



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.







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

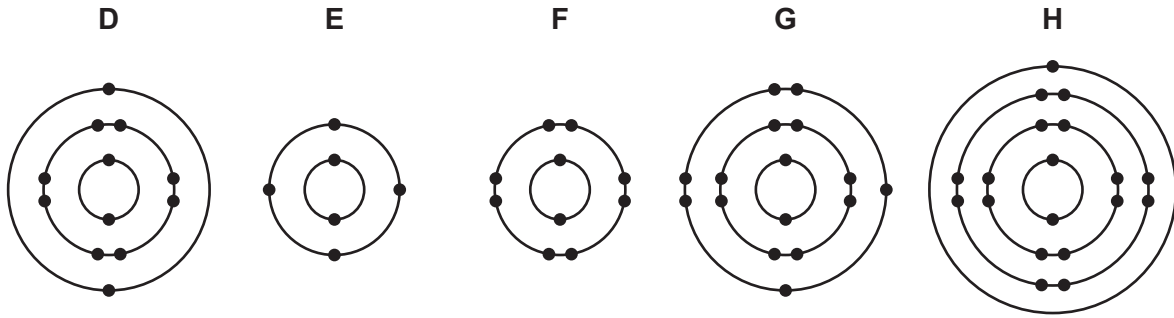


Fig. 1.1

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]

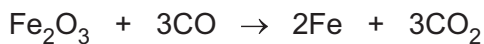
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2 (a) Iron is extracted in a blast furnace by the reduction of iron(III) oxide with carbon monoxide.



(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, ΔH .

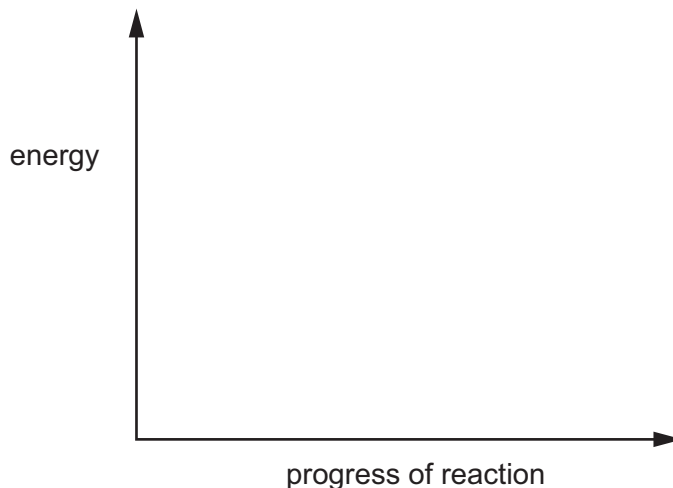


Fig. 2.1

[3]

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(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, Fe(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 Fe(CO)₅(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]



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

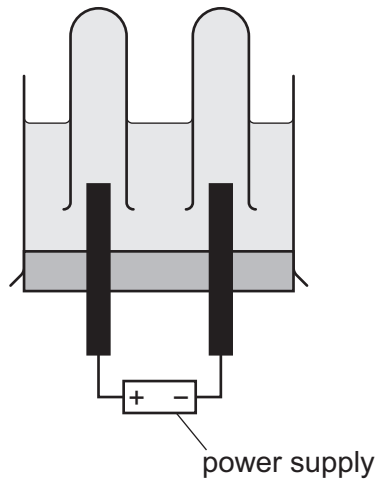


Fig. 3.1

(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.

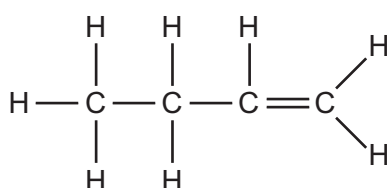


Fig. 4.1

(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.

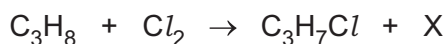
..... [1]

(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]

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- (e) Ethene reacts with bromine at room temperature.

