EXAM PAPERS PRACTICE

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Detailed mark scheme

Suitable for all boards

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Level: CIE AS and A Level (9701)
Subject: Chemistry
Topic: CIE Chemistry
Type: Mark Scheme

Chemistry CIE AS & A Level
To be used for all exam preparation for 2025+

CHEMISTRY AS and A

This to be used by all students studying CIE AS and A level Chemistry (9701) But students of other boards may find it useful

Mark Scheme

Answer 1.

a) The trend in the atomic radius of successive elements in Period 3 is:

- Decreases (across the period); [1 mark]

[Total: 1 mark]

- This can be counter-intuitive and students often give the incorrect answer
- As you across a period, the nuclear charge increases as each successive element has an extra proton
- The attraction between the outer electrons and the nucleus is therefore greater, which pulls the outer electrons closer to the nucleus, decreasing the atomic radius

b)

i) Aluminium has a much higher electrical conductivity than sulfur because:

- Aluminium has a giant metallic lattice / structure
  AND
  With free / delocalised electrons (to carry the charge); [1 mark]
- Sulfur is a simple molecule / has a simple molecular structure
  AND
  With no free / delocalised electrons (to carry the charge); [1 mark]

ii) Aluminium has a higher electrical conductivity than magnesium because:

- Aluminium has more outer electrons (than magnesium)
  OR
  Aluminum has 3 outer electrons **AND** magnesium has 2 outer electrons; [1 mark]
- So it has more delocalised electrons (than magnesium) to carry the charge; [1 mark]

[Total: 4 marks]

- When told to refer to the structure of elements, you must identify the type of structure that each element exists as
- As these are all elements, the bonding will either be metallic or covalent
  - Ionic bonding only exists between ions of different elements
- This means that when you refer to whether an element conducts electricity, you need to refer to whether the structure contains free / delocalised electrons that are able to carry the charge

c)

i) The melting point of silicon is high because:

- Silicon has a giant molecular lattice / structure; [1 mark]
- With strong covalent bonds (between silicon atoms); [1 mark]
- Which require a large amount of energy to overcome; [1 mark]

ii) The melting point of phosphorus is low because:

- Phosphorus has a simple molecular structure / is a simple molecule; [1 mark]
- With weak instantaneous dipole-induced dipole forces / id-id forces / intermolecular forces; [1 mark]
- Which only require a small amount of energy to overcome; [1 mark]

[Total: 6 marks]

- For each explanation, you need to state:
  - The type of structure that the element has
  - The type and strength of bonds / forces between atoms / molecules
  - The relative amount of energy needed to overcome these bonds / forces

Answer 2.

a) The general increase in melting point from Na to Al is because:

- The elements have metallic bonding; [1 mark]
- The strength of the attraction between the positive metal ions and delocalised electrons increases
  OR
  More energy is needed to break the attraction between the positive metal ions and delocalised electrons; [1 mark]
- Due to an increasing number of delocalised electrons / increasing cation charge / charge density; [1 mark]

[Total: 3 marks]

- Think about the group of the Periodic Table each element is in
  - Sodium is in Group 1 so each atom donates one electrons into the 'sea' of delocalised electrons forming Na^+ ions
  - Magnesium is in Group 2 so each atom donates two forming Mg^{2+} ions
  - Aluminium is in Group 3 so each atom donates three, forming Al^{3+} ions
  - The larger charge on the aluminium ions allows for a greater electrostatic attraction between the nucleus and electrons, needing more energy to overcome it and consequently a higher melting point

b) The variation of melting points from P to Ar is because:

- All contain instantaneous dipole-induced dipole forces between molecules; [1 mark]
- These forces are greatest in sulfur
  OR
  The relative magnitude of these forces is S > P > Cl > Ar; [1 mark]
- (Because) sulfur has the greatest number of electrons
  OR
  The number of electrons (in the molecules) decreases; [1 mark]

[Total: 3 marks]

- Although S, P and Cl have strong covalent bonds between the atoms, it is the van der Waals' forces between the molecules (in this case, instantaneous dipole-induced dipole forces) that are overcome at melting point
- The stronger the instantaneous dipole-induced dipole forces between molecules the more energy needed to overcome them and the higher the melting point
  - The more electrons a molecule has, the stronger the instantaneous dipole-induced dipole forces
- Consider the size of the molecules going from P to Ar when answering this question:
  - P_4, S_8, Cl_2, Ar
  - Sulfur molecules are the largest with the most electrons and therefore stronger instantaneous dipole-induced dipole forces between molecules
  - Argon exists as single atoms so the instantaneous dipole-induced dipole forces will be very weak in comparison

c) Si has a much higher melting point than any of the other elements in the period because:

- Si has a giant covalent structure
  OR
  There are strong covalent bonds; [1 mark]

[Total: 1 mark]

