a γ ray and a β particle?

9702 12 10/Q39

	γ ray	β particle
A	high speed electron	electromagnetic radiation
B	electromagnetic radiation	electron from nucleus
C	electromagnetic radiation	high speed electron
D	high speed electron	electron from nucleus

- 64 Which is not conserved in nuclear processes?

9702 12 10/Q40

- A charge
B momentum
C total number of neutrons
D total number of nucleons

- 65 The graph shows the number of nuclei arranged according to the number of protons and the number of neutrons in each.

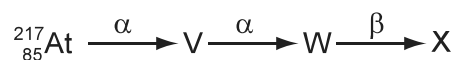
9702 13 10/Q40

A nucleus of the nuclide ${}_{3}^{8}\text{Li}$ decays by emitting a β particle.

What is the resulting nuclide?

number of protons	4					A	B	
3				${}_{3}^{6}\text{Li}$	${}_{3}^{7}\text{Li}$	${}_{3}^{8}\text{Li}$		
2		${}_{2}^{3}\text{He}$	${}_{2}^{4}\text{He}$			C	D	
1	${}_{1}^{1}\text{H}$	${}_{1}^{2}\text{H}$						
	0	1	2	3	4	5	6	
	number of neutrons							

- 66 The following represents a sequence of radioactive decays in which the α particles and one β particle
- 9702 13 10/Q39



What is the nuclide

- A ${}_{8}^{213}\text{At}$ B ${}_{77}^{21}\text{Fr}$ C ${}_{82}^{209}$ D ${}_{81}^{217}$

- 67 What is not conserved in nuclear processes

9702 13 10/Q37

- A charge
B momentum
C the total number of neutrons
D the total number of nucleons

- 68 What are the correct descriptions of a γ ray and a β particle

9702 13 10/Q38

	γ ray	β particle
A	is seen as electron	electromagnetic radiation
B	electromagnetic radiation	isium 4 nucleus
C	electromagnetic radiation	is seen as electron
D	is seen as electron	isium 4 nucleus

- 69 In a magnesium nucleus ${}_{12}^2$ g is it a gamma ray a sodium nucleus ${}_{11}^{24}$ a isomer and another particle is emitted

What are the nucleon number, mass number and proton number of the other particle produced in this nuclear reaction

9702 11 10/Q39

	nucleon number	proton number
A	0	1
B	0	1
C	1	1
D	1	1

- 70 Radium 238 ${}_{92}^{238}$ decays by α emission into a daughter product which in turn decays by β emission into a grand daughter product
- 9702 13 11/Q40

What is the grand daughter product

- A ${}_{90}^{234}$ B ${}_{91}^{234}$ a C ${}_{92}^{234}$ D ${}_{90}^{230}$

71 Radium 23 has a mass number of 239. It has 92 protons and 147 neutrons in its nucleus.

9702 11 10/Q38

	nucleons	protons	neutrons
A	92	23	143
B	143	92	23
C	23	92	143
D	23	143	92

72 Which nuclear equation represents the beta decay of a nucleus of argon-40 into potassium-40?

9702 11 10/Q40

- A ${}^{40}_{21}\text{Ar} \rightarrow {}^{40}_{19}\text{Ar} + {}^0_{-1}\text{e}$
- B ${}^{40}_{20}\text{Ar} \rightarrow {}^{40}_{19}\text{Ar} + {}^0_1\text{e}$
- C ${}^{40}_{18}\text{Ar} \rightarrow {}^{40}_{19}\text{Ar} + {}^0_1\text{e}$
- D ${}^{40}_{19}\text{Ar} \rightarrow {}^{40}_{19}\text{Ar} + {}^0_0\gamma$

73 A counter recording rate of activity is measured from a radioactive source gives the following counts in each 10-second interval.

9702 12 10/Q40

time / min	counts
0 - 10	424
10 - 20	39
20 - 30	413
30 - 40	33
40 - 50	3
50 - 60	294
60 - 70	301
70 - 80	23
80 - 90	212

What can be deduced from these readings?

- A The rate of activity is constant at the end of 90 minutes.
- B The rate of activity is constant at the end of 90 minutes.
- C The rate of activity is spontaneous and at the end of 90 minutes.
- D The rate of activity is spontaneous and at the end of 90 minutes.

- 74 In the α particle scattering experiment α particles were fired at a thin gold foil. A small proportion of the α particles were deflected through large angles.

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Which statement gives the correct conclusion that can be drawn from these results?

- A The atom is made up of electrons, protons and neutrons.
- B The nucleus is at the centre of the atom.
- C The nucleus is made up of protons and neutrons.
- D The atom contains a very small, charged nucleus.

