ATOMIC STRUCTURE WS 1

SECTION A

1 Which one the following has more neutrons than electrons and more electrons than protons?

A $^{19}F^{--}$

B $^{37}Cl^{--}$

C ^{9}Be

D $^{9}Be^{2+}$

2 Chlorine exists as two isotopes ^{35}Cl with an abundance of 75.5% and ^{37}Cl with an abundance of 24.5%.

Phosphorus has only one isotope, ^{31}P. The mass spectrum of PCl_3 has four lines at m/z = 136, 138, 140 and 142.

Which one of these lines will have the smallest height?

A 136

B 140

C 138

D 142

3 Antimony has two isotopes ^{121}Sb and ^{123}Sb. The relative atomic mass of a naturally occurring sample of antimony is measured as 121.75.

Which one of the following is the best approximate estimate of the percentage of ^{121}Sb present in the naturally occurring sample?

A 20%

B 60%

C 40%

D 80%

4 When sulfur, ^{32}S is bombarded with neutrons ^{1}n, two particles are formed. One of them is a hydrogen atom, ^{1}H and the other is an element, X.

$$^{32}S + {}^{1}n \quad {}^{1}H + X$$

Which one of the following correctly represents X?

A ^{32}S

B ^{32}P

C ^{33}S

D ^{33}P

5 What is the number of protons, electrons, and neutrons in boron-11?

A 5 protons, 5 electrons and 11 neutrons

B 5 protons, 5 electrons and 10.8 neutrons

C 5 protons, 5 electrons and 6 neutrons

D 11 protons, 11 electrons and 5 neutrons

6 What is the number of protons, electrons, and neutrons in $^{34}S^{2-}$?

A 18 protons, 16 electrons and 18 neutrons
C 16 protons, 18 electrons and 18 neutrons
B 16 protons, 18 electrons and 18 neutrons
D 16 protons, 16 electrons and 18 neutrons

7 Which statements about the isotopes of chlorine, ^{35}Cl and ^{37}Cl are correct?

I. They have the same chemical properties.

II. The have the same atomic number.

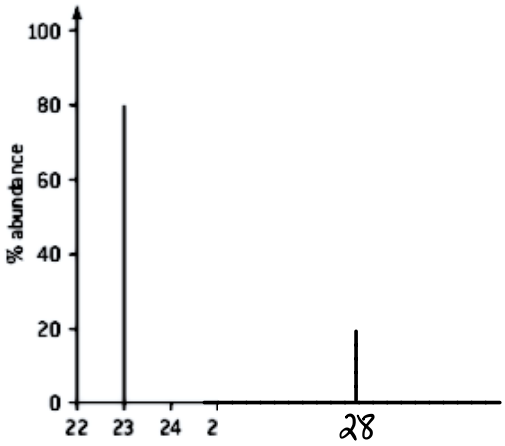
III. The have the same physical properties.

A I and II only
C II an III only
B I and III only
D I, II and III

8 A sample of element X contains 69% of ^{63}X and 31% of ^{65}X. What is the relative atomic mass of X in this sample?

A 63.0
C 65.0
B 63.6
D 69.0

9 What is the relative atomic mass of an element with the mass spectrum shown below?



A 24
C 26
B 25
D 27

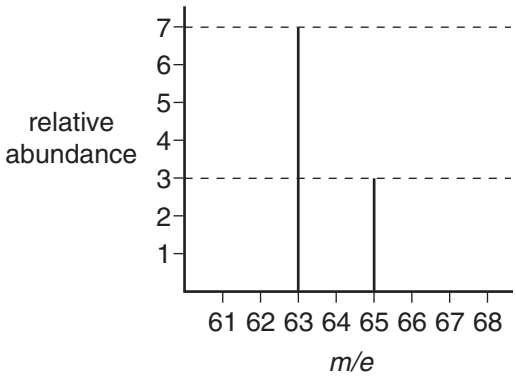
10 In the radioactive decay of an isotope of lead to an isotope of bismuth, a particle $^{0}_{-1}X$ is emitted.

Which particle is $^{0}_{-1}X$?

A electron
B ion
C neutron
D proton

[S'02 Q1]

11 The diagram shows the mass spectrum of a sample of naturally-occurring copper.



What is the relative atomic mass of this copper?

A 63.3 **B** 63.5 **C** 63.6 **D** 64.0

[S'02 Q3]

12 Which isotope of an element in the third period of the Periodic Table contains the same number of neutrons as $^{32}_{16}S$?

A $^{23}_{11}Na$
B $^{24}_{12}Mg$
C $^{28}_{14}Si$
D $^{31}_{15}P$

[S'03 Q3]

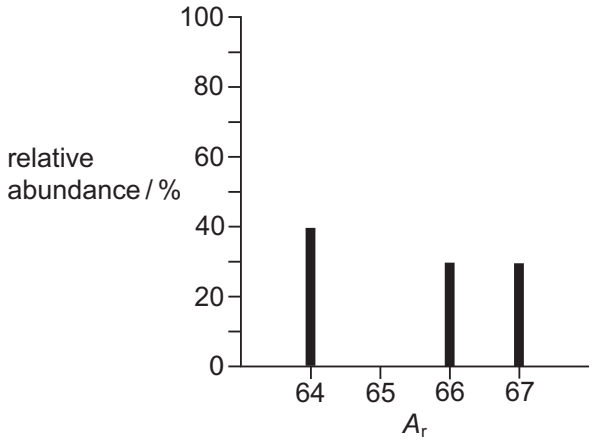
13 Unnilpentium is an artificial element. One of its isotopes is $^{262}_{105}Unp$.

Which of the following statements is correct?

A $^{262}_{105}Unp$ has a nucleon number of 105.
B The atom $^{260}_{105}X$ is an isotope of $^{262}_{105}Unp$.
C There are 262 neutrons in $^{262}_{105}Unp$.
D The proton number of $^{262}_{105}Unp$ is 262.

[W'03 Q4]

14 The diagram shows the mass spectrum of a sample of zinc. Use the data to calculate the relative atomic mass of the sample.



A 65 **B** 65.25 **C** 65.5 **D** 65.66

[W'04 Q2]

15 It is now thought that where an element exists as several isotopes, the stable ones usually contain a 'magic number' of neutrons. One of these magic numbers is 126.

Which isotope is unstable?

