

- 1 The nucleus of one of the isotopes of nickel is represented by  ${}_{28}^{60}\text{Ni}$ .

Which line in the table correctly describes a neutral atom of this isotope?

	number of protons	number of neutrons	number of orbital electrons
<b>A</b>	28	32	28
<b>B</b>	28	60	28
<b>C</b>	60	28	28
<b>D</b>	60	32	32

- 2 A nucleus of bohrium  ${}^x_y\text{Bh}$  decays to mendelevium  ${}_{101}^{255}\text{Md}$  by a sequence of three  $\alpha$ -particle emissions.

bohrium  ${}^x_y\text{Bh} \longrightarrow$  dubnium +  $\alpha$

$\longleftarrow$  lawrencium +  $\alpha$

$\longleftarrow$  mendelevium  ${}_{101}^{255}\text{Md}$  +  $\alpha$

How many neutrons are there in a nucleus of  ${}^x_y\text{Bh}$ ?

- A** 267  
**B** 261  
**C** 160  
**D** 154
- 3 Which set of radioactive emissions corresponds to the descriptions given in the table headings?

	high-speed electrons	high-speed helium nuclei	high-frequency photons
<b>A</b>	$\alpha$	$\beta$	$\gamma$
<b>B</b>	$\alpha$	$\gamma$	$\beta$
<b>C</b>	$\beta$	$\alpha$	$\gamma$
<b>D</b>	$\beta$	$\gamma$	$\alpha$

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

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  ${}^{90}_{38}\text{Sr} \rightarrow {}^{90}_{37}\text{Sr} + {}^0_{+1}\beta$

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

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
<b>A</b>	0	3
<b>B</b>	1	1
<b>C</b>	1	2
<b>D</b>	2	1

- 6 A nucleus of the nuclide  ${}^{241}_{94}\text{Pu}$  decays by emission of a  $\beta$ -particle followed by the emission of an  $\alpha$ -particle.

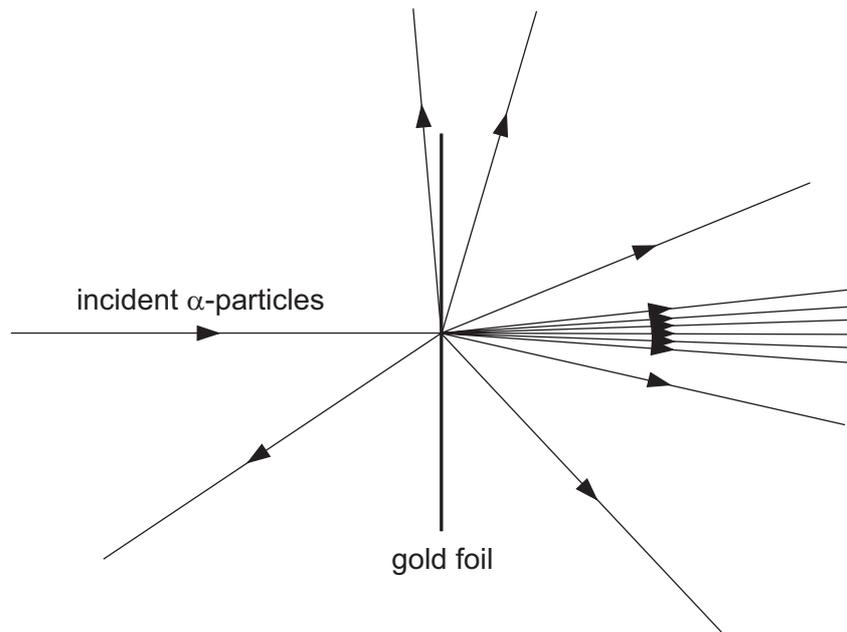
Which of the nuclides shown is formed?

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

- 7 Which two nuclei contain the same number of neutrons?

