1 This question is about the elements in Period 3 of the Periodic Table.

(a) State the element in Period 3 that has the highest melting point.
Explain your answer.

Element .....

Explanation .....

.....

.....

.....

.....

(3)

(b) State the element in Period 3 that has the highest first ionisation energy.
Explain your answer.

Element .....

Explanation .....

.....

.....

.....

.....

(3)

(c) Suggest the element in Period 3 that has the highest electronegativity value.

.....

(1)

(d) Chlorine is a Period 3 element.
Chlorine forms the molecules ClF_3 and CCl_2

(i) Use your understanding of electron pair repulsion to draw the shape of ClF_3 and the shape of CCl_2
Include any lone pairs of electrons that influence the shape.

Shape of ClF_3 Shape of CCl_2

(2)

(ii) Name the shape of CCl_2

.....

(1)

(iii) Write an equation to show the formation of one mole of ClF_3 from its elements.

.....

(1)

(Total 11 marks)

2 Which of these elements has the highest second ionisation energy?

A Na ⬭

B Mg ⬭

C Ne ⬭

D Ar ⬭

(Total 1 mark)

3 (a) Explain why the atomic radii of the elements decrease across Period 3 from sodium to chlorine.

.....

.....

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.....

(2)

(b) Explain why the melting point of sulfur (S_8) is greater than that of phosphorus (P_4).

.....

.....

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.....

(2)

(c) Explain why sodium oxide forms an alkaline solution when it reacts with water.

.....

.....

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.....

.....

(2)

(d) Write an ionic equation for the reaction of phosphorus(V) oxide with an excess of sodium hydroxide solution.

.....

(1)

(Total 7 marks)

4 (a) Nickel is a metal with a high melting point.

(i) State the block in the Periodic Table that contains nickel.

.....

(1)

(ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

.....

.....

.....

.....

.....

(2)

(iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel. In your answer, include at least six particles of each type.

(2)

(iv) Explain why nickel is ductile (can be stretched into wires).

.....

.....

.....

(1)

(b) Nickel forms the compound nickel(II) chloride ($NiCl_2$).

(i) Give the full electron configuration of the Ni^{2+} ion.

.....

(1)

(ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using $SOCl_2$
Identify **one** substance that could react with both gaseous products.

.....$NiCl_2.6H_2O(s)$ + ... $SOCl_2(g)$ ⟶ .....$NiCl_2(s)$ + ...$SO_2(g)$ + ...$HCl(g)$

Substance .....

(2)
(Total 9 marks)

5 The elements in Period 2 show periodic trends.

(a) Identify the Period 2 element, from carbon to fluorine, that has the largest atomic radius. Explain your answer.

Element .....

Explanation .....

.....

.....

.....

(3)

(b) State the general trend in first ionisation energies from carbon to neon.
Deduce the element that deviates from this trend and explain why this element deviates from the trend.

Trend .....

Element that deviates .....

Explanation .....

.....

.....

.....

(4)

(c) Write an equation, including state symbols, for the reaction that occurs when the first ionisation energy of carbon is measured.

.....

(1)

(d) Explain why the second ionisation energy of carbon is higher than the first ionisation energy of carbon.

.....

.....

.....

.....

(1)

(e) Deduce the element in Period 2, from lithium to neon, that has the highest second ionisation energy.

.....

(1)
(Total 10 marks)

6 The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb

(a) State the number of protons and the number of neutrons in an atom of the isotope ^{85}Rb

Number of protons .....

Number of neutrons .....

(2)

(b) (i) Explain how the gaseous atoms of rubidium are ionised in a mass spectrometer

.....

.....

.....

.....

(2)

(ii) Write an equation, including state symbols, to show the process that occurs when the **first** ionisation energy of rubidium is measured.

.....

(1)

(c) The table shows the first ionisation energies of rubidium and some other elements in the same group.

Element	sodium	potassium	rubidium
First ionisation energy / kJ mol^{-1}	494	418	402

State **one** reason why the first ionisation energy of rubidium is lower than the first ionisation energy of sodium.

.....

.....

.....

(1)

(d) (i) State the block of elements in the Periodic Table that contains rubidium.

.....

(1)

(ii) Deduce the full electron configuration of a rubidium atom.

.....

(1)

(e) A sample of rubidium contains the isotopes ^{85}Rb and ^{87}Rb only.
The isotope ^{85}Rb has an abundance 2.5 times greater than that of ^{87}Rb

Calculate the relative atomic mass of rubidium in this sample.
Give your answer to one decimal place.

.....

.....

.....

.....

(3)

(f) By reference to the relevant part of the mass spectrometer, explain how the abundance of an isotope in a sample of rubidium is determined.

Name of relevant part .....

Explanation .....

.....

.....

(2)

(g) Predict whether an atom of ^{88}Sr will have an atomic radius that is larger than, smaller than or the same as the atomic radius of ^{87}Rb. Explain your answer.

Atomic radius of ^{88}Sr compared to ^{87}Rb .....

Explanation .....

.....

.....

.....

(3)
(Total 16 marks)

7 Trends in physical properties occur across all Periods in the Periodic Table.
This question is about trends in the Period 2 elements from lithium to nitrogen.

(a) Identify, from the Period 2 elements lithium to nitrogen, the element that has the largest atomic radius.

.....

(1)

(b) (i) State the general trend in first ionisation energies for the Period 2 elements lithium to nitrogen.

.....

(1)

(ii) Identify the element that deviates from this general trend, from lithium to nitrogen, and explain your answer.

Element .....

Explanation .....

.....

.....

(Extra space) .....

.....

(3)

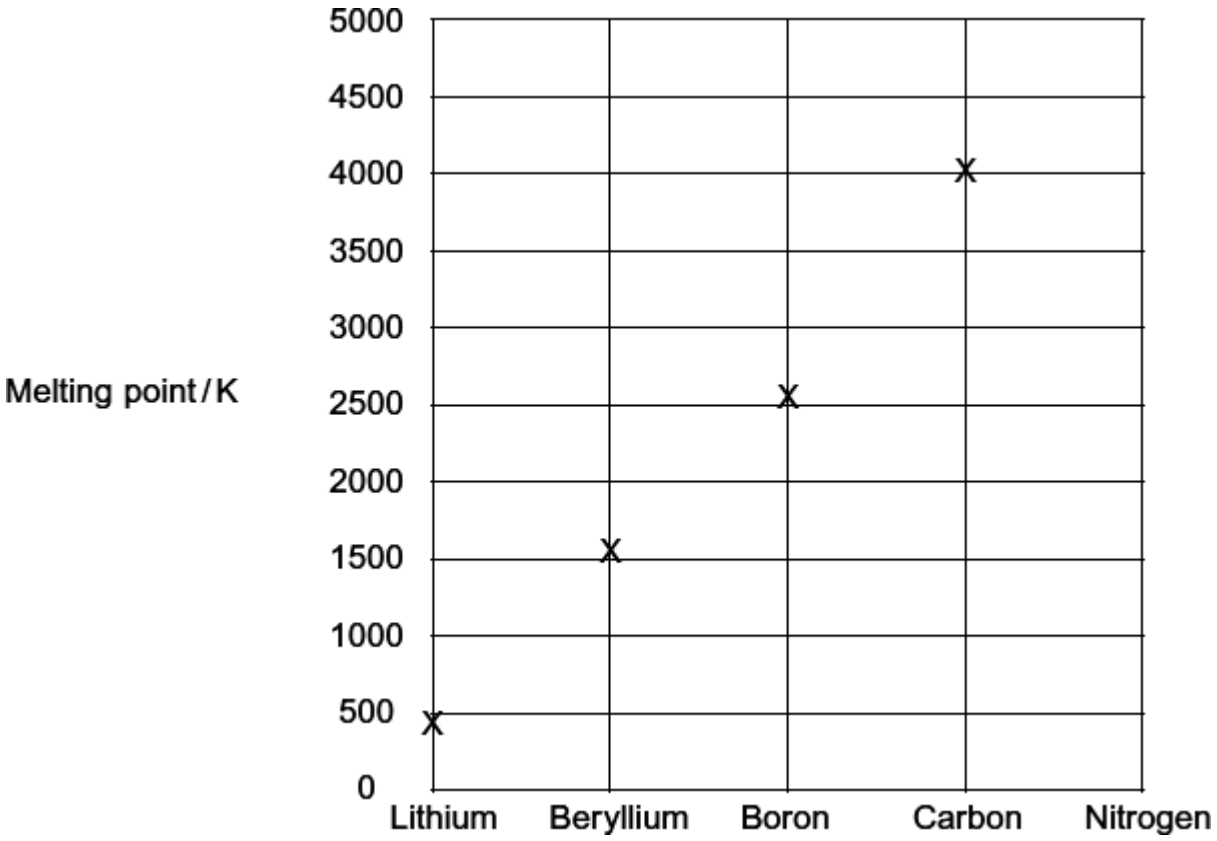
(c) Identify the Period 2 element that has the following successive ionisation energies.

