Q1 This question is about the Period 2 elements lithium to nitrogen.

The elements in Period 2 show periodic trends similar to those in Period 3.

(a) State why carbon is classified as a p block element.

_____

_____ **(1)**

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

_____

_____

_____

_____ **(3)**

(c) Explain why there is a general increase in first ionisation energy from lithium to nitrogen.

_____

_____

_____

_____ **(2)**

(d) Identify the element, from lithium to nitrogen, that does **not** follow the trend of increasing first ionisation energy.

Explain why this element does **not** follow the trend.

Element _____

Explanation _____

_____

_____ **(3)**

(e) Identify the element, from lithium to nitrogen, that has the largest atomic radius.

_____ **(1)**

(g) The nitride ion has the formula N^{3-}

Give the electron configuration of the N^{3-} ion.

Give the formula of beryllium nitride.

Electron configuration _____

Formula _____

(2)

(h) An oxide of lithium contains 30.0% lithium by mass.

What is the empirical formula of this oxide of lithium?

Tick (✓) one box.

Li_2O ☐

LiO ☐

LiO_2 ☐

(1)

Q2

Which block in the Periodic Table contains the element samarium (Sm)?

A d block ⬭

B f block ⬭

C p block ⬭

D s block ⬭

(Total 1 mark)

Q3

Which is the correct classification for the element yttrium (Y)?

A s block ○

B p block ○

C d block ○

D f block ○

(Total 1 mark)

Q4

Which element is in the f-block of the Periodic Table?

A Palladium ○

B Phosphorus ○

C Platinum ○

D Plutonium ○

(Total 1 mark)

Q5

(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)

Q6

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) ATOMIC STRUCTURE: 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)

Q7

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.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q8

(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)

Q9

(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)

Q10

(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)

Q11

(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.

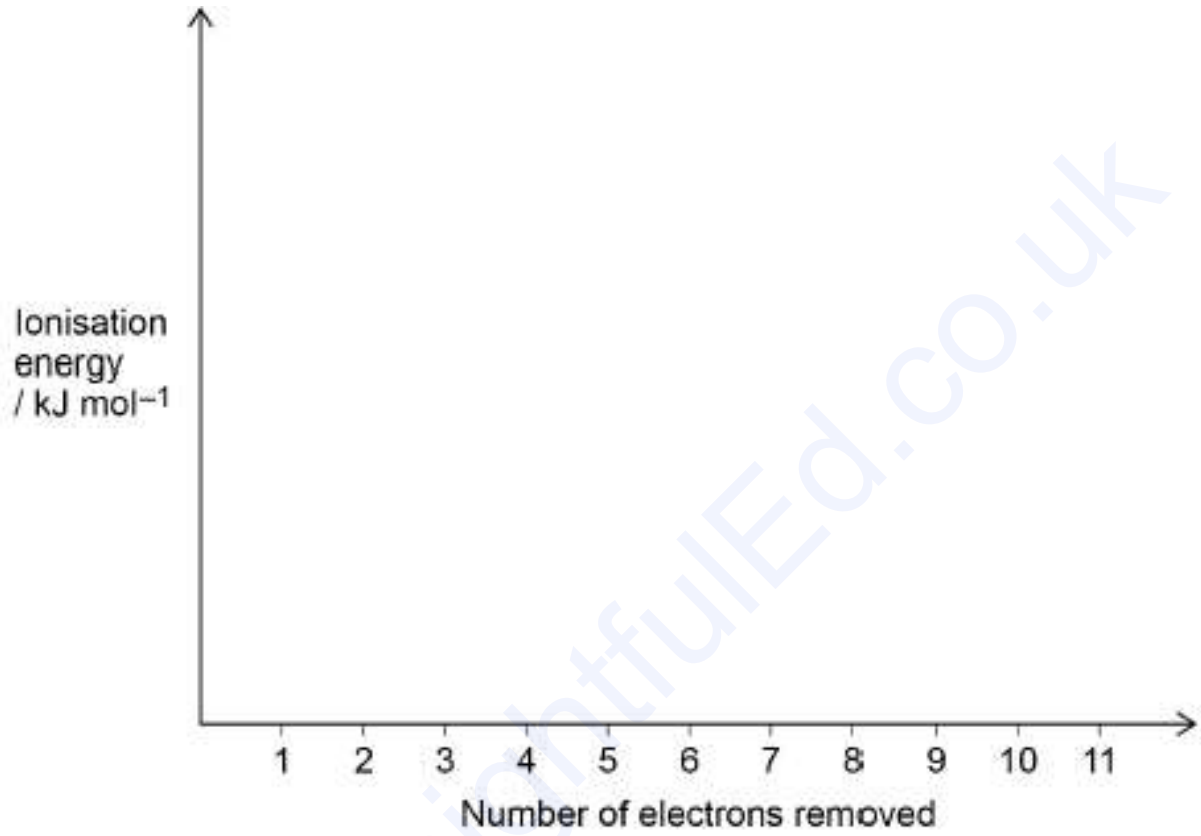
(13)