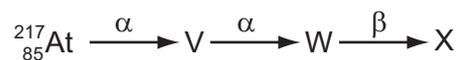
- A  ${}^{12}_6\text{C}$  and  ${}^{14}_6\text{C}$   
 B  ${}^{16}_7\text{N}$  and  ${}^{15}_8\text{O}$   
 C  ${}^{23}_{11}\text{Na}$  and  ${}^{24}_{12}\text{Mg}$   
 D  ${}^{32}_{14}\text{Si}$  and  ${}^{32}_{15}\text{P}$

- 8 A thin gold foil is bombarded with  $\alpha$ -particles as shown.



The results of this experiment provide information about the

- A binding 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.
- 9 Isotopes of a given element all have the same
- A charge/mass ratio.
  - B neutron number.
  - C nucleon number.
  - D proton number.
- 10 The following represents a sequence of radioactive decays involving two  $\alpha$ -particles and one  $\beta$ -particle.



What is the nuclide X?

- A  ${}_{85}^{213}\text{At}$
- B  ${}_{77}^{215}\text{Ir}$
- C  ${}_{82}^{209}\text{Pb}$
- D  ${}_{81}^{217}\text{Tl}$

- 11 A student conducts an experiment using an  $\alpha$ -particle source.

When considering safety precautions, what can be assumed to be the maximum range of  $\alpha$ -particles in air?

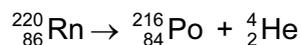
- A between 0 and 5 mm  
 B between 5 mm and 200 mm  
 C between 200 mm and 500 mm  
 D between 500 mm and 1000 mm
- 12 What is a correct order of magnitude estimate for the diameter of a typical atomic nucleus?  
 A  $10^{-14}$  m      B  $10^{-18}$  m      C  $10^{-22}$  m      D  $10^{-26}$  m

- 13 The decay of a nucleus of neptunium is accompanied by the emission of a  $\beta$ -particle and  $\gamma$ -radiation.

What effect (if any) does this decay have on the proton number and the nucleon number of the nucleus?

	proton number	nucleon number
<b>A</b>	increases	decreases
<b>B</b>	decreases	increases
<b>C</b>	unchanged	decreases
<b>D</b>	increases	unchanged

- 14 Radon-220 is radioactive and decays to Polonium-216 with the emission of an  $\alpha$ -particle. The equation for the radioactive decay is shown.



How many neutrons are in the radon and polonium nuclei?

	Rn	Po
<b>A</b>	86	84
<b>B</b>	134	132
<b>C</b>	220	212
<b>D</b>	220	216

- 15 A detector is exposed to a radioactive source. Fluctuations in the count-rate are observed.

What do these fluctuations indicate about radioactive decay?

- A It is random.
- B It is spontaneous.
- C It is exponential.
- D It is non-linear.

- 16 The symbol  ${}_{32}^{77}\text{Ge}$  represents a nucleus of germanium that decays to a nucleus of arsenic by emitting a  $\beta$ -particle.

What is the symbol of this arsenic nucleus?

- A  ${}_{32}^{76}\text{As}$
- B  ${}_{32}^{78}\text{As}$
- C  ${}_{31}^{78}\text{As}$
- D  ${}_{33}^{77}\text{As}$

