



Cambridge International AS Level Chemistry (9701)

Topical Paper Theory Structured

ATOMIC STRUCTURE

TOPICAL PAST PAPER

2026 EDITION

Q1

9701/22/F/M/21/Q2(g)(iii)

Electronic Configuration

(iii) Give the electronic configuration of $Cl^{\bullet}$. $1s^2$ [1]

Q2

9701/22/F/M/22/Q1(c)

Electronic Configuration

(c) Element **E** is in Period 3 of the Periodic Table.The first eight ionisation energy values of **E** are shown in Table 1.1.

Table 1.1

ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol^{-1}	577	1820	2740	11 600	14 800	18 400	23 400	27 500

Deduce the full electronic configuration of **E**.
Explain your answer.

full electronic configuration of **E** = ...

explanation

.....

.....

[3]

Q3

9701/22/F/M/23/Q1(c)(iii)

Electronic Configuration

(iii) Give the full electronic configuration of $S^{2+}(g)$.

..... [1]

Q4

9701/22/M/J/21/Q1(f)(ii)

Electronic Configuration

(ii) Complete the electron configuration of the magnesium cation present in these salts.

$1s^2$ [1]

Q5

9701/21/M/J/22/Q1(d)(ii)

Electronic Configuration

(ii) State the full electronic configuration of an atom of $^{25}_{12}\text{Mg}$.

..... [1]

Q6

9701/21/M/J/23/Q1(b)

Electronic Configuration

(b) Identify the sub-shell in an atom of Te that contains electrons with the lowest energy.

..... [1]

Q7

9701/23/M/J/23/Q1(d)(iii)

Electronic Configuration

(iii) State the full electronic configuration of Cu^{2+} .

..... [1]

Q8

9701/22/M/J/24/Q3(c)

Electronic Configuration

(c) Determine the full electronic configuration of Fe^{3+} .

..... [1]

Q9

9701/21/M/J/25/Q2(c)

Electronic Configuration

(c) Deduce the number of pairs of electrons in the shell with principal quantum number $n = 3$ in an Fe atom.

number of pairs of electrons [1]

Q10

9701/22/M/J/25/Q2(b)

Electronic Configuration

(b) Deduce the number of pairs of electrons in the 3d sub-shell in an iron(II) ion.

..... [1]

Q11

9701/23/M/J/25/Q1(a)(i)(ii)

Electronic Configuration

(a) (i) Give the full electronic configuration of a fluorine atom.

..... [1]

(ii) Deduce the number of pairs of electrons in the second energy shell, $n = 2$, of an oxygen atom.

..... [1]

Q12

9701/24/M/J/25/Q1(c)(iv)

Electronic Configuration

(iv) In the third ionisation energy of argon, the ion produced has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^3$.

Complete Fig. 1.3 to show the arrangement of electrons in the orbitals of this ion.

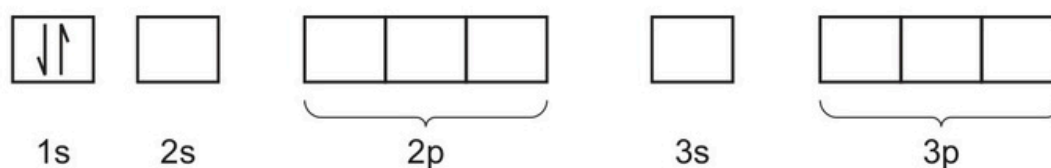


Fig. 1.3

[1]

Q13

9701/21/O/N/22/Q1(b)(ii)

Electronic Configuration

(ii) State the full electronic configuration of an atom of potassium.

..... [1]

Q14

9701/23/O/N/22/Q1(b)(ii)

Electronic Configuration

(ii) State the full electronic configuration of an atom of potassium.

..... [1]

Q15

9701/21/O/N/23/Q1(a)(i)

Electronic Configuration

Table 1.1 shows some properties of the elements P to Cl.

The first ionisation energy of S is **not** shown.

Table 1.1

property	P	S	Cl
number of electrons in 3p subshell			
total number of unpaired electrons			
first ionisation energy /kJ mol ⁻¹	1060		1260
formula of most common anion	P ³⁻	S ²⁻	Cl ⁻

(a) (i) Complete Table 1.1 to show the number of electrons in the 3p subshell and the total number of unpaired electrons in an atom of P, S and Cl. [2]

Q16

9701/21/O/N/23/Q1(b)(i)

Electronic Configuration

(b) P^{3-} , S^{2-} and Cl^{-} have the same number of electrons.

(i) Give the full electronic configuration of P^{3-} .

..... [1]

Q17

9701/22/O/N/23/Q1(b)(i)

Electronic Configuration

(b) Table 1.1 shows some properties of the elements Si to S.

The first ionisation energy of P is **not** shown.

Table 1.1

property	Si	P	S
total number of electrons in s subshells			
total number of electrons in p subshells			
first ionisation energy / kJ mol^{-1}	786		1000
formula of most common chloride	SiCl_4	PCl_5	SCl_2

(i) Complete Table 1.1 to show the total number of s and p electrons in an atom of Si, P and S.

[2]

Q18

9701/23/O/N/23/Q1(a)(i)

Electronic Configuration

Table 1.1 shows some properties of the elements P to Cl.

The first ionisation energy of S is **not** shown.

Table 1.1

property	P	S	Cl
number of electrons in 3p subshell			
total number of unpaired electrons			
first ionisation energy / kJ mol ⁻¹	1060		1260
formula of most common anion	P ³⁻	S ²⁻	Cl ⁻

- (a) (i) Complete Table 1.1 to show the number of electrons in the 3p subshell and the total number of unpaired electrons in an atom of P, S and Cl. [2]

Q19

9701/23/O/N/23/Q1(b)(i)

Electronic Configuration

(b) P³⁻, S²⁻ and Cl⁻ have the same number of electrons.

- (i) Give the full electronic configuration of P³⁻.

..... [1]

Q20

9701/21/O/N/24/Q1(a)(i),(iii)

Electronic Configuration

1 Cobalt, rhodium and iridium are metals in the same group of the Periodic Table.

- (a) The shorthand electronic configuration of cobalt is [Ar]3d⁷4s².

- (i) Identify what is meant by [Ar] by giving its full electronic configuration.

..... [1]

- (iii) Deduce the number of unpaired electrons in a cobalt atom.

..... [1]

Q21

9701/22/O/N/24/Q1(a)(i)(iii)

Electronic Configuration

1 Vanadium, niobium and tantalum are metals in the same group of the Periodic Table.

(a) The shorthand electronic configuration of vanadium in the ground state is $[\text{Ar}]3d^34s^2$.

(i) State what is meant by the term ground state.

..... [1]

(ii) Show the electronic configuration of vanadium using electrons in boxes notation.



[1]

(iii) Deduce the total number of electrons in the p sub-shells of a vanadium atom.

..... [1]

Q22

9701/23/O/N/24/Q1(a)(i),(iii)

Electronic Configuration

1 Cobalt, rhodium and iridium are metals in the same group of the Periodic Table.

(a) The shorthand electronic configuration of cobalt is $[\text{Ar}]3d^74s^2$.

(i) Identify what is meant by $[\text{Ar}]$ by giving its full electronic configuration.

..... [1]

(iii) Deduce the number of unpaired electrons in a cobalt atom.

..... [1]

Q23

9701/21/O/N/25/Q1(b)(i)(ii)

Electronic Configuration

(b) The shorthand electronic configuration of chromium is $[\text{Ar}] 3d^54s^1$.

