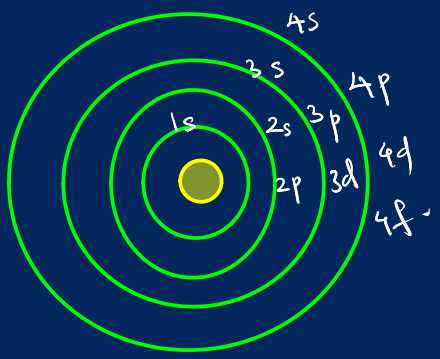
Subshell Electronic Configuration

Shell → Sub shell → Orbital



1st shell → $1s^2$

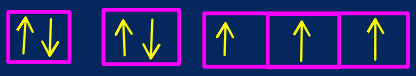
2nd shell → $2s^2$ $2p^6$

3rd shell → $3s^2$ $3p^6$ $3d^{10}$

4th shell → $4s^2$ $4p^6$ $4d^{10}$ $4f^{14}$.

Configuration : $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$

$_7N$ → $1s^2$ $2s^2$ $2p^3$



$_{15}P$ → $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^3$

$[Ne]\ 3s^2\ 3p^3$ ⇒ $[Ne]$

$_{11}Na$ → $1s^2$ $2s^2$ $2p^6$ $3s^1$ } ⇒ $[Ne]$

→ $[Ne]\ 3s^1$

$_{26}Fe$ → $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^6$ } $[Ar]$

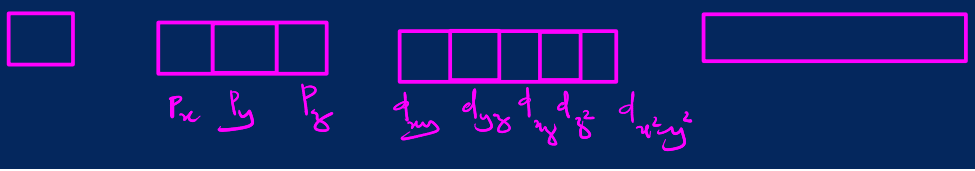
$[Ar]\ 4s^2\ 3d^6$

$[Ne] = 1s^2\ 2s^2\ 2p^6$

$[Ar] = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

4 – Subshells

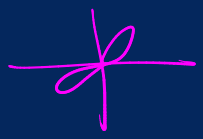
s p d f



$_{24}Cr \longrightarrow [Ar]\ 4s^1 3d^5$

$_{29}Cu \longrightarrow [Ar]\ 4s^1 3d^{10}$

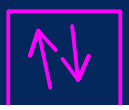
s – Spherical 

p – Dumb-bell 

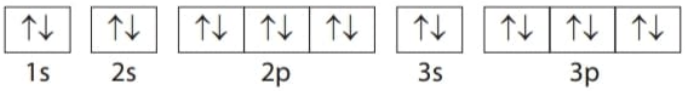
d – Double dumbbell 

Hunds rule - pairing of electrons in a orbtial happen only after filling individually in the dege nearte (similiar energy) orbitals

Pauli's Exclusion Principle ; an orbital can have maximum 2 electrons
or
no orbital can have more than 2 electron with opposite spin



9 Which ion does **not** have the electronic configuration shown?



- ☒ **A** K^+ → 18 e^- (19)
- ☒ **B** Ca^{2+} → 18 e^-
- ☒ **C** Ti^{2+} → 22 − 2 = 20 (22)
- ☒ **D** Sc^{3+} ⇒ 21 − 3 = 18 (21)

(Total for Question 9 = 1 mark)

10 What is the electronic configuration of the nitride ion, N^{3-}?

- ☒ **A** $1s^2\ 2s^2$
- ☒ **B** $1s^2\ 2s^2\ 2p^3$
- ☒ **C** $1s^2\ 2s^2\ 2p^4$
- ☒ **D** $1s^2\ 2s^2\ 2p^6$