- 75 Which statement about the nuclei of the atoms of an element is correct?

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- A The nucleus of an element contains an equal number of neutrons and protons.
- B The nucleus of an element contains the same number of neutrons as all of the other nuclei of that element, but the number of protons may differ.
- C The nucleus of an element contains the same number of protons as all of the other nuclei of that element, but the number of neutrons may differ.
- D The number of protons in a nucleus differs from isotope to isotope of an element, as does the number of neutrons.

- 76 In a magnesium nucleus $^{24}_{12}\text{Mg}$ is it a gamma ray? A sodium nucleus $^{24}_{11}\text{Na}$ is formed and another particle is emitted.

9702 13

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What are the nucleon number, mass number and proton number of the other particle produced in this nuclear reaction?

	nucleon number	proton number
A	0	1
B	0	1
C	1	1
D	1	1

- 77 The first artificial radioactive substance was made by bombarding aluminium with α particles. This produced an unstable isotope of phosphorus $^{30}_{15}\text{P}$.

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What is the product of this reaction?

- A an α particle
- B a β particle
- C a γ ray
- D a neutron

78 In nuclear reactions, a stable nucleus of argon, Ar, decays into potassium

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- A ${}_{21}^{44}\text{Ar} \rightarrow {}_{19}^{40}\text{Ar} + {}_2^4\text{He}$
- B ${}_{20}^{40}\text{Ar} \rightarrow {}_{19}^{40}\text{Ar} + {}_1^0\text{e}$
- C ${}_{18}^{40}\text{Ar} \rightarrow {}_{19}^{40}\text{Ar} + {}_1^0\text{e}$
- D ${}_{19}^{40}\text{Ar} \rightarrow {}_{19}^{40}\text{Ar} + {}_0^0\gamma$

79 Radium-226 is represented by the symbol ${}_{82}^{226}\text{Ra}$

9702 13

10/Q39

Calculate the number of nucleons, protons and neutrons in a ${}_{82}^{226}\text{Ra}$ nucleus

	nucleons	protons	neutrons
A	92	23	143
B	143	92	23
C	23	92	143
D	23	143	92

80 A uranium nucleus ${}_{92}^{238}\text{U}$ undergoes α decay, producing a nucleus

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that undergoes β decay, producing a nucleus

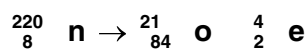
Calculate the atomic number and nucleon number of the nucleus

	proton number	nucleon number
A	89	234
B	89	23
C	91	234
D	91	23

81 A neutron is radioactive and decays to a proton and an electron. The equation for the radioactive decay is shown below.

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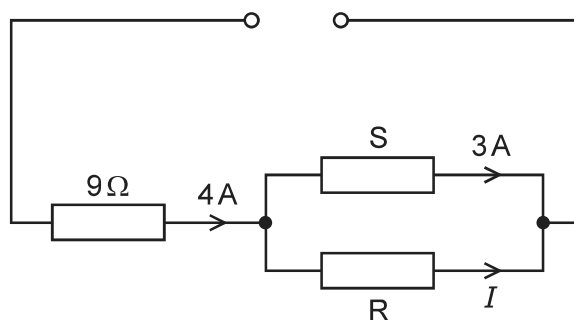
Calculate the number of neutrons in a neutron nucleus.

	n	p
A	8	84
B	134	132
C	220	212
D	220	21

- 82 Radium 238 $^{238}_{92}\text{Ra}$ decays by α emission into a daughter product which in turn decays by β emission into a grand daughter product. 9702 11 11/Q39
- What is the grand daughter product?
- A $^{234}_{90}\text{Po}$ B $^{234}_{91}\text{Pa}$ C $^{234}_{92}\text{U}$ D $^{230}_{90}\text{Th}$
- 83 Which statement about nuclei is correct? 9702 11 11/Q40
- A Different isotopic nuclei have different proton numbers
- B For some nuclei the nucleon number can be less than the proton number
- C In some nuclear processes mass energy is not conserved
- D Nucleon numbers of nuclei are unchanged by the emission of β particles
- 84 Which statement about nuclei is correct? 9702 13 11/Q38
- A Different isotopic nuclei have different proton numbers
- B For some nuclei the nucleon number can be less than the proton number
- C In some nuclear processes mass energy is not conserved
- D Nucleon numbers of nuclei are unchanged by the emission of β particles
- 85 The first artificial radioactive substance was made by bombarding aluminium $^{27}_{13}\text{Al}$ with α particles. This produced an unstable isotope of phosphorus $^{30}_{15}\text{P}$. 9702 13 11/Q39
- What is the daughter product of this reaction?
- A an α particle
- B a β particle
- C a γ ray
- D a neutron
- 86 An experiment in which α particles were directed at a gold foil produced results which led to the discovery of the structure of the atom. 9702 11 12/Q39
- Which conclusion can be drawn from the results of this experiment?
- A Atomic nuclei occupy a very small fraction of the volume of an atom
- B Electrons orbit the atomic nucleus
- C Some atoms of the same element contain different numbers of neutrons
- D The atomic nucleus contains protons and neutrons