(Total 16 marks)

Q12

This question is about the elements in Period 3.

(a) On the axes, sketch a graph to show the successive ionisation energies of sodium.



(2)

(b) Explain, in terms of structure and bonding, why the melting point of magnesium is higher than the melting point of sodium.

(2)

Magnesium can be used in the extraction of titanium.

(c) Write an equation to show how magnesium is used to extract titanium from titanium(IV) chloride.

_____

(1)

(d) After the extraction of titanium in part (c), the unreacted magnesium can be removed using an aqueous solution of sulfuric acid to form magnesium sulfate.
The titanium does not react with the acid.

Write an equation for the reaction of magnesium with sulfuric acid.

State why magnesium sulfate can be separated easily from titanium.

Equation

_____

Why separated easily

_____

_____

_____

(2)

(e) The melting point of titanium chloride is 214 K
The melting point of sodium chloride is 1074 K

Which of the following shows the correct type of bonding in each compound?

Tick **one** (✓) box.

Titanium(IV) chloride	**Sodium chloride**	**Tick** (✓)
ionic	covalent	
ionic	ionic	
covalent	ionic	

(1)

(f) Identify the element in Period 3 that has the highest melting point.

_____

_____

(1)

(g) Identify the element in Period 3, from sodium to chlorine, that has the largest atomic radius.

_____

(1)

The table shows the electronegativity values of some Period 3 elements.

	Si	**P**	**S**	**Cl**
Electronegativity	1.9	2.2	2.6	3.2

(h) State the meaning of electronegativity.

_____

_____

(1)

(i) Use the data in the table above to suggest the formula of the compound with the most polar bonds formed by two of these elements.

_____

_____

(1)

(Total 12 marks)

Q13

This question is about some elements in Period 3.

The table shows data about some elements in Period 3.

Element	**First ionisation energy / kJ mol^{-1}**	**Atomic radius / nm**
magnesium	736	–
aluminium	577	–
silicon	786	0.117
phosphorus	1060	0.110
sulfur	1000	0.104

(a) Explain why the first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

_____

_____

(2)

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

(2)

(c) Identify the element in Period 3 that has the highest **third** ionisation energy.

(1)

(d) Explain the decrease in atomic radius of the elements silicon, phosphorus and sulfur.

(2)

(Total 7 marks)

Q14

This question is about the Period 3 elements Na to S and their compounds.

(a) A small piece of sodium is added to a beaker of cold water.
The sodium floats on the water.

Describe **two** other observations made when sodium reacts with water.

Write an equation, including state symbols, for the reaction.

Observation 1

Observation 2

_____

Equation

_____

_____

(3)

(b) A Period 3 element (Na to S) reacts with oxygen to form a colourless gas.

Identify the element.

_____

_____

(1)

(c) Separate samples of solid sodium chloride and liquid silicon tetrachloride are added to water.

