



## Cambridge O Level

CANDIDATE  
NAME



CENTRE  
NUMBER

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### CHEMISTRY

5070/21

Paper 2 Theory

October/November 2024

1 hour 45 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.

This document has **20** pages. Any blank pages are indicated.

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2

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1 (a) Fig. 1.1 shows the electronic configurations of five atoms, **D**, **E**, **F**, **G** and **H**.

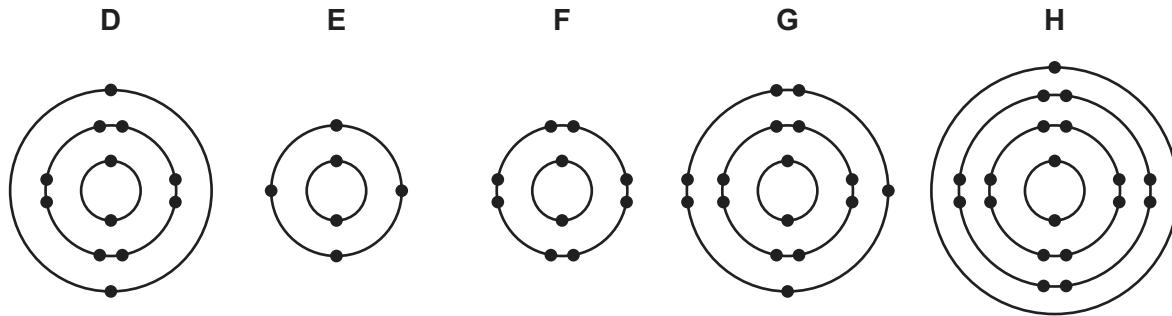


Fig. 1.1

Answer the questions about these electronic configurations.

Each electronic configuration may be used once, more than once or not at all.

State which electronic configuration, **D**, **E**, **F**, **G** or **H**, represents:

(i) an atom of an element in Group VI of the Periodic Table

..... [1]

(ii) an atom that forms an ion that gives a lilac colour in a flame test

..... [1]

(iii) an atom of a monatomic gas

..... [1]

(iv) an atom of an element that is used in the treatment of the domestic water supply to remove tastes and odours

..... [1]

(v) an atom that forms a stable ion by losing two electrons.

..... [1]

(b) Deduce the number of protons and neutrons in the chromium atom shown.



number of protons .....

number of neutrons .....

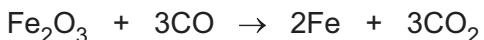
[2]

[Total: 7]





2 (a) Iron is extracted in a blast furnace by the reduction of iron(III) oxide with carbon monoxide.



(i) This reaction is a redox reaction.

State the meaning of the term redox reaction.

.....  
..... [1]

(ii) Explain how carbon monoxide acts as a reducing agent in this reaction.

..... [1]

(b) Calcium carbonate is added to the blast furnace. The calcium carbonate undergoes thermal decomposition.



The thermal decomposition of calcium carbonate is endothermic.

Complete the reaction pathway diagram in Fig. 2.1 to show:

- the reactant and products
- a labelled arrow for the activation energy,  $E_a$
- a labelled arrow for the enthalpy change,  $\Delta H$ .

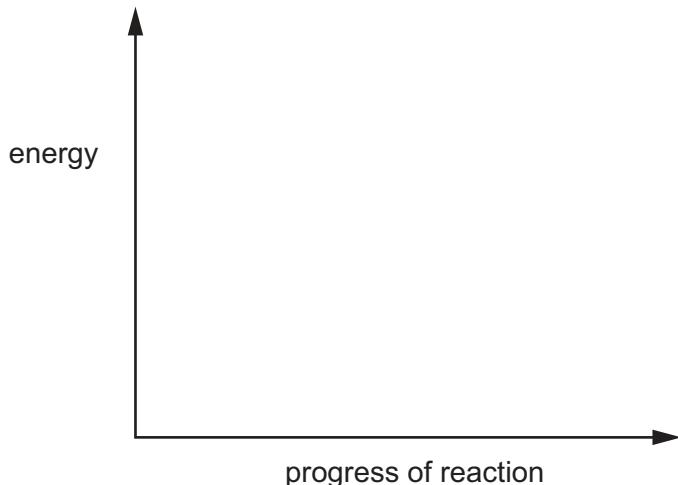


Fig. 2.1

[3]





(c) Describe how slag is formed in the blast furnace.