	First	Second	Third	Fourth	Fifth	Sixth
Ionisation energy / kJ mol^{-1}	1090	2350	4610	6220	37 800	47 000

.....

(1)

(d) Draw a cross on the diagram to show the melting point of nitrogen.



(1)

(e) Explain, in terms of structure and bonding, why the melting point of carbon is high.

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(3)
(Total 10 marks)

8 This question is about the first ionisation energies of some elements in the Periodic Table.

(a) Write an equation, including state symbols, to show the reaction that occurs when the first ionisation energy of lithium is measured.

.....

(1)

(b) State and explain the general trend in first ionisation energies for the Period 3 elements aluminium to argon.

Trend .....

Explanation .....

.....

.....

(Extra space).....

.....

(3)

(c) There is a similar general trend in first ionisation energies for the Period 4 elements gallium to krypton.

State how selenium deviates from this general trend and explain your answer.

How selenium deviates from this trend .....

Explanation .....

.....

.....

(Extra space).....

(3)

(d) Suggest why the first ionisation energy of krypton is lower than the first ionisation energy of argon.

.....

.....

.....

(1)

(e) The table below gives the successive ionisation energies of an element.

	First	Second	Third	Fourth	Fifth
Ionisation energy / kJ mol^{-1}	590	1150	4940	6480	8120

Deduce the group in the Periodic Table that contains this element.

.....

(1)

(f) Identify the element that has a 5+ ion with an electron configuration of
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$

.....

(1)
(Total 10 marks)

9 Indium is in Group 3 in the Periodic Table and exists as a mixture of the isotopes ^{113}In and ^{115}In.

(a) Use your understanding of the Periodic Table to complete the electron configuration of indium.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$ .....

(1)

(b) A sample of indium must be ionised before it can be analysed in a mass spectrometer.

(i) State what is used to ionise a sample of indium in a mass spectrometer.

.....

.....

(1)

(ii) Write an equation, including state symbols, for the ionisation of indium that requires the minimum energy.

.....

(1)

(iii) State why more than the minimum energy is **not** used to ionise the sample of indium.

.....

.....

(1)

(iv) Give two reasons why the sample of indium must be ionised.

Reason 1 .....

Reason 2 .....

(2)

(c) A mass spectrum of a sample of indium showed two peaks at *m/z* = 113 and *m/z* = 115.
The relative atomic mass of this sample of indium is 114.5

(i) Give the meaning of the term *relative atomic mass*.

.....

.....

.....

.....

(2)

(ii) Use these data to calculate the ratio of the relative abundances of the two isotopes.

.....

.....

.....

(2)

(d) State and explain the difference, if any, between the chemical properties of the isotopes ^{113}In and ^{115}In

Difference in chemical properties .....

Explanation .....

(2)

(e) Indium forms a compound **X** with hydrogen and oxygen. Compound **X** contains 69.2% indium and 1.8% hydrogen by mass.
Calculate the empirical formula of compound **X**.

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(3)
(Total 15 marks)

10 The following table gives the melting points of some elements in Period 3.

Element	Na	Al	Si	P	S
Melting point / K	371	933	1680	317	392

(a) State the type of structure shown by a crystal of silicon.
Explain why the melting point of silicon is very high.

.....

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(3)

(b) State the type of structure shown by crystals of sulfur and phosphorus.
Explain why the melting point of sulfur is higher than the melting point of phosphorus.

.....

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(3)

(c) Draw a diagram to show how the particles are arranged in aluminium and explain why aluminium is malleable.
(You should show a minimum of six aluminium particles arranged in two dimensions.)

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(3)

(d) Explain why the melting point of aluminium is higher than the melting point of sodium.

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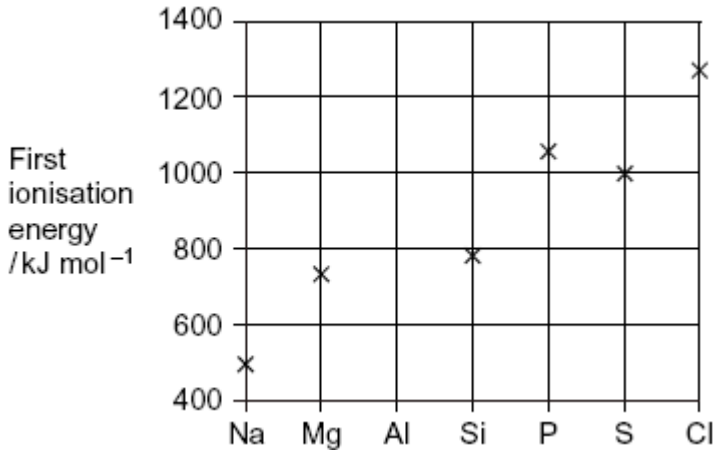
.....

.....

(3)

(Total 12 marks)

11 The following diagram shows the first ionisation energies of some Period 3 elements.



(a) Draw a cross on the diagram to show the first ionisation energy of aluminium.

(1)

(b) Write an equation to show the process that occurs when the first ionisation energy of aluminium is measured.

.....

(2)

(c) State which of the first, second or third ionisations of aluminium would produce an ion with the electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^1$

.....

(1)

(d) Explain why the value of the first ionisation energy of sulfur is less than the value of the first ionisation energy of phosphorus.

.....

.....

.....

.....

(2)

(e) Identify the element in Period 2 that has the highest first ionisation energy and give its electron configuration.

Element .....

Electron configuration .....

(2)

(f) State the trend in first ionisation energies in Group 2 from beryllium to barium. Explain your answer in terms of a suitable model of atomic structure.

Trend .....

Explanation .....

.....

.....

.....

(3)

(Total 11 marks)

12 Ionisation energies provide evidence for the arrangement of electrons in atoms.

(a) Complete the electron configuration of the Mg^+ ion.

$1s^2$ .....

(1)

(b) (i) State the meaning of the term *first ionisation energy*.

.....

.....

.....

(2)

(ii) Write an equation, including state symbols, to show the reaction that occurs when the **second** ionisation energy of magnesium is measured.

.....

(1)

(iii) Explain why the second ionisation energy of magnesium is greater than the first ionisation energy of magnesium.

.....

.....

.....

(1)

(iv) Use your understanding of electron arrangement to complete the table by suggesting a value for the third ionisation energy of magnesium.

	First	Second	Third	Fourth	Fifth
Ionisation energies of magnesium / kJ mol^{-1}	736	1450		10 500	13 629

(1)

(c) State and explain the general trend in the first ionisation energies of the Period 3 elements sodium to chlorine.

Trend .....

Explanation .....

.....

.....