87 The circuit is as shown. A current of 4 A flows through the 9 Ω resistor.

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What must be known in order to determine the value of

- A the electromotive force
- B the resistance of resistor R
- C the resistance of resistor S
- D the resistance of resistor 9Ω

88 Which statement concerning α particles is correct?

9702 12 11/Q39

- A An α particle has a charge of $4e$
- B An α particle is a helium atom
- C Ten α particles travel through air to cause ionisation
- D Ten α particles travel through a sheet of gold foil to make a track

89 A nucleus of the nuclide ${}^{241}_{94}\text{Pu}$ emits an α particle. The nucleus of the daughter nuclide is formed.

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Which nucleus is formed?

- A ${}^{239}_{93}\text{Pa}$
- B ${}^{239}_{91}\text{Pa}$
- C ${}^{237}_{93}\text{Pa}$
- D ${}^{237}_{92}\text{Pa}$

90 A nuclide ${}^{222}_{86}\text{Rn}$ is the start of a decay chain that forms the stable nuclide ${}^{214}_{83}\text{Bi}$. How many α and β particles are emitted in the decay chain?

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The table shows the number of α and β particles emitted in the decay chain.

	α particles	β particles
A	1	1
B	2	1
C	1	2
D	2	2

91 The decay is spontaneous and random in nature

9702/12/12/Q39

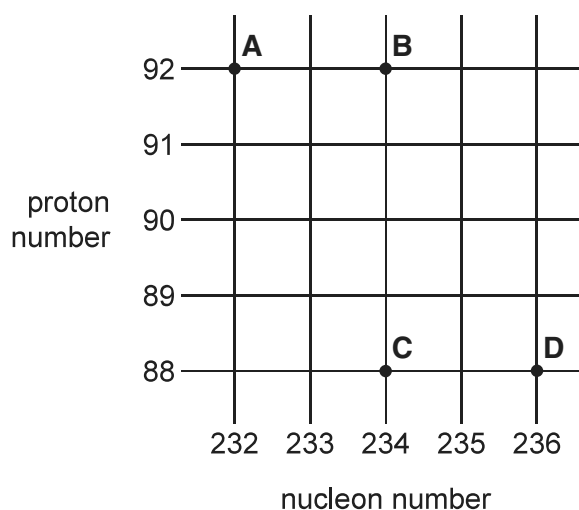
Which of the following is correct experimental evidence for these properties?

	spontaneous nature of decay	random nature of decay
A	the decay rate is not affected by pressure	the decay rate is not affected by temperature
B	the decay rate is not affected by pressure	the rate at which radiation is received at a counter fluctuates
C	the decay rate is not affected by temperature	the decay rate is not affected by pressure
D	the rate at which radiation is received at a counter fluctuates	the decay rate is not affected by pressure

92 Thorium $^{234}_{90}\text{Th}$ decays by β emission into a daughter product which in turn decays by β emission into a grand daughter product

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Which letter in the diagram represents the grand daughter product?



93 An experiment in which α particles were directed at a gold foil produced the following results into the structure of the atom

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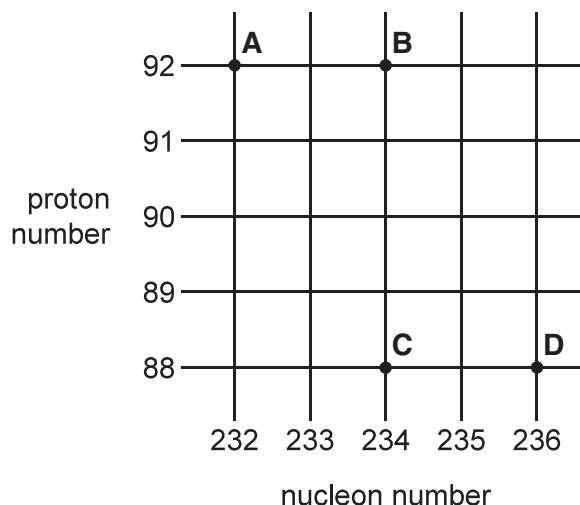
Which conclusion can be drawn from the results of the experiment?