A ^{209}Bi **B** ^{208}Pb **C** ^{210}Po **D** ^{208}Tl

[W'04 Q4]

16 In which species are the numbers of electrons and neutrons equal?

A $^{9}_{4}Be$ **B** $^{19}_{9}F$ **C** $^{23}_{11}Na^{+}$ **D** $^{18}_{8}O^{2-}$

[S'05 Q4]

17 Which ion has more electrons than protons and more protons than neutrons?

[H = $^{1}_{1}H$; D = $^{2}_{1}H$; O = $^{16}_{8}O$]

A D^{-} **B** H_3O^{+} **C** OD^{-} **D** OH^{-}

[W'05 Q2]

18 A sample of chlorine containing isotopes of mass numbers 35 and 37 was analysed in a mass-spectrometer.

How many peaks corresponding to Cl_2^+ were recorded?

A 2 **B** 3 **C** 4 **D** 5

[S'06 Q2]

19 A radioactive isotope of thallium, $^{201}_{81}Tl$, is used to assess damage in heart muscles after a heart attack.

Which statement about $^{201}_{81}Tl$ is correct?

A This isotope has a nucleon number of 120.

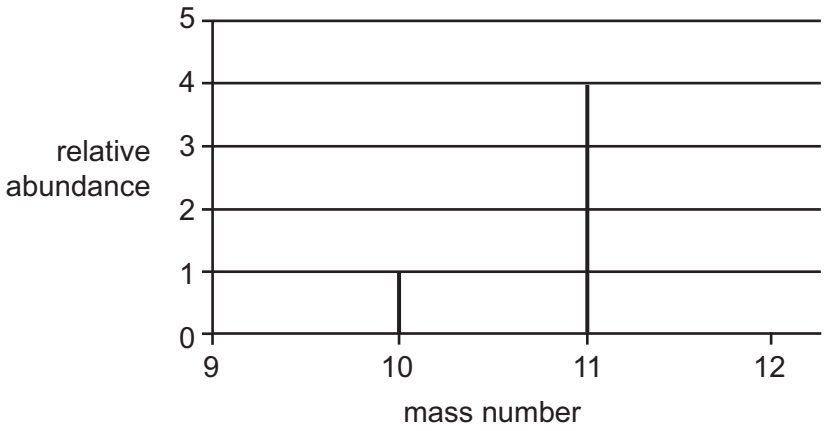
B The number of electrons in one atom of this isotope is 81.

C The number of neutrons in one atom of this isotope is 201.

D $^{201}_{82}X$ is an isotope of $^{201}_{81}Tl$.

[S'06 Q4]

20 The isotopic composition of an element is indicated below.



What is the relative atomic mass of the element?

A 10.2 **B** 10.5 **C** 10.8 **D** 11.0

[S'07 Q1]

21 John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

A Atoms are very small in size.

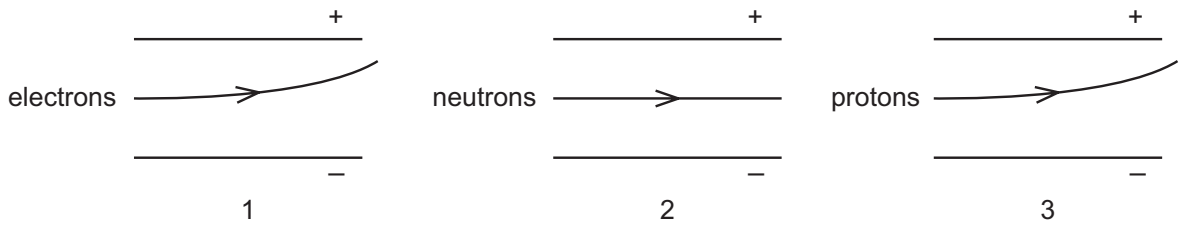
B No atom can be split into simpler parts.

C All the atoms of a particular element have the same mass.

D All the atoms of one element are different in mass from all the atoms of other elements.

[S'07 Q3]

22 The diagrams show the possible paths of subatomic particles moving in an electric field in a vacuum.



Which diagrams are correct?

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

[S'07 Q4]

23 Skin cancer can be treated using a radioactive isotope of phosphorus, $^{32}_{15}P$. A compound containing the phosphide ion $^{32}_{15}P^{3-}$, wrapped in a plastic sheet, is strapped to the affected area.

What is the composition of the phosphide ion, $^{32}_{15}P^{3-}$?

	protons	neutrons	electrons
A	15	17	18
B	15	17	32
C	17	15	17
D	32	17	15

[S'08 Q3]

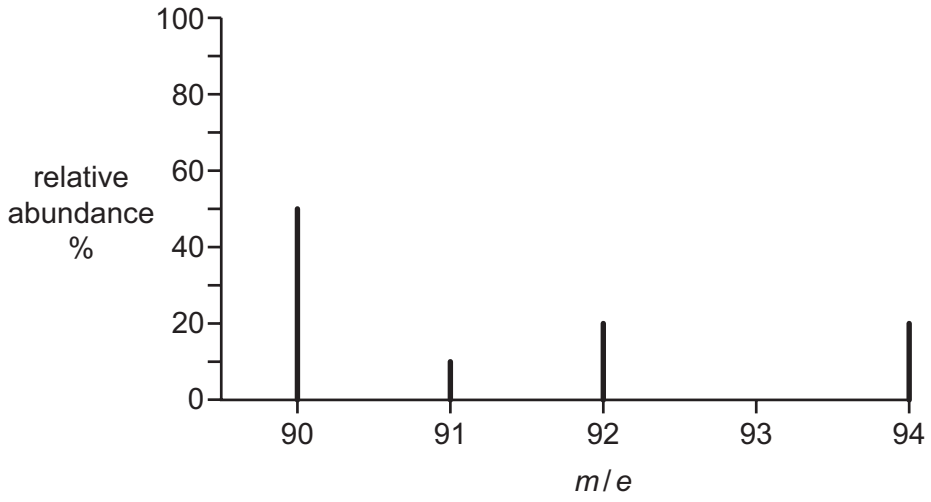
24 Hard water contains calcium ions and hydrogencarbonate ions arising from dissolved calcium hydrogencarbonate, $Ca(HCO_3)_2$.

How many electrons are present in the hydrogencarbonate anion?

A 30 **B** 31 **C** 32 **D** 33

[W'08 Q4]

25 An element **X** consists of four isotopes. The mass spectrum of **X** is shown in the diagram.



What is the relative atomic mass of **X**?

A 91.00 **B** 91.30 **C** 91.75 **D** 92.00

[W'09 1 Q4]

26 Helium, He, is the second element in the Periodic Table.

Tritium is the isotope of hydrogen ^{3}H.

What is the same in an atom of ^{4}He and an atom of ^{3}H?