The pH of each solution formed is measured.

	pH
sodium chloride	7
silicon tetrachloride	0

Write an equation, including state symbols, to represent the process that occurs when each substance is added to water.

Equation when sodium chloride is added to water

_____

_____

Equation when silicon tetrachloride is added to water

_____

_____

(2)

(d) A small amount of phosphorus(V) oxide is added to an excess of aqueous sodium hydroxide.

Write an equation for this reaction.

Draw the structure of the anion formed in this reaction.

Equation

_____

_____

Structure

(2)

(Total 8 marks)

Q15

This question is about the Period 2 elements lithium to nitrogen.

The elements in Period 2 show periodic trends similar to those in Period 3.

(a) State why carbon is classified as a p block element.

(1)

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

(3)

(c) Explain why there is a general increase in first ionisation energy from lithium to nitrogen.

(2)

(d) Identify the element, from lithium to nitrogen, that does **not** follow the trend of increasing first ionisation energy.

Explain why this element does **not** follow the trend.

Element

_____

Explanation

_____

_____

_____

_____

(3)

(e) Identify the element, from lithium to nitrogen, that has the largest atomic radius.

_____

_____

(1)

(f) Identify the element, from lithium to nitrogen, that has the largest **third** ionisation energy.

_____

_____

(1)

(g) The nitride ion has the formula N^{3-}

Give the electron configuration of the N^{3-} ion.

Give the formula of beryllium nitride.

Electron configuration

_____

Formula

_____

_

(2)

(h) An oxide of lithium contains 30.0% lithium by mass.

What is the empirical formula of this oxide of lithium?

Tick (✓) one box.

Li_2O ☐

LiO ☐

LiO_2 ☐

(1)

(Total 14 marks)

Q16

This question is about Period 3 elements and their compounds.

(a) State **two** observations that you would make when magnesium is burned in oxygen.

Write an equation for the reaction.

Observation 1

_____

Observation 2

_____

Equation

_____

(3)

(b) A strip of magnesium is added to some cold water. At first, there is no visible change but magnesium does react very slowly with cold water.

Write an equation for the reaction.

Explain how an indicator can be used to show that a reaction is occurring.

Equation

_____

Explanation

_____

_____

_____

(3)

(c) Write an equation for the reaction of aluminium oxide with aqueous potassium hydroxide.

_____

(1)

(d) Draw the structure of the acid formed when phosphorus(V) oxide reacts with water.

(1)

Q17

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

(a) Write an equation, including state symbols, for the first ionisation energy of magnesium.

_____

(1)

(b) Explain why the first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

_____

_____

_____

(2)

(c) Identify the element in Period 3 with the largest atomic radius.

Explain your answer.

Element

_____

Explanation

_____

_____

_____

_____

(3)

(d) Silicon has the highest melting point of the elements in Period 3.

Explain this statement in terms of structure and bonding.

(3)

(Total 9 marks)

Q18

This question is about compounds of the elements in Period 3.

(a) Phosphorus burns in air to form phosphorus(V) oxide.

Write an equation for this reaction.

(1)

(b) Sulfur forms two oxides, SO_2 and SO_3
Both oxides react with water to form acidic solutions.

State the formula of each acid formed and the approximate pH of a 0.1 mol dm^{-3} solution of each acid.

Formula of acid formed by
SO_2 _____

pH
_____

Formula of acid formed by
SO_3 _____

pH
_____

(2)

(c) Aluminium oxide can act as an acid and can act as a base.

Write an equation to show aluminium oxide acting as an acid.

_____

(1)

(d) **BONDING/P3** Silicon reacts with oxygen to form SiO_2 and with chlorine to form $SiCl_4$

The table shows the melting points of SiO_2 and $SiCl_4$

Compound	Melting point / °C
SiO_2	1710
$SiCl_4$	–69

Explain, in terms of structure and bonding, why SiO_2 has a very high melting point but $SiCl_4$ has a very low melting point.