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

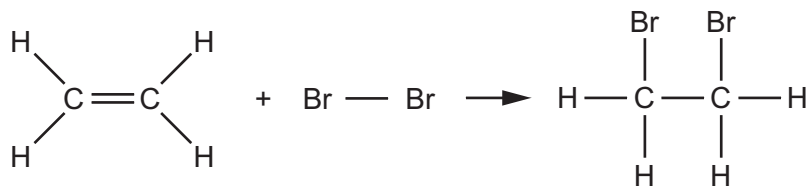


Fig. 4.2

- (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]

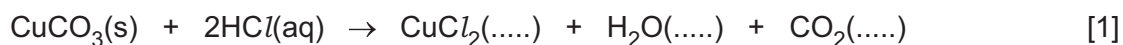
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- 5 A student adds large pieces of copper(II) carbonate to dilute hydrochloric acid. The copper(II) carbonate is in excess.

(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.

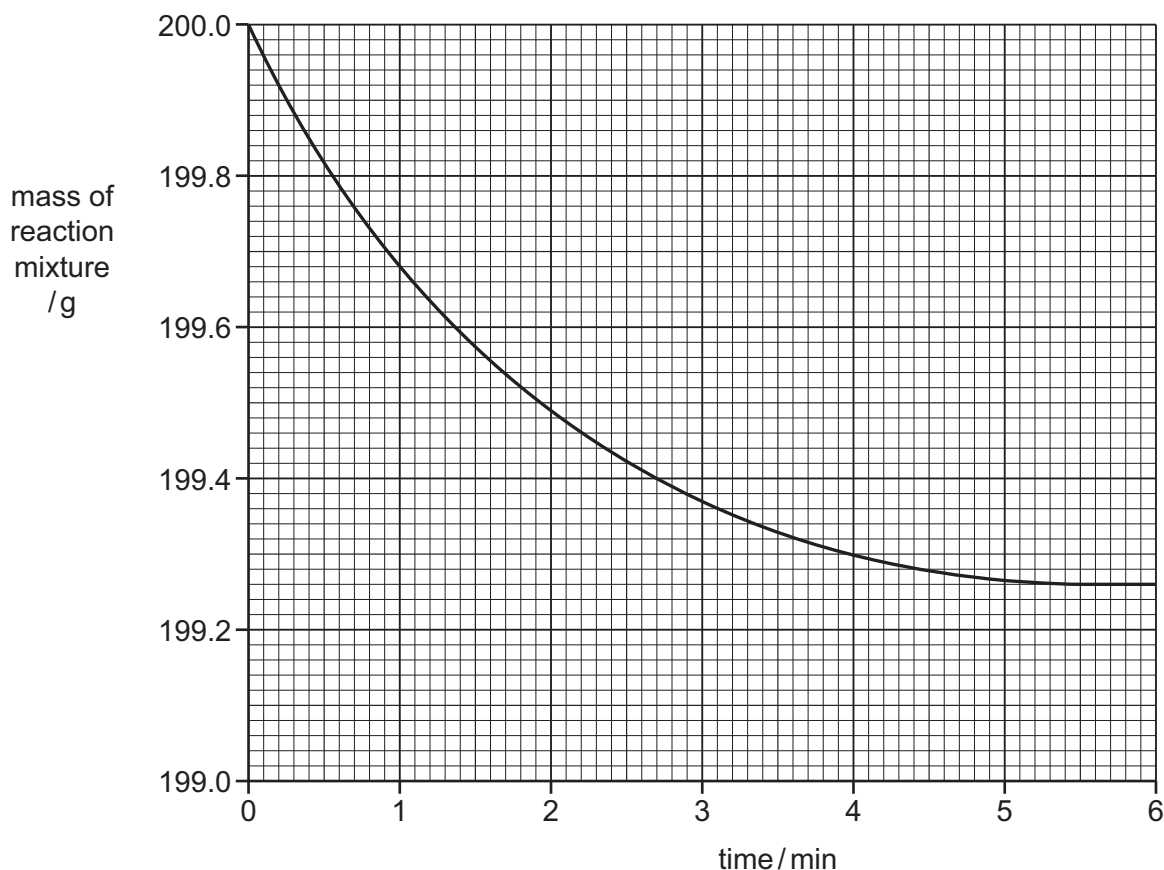


Fig. 5.1

- (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 cm³ of 0.500 mol/dm³ 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 = dm³ [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 Cu₂O.

