

1. Atomic Structure

1.4 Ionisation energy

Paper 1

Question Paper

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

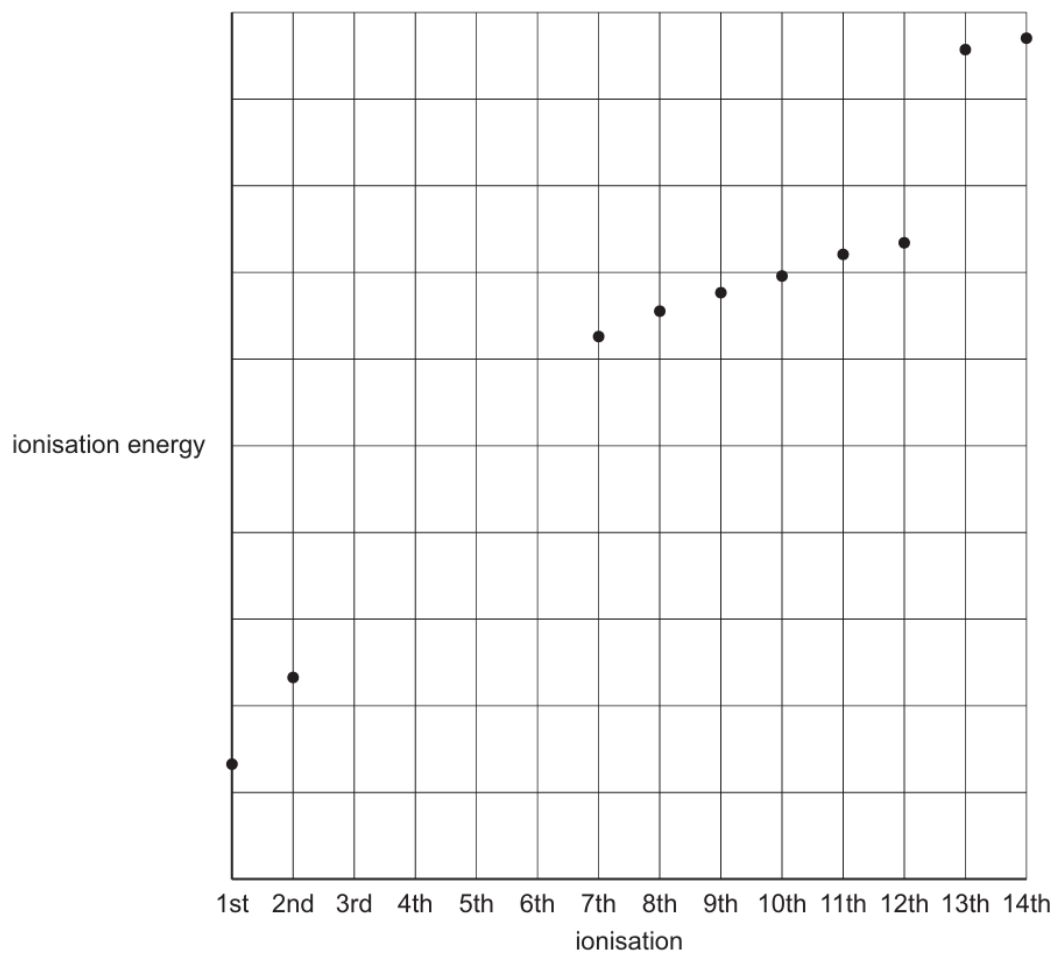
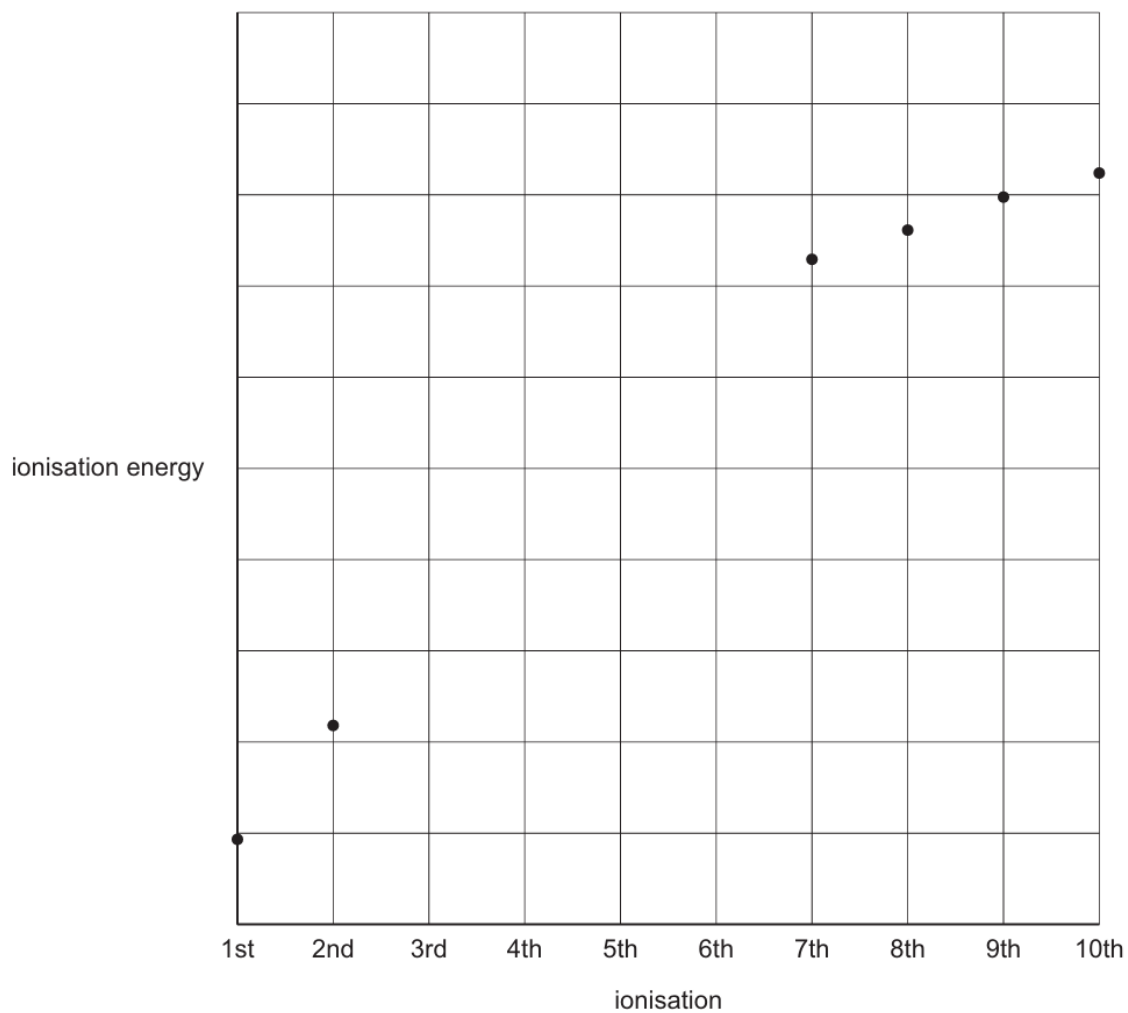