A the number of electrons

B the number of neutrons

C the number of protons

D the relative atomic mass

[S'11 2 Q1]

27 In which species are the numbers of protons, neutrons and electrons all different?

A $^{11}_{5}B$ **B** $^{19}_{9}F^{-}$ **C** $^{23}_{11}Na^{+}$ **D** $^{24}_{12}Mg^{2+}$

[S'12 2 Q2]

28 The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give an isotope of a different element, ^{68}X, which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.

Which statement about the composition of an atom of ^{68}X is correct?

A It has 4 electrons in its outer p orbitals.

B It has 13 electrons in its outer shell.

C It has 37 neutrons.

D Its proton number is 32.

[S'12 1 Q2]

29 *Use of the Data Booklet is relevant to this question.*

In which species are the numbers of protons, neutrons and electrons **all** different?

A $^{19}_{9}F^-$ **B** $^{23}_{11}Na^+$ **C** $^{31}_{15}P$ **D** $^{32}_{16}S^{2-}$

[S'10 1 Q1]

30 In which species are the numbers of protons, neutrons and electrons all different?

A $^{27}_{13}Al$ **B** $^{35}_{17}Cl^-$ **C** $^{32}_{16}S^{2-}$ **D** $^{39}_{19}K^+$

[S'13 1 Q5]

31 *Use of the Data Booklet is relevant to this question.*

The most common ion-molecule reaction in gas clouds of the Universe is as shown.

$$H_2(g) + H_2^+(g) \rightarrow H(g) + H_3^+(g)$$

What could be the composition of an H_3^+ ion?

	protons	neutrons	electrons
A	2	1	1
B	2	1	2
C	3	0	1
D	3	0	2

[S'14 3 Q4]

32 *Use of the Data Booklet is relevant to this question.*

In some types of spectroscopy, it is important to know if ions are isoelectronic. This means that they contain equal numbers of electrons.

Which ion is **not** isoelectronic with K^+?

A Ca^{2+} **B** Cl^- **C** S^{2-} **D** Ti^{3+}

[W'14 3 Q2]

33 *Use of the Data Booklet is relevant to this question.*

In which option do all three particles have the same electronic configuration **and** the same number of neutrons?

A $^{15}N^{3-}$ $^{16}O^{2-}$ $^{19}F^-$

B $^{18}O^{2-}$ $^{19}F^-$ ^{20}Ne

C $^{19}F^-$ ^{20}Ne $^{23}Na^+$

D ^{22}Ne ^{23}Na $^{24}Mg^{2+}$

[S'15 2 Q1]

34 Which species contains the smallest number of electrons?

A B^{3+} **B** Be^{2+} **C** H^- **D** He^+

[M'16 2 Q4]

35 When nuclear reactions take place, the elements produced are different from the elements that reacted. Nuclear equations, such as the one below, are used to represent the changes that occur.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3\,{}^{1}_{0}n$$

The nucleon (mass) number total is constant at 236 and the proton number total is constant at 92.

In another nuclear reaction, uranium-238 is reacted with deuterium atoms, ${}^{2}_{1}H$. An isotope of a new element, **J**, is formed as well as two neutrons.

$$^{238}_{92}U + {}^{2}_{1}H \rightarrow \mathbf{J} + 2\,{}^{1}_{0}n$$

What is isotope **J**?

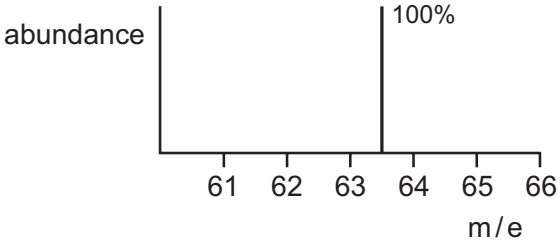
A ^{238}Np **B** ^{238}Pu **C** ^{240}Np **D** ^{240}Pu

[S'16 1 Q4]

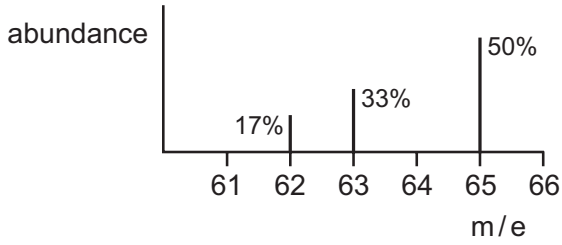
36 The relative atomic mass of copper is 63.5.

Which chart is a correct mass spectrum that would lead to this value?

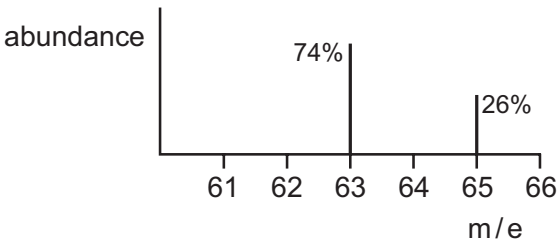
A



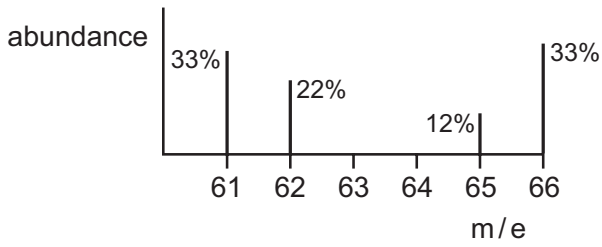
B



C



D



[S'16 3 Q4]

37 Neutrons are passed through an electric field. The mass of one neutron relative to $\frac{1}{12}$ the mass of a ^{12}C atom and any deflection in the electric field is recorded.

Which row is correct?

	mass of neutron	behaviour of beam of neutrons in an electric field
A	0	deflected
B	1	deflected
C	0	not deflected
D	1	not deflected

[S'18 3 Q2]

SECTION B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

1 The isotope cobalt-60 ($^{60}_{27}Co$) is used to destroy cancer cells in the human body.

Which statements about an atom of cobalt-60 are correct?

1 It contains 33 neutrons.

2 Its nucleus has a relative charge of 27+.

3 It has a different number of neutrons from the atoms of other isotopes of cobalt.

[S'04 Q31]

2 The relative molecular mass of a molecule of chlorine is 72.

Which properties of the atoms in this molecule are the same?

1 radius

2 nucleon number

3 relative isotopic mass

[S'05 Q31]

3 *Use of the Data Booklet is relevant to this question.*

The technetium–99 isotope (^{99}Tc) is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc?

1 It has 13 more neutrons than protons.

2 It has 43 protons.

3 It has 99 nucleons.

[S'07 Q31]

4 On a scale in which the mass of a ^{12}C atom is 12 the relative molecular mass of a particular sample of chlorine is 72.