(Total for Question 10 = 1 mark)

☒ **B** $1s^2\ 2s^2\ 2p^3$

☒ **C** $1s^2\ 2s^2\ 2p^4$

☒ **D** $1s^2\ 2s^2\ 2p^6$

(Total for Question 10 = 1 mark)

11 Which of these ions has the smallest ionic radius? → Highest Attraction.

☒ **A** Al^{3+} 13 P and 10 $\bar{e}$

☒ **B** Ga^{3+}

☒ **C** Mg^{2+} 12 P & 10 $\bar{e}$

☒ **D** F^- 9 P & 10 $\bar{e}$ → least attraction.

(Total for Question 11 = 1 mark)

B
Al +3
Ga +3

Mg Al $_9F$

18 This question is about the structure of atoms.

(a) State what is meant by the term orbital.

(2)

3D Area around the nuclues where the chance to find electrons are maximum

(b) State the shape of an s orbital and the shape of a p orbital.

(1)

s – spherical

p – dumb bell.

(c) Describe what can be deduced about the electronic structure of sodium from its successive ionisation energies.

(3)

$_{11}Na$ → 2, 8, 1

$_{11}Na^{+1}$ → 2, 8

$_{11}Na^{+2}$ → 2, 1

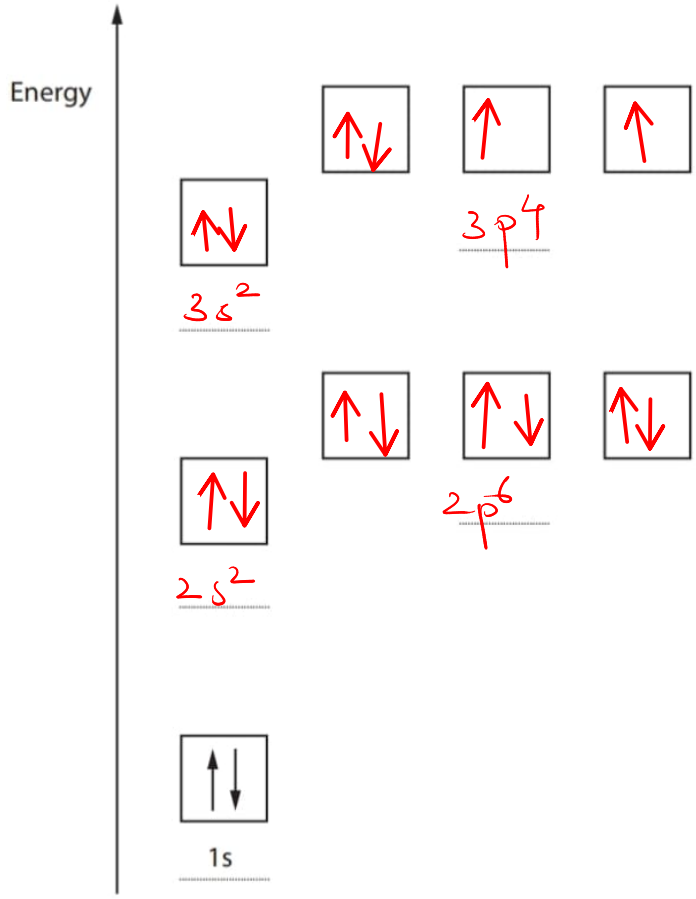
1st I.E < 2nd I.E < 11th I.E

Answer ALL the questions. Write your answers in the spaces provided.

18 This question is about the element sulfur.

(a) Complete the diagram to show the electronic configuration for a sulfur atom in the ground state.
Include labels for each subshell.

(2)



(b) Write an equation for the **first** ionisation energy of sulfur.
Include state symbols.