SiO_2 _____

_____

_____

_____

_____

$SiCl_4$ _____

(4)

(Total 8 marks)

Q19

This question is about some Period 3 oxides and chlorides.

(a) Suggest why silicon dioxide can be described as an acidic oxide even though it is insoluble in water.

_____

(1)

The table below shows the melting points of some Period 3 oxides.

	Na_2O	**SO_2**	**SO_3**
Melting point/K	1548	200	290

(b) Explain, in terms of structure and bonding, why sodium oxide has a high melting point.

_____

(3)

(c) Explain why sulfur trioxide has a higher melting point than sulfur dioxide.

(2)

A small amount of each of the Period 3 chlorides NaCl, $MgCl_2$, $AlCl_3$ and PCl_5 is added to separate samples of deionised water.

The pH values of the resulting solutions are measured.

(d) State why NaCl forms a neutral solution.

(1)

Both $AlCl_3$ and PCl_5 form acidic solutions.

(e) The equation for the reaction of $AlCl_3$ with water is

$$AlCl_3 + 6H_2O \longrightarrow [Al(H_2O)_6]^{3+} + 3Cl^-$$

Explain why the solution formed is acidic. Use an equation in your answer.

(2)

(f) Identify the **two** acids formed when PCl_5 reacts with water.

_____

_____

_____

_____

(1)

(Total 10 marks)

Q20

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

(a) Identify the element in Period 2 that has the highest electronegativity value.

_____

_____

(1)

(b) Identify the element in Period 2 that has the highest first ionisation energy.

Explain your answer.

Element

_____

_

Explanation

_____

_____

_____

_____

_____

_____

_____

_____

(3)

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

_____

_____

(1)

(d) Identify the element in Period 2 that has the highest melting point.

Explain your answer.

Element

_____

_

Explanation

_____

_____

_____

_____

_____

_____

_____

(3)

(e) Draw the shape of a tetrafluoromethane molecule (CF_4) and the shape of a chlorine trifluoride molecule (ClF_3).

Include any lone pairs of electrons that influence the shape.

Name the shape of the CF_4 molecule.

Shape of CF_4 Shape of ClF_3

Name of shape of CF_4 _____

(3)

(f) Explain why the boiling point of CF_4 is very low.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(g) A compound, which contains carbon, chlorine and fluorine only, has a relative molecular mass (M_r) of 204.0

Elemental analysis shows that the compound contained 69.6% chlorine and 18.6% fluorine by mass.

Calculate the molecular formula of this compound.

Molecular formula _____

(4)

(Total 17 marks)

Mark Schemes

Q1

(a) outer electrons in (2)p orbital

allow highest energy level being filled is (2)p sub-shell

1

(b) macromolecular **or** giant covalent

allow giant molecular or giant atomic

1

covalent bonds

1

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

allow many (covalent) bonds must be broken

1

(c) increase in number of protons **or** increased nuclear change

1

similar shielding

or

stronger attraction between nucleus/protons and outer shell electrons

ignore atomic radius decreases

1

(d) B **or** boron

1

electron removed from a (2)p orbital

1

that is higher in energy (so more easily lost)

1

*allow max. 2 marks if M1 = Al **or** aluminium*

(e) Li **or** lithium

1

(g) $1s^2 2s^2 2p^6$

1

Be_3N_2

1

(h) LiO

1

Q2

B

f block

[1]

Q3

C

[1]

Q4

D

[1]

Q5

(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 delocalised / mobile / free / sea of electrons

Ignore atoms.

1

Strong attraction between them or strong metallic bonds

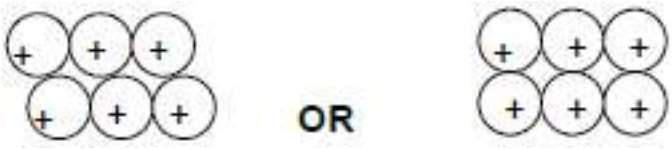
Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

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

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

1

(iii)



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) Layers / planes / sheets of atoms or ions 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) $NiCl_2.6H_2O + \mathbf{6}\ SOCl_2 \longrightarrow NiCl_2 + \mathbf{6}\ SO_2 + \mathbf{12}\ HCl$

Allow multiples.