(3)

(d) State how the element sulfur deviates from the general trend in first ionisation energies across Period 3. Explain your answer.

How sulfur deviates from the trend .....

.....

Explanation .....

.....

.....

(3)

(e) A general trend exists in the first ionisation energies of the Period 2 elements lithium to fluorine. Identify **one** element which deviates from this general trend.

.....

(1)

(Total 13 marks)

13 (a) Complete the electronic configuration for the sodium ion, Na^+

$1s^2$ .....

(1)

(b) (i) Write an equation, including state symbols, to represent the process for which the energy change is the second ionisation energy of sodium.

.....

(2)

(ii) Explain why the second ionisation energy of sodium is greater than the second ionisation energy of magnesium.

.....

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.....

.....

(3)

(iii) An element **X** in Period 3 of the Periodic Table has the following successive ionisation energies.

	First	Second	Third	Fourth
Ionisation energies / kJ mol^{-1}	577	1820	2740	11600

Deduce the identity of element **X**.

.....

(1)

(c) State and explain the trend in atomic radius of the Period 3 elements from sodium to chlorine.

Trend .....

Explanation .....

.....

.....

(3)

(d) Explain why sodium has a lower melting point than magnesium.

.....

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.....

(3)

(e) Sodium reacts with ammonia to form the compound $NaNH_2$ which contains the NH_2^- ion.

Draw the shape of the NH_2^- ion, including any lone pairs of electrons.

Name the shape made by the three atoms in the NH_2^- ion.

Shape of NH_2^-

Name of shape .....

(2)

(f) In terms of its electronic configuration, give **one** reason why neon does not form compounds with sodium.

.....

(1)

(Total 16 marks)

14 This question is about the elements in Period 3 from Na to P

(a) (i) Explain the meaning of the term *first ionisation energy*.

.....

.....

.....

(2)

(ii) State and explain the general trend in first ionisation energies for the elements Na to P

Trend .....

Explanation .....

.....

.....

(3)

(iii) State which one of the elements from Na to P deviates from this general trend and explain why this occurs.

Trend .....

Explanation .....

.....

.....

(3)

(b) State which one of the elements from Na to P has the highest melting point and explain your answer.

Element .....

Explanation .....

.....

.....

(3)

(Total 11 marks)

15 The elements phosphorus, sulfur, chlorine and argon are in the p block of the Periodic Table.

(a) State why these elements are classified as p block elements.

.....

(1)

(b) State the trend in atomic radius from phosphorus to chlorine and explain the trend.

Trend .....

Explanation .....

.....

.....

(3)

(c) In terms of structure and bonding, explain why sulfur has a higher melting point than phosphorus.

.....

.....

.....

.....

(3)

(d) In terms of atomic structure, explain why the van der Waals' forces in liquid argon are very weak.

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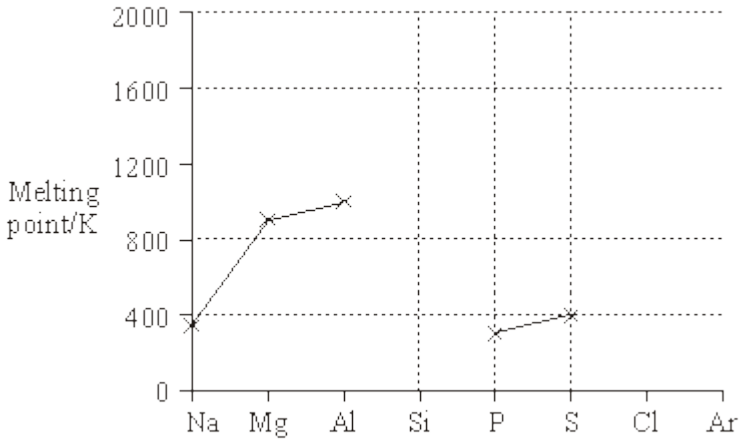
.....

(2)

(Total 9 marks)

16 (a) The diagram below shows the melting points of some of the elements in Period 3.



(i) On the diagram, use crosses to mark the approximate positions of the melting points for the elements silicon, chlorine and argon. Complete the diagram by joining the crosses.

(ii) By referring to its structure and bonding, explain your choice of position for the melting point of silicon.

.....

.....

.....

(iii) Explain why the melting point of sulphur, S_8, is higher than that of phosphorus, P_4

.....

.....

(8)

(b) State and explain the trend in melting point of the Group II elements Ca–Ba.

Trend .....

Explanation .....

.....

.....

(3)
(Total 11 marks)

17 (a) State the meaning of the term *first ionisation energy* of an atom.

.....

.....

(2)

(b) Complete the electron arrangement for the Mg^{2+} ion.

1s^2 .....

(1)

(c) Identify the block in the Periodic Table to which magnesium belongs.

.....

(1)

(d) Write an equation to illustrate the process occurring when the **second** ionisation energy of magnesium is measured.

.....

(1)

(e) The Ne atom and the Mg^{2+} ion have the same number of electrons. Give **two** reasons why the first ionisation energy of neon is lower than the third ionisation energy of magnesium.

Reason 1 .....

Reason 2 .....

(2)

(f) There is a general trend in the first ionisation energies of the Period 3 elements, Na – Ar

(i) State and explain this general trend.

Trend ....

Explanation .....

.....

.....

(ii) Explain why the first ionisation energy of sulphur is lower than would be predicted from the general trend.

.....

.....

.....

(5)
(Total 12 marks)

18 (a) When aluminium is added to an aqueous solution of copper(II) chloride, $CuCl_2$, copper metal and aluminium chloride, $AlCl_3$, are formed. Write an equation to represent this reaction.

.....

(1)

(b) (i) State the general trend in the first ionisation energy of the Period 3 elements from Na to Ar.

.....

(ii) State how, and explain why, the first ionisation energy of aluminium does not follow this general trend.

.....

.....

.....

.....

(4)

(c) Give the equation, including state symbols, for the process which represents the second ionisation energy of aluminium.

.....

(1)

(d) State and explain the trend in the melting points of the Period 3 metals Na, Mg and Al.

Trend .....

Explanation .....

.....

.....

(3)
(Total 9 marks)

19 Which one of the following statements is correct?

A The first ionisation energies of the elements in Period 3 show a general decrease from sodium to chlorine.

B The electronegativities of Group 2 elements decrease from magnesium to barium.

C The strength of the intermolecular forces increases from hydrogen fluoride to hydrogen chloride.

D The ability of a halide ion to act as a reducing agent decreases from fluoride to iodide.

(Total 1 mark)

20 (a) (i) Complete the electronic configuration of aluminium.

$1s^2$ .....

(ii) State the block in the Periodic Table to which aluminium belongs.

.....

(2)

(b) Describe the bonding in metals.

.....

.....

.....

(2)

(c) Explain why the melting point of magnesium is higher than that of sodium.

.....

.....

.....

.....

(3)

(d) Explain how metals conduct electricity.

.....

.....

.....

(2)

(Total 9 marks)

21 (a) Complete the following table.

Particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

(3)

(b) An atom of element **Z** has two more protons and two more neutrons than an atom of $^{34}_{16}S$.
Give the symbol, including mass number and atomic number, for this atom of **Z.**

.....

(2)

(c) Complete the electronic configurations for the sulphur atom, S, and the sulphide ion, S^{2-}.

S $1s^2$ .....

S^{2-} $1s^2$ .....

(2)

(d) State the block in the Periodic Table in which sulphur is placed and explain your answer.

Block .....

Explanation .....

(2)

(e) Sodium sulphide, Na_2S, is a high melting point solid which conducts electricity when molten. Carbon disulphide, CS_2, is a liquid which does not conduct electricity.

(i) Deduce the type of bonding present in Na_2S and that present in CS_2

Bonding in Na_2S .....

Bonding in CS_2.....

