



# Cambridge IGCSE™

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**CHEMISTRY****0620/41**

Paper 4 Theory (Extended)

**October/November 2023****1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

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This document has **16** pages. Any blank pages are indicated.

- 1 A list of gases is shown.

**ammonia**  
**carbon dioxide**  
**carbon monoxide**  
**ethene**  
**fluorine**  
**oxygen**  
**sulfur dioxide**  
**xenon**

Answer the following questions using only the gases from the list.  
Each gas may be used once, more than once or not at all.

Give the name of the gas that:

- (a) causes acid rain

..... [1]

- (b) forms an alkaline solution when dissolved in water

..... [1]

- (c) is inert

..... [1]

- (d) is a product of photosynthesis

..... [1]

- (e) can form a polymer

..... [1]

- (f) is produced in the test for nitrate ions.

..... [1]

[Total: 6]

2 Boron and aluminium are Group III elements.

- (a) Boron has only two naturally occurring isotopes,  $^{10}\text{B}$  and  $^{11}\text{B}$ .

Complete Table 2.1 to show the numbers of protons, neutrons and electrons in an atom of  $^{11}\text{B}$ .

**Table 2.1**

number of protons	number of neutrons	number of electrons

[2]

- (b) The relative atomic mass of boron to one decimal place is 10.8.

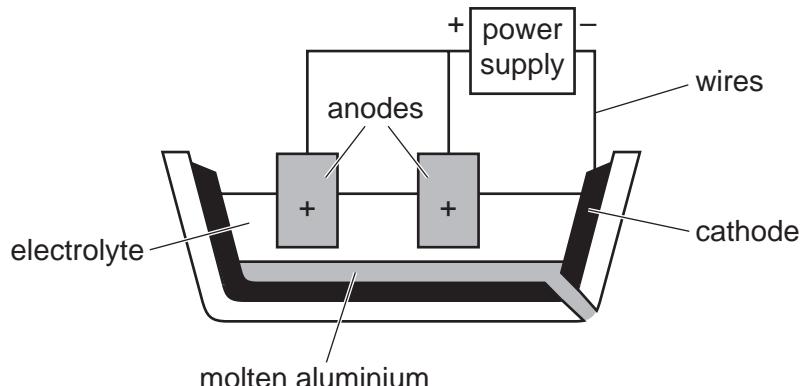
- (i) Determine the relative abundance of  $^{10}\text{B}$  present in boron. Give your answer as a percentage.

..... % [1]

- (ii) Use the relative atomic mass of boron to calculate the number of atoms in 0.540 g of boron. Give your answer in standard form.

number of atoms = ..... [2]

- (c) Aluminium is extracted from its purified ore as shown in Fig. 2.1.



**Fig. 2.1**

- (i) Name the ore of aluminium.

..... [1]

- (ii) The electrolyte contains aluminium oxide and one other substance.

Name the other substance and explain why it is used.

name .....

explanation .....

..... [2]

- (iii) Write the ionic half-equation for the reaction at the cathode.

..... [2]

- (iv) Explain why the anodes need frequent replacement.

.....

..... [2]

- (d) State **two** physical properties of aluminium that make it suitable for use in overhead electrical cables.

1 .....

2 .....

[2]

- (e) Explain the apparent unreactivity of aluminium.

.....  
..... [2]

- (f) Aluminium reacts with fluorine to form aluminium fluoride,  $\text{AlF}_3$ , an ionic compound.

- (i) Write the symbol equation for this reaction.

..... [2]

- (ii) Complete Fig. 2.2 to show the electronic configuration of one aluminium ion and one fluoride ion.  
Show the charges on the ions.

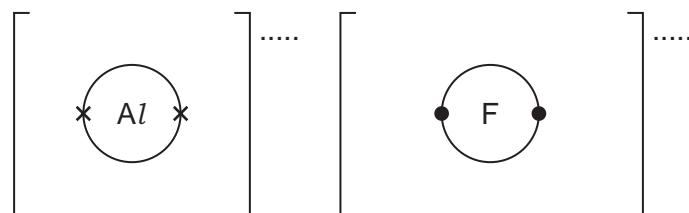


Fig. 2.2

[3]

[Total: 21]

- 3 Order of reactivity can be determined by displacement reactions.