Deduce the oxidation number of copper in Cu₂O.

..... [1]



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

.....

.....

.....

.....

..... [3]

[Total: 14]

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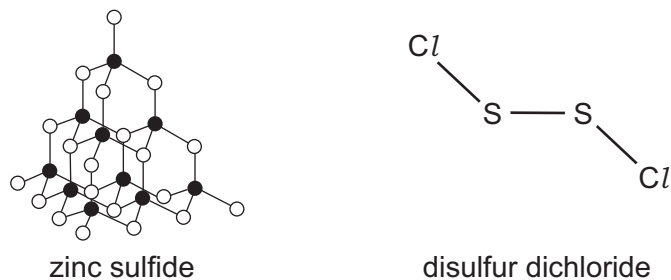
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6 Fig. 6.1 shows the structures of zinc sulfide and disulfur dichloride.

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.

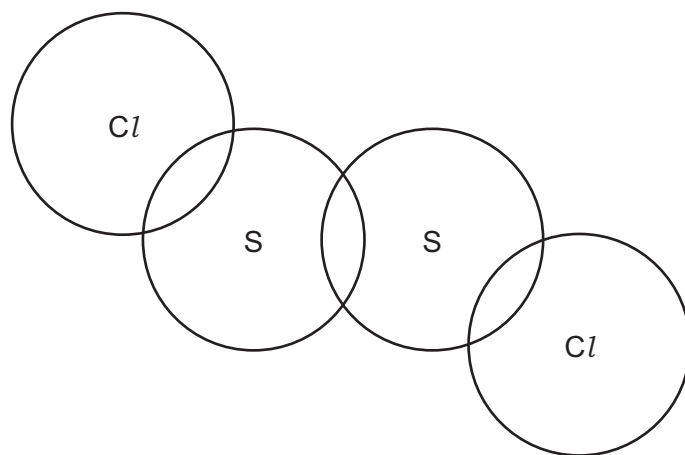
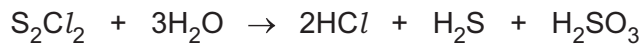


Fig. 6.2





(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]

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7 (a) Propanoic acid can be represented by the formula CH₃CH₂COOH.

(i) Propanoic acid reacts with methanol, CH₃OH, to produce an ester.

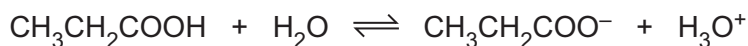
Name the ester formed and draw its displayed formula.

name

displayed formula

[2]

(ii) Propanoic acid is a weak acid.



Explain how this equation shows that:

- CH₃CH₂COOH is an acid by referring to proton transfer

.....

- CH₃CH₂COOH is a **weak** acid.

.....

[2]

(iii) Propanoic acid reacts with magnesium.

Name the two products of this reaction.

1

2

[2]



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(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.

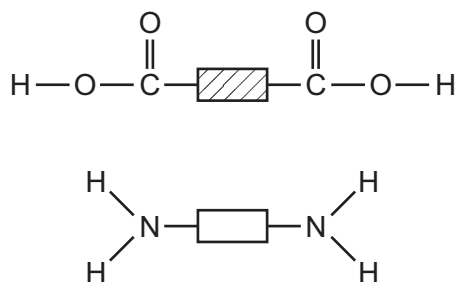


Fig. 7.1

(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]

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(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

		Group															
I	II	III	IV	V	VI	VII	VIII					VIII					
3 Li lithium 7	4 Be beryllium 9	1 H hydrogen 1	5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20	11 Na sodium 23	12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40	
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium —	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —
87 Fr francium —	88 Ra radium —	89–103 actinoids	104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	117 Ts tennessine —	118 Og oganesson —

Key
atomic number
atomic symbol
name
relative atomic mass

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