Which properties of the atoms in this sample are always the same?

1 radius

2 nucleon number

3 isotopic mass

[S'09 1 Q31]

5 The phosphide ion $^{31}_{15}P^{3-}$ and sulfide ion $^{32}_{16}S^{2-}$ have the same number of which sub-atomic particles?

1 neutrons

2 electrons

3 protons

[S'12 2 Q32]

6 The $^{1}H_3^{+}$ ion was first characterised by J. J. Thomson over a century ago. ^{6}Li is a rare isotope of lithium which forms the $^{6}Li^{+}$ ion.

Which statements are correct?

1 Both ions contain the same number of protons.

2 Both ions contain the same number of electrons.

3 Both ions contain the same number of neutrons.

[S'04 3 Q31]

7 In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and were called ununquadium (Uuq) and ununhexium (Uuh).

	Uuq	Uuh
proton number	114	116
nucleon number	289	292

Which statements about these elements are correct?

1 One atom of Uuh has one more neutron than one atom of Uuq.

2 One Uuq^{2-} ion has the same number of electrons as one atom of Uuh.

3 One Uuh^{+} ion has the same number of electrons as one Uuq^{-} ion.

[S'14 3 Q31]

8 Which statements are correct when referring to the isotopes of a single element?

1 The isotopes have different masses.

2 The isotopes have different numbers of nucleons.

3 The isotopes have different chemical reactions.

[S'14 3 Q32]

9 *Use of the Data Booklet is relevant to this question.*

Which statements about the phosphide ion, $^{31}P^{3-}$, and the chloride ion, $^{35}Cl^{-}$, are correct?

1 They have the same number of electrons.

2 They have the same number of neutrons.

3 They have the same number of protons.

[S'15 2 Q31]

10 X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

1 $^{38}_{18}Ar$

2 $^{40}_{20}Ca^{2+}$

3 $^{39}_{19}K^{+}$

[S'16 1 Q31]

11 A sample of boron contains aluminium as the only impurity. A mass spectrum of the mixture shows three lines corresponding to three ions, X^+, Y^+ and Z^+.

ion	X^+	Y^+	Z^+
m/e	10	11	27
percentage abundance	15.52	74.48	10.00

Which statements are correct?

1 There are more electrons in Z^+ than in X^+.

2 The A_r of boron in the sample is 10.83 to four significant figures.

3 There are more protons in Y^+ than in X^+.

12 In which pairs do both species have the same number of electrons?

1 ^{35}Cl and ^{37}Cl

2 $^{35}Cl^{-}$ and ^{40}Ar

3 ^{40}Ar and $^{40}K^{+}$

[S'18 2 Q32]

ATOMIC STRUCTURE WS 2

1 Give the numbers of protons, neutrons and electrons present in each of the following atoms:

a) ^{40}Ar

b) ^{127}I

c) $^{197}Au^{+}$

d) $^{52}Cr^{3+}$

2 This question concerns the following five species:

$^{16}O^{2-}$ ^{19}F ^{20}Ne ^{23}Na $^{25}Mg^{2+}$

a) Which two species have the same number of neutrons? ^{19}F and ^{20}Ne

b) Which two species have the same ratio of neutrons to protons? $^{16}O^{2-}$ and ^{20}Ne

c) Which two species do not have 10 electrons? ^{19}F and ^{23}Na

3 The element Rhenium (Re) has two main isotopes, ^{185}Re with an abundance of 37.1% and ^{187}Re with an abundance of 62.9%.

Calculate the weighted mean atomic mass of rhenium.

$$\frac{37.1(185) + 62.9(187)}{100} = 186.26$$

4 Antimony has two main isotopes, ^{121}Sb and ^{123}Sb. A forensic scientist was asked to help a crime investigation by analysing the antimony in a bullet. This was found to contain 57.3% of ^{121}Sb and 42.7% of ^{123}Sb.

a) Calculate the relative atomic mass of the sample of antimony from the bullet. *(Write your answer to three significant figures)*

$$\frac{57.3(21) + 42.7(123)}{100} = 121.85$$

b) State one similarity and one difference between isotopes in terms of subatomic particles.

Same number of protons

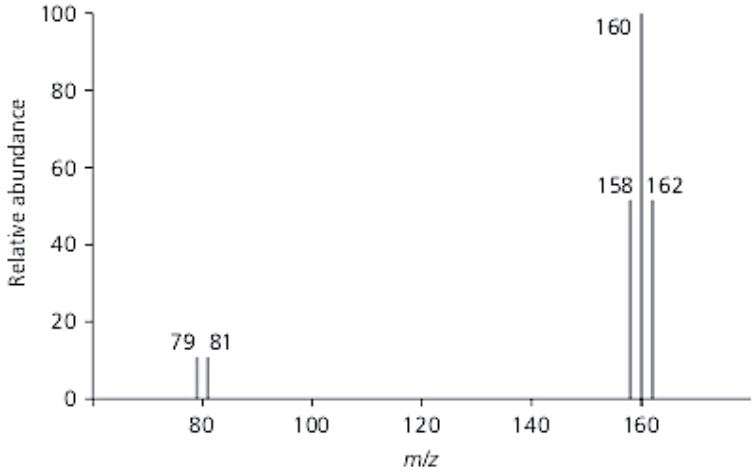
different number of neutrons.

5 Bromine exists as a molecule with two bromine atoms combined together. Bromine has two isotopes: bromine-79 and bromine-81

a) A molecule of bromine containing two atoms of bromine can be written as $^{79}Br_2$. Write the formulae for the two other possible molecules of bromine.

$^{81}Br_2$, $^{79}Br - {}^{81}Br$

b) The mass spectrum of molecules of bromine is shown below:



i. Explain why these peaks are observed.

Br has two isotopes in equal abundance.
Peaks 158 to 162 are caused by Br_2.

ii. The peaks at 79 and 81 are the same height. What does this tell you about the relative abundances of the two isotopes?

^{79}Br and ^{81}Br are in equal proportions.

iii. Explain why the peak at 160 is twice the height of the peaks at 158 and 162.

Likely hood of Br molecule of Mr of 160 is twice as much the likely hood of form $^{79}Br_2$ and $^{81}Br_2$

6 a) Explain why the relative atomic mass of copper is not an exact whole number?

Because its the weighted average mass of ^{63}Cu and ^{65}Cu.

b) The relative atomic mass of copper is 63.5. Calculate the relative abundance of the two copper isotopes with the relative isotopic masses of 63.0 and 65.0.