- A Atomic nuclei occupy a very small fraction of the volume of an atom
- B Electrons orbit the atomic nucleus
- C Some atoms of the same element contain different numbers of neutrons
- D The atomic nucleus contains protons and neutrons

- 94 Polonium $^{234}_{90}\text{Po}$ decays by β emission into a daughter nuclide which in turn decays by β emission into a grand daughter nuclide

9702 13 12/Q39

The letter in the diagram represents the grand daughter nuclide



- 95 A material contains a radioactive isotope that disintegrates so that the emission of α particles is at a rate of 100 s^{-1}

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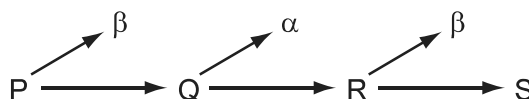
Which statement about this material is correct?

- A The number of atoms in the material diminishes at a rate of 100 s^{-1}
- B The number of neutrons in the material diminishes at a rate of 100 s^{-1}
- C The number of nucleons in the material diminishes at a rate of 400 s^{-1}
- D The number of protons in the material diminishes at a rate of 100 s^{-1}

- 96 In a radioactive decay series three successive decays each result in a particle being emitted

The first decay results in the emission of a β particle, the second decay results in the emission of an α particle, and the third decay results in the emission of another β particle

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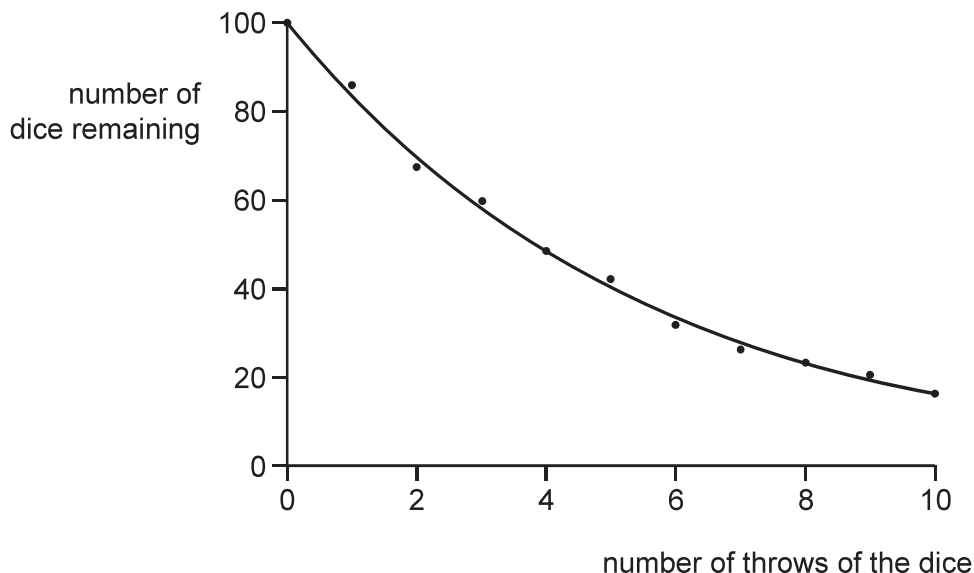
Which statements are correct?

Which statement is correct?

- A P and R are isotopes in a series
- B P and S are isotopes of the same element
- C S is a different element of the same atomic number
- D S is a different element of the same mass

- 97 A class of students use dice to simulate radioactive decay. After each throw, they remove the dice showing a one or two and record the results.

9702 11 12/Q38



What could the scatter points about the best fit curve represent or illustrate?

- A background count not being taken into account
- B more than one throw of the dice being represented
- C the random nature of radioactive decay
- D the spontaneous nature of radioactive decay

- 98 Which statement about alpha, beta and gamma radiation is correct?

9702 11 12/Q39

- A Alpha radiation has the greatest ionising power
- B Beta radiation has the greatest ionising power
- C Gamma radiation has the greatest ionising power
- D Alpha, beta and gamma radiation are nearly equally ionising powers

- 99 A different nucleus can be formed from an initial stable nucleus by an energetic α particle.

9702 12 12/Q40

${}_{11}^{23}\text{Na}$ is formed by an energetic α particle.

What could be the products of this nuclear reaction?