(ii) By reference to all the atoms involved explain, in terms of electrons, how Na_2S is formed from its atoms.

.....

.....

(iii) Draw a diagram, including all the outer electrons, to represent the bonding present in CS_2

(iv) When heated with steam, CS_2 reacts to form hydrogen sulphide, H_2S, and carbon dioxide.
Write an equation for this reaction.

.....

(7)
(Total 16 narks)

22 (a) Explain why certain elements in the Periodic Table are classified as p-block elements. Illustrate your answer with an example of a p-block element and give its electronic configuration.

(3)

(b) Explain the meaning of the term *periodicity* as applied to the properties of rows of elements in the Periodic Table. Describe and explain the trends in atomic radius, in electronegativity and in conductivity for the elements sodium to argon.

(13)
(Total 16 marks)

23

(a) **P** and **Q** are oxides of Period 3 elements.

Oxide **P** is a solid with a high melting point. It does not conduct electricity when solid but does conduct when molten or when dissolved in water. Oxide **P** reacts with water forming a solution with a high pH.

Oxide **Q** is a colourless gas at room temperature. It dissolves in water to give a solution with a low pH.

(i) Identify **P**. State the type of bonding present in **P** and explain its electrical conductivity. Write an equation for the reaction of **P** with water.

(ii) Identify **Q**. State the type of bonding present in **Q** and explain why it is a gas at room temperature. Write an equation for the reaction of **Q** with water.

(9)

(b) **R** is a hydroxide of a Period 3 element. It is insoluble in water but dissolves in both aqueous sodium hydroxide and aqueous sulphuric acid.

(i) Give the name used to describe this behaviour of the hydroxide.

(ii) Write equations for the reactions occurring.

(iii) Suggest why **R** is insoluble in water.

(6)
(Total 15 marks)

24

(a) State the meaning of the term *electronegativity*.

.....

.....

(2)

(b) State and explain the trend in electronegativity values across Period 3 from sodium to chlorine.

Trend .....

Explanation .....

(3)

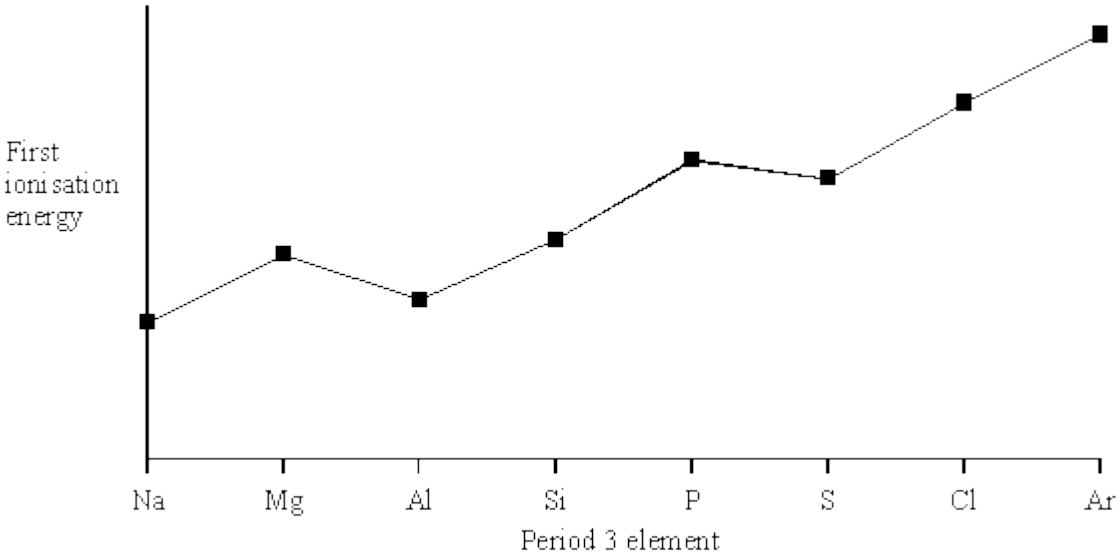
(c) What is meant by the term *first ionisation energy*?

.....

.....

(2)

(d) The diagram below shows the variation in first ionisation energy across Period 3.



(i) What is the maximum number of electrons that can be accommodated in an s sub-level?

.....

.....

(ii) What evidence from the diagram supports your answer to part (d)(i)?

.....

.....

(iii) What evidence from the diagram supports the fact that the 3p sub-level is higher in energy than the 3s?

.....

.....

(iv) What evidence from the diagram supports the fact that no more than three unpaired electrons can be accommodated in the 3p sub-level?

.....

.....

.....

(5)
(Total 12 marks)

1

(a) Silicon / Si

If not silicon then CE = 0 / 3

1

covalent (bonds)

M3 dependent on correct M2

1

Strong or many of the (covalent) bonds need to be broken / needs a lot of energy to break the (covalent) bonds

Ignore hard to break

1

(b) Argon / Ar

If not argon then CE = 0 / 3. But if Kr chosen, lose M1 and allow M2+M3

1

Large(st) number of protons / large(st) nuclear charge

Ignore smallest atomic radius

1

Same amount of shielding / same number of shells / same number of energy levels

Allow similar shielding

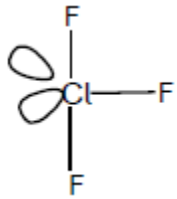
1

(c) Chlorine / Cl

*Not Cl_2, Not C**L**, Not Cl^2*

1

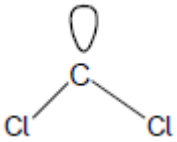
(d) (i)



Or any structure with 3 bonds and 2 lone pairs

Ignore any angles shown

1



Or a structure with 2 bonds and 1 lone pair

1

(ii) Bent / v shape

Ignore non-linear, angular and triangular

Apply list principle

1

(iii) $\frac{1}{2}Cl_2 + \frac{3}{2}F_2 \longrightarrow ClF_3$

No multiples

Ignore state symbols

1

[11]

2 A

[1]

3 (a) The number of protons increases (across the period) / nuclear charge increases

1

Therefore, the attraction between the nucleus and electrons increases

Can only score M2 if M1 is correct

1

(b) S_8 molecules are bigger than P_4 molecules

Allow sulfur molecules have bigger surface area and sulfur molecules have bigger M_r

1

Therefore, van der Waals / dispersion / London forces between molecules are stronger in sulfur

1

(c) Sodium oxide contains O^{2-} ions

1

These O^{2-} ions react with water forming OH^- ions

$O^{2-} + H_2O \longrightarrow 2OH^-$ scores M1 and M2

1

(d) $P_4O_{10} + 12OH^- \longrightarrow 4PO_4^{3-} + 6H_2O$

1

[7]

4 (a) (i) d (block) **OR** D (block)

Ignore transition metals / series.

Do not allow any numbers in the answer.

1

(ii) Contains positive (metal) ions or protons or nuclei and <u>delocalised / mobile / free / sea of</u> electrons

Ignore atoms.

1

<u>Strong attraction</u> between them or <u>strong metallic</u> bonds

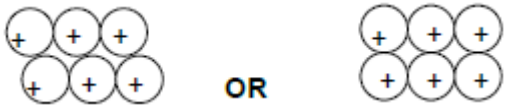
Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

If strong attraction between incorrect particles, then CE = 0 / 2.

If molecules / intermolecular forces / covalent bonding / ionic bonding mentioned then CE=0.

1

(iii)



OR

M1 is for regular arrangement of atoms / ions (min 6 metal particles).

M2 for + sign in each metal atom / ion.

Allow 2^+ sign.

2

(iv) <u>Layers / planes / sheets of atoms or ions</u> can slide over one another

QoL.

1

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ (4s^0)$

Only.

1

(ii) $NiCl_2.6H_2O$ + **6** $SOCl_2 \longrightarrow NiCl_2$ + **6** SO_2 + **12** HCl

Allow multiples.