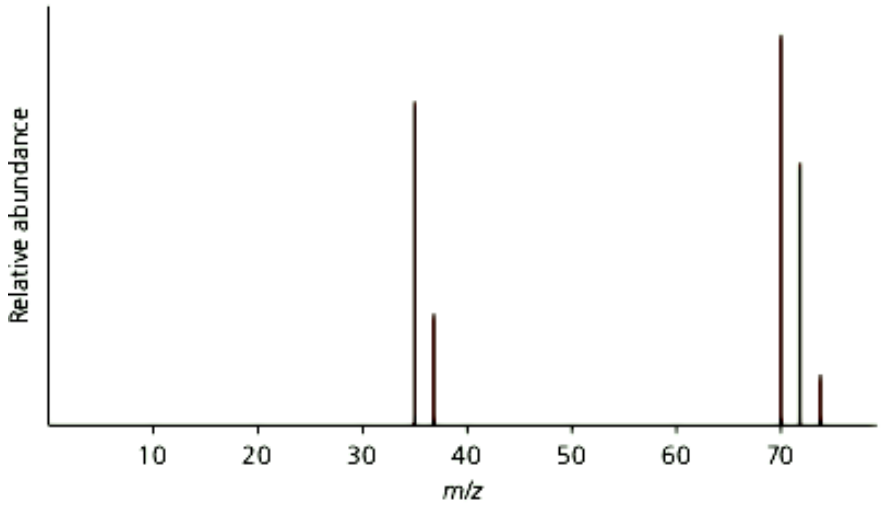
$$\frac{63x + 65(100-x)}{100} = 63.5$$

$x = 75\% \rightarrow {}^{63}Cu$

$100 - x = 25\% \rightarrow {}^{65}Cu$

7 Chlorine exists as a molecule with two chlorine atoms combined together. Chlorine has two isotopes: chlorine-35 and chlorine-37.

The mass spectrum of chlorine os shown below:



a) The peak at 35 is three times as high as the peak at 37. Calculate the relative atomic mass of chlorine.

$$\frac{35(3) + 37(1)}{4} = 35.5$$

b) Explain why the peaks are observed at 70, 72 and 74.

$^{35}Cl - {}^{35}Cl$, $^{35}Cl - {}^{37}Cl$, $^{37}Cl - {}^{37}Cl$ are responsible for the peaks, respectively.

c) The heights of the peaks at 70, 72 and 74 are in the ratio 9 :6 :1. Explain why the heights are in this ratio.

$^{35}Cl - {}^{35}Cl$ is responsible for the highest peak as ^{35}Cl is the most abundant. $^{37}Cl - {}^{37}Cl$ is responsible for the smallest peak as its the rarest. Peak at 72 is caused by $^{35}Cl - {}^{37}Cl$

8 The data about silicon in the table below were obtained from a mass spectrometer.

m/z	% abundance
28	92.2
29	4.7
30	3.1

28.1

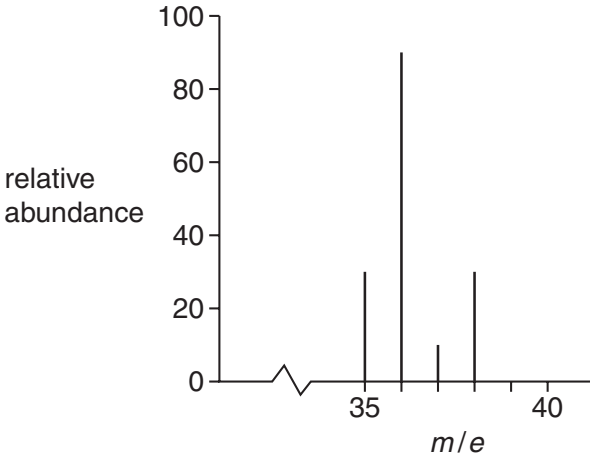
Calculate the relative atomic mass of silicon to one decimal place.

9 **(a)** Define *an isotope* in terms of its sub-atomic particles.

same protons, different neutrons.

[1]

(b) In a mass spectrometer some hydrogen chloride molecules will split into atoms. The mass spectrum of HC*l* is given. Chlorine has two isotopes. The hydrogen involved here is the isotope $^{1}_{1}H$ only.



(i) What particle is responsible for the peak at mass 35? $^{35}Cl^{+}$

(ii) What particle is responsible for the peak at mass 38? $H-{}^{37}Cl^{+}$

[2]

(c) Use the relative heights of the peaks to determine the proportions of the two isotopes of chlorine. Explain simply how you obtained your answer.

^{35}Cl : ^{37}Cl

30 : 10

3 : 1

[2]

(d) Use your answer to **(c)** to explain why chlorine has a relative atomic mass of 35.5.

$$\bar{x} = \frac{3(35) + 37}{4} = 35.5$$

[1]

[S'03 Q1]

10 Iron and cobalt are adjacent elements in the Periodic Table. Iron has three main naturally occurring isotopes, cobalt has one.

(a) Explain the meaning of the term *isotope*.

Atoms of the same element having the same number of protons but no. of neutrons. [2]

(b) The most common isotope of iron is ^{56}Fe; the only naturally occurring isotope of cobalt is ^{59}Co.

Use the *Data Booklet* to complete the table below to show the atomic structure of ^{56}Fe and of ^{59}Co.

	number of		
isotope	protons	neutrons	electrons
^{56}Fe	26	30	26
^{59}Co	27	32	27

[3]

(c) A sample of iron has the following isotopic composition by mass.

isotope mass	54	56	57
% by mass	5.84	91.68	2.17

(i) Define the term *relative atomic mass*.

Weighted average mass of all naturally occuring isotopes of the element to 1/12 th the mass of carbon 12 isotope.

(ii) By using the data above, calculate the relative atomic mass of iron to **three** significant figures.

$$\frac{54(5.84) + 56(91.68) + 57(2.17)}{99.69} = 55.9$$

[5]

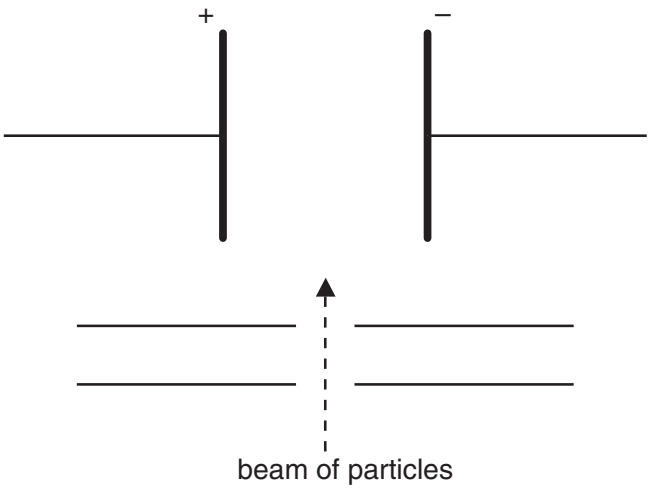
[S'05 Q1]

Why not a 100?

