OXFORD

INTERNATIONAL AQA EXAMINATIONS

Topic Test@ OxfordAQA International A level Chemistry

AS Inorganic

Name: _____

Class: _____

Date: _____

Time: **78 minutes**

Marks: **74 marks**

Comments:

1 Which of these atoms has the largest atomic radius?

A Ar ⬭

B Cl ⬭

C Mg ⬭

D Na ⬭

(Total 1 mark)

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

A Na ⬭

B Mg ⬭

C Ne ⬭

D Ar ⬭

(Total 1 mark)

3 Which of these atoms has the highest electronegativity?

A Na ⬭

B Mg ⬭

C Cl ⬭

D Ar ⬭

(Total 1 mark)

4 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 _____

_____

_____

(3)

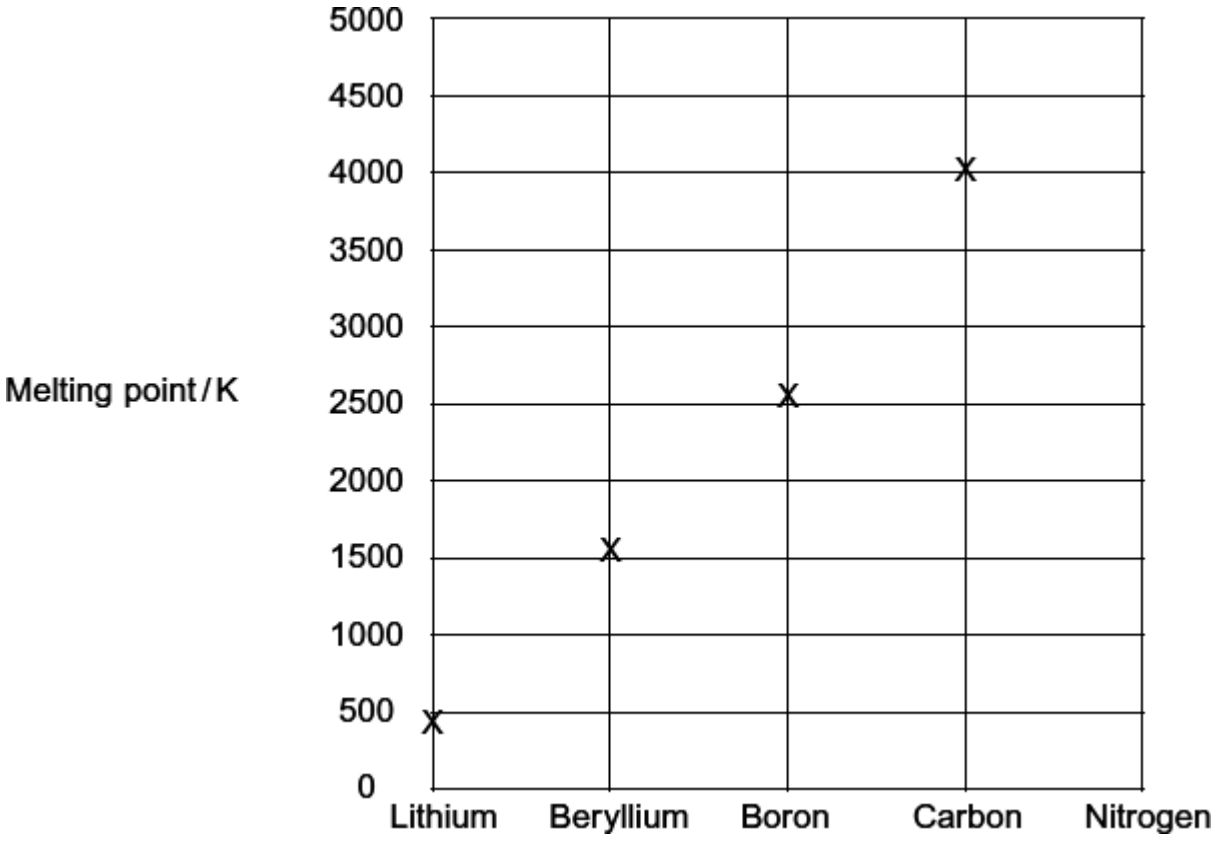
(c) Identify the Period 2 element that has the following successive ionisation energies.