(i) Complete the full electronic configuration of chromium.

..... $3d^54s^1$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of chromium.

..... [1]

Q24

9701/22/O/N/25/Q1(b)(i)(ii)

Electronic Configuration

(b) The shorthand electronic configuration of manganese is $[\text{Ar}] 3d^5 4s^2$.

(i) Complete the full electronic configuration of manganese.

..... $3d^5 4s^2$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of manganese.

..... [1]

Q25

9701/23/O/N/25/Q1(b)(i)(ii)

Electronic Configuration

(b) The shorthand electronic configuration of chromium is $[\text{Ar}] 3d^5 4s^1$.

(i) Complete the full electronic configuration of chromium.

..... $3d^5 4s^1$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of chromium.

..... [1]

Q26

9701/22/F/M/25/Q2(c)(i)(iii)

Protons, Electrons and Neutrons

(c) All the Group 2 elements except beryllium have more than one stable isotope.

(i) Beryllium exists as the single isotope ${}^9_4\text{Be}$.

Describe the distribution of mass within an atom of ${}^9_4\text{Be}$.

.....

.....

.....

..... [2]

(ii) Complete Table 2.2 to show the numbers of protons and neutrons in the isotopes of magnesium.

Table 2.2

isotope	number of protons	number of neutrons
magnesium-24		
magnesium-25		
magnesium-26		

[2]

(iii) Fig. 2.1 shows the behaviour of a beam of protons in an electric field.

Complete Fig. 2.1 to show the behaviour of separate beams of neutrons and electrons in the same electric field.

Label your diagram clearly. Assume that the beams of each particle are moving at the same velocity.

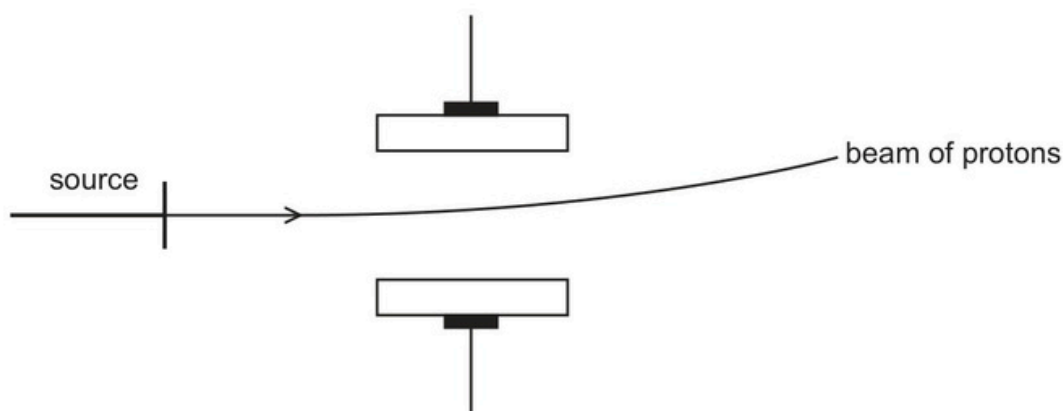


Fig. 2.1

[3]

Q27

9701/21/M/J/22/Q1(d)(i)

Protons, Electrons and Neutrons

(d) (i) $^{25}_{12}\text{Mg}$ is an isotope of magnesium.

Determine the number of protons and neutrons in an atom of $^{25}_{12}\text{Mg}$.

number of protons

number of neutrons

[1]

Q28

9701/23/M/J/22/Q1(e)

Protons, Electrons and Neutrons

(e) An isotope of copper has a relative isotopic mass of 65.

Complete Table 1.2 for an atom of copper-65.

Table 1.2

	atomic number	nucleon number	number of neutrons	electronic arrangement
copper-65				

[3]

Q29

9701/21/M/J/23/Q1(a)

Protons, Electrons and Neutrons

- 1 Tellurium is an element in Group 16. The most common isotope of tellurium is ^{130}Te . Its electronic configuration is $[\text{Kr}] 4d^{10} 5s^2 5p^4$.

(a) Complete Table 1.1.

Table 1.1

	nucleon number	number of neutrons	number of electrons
^{130}Te			

[3]

Q30

9701/22/M/J/24/Q1(a)

Protons, Electrons and Neutrons

- 1 (a) Complete Table 1.1 using relevant information from the Periodic Table.

Table 1.1

	nucleon number	proton number	number of electrons
Mg ²⁺	24		
Al ³⁺	27		

[2]

Q31

9701/21/M/J/25/Q2(b)(ii)

Protons, Electrons and Neutrons

- (ii) Complete Table 2.1 to show the number of protons and nucleons in one atom of ⁵⁶Fe.

Table 2.1

particle	number of particles in one atom of ⁵⁶ Fe
protons	
nucleons	

[2]

Q32

9701/21/O/N/22/Q1(a)(i)

Protons, Electrons and Neutrons

- (a) Gallium has two stable isotopes, ⁶⁹Ga and ⁷¹Ga.
- (i) Complete Table 1.1 to show the numbers of protons, neutrons and electrons in the two stable isotopes of gallium.

Table 1.1

isotope	number of protons	number of neutrons	number of electrons
⁶⁹ Ga			
⁷¹ Ga			

[2]

Q33

9701/23/O/N/22/Q1(a)(i)

Protons, Electrons and Neutrons

(a) Gallium has two stable isotopes, ^{69}Ga and ^{71}Ga .

(i) Complete Table 1.1 to show the numbers of protons, neutrons and electrons in the two stable isotopes of gallium.

Table 1.1

isotope	number of protons	number of neutrons	number of electrons
^{69}Ga			
^{71}Ga			

[2]

Q34

9701/21/O/N/24/Q1(b)

Protons, Electrons and Neutrons

(b) Table 1.1 gives some details of the stable naturally occurring isotopes of rhodium and iridium.

Table 1.1

isotope	number of protons	number of neutrons	total number of electron shells
$^{103}_{45}\text{Rh}$		58	
$^{191}_{77}\text{Ir}$			6
$^{193}_{77}\text{Ir}$			6

Complete Table 1.1.

[3]

Q35

9701/22/O/N/24/Q1(b)(i)

Protons, Electrons and Neutrons

(b) Pelopium was the suggested name for a new element discovered in a mineral.

Pelopium was later found to be a mixture of niobium, Nb, and tantalum, Ta.

Only one naturally occurring isotope exists for each of Nb and Ta.

(i) Complete Table 1.1.

Table 1.1

isotope	relative isotopic mass	number of protons	number of neutrons
$^{93}_{41}\text{Nb}$	92.91		
$^{181}_{73}\text{Ta}$	180.95		

[2]

Q36

9701/23/O/N/24/Q1(b)

Protons, Electrons and Neutrons

(b) Table 1.1 gives some details of the stable naturally occurring isotopes of rhodium and iridium.

Table 1.1

isotope	number of protons	number of neutrons	total number of electron shells
$^{103}_{45}\text{Rh}$		58	
$^{191}_{77}\text{Ir}$			6
$^{193}_{77}\text{Ir}$			6

Complete Table 1.1.

[3]

Q37

9701/21/O/N/25/Q1(a)(i)(ii)

Protons, Electrons and Neutrons

(a) Cr exists as four stable isotopes.

(i) The most common isotope of Cr is chromium-52.

Determine the number of protons, neutrons and electrons in an atom of chromium-52.

number of protons neutrons electrons [1]

(ii) Describe how an atom of chromium-54 differs from an atom of chromium-52. Refer to numbers of particles in your answer.