Add all the percentages by mass.

11 In the 19th and 20th centuries, scientists established the atomic theory and showed that three sub-atomic particles, electron, neutron and proton, exist. The masses and charges of these three particles were subsequently determined.

When separate beams of electrons, neutrons or protons are passed through an electric field in the apparatus below, they behave differently.



(a) (i) Which of these three particles will be deflected the most by the electric field?

Electron

(ii) In which direction will this particle be deflected?

towards the positive plate

(iii) Explain your answer.

Electrons have the least mass and carry a negative charge and will deviate the most towards the positive plate. [4]

(b) (i) Define the term *proton number*.

Number of protons in the element.

(ii) Why is the proton number of an atom of an element usually different from the nucleon number of an atom of the element?

[2]

(c) Protons and neutrons have been used in nuclear reactions which result in the formation of artificial elements. In such processes, protons or neutrons are accelerated to high speeds and then fired like 'bullets' at the nucleus of an atom of an element.

Suggest why neutrons are more effective than protons as 'nuclear bullets'.

They are neutral in charge and aren't repelled by the nucleas. [2]

(d) In some cases, when neutrons are fired at atoms of an element, the neutrons become part of the nucleus of those atoms.

What effect does the presence of an extra neutron have on the chemical properties of the new atoms formed? Explain your answer.

None, as chemical properties are entirely dependent on electron behavior. [2]

[Total: 10]

[W'06 Q1]

12 Magnesium, Mg, and radium, Ra, are elements in Group II of the Periodic Table.

Magnesium has three isotopes.

(a) Explain the meaning of the term *isotope*.

Same protons, different neutrons.

[2]

A sample of magnesium has the following isotopic composition by mass.

isotope mass	24	25	26
% by mass	78.60	10.11	11.29

(b) Calculate the relative atomic mass, A_r, of magnesium to **four** significant figures.

$$\frac{24(78.6) + 25(10.11) + 26(11.29)}{90} = 24.33$$

$78.6 + 10.11 + 11.29 = 90$

A_r = 24.33

[2]

Radium, proton number 88, and uranium, proton number 92, are radioactive elements.

The isotope ^{226}Ra is produced by the radioactive decay of the uranium isotope ^{238}U.

(c) Complete the table below to show the atomic structures of the isotopes ^{226}Ra and ^{238}U.

	number of		
isotopes	protons	neutrons	electrons
^{226}Ra	88	138	88
^{238}U	92	146	92

[3]

(d) Radium, like other Group II elements, forms a number of ionic compounds.

(i) What is the formula of the radium cation?

Ra^{2+}

(ii) Use the *Data Booklet* to suggest a value for the energy required to form one mole of the gaseous radium cation you have given in **(i)** from one mole of gaseous radium atoms. Explain your answer.

1000 - 1400 $KJmol^{-1}$. Going down the group, size of atoms increases, sheilding increases, electrons are further away from nuclear pull ∴ I.E decreases. [3]

[W'09 1 Q1]

13 The element magnesium, Mg, proton number 12, is a metal which is used in many alloys which are strong and light.

Magnesium has several naturally occurring isotopes.

(a) What is meant by the term *isotope*?

Same protons, different neutrons

[2]

(b) Complete the table below for two of the isotopes of magnesium.

isotope	number of protons	number of neutrons	number of electrons
^{24}Mg	12	12	12
^{26}Mg	12	14	12

[2]

A sample of magnesium had the following isotopic composition:
^{24}Mg, 78.60%; ^{25}Mg, 10.11%; ^{26}Mg, 11.29%.

(c) Calculate the relative atomic mass, A_r, of magnesium in the sample.
Express your answer to an appropriate number of significant figures.

$$\frac{24(78.6) + 25(10.11) + 26(11.29)}{100} = 24.33$$

$$= 24.3$$

[2]

[W'10 3 Q1]

14 Sulfur, S, and polonium, Po, are both elements in Group VI of the Periodic Table.

Sulfur has three isotopes.

(a) Explain the meaning of the term *isotope*.

same protons
different neutrons.

.....[2]

(b) A sample of sulfur has the following isotopic composition by mass.

isotope mass	32	33	34
% by mass	95.00	0.77	4.23

Calculate the relative atomic mass, A_r, of sulfur to **two** decimal places.

$0.95(32) + 0.0077(33) + 0.0423(34) = 32.0923$

A_r = 32.09

[2]

(c) Isotopes of polonium, proton number 84, are produced by the radioactive decay of several elements including thorium, Th, proton number 90.

The isotope ^{213}Po is produced from the thorium isotope ^{232}Th.

Complete the table below to show the atomic structures of the isotopes ^{213}Po and ^{232}Th.

	number of		
isotope	protons	neutrons	electrons
^{213}Po	84	129	84
^{232}Th	90	142	90

[3]

Radiochemical reactions, such as nuclear fission and radioactive decay of isotopes, can be represented by equations in which the nucleon (mass) numbers must balance and the proton numbers must also balance.

For example, the nuclear fission of uranium-235, $^{235}_{92}U$, by collision with a neutron, $^{1}_{0}n$, produces strontium-90, xenon-143 and three neutrons.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{90}_{38}Sr + {}^{143}_{54}Xe + 3\,{}^{1}_{0}n$$

In this equation, the nucleon (mass) numbers balance because: 235 + 1 = 90 + 143 + (3x1).

The proton numbers also balance because: 92 + 0 = 38 + 54 + (3x0).

(d) In the first stage of the radioactive decay of $^{232}_{90}Th$, the products are an isotope of element *E* and an alpha-particle, $^{4}_{2}He$.

(i) By considering nucleon and proton numbers only, construct a balanced equation for the formation of the isotope of *E* in this reaction.

$^{232}_{90}Th \rightarrow$ $^{228}_{88}$E + $^{4}_{2}He$

Show clearly the nucleon number and proton number of the isotope of *E*.

nucleon number of the isotope of *E* 228

proton number of the isotope of *E* 88

(ii) Hence state the symbol of the element *E*.

Ra [3]

15 **(a)** Explain what is meant by the term *nucleon number*.

Total no. of subatomic particles present in the nucleus. i.e. protons and neutrons. [1]

(b) Bromine exists naturally as a mixture of two stable isotopes, ^{79}Br and ^{81}Br, with relative isotopic masses of 78.92 and 80.92 respectively.