1

$NaOH / NH_3 / CaCO_3 / CaO$

Allow any name or formula of alkali or base.

Allow water.

1

[9]

Q6

(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 = 85.6

1

(f) Detector

Mark independently

Allow detection (plate).

1

Current / digital pulses / electrical signal related to abundance

Not electrical charge.

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]

Q7

(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]

Q8

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

(Not 'atomic' radius fo Mg^{2+})

1

Mg^{2+} has more protons than Ne / higher nuclear charge or e^- is removed from a charged Mg^{2+}ion / neutral neon atom

(accept converse arguments)
*(If used 'It' or Mg/magnesium/Mg^{3+} etc. & 2 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]

Q9

(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) <u>delocalised</u> 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]

Q10

(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

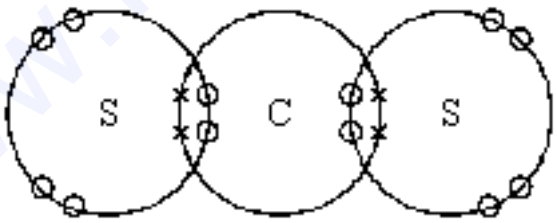
(e) (i) *Bonding in* Na_2S: ionic **(1)**
Bonding in CS_2: covalent **(1)**

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)**
<u>All correct</u> including <u>lone pairs</u> **(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

Q11

(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]

Q12

(a) plot shows a general increase

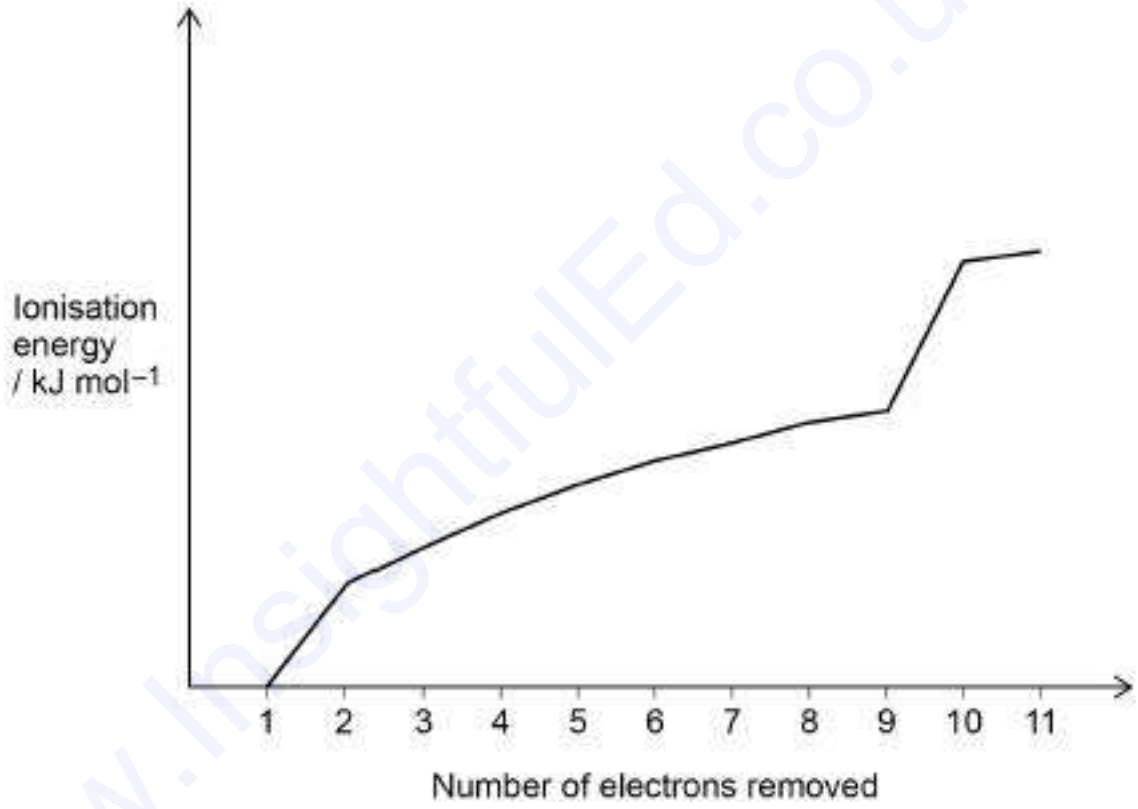
all successive ionisation energies (IE) must be higher than the previous