..... [1]
.....

Q38

9701/22/O/N/25/Q1(a)(i)(ii)

Protons, Electrons and Neutrons

(a) Mn is usually found as a single isotope, manganese-55.

(i) Determine the number of protons, neutrons and electrons in an atom of manganese-55.

number of protons neutrons electrons [1]

(ii) Define isotopes.

..... [1]
.....

Q39

9701/23/O/N/25/Q1(a)(i)(ii)

Protons, Electrons and Neutrons

(a) Cr exists as four stable isotopes.

(i) The most common isotope of Cr is chromium-52.

Determine the number of protons, neutrons and electrons in an atom of chromium-52.

number of protons neutrons electrons [1]

(ii) Describe how an atom of chromium-54 differs from an atom of chromium-52. Refer to numbers of particles in your answer.

.....
..... [1]

Q40

9701/22/F/M/21/Q2(b)(i)(ii)

Ionisation Energy

(b) Chlorine has the highest first ionisation energy of the Period 3 elements Na to Cl.

(i) Construct an equation for the first ionisation energy of chlorine.

Include state symbols.

..... [1]

(ii) Explain the general increase in the first ionisation energies of the Period 3 elements.

.....
.....
.....
..... [2]

- 1 Fig. 1.1 shows how **first** ionisation energies vary across Period 2.

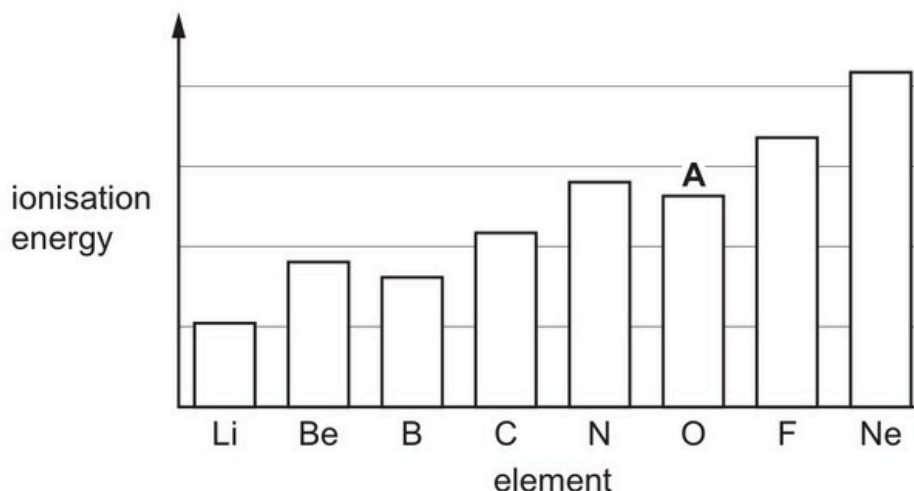


Fig. 1.1

- (a) Construct an equation to represent the **first** ionisation energy of oxygen. Include state symbols.

..... [1]

- (b) (i) State and explain the general trend in first ionisation energies across Period 2.

.....
.....
.....
.....
..... [3]

- (ii) Explain why ionisation energy **A** in Fig. 1.1 does **not** follow the general trend in first ionisation energies across Period 2.

.....
.....
.....
..... [2]

Q42

9701/22/F/M/23/Q1(c)(i)(ii)

Ionisation Energy

Use the information in Table 1.1 to answer the following questions.

Table 1.1

element	H	Li	C	O	S
Pauling electronegativity value	2.1	1.0	2.5	3.5	2.6
first ionisation energy / kJ mol^{-1}	1310	519	1090	1310	1000
second ionisation energy / kJ mol^{-1}	—	7300	2350	3390	2260

(c) (i) Write an equation that represents the first ionisation energy of H.

..... [1]

(ii) Explain why there is no information given in Table 1.1 for the second ionisation energy of H.

..... [1]

Q43

9701/22/F/M/25/Q2(b)(ii)

Ionisation Energy

(ii) Table 2.1 shows successive ionisation energy values for beryllium, Be.

Table 2.1

	1st	2nd	3rd	4th
ionisation energy / kJ mol^{-1}	900	1760	14 800	21 000

Use Table 2.1 to state and explain:

- the general trend in these values
- the significance of the large difference between the 2nd and 3rd ionisation energies.

.....

.....

.....

..... [2]

Q44

9701/23/M/J/22/Q1(a)(d)

Ionisation Energy

- 1 (a) Define first ionisation energy.

.....

 [2]

- (b) Successive ionisation energies for element **A** are shown in Table 1.1.

Table 1.1

ionisation	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol ⁻¹	1310	3390	5320	7450	11 000	13 300	71 000	84 100

Use Table 1.1 to deduce the group of the Periodic Table that **A** belongs to. Explain your answer.

Group

..... [1]

- (c) Across Period 3 there is a general trend for first ionisation energies to increase due to the increase in attraction between the nucleus and the outer electron.

Explain why the first ionisation energy of sulfur is less than the first ionisation energy of phosphorus.

.....

 [2]

- (d) In an Al^{2+} ion the nuclear attraction for the outer electron is stronger than in an atom of Na.

Compare the electronic structures of Al^{2+} and an atom of Na and explain why the third ionisation energy of aluminium is greater than the first ionisation energy of sodium.

.....

 [2]

Q45

9701/21/M/J/23/Q1(c)(d)(ii)

Ionisation Energy

- (c) Construct an equation to represent the first ionisation energy of Te.

..... [1]

- (d) (i) The radius of Te ions decreases after each successive ionisation.

State **two** factors that are responsible for the increase in the first six ionisation energies of Te.

.....
.....
..... [2]

- (ii) Sketch a graph in Fig. 1.1 to show the trend in the first **seven** ionisation energies of Te.

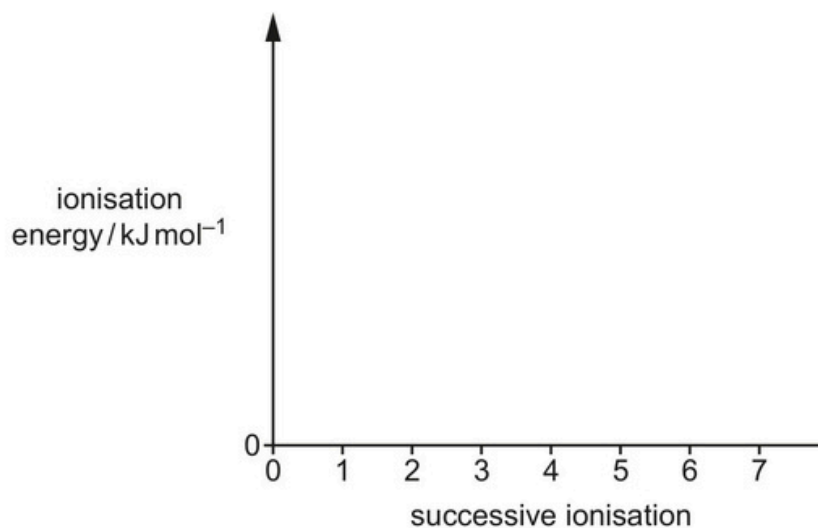


Fig. 1.1

[2]

Q46

9701/21/M/J/25/Q2(d)(e)

Ionisation Energy

- (d) Write an equation to represent the first ionisation energy of iron.