	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.

(3)

(Total 10 marks)

5 (a) State and explain the trend in electronegativities across Period 3 from sodium to sulfur.

(4)

(b) Explain why the oxides of the Period 3 elements sodium and phosphorus have different melting points. In your answer you should discuss the structure of and bonding in these oxides, and the link between electronegativity and the type of bonding.

(6)

(c) A chemical company has a waste tank of volume 25 000 dm^3. The tank is full of phosphoric acid (H_3PO_4) solution formed by adding some unwanted phosphorus(V) oxide to water in the tank.

A 25.0 cm^3 sample of this solution required 21.2 cm^3 of 0.500 mol dm^{-3} sodium hydroxide solution for complete reaction.

Calculate the mass, in kg, of phosphorus(V) oxide that must have been added to the water in the waste tank.

(5)

(Total 15 marks)

6 Barium chloride solution was added, dropwise, to magnesium sulfate solution until no more white precipitate was formed. The mixture was filtered.

Give the formulae of the **two** main ions in the filtrate.

(Total 1 mark)

7 This question is about magnesium and its reactions.

(a) A 0.750 g sample of magnesium metal reacts exactly with 31.00 cm^3 of hydrochloric acid of unknown concentration.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

Calculate the concentration, in g dm^{-3}, of the hydrochloric acid used in this reaction.

Give your answer to **three** significant figures.

Concentration _____ g dm^{-3}

(4)

(b) Calculate the percentage atom economy for the formation of hydrogen in the reaction shown in part (a).

Give your answer to **one** decimal place.

Atom economy _____ %

(2)

(c) Draw a labelled diagram to show the arrangement of particles in a crystal of magnesium.

Your diagram should contain **six** magnesium particles.

(2)

(d) Suggest why magnesium is ductile (can be stretched into wires).

_____

_____

(1)

(e) State **two** observations made when magnesium reacts with steam.

Write an equation for the reaction.

Observation 1 _____

_____

Observation 2 _____

_____

Equation _____

_____

(3)

(Total 12 marks)

8 In an experiment to determine its solubility in water, solid barium hydroxide was added to 100cm^3 of water until there was an excess of the solid. The mixture was filtered and an excess of sulfuric acid was added to the filtrate. The barium sulfate produced was obtained from the reaction mixture, washed with cold water and dried. The mass of barium sulfate was then recorded.

(a) Explain why the mixture was filtered before the addition of sulfuric acid.

_____

_____

(1)

(b) State how the barium sulfate produced was obtained from the reaction mixture.

_____

_____

(1)

(c) Explain why the barium sulfate was washed before it was dried.

_____

_____

(1)

(d) Write an equation for the reaction between barium hydroxide and sulfuric acid.

_____

(1)

(e) In an experiment, 4.25 g of barium sulfate were formed when an excess of sulfuric acid was added to 100 cm^3 of a saturated solution of barium hydroxide.

(i) Use data from the Periodic Table to calculate the M_r of barium sulfate.
Give your answer to one decimal place.

_____

(1)

(ii) Calculate the amount, in moles, of $BaSO_4$ in 4.25 g of barium sulfate.

_____

_____

(1)

(iii) Use your answer from part (ii) to calculate the mass of barium hydroxide (M_r = 171.3) present in 1 dm^3 of saturated solution. Show your working.

_____

_____

_____

(2)

(f) Barium sulfate is taken by mouth by patients so that an outline of a human digestive system can be viewed using X-rays. Explain why patients do **not** suffer any adverse effects from barium sulfate when it is known that solutions containing barium ions are toxic.

_____

_____

(1)

(Total 9 marks)

9 Which of these species is the best reducing agent?

A Cl_2 ⬭

B Cl^- ⬭

C I_2 ⬭

D I^- ⬭

(Total 1 mark)

10 Which substance is **not** produced in a redox reaction when solid sodium iodide reacts with concentrated sulfuric acid?