(i) Define the term *relative isotopic mass*.

Weighted average mass of all naturally occuring isotopes of the same element to 1/12th the mass of carbon-12 isotope. [2]

(ii) Using the relative atomic mass of bromine, 79.90, calculate the relative isotopic abundances of ^{79}Br and ^{81}Br.

$$\frac{78.92x + 80.92(100-x)}{100} = 79.9$$

$$x = 51\%$$

$$100-x = 49\%$$

[3]

(c) Bromine reacts with the element **A** to form a compound with empirical formula ABr_3. The percentage composition by mass of ABr_3 is **A**, 4.31; Br, 95.69.

Calculate the relative atomic mass, A_r, of **A**.
Give your answer to **three** significant figures.

A : Br

$\frac{4.31}{x}$: $\frac{95.69}{79.9}$

1 : 3

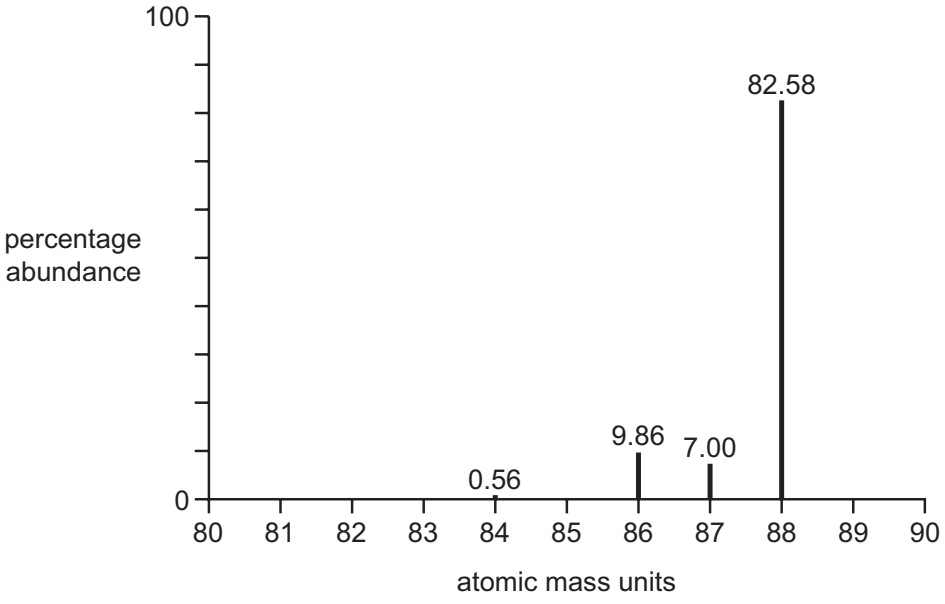
A:B = 1:3, so, $\frac{95.69/79.9}{3} = \frac{4.31}{x}$

$\frac{4.31}{x} = \frac{95.69}{79.9 \times 3}$

$x = 10.796$

A_r of **A** = 10.8 [3]

16 A sample of strontium, atomic number 38, gave the mass spectrum shown. The percentage abundances are given above each peak.



(ii) Explain why there are four different peaks in the mass spectrum of strontium.

4 peaks imply there are 4 isotopes of Strotium

..... [1]

(iii) Calculate the atomic mass, A_r, of this sample of strontium.
Give your answer to **three** significant figures.

$$\frac{84(0.56) + 86(9.86) + 87(7) + 88(82.58)}{100} = 87.71$$

A_r = 87.7 [2]

[W'14 2 Q1]

17 **(a)** Chemists recognise that atoms are made of three types of particle.

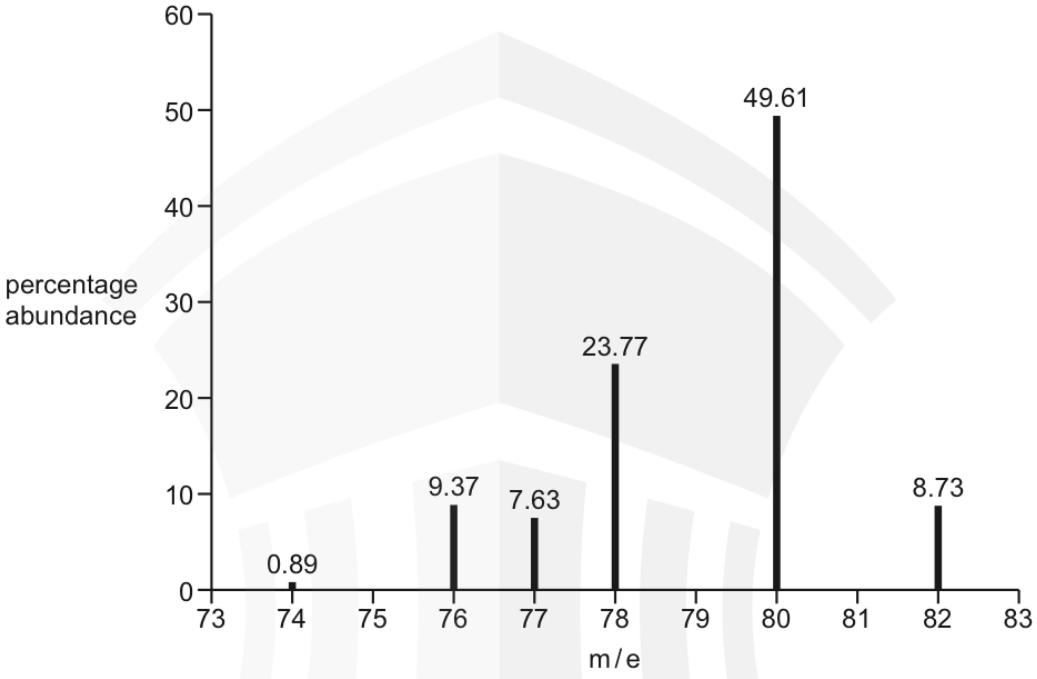
Complete the following table with their names and properties.

name of particle	relative mass	relative charge
Neutron	1	0
Electron	1/1836	-1
Proton	1	+1

[3]

(b) The relative atomic mass of an element can be determined using data from its mass spectrum.

The mass spectrum of element **X** is shown, with the percentage abundance of each isotope labelled.



(i) Define the terms *relative atomic mass* and *isotope*.

relative atomic mass ..... Weighted average mass of all naturally occuring isotopes of the element to 1/12th the mass of carbon-12 isotope. .....

isotope ..... Atoms with the same number of protons but different number of neutrons. .....