..... [1]

- (e) Suggest how the value for the first ionisation energy of ^{54}Fe compares to the first ionisation energy of ^{56}Fe . Explain your answer in terms of the factors that affect ionisation energy.

.....
.....
.....
.....
..... [4]

Q47

9701/23/M/J/25/Q1(b)(i)(ii)

Ionisation Energy

- (b) (i) Write an equation to represent the first ionisation energy of sulfur.

..... [1]

- (ii) Explain why the first ionisation energy of sulfur is less than the first ionisation energy of phosphorus.

.....
.....
.....
..... [2]

Q48

9701/24/M/J/25/Q1(c)(i)(iii)

Ionisation Energy

(c) The **third** ionisation energies of the Period 3 elements are shown in Fig. 1.2.

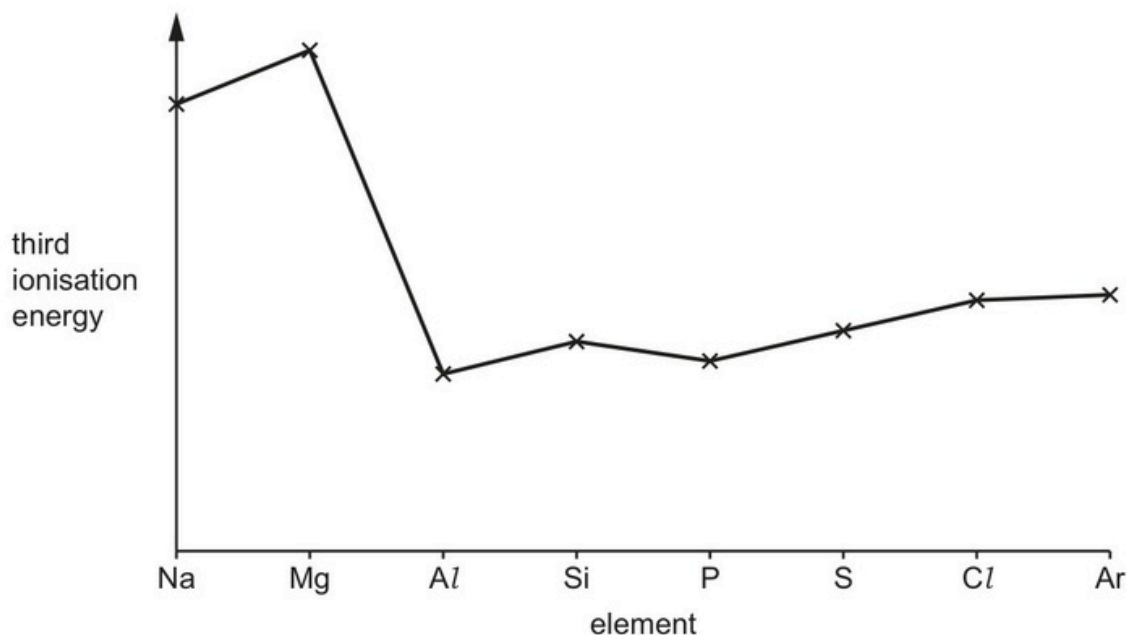


Fig. 1.2

- (i) Write an equation, including state symbols, to represent the **third** ionisation energy of argon.

..... [2]

- (ii) The differences in the values for third ionisation energy shown in Fig. 1.2 are due to differences in the strength of attraction between the nucleus and the outer electron of each ion.

State **two** factors that affect the strength of attraction between the nucleus and the outer electron.

1

2

[2]

- (iii) Use Fig. 1.2 to suggest the most significant factor that determines the size of attraction between the nucleus and the outer electron. Explain your answer.

.....

.....

..... [2]

Q49

9701/22/O/N/21/Q2(a)(ii)(iii)

Ionisation Energy

- 2 (a) Table 1 gives physical data for some of the Period 3 elements.

Table 1

atomic number, Z	11	12	13	14	15	16	17
bonding present in element	M						C
first ionisation energy / kJ mol^{-1}	494	736	577	786	1060	1000	1260
maximum oxidation number							+7
anionic radius / nm	–	–	–	0.271	0.212	0.184	0.181

- (ii) Explain the difference between the first ionisation energies of the elements with atomic numbers 11 and 17.

.....
.....
.....
.....
..... [2]

- (iii) Explain the difference between the first ionisation energies of the elements with atomic numbers 15 and 16.

.....
.....
.....
.....
..... [2]

Q50

9701/21/O/N/22/Q1(b)(iii)

Ionisation Energy

- (iii) The first, second and third ionisation energies of potassium are 418, 3070 and 4600 kJ mol⁻¹, respectively.

Use this information to explain why potassium is in Group 1.

.....

.....

.....

..... [2]

Q51

9701/23/O/N/22/Q1(b)(iii)

Ionisation Energy

- (iii) The first, second and third ionisation energies of potassium are 418, 3070 and 4600 kJ mol⁻¹, respectively.

Use this information to explain why potassium is in Group 1.

.....

.....

.....

..... [2]

Table 1.1 shows some properties of the elements P to Cl.

The first ionisation energy of S is **not** shown.

Table 1.1

property	P	S	Cl
number of electrons in 3p subshell			
total number of unpaired electrons			
first ionisation energy /kJ mol ⁻¹	1060		1260
formula of most common anion	P ³⁻	S ²⁻	Cl ⁻

- (ii) Construct an equation to represent the first ionisation energy of P.

..... [1]

- (iii) Three possible values for the first ionisation energy of S are given.

1000 kJ mol⁻¹

1160 kJ mol⁻¹

1320 kJ mol⁻¹

Circle the correct value.

Explain your choice by comparing your chosen value to those of P and Cl.

.....

.....

.....

.....

.....

..... [4]

(b) Table 1.1 shows some properties of the elements Si to S.

The first ionisation energy of P is **not** shown.

Table 1.1

property	Si	P	S
total number of electrons in s subshells			
total number of electrons in p subshells			
first ionisation energy / kJ mol^{-1}	786		1000
formula of most common chloride	SiCl_4	PCl_5	SCl_2

(ii) Construct an equation to represent the first ionisation energy of Si.

..... [1]

(iii) Three possible values for the first ionisation energy of P are given.

619 kJ mol^{-1}

893 kJ mol^{-1}

1060 kJ mol^{-1}

Circle the correct value.

Explain your choice, including a comparison of your chosen value to those of Si and S.

.....

.....

.....

.....

.....

..... [4]

Table 1.1 shows some properties of the elements P to Cl.

The first ionisation energy of S is **not** shown.

Table 1.1

property	P	S	Cl
number of electrons in 3p subshell			
total number of unpaired electrons			
first ionisation energy /kJ mol ⁻¹	1060		1260
formula of most common anion	P ³⁻	S ²⁻	Cl ⁻

(ii) Construct an equation to represent the first ionisation energy of P.

..... [1]

(iii) Three possible values for the first ionisation energy of S are given.

1000 kJ mol⁻¹

1160 kJ mol⁻¹

1320 kJ mol⁻¹

Circle the correct value.

Explain your choice by comparing your chosen value to those of P and Cl.

.....

.....

.....

.....

.....

..... [4]

(c) Fig. 3.1 shows a sketch of some of the ionisation energies of silicon, Si.