Fig. 3.1

(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]

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



- (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]

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

(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.

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..... [2]

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

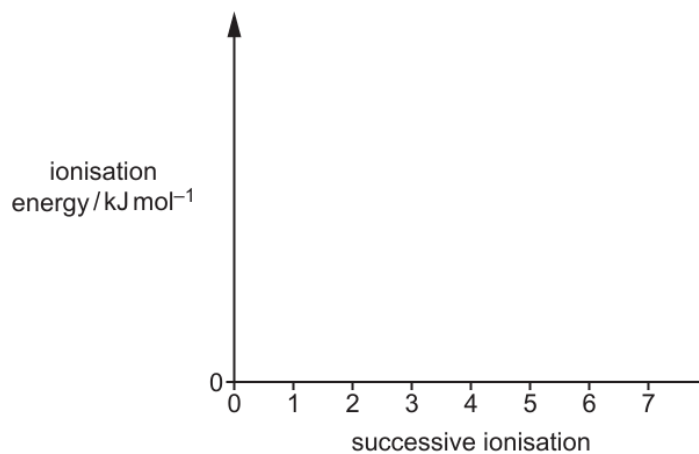


Fig. 1.1

[2]

- 4 The elements phosphorus, sulfur and chlorine are in Period 3 of the Periodic Table.