Include a symbol equation in your answer.

.....  
.....  
.....

[2]

(d) Iron is a transition element.

Transition elements have coloured compounds.

State two **other** physical properties that are typical of transition elements and **not** of Group I metals.

1 .....

2 .....

[2]

(e) The equation shows the decomposition of iron pentacarbonyl,  $\text{Fe}(\text{CO})_5$ , in a closed container.



(i) Predict and explain what happens to the position of equilibrium when the pressure is decreased. The temperature remains the same.

prediction .....

explanation .....

[2]

(ii) This reaction can be used to produce pure iron.

Describe and explain, by referring to the equation, how a sample of pure iron that is free from  $\text{Fe}(\text{CO})_5(\text{l})$  is produced from the equilibrium mixture.

.....  
.....  
.....

[2]

(f) Iron reacts with hot concentrated sulfuric acid.

The products are iron(III) sulfate, sulfur dioxide and a liquid that turns anhydrous copper(II) sulfate blue.

Construct the symbol equation for this reaction.

.....

[2]

[Total: 15]

[Turn over]





3 Fig. 3.1 shows the apparatus used for the electrolysis of concentrated aqueous sodium chloride using graphite electrodes.

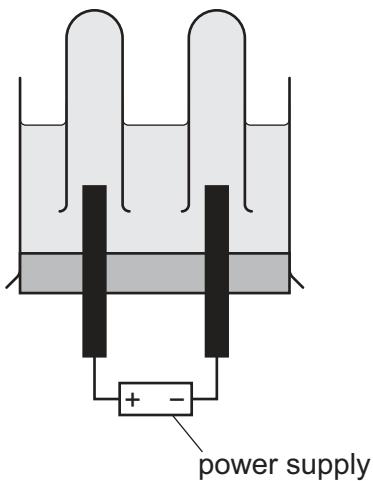


Fig. 3.1

(a) Label the cathode on Fig. 3.1. [1]

(b) Explain why concentrated aqueous sodium chloride conducts electricity.

..... [1]

(c) (i) Name the product formed at the cathode.

..... [1]

(ii) Chlorine is formed at the anode.

Construct the ionic half-equation for the reaction at the anode.

..... [1]

(d) Graphite is suitable as an electrode because it conducts electricity.

State one **other** property of graphite that makes it suitable for use as an electrode.

..... [1]

(e) State the product formed at the cathode when molten sodium chloride is electrolysed.

..... [1]

[Total: 6]





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4 This question is about alkanes and alkenes.

(a) But-1-ene belongs to the alkene homologous series.

Members of the same homologous series differ from one member to the next by a  $-\text{CH}_2-$  group and have similar chemical properties.

State two **other** characteristics of a homologous series.

1 .....

2 .....

[2]

(b) Fig. 4.1 shows the displayed formula of but-1-ene.

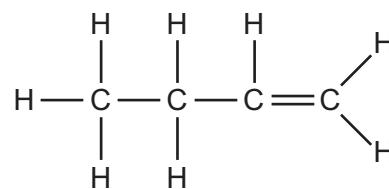


Fig. 4.1

(i) Explain how Fig. 4.1 shows that but-1-ene is an unsaturated compound.

..... [1]

(ii) Give the structural formula of but-1-ene.

..... [1]

(iii) Draw the displayed formula of an isomer of but-1-ene.

[1]





(c) Undecane,  $C_{11}H_{24}$ , is present in the kerosene/paraffin fraction from the distillation of petroleum.