(2)

$S_{(g)} \longrightarrow S^{+1}_{(g)} + 1e^-$

6 A p-block element in **Period 3** of the Periodic Table reacts to form an ionic compound.

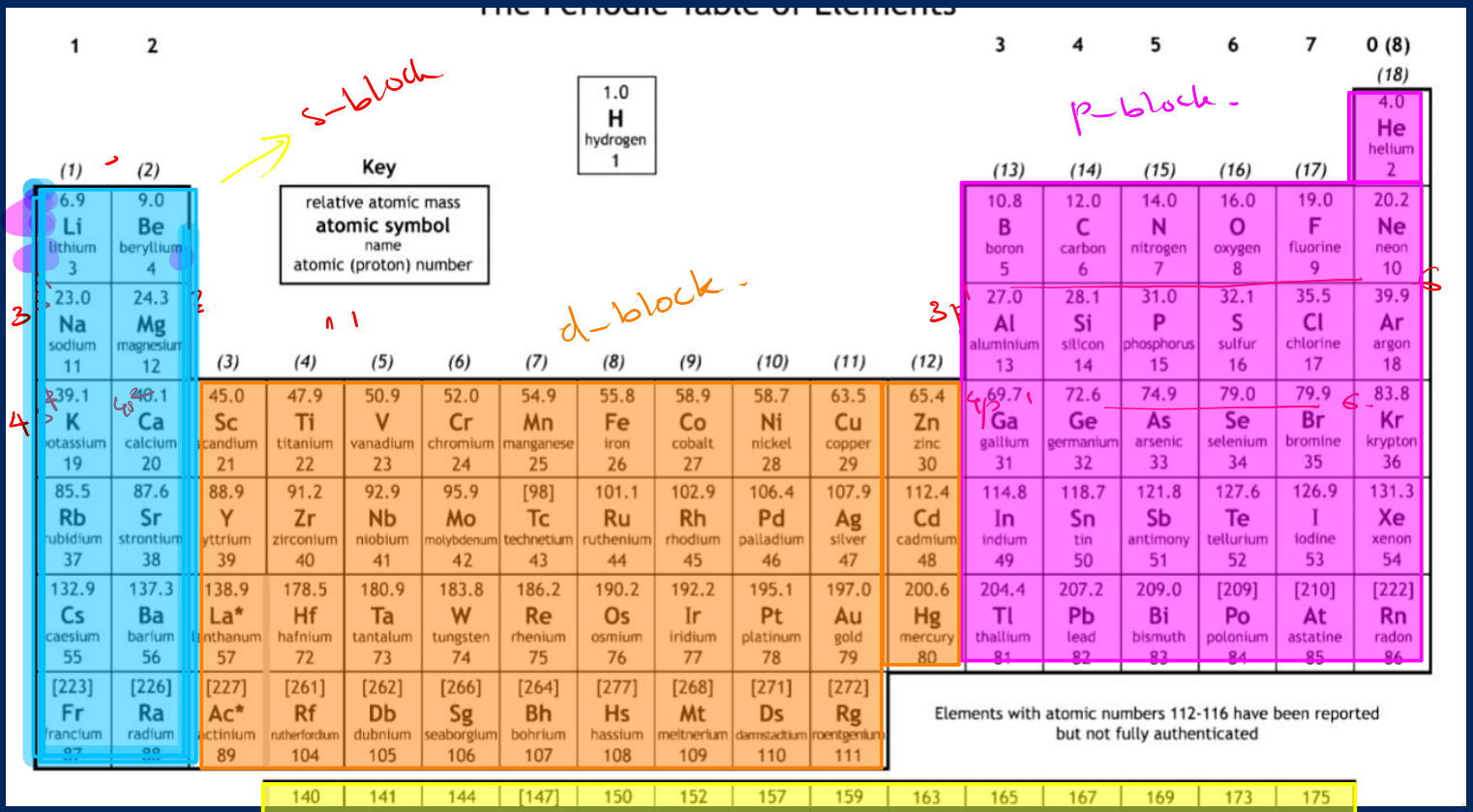
What could be the electronic configuration of the **ion** formed by this element?

