Nuclear Physics

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

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

	number of protons	number of neutrons	number of orbital electrons
A	28	32	28
B	28	60	28
C	60	28	28
D	60	32	32

2 A nucleus of bohrium $^{x}_{y}Bh$ decays to mendelevium $^{255}_{101}Md$ by a sequence of three α-particle emissions.

bohrium $^{x}_{y}Bh \longrightarrow$ dubnium + α

$\longrightarrow$ lawrencium + α

$\longrightarrow$ mendelevium $^{255}_{101}Md$ + α

How many neutrons are there in a nucleus of $^{x}_{y}Bh$?

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
A	α	β	γ
B	α	γ	β
C	β	α	γ
D	β	γ	α

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

Which equation could represent this nuclear decay?

A $^{90}_{38}Sr \rightarrow {}^{90}_{39}Sr + {}^{0}_{-1}\beta$

B $^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}\beta$

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

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

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 ($+1.6 \times 10^{-19}$ 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

6 A nucleus of the nuclide $^{241}_{94}Pu$ decays by emission of a β-particle followed by the emission of an α-particle.

Which of the nuclides shown is formed?

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

7 Which two nuclei contain the same number of neutrons?

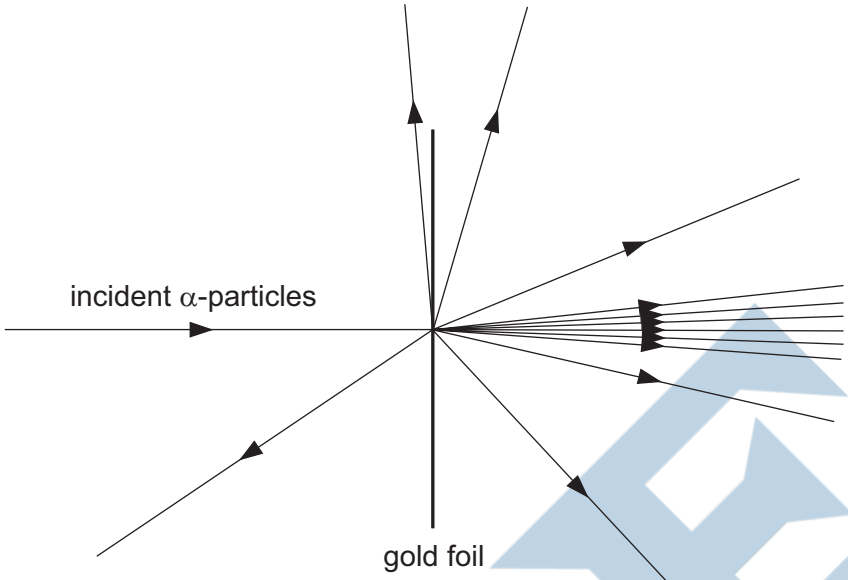
A $^{12}_{6}C$ and $^{14}_{6}C$

B $^{16}_{7}N$ and $^{15}_{8}O$

C $^{23}_{11}Na$ and $^{24}_{12}Mg$

D $^{32}_{14}Si$ and $^{32}_{15}P$

8 A thin gold foil is bombarded with α-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 α-particles and one β-particle.

$$^{217}_{85}\text{At} \xrightarrow{\alpha} \text{V} \xrightarrow{\alpha} \text{W} \xrightarrow{\beta} \text{X}$$

What is the nuclide X?

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

11 A student conducts an experiment using an α-particle source.

When considering safety precautions, what can be assumed to be the maximum range of α-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 β-particle and γ-radiation.

What effect (if any) 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

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

$$^{220}_{86}\text{Rn} \rightarrow {}^{216}_{84}\text{Po} + {}^{4}_{2}\text{He}$$

How many neutrons are in the radon and polonium nuclei?

	Rn	Po
A	86	84
B	134	132
C	220	212
D	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 $^{77}_{32}\text{Ge}$ represents a nucleus of germanium that decays to a nucleus of arsenic by emitting a β-particle.

What is the symbol of this arsenic nucleus?