M2 dependent on M1

1

plot has sharp increase between 1st IE and 2nd IE
and
between 9th IE and 10th IE

M2 dependent on M1



1

(b) Mg has smaller ions
or
Mg ions have bigger charge density
or
Mg^{2+} has a higher charge than Na^{+}
or
Mg atoms are smaller than Na atoms

must be a comparison

ignore reference to nuclear charge

1

stronger <u>attraction</u> with <u>delocalised / free / sea</u> of electrons

allow metallic bonding is stronger

1

(c) $2\ Mg + TiCl_4 \rightarrow 2\ MgCl_2 + Ti$

allow multiples

1

(d) $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

1

$MgSO_4$ / it is soluble

allow $MgSO_4$ is in (aqueous) solution

1

(e) covalent ionic

1

(f) Si / silicon

1

(g) Na / sodium

1

(h) power of an atom to attract electron density / pair of electrons / two electrons towards itself in a covalent bond

1

(i) $SiCl_4$

1

[12]

Q13

(a) (outer) electron (in aluminium) in (3)p orbital / sub-shell (sub-level)

do not accept p energy level / shell

1

(3p) higher in energy

allow (3)p more shielded than (3)s

1

(b) (outer) electrons in (3)p orbital **or** sub-shell begin to pair

1

(paired electrons) repel

1

(c) magnesium / Mg

1

(d) bigger nuclear charge **or** more protons (in nucleus)

1

electrons are added to the same shell **or** similar / same shielding

1

[7]

Q14

(a) any **two** from:

- fizzes
  allow yellow flame
- moves
- molten ball
- sodium piece gets smaller / disappear
  do not accept sodium piece dissolves

2

1

$2\ Na(s) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + H_2(g)$

(b) sulfur / S / S_8

1

(c) $NaCl(s)\ (+aq) \rightarrow Na^+(aq) + Cl^-(aq)$
allow NaCl(s) (+(aq) → NaCl(aq)

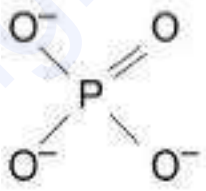
1

$SiCl_4(l) + 2\ H_2O(l) \rightarrow SiO_2(s) + 4\ HCl(aq)$
allow $SiCl_4(l) + 4\ H_2O(l) \rightarrow Si(OH)_4(s) + 4\ HCl(aq)$

1

(d) $P_4O_{10} + 12\ NaOH \rightarrow 4\ Na_3PO_4 + 6\ H_2O$
$P_4O_{10} + 12\ OH^- \rightarrow 4\ PO_4^{3-} + 6\ H_2O$

1



1

[8]

Q15

(a) outer electrons in (2)p orbital

allow highest energy level being filled is (2)p sub-shell

1

(b) macromolecular **or** giant covalent

allow giant molecular or giant atomic

1

covalent bonds

1

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

allow many (covalent) bonds must be broken

1

(c) increase in number of protons **or** increased nuclear change

1

similar shielding
or
stronger attraction between nucleus/protons and outer shell electrons

ignore atomic radius decreases

1

(d) B **or** boron

1

electron removed from a (2)p orbital

1

that is higher in energy (so more easily lost)