1

$NaOH$ / NH_3 / $CaCO_3$ / CaO

Allow any name or formula of alkali or base.

Allow water.

1

[9]

5 (a) Carbon / C

If M1 incorrect, CE = 0 / 3

1

Fewest protons / smallest nuclear charge / least attraction between protons (in the nucleus) and electrons / weakest nuclear attraction to electrons

Allow comparative answers.

Allow converse answers for M2

1

Similar shielding

Allow same shielding.

1

(b) Increase

1

Oxygen / O

If not oxygen, then cannot score M2, M3 and M4

1

Paired electrons in a (2)p orbital

If paired electrons in incorrect p orbital, lose M3 but can award M4

1

(Paired electrons in a p orbital) repel

1

(c) $C(g) \rightarrow C^{+}(g) + e^{(-)}$

OR

$C(g) + e^{(-)} \rightarrow C^{+}(g) + 2e^{(-)}$

OR

$C(g) - e^{(-)} \rightarrow C^{+}(g)$

Ignore state symbols for electron.

1

(d) (More energy to) remove an electron from a (more) positive ion / cation

Allow electron closer to the nucleus in the positive ion.

1

(e) Lithium / lithium / Li

If formula given, upper and lower case letters must be as shown.

1

[10]

6

(a) 37

These answers only.

Allow answers in words.

1

48

Ignore any sum(s) shown to work out the answers.

1

(b) (i) Electron gun / high speed/high energy electrons

Not just electrons.

Not highly charged electrons.

1

Knock out electron(s)

Remove an electron.

1

(ii) $Rb(g) \rightarrow Rb^{+}(g) + e^{(-)}$

OR

$Rb(g) + e^{(-)} \rightarrow Rb^{+}(g) + 2e^{(-)}$

OR

$Rb(g) - e^{(-)} \rightarrow Rb^{+}(g)$

Ignore state symbols for electron.

1

(c) Rb is a bigger (atom) / e further from nucleus / electron lost from a higher energy level/ More shielding in Rb / less attraction of nucleus in Rb for outer electron / more shells

Answer should refer to Rb not Rb molecule

If converse stated it must be obvious it refers to Na

Answer should be comparative.

1

(d) (i) s / block s / group s

Only

1

(ii) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^1$

Allow $3d^{10}$ before $4s^2$

Allow in any order.

1

(e) $\frac{(85 \times 2.5) + 87 \times 1}{3.5}$

M1 is for top line

1

1

$= \underline{85.6}$

Only

1

OR

$\frac{(58 \times 5) + 87 \times 2}{7}$

M1 ^{85}Rb 71.4% and ^{87}Rb 28.6%

M2 divide by 100

1

1

$\underline{85.6}$

M3 = <u>85.6</u>

1

(f) Detector

Mark independently

Allow detection (plate).

1

Current / digital pulses / electrical signal related to abundance

Not electrical <u>charge</u>.

1

(g) Smaller

Chemical error if not smaller, CE = 0/3

If blank mark on.

1

Bigger nuclear charge / more protons in Sr

Not bigger nucleus.

1

Similar/same shielding

QWC

(Outer) <u>electron</u> entering same shell/sub shell/orbital/same number of shells.

Do not allow incorrect orbital.

1

[16]

7

(a) Lithium / Li

Penalise obvious capital I (second letter).

1

(b) (i) Increase / gets bigger

Ignore exceptions to trend here even if wrong

1

(ii) Boron / B

If not Boron, CE = 0/3

1

Electron removed from (2)p orbital /sub-shell / (2)p electrons removed

If p orbital specified it must be 2p

1

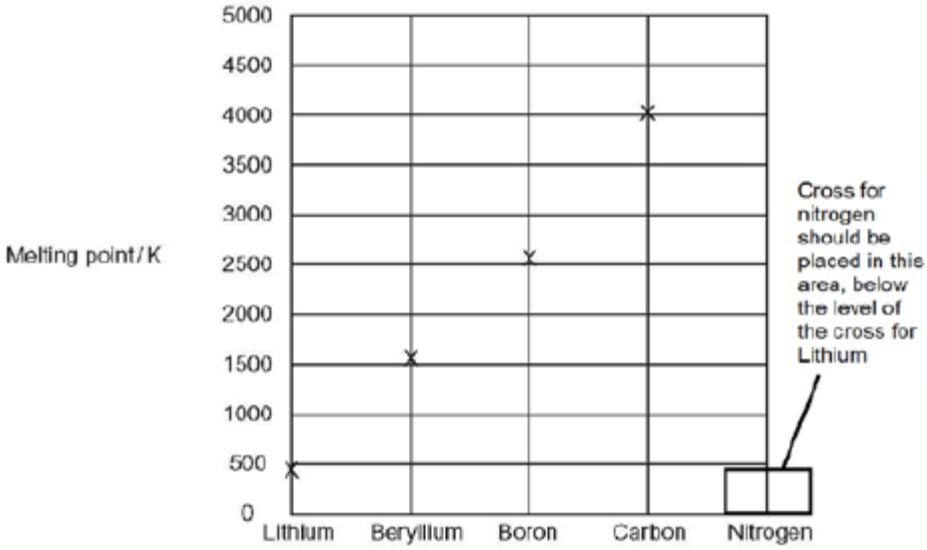
Which is higher in energy (so more easily lost) / more shielded (so more easily lost) / further from nucleus

1

(c) C / carbon

1

(d) Below Li



The cross should be placed on the diagram, on the column for nitrogen, below the level of the cross printed on the diagram for Lithium.

1

(e) Macromolecular / giant molecular / giant atomic

Allow giant covalent (molecule) = 2

1

Covalent bonds in the structure

1

Strong (covalent) bonds must be broken or overcome / (covalent) bonds need a lot of energy to break

Ignore weakening / loosening bonds

If ionic / metallic/molecular/ dipole dipole/ H bonds/ bonds between molecules, CE = 0/3

Ignore van der Waals forces

Ignore hard to break

1

[10]

8 (a) $Li(g) \rightarrow Li^+(g) + e^-(g)$

$Li(g) - e^-(g) \rightarrow Li^+(g)$

$Li(g) + e^-(g) \rightarrow Li^+(g) + 2e^-$

One mark for balanced equation with state symbols

Charge and state on electron need not be shown

1

(b) Increases

If trend wrong then CE = 0/3 for (b). If blank mark on.

1

Increasing nuclear charge / increasing no of protons

Ignore effective with regard to nuclear charge

1

Same or similar shielding / same no of shells / electron (taken) from same (sub)shell / electron closer to the nucleus / smaller atomic radius

1

(c) Lower

If not lower then CE = 0/3

1

Paired electrons in a (4) p orbital

If incorrect p orbital then M2 = 0

1

(Paired electrons) repel

If shared pair of electrons M2 + M3 = 0

1

(d) Kr is a bigger atom / has more shells / more shielding in Kr / electron removed further from nucleus/ electron removed from a higher (principal or main) energy level

CE if molecule mentioned

Must be comparative answer

QWC

1

(e) 2 / two / II

1

(f) Arsenic / As

1

[10]

9 (a) $\underline{4d^{10}\ 5s^2\ 5p^1}$ in any order

Allow subscripts for numbers

Allow capitals

1

(b) (i) Using an electron gun/(beam of) high energy/fast moving electrons

Ignore 'knocks out an electron'

1

(ii) $In(g) + e^- \rightarrow In^+(g) + 2e^-$

OR

$In(g) \rightarrow In^+(g) + e^-$

$In(g) - e^- \rightarrow In^+(g)$

The state symbols need not be present for the electron - but if they are they must be (g)

No need to show charge on electron

If I CE = 0

Ignore any equations using M

1

(iii) So no more than 1 electron is knocked out/so only one electron is knocked out/prevent further ionisation