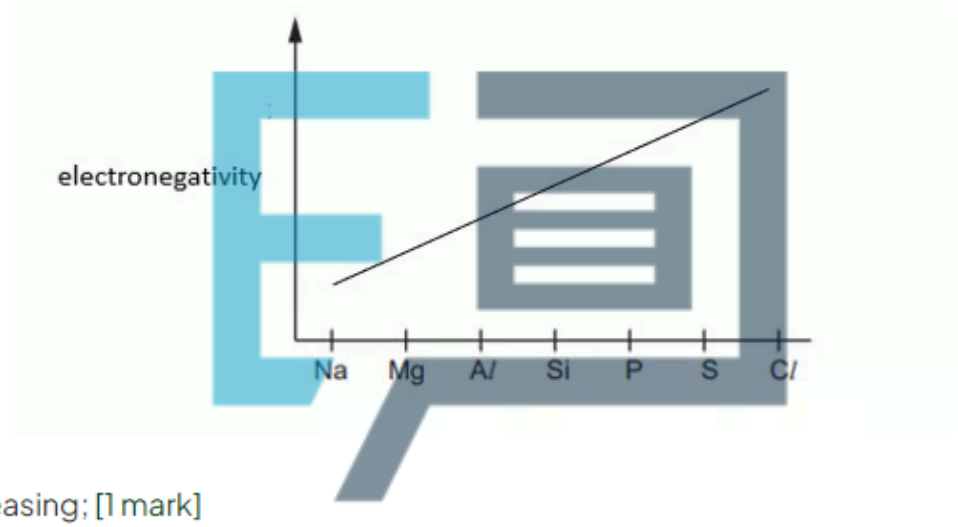
- Silicon has strong covalent bonds between the atoms
- Covalent bonds are much stronger than any van der Waals' force needing more energy to overcome them
- It is important you learn the trends across Period 3, they could be asked in a similar manner to this question, broken down into steps, or in the form of a 6 mark question

d)

i) Electronegativity is defined as:

- The ability of an atom to attract electrons / a pair of electrons to itself; [1 mark]
- In a covalent bond; [1 mark]

ii) A sketch to show how electronegativity changes along Period 3:



- Line increasing; [1 mark]

iii) Explaining your answer to part (ii):

- (Going across Period 3) nuclear charge increases

AND

Atomic radius decreases; [1 mark]

- (But) there is similar shielding; [1 mark]

[Total: 5 marks]

- You can deduce from part (i) being one mark that the trend must be a simple one i.e either a single line increasing or decreasing
- The nuclear charge refers to the charge in the nucleus of the atom
- Going across a period / row in the Periodic Table, each element has one more proton than the one before it increasing the charge in the nucleus but the number of energy levels remains the same
- If the nuclear charge and atomic radius decreases, but shielding by inner electrons remains the same across the Periodic Table, electrons will be more strongly attracted to the nucleus of the atom
- Notice the question doesn't identify the trend so this should be your first marking point

Answer 3.

a)

i) Ionic radius is:

- The size of an ion
  AND
  Measured from the nucleus to the outermost electron shell; [1 mark]

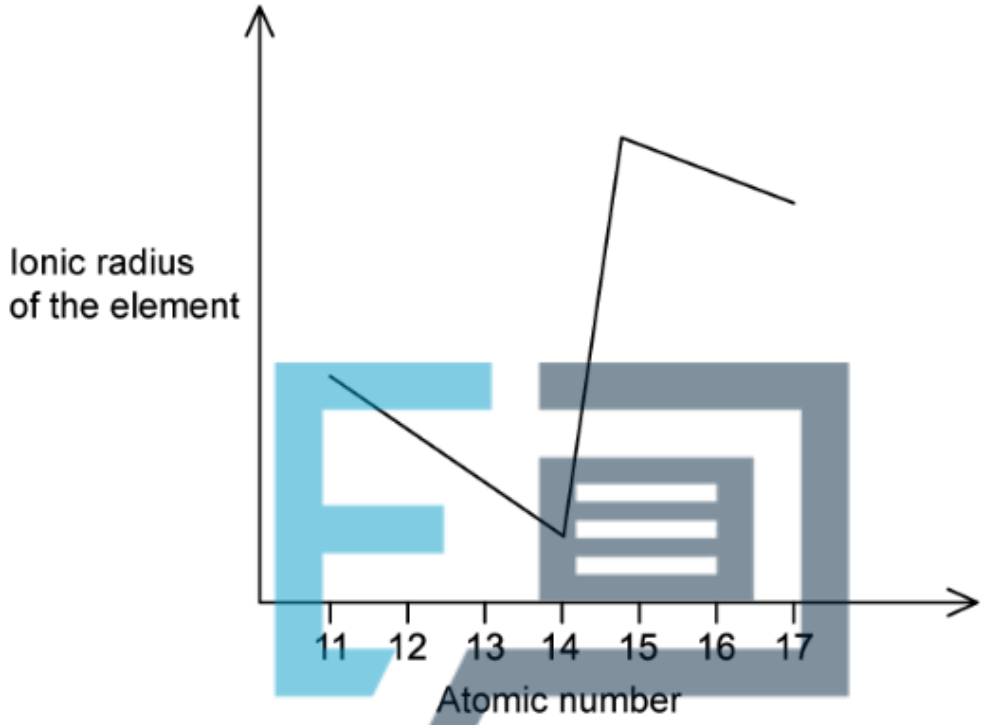
ii) How ionic radius differs between cations and anions:

- Cations are smaller than their parent atoms
  AND
  (Because) they lose outer shell electrons; [1 mark]
- This results in a greater nuclear charge pulling the remaining electrons closer; [1 mark]
- Anions are larger than their parent atoms
  AND
  (Because) they gain electrons; [1 mark]
- This results in increased electron-electron repulsion expanding the electron cloud; [1 mark]

[Total: 5 marks]

- You are expected to know what the ionic and atomic radii are
- Cations are positive, which means that they are losing their outermost electrons
  - This results in them having a smaller radius
- Anions are negative, which means that they are gaining electrons
  - This results in them having a larger radius

b) The graph to show the trend in the ionic radius of successive elements in Period 3 is:



- Decrease from 11 - 14; [1 mark]
- Sharp increase from 14 - 15; [1 mark]
- Decrease from 15 - 17

AND

The decrease from 15 - 17 is less steep than the decrease from 11 - 14; [1 mark]

[Total: 3 marks]

- You should be able to describe and explain the trend in ionic radius across Period 3

c) The trend in part **(b)** is because:

The ionic radius of 11–14:

- Decreases because the nuclear charge increases across the period
  AND
  The shielding remains (roughly) constant; [1 mark]

Large jump from 14 - 15:

- Electrons are now being added to the outer shell to form anions
  AND
  So, there is a weaker force of attraction (between the nucleus and outermost electron); [1 mark]

The ionic radius of 15 -17:

- Decreases because the nuclear charge increases across the period
  AND
  The shielding remains (roughly) constant; [1 mark]

[Total: 3 marks]

- You need to be able to explain the ionic radius as you move across Period 3
- There are 3 main sections to this:
  - Na - Si
  - Si - P
  - P - Cl
- The portions from Na - Si and P - Cl show a similar pattern due to the increasing nuclear charge and similar shielding
  - This does not consider the fact that P - Cl has a larger ionic radius
- The jump from Si - P is due to the difference in how the ions are formed
  - From Na - Si, the ions are formed by losing electrons which results in a smaller ionic radius
  - From P to Cl, the ions are formed by gaining electrons

Answer 4.

a) The difference in melting points between Na and Mg is due to:

- Magnesium ions have a greater charge; [1 mark]
- Magnesium has more delocalised / outer electrons; [1 mark]
- Magnesium has greater attraction between ions and electrons
  OR
  Magnesium has stronger metallic bonds; [1 mark]

[Total: 3 marks]

- The reverse argument is also allowed for the marks
- Both sodium and magnesium are metals and hence have metallic bonding
- The strength of these bonds depends on;
  - The size and charge of the positive ion (charge density of the positive ion)
  - The number of delocalised electrons in the lattice

b) Phosphorous has a lower melting point than sulfur because:

- Phosphorous exists as P_4 molecules
  AND
  Sulfur exists as S_8 molecules; [1 mark]
- Phosphorous is a smaller molecule (than sulfur)
  AND
  Has fewer electrons (than sulfur); [1 mark]
- Therefore, phosphorous has weaker van der Waals' / intermolecular forces (resulting in a lower melting point); [1 mark]

[Total: 3 marks]

- **Remember:** For most chemicals, melting and boiling points are dependent on the intermolecular forces
- Phosphorous and sulfur both contain temporary dipoles
- But, the size of the molecules and the number of electrons are the main factors to consider here
  - Smaller molecules and fewer electrons mean less van der Waals' / intermolecular forces
  - This results in a lower melting / boiling point as less energy is required to overcome the weaker forces

c) The trend in atomic radius shown in Table 3.1 is:

- The atomic radius decreases as you move across Period 3; [1 mark]

Explanation:

- The nuclear charge increases
  OR
  There are more protons in the nucleus; [1 mark]
- Shielding remains the same
  OR
  The number of electron shells is the same for all elements; [1 mark]
- So, there is a greater force of attraction between the nucleus and the outermost electrons (resulting in a smaller atomic radius); [1 mark]

[Total: 4 marks]

- You should be able to explain the trend in atomic radius across Period 3
- The explanation uses standard periodicity points about nuclear charge and shielding
  - These combine to affect the overall force of attraction between the nucleus and outermost electrons