OXFORD INTERNATIONAL AQA EXAMINATIONS

Topic Test: OxfordAQA International A level Chemistry

AS Physical Chemistry: Unit 1 content

Name: ____________________

Class: ____________________

Date: ____________________

Time: **80 minutes**

Marks: **69 marks**

Comments:

1 Which change requires the largest amount of energy?

A $He^{+}(g) \longrightarrow He^{2+}(g) + e^{-}$ ⬭

B $Li(g) \longrightarrow Li^{+}(g) + e^{-}$ ⬭

C $Mg^{+}(g) \longrightarrow Mg^{2+}(g) + e^{-}$ ⬭

D $N(g) \longrightarrow N^{+}(g) + e^{-}$ ⬭

(Total 1 mark)

2 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)

3 (a) The abundance of each isotope in a time of flight (TOF) mass spectrum of a sample of germanium is shown in the table.

m/z	70	72	74
Abundance (%)	24.4	32.4	43.2

Give the formula of the ion that will reach the detector first.

(1)

(b) Use the data in Table above to calculate the relative atomic mass of this sample of germanium.

Give your answer to one decimal place.

Relative atomic mass = ____________________

(2)

(c) Explain how the abundance of each isotope is determined in a TOF mass spectrometer.

____

____

____

____

____

(2)

(d) Calculate the mass, in kg, of one atom of ^{72}Ge

The Avogadro constant = 6.02×10^{23} mol^{-1}.

Give your answer to the appropriate number of significant figures.

Mass = ____________________ kg

(2)

(e) In a TOF mass spectrometer, the ions are accelerated to the same kinetic energy (KE).

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = velocity (m s^{-1})

$v = \frac{d}{t}$ where d = distance (m) and t = time (s)

A $^{72}Ge^{+}$ ion is accelerated to a kinetic energy of 3.98×10^{-16} J as it travels down the flight tube that is 3.00 m long.

Calculate the time taken for the $^{72}Ge^{+}$ ion to reach the detector.
Use your answer to part (d) in your calculation.

Time = ____________________ s

(3)

(Total 10 marks)

4 A student is provided with a 5.00 cm^3 sample of 1.00×10^{-2} mol dm^{-3} hydrochloric acid. The student is asked to devise a method to prepare a hydrochloric acid solution with a concentration of 5.00×10^{-4} mol dm^{-3} by diluting the sample with water.

Which of these is the correct volume of water that should be added?

A 45.0 cm^3 ○

B 95.0 cm^3 ○

C 100 cm^3 ○

D 995 cm^3 ○

(Total 1 mark)

5 Hydrated ethanedioic acid has the formula $H_2C_2O_4.xH_2O$

A student completed an experiment to determine the value of x in the formula.

(a) The student made up a solution of ethanedioic acid in a volumetric flask as follows

- 2.00 g of solid hydrated ethanedioic acid were placed in a weighing bottle.
- The solid acid was transferred to a beaker and dissolved in some distilled water.
- The solution formed was then transferred to a clean 250 cm^3 volumetric flask through a funnel.
- The beaker and funnel were washed and the washings were transferred to the volumetric flask.
- Distilled water was added up to the 250 cm^3 mark.

Give **two** improvements to the student's method.

Improvement 1 ____

____

____

Improvement 2 ____

____

____

(2)

(b) 25.0 cm^3 of the solution of ethanedioic acid were titrated with a 0.115 mol dm^{-3} sodium hydroxide solution.

Aqueous sodium hydroxide solution was added from a burette and 27.35 cm^3 were needed for neutralisation.

Ethanedioic acid reacts with sodium hydroxide as follows

$$H_2C_2O_4(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 2H_2O(l)$$

Calculate the value of x in $H_2C_2O_4.xH_2O$

You **must** show your working.

x ____________________

(5)

(c) State why it is important to fill the space below the tap in the burette before beginning an accurate titration.

____

____

(1)

(d) State why the funnel used to fill the burette should be removed before starting the titration.

____

____

(1)

(e) State why rinsing the inside of the conical flask with distilled water during a titration can improve the accuracy of the end point.

____

____

(1)

(f) The total uncertainty in the titre is ±0.15 cm^3

Calculate the total percentage uncertainty in the titre value in this experiment.