Allow stop 2+ and 3+/other ions being formed

Not to get wrong m/z

1

(iv) Any two processes from

- Accelerate (owtte)
- Deflect (owtte)
- Detect (owtte)

Ignore wrong causes of process

2 max

(c) (i) Average/mean mass of (1) atom(s) (of an element)

1

1/12 mass of one atom of ^{12}C

1

OR

(Average) mass of one mole of atoms

1/12 mass of one mole of ^{12}C

OR

(Weighted) average mass of all the isotopes

1/12 mass of one atom of ^{12}C

OR

Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12

Not average mass of 1 molecule

Allow the wording Average mass of 1 atom of an element compared to 1/12 mass atom of ^{12}C (or mass 1/12 atom of ^{12}C)

Allow if moles of atoms on both lines

Accept answer in words

Can have top line × 12 instead of bottom line ÷12

If atoms/moles mixed, max = 1

(ii) $\frac{113x + 115y}{x + y} = 114.5$

Allow idea that there are 4 × 0.5 divisions between 113 and 115

1

ratio (113:115) = 1:3 **OR** 25:75 **OR** 0.5:1.5 etc

Correct answer scores M1 and M2

If 1:3 for In(115):In(113), max = 1

1

(d) None

1

Same no of electrons (in the outer shell)/same electron configuration)

Ignore electrons determine chemical properties/ignore protons

M2 dependent on M1 being correct

1

(e) 29.0%/29% O

If no O calculated, allow M2 if In and H divided by the correct A_r

1

$$\frac{69.2}{114.8/114.5} \qquad \frac{1.8}{1} \qquad \frac{29.0}{16}$$

1

or

0.603 1.8 1.81

1 3 3

EF = In H_3O_3

Allow $In(OH)_3$

Do not allow last mark just for ratio 1:3:3

If InO_3H_3 given with no working then allow 3 marks

If I not In, lose M3

1

[15]

10 (a) Macromolecular/giant covalent/giant molecular/giant atomic

If IMF/H-bonds/Ionic/metallic CE = 0/3

covalent bond between molecules CE = 0/3

If giant unqualified M1 = 0 but mark on

1

Many/strong covalent bonds

M2 and M3 can only be scored if covalent mentioned in answer

Ignore metalloid and carbon

Ignore bp

1

Bonds must be broken/overcome

Ignore numbers of bonds and references to energy

1

(b) (Simple) molecular

QoL

Do not allow simple covalent for M1

Giant covalent/ionic/metallic, CE = 0

If breaking covalent bonds CE= 0/3

1

S bigger molecule (than P) or S_8 and P_4 references

QoL

Allow more electrons in sulfur molecule or S_8

Do not allow S is bigger then P

Allow S molecule has a bigger M_r

Do not allow contradictions

1

So more/stronger van der Waals' forces (to be broken or overcome)

Not just more energy to break

1

(c) Regular arrangement of minimum of 6 particles in minimum of 2 rows

Ignore e–

Do not allow ring arrangements OR structures bonded with electrons

1

+ charge in each one (of 6)

Allow +, (1+, 2+ or 3+) in ions/or in words

1

Rows/planes/sheets/layers (of atoms/ions) can slide (owtte) over one another

M3 independent

If ionic bonding/molecules/IMF/vdw/covalent, penalise M3

Ignore layers of electrons sliding

1

(d) Bigger charge (3+ compared to 1+)

CE = 0 if molecules, ionic, covalent, IMF

(Allow Al^{2+})

OR smaller atom/ion in Al/more protons/bigger nuclear charge

1

More free/<u>delocalised</u> electrons (in Al)/bigger sea of electrons in Al

Accept 2 or 3 delocalised electrons compared to 1 in Na

1

Stronger metallic bonding/stronger (electrostatic) attraction between the (+) ions or nuclei and the (delocalised) electrons (or implied)

Must be implied that the electrons are the delocalised ones not the electrons in the shells.

Accept converse arguments

1

[12]

11 (a) Cross between the Na cross and the Mg cross

1

(b) $Al(g) \rightarrow Al^{+}(g) + e–$

$Al(g) – e– \rightarrow Al^{+}(g)$

$Al(g) + e– \rightarrow Al^{+}(g) + 2e–$

One mark for state symbols consequential on getting equation correct.

Electron does not have to have the – sign on it

Ignore (g) if put as state symbol with e^{-} but penalise state symbol mark if other state symbols on e^{-}

2

(c) 2^{nd}/second/2/II

Only

1

(d) Paired electrons <u>in (3)p orbital</u>

Penalise wrong number

If paired electrons repel allow M2

1

repel

1

(e) Neon/Ne

No consequential marking from wrong element

1

$1s^2 2s^2 2p^6$/[He}$2s^2 2p^6$

Allow capital s and p
Allow subscript numbers

1

(f) Decreases

CE if wrong

1

Atomic radius increases/electron removed further from nucleus
or nuclear charge/electron in higher energy level/Atoms
get larger/more shells

Accept more repulsion between more electrons for M2
Mark is for distance from nucleus
Must be comparative answers from M2 and M3
CE M2 and M3 if mention molecules
Not more sub-shells

1

As group is descended more shielding

1

[11]

12 (a) $2s^2 2p^6 3s^1$

$1s^2$ can be rewritten
Allow $2s^2 2p_x^2 2p_y^2 2p_z^2 3s^1$
Allow subscripts and capitals

1

(b) (i) Energy/enthalpy (needed) to remove one mole of electrons from one mole of atoms/compounds/molecules/elements

1

OR

Energy to form one mole of positive ions from one mole of atoms

OR

Energy/enthalpy to remove one electron from one atom

In the gaseous state (to form 1 mol of gaseous ions)

Energy given out loses M1

M2 is dependent on a reasonable attempt at M1

Energy needed for this change

$X(g) \rightarrow X^{+}(g) + e^{(-)}$ = 2 marks

This equation alone scores one mark

1

(ii) $Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{(-)}$

$Mg^{+}(g) + e^{(-)} \rightarrow Mg^{2+}(g) + 2e^{(-)}$

$Mg^{+}(g) - e^{(-)} \rightarrow Mg^{2+}(g)$

Do not penalise MG

Not equation with X

1

(iii) Electron being removed from a positive ion (therefore need more energy)/electron being removed is closer to the nucleus/Mg^{+} smaller (than Mg)/Mg^{+} more positive than Mg

Allow from a + particle/species

Not electron from a higher energy level/or higher sub-level

More protons = 0

1

(iv) Range from 5000 to 9000 kJ mol^{-1}

1

(c) Increase

If decrease CE = 0/3

If blank mark on

1

Bigger nuclear <u>charge</u> (from Na to Cl)/more <u>protons</u>

QWC

1

electron (taken) from same (sub)shell/similar or same shielding/ electron closer to the nucleus/smaller atomic radius

If no shielding = 0

Smaller ionic radius = 0

1

(d) Lower

If not lower CE = 0/3
If blank mark on
Allow does not increase

1

Two/pair of electrons in (3)p orbital or implied

Not 2p

1

repel (each other)

M3 dependent upon a reasonable attempt at M2

1

(e) Boron/B or oxygen/O/O_2

1

[13]

13 (a) $2s^2\ 2p^6$;

If ignored the $1s^2$ given and written $1s^2 2s^2 2p^6$ mark as correct
Allow capitals and subscripts

1

(b) (i) $Na^+(g) \rightarrow Na^{2+}(g) + e^{(-)}$;

One mark for equation and one mark for state symbols

$Na^+(g) + e^{(-)} \rightarrow Na^{2+}(g) + 2e^{(-)}$;

M2 dependent on M1
Allow $Na^+(g) - e^{(-)} \rightarrow Na(g)$
Allow $X^+(g) \rightarrow X^{2+}(g) + e$ = 1 mark

2

(ii) $Na^{(2+)}$ requires loss of e^- from a 2(p) orbital or 2nd energy level or 2nd shell and $Mg^{(2+)}$ requires loss of e^- from a 3(s) orbital or 3rd energy level or 3rd shell / $Na^{(2+)}$ loses e from a lower (energy) orbital/ or vice versa;

Not from 3p

1

Less shielding (in Na);

Or vice versa for Mg

1

$e^{(-)}$ closer to nucleus/ more attraction (of electron to nucleus) (in Na);

M3 needs to be comparative

1

(iii) Aluminium /Al;

1

(c) Decreases;

If not decreases CE = 0
If blank, mark on

1

Increasing nuclear charge/ increasing number of protons;

1

Electrons in same shell or level/ same shielding/ similar shielding;

1

(d) Answer refers to Na;

Allow converse answers relating to Mg.