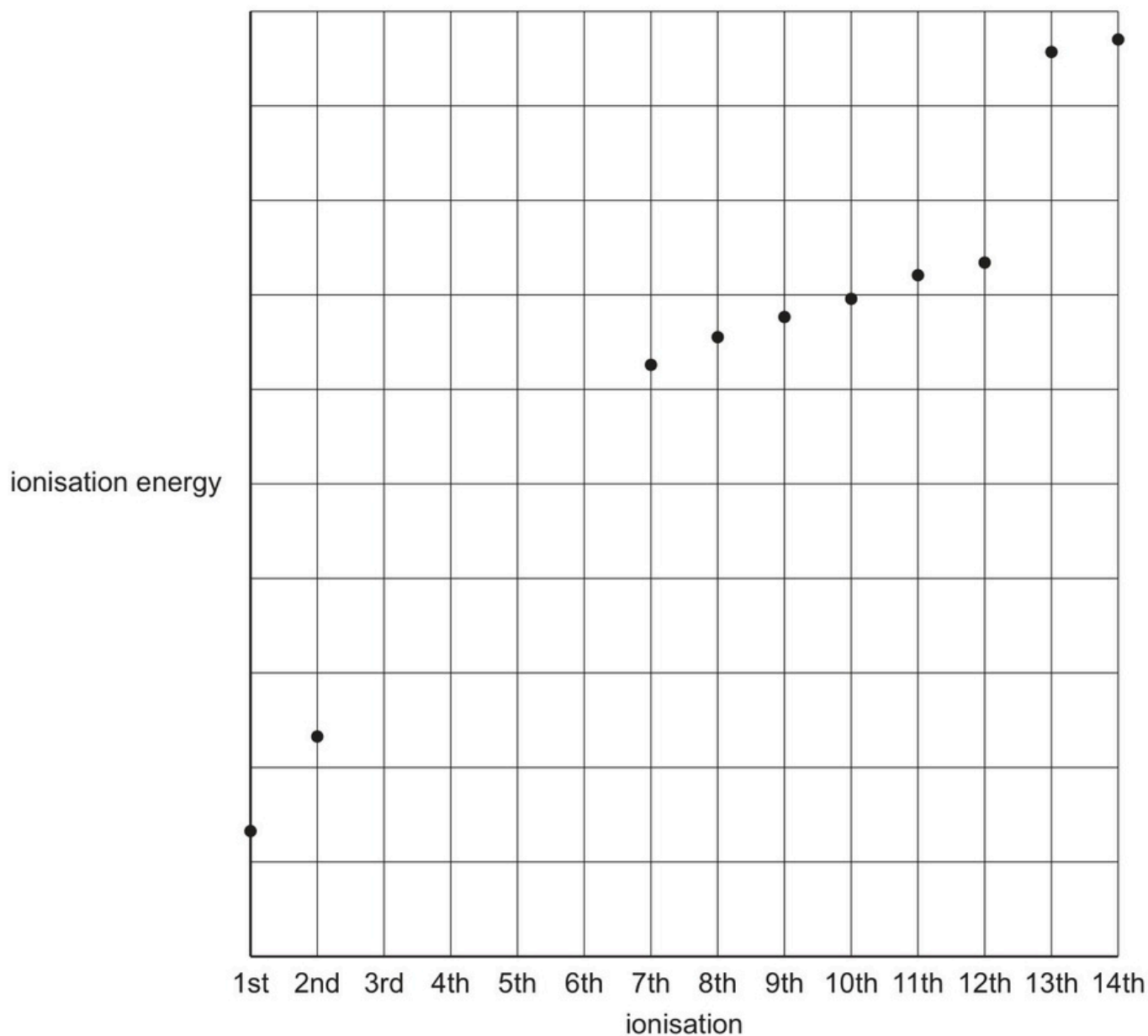


Fig. 3.1

(i) Complete the graph in Fig. 3.1 to show the third to sixth ionisation energies of Si.

[2]

(ii) Construct an equation to represent the second ionisation energy of Si.

..... [1]

(c) Fig. 3.1 shows a sketch of some of the ionisation energies of phosphorus, P.

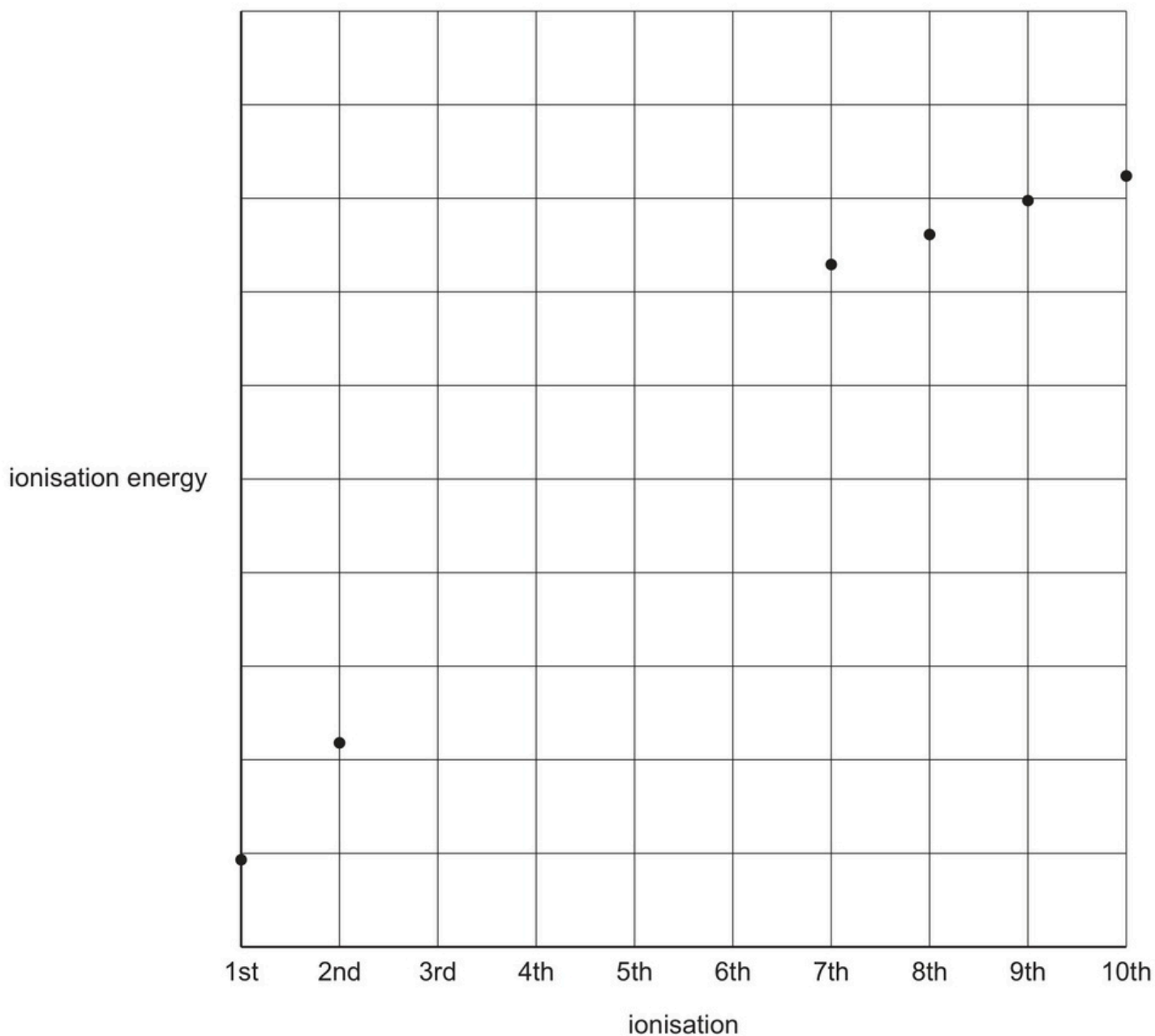


Fig. 3.1

(i) Construct an equation to represent the third ionisation energy of P.