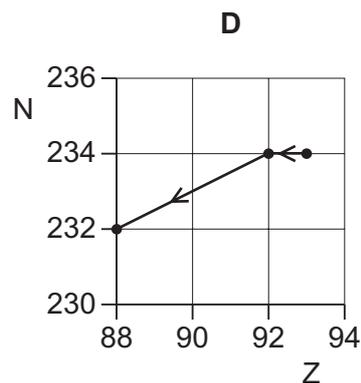
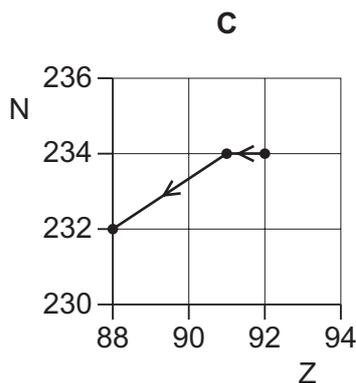
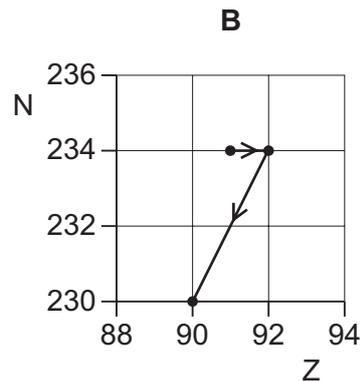
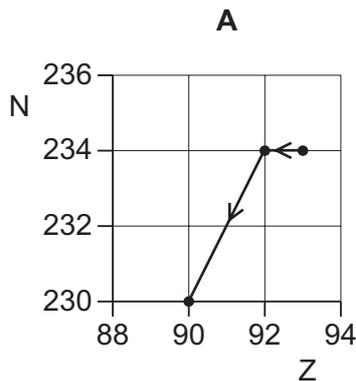
- 17 Each of the nuclei below is accelerated from rest through the same potential difference.

Which one completes the acceleration with the **lowest** speed?

- A  ${}^1_1\text{H}$
- B  ${}^4_2\text{He}$
- C  ${}^7_3\text{Li}$
- D  ${}^9_4\text{Be}$

- 18 A radioactive nucleus is formed by  $\beta$ -decay. This nucleus then decays by  $\alpha$ -emission.

Which graph of proton number  $Z$  plotted against nucleon number  $N$  shows the  $\beta$ -decay followed by the  $\alpha$ -emission?



19 What is the approximate mass of a nucleus of uranium?

- A  $10^{-15}$  kg      B  $10^{-20}$  kg      C  $10^{-25}$  kg      D  $10^{-30}$  kg

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

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

21 In an experiment to investigate the nature of the atom, a very thin gold film was bombarded with  $\alpha$ -particles.

What pattern of deflection of the  $\alpha$ -particles was observed?

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

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

What is the resulting nucleus?

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

23 Which conclusion can be drawn from the results of the experiment showing the scattering of  $\alpha$ -particles by gold foil?

- A Electrons orbit the atomic nucleus in well-defined paths.  
 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 with the size of the atom.

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

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

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

- 25 An atomic nucleus emits a  $\beta$ -particle.

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

	proton number	nucleon number
<b>A</b>	-1	+1
<b>B</b>	0	-1
<b>C</b>	+1	-1
<b>D</b>	+1	0

- 26 Which are the correct descriptions of a  $\gamma$ -ray and a  $\beta$ -particle?

	$\gamma$ -ray	$\beta$ -particle
<b>A</b>	high-speed electron	electromagnetic radiation
<b>B</b>	electromagnetic radiation	Helium-4 nucleus
<b>C</b>	electromagnetic radiation	high-speed electron
<b>D</b>	high-speed electron	Helium-4 nucleus

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

Which is an isotope of Uranium-235?

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

- 28 The symbol  ${}^{77}_{32}\text{Ge}$  represents a nuclide of germanium that decays to a nuclide of arsenic (As) by emitting a  $\beta$ -particle.

What is the symbol of this arsenic nuclide?

- A  ${}^{76}_{32}\text{As}$       B  ${}^{78}_{32}\text{As}$       C  ${}^{78}_{31}\text{As}$       D  ${}^{77}_{33}\text{As}$

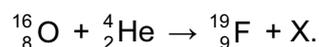
- 29 The table shows three properties of different types of ionising radiation.

	X	Y	Z
charge	0	$-1e$	$+2e$
mass	0	$\frac{1}{1840}u$	$4u$
speed	$c$	$\sim 0.9c$	$\sim 0.1c$

What are the radiations X, Y and Z?

	X	Y	Z
A	alpha	beta	X-rays
B	gamma	alpha	beta
C	gamma	beta	alpha
D	X-rays	alpha	beta

- 30 A nuclear reaction is represented by the equation



What is particle X?