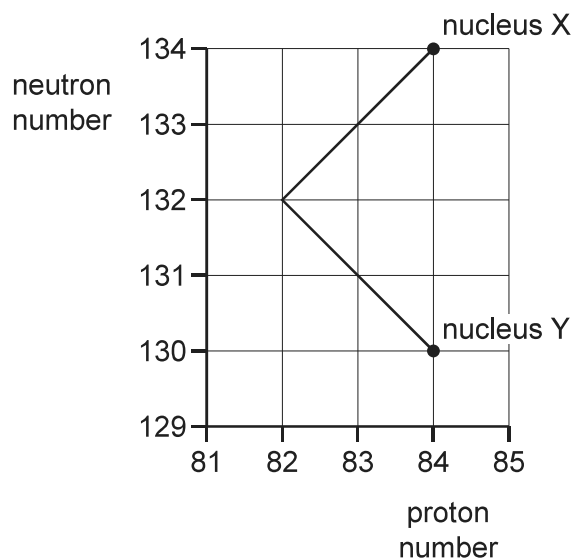
- A ${}_{10}^2\text{He}$ and a neutron
- B ${}_{11}^2\text{Na}$ and a proton
- C ${}_{12}^2\text{Mg}$ and β
- D ${}_{13}^{27}\text{Al}$ and γ

- 100 A nuclear isotope emits radiation which is detected by a Geiger-Müller tube at a distance of about 10 cm from the radioactive source. The radiation is stopped by a 2 mm thick sheet of lead.
- 9702/13 12/Q38

What can be deduced from this information about the emission from the isotope?

- A It could be an α or β radiation but not gamma radiation.
- B It could be an α or β gamma radiation but not α or β radiation.
- C It could be α or β gamma radiation but not α or β radiation.
- D It could be an α or β or gamma radiation.
- 101 What remains constant during β emission from a number of identical nuclei in a substance?
- 9702/13 12/Q39
- A Energy of the β particles.
- B Neutron number of the nuclei.
- C Nucleon number of the nuclei.
- D Proton number of the nuclei.

- 102 The graph of neutron number against proton number represents a sequence of radioactive decays.
- 9702/13 12/Q40



Nucleus X is at the start of the sequence and after the decays have occurred, nucleus Y is formed.

What is emitted during the sequence of decays?

- A one α particle and one β particle.
- B one α particle and two β particles.
- C two α particles and two β particles.
- D two β particles and one α particle.

- 103 A nickel nucleus ${}_{28}^{90}\text{Ni}$ can be transformed by a process termed capture of a neutron. This process takes place when a neutron is captured by a nucleus and an alpha particle is emitted.

9702 11 13/Q38

Which of the following is the resulting nucleus?

- A ${}_{28}^{88}\text{Ni}$ B ${}_{27}^{88}\text{Co}$ C ${}_{27}^{89}\text{Co}$ D ${}_{29}^{89}\text{Cu}$

- 104 It was once thought that the mass of an atom is spread uniformly throughout the volume of the atom. However, alpha particles are directed at a piece of gold foil. The results of the experiment led scientists to believe instead that nearly all the mass of the gold atom is concentrated at a point inside the atom.

9702 11 13/Q39

Which of the following is correct? The mass of the gold atom is concentrated at a point.

- A All alpha particles bounce back.
 B Most alpha particles are not deflected.
 C Some alpha particles pass straight through without deflection.
 D Some alpha particles are absorbed.

- 105 Which pair of nuclei are isotopes of one another?

9702 11 13/Q40

	nucleon number	number of neutrons
A	18	112
	180	118
B	18	112
	182	108
C	184	110
	187	110
D	18	110
	18	112

- 106 An actinium nucleus has a nucleon number of 227 and a proton number of 89. It decays to form a radium nucleus emitting an alpha particle and an alpha particle in the process.

9702 12 13/Q40

What are the nucleon number and the proton number of the radium nucleus?