..... [1]

(ii) Complete the graph in Fig. 3.1 to show the third to sixth ionisation energies of P.

[2]

Q57

9701/23/O/N/24/Q3(c)(i)(ii)

Ionisation Energy

(c) Fig. 3.1 shows a sketch of some of the ionisation energies of silicon, Si.

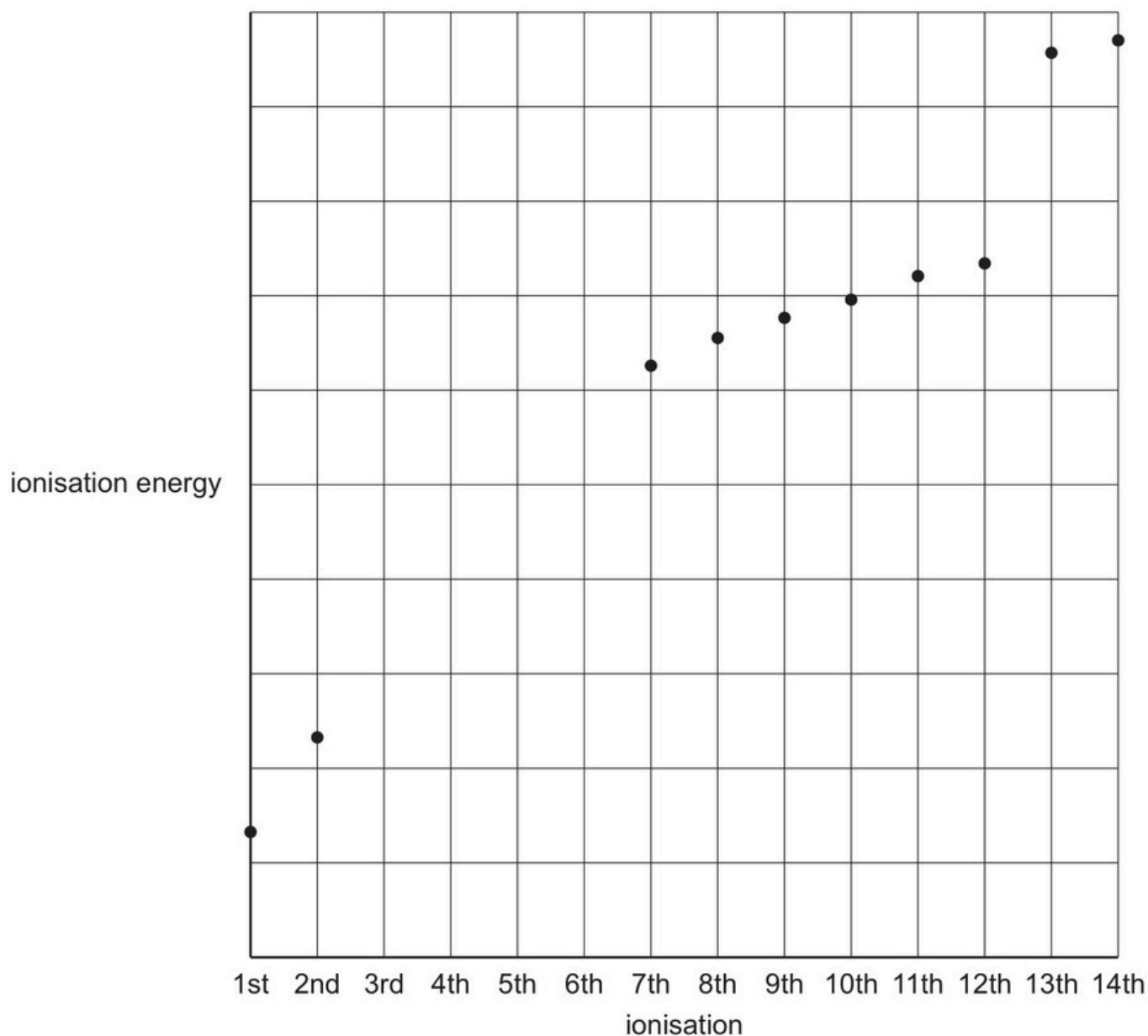


Fig. 3.1

(i) Complete the graph in Fig. 3.1 to show the third to sixth ionisation energies of Si.

[2]

(ii) Construct an equation to represent the second ionisation energy of Si.

..... [1]

Q1 9701/22/F/M/21/Q2(g)(iii) Electronic Configuration

2(g)(iii)	$(1s^2) 2s^2 2p^6 3s^2 3p^5$	1
-----------	------------------------------	----------

Q2 9701/22/F/M/22/Q1(c) Electronic Configuration

1(c)	$1s^2 2s^2 2p^6 3s^2 3p^1$ [1] greatest jump between 3rd and 4th ionisations [1] indicates three electrons in outer shell [1]	3
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Q3 9701/22/F/M/23/Q1(c)(iii) Electronic Configuration

1(c)(iii)	$1s^2 2s^2 2p^6 3s^2 3p^2$	1
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Q4 9701/22/M/J/21/Q1(f)(ii) Electronic Configuration

1(f)(ii)	<i>electronic configuration of Mg^{2+} ($1s^2$) $2s^2 2p^6$</i>	1
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Q5 9701/21/M/J/22/Q1(d)(ii) Electronic Configuration

1(d)(ii)	$1s^2 2s^2 2p^6 3s^2$	1
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Q6 9701/21/M/J/23/Q1(b) Electronic Configuration

1(b)	1 s	1
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Q7 9701/23/M/J/23/Q1(d)(iii) Electronic Configuration

1(d)(iii)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 (4s^0)$	1
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Q8 9701/22/M/J/24/Q3(c) Electronic Configuration

3(c)	full electronic configuration of Fe^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$	1
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Q9 9701/21/M/J/25/Q2(c) Electronic Configuration

2(c)	5	1
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Q10 9701/22/M/J/25/Q2(b) Electronic Configuration

2(b)	1 (pair)	1
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Q11 9701/23/M/J/25/Q1(a)(i)(ii) Electronic Configuration

1(a)(i)	$1s^2 2s^2 2p^5$	1
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1(a)(ii)	2 (pairs)	1
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Q12 9701/24/M/J/25/Q1(c)(iv) Electronic Configuration

1(c)(iv)	1s 2s 2p 3s 3p	1
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Q13

9701/21/O/N/22/Q1(b)(ii)

Electronic Configuration

1(b)(ii)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	1
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Q14

9701/23/O/N/22/Q1(b)(ii)

Electronic Configuration

1(b)(ii)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	1
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Q15

9701/21/O/N/23/Q1(a)(i)

Electronic Configuration

1(a)(i)	total # 3p e ⁻	3	4	5	1
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Q16

9701/21/O/N/23/Q1(b)(i)

Electronic Configuration

1(b)(i)	$1s^2 2s^2 2p^6 3s^2 3p^6$	1
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Q17

9701/22/O/N/23/Q1(b)(i)

Electronic Configuration

1(b)(i)	total e ⁻ in s subshell	6	6	6	1
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Q18

9701/23/O/N/23/Q1(a)(i)

Electronic Configuration

1(a)(i)	total # 3p e ⁻	3	4	5	1
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Q19