- A an  $\alpha$ -particle  
 B a  $\beta$ -particle  
 C a neutron  
 D a proton

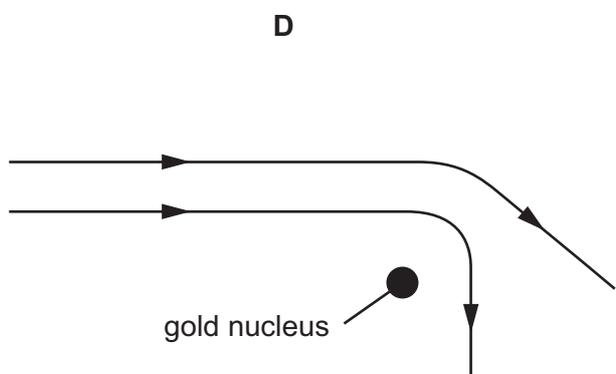
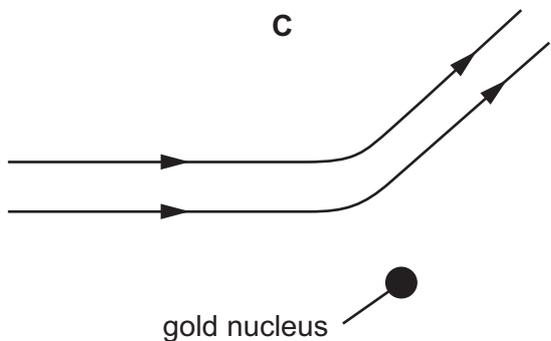
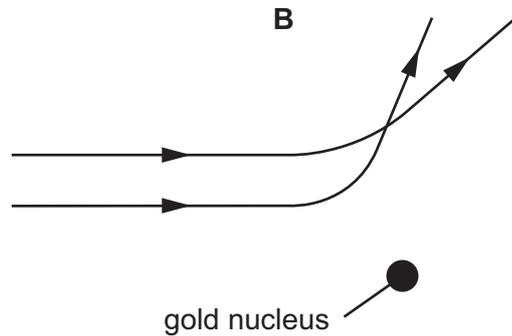
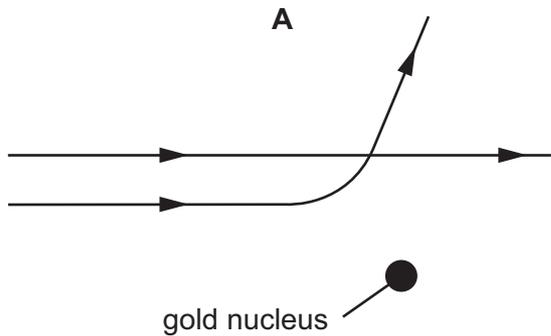
- 31 A nucleus Q has the notation  ${}^y_x\text{Q}$ .

Which of the following is an isotope of Q?

- A  ${}^{y-1}_x\text{Q}$       B  ${}^y_{x-1}\text{Q}$       C  ${}^y_{x+1}\text{Q}$       D  ${}^{y-1}_{x+1}\text{Q}$

32 Two  $\alpha$ -particles with equal energies are fired towards the nucleus of a gold atom.

Which diagram best represents their paths?