$Cl^- \longrightarrow 3s^2 3p^5 + 1$

- ☒ **A** $1s^2 2s^2 2p^6 3s^2$ ✗ → s-block
- ☒ **B** $1s^2 2s^2 2p^6 3s^2 3p^6$ → Stable Anion
- ☒ **C** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ ✗ → d-block
- ☒ **D** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ → 4th period

3s 3p

(Total for Question 6 = 1 mark)



6 Which ion has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6$ in its ground state?

- ☒ **A** Al^{3+} → $1s^2 2s^2 2p^6$
- ☑ **B** Cl^- → $[Ne]\ 3s^2 3p^5$ +1
- ☒ **C** N^{3-} → $1s^2 2s^2 2p^3$ +3
- ☒ **D** Na^+ → $1s^2 2s^2 2p^6$ ~~$3s^1$~~

(Total for Question 6 = 1 mark)

Answer ALL the questions. Write your answers in the spaces provided.

12 This question is about the chlorides of beryllium and calcium.

(a) Complete the electronic configurations of the atoms of beryllium and calcium using the s, p, d notation.

(2)

Be $1s^2$ $2s^2$

Ca $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$

$4s^{1-1} = 4s^0$

$3d^{10-1} = 3d^9$

20 This question is about copper and its compounds.

(a) Complete the electronic configurations of Cu and Cu^{2+}.

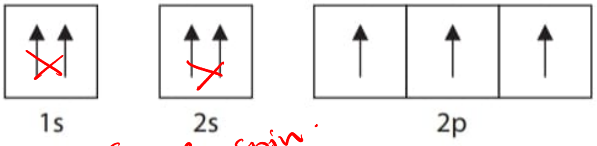
(2)

Cu [Ar] $4s^1 3d^{10}$

Cu^{2+} [Ar] $3d^9$

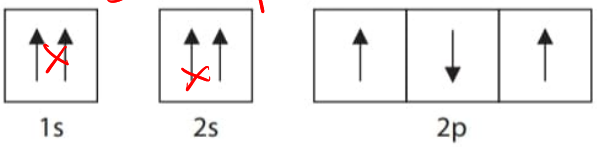
8 What is the electronic configuration of a nitrogen atom?

☒ **A**

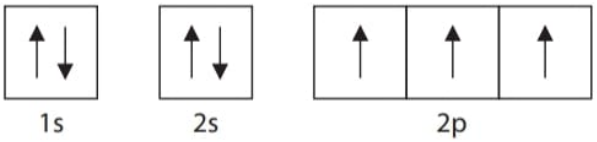


Same spin.

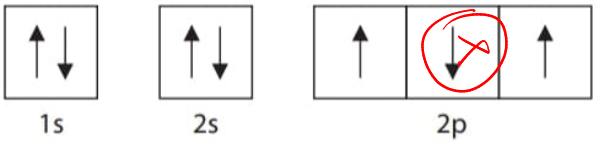
☒ **B**



☒ **C**



☒ **D**



(Total for Question 8 = 1 mark)

9 The element manganese has the atomic number $Z = 25$.

What are the numbers of s, p and d electrons in an atom of manganese?

	s electrons	p electrons	d electrons
☒ **A**	6	12	7
☒ **B**	8	12	5
☒ **C**	6	18	1
☒ **D**	8	17	0

$1s^2 2s^2 3s^2 4s^2$ $2p^6 3p^6$

(Total for Question 9 = 1 mark)

8 Which is the equation for the **second** ionisation of element J?

☒ **A** $J(g) \rightarrow J^{2+}(g) + 2e^-$ → 1st & 2nd

☒ **B** $J^+(g) \rightarrow J^{2+}(g) + e^-$ 2nd I.E.

☒ **C** $J^+(g) \rightarrow J^{3+}(g) + 2e^-$ →

☒ **D** $J^{2+}(g) \rightarrow J^{3+}(g) + e^-$ → 3rd I.E.