9701/23/O/N/23/Q1(b)(i)

Electronic Configuration

1(b)(i)	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶	1
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Q20

9701/21/O/N/24/Q1(a)(i),(iii)

Electronic Configuration

1(a)(i)	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶	1
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1(a)(iii)	3 (three)	1
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Q21

9701/22/O/N/24/Q1(a)(i)(iii)

Electronic Configuration

1(a)(i)	lowest energy state owtte examples • (with) lowest energy • (with) no external energy • (with) no added energy • (where) electrons are not promoted to a higher energy level • most energetically stable	1						
1(a)(ii)	[Ar] <table><tr><td>↑</td><td>↑</td><td>↑</td><td></td><td></td><td>↑↓</td></tr></table> <i>The 3 × d electrons may go in any of the d orbitals</i>	↑	↑	↑			↑↓	1
↑	↑	↑			↑↓			
1(a)(iii)	12	1						

Q22

9701/23/O/N/24/Q1(a)(i),(iii)

Electronic Configuration

1(a)(i)	$1s^2 2s^2 2p^6 3s^2 3p^6$	1
1(a)(iii)	3 (three)	1

Q23

9701/21/O/N/25/Q1(b)(i)(ii)

Electronic Configuration

1(b)(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 (3d^5 4s^1)$	1
1(b)(ii)	6	1

Q24

9701/22/O/N/25/Q1(b)(i)(ii)

Electronic Configuration

1(b)(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 (3d^5 4s^2)$	1
1(b)(ii)	5	1

Q25

9701/23/O/N/25/Q1(b)(i)(ii)

Electronic Configuration

1(b)(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 (3d^5 4s^1)$	1
1(b)(ii)	6	1

Q26

9701/22/F/M/25/Q2(c)(i)(iii)

Protons, Electrons and Neutrons

2(c)(i)	most of the mass is in the nucleus because protons and neutrons / nucleons are found in the nucleus			2													
2(c)(ii)	<table><tr><td>isotope</td><td>number of protons</td><td>number of neutrons</td></tr><tr><td>magnesium-24</td><td>12</td><td>12</td></tr><tr><td>magnesium-25</td><td>12</td><td>13</td></tr><tr><td>magnesium-26</td><td>12</td><td>14</td></tr></table>			isotope	number of protons	number of neutrons	magnesium-24	12	12	magnesium-25	12	13	magnesium-26	12	14	2	
	isotope	number of protons	number of neutrons														
	magnesium-24	12	12														
	magnesium-25	12	13														
magnesium-26	12	14															
2(c)(iii)	neutron beam	horizontal straight line from same source		3													
	electron beam	downwards curving line from same source															
		line deflected more than proton beam															

Q27

9701/21/M/J/22/Q1(d)(i)

Protons, Electrons and Neutrons

1(d)(i)	number of protons: 12 number of neutrons: 13	1
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Q28

9701/23/M/J/22/Q1(e)

Protons, Electrons and Neutrons

1(e)		atomic no.	nucleon no.	no.of neutrons	electronic arrangement
	copper –65	29	65	65 – 29 = 36	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ¹⁰ 4s ¹

M1 29 **AND** 65

M2 nucleon no – atomic no
ALLOW ecf from M1

M3 electronic arrangement

Q29

9701/21/M/J/23/Q1(a)

Protons, Electrons and Neutrons

1(a)		nucleon number	number of neutrons	number of electrons
	Tellurium-130	130	78	52

Q30

9701/22/M/J/24/Q1(a)

Protons, Electrons and Neutrons

1(a)					2
	Mg ²⁺	24	12	10	
	Al ³⁺	27	13	10	
4 correct = 2 marks 2 or 3 correct = 1 mark 0 or 1 correct = 0 marks					

Q31

9701/21/M/J/25/Q2(b)(ii)

Protons, Electrons and Neutrons

2(b)(ii)	particle	number of particles in one atom of ⁵⁶ Fe	2
	protons	26	
	nucleons	56	

Q32

9701/21/O/N/22/Q1(a)(i)

Protons, Electrons and Neutrons

1(a)(i)	columns 1 & 3 identical				1
	isotope	No of p's	No of n's	No of e's	
	⁶⁹ Ga	31	38	31	
	⁷¹ Ga	31	40	31	

Q33

9701/23/O/N/22/Q1(a)(i)

Protons, Electrons and Neutrons

1(a)(i)	columns 1 & 3 identical				1
	isotope	No of p's	No of n's	No of e's	
	⁶⁹ Ga	31	38	31	
	⁷¹ Ga	31	40	31	

Q34

9701/21/O/N/24/Q1(b)

Protons, Electrons and Neutrons

1(b)	isotope	number of protons	number of neutrons	total number of electron shells	3
	$^{103}_{45}\text{Rh}$	• 45	58	• 5	
	$^{191}_{77}\text{Ir}$	• 77	• 114	6	
	$^{193}_{77}\text{Ir}$	• 77	• 116	6	

Q35

9701/22/O/N/24/Q1(b)(i)

Protons, Electrons and Neutrons

1(b)(i)	isotope	RIM	# protons	# neutrons	2
	$^{93}_{41}\text{Nb}$	92.91	• 41	• 52	
	$^{181}_{73}\text{Ta}$	180.95	• 73	• 108	

Q36

9701/23/O/N/24/Q1(b)

Protons, Electrons and Neutrons

1(b)	isotope	number of protons	number of neutrons	total number of electron shells	3
	$^{103}_{45}\text{Rh}$	• 45	58	• 5	
	$^{191}_{77}\text{Ir}$	• 77	• 114	6	
	$^{193}_{77}\text{Ir}$	• 77	• 116	6	

Q37

9701/21/O/N/25/Q1(a)(i)(ii)

Protons, Electrons and Neutrons

1(a)(i)	24 protons 28 neutrons 24 electrons	1
1(a)(ii)	(^{54}Cr has two) more neutrons (than ^{52}Cr)	1

Q38

9701/22/O/N/25/Q1(a)(i)(ii)

Protons, Electrons and Neutrons

1(a)(i)	25 protons 30 neutrons 25 electrons	1
1(a)(ii)	(atoms of an element) with the same number of protons and different number of neutrons	1

Q39

9701/23/O/N/25/Q1(a)(i)(ii)

Protons, Electrons and Neutrons

1(a)(i)	24 protons 28 neutrons 24 electrons	1
1(a)(ii)	(⁵⁴ Cr has two) more neutrons (than ⁵² Cr)	1

Q40

9701/22/F/M/21/Q2(b)(i)(ii)

Ionisation Energy

2(b)(i)	$\text{Cl(g)} - \text{e}^- \rightarrow \text{Cl}^{\text{+}}(\text{g})$	1
2(b)(ii)	M1: increasing proton number but similar shielding M2: greater attraction of nucleus (for outer / valence electrons)	2

Q41

9701/22/F/M/22/Q1(a)(b)(ii)

Ionisation Energy

1(a)	$\text{O(g)} \rightarrow \text{O}^{\text{+}}(\text{g}) + \text{e}^-$	1
1(b)(i)	increase across period AND increased nuclear attraction for (valence / outer) electrons [1] increase in (positive) nuclear charge / number of protons (in the nucleus) [1] similar shielding (of outer electrons) [1]	3
1(b)(ii)	spin-pair repulsion (of electrons) in (2)p <u>orbital</u> [1] outweighs increased nuclear charge [1]	2