[3]

(ii) Use the data in the mass spectrum to calculate the relative atomic mass, A_r, of **X**. Give your answer to **two** decimal places and suggest the identity of **X**.

$$\frac{(74\times0.84)+(76\times9.37)+(77\times7.63)+(78\times23.77)+(80\times49.61)+(82\times8.73)}{100}$$

A_r of **X** ..... 79.01 .....

identity of **X** ..... Se .....

[2]

(c) The element tellurium, Te, reacts with chlorine to form a single solid product, with a relative formula mass of 270. The product contains 52.6% chlorine by mass.

(i) Calculate the molecular formula of this chloride.

Te	:	Cl
47.4	:	52.6
128		35.5
0.37	:	1.48
1	:	4

empirical : $TeCl_4$

n(mass $TeCl_4$) = 270

$269.6n = 270$

$n = 1$

molecular formula ..... $TeCl_4$ ..... [3]

18 **(a)** Chemists recognise that atoms are made of three types of particle.

Complete the following table with their names and properties.

name of particle	relative mass	relative charge
Proton	1	+1
Electron	1/1836	-1
Neutron	1	0

[3]

(b) Most elements exist naturally as a mixture of isotopes, each with their own relative isotopic mass. The mass spectrum of an element reveals the abundances of these isotopes, which can be used to calculate the relative atomic mass of the element.

Magnesium has three stable isotopes. Information about two of these isotopes is given.

isotope	relative isotopic mass	percentage abundance
^{24}Mg	24.0	79.0
^{26}Mg	26.0	11.0

(i) Define the term *relative isotopic mass*.

Mass of an atom of the isotope relative to 1/12th the mass of carbon-12 isotope.

[2]

(ii) The relative atomic mass of magnesium is 24.3.

Calculate the percentage abundance and hence the relative isotopic mass of the third isotope of magnesium. Give your answer to **three** significant figures

$100 - (79 + 11) = 10$

percentage abundance = 10.0

$$\frac{(24 \times 79.0) + (26 \times 11.0) + (x \times 10.0)}{100} = 24.3$$

isotopic mass = 24.8

[3]

(c) Neon has three stable isotopes.

isotope	mass number	percentage abundance
1		9.25
2	20	90.48
3	21	0.27

(i) Define the term *relative atomic mass*.

weighted average mass of all naturally occurring isotopes of the element to $\frac{1}{12}$th the mass of carbon-12 isotope [2]

(ii) Use the relative atomic mass of neon, 20.2, to calculate the mass number of isotope 1.

$$A_r = \frac{(20 \times 90.48) + (21 \times 0.27) + (x \times 9.25)}{100} = 20.2$$

mass number = 22 [2]

20 **(a)** Complete the table to show the composition and identity of some atoms and ions.

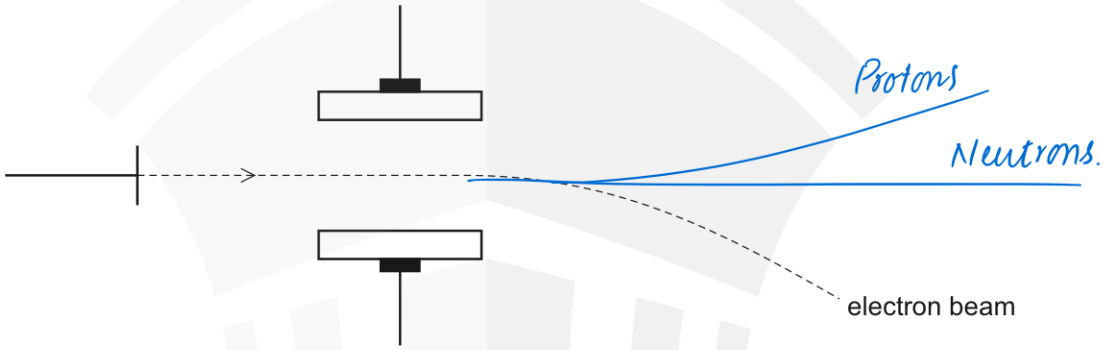
name of element	nucleon number	atomic number	number of protons	number of neutrons	number of electrons	overall charge
lithium	6	3	3	3	2	+1
oxygen	17	8	8	9	10	-2
iron	54	26	26	28	24	+2
chlorine	35	17	17	18	17	0

[4]

(b) Beams of protons, neutrons and electrons behave differently in an electric field due to their differing properties.

The diagram shows the path of a beam of electrons in an electric field.

Add and label lines to represent the paths of beams of protons and neutrons in the same field.



[3]

(d) A sample of strontium exists as a mixture of four isotopes. Information about three of these isotopes is given in the table.

mass number	86	87	88
abundance	9.86%	7.00%	82.58%

(i) Calculate the abundance of the fourth isotope.

$100 - (9.86 + 7 + 82.58)$

abundance = 0.56 % [1]

(ii) The relative atomic mass of this sample of strontium is 87.71.

Calculate the mass number of the fourth isotope.

$100 \times 87.71 = (9.86)(86) + (7)(87) + (82.58)(88) + 0.56x$

$8771 - 8724 = 0.56x$

$x = 83.92$

mass number = 83.9 [2]

21 A sample of oxygen exists as a mixture of three isotopes. Information about two of these isotopes is given in the table.

mass number	16	17	x
abundance	99.76%	0.04%	0.2

(i) Calculate the abundance of the third isotope.

$100 - (99.76 + 0.04)$

abundance = 0.2 % [1]

(ii) The relative atomic mass of this sample of oxygen is 16.0044.

Calculate the mass number of the third isotope. You **must** show your working.

$$16.0044 = \frac{16(99.76) + 17(0.04) + 0.2x}{100}$$

mass number = 18 [2]

[S'16 2 Q1]

$16.0044 \times 100 = 1596.16 + 0.68 + 0.2x$

$1600.44 = 1596.84 + 0.2x$

$1600.44 - 1596.84 = 0.2x$

$x = 18$

22 A naturally occurring sample of cerium contains only **four** isotopes. Data for **three** of the isotopes are shown in the table.

isotope	^{136}Ce	^{138}Ce	^{140}Ce	^{142}Ce
relative isotopic mass	135.907	137.906	139.905	to be calculated
percentage abundance	0.185	0.251	88.450	to be calculated

The A_r of the sample is 140.116.

Use these data to calculate the **relative isotopic mass** of the fourth isotope in this sample of cerium.

Give your answer to **three** decimal places.

$$\frac{(135.907 \times 0.185) + (137.906 \times 0.251) + (139.905 \times 88.45) + (x \times 11.114)}{100} = 140.116$$

141.915

relative isotopic mass = ... [3]

[M'17 Q1]