Na fewer protons/smaller nuclear charge/ fewer delocalised electrons;

Allow Mg is 2+ and Na is +.
If vdw CE = 0.

1

Na is a bigger ion/ atom;

1

Smaller attraction between nucleus and delocalised electrons;

If mentioned that charge density of Mg^{2+} is greater then allow first 2 marks.
(ie charge / size / attraction).
M3 allow weaker metallic bonding.

1

(e) (Bent) shape showing 2 lone pairs + 2N−H bond pairs;

Atoms must be labelled.
Lone pairs can be with or without lobes.

1

Bent / v shape/ triangular;

Not tetrahedral.
Allow non-linear.
Bent-linear = contradiction.

1

(f) Ne has full sub-levels/ can't get any more electrons in the sub-levels/
Ne has full shells;

Not $2s^2\ 2p^6$ alone.
Not stable electron configuration.

1

[16]

14 (a) (i) Energy/enthalpy (change)/ΔH/ needed to remove 1 mole of electrons;

Allow 1 electron
Not heat alone

1

From 1 mol of gaseous atoms;

From 1 gaseous atom
Not mix and match moles and one electron.
Allow 1 for balanced eq with ss

1

(ii) Increase;

If blank mark on
If incorrect CE = 0

1

Increasing nuclear charge/ increasing number of protons;

Not increasing atomic number

1

Same or similar shielding /same number of shells or energy levels/ (atomic) radius decreases/electron closer to nucleus;

Not same distance from nucleus.

1

(iii) Aluminium/Al;

If incorrect CE = 0

1

<u>Electron</u> in higher energy /p or 3p orbital;

Not 2p
Ignore shielding

1

Less energy needed to lose electron/ electron more easily lost/ ionisation energy less;

1

(b) Silicon/Si;

If incorrect CE = 0
If silicone, silica Si_8, Si_4 mark on.

1

Macromolecular/ Giant molecular or atomic or covalent;

If IMFor ionic or metallic in Silicon then CE = 0 for explanation

1

Many or strong <u>covalent</u> bonds need to be <u>broken</u>/
lots of energy needed to <u>break the covalent</u> bonds;

Not loosened bonds

1

[11]

15 (a) Outer electrons are in p orbitals

1

(b) decreases

1

Number of protons increases

1

Attracting outer electrons in the same shell (or similar shielding)

1

(c) Sulfur molecules (S_8) are larger than phosphorus (P_4)

1

Therefore van der Waals' forces between molecules are stronger

1

Therefore more energy needed to loosen forces between molecules

1

(d) Argon particles are single atoms with electrons closer to nucleus

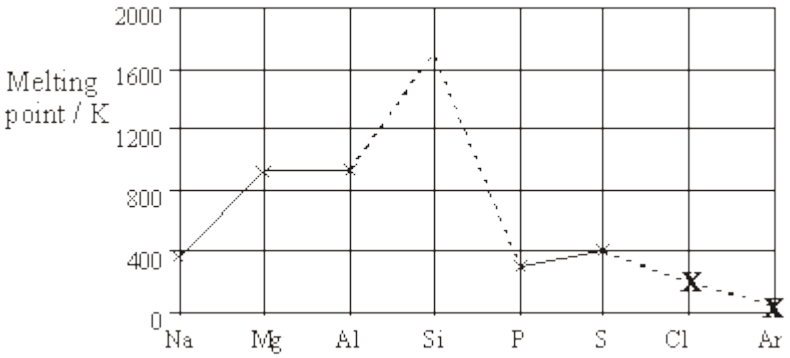
1

Cannot easily be polarised (or electron cloud not easily distorted)

1

[9]

16 (a) (i)



M1 Si: cross ≥ 1200

1

M2 Cl: cross below S

1

M3 Ar: cross below Cl

[allow, even if M2 wrong)

[If Cl cross missing and Ar below S, allow M3]

1

(ii) Si is macromolecular/giant molecular/giant covalent/ giant atomic

1

Covalent bonds need to be broken/accept 'overcome'

[Not loosened/weakened]

1

Covalent bonds are strong / many covalent bonds involved/ requires much energy/hard to break

[Tied to 'break' or near miss in M2] [Not 'structure' is broken]

[Must mention 'covalent' somewhere in part (a)(ii) to earn M2/M3]

[If van der Waals'/IMF mentioned M2/M3 = CE = 0.

[If ions mentioned M1/M2/M3 = CE = 0]

1

(iii) Intermolecular force = van der Waals'/induced dipole–dipole/dispersion forces

1

QoL Sulphur has greater M_r / size / surface area/more electrons/more atoms **so** stronger intermolecular forces (comparison)

[Mark separately] [Not 'more shells']

1

(b) Trend: Decreases

[If trend wrong = CE = 0]

1

Increase in size of ion/atom / more shells / decrease in charge density / decrease in charge size ratio

1

Weaker attraction for delocalised/free/sea of electrons / weaker metallic bonding

[Ignore shielding]

[van der Waals' etc. = CE = 0 for M2 and M3]

1

[11]

17 (a) enthalpy/energy change/required when an electron is removed/ knocked out / displaced/ to form a uni-positive ion

(ignore 'minimum' energy)

1

from a <u>gaseous</u> atom

(could get M2 from a correct equation here)
(accept 'Enthalpy/energy change for the process...' followed by an appropriate equation, for both marks)
(accept molar definitions)

1

(b) $1s^2\ 2s^2 2p^6$

(accept capitals and subscripts)

1

(c) 's' block

(not a specific 's' orbital – e.g. 2s)

1

(d) $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$ or

$Mg^+(g) + e^- \rightarrow Mg^{2+}(g) + 2e^-$ or

$Mg^+(g) - e^- \rightarrow Mg^{2+}(g)$

1

(e) $\underline{Mg^{2+}}$ ion smaller than Ne atom / Mg^{2+} e^- closer to nucleus

(Not '<u>atomic'</u> radius fo Mg^{2+})

1

$\underline{Mg^{2+}}$ has more protons than Ne / higher nuclear charge or

$\underline{e^-}$ <u>is removed</u> from a charged Mg^{2+}ion / neutral neon atom

(accept converse arguments)

*(If used 'It' or Mg/magnesium/Mg^{3+} etc. & <u>2</u> correct reasons, allow **(1)**)*

1

(f) (i) trend: increases

(if 'decreases', CE = 0/3)

1

Expl^n: more protons / increased proton number / increased nuclear charge

(NOT increased atomic number)

1

same shell / same shielding / smaller size

1

(ii) QoL reference to the e^- pair in the 3p sub-level

(penalise if wrong shell, e.g. '2p', quoted)

1

repulsion between the e^-in this e^-pair

(if not stated, 'e $^-$ pair' must be clearly implied)

(mark M4 and M5 separately)

1

[12]

18

(a) $2Al + 3CuCl_2 \rightarrow 2AlCl_3 + 3Cu$;

(accept multiples/fractions)