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]

- (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]

5 The elements silicon, phosphorus and sulfur are in Period 3 of the Periodic Table.

(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]

(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]

6 Atoms with nuclei containing an odd number of protons tend to have fewer isotopes than those with an even number of protons.

(b) Potassium also has two stable isotopes. Both isotopes have the same chemical properties.

(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.

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..... [2]

- 7 (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

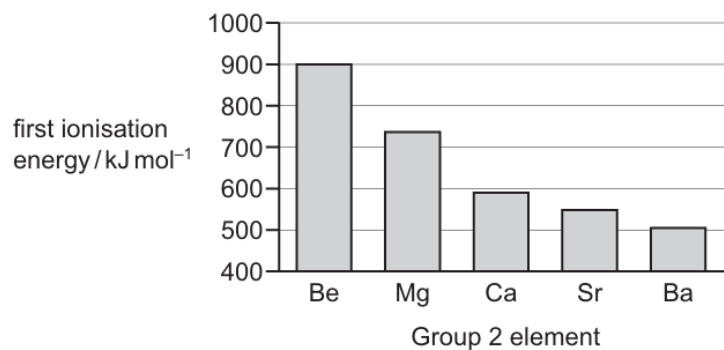
- (ii) Explain the difference between the first ionisation energies of the elements with atomic numbers 11 and 17.

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..... [2]

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

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..... [2]

- 8 The graph shows the first ionisation energies of some of the elements in Group 2.



- (a) Write an equation for the first ionisation energy of Mg.

Include state symbols.

..... [1]

- (b) Explain the observed trend in first ionisation energies down Group 2.

.....

 [3]

- (c) The second ionisation energy of Be is 1757 kJ mol⁻¹.

Explain why the second ionisation energy of Be is higher than the first ionisation energy of Be.

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 [2]

9 (a) Group 2 elements share common chemical properties.

- (i) Calcium reacts in cold water more quickly than magnesium because more energy is required to remove the outer electrons in magnesium. This occurs even though calcium atoms have a greater nuclear charge.

Explain why more energy is required to remove the outer electrons in magnesium than in calcium.

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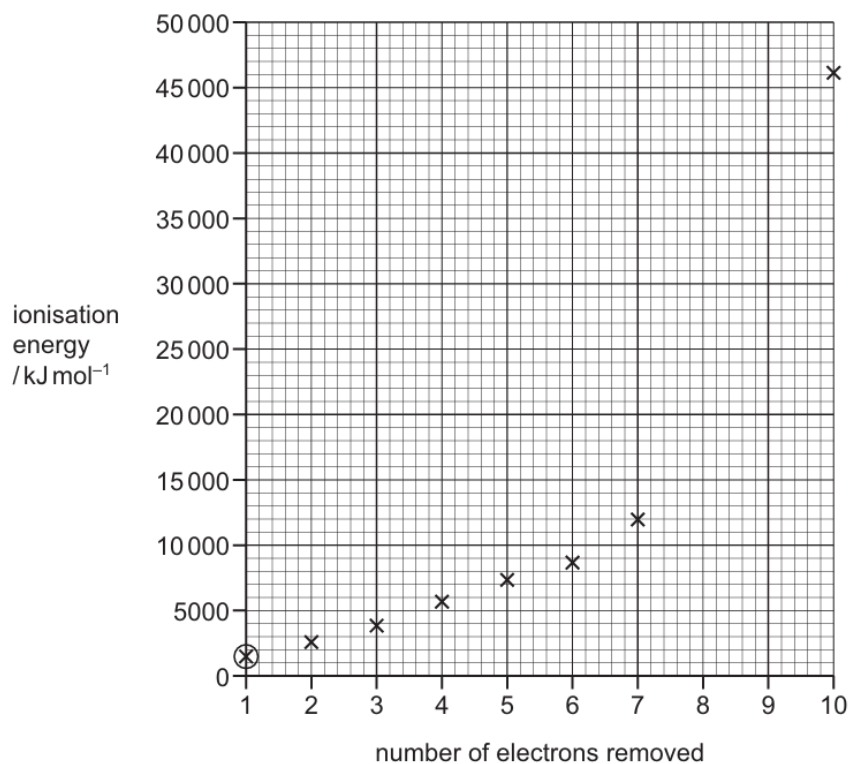
 [2]

10 (a) Construct an equation for the **second** ionisation energy of argon.