(i) Give **one** use of the kerosene/paraffin fraction.

..... [1]

(ii) When undecane is cracked, shorter hydrocarbon molecules are formed.

Construct the symbol equation for a reaction in which undecane is cracked and the only products are butane, propene and ethene.

..... [2]

(d) Propane reacts with chlorine to form chloropropane and one other product, X.



(i) Name product X.

..... [1]

(ii) State the essential condition for this reaction.

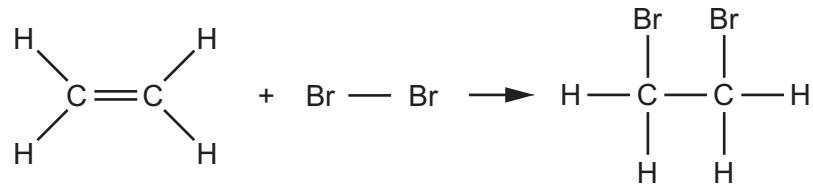
..... [1]





(e) Ethene reacts with bromine at room temperature.

Fig. 4.2 shows the displayed formulae of the reactants and product.



**Fig. 4.2**

(i) Calculate the enthalpy change of this reaction in kJ/mol.

Use the bond energies in Table 4.1.

**Table 4.1**

type of bond	C=C	C–H	Br–Br	C–C	C–Br
bond energy in kJ/mol	612	413	193	347	290

enthalpy change = ..... kJ/mol  
[3]

(ii) Describe the colour change when a sample of excess ethene is added to a few drops of aqueous bromine.

from ..... to ..... [1]

[Total: 14]





5 A student adds large pieces of copper(II) carbonate to dilute hydrochloric acid. The copper(II) carbonate is in excess.

(a) Complete the equation by adding state symbols for the products.



(b) Fig. 5.1 shows how the mass of the reaction mixture changes with time as the reaction proceeds.