	nucleon number	proton number
A	223	87
B	223	88
C	224	87
D	22	8

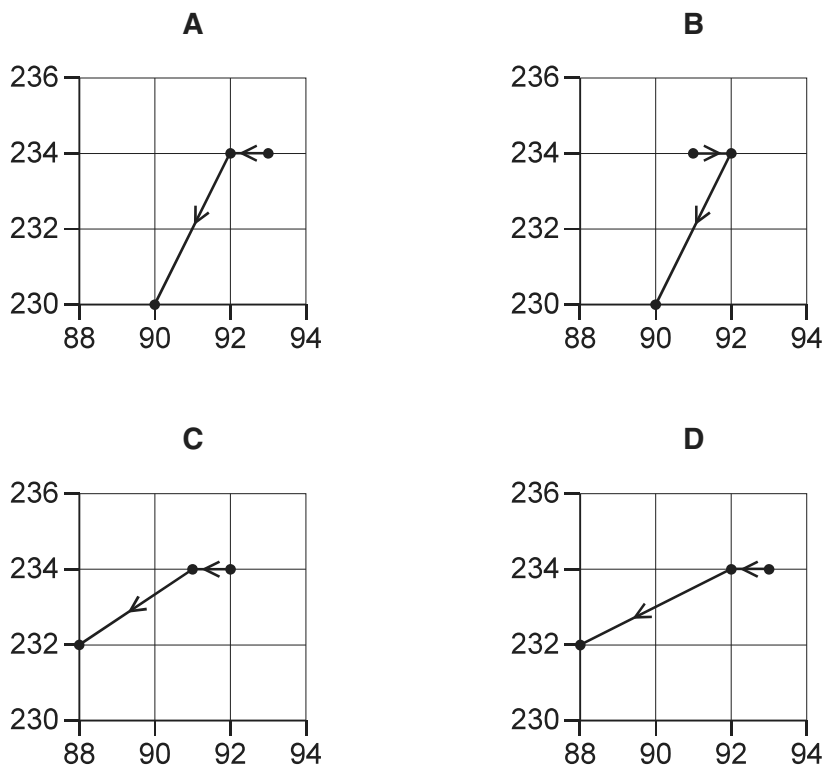
107 at is t e a ro imate mass o an a a article

9702 12 13/Q39

- A 10^{28} g
 B 10^2 g
 C 10^{24} g
 D 10^{22} g

108 A ra ioacti e nuceus is orme β eca is nuceus t en eca s α emission 9702 13 13/Q40

ic gra o nuceon num er otte against roton num er s o s t e β eca o o e
 t e α emission



109 e eca o a nuceus o ne tunium is accom anie t e emission o a β article an γ
 ra iation 9702 13 13/Q39

ate ect i an oest is eca a e on t e roton num er an on t e nuceon num er o t e
 nuceus

	roton num er	nuceon num er
A	increases	ecreases
B	ecreases	increases
C	unc ange	ecreases
D	increases	unc ange

- 110 Scientists investigating the count rate from a radioactive source observe that the count rate fluctuates
9702 13 13/Q38

about these fluctuations implies about the nature of radioactive decay

- A It involves atomic nuclei
- B It is predictable
- C It is random
- D It is spontaneous

- 111 In α particles are fired at a target in metal foil most of the particles pass straight through but a few are deflected at large angles
9702 11 13/Q39

This change would increase the proportion of α particles deflected at large angles

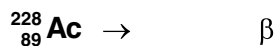
- A using α particles of greater kinetic energy
- B using a foil made of a metal with fewer protons in its nuclei
- C using a more thickness of foil
- D using an alpha source with a higher activity

- 112 Polonium-239 $^{239}_{94}\text{Po}$ decays emitting α radiation
9702 11 13/Q40

The nuclide is formed from one of these decay reactions. The product nuclides are represented

- A $^{23}_{92}\text{Po}$ B $^{237}_{92}\text{Po}$ C $^{239}_{93}\text{Po}$ D $^{239}_{9}\text{Po}$

- 113 A nucleus of the nuclide $^{228}_{89}\text{Ac}$ decays emitting an alpha particle. The nuclear equation for this decay is
9702 13 13/Q39



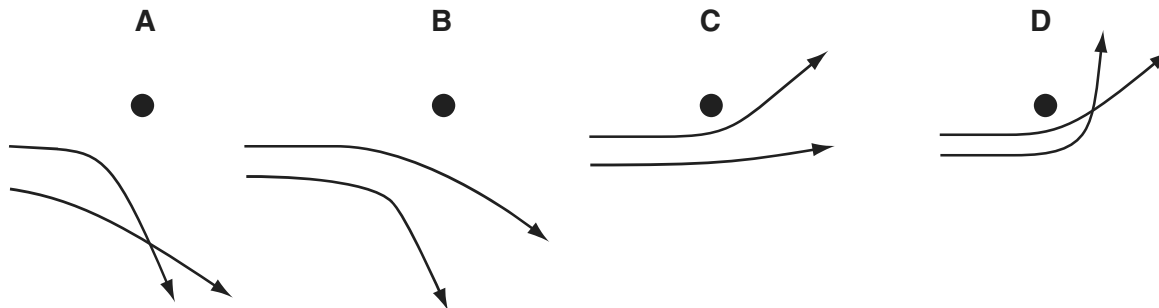
Which pair of values of n and p is correct

A	224	87
B	224	89
C	228	88
D	228	90

114 α particles have the same energies and are emitted from a large nucleus

9702 13 13/Q40

The diagram represents their paths



115 A nucleus decays into a nucleus emitting an α particle or a β particle

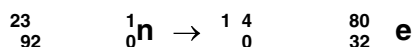
9702 12 14/Q38

Which statement about this nuclear decay is correct

- A Beta particle decay occurs when a proton changes into a neutron
- B Nucleus has the same nucleon number as nucleus
- C Nucleus is an isotope of nucleus
- D The total mass of the products is equal to the mass of the initial nucleus