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

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

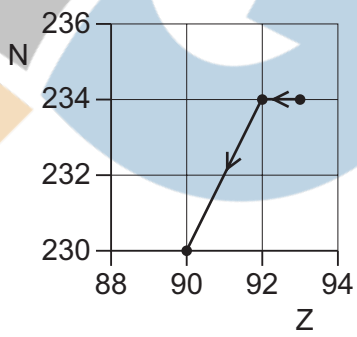
Which one completes the acceleration with the **lowest** speed?

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 β-decay. This nucleus then decays by α-emission.

Which graph of proton number Z plotted against nucleon number N shows the β-decay followed by the α-emission?

A



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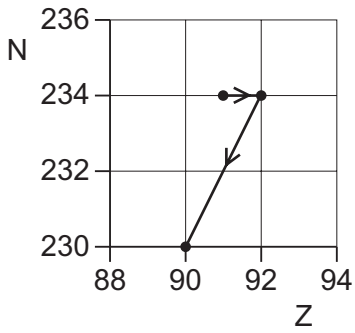

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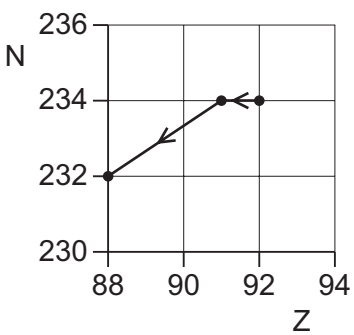

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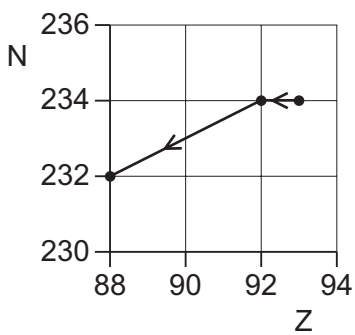


19 What is the approximate mass of a nucleus of uranium?

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 α-particles.

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.

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

What is the resulting nucleus?

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

23 Which conclusion can be drawn from the results of the experiment showing the scattering of α-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 $^{59}_{28}Ni$ 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 $^{58}_{28}Ni$ **B** $^{58}_{27}Co$ **C** $^{59}_{27}Co$ **D** $^{59}_{29}Cu$

25 An atomic nucleus emits a β-particle.

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

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

	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

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
A	235	91	144
B	236	92	144
C	237	94	143
D	238	95	143

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

What is the symbol of this arsenic nuclide?

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

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

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

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

$$^{16}_{8}\mathrm{O} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{19}_{9}\mathrm{F} + \mathrm{X}.$$

What is particle X?

A an α-particle

B a β-particle

C a neutron

D a proton

31 A nucleus Q has the notation $^{y}_{x}\mathrm{Q}$.

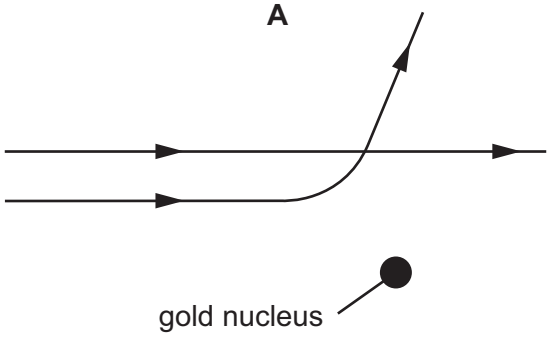
Which of the following is an isotope of Q?

A $^{y-1}_{x}\mathrm{Q}$ **B** $^{y}_{x-1}\mathrm{Q}$ **C** $^{y}_{x+1}\mathrm{Q}$ **D** $^{y-1}_{x+1}\mathrm{Q}$

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

Which diagram best represents their paths?