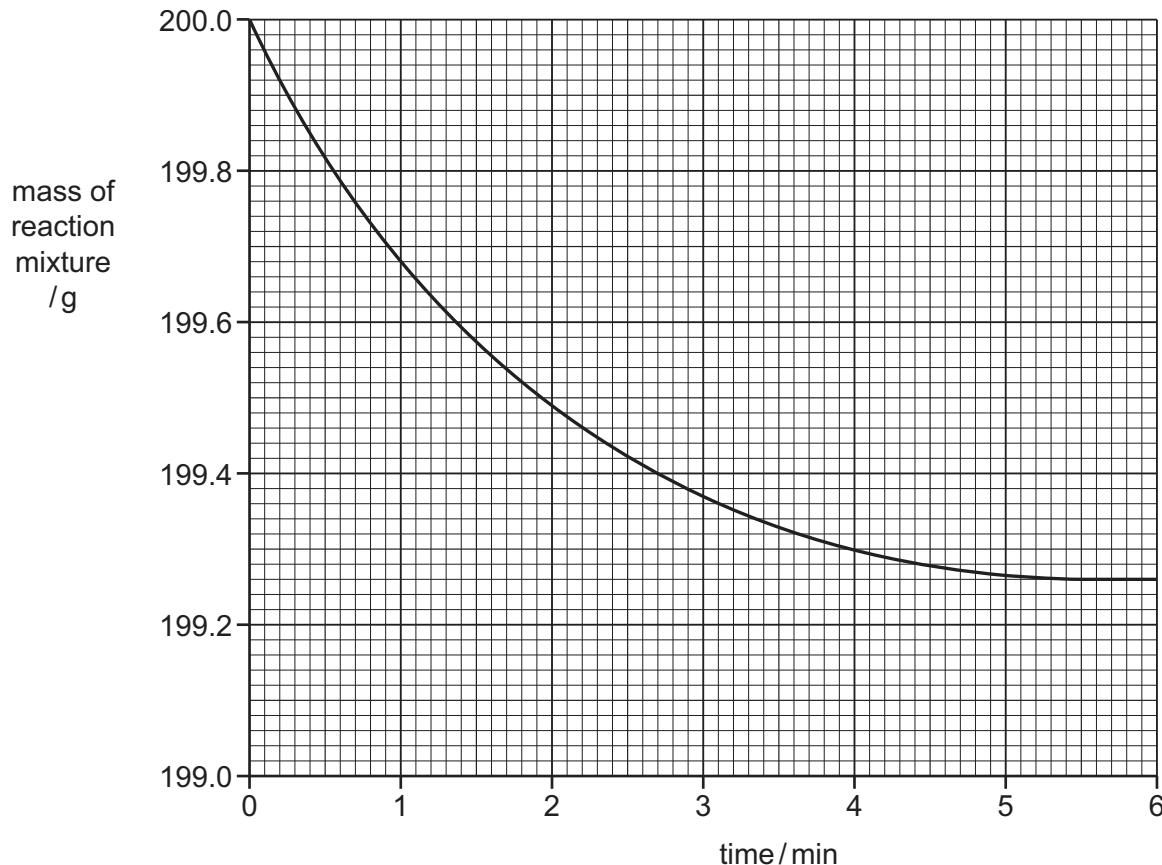


Fig. 5.1

(i) In another experiment, powdered copper(II) carbonate is used instead of large pieces of copper(II) carbonate. All other conditions and the mass of copper(II) carbonate stay the same.

Draw a line on the grid in Fig. 5.1 to show how the mass of the reaction mixture changes with time. [2]





(ii) The initial experiment is repeated using large pieces of copper(II) carbonate and hydrochloric acid of a higher concentration.

All other conditions stay the same.

Describe and explain the difference in rate of reaction when hydrochloric acid of a higher concentration is used.

.....  
.....  
.....

[2]

(c) Excess copper(II) carbonate is added to 22.0 cm<sup>3</sup> of 0.500 mol/dm<sup>3</sup> hydrochloric acid.

Calculate the volume of carbon dioxide released measured at room temperature and pressure.

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

volume of carbon dioxide gas = ..... dm<sup>3</sup> [3]

(d) (i) Describe the observations made when:

- a few drops of aqueous ammonia are added to an aqueous solution containing copper(II) ions

.....

- excess aqueous ammonia is added to an aqueous solution containing copper(II) ions.

.....

[2]

(ii) An ionic compound of copper has the formula Cu<sub>2</sub>O.

Deduce the oxidation number of copper in Cu<sub>2</sub>O.

.....

[1]

[Turn over]





(e) Describe how to prepare crystals of ammonium chloride by reacting aqueous ammonia with dilute hydrochloric acid.

.....

.....

.....

.....

.....

[3]

[Total: 14]

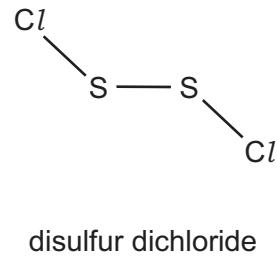
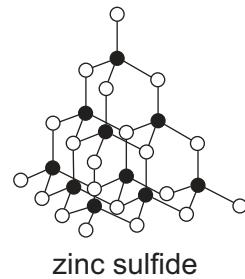
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6 Fig. 6.1 shows the structures of zinc sulfide and disulfur dichloride.

Zinc sulfide has a structure similar to diamond.



**Key:**

- zinc atoms
- sulfur atoms

**Fig. 6.1**

(a) (i) Explain why zinc sulfide does **not** conduct electricity.

Use the information in Fig. 6.1.

..... [1]

(ii) Predict one **other** physical property of zinc sulfide.