1

*allow max. 2 marks if M1 = Al **or** aluminium*

(e) Li **or** lithium

1

(f) Be **or** beryllium

1

(g) $1s^2 2s^2 2p^6$

1

Be_3N_2

1

(h) LiO

1

[14]

Q16

(a) (bright) white light / white flame

Not just bright light

1

white ash / white powder / white solid

Not white ppt

1

$2\ Mg + O_2 \longrightarrow 2\ MgO$

allow multiples
ignore state symbols

1

(b) $Mg + 2\ H_2O \longrightarrow Mg(OH)_2 + H_2$

allow multiples
ignore state symbols

1

named indicator and appropriate colour (e.g. phenolphthalein turns pink)

Ignore use of pH meter

1

$Mg(OH)_2$ is a (weak) alkali
OR
($Mg(OH)_2$ is slightly soluble, so) OH^- ions present
OR
pH = 9-10

1

(c) $Al_2O_3 + 2\ KOH + 3\ H_2O \longrightarrow 2\ KAl(OH)_4$

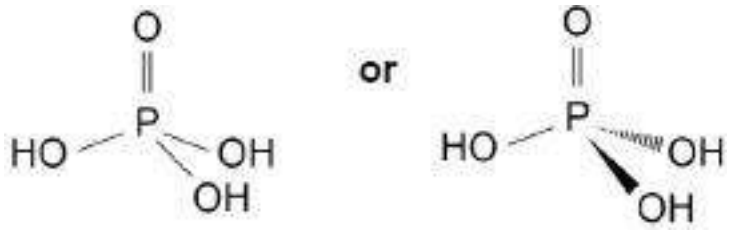
OR

$Al_2O_3 + 2\ OH^- + 3\ H_2O \longrightarrow 2\ Al(OH)_4^-$

allow multiples
ignore state symbols
allow:
$Al_2O_3 + 4\ KOH + 3\ H_2O \longrightarrow 2\ K_2Al(OH)_5$
$Al_2O_3 + 6\ KOH + 3\ H_2O \longrightarrow 2\ K_3Al(OH)_6$
$Al_2O_3 + 4\ OH^- + 3\ H_2O \longrightarrow 2\ Al(OH)_5^{2-}$
$Al_2O_3 + 6\ OH^- + 3\ H_2O \longrightarrow 2\ Al(OH)_6^{3-}$

1

(d)



allow ionised forms
does not need to be 3D

1

Q17

(a) $Mg(g) \longrightarrow Mg^{+}(g) + e^{-}$

1

(b) Electron removed from a (3)p orbital

1

Which is higher in energy (so more easily lost)
Allow greater shielding (from $3s^2$)

1

(c) Sodium

1

If not sodium then CE = 0/3

Smallest number of protons

1

All electrons in period 3 elements enter the same (3rd) principal energy level OR elements in period 3 have similar shielding

1

(d) Macromolecular/giant atomic/giant covalent molecule

1

covalent bonds

1

Many/strong (covalent) bonds need to be broken or take a lot of energy to break

1

[9]

Q18

(a) $P_4 + 5O_2 \longrightarrow P_4O_{10}$

allow multiples or fractions
ignore state symbol
allow
$4P + 5O_2 \longrightarrow P_4O_{10}$
reject any formula for phosphorous that is not P or P_4

1

(b) Formulae:
H_2SO_3 **AND** H_2SO_4

*If no mark awarded then award 1 mark for correct formula **and** pH for one oxide*

1

pH values
SO_2 any in range 2 to 5
AND
SO_3 any in range 0 to 1

1

(c) $Al_2O_3 + 2NaOH + 3H_2O \longrightarrow 2NaAl(OH)_4$

ignore state symbols
Allow any of:
$Al_2O_3 + 2OH^- + 3H_2O \longrightarrow 2Al(OH)_4^-$
$Al_2O_3 + 6OH^- + 3H_2O \longrightarrow 2Al(OH)_6^{3-}$
$Al_2O_3 + 6NaOH + 3H_2O \longrightarrow 2Na_3Al(OH)_6$
Reject reactions with carbonates and hydrogen carbonates