A



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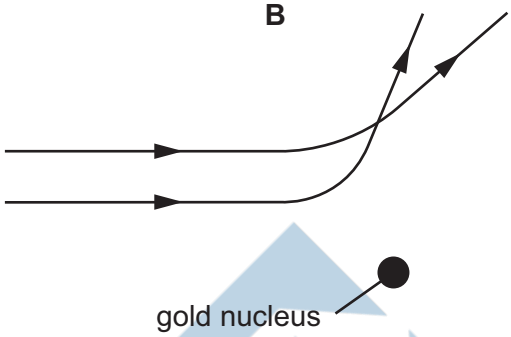

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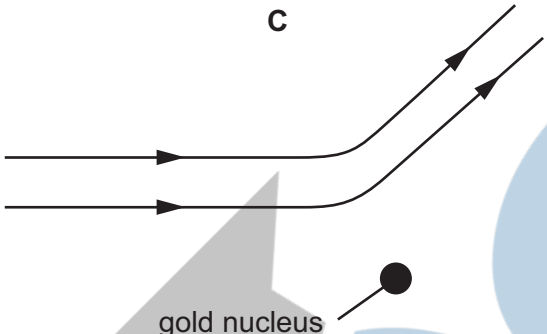

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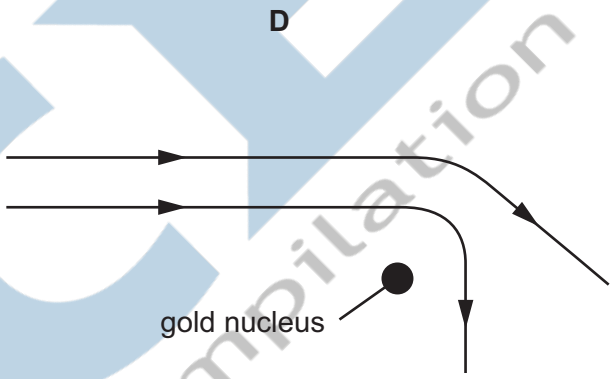


33 How is it possible to distinguish between the isotopes of uranium?

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?

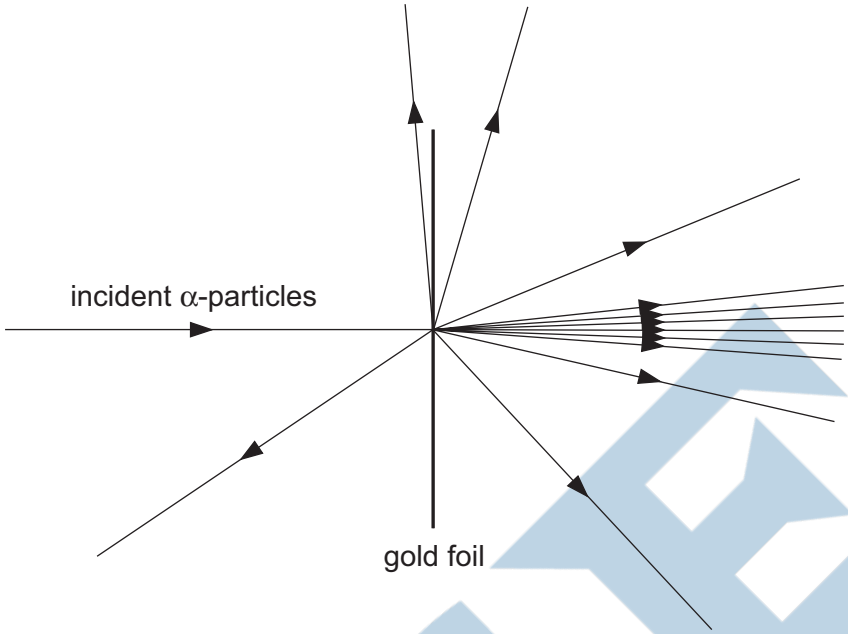
A energy and mass together

B nucleon number

C neutron number

D charge

35 A thin gold foil is bombarded with α-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, $^{100}_{40}Zr$, is a β-emitter. The product nucleus is also a β-emitter.

What is the final resulting nucleus of these two decays?

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

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

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

A α-particle

B electron

C neutron

D proton

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

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

	$\alpha-$particles	$\beta-$particles
A	1	1
B	2	1
C	1	2
D	2	2

38 Which conclusion can be drawn from the results of the experiment showing the scattering of α-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 α-particles is correct?

A An α-particle has charge $+4e$.

B An α-particle is a helium atom.

C When α-particles travel through air, they cause ionisation.

D When α-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
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

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

What was emitted in these two stages?

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