- (a) A student investigates the reactivities of four metals by carrying out a series of experiments.

Each of the metals lead, manganese, silver and zinc are added separately to aqueous metal nitrates of the other metals.

- (i) Table 3.1 shows some of the results.

**Table 3.1**

aqueous solution	lead Pb	manganese Mn	silver Ag	zinc Zn
lead(II) nitrate		✓		
manganese(II) nitrate				
silver nitrate	✓	✓		✓
zinc nitrate	✗	✗		

key

✓ = displacement reaction occurs

✗ = displacement reaction does not occur

Complete Table 3.1 and place the four metals in their order of reactivity with the most reactive first.

1 ..... most reactive

2 .....

3 .....

4 .....

[3]

- (ii) Suggest why the metal nitrates and not the metal sulfates of these four metals are used as the aqueous solutions.

..... [1]

- (iii) Write the symbol equation for the reaction between zinc and silver nitrate.

..... [2]

- (b) The reactivity of Group VII elements can be investigated experimentally.

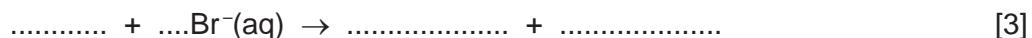
A student bubbles chlorine gas into a test-tube containing aqueous potassium bromide.

- (i) Describe the colour change seen in the test-tube.

from ..... to ..... [2]

- (ii) Complete the ionic equation for this reaction.

Include state symbols.



- (iii) The reactivity trend seen in Cl, Br and I applies to all the elements in Group VII.

Use the Periodic Table to identify the Group VII element which **cannot** displace any other Group VII elements.

..... [1]

[Total: 12]

- 4** Aqueous hydrogen peroxide,  $\text{H}_2\text{O}_2$ , slowly forms water and oxygen at room temperature and pressure, r.t.p. This reaction is catalysed by manganese(IV) oxide.

The equation is shown.



- (a)** State the test for oxygen gas.

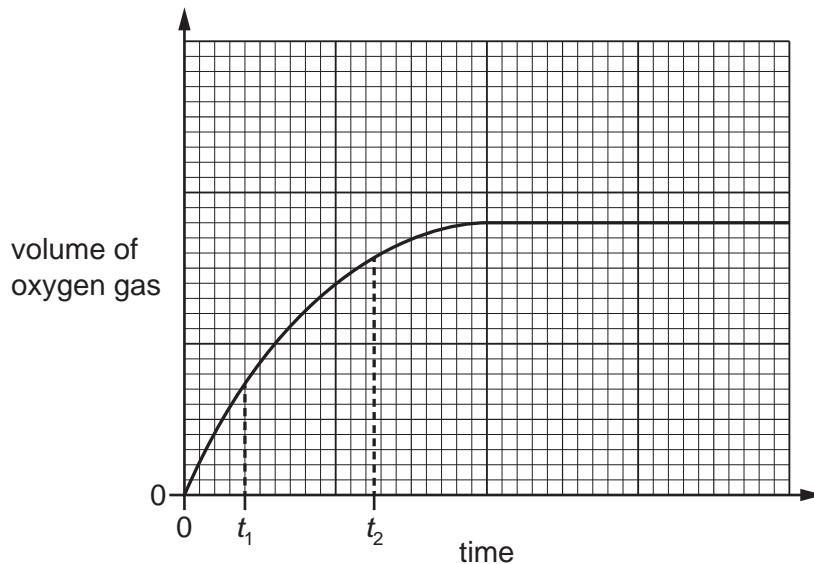
test .....

observations .....

[1]

- (b)** A student investigates the rate of formation of oxygen gas when manganese(IV) oxide is added to aqueous hydrogen peroxide.