A H_2S ⬭

B HI ⬭

C SO_2 ⬭

D I_2 ⬭

(Total 1 mark)

11 Reactions that involve oxidation and reduction are used in a number of important industrial processes.

(a) Iodine can be extracted from seaweed by the oxidation of iodide ions.
In this extraction, seaweed is heated with MnO_2 and concentrated sulfuric acid.

(i) Give the oxidation state of manganese in MnO_2

_____

(1)

(ii) Write a half-equation for the reaction of MnO_2 in acid to form Mn^{2+} ions and water as the only products.

_____

(1)

(iii) In terms of electrons, state what happens to the iodide ions when they are oxidised.

_____

_____

(1)

(b) Chlorine is used in water treatment. When chlorine is added to cold water it reacts to form the acids HCl and HClO
The following equilibrium is established.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + Cl^-(aq) + HClO(aq)$$

(i) Give the oxidation state of chlorine in Cl_2 and in HClO

Cl_2 _____

HClO _____

(2)

(ii) Deduce what happens to this equilibrium as the HClO reacts with bacteria in the water supply. Explain your answer.

(2)

(c) Concentrated sulfuric acid is reduced when it reacts with solid potassium bromide. Concentrated sulfuric acid is **not** reduced when it reacts with solid potassium chloride.

(i) Write the two half-equations for the following redox reaction.

$$2H^+ + 2Br^- + H_2SO_4 \longrightarrow Br_2 + SO_2 + 2H_2O$$

Half-equation 1

Half-equation 2

(2)

(ii) Write an equation for the reaction of solid potassium chloride with concentrated sulfuric acid.

(1)

(iii) Explain why chloride ions are weaker reducing agents than bromide ions.

(2)

(Total 12 marks)

12 Chlorine is a powerful oxidising agent.

(a) Write the **simplest ionic** equation for the reaction between chlorine and aqueous potassium bromide.

State what is observed when this reaction occurs.

(2)

(b) Write an equation for the reaction between chlorine and cold, dilute, aqueous sodium hydroxide.

Give a major use for the solution that is formed by this reaction.

Give the IUPAC name of the chlorine-containing compound formed in this reaction in which chlorine has an oxidation state of +1.

(3)

(c) Write an equation for the equilibrium reaction that occurs when chlorine gas reacts with cold water.

Give **one** reason why chlorine is used for the treatment of drinking water even though the gas is very toxic.

(2)

(d) State how you could test a sample of water to show that it contains chloride ions.

In your answer, give a reagent, **one** observation and the **simplest ionic** equation for the reaction with the reagent.

_____

_____

_____

_____

_____

_____

(3)

(Total 10 marks)

1 D

[1]

2 A

[1]

3 C

[1]

4 (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

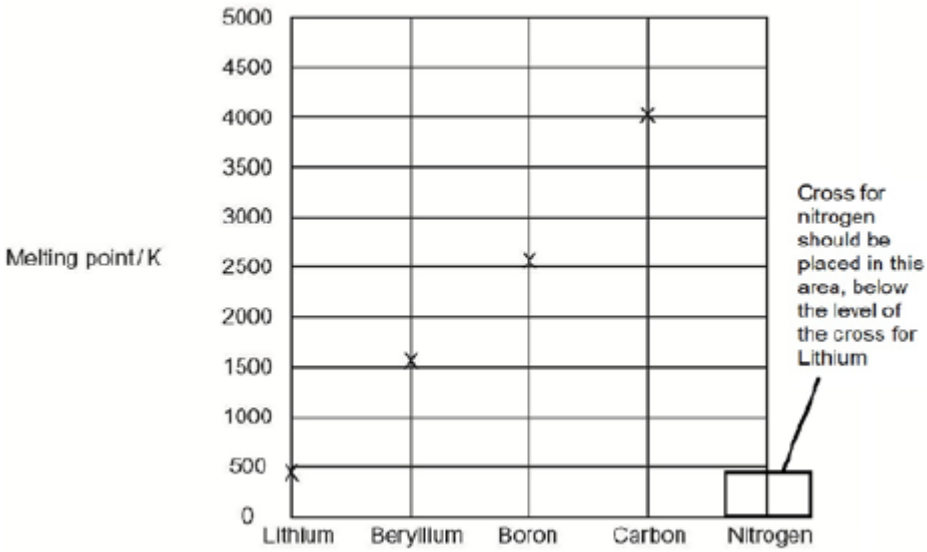
Which is higher in energy (so more easily lost) / more shielded (so more easily lost) / further from nucleus