Q42

9701/22/F/M/23/Q1(c)(i)(ii)

Ionisation Energy

1(c)(i)	$\text{H(g)} \rightarrow \text{H}^{\text{+}}(\text{g}) + \text{e}^-$	1
1(c)(ii)	H (cannot undergo second ionisation because it only) has one electron / $\text{H}^{\text{+}}$ has no electron	1

Q43

9701/22/F/M/25/Q2(b)(ii)

Ionisation Energy

2(b)(ii)	ionisation energies increase because less shielding / successive ionic radii are smaller / greater attraction (of electron) to nucleus (large difference between 2nd and 3rd IE) because 3rd e^- coming from an inner shell / lower energy level	2
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Q44

9701/23/M/J/22/Q1(a)(d)

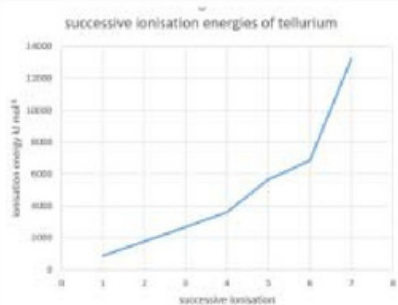
Ionisation Energy

1(a)	- energy required - when one electron is removed - from each atom in one mole of - gaseous atoms two or three points for one mark, four points for two marks	2
1(b)	Group VI / 16 AND large increase (in IE) after 6th	1
1(c)	M1 reference to spin pair repulsion in (3)p orbital (in S) OR due to repulsion of two electrons in a (3)p orbital (in S) M2 outweighs increased nuclear charge (in S)	2
1(d)	M1 <i>similarity in electronic structure / shielding of Al^{2+} and Na</i> both remove electron from (3)s ¹ / single electron in (3)s (sub-level / orbital) OR Al^{2+} and Na have same electronic configuration OR shielding (of outer electron) is the same M2 <i>greater nuclear charge / number of protons</i> Al^{2+} has greater nuclear charge OR 13p compared to 11p	2

Q45

9701/21/M/J/23/Q1(c)(d)(ii)

Ionisation Energy

1(c)	$Te(g) \rightarrow Te^+(g) + e^{-}$	1
1(d)(i)	<i>any two factors responsible for increase in IE in first 6 IE from:</i> (increased) nuclear attraction / attraction for nucleus (decreased) shielding (by sub-shells) (IE 4 to 5) - spin-pair repulsion (IE 1 to 2)	2
1(d)(ii)	 M1 general increase M2 jumps from 4 to 5 and (largest) 6 to 7	2

Q46

9701/21/M/J/25/Q2(d)(e)

Ionisation Energy

2(d)	$Fe(g) \rightarrow Fe^+(g) + e^{-}$	1
2(e)	M1 same electronic configuration OR same shielding M2 same number of protons OR same nuclear charge M3 so same nuclear attraction to outer shell electron M4 no change / will not be affected	4

Q47

9701/23/M/J/25/Q1(b)(i)(ii)

Ionisation Energy

1(b)(i)	$S(g) \rightarrow S^+(g) + e^{-}$ OR $S(g) - e^{-} \rightarrow S^+(g)$	1
1(b)(ii)	M1 pair of electrons in a 3p orbital (in S) repel each other M2 outweighs the effect of increase in nuclear charge	2

Q48

9701/24/M/J/25/Q1(c)(i)(iii)

Ionisation Energy

1(c)(i)	$\text{Ar}^{2+}(\text{g}) \rightarrow \text{Ar}^{3+}(\text{g}) + \text{e}^{(-)}$ M1 a correct equation which represents an ionisation process e.g. $\text{X}^{n+} \rightarrow \text{X}^{(n+1)+} + \text{e}^{(-)}$ M2 correct equation to show third ionisation energy of Ar including (g) state symbols	2
1(c)(ii)	M1 nuclear charge M2 distance of outer electron(s) from nucleus OR ionic radius OR shielding (by inner shells and / or sub-shells)	2
1(c)(iii)	M1 (most significant factor) = distance of outer electron(s) from nucleus OR ionic radius OR shielding OR shells M2 (3rd IE) value for (Na and) Mg is (much) greater than Al (to Ar) OR (Na and) Mg has electron(s) removed from a shell that is closer to the nucleus / less shielding OR (Na and) Mg has electron(s) removed from a shell that is lower in energy	2

Q49

9701/22/O/N/21/Q2(a)(ii)(iii)

Ionisation Energy

2(a)(ii)	All 3 points correct scores two marks Any 2 points scores one mark - nuclear charge increases <i>OR</i> increasing proton number e.g. 17 / Cl has a greater nuclear charge - describe the similarity in shielding between the two elements e.g. they have almost the same shielding - describe the overall effect in terms of greater nuclear attraction for (outer) electrons e.g. (outer) electrons are attracted more (strongly) to the nucleus	2
2(a)(iii)	M1 describes the difference between 1st IE of elements 15 and 16 (P and S) in terms of either: spin-pair repulsion (in element 16 / S) OR electron pair repulsion (in element 16 / S) M2 describes the location of the electron pair in the (3)p orbital which repel each other	2

Q50

9701/21/O/N/22/Q1(b)(iii)

Ionisation Energy

1(b)(iii)	M1 big increase in IE between first and second M2 second (and third) electron(s) is removed from inner shell OR second (and third) electron(s) is removed from a shell closer to the nucleus OR second (and third) electron(s) has a stronger nuclear attraction ora	2
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Q51

9701/23/O/N/22/Q1(b)(iii)

Ionisation Energy

1(b)(iii)	M1 big increase in IE between first and second M2 second (and third) electron(s) is removed from inner shell OR second (and third) electron(s) is removed from a shell closer to the nucleus OR second (and third) electron(s) has a stronger nuclear attraction ora	2
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Q52

9701/21/O/N/23/Q1(a)(ii)(iii)

Ionisation Energy

1(a)(ii)	$\text{P(g)} \rightarrow \text{P}^{\text{+}}(\text{g}) + \text{e}^{(-)}$	1
1(a)(iii)	1000 (kJmol^{-1})	1

Q53

9701/22/O/N/23/Q1(b)(ii)(iii)

Ionisation Energy

1(b)(ii)	$\text{Si(g)} \rightarrow \text{Si}^{\text{+}}(\text{g}) + \text{e}^{-}$	1
1(b)(iii)	1060 (is circled)	1

Q54

9701/23/O/N/23/Q1(a)(ii)(iii)

Ionisation Energy

1(a)(ii)	$\text{P(g)} \rightarrow \text{P}^{\text{+}}(\text{g}) + \text{e}^{(-)}$	1
1(a)(iii)	1000 (kJmol^{-1})	1

Q55

9701/21/O/N/24/Q3(c)(i)(ii)

Ionisation Energy

3(c)(i)	M1 general increase	1
3(c)(ii)	$\text{Si}^{\text{+}}(\text{g}) \rightarrow \text{Si}^{2+}(\text{g}) + \text{e}^{-}$	1

Q56

9701/22/O/N/24/Q3(c)(i)(ii)

Ionisation Energy

3(c)(i)	$P^{2+}(g) \rightarrow P^{3+}(g) + e^{-}$	1
3(c)(ii)	general increase	1

Q57

9701/23/O/N/24/Q3(c)(i)(ii)

Ionisation Energy

3(c)(i)	M1 general increase	1
3(c)(ii)	$Si^{+}(g) \rightarrow Si^{2+}(g) + e^{-}$	1