Percentage ______________________ %

(1)

(Total 11 marks)

6 Which type of bond is formed between N and B when a molecule of NH_3 reacts with a molecule of BF_3?

A Ionic. ⬭

B Covalent. ⬭

C Co-ordinate. ⬭

D Van der Waals. ⬭

(Total 1 mark)

7 Which of these species has a trigonal planar structure?

A PH_3 ⬭

B BCl_3 ⬭

C H_3O^+ ⬭

D CH_3^- ⬭

(Total 1 mark)

8 Which of these atoms has the highest electronegativity?

A Na ⬭

B Mg ⬭

C Cl ⬭

D Ar ⬭

(Total 1 mark)

9 This question is about bonding and structure.

(a) Draw the shape of the PCl_3 molecule and the shape of the SF_3^- ion.
Include any lone pairs of electrons that influence the shape.

Name the shape of the PCl_3 molecule.

Suggest the bond angle in the PCl_3 molecule.

	PCl_3 molecule	**SF_3^- ion**
Shape		
Name of shape		
Bond angle		

(4)

(b) Which substance does **not** have hydrogen bonding between its molecules?

Tick (✓) **one** box.

NH_3 ☐

H_2O ☐

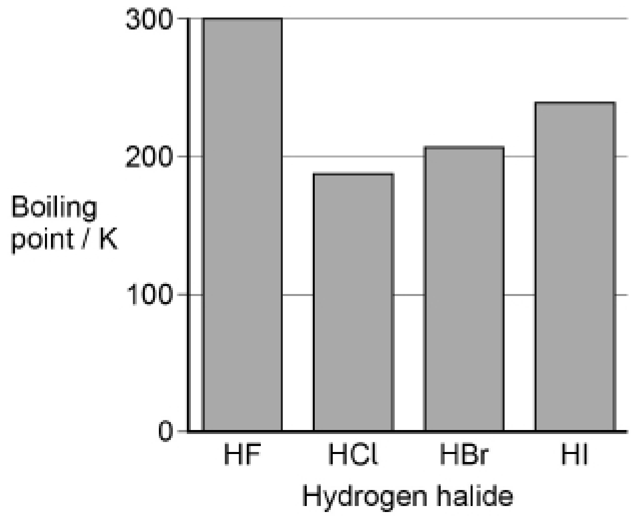
CHF_3 ☐

CH_3OH ☐

(1)

(Total 5 marks)

10 The graph shows the boiling points of the hydrogen halides, HF to HI



(a) State the strongest type of intermolecular force in HI

____

(1)

(b) Explain why the boiling point of HF is greater than the boiling point of HCl

____

____

____

____

(2)

(c) Explain why the boiling points increase from HCl to HI

____

____

____

____

____

(2)

(d) Draw a diagram to show how two molecules of HF are attracted to each other.
Include all partial charges and all lone pairs of electrons in your diagram.

(3)

(e) When one molecule of a hydrogen halide dissolves in water, a reaction occurs that forms an ion with the formula H_3O^+.
One of the bonds in this ion is formed in a different way from the other two bonds.

Draw a diagram of the ion, showing the two different ways of representing the bonds.

Compare the two different ways in which the H–O bonds in this ion are formed.

Diagram

Comparison ____

____

____

____

(4)
(Total 12 marks)

11 Which of these species is the best reducing agent?

A Cl_2 ⬭

B Cl^- ⬭

C I_2 ⬭

D I^- ⬭

(Total 1 mark)

12 Iodine reacts with concentrated nitric acid to produce nitrogen dioxide (NO_2).

(a) (i) Give the oxidation state of iodine in each of the following.

I_2 ____________________________________

HIO_3 ____________________________________

(2)

(ii) Complete the balancing of the following equation.

$$I_2 \quad + \quad 10HNO_3 \longrightarrow \;.........HIO_3 \quad + \quad ....NO_2 \quad + \quad ....H_2O$$

(1)

(b) In industry, iodine is produced from the $NaIO_3$ that remains after sodium nitrate has been crystallised from the mineral Chile saltpetre.
The final stage involves the reaction between $NaIO_3$ and NaI in acidic solution.
Half-equations for the redox processes are given below.

$$IO_3^- \quad + \quad 5e^- \quad + \quad 6H^+ \longrightarrow 3H_2O \quad + \quad \frac{1}{2}I_2$$

$$I^- \longrightarrow \frac{1}{2}I_2 \quad + \quad e^-$$

Use these half-equations to deduce an overall ionic equation for the production of iodine by this process. Identify the oxidising agent.

Overall ionic equation

The oxidising agent ____________________________________

(2)

(c) When concentrated sulfuric acid is added to potassium iodide, solid sulfur and a black solid are formed.

(i) Identify the black solid.

____

(1)

(ii) Deduce the half-equation for the formation of sulfur from concentrated sulfuric acid.