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]

5 (a) Electronegativity increases

1

Proton number increases (increase in nuclear charge)

1

Same number of electron shells/levels

Or same radius or Shielding of outer electrons remains the same

1

Attraction of bond pair to nucleus increases

Allow 'electrons in bond' instead of 'bond pair'

1

(b) Big difference in electronegativity leads to ionic bonding, smaller covalent

Lose a mark if formula incorrect

1

Sodium oxide ionic lattice

1

Strong forces of attraction between ions

1

P_4O_{10} covalent molecular

Must have covalent and molecular (or molecules)

1

Weak (intermolecular) forces between molecules

Or weak vdW, or weak dipole–dipole between molecules

1

melting point Na_2O greater than for P_4O_{10}

Or argument relating mpt to strength of forces

1

(c) Moles NaOH = $0.0212 \times 0.5 = 0.0106$

M1 moles of NaOH correct

1

Moles of H_3PO_4 = 1/3 moles of NaOH (= 0.00353)

M2 is for 1/3

1

Moles of P in 25000 l = $0.00353 \times 10^6 = 3.53 \times 10^3$

M3 is for factor of 1,000,000

1

Moles of $P_4O_{10} = 3.53 \times 10^3/4$

M4 is for factor of 1/4 (or 1/2 if P_2O_5)

1

Mass of $P_4O_{10} = 3.53 \times 10^3/4 \times 284 = 0.251 \times 10^6$ g
= 251 kg

(Or if P_2O_5 $3.53 \times 10^3/2 \times 142$)
M5 is for multiplying moles by M_r with correct units
allow conseq on incorrect M4
(allow 250-252)

1

[15]

6 Mg^{2+} and Cl^-

Do not allow names.

[1]

7 (a) amount of Mg = 0.75/24.3 (= 0.0309 mol)

1

amount of HCl = 2 × 0.0309 (= 0.0618 mol)

1

conc = mol/vol = 0.0618 / 31 × 10^{-3} (= 1.99 mol dm^{-3})

1

conc in g dm^{-3} = (1.99 mol dm^{-3} × 36.5) = 72.7 to 72.8 (g dm^{-3})

answer to 3 significant figures

Allow answer in range 72.6 − 73.0

1

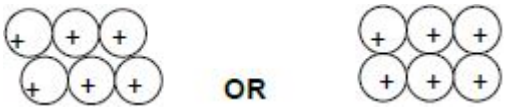
(b) (2/97.3) × 100

1

2.1 (%)

1

(c) regular close arrangement of particles (min 6 metal particles).



Allow delocalised electrons anywhere on diagram

1

(2)+ sign in each metal ion.

1

(d) layers of atoms/ions slide over one another

1

(e) white powder/ash/solid

ignore black solid

1

(bright) white light

1

$Mg + H_2O \longrightarrow MgO + H_2$

ignore state symbols; allow multiples

1

[12]

8 (a) Remove undissolved barium hydroxide / excess solid

Do not accept 'remove impurities'.

1

(b) Filtration

Do not accept 'decanting' or 'sieving'.

Ignore references to heating or drying.

1

(c) Remove (excess) sulfuric acid

1

(d) $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$

Accept multiples.

Accept $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

Ignore state symbols.

1

(e) (i) 233.4

Accept 233

1

(ii) 0.018(2)

Do not penalise additional significant figures, but do not allow 0.02

Allow consequential answer from (i).

1

(iii) 0.018(2) × 171.3 = 3.12

Do not penalise precision.

If 0.018 used, answer = 3.08

1

× 10 = 31.2

Do not penalise precision.

Allow this mark if 0.18(2) used directly.

Correct answer without working scores one mark only.

Allow consequential answer on (ii)

1

(f) Barium sulfate / it is insoluble

Do not accept answers based on small amount ingested.

Do not accept barium.