OR

$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$;

1

(b) (i) increases;

1

(ii) lower than expected / lower than Mg /

1

less energy needed to ionise; e^- removed from (3)p sub-level;

1

('e^- removed' may be implied)

of higher energy / further away from nucleus / shielded by 3s e^-s;

1

(c) $Al^+(g) \rightarrow Al^{2+}(g) + e^-$;

1

(d) trend: increases;

1

more protons / higher charge on cation / more delocalised e^- / smaller atomic/ionic radius;
stronger attraction between (cat)ions and delocalised/free/mobile e^-

1

OR

stronger metallic bonding;

1

[9]

19 B

[1]

20 (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **(1)**

Allow subscripted electron numbers

(ii) p (block) **(1)**

Allow upper or lower case 's' and 'p' in (a)(i) and (a)(ii)

2

(b) Lattice of metal / +ve ions/ cations / atoms **(1)**

Not +ve nuclei/centres

Accept regular array/close packed/tightly packed/uniformly arranged

(Surrounded by) delocalised electrons **(1)**

Note: Description as a 'giant ionic lattice' = CE

2

(c) Greater nuclear or ionic charge or more protons **(1)**

Smaller atoms / ions **(1)**

Accept greater charge density for either M1 or M2

More delocalised electrons / e^- in sea of e^- / free e^- **(1)**

Stronger attraction between ions and delocalised / free electrons etc. **(1)**

Max 3

Note: 'intermolecular attraction/ forces' or covalent molecules = CE

Accept stronger 'electrostatic attraction' if phrase prescribed elsewhere
Ignore references to m/z values
If Mg or Na compared to Al, rather than to each other, then: ***Max 2***
*Treat description that is effectively one for Ionisation Energy as a '****contradiction****'*

3

(d) (Delocalised) electrons **(1)**

Move / flow in a given direction (idea of moving non-randomly)
or under the influence applied pd *QoL mark* **(1)**

Allow 'flow through metal'

Not: 'Carry the charge'; 'along the layers'; 'move through the metal'

2

[9]

21 (a)

Particle	Relative charge	Relative mass	
Proton	+1 **or** 1+	1	**(1)**
Neutron	0 **or** no charge/neutral/zero	1 (<u>not</u> – 1)	**(1)**
Electron	–1 or 1–	1/1800 to 1/2000	**(1)**

or negligible
or zero
or 5.0×10^{-4} to 5.6×10^{-4}

if 'g' in mass column - wrong
penalise once

3

(b) $^{38}_{18}Ar$ **(1)(1)**

Allow numbers before or after Ar

2

(c) *S*: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ **(1)**

Allow upper case letters

S^{2-}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ **(1)**

If use subscript penalise once

2

(d) *Block*: p **(1)**
Explanation: Highest energy or outer orbital is (3) p

OR outer electron, valency electron in (3) p
NOT 2p etc.

2

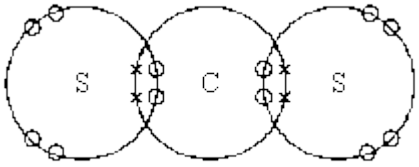
(e) (i) *Bonding in* Na_2S: ionic **(1)**
Bonding in CS_2: covalent **(1)**

ignore other words such as dative / polar / co-ordinate

(ii) Clear indication of electron transfer from Na to S **(1)**
1 e^- from each (of 2) Na atoms or 2 e^- from 2 Na atoms **(1)**

QoL correct English

(iii)



Correct covalent bonds **(1)**
All correct including lone pairs **(1)**

Allow all •s or all ×s

M2 tied to M1

NOT separate e⁻s in S• - 2 l p

(iv) $CS_2 + 2H_2O \rightarrow CO_2 + 2H_2S$ **(1)**

Ignore state symbols even if wrong

7

[16]

22 (a) Elements in the p block have their outer electron(s) in p orbital(s) or levels or sub-shells **(1)**
example of element **(1)**
correct electronic configuration **(1)**

3

(b) Pattern in the change in the properties of a row of elements **(1)**

OR Trend in the properties of elements across a period

Repeated in the next row **(1)**

OR element underneath (or in same group) has similar properties

atomic radius
decreases across the row **(1)**

CE if trend is wrong

number of protons increases **(1)** (or nuclear charge increases)
more attraction for electrons in the same shell **(1)**

electronegativity
increases across the row **(1)**
number of protons increases **(1)** (or nuclear charge)
atomic radius decreases **(1)** (or shielding remains the same or electrons in the same shell) more attraction for bonding or shared electrons **(1)**

conductivity
decreases row **(1)**

OR significant drop from Al to Si

Na–Al metals **(1)**

OR metallic bonding or description of metallic bonding

Two of Si - Ar non metals **(1)**

OR molecular or covalent

EITHER electrons free to move (or delocalised) in metals
OR electrons unable to move in non-metals **(1)**

13

[16]

23 (a) (i) Deductions:

Ionic **(1)**
Ions not free to move in the solid state **(1)**
Ions free to move when molten or in aqueous solution **(1)**
Identity of **P**: Na_2O or sodium oxide **(1)**

N.B. If a formula given this must be correct

Equation: $Na_2O + H_2O \rightarrow 2\ NaOH$ **(1)**

5

(ii) Deductions:

Covalent
Intermolecular forces are weak or van der Waals forces,
or dipole-dipole

N.B. Any answer including a reference to hydrogen bonding is incorrect

Identity of **Q**: SO_2 or sulphur dioxide **(1)**

Equation: $SO_2 + H_2O \rightarrow H_2SO_3$ **(1)**

NB Allow max one for SO_3

4

(b) (i) Amphoteric **(1)**

(ii) Equation with NaOH

$Al(OH)_3 + NaOH \rightarrow NaAl(OH)_4$

OR $Al(OH)_3(H_2O)_3 + OH^- \rightarrow [Al(OH)_4(H_2O)_2]^- + H_2O$

OR $Al(OH)_3 + OH^- \rightarrow [Al(OH)_4]^-$

R identified as $Al(OH)_3$ or $Al(OH)_3(H_2O)_3$ **(1)**
A balanced equation **(1)**

N.B. Allow equation with six co-ordinate Aluminium and up to six OH^- ligands
N.B. Allow equation mark if $M(OH)_3$ given in a balanced equation

Equation with H_2SO_4

$2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$

OR $Al(OH)_3(H_2O)_3 + H^+ \rightarrow [Al(OH)_2(H_2O)_4]^+ + H_2O$

NB Allow equations with six co-ordinate Aluminium and up to six H_2O ligands NB Allow equation mark if $M(OH)_3$ given in a balanced equation

Correct Al species as product **(1)**
A balanced equation **(1)**

(iii) Large lattice energy
or strong covalent bonds
or ΔH_{soln} is very positive
or ΔG is positive
or sum of hydration energies less than covalent bond energies **(1)**

6

[15]

24

(a) Ability (or power) of an atom to attract electron density
(or electrons or -ve charge) **(1)**
in a covalent bond **(1)**

or shared pair
If remove an electron lose first mark

2

(b) *Trend:* increases **(1)**
Explanation: nuclear charge (number of protons) increases **(1)**
electrons in same shell **(1)**

OR similar shielding
OR atoms similar size or smaller
OR 1 mol of e^-

3

(c) Heat / enthalpy / energy for removal of one electron **(1)**
from a gaseous atom **(1)**
can score in an equation

must have first mark to score the second

2

(d) (i) 2 **(1)**

(ii) Two elements (or Na / Mg) before the drop (in energy) to Al **(1)**

(iii) ionisation energy of Al < that for Mg **(1)**

(iv) fall in energy from P to S **(1)**

or discontinuity in trend

From Al to P there are 3 additional electrons **(1)**

or three elements
For second mark idea of block of 3 elements

5

[12]