1

(d) **M1** SiO_2 giant (lattice) and covalent

Allow "macromolecular" for "giant lattice" and "giant covalent" for M1

1

M2 strong (covalent) bonds (between atoms) / require lots of energy to overcome − break

If SiO_2 is not covalent, lose M2

1

M3 $SiCl_4$ (simple) molecular

1

M4 weak forces between molecules / weak van der Waal's forces / weak intermolecular forces
and
require little energy to overcome

if breaking covalent bonds in $SiCl_4$ then do not award M4

1

If SiO_2 stated as not covalent, do not award M1 or M2
If $SiCl_4$ stated as not covalent, do not award M3 or M4

[8]

Q19

(a) SiO_2 reacts with bases / NaOH / CaO / $CaCO_3$

1

(b) It is an ionic lattice / giant ionic

Allow giant lattice if ions mentioned in answer

1

Contains oppositely charged ions/ + and − ions

1

with strong forces of attraction between the ions

1

Allow a lot of energy to separate oppositely charged ions.

M3 dependent on M2

Max 1/3 if mention of electronegativity ie M1 only

CE = 0/3 if mention of atoms / molecules / metallic

(c) SO_3 is a bigger molecule than SO_2

CE = 0 if mention of ions

1

so van der Waals' forces between molecules are stronger

1

(d) no reaction or no hydrolysis or only dissolving occurs

Allow NaCl is the salt of a strong acid and a strong alkali

1

(e) Al^{3+} small and highly charged (and weakens the O−H bond the ligand)

Allow Al^{3+} is highly polarising

Allow Al^{3+} weakens the O−H bond

1

$[Al(H_2O)_6]^{3+} + H_2O \longrightarrow [Al(H_2O)_5(OH)]^{2+} + H_3O^+$

Accept equations with more than one H_2O reacting

Allow formation of H^+

1

(f) phosphoric(V) acid or H_3PO_4

allow phosphoric acid

AND

hydrochloric acid or HCl

1

[10]

Q20

(a) F/ fluorine

1

(b) Ne

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

Allow similar shielding

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) $O(g) \longrightarrow O^{+}(g) + e^{(-)}$

1

(d) C

If not carbon then CE = 0 / 3

1

covalent (bonds)

M3 dependent on correct M2

1

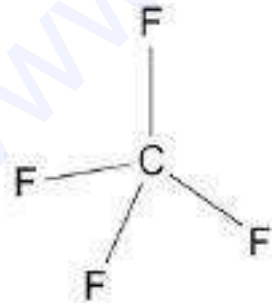
Strong or many of the (covalent) bonds need to be broken / needs a lot of energy to break the (covalent) bonds

Mention of ions would lose M2 and M3

Ignore IMF

1

(e)



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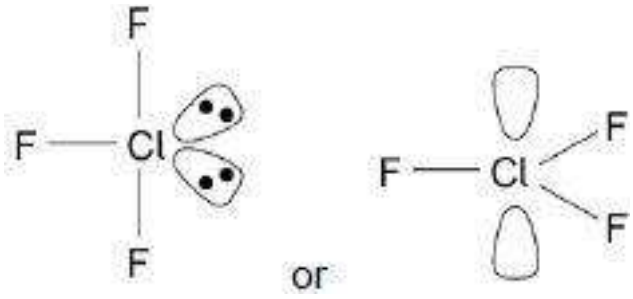

1

Shape = tetrahedral

1

(f) van der Waals / vdw forces between the molecules

not breaking covalent bonds

1

that are very weak (and easily broken by heat)

1

(g)

C	Cl	F		
11.8 % (M1)	69.6 %	18.6 %		
12	35.5	19		
(= 0.983	= 1.961	= 0.980)		
1	2	1	OR	CCl_2F

M1 11.8%

M2 dividing by correct A_r

3

CCl_2F has M_r = 102

MF = $C_2Cl_4F_2$

M4 correct MF

Allow alternative methods

1

[17]