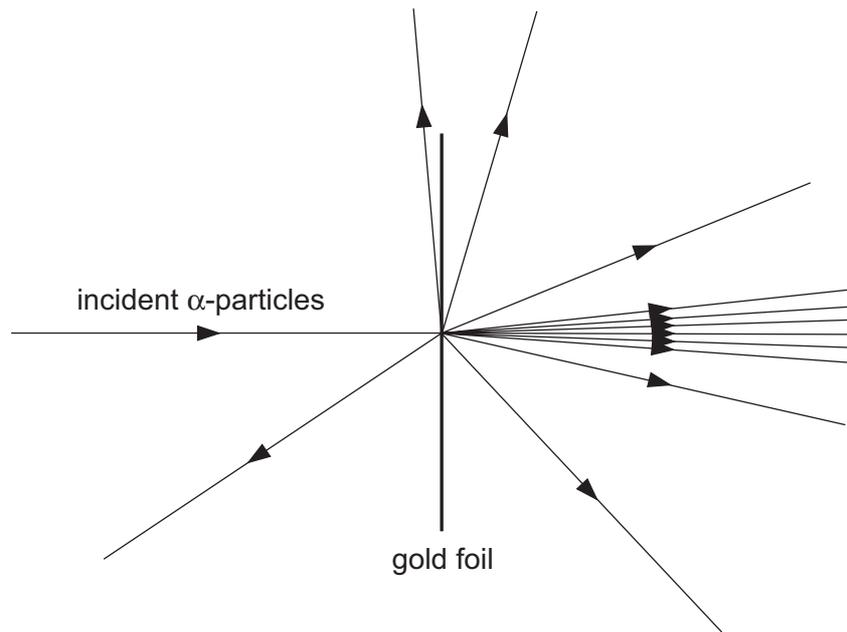
33 How is it possible to distinguish between the isotopes of uranium?

- A Their nuclei have different charge and different mass, and they emit different particles when they 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 when they decay.

34 What is **not** conserved in nuclear processes?

- A energy and mass together
- B nucleon number
- C neutron number
- D charge

35 A thin gold foil is bombarded with  $\alpha$ -particles as shown.



What can be deduced from this experiment?

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

36 A zirconium nucleus,  ${}_{40}^{100}\text{Zr}$ , is a  $\beta$ -emitter. The product nucleus is also a  $\beta$ -emitter.

What is the final resulting nucleus of these two decays?

- A  ${}_{38}^{100}\text{Sr}$       B  ${}_{42}^{100}\text{Mo}$       C  ${}_{40}^{98}\text{Zr}$       D  ${}_{40}^{102}\text{Zr}$

37 The following particles are each accelerated from rest through the same potential difference.

Which one completes the acceleration with the **greatest** momentum?

- A  $\alpha$ -particle
- B electron
- C neutron
- D proton

37 Radon  ${}^{222}_{86}\text{Rn}$  decays by  $\alpha$ - and  $\beta$ -emission to bismuth  ${}^{214}_{83}\text{Bi}$ .

For the decay of each nucleus of radon, how many  $\alpha$ - and  $\beta$ -particles are emitted?

	$\alpha$ -particles	$\beta$ -particles
<b>A</b>	1	1
<b>B</b>	2	1
<b>C</b>	1	2
<b>D</b>	2	2

38 Which conclusion can be drawn from the results of the experiment showing the scattering of  $\alpha$ -particles by gold foil?

- A** Electrons orbit the atomic nucleus in well-defined paths.
- 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 with the size of the atom.

39 Which statement concerning  $\alpha$ -particles is correct?

- A** An  $\alpha$ -particle has charge  $+4e$ .
- B** An  $\alpha$ -particle is a helium atom.
- C** When  $\alpha$ -particles travel through air, they cause ionisation.
- D** When  $\alpha$ -particles travel through a sheet of gold foil, they make the gold radioactive.

40 Where are electrons, neutrons and protons found in an atom?

	electrons	neutrons	protons
<b>A</b>	in the nucleus	in the nucleus	orbiting the nucleus
<b>B</b>	in the nucleus	orbiting the nucleus	in the nucleus
<b>C</b>	orbiting the nucleus	in the nucleus	orbiting the nucleus
<b>D</b>	orbiting the nucleus	in the nucleus	in the nucleus

41 A  ${}^{238}_{92}\text{U}$  nucleus decays in two stages to a  ${}^{234}_{91}\text{Pa}$  nucleus.

What was emitted in these two stages?

- A**  $\alpha + \beta$
- B**  $\alpha + \gamma$
- C**  $\beta + \beta$
- D**  $\beta + \gamma$