..... [1]

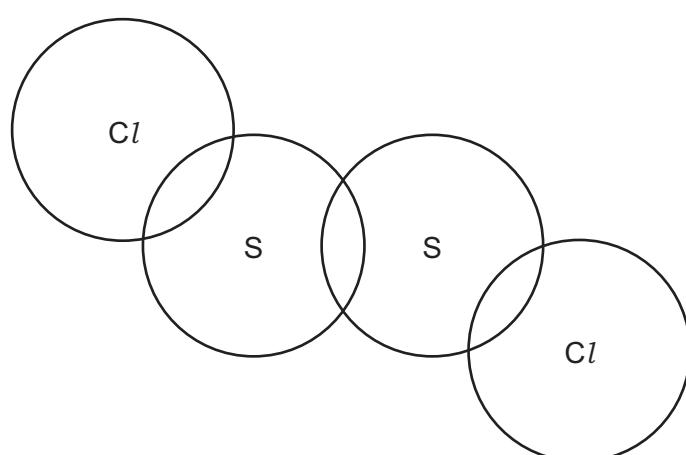
(b) Explain why disulfur dichloride has a low melting point.

Use the information in Fig. 6.1.

..... [1]

(c) Complete Fig. 6.2 to show the dot-and-cross diagram for the electronic configuration of disulfur dichloride.

Show only the outer shell electrons.



**Fig. 6.2**

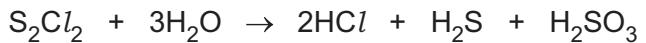
[1]

[Turn over]





(d) Disulfur dichloride reacts with water as shown.



13.5 g of disulfur dichloride is reacted with 8.00 g of water.

Show by calculation that water is in excess.

[3]

(e) Sulfur dioxide is an air pollutant.

(i) State **one** adverse effect of sulfur dioxide in the air.

..... [1]

(ii) Describe two ways of reducing the emissions of sulfur dioxide in the air.

1 .....

2 .....

[2]

[Total: 10]





7 (a) Propanoic acid can be represented by the formula  $\text{CH}_3\text{CH}_2\text{COOH}$ .

(i) Propanoic acid reacts with methanol,  $\text{CH}_3\text{OH}$ , to produce an ester.

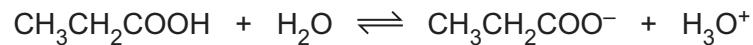
Name the ester formed and draw its displayed formula.

name .....

displayed formula

[2]

(ii) Propanoic acid is a weak acid.



Explain how this equation shows that:

- $\text{CH}_3\text{CH}_2\text{COOH}$  is an acid by referring to proton transfer

.....

- $\text{CH}_3\text{CH}_2\text{COOH}$  is a **weak** acid.

.....

[2]

(iii) Propanoic acid reacts with magnesium.

Name the two products of this reaction.

1 .....

2 .....

[2]





(iv) Magnesium is a solid at room temperature.

Describe the motion and separation of the particles in a solid.

motion .....

separation .....

[2]

(b) Fig. 7.1 shows the simplified structures of two molecules that combine to form a polyamide.

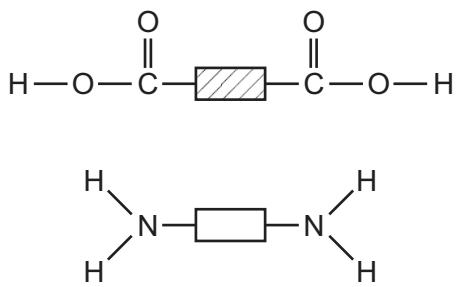


Fig. 7.1

(i) Complete the diagram in Fig. 7.2 to show the structure of two repeat units of this polyamide.

Show all of the atoms and all of the bonds in the linkages.



Fig. 7.2

[3]





(ii) Polyamides are polymers.

State the meaning of the term polymer.

.....  
.....  
.....

[2]

(iii) Polyamides are condensation polymers.

State **one** difference between condensation polymerisation and addition polymerisation.

.....  
.....

[1]

[Total: 14]







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## The Periodic Table of Elements

The volume of one mole of any gas is  $24\text{ dm}^3$  at room temperature and pressure (r.t.p.).