(Total for Question 8 = 1 mark)

9 Which is a reason why fluorine has a higher first ionisation energy than oxygen?

☒ **A** a fluorine atom has fewer unpaired electrons

☒ **B** a fluorine atom has fewer shells of electrons

☒ **C** a fluorine atom has more electrons

☒ **D** a fluorine atom has more protons

(Total for Question 9 = 1 mark)

10 Which is the electronic configuration of chromium?

☒ **A** [Ar]

10 Which is the electronic configuration of chromium?

		3d	4s
☒ **A**	[Ar]	↑↓ ↑↓	↑↓
☒ **B**	[Ar]	↑ ↑ ↑ ↑	↑↓
☒ **C**	[Ar]	↑ ↑ ↑ ↑ ↑	↑
☒ **D**	[Ar]	↑ ↑ ↑ ↑	↑↑

More Stable Arrangement

(Total for Question 10 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

4 What is the electronic configuration of an oxygen atom in its ground state?

	1s	2s	$2p_x$	$2p_y$	$2p_z$	3s
☒ **A**	↑↓	↑↓	↑↓	↑↓		
☒ **B**	↑↓	↑↓	↑↑	↑	↑	
☒ **C**	↑↓	↑↓	↑	↑	↑	↑
☒ **D**	↑↓	↑↓	↑↓	↑	↑	

(Total for Question 4 = 1 mark)

Ionisaton Energy

Energy required to remove valance electron from an isolated gaseous atom

$Na_{(g)} \longrightarrow Na^{+1}_{(g)} + 1e^-$ 1st . I. Energy

$Na^{+1}_{(g)} \longrightarrow Na^{+2} + 1e^-$ 2nd I. Energy

$Na^{+2} + 1e^- \longrightarrow Na^{+3} + 1e^-$ 3rd I. Energy

$Mg_{(g)} \longrightarrow Mg^{+1}_{(g)} + 1e^-$ I^{st} I.E

$Mg^{+}_{(g)} \longrightarrow Mg^{+2}_{(g)} + 1e^-$ 2^{nd} I.E

$Mg + Mg^{+1} \longrightarrow Mg^{+1} + Mg^{+2} + 2e^-$

$Mg_{(g)} \longrightarrow Mg^{+2} + 2e^-$ I^{st} & 2^{nd} I.E

Ex:-

Ionisation Energy of Aluminium :-

$Al_{(g)} \longrightarrow Al^{+1}_{(g)} + 1e^-$ I^{st} I.Energy.

0 ; $1-1=0$

$Al^{+1}_{(g)} \longrightarrow Al^{+2}_{(g)} + 1e^{-1}$ 2^{nd} I.Energy.

$+1$; $+2-1=+1$

$Al^{+2}_{(g)} \longrightarrow Al^{+3}_{(g)} + 1e^-$ 3^{rd} I.Energy.

$_{13}Al \rightarrow 2, 8, 1$

$_{13}Al \rightarrow 1s^2 2s^2 2p^6$

4th ionisation enrgy of Aluminum will show big jump from 3rd to 4th KIonisation energy.

$Al_{(g)} \longrightarrow Al^{+1}_{(g)} + 1e^-$

$Al^{+1}_{(g)} \longrightarrow Al^{+2}_{(g)} + 1e^{-1}$

$Al^{+2}_{(g)} \longrightarrow Al^{+3}_{(g)} + 1e^-$

$Al_{(g)} \longrightarrow Al^{+3}_{(g)} + 3e^-$

Successive Ionisation Energy

Order :- 1^{st} I.E < 2^{nd} I.E < 3^{rd} I.E .