____

(1)

(d) When iodide ions react with concentrated sulfuric acid in a different redox reaction, the oxidation state of sulfur changes from +6 to -2. The reduction product of this reaction is a poisonous gas that has an unpleasant smell.
Identify this gas.

____

(1)

(e) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(ii) Write the **simplest ionic** equation for the formation of the yellow precipitate.

____

(1)

(ii) State what is observed when concentrated ammonia solution is added to this precipitate.

____

____

(1)

(iii) State why the silver nitrate is acidified when testing for iodide ions.

____

____

(1)

(f) Consider the following reaction in which iodide ions behave as reducing agents.

$$Cl_2(aq) \quad + \quad 2I^-(aq) \longrightarrow I_2(aq) \quad + \quad 2Cl^-(aq)$$

(i) In terms of electrons, state the meaning of the term *reducing agent*.

____

____

(1)

(ii) Write a half-equation for the conversion of chlorine into chloride ions.

___

(1)

(iii) Suggest why iodide ions are stronger reducing agents than chloride ions.

___

___

___

___

(2)

(Total 15 marks)

Mark schemes

1 A

[1]

2 (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]

3 (a) $^{70}Ge^{+}$ 1

(b) $$A_r = \frac{(70 \times 24.4) + (72 \times 32.4) + (74 \times 43.2)}{100}$$ 1

= 72.4 1

(c) Ions hit the detector and accept electrons causing current to flow 1

Bigger current = higher abundance of that ion 1

(d) 1.20×10^{-25} (kg)

This answer scores 2 marks

1 mark for 1.20×10^{-22} or 1.196×10^{-25} or 1.196×10^{-22}

2

(e) $$KE = \frac{1}{2} m \frac{d^2}{t^2} \quad \text{OR} \quad 3.98 \times 10^{-16} = \frac{1}{2} \times 1.196 \times 10^{-25} \times \frac{3^2}{t^2}$$

Allow consequential marking based on answer to (d)

1

$$t^2 = \frac{0.5 \times 1.196 \times 10^{-25} \times 3^2}{3.98 \times 10^{-16}}$$ 1

$t = 3.68 \times 10^{-5}$ (s) 1

[10]

4 B

[1]

5 (a) Reweigh weighing bottle after solid transferred to beaker/rinse weighing boat and transfer washings to beaker

Allow correct alternative improvements such as weigh directly into beaker <u>and</u> transfer washings into beaker.

Allow dissolve directly into volumetric flask <u>and</u> transfer washings from weighing bottle into volumetric flask

Invert flask (to ensure thorough mixing)

Ignore use dropper to top up to mark.

2

(b) n(NaOH) = 27.35 × 0.115 / 1000 = 3.145 × 10^{-3} mol

1

n(acid in 25.0 cm^3) = 3.145 × 10^{-3} / 2 = 1.57 × 10^{-3} mol

M1 divided by 2

1

n(acid in 250 cm^3) = 1.57 × 10^{-3} × 10 = 1.57 × 10^{-2}

M2 × 10

1

RFM of acid = 2.00 / 1.57 × 10^{-2} = 127.2

2.00/M3

1

x = (127.2 − 90) / 18.0 = 2.(07)

1

Alternative M4: Mass $Na_2C_2O_4$ = 1.42 g and Mass H_2O = 0.58 g

If incorrect ratio used can only score M1, M3 and M4

If missing x10 can only score M1, M2 and M4

All working must be shown to score M5

(c) (will fill during titration and cause) titre value to be too high or would appear to have more moles of acid or volume of NaOH added would be less than the recorded volume

Do not allow "to improve accuracy" or "incorrect endpoint" or "remove air bubbles" unless qualified.

1

(d) To prevent drops (of NaOH/solution) entering the burette or lower the value recorded

Do not allow "it may affect result" unless qualified.

Do not allow "there may be drops left in the funnel"

1

(e) Returns reagent on the sides of the flask to the reaction mixture (to ensure that all of the acid/alkali reacts)

Do not allow "to improve accuracy" or "to ensure that all the solution reacts" unless qualified.