..... [1]

(b) The graph shows successive ionisation energies for the element argon.

Complete the graph with predictions for the eighth and ninth ionisation energies of argon. Use a cross (×) for each data point. [2]



11 In the Periodic Table, the p block contains elements whose outer electrons are found in the p subshell.

(a) Elements in the p block show a general increase in first ionisation energy as the atomic number increases.

(i) Draw the shape of a p orbital.

[1]

(ii) Write an equation to show the first ionisation energy of silicon.

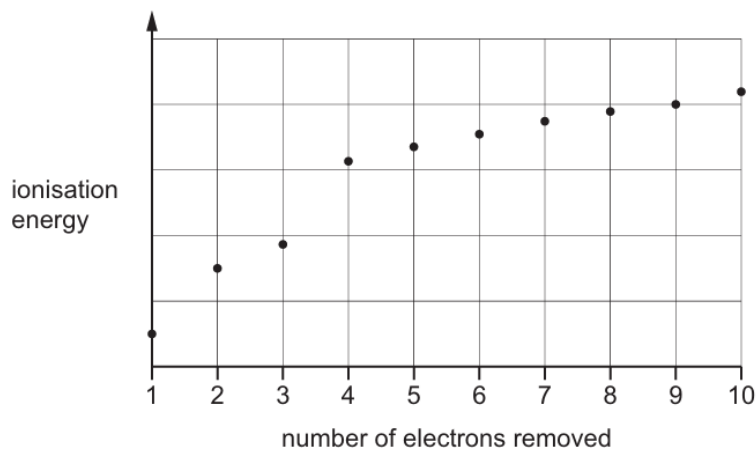
..... [1]

(iii) Explain why there is a general increase in first ionisation energies of the elements across Period 3.

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..... [2]

(iv) Element **A** is in the p block.

The graph shows the successive ionisation energies for the removal of the first ten electrons of **A**.



State and explain the group of the Periodic Table that element **A** belongs to.

group number

explanation

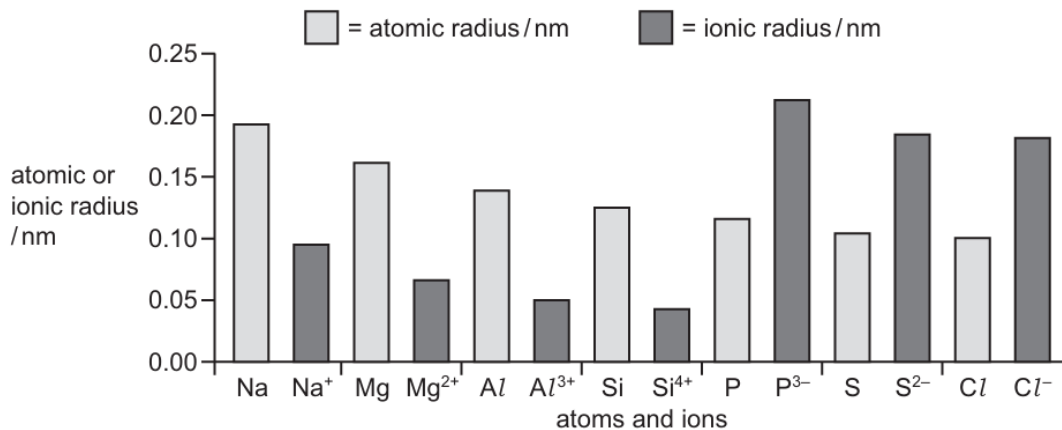
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[2]

12 The elements in the third period exhibit periodicity in both their chemical and physical properties.

(a) A graph of the atomic and ionic radii across the third period is shown.



(b) The first ionisation energies of the elements across the third period show a general increase.

Aluminium and sulfur do **not** follow this general trend.

(i) Explain why aluminium has a lower first ionisation energy than magnesium.

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..... [2]

(ii) Explain why sulfur has a lower first ionisation energy than phosphorus.

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..... [2]