Eg:- $_{11}Na \longrightarrow 2,8,1$

$Na^{+1} \longrightarrow 2,8$

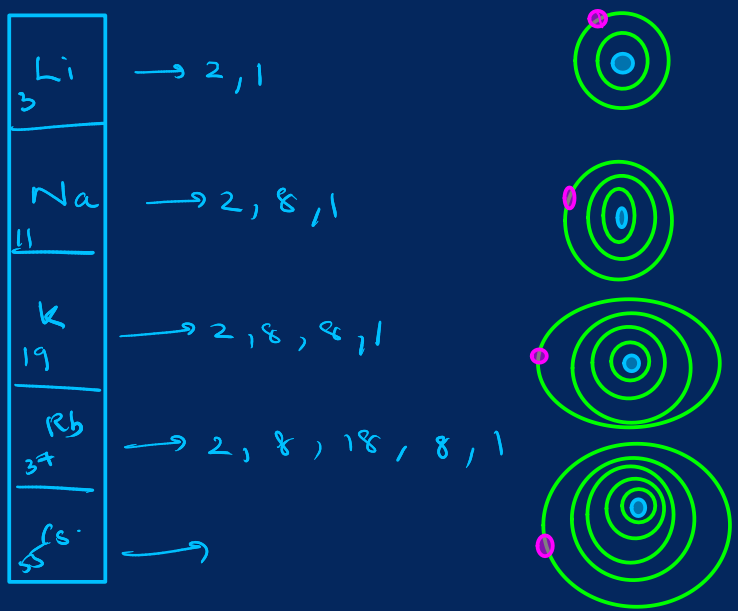
$Na^{+2} \longrightarrow 2,7$

$Na^{+3} \longrightarrow 2,6$

Reason:- the Nuclear charge Increases, therefore its becoming more difficult to remove the valancee^- electrons from outer shell.

Trend in the Ionization Energy

Down the Group :-



down in a group:
Atomic number increases, number of shells increases, becasue of this, nuclear attraction on the valance electron dec reases and atomic siza increases.

Ionization decreases down in the Group.

II. I.E across the period

$\overset{+3}{Li} < \overset{+4}{Be} > \overset{+5}{B} < \overset{+6}{C} < \overset{+7}{N} > \overset{+8}{O} < \overset{+9}{F} < Ne$

3 ↓ 2,1 | 4 ↓ 2,2 | 5 ↓ 2,3 | 6 ↓ 2,4 | 7 ↓ 2,5 | 8 ↓ 2,6 | 9 ↓ 2,7 | 10 → 2,8 .

across the period, atomic number increases, but the number of shell is remains fixed. also nulcear charge increases so the atomic size decreases.

∴ Ionisation Energy Increases Across the period

Exceptions in General Trend :-

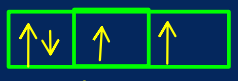
$_4Be \longrightarrow 1s^2\ 2s^2$

$_5B \longrightarrow 1s^2\ 2s^2\ 2p^1$

The removal of e^- from 2p of B is more easier than removing e^- from 2s of Be.

$_7N \longrightarrow 1s^2\ 2s^2\ 2p^3$

$_8O \longrightarrow 1s^2\ 2s^2\ 2p^4$



$e^- - e^-$ Repulsion.

∴ N > O.

3 The first seven ionisation energies, in kJ mol^{-1}, of an element are shown.

1010, 1900, 2910, 4960, 6270, 21 300, 25 400

In which group of the Periodic Table is this element located?

- ☒ **A** Group 3
- ☒ **B** Group 4
- ☒ **C** Group 5
- ☒ **D** Group 6

(Total for Question 3 = 1 mark)