116 A slowing neutron collides with a nucleus of uranium 235, which results in a nuclear reaction that is represented by the following nuclear equation

9702 12 14/Q39



Where represents one or more particles

What does represent

- A one neutron
- B two electrons
- C two neutrons
- D two protons

117 The first artificial radioactive substance was made by bombarding aluminium with α particles

9702 12 14/Q40

The reaction is represented by the following nuclear equation

What is the product of this reaction

- A an α particle
- B a β particle
- C a neutron
- D a proton

- 118 An isotope of thorium has a nucleon number of 232 and a proton number of 90. It decays to form another isotope of thorium with a nucleon number of 228.

9702 12 14/Q39

How many α particles and β particles are emitted from a nucleus of thorium during this decay?

	α particles	β particles
A	0	4
B	1	0
C	1	2
D	2	1

- 119 Four nuclei are represented as follows:

9702 12 14/Q40



Which statement about these nuclei is correct?

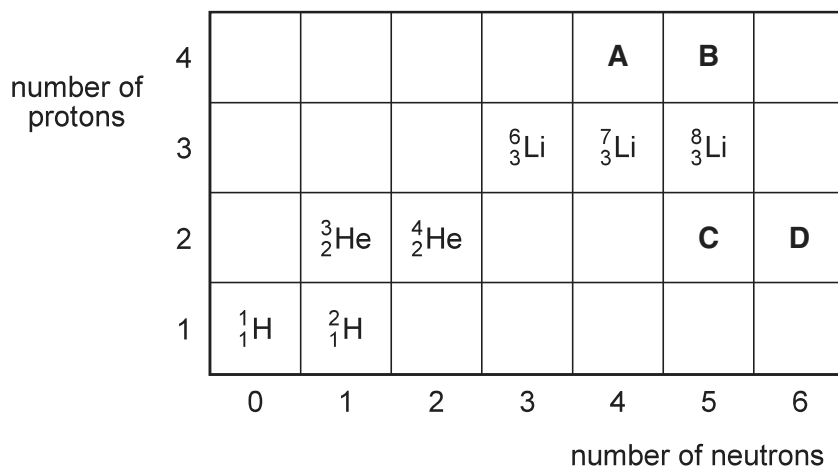
- A An uncharged atom of element X has 24 orbital electrons.
 B Nucleus Y converts into Z emitting an α particle.
 C Nuclei X and Z are isotopes of the same element.
 D When a source of neutrons emits an α particle, nucleus W transforms into X.

- 120 The graph shows the number of nuclei arranged according to the number of protons and the number of neutrons in each.

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A nucleus of the nuclide ${}^8_3\text{Li}$ decays emitting a β particle.

What is the resulting nuclide?



- 125 The isotope $^{222}_{88}\text{Ra}$ in a sequence of emissions to form the isotope $^{206}_{82}\text{Pb}$. At each stage of the sequence it emits either an α particle or a β particle. What is the number of stages in the sequence?

A 4 B 8 C 1 D 20

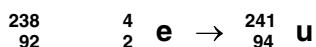
- 126 What is the approximate mass of a nucleus of uranium? 9702 11 14/Q40

A 10^{-1} g B 10^{-20} g C 10^{-2} g D 10^{-30} g

- 127 The nucleus of a radioactive isotope of an element emits an α particle. The daughter nucleus then emits a β particle and then the daughter nucleus of that reaction emits another β particle. Which statement is correct? 9702 13 14/Q38

A It is a different isotope of the original element.
 B It is a nucleus of a different element of higher proton number.
 C It is a nucleus of the same element but of higher proton number.
 D It is identical to the original nucleus.

- 128 A nuclear reaction is shown. 9702 13 14/Q39



What is the product?

A an α particle
 B an electron
 C a neutron
 D a proton

- 129 The nuclei $^{222}_{88}\text{Ra}$ in a sequence of stages to form the nucleus $^{206}_{82}\text{Pb}$. 9702 11 14/Q40

Four of the nuclei in the sequence are α particle emitters. How many are β particle emitters?