1

(f) 0.15/27.35 × 100 = 0.55 %

(0.548%); at least 2 significant figures

1

[11]

6 C

[1]

7 B

[1]

8 C

[1]

9 (a) PCl_3

pyramidal/tetrahedral shape with 1 lone pair

1

(triangular) pyramidal/tetrahedral shape

(allow 100° for correct angle PCl_3)

1

106.5° − 107.5°

1

SF_3^- ion

structure with 3 bond pairs and 2 lone pairs

1

(b) CHF_3

1

[5]

10 (a) van der Waals' forces

1

(b) HF has hydrogen bonding

1

Which is stronger than the forces between HCl molecules

1

(c) Size of <u>molecule</u> increases (from HCl to HI)

Allow M_r increases/number of electrons increases

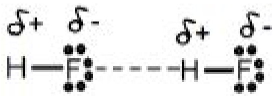
1

So van der Waals' forces (between molecules) become stronger

Allow more vdW between molecules

1

(d)



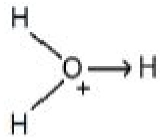
M1 is for all three lone pairs on F in both molecules

M2 is for all four partial charges

M3 is for hydrogen bond shown as dashed line from lone pair on F to H of second molecule

3

(e)



(comparison)

M3 for covalent bond formation described as each atom (H and O) supplying one electron

M4 for co-ordinate bond formation described as one atom or the O atom supplying both or a pair of electrons (to H)

M1 is for all four atoms and 3 covalent bonds

M2 is for correct use of arrow to represent the co-ordinate bond

Allow use of dots and crosses

Do not penalise + charge missing or in wrong place

Do not penalise absence of lone pair

Allow reference to sharing electrons between atoms

4

[12]

11 D

[1]

12 (a) (i) **M1** **0**

M2 **(+) 5**

Accept Roman V for M2

2

(ii) $I_2 + 10HNO_3 \longrightarrow \mathbf{2}HIO_3 + \mathbf{10}NO_2 + \mathbf{4}H_2O$

Accept multiples

1

(b) **M1** $IO_3^- + \mathbf{6}H^+ + \mathbf{5}I^- \longrightarrow \mathbf{3}I_2 + \mathbf{3}H_2O$

For M1, ignore state symbols

Credit multiples

Accept 2½I_2 + ½I_2 as alternative to 3I_2

Electrons must be cancelled

M2 $NaIO_3$ ***OR*** IO_3^- ***OR*** iodate ions ***OR*** iodate(V) ions etc.

For M2 Do not penalise an incorrect name for the correct oxidising agent that is written in addition to the formula.

Accept “the iodine in iodate ions” but NOT “iodine” alone

Accept “the iodine / I in iodate ions” but NOT “iodine” alone

2

(c) (i) Iodine ***OR*** I_2

Insist on correct name or formula

1

(ii) $H_2SO_4 + \mathbf{6}H^+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Ignore state symbols

$SO_4^{2-} + \mathbf{8}H+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Credit multiples

Do not penalise absence of charge on the electron

1

(d) hydrogen sulfide

OR H_2S

OR hydrogen sulphide

1

(e) (i) $Ag^+ + I^- \longrightarrow AgI$ ONLY

Ignore state symbols

No multiples

1

(ii) The (yellow) precipitate / solid / it does not dissolve / is insoluble

ignore "nothing (happens)"

OR turns to a white solid

ignore "no observation"

OR stays the same

OR no (visible/ observable) change

OR no effect / no reaction

1

(iii) The silver nitrate is acidified to

- react with / remove (an)ions that would interfere with the test

  Ignore reference to "false positive"

- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test

  Do not penalise an incorrect formula for an ion that is written in addition to the name.

- remove (other) ions that react with the silver nitrate

- react with / remove carbonate / hydroxide / sulfite (ions)

  If only the formula of the ion is given, it must be correct

1

(f) (i) An electron donor

Penalise "electron pair donor"

OR (readily) donates / loses / releases / gives (away) electron(s)

Penalise "loss of electrons" alone

Accept "electron donator"

1

(ii) Cl_2 + **2**e^- ⟶ **2**Cl^-

Ignore state symbols

Do not penalise absence of charge on electron

*Credit Cl_2 ⟶ **2**Cl^- – **2**e^-*

Credit multiples

1

(iii) For M1 and M2, iodide ions are stronger reducing agents than chloride ions, because

Ignore general statements about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of ions

CE=0 for the clip if "iodine ions / chlorine ions" ***QoL***

Iodide ions / they are larger /have more electron levels(shells) (than chloride ions) / larger atomic / ionic radius

CE=0 for the clip if "iodide ions are bigger molecules / atoms" ***QoL***

OR electron to be lost/outer shell/level (of the iodide ion) is further the nucleus

OR iodide ion(s) / they have greater / more shielding

Insist on iodide ions in M1 and M2 or the use of it / they / them, in the correct context (or chloride ions in the converse argument)

OR converse for chloride ion

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

The electron(s) lost /outer shell/level electron from (an) iodide ion(s) less strongly held by the nucleus compared with that lost from a chloride ion

OR converse for a chloride ion

2

[15]