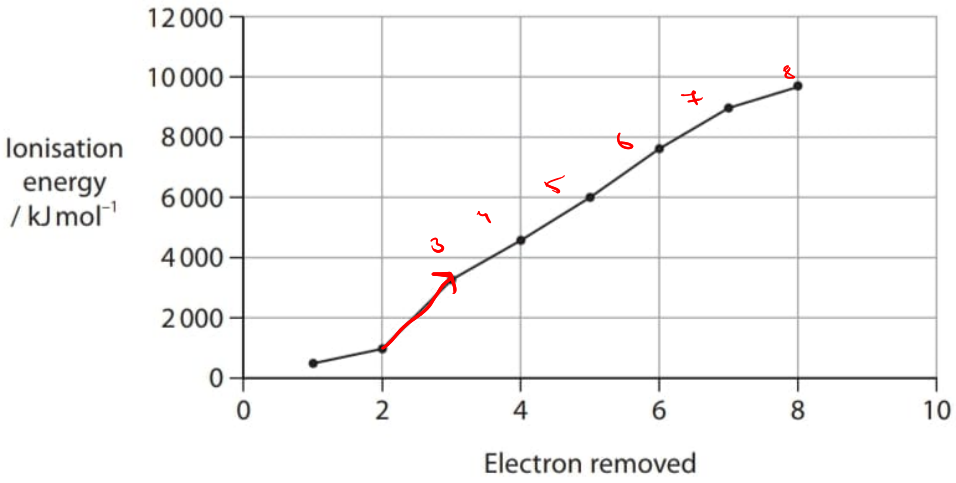
8 Which is the equation for the **second** ionisation of element J?

- ☒ **A** $J(g) \rightarrow J^{2+}(g) + 2e^-$ 1st & 2nd
- ☒ **B** $J^+(g) \rightarrow J^{2+}(g) + e^-$
- ☒ **C** $J^+(g) \rightarrow J^{3+}(g) + 2e^-$
- ☒ **D** $J^{2+}(g) \rightarrow J^{3+}(g) + e^-$ 3rd I.E

(Total for Question 8 = 1 mark)

14 This question is about barium and barium compounds.

(a) The graph shows the first eight ionisation energies of barium.



(i) Write an equation, including state symbols, for the **third** ionisation energy of barium.

(1)

$Ba^{+2}_{(g)} \longrightarrow Ba^{+3}_{(g)} + e^-$

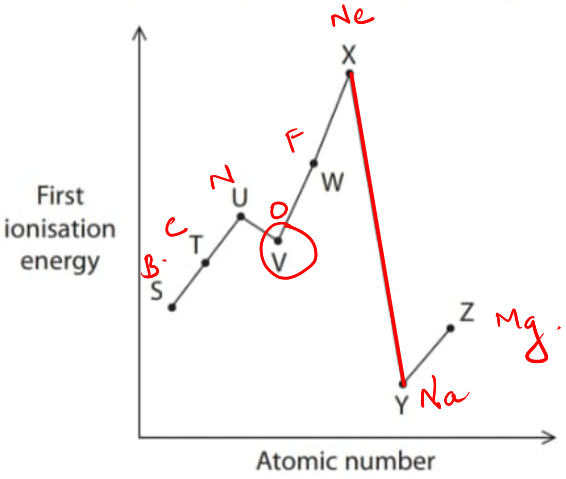
(ii) State how the graph confirms that barium is in Group 2 in the Periodic Table.

(1)

Jump in I.E from 2 → 3

11 The graph shows the first ionisation energies of some consecutive elements from Periods 2 and 3 of the Periodic Table.

The letters used to label the elements are **not** their chemical symbols.



(a) Which element has only **one** p orbital containing a pair of electrons?

(1)

- ☒ **A** element U
- ☒ **B** element V
- ☒ **C** element W
- ☒ **D** element X

(b) Which element is the least reactive?

(1)

- ☒ **A** element S
- ☒ **B** element X
- ☒ **C** element Y
- ☒ **D** element Z

(c) Which element has the greatest **second** ionisation energy?