A 2 B 4 C 8 D 12

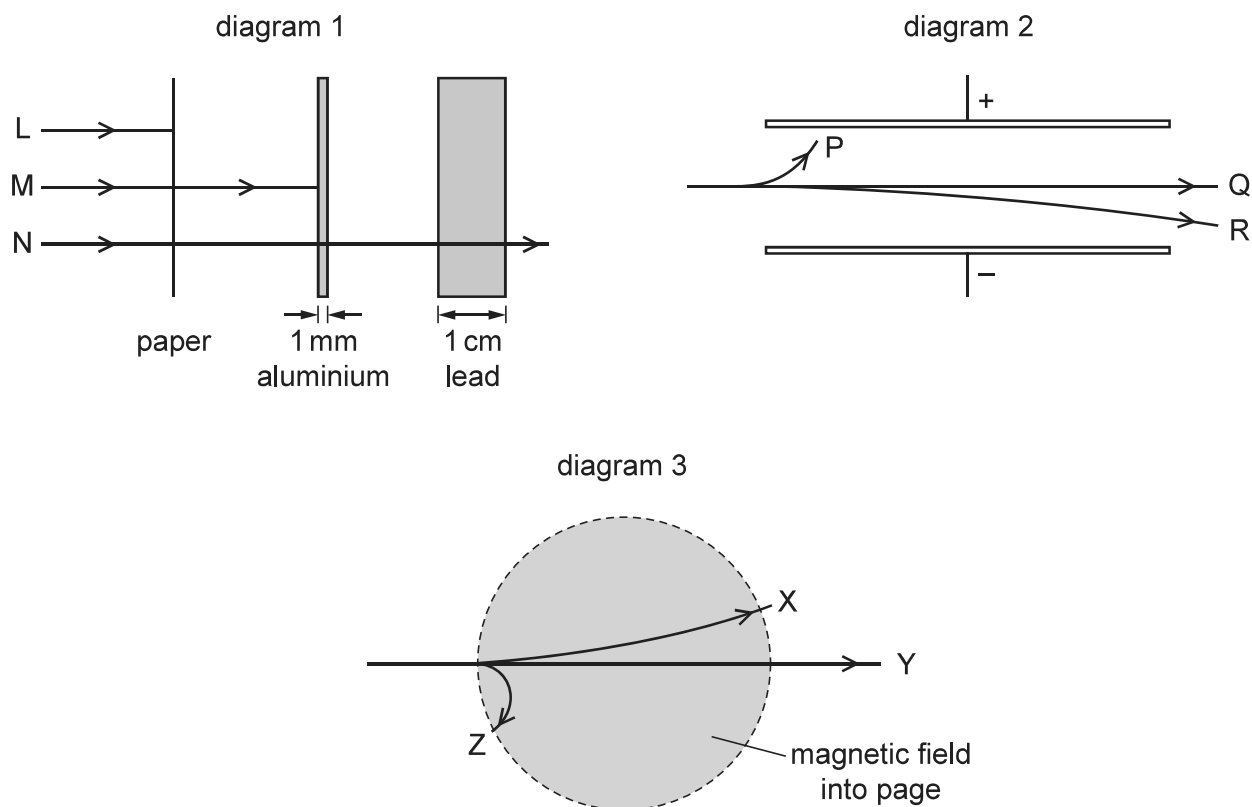
130 **A** alpha and gamma radiations

1 are absorbed to different extents in solids

2 are deflected in an electric field

3 are deflected in a magnetic field

The diagrams illustrate these behaviours



Which three rays on these diagrams refer to the same ionisation

A**B****C****D**

131 The nuclear equation for a fission reaction is shown below

9702 13 1 /Q40



What are the values of A and

A	37	0
B	37	1
C	37	2
D	38	2

132 A radioactive substance contains a number of identical nuclei that emit β particles 9702 12 1 /Q39

which proportion of these nuclei remains undisturbed after the emission

- A charge
- B neutron number
- C nucleon number
- D proton number

133 A uranium-238 nucleus $^{238}_{92}\text{U}$ undergoes nuclear decay to form uranium-234 $^{234}_{92}\text{U}$ 9702 12 1 /Q40

in a series of decays. The final product is

- A emission of four β particles
- B emission of four γ rays
- C emission of one α particle and two β particles
- D emission of two α particles and eight β particles

134 In α particles are directly attracted to the nucleus 9702 11 1 /Q39

1. a most α particles have sufficient energy to pass right through the nucleus

2. a few α particles are deflected through large angles

What are the reasons for these effects?

	1	2
A	most α particles have enough energy to pass right through the nucleus	the nucleus is so small so most α particles pass straight through
B	most α particles miss the nucleus	most α particles have enough energy to pass straight through
C	the nucleus is so small so most α particles miss the nucleus	occasionally an α particle is deflected by the nucleus
D	the positive charge in an atom is not concentrated enough to deflect an α particle	occasionally an α particle experiences many small deflections in the same direction