1

[9]

9 D

[1]

10 B

[1]

11 (a) (i) MnO_2 (+) 4

1

(ii) $MnO_2 + \mathbf{4}H^+ + \mathbf{2}e^- \longrightarrow Mn^{2+} + \mathbf{2}H_2O$

Or multiples

Ignore state symbols

Credit electrons subtracted from RHS

Ignore absence of charge on e

1

(iii) Iodide ion(s) is/are oxidised because they have lost electron(s)

Do not penalise reference to iodine; the mark is for electron loss

1

(b) (i) **M1** Cl_2 0

M2 HClO (+) 1

2

(ii) **M1** Equilibrium will shift/move to the right

OR L to R

OR to favour the forward reaction

OR to produce more HClO

M2 **Consequential on correct M1**

To oppose the loss of HClO

OR replaces the HClO (that has reacted)

for M2

NOT just "to oppose the change"

2

(c) (i) The answers can be in **either order**

M1 $\mathbf{2}Br^- \longrightarrow Br_2 + \mathbf{2}e^-$

M2 $\mathbf{4}H^+ + SO_4^{2-} + \mathbf{2}e^- \longrightarrow SO_2 + \mathbf{2}H_2O$

OR

$\mathbf{2}H^+ + H_2SO_4 + \mathbf{2}e^- \longrightarrow SO_2 + \mathbf{2}H_2O$

NOT multiples

Ignore state symbols

Credit electrons subtracted from incorrect side

Ignore absence of charge on e

2

(ii) $KCl + H_2SO_4 \longrightarrow KHSO_4 + HCl$

OR

$\mathbf{2}KCl + H_2SO_4 \longrightarrow K_2SO_4 + \mathbf{2}HCl$

Credit ionic equations

1

(iii) For M1 and M2, chloride ions are weaker reducing agents than bromide ions, because

M1 Relative size of ions

Chloride ions are <u>smaller</u> than bromide ions OR chloride ion electron(s) are <u>closer</u> to the nucleus OR chloride ion has fewer (electron) shells/levels OR chloride ion has less shielding (or converse for bromide ion)

M2 Strength of attraction for electron being lost

Outer shell/level electron(s) OR electron(s) lost from a chloride ion is more strongly held by the nucleus compared with that lost from a bromide ion (or converse for bromide ion)

If the forces are described as intermolecular or Van der Waals then CE = 0

Ignore general reference to Group 7 trend

For M1 accept reference to chlorine/bromine or reference to atoms of these but NOT "chloride/bromide atoms" or "chlorine/bromine molecules"

For M2 insist on reference to the correct ions

This is the expected answer, but award credit for a candidate who gives a correct explanation in terms of hydration enthalpy, electron affinity and atomisation enthalpy.

2

[12]

12 (a) M1 $Cl_2 + \mathbf{2}Br^- \longrightarrow \mathbf{2}Cl^- + Br_2$

Accept a correct equation using ½ Cl_2 but no other multiples

M2 solution goes <u>orange / yellow</u> (from colourless)

Ignore reference to brown colour

Penalise incorrect observations eg fumes, precipitates

2

(b) M1 $Cl_2 + 2NaOH \longrightarrow NaClO + NaCl + H_2O$

(NaOCl)

Or a correct ionic equation

Ignore reference to "swimming pools" and to "disinfectant"

M2 bleach or kills bacteria / bacteriacide / micro-organisms / microbes

M3 <u>sodium chlorate(I)</u> ONLY

3

(c) M $Cl_2 + H_2O \rightleftharpoons$ HClO + HCl

(HOCl)

*Equilibrium symbol **required** in **M1***

Accept ionic RHS

M2

The (health) benefit outweighs the risk or wtte

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

2

(d) M1 Silver nitrate OR $AgNO_3$ (with or without nitric acid)

*For **M1***

If only the formula is written then it must be correct

If both the formula and the name are written then ignore incorrect attempt at the formula, but penalise an incorrect name

M2 (depends on M1)

white precipitate / white solid

*If the reagent is incomplete eg Ag^+ ions, penalise **M1** and mark on*

M3 $Ag^+ + Cl^- \longrightarrow AgCl$

*Penalise both **M1** and **M2** for alkaline $AgNO_3$ **OR** for the use of HCl to acidify the silver nitrate **OR** for Tollens' reagent*

3

[10]