(1)

- ☒ **A** element S
- ☒ **B** element T
- ☒ **C** element X
- ☒ **D** element Y

(Total for Question 11 = 3 marks)

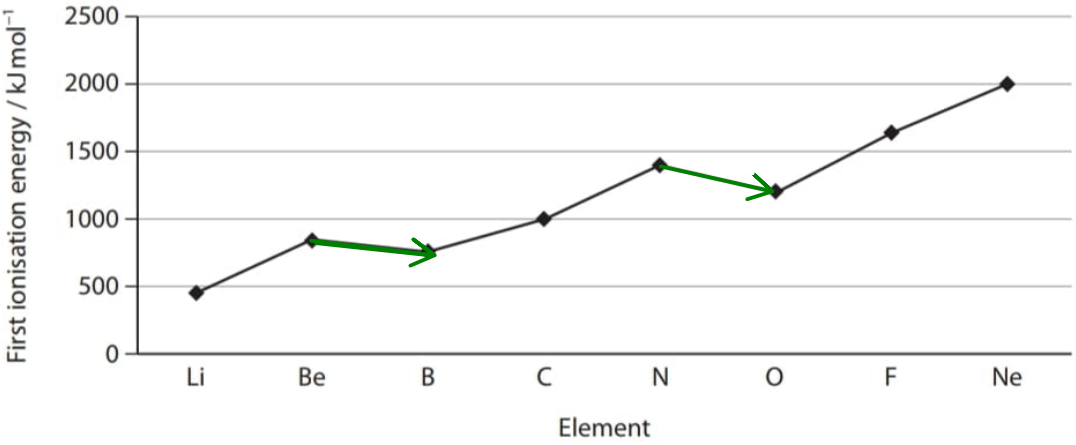
7 Which equation represents the first ionisation energy of iodine?

- ☒ **A** $I_2(s) \rightarrow 2I^+(g) + 2e^-$
- ☒ **B** $I_2(g) \rightarrow 2I^+(g) + 2e^-$
- ☒ **C** $\frac{1}{2}I_2(s) \rightarrow I^+(g) + e^-$
- ☒ **D** $I(g) \rightarrow I^+(g) + e^-$

(Total for Question 7 = 1 mark)

23 This question is about the ionisation energies of the elements in Period 2 of the Periodic Table.

(a) The first ionisation energies of the Period 2 elements are shown.



(i) Give an equation that represents the first ionisation energy of lithium. Include state symbols.

(1)

$Li_{(g)} \rightarrow Li^+_{(g)} + e^-$

(ii) Explain why there is a general increase in the first ionisation energy across the period.

(2)

Stron Attraction.

(iii) Explain why the first ionisation energy of oxygen is lower than that of nitrogen.

(2)

$e^- - e^-$ Repulsion compared to N; so it make oxygen least stable compared to N configuration

(b) All the successive ionisation energies of nitrogen are shown in the table.

Ionisation number	1	2	3	4	5	6	7
Ionisation energy / kJ mol^{-1}	1402	2856	4578	7475	9445	53 267	64 360

Explain the trend in the successive ionisation energies of nitrogen.

(2)

1. State the three factors that determine the magnitude of the first ionisation energy of an element.

2. Write equations to represent:

(a) the first ionisation energy of sodium

(b) the second ionisation energy of calcium

(c) the third ionisation energy of carbon.

3. Draw a sketch graph for the logarithm to base 10 for the successive ionisation energies of phosphorus.

4. The table below shows the first four ionisation energies, in kJ mol^{-1}, of five elements: A, B, C, D and E.

ELEMENT	FIRST IONISATION ENERGY	SECOND IONISATION ENERGY	THIRD IONISATION ENERGY	FOURTH IONISATION ENERGY
A	496	4563	6913	9544
B	738	1451	7733	10 541
C	578	1817	2745	11 578
D	900	1757	14 849	21 007
E	631	1235	2389	7089

(a) Which two elements are in the same group of the Periodic Table? Explain your answer.

(b) In which group of the Periodic Table is element C likely to occur? Explain your answer.

(c) Which element requires the least amount of energy to form a 2+ ion? Explain your answer.

5. The first four ionisation energies, in kJ mol^{-1}, of calcium are 590, 1145, 4912 and 6474.

(a) Explain why the second ionisation energy of calcium is larger than the first.

(b) Explain why the third ionisation energy is much larger than the second.