The volume of oxygen gas formed is measured at regular time intervals at r.t.p. The results are plotted onto the graph in Fig. 4.1.



**Fig. 4.1**

- (i)** State how the graph in Fig. 4.1 shows the rate of reaction at time  $t_2$ , is lower than at time  $t_1$ .

..... [1]

- (ii)** Explain, using collision theory, why the rate of reaction at time  $t_2$  is lower than at time  $t_1$ .

.....

.....

..... [2]

- (iii)** On Fig. 4.1, sketch the graph obtained when the experiment is repeated using aqueous hydrogen peroxide at a higher temperature. All other conditions remain the same. [2]

- (c) Manganese(IV) oxide is added to  $20\text{ cm}^3$  of aqueous hydrogen peroxide. The total volume of oxygen gas produced is  $72\text{ cm}^3$  at r.t.p.



Calculate the concentration of the aqueous hydrogen peroxide in  $\text{g/dm}^3$  using the following steps.

- Calculate the number of moles of oxygen gas produced.

..... mol

- Determine the number of moles of hydrogen peroxide which reacts.

..... mol

- Calculate the concentration of aqueous hydrogen peroxide in  $\text{mol/dm}^3$ .

.....  $\text{mol/dm}^3$

- Calculate the concentration of aqueous hydrogen peroxide in  $\text{g/dm}^3$ .

.....  $\text{g/dm}^3$   
[5]

- (d) Suggest the identity of one **other** metal oxide which also catalyses this reaction.

..... [1]

[Total: 12]

- 5 Methane reacts with steam to produce hydrogen gas.



The reaction takes place at 1000 °C and 100 kPa pressure.

- (a) The reaction is reversible and reaches an equilibrium in a closed system.

State **two** features of an equilibrium.

1 .....

2 .....

[2]

- (b) State and explain, in terms of equilibrium, what happens to the concentration of hydrogen when:

- (i) the pressure is increased

..... [2]

- (ii) the temperature is increased

..... [2]

- (iii) a catalyst is used.

..... [2]

- (c) Methane is a greenhouse gas which contributes to global warming.

- (i) Name a greenhouse gas found in clean, dry air.

..... [1]

- (ii) Explain, in terms of thermal energy, how greenhouse gases cause global warming.

.....  
.....  
.....  
..... [3]

[Total: 12]

- 6 Ethanol is manufactured by **two** methods:

method 1 fermentation of aqueous glucose

method 2 catalytic addition of steam to an alkene.

- (a) Method 1 takes place at room temperature and pressure.

State **two** other conditions needed in method 1.

1 .....

2 .....

[2]

- (b) (i) State the typical temperature and pressure used in method 2.

temperature ..... °C

pressure ..... kPa

[2]

- (ii) Name the alkene used in method 2.

..... [1]

- (iii) State why the reaction in method 2 is referred to as an addition reaction.

..... [1]

- (c) The catalyst in method 2 is phosphoric acid,  $H_3PO_4$ . Dilute phosphoric acid is a weak acid which contains phosphate ions,  $PO_4^{3-}$ .

- (i) State what is meant by the term acid.

..... [1]

- (ii) State the meaning of weak in the term weak acid.

..... [1]

- (iii) Determine the oxidation number of phosphorus in the  $PO_4^{3-}$  ion.

Show your working.

oxidation number = ..... [2]

(d) Give **one** advantage of each method of production of ethanol.

method 1 .....

method 2 .....

[2]

(e) Ethanol can be converted to ethanoic acid by reacting it with an acidified oxidising agent.

(i) Name the acidified oxidising agent.

..... [1]

(ii) State, in terms of redox, what type of reagent ethanol is in this reaction.

..... [1]

(f) Ethanoic acid reacts with calcium to form a salt and one other product.

(i) Name the salt.

..... [1]

(ii) Write the formula of the salt.

..... [1]

(iii) Identify the other product.

..... [1]

[Total: 17]

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## The Periodic Table of Elements

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