Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

247671728 9

CHEMISTRY **0620/31**

Paper 3 Theory (Core) **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.

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

1 A list of substances is shown.

ammonium nitrate
carbon monoxide
copper(II) chloride
ethane
ethene
litmus
methane
methyl orange
sodium chloride
sodium sulfate
sulfur dioxide
thymolphthalein

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

Give the name of the substance that:

(a) turns from blue to colourless when an acid is added

..... [1]

(b) is in many fertilisers

..... [1]

(c) is a salt which has a negative ion with a charge of 2–

..... [1]

(d) is a waste gas from digestion in animals

..... [1]

(e) is a hydrocarbon with a total of five atoms in a molecule

..... [1]

(f) is a compound of a transition element.

..... [1]

[Total: 6]

2 **(a)** Fig. 2.1 shows the distillation apparatus that can be used to separate water from aqueous copper(II) sulfate.

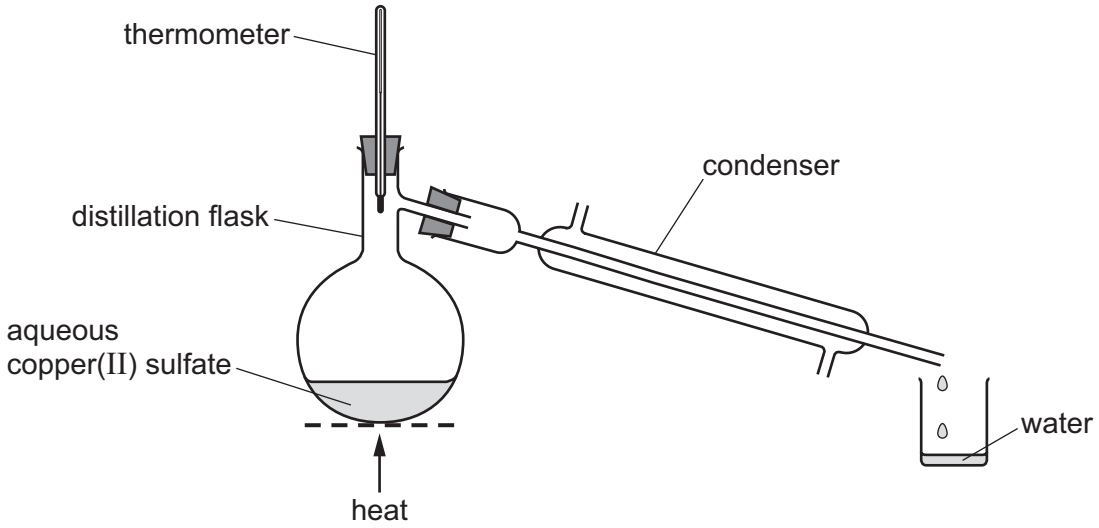


Fig. 2.1

Explain how distillation separates water from aqueous copper(II) sulfate.

.....

.....

..... [2]

(b) Fig. 2.2 shows a fractionating column for separating petroleum into different hydrocarbon fractions.

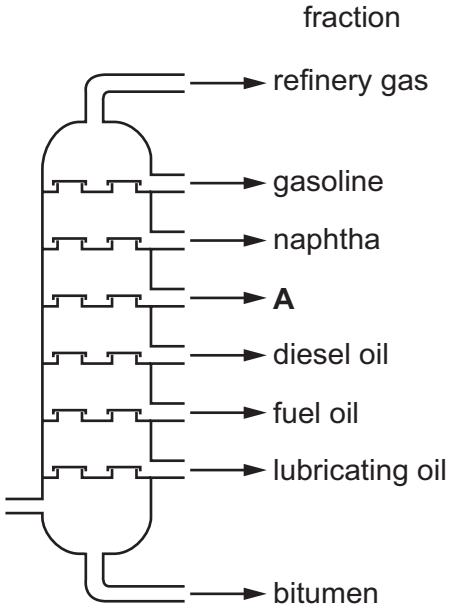


Fig. 2.2

(i) On Fig. 2.2, draw an **X** inside the column to show where the hydrocarbon with the highest viscosity collects. [1]

(ii) Name the fraction labelled **A** in Fig. 2.2.

..... [1]

(iii) State the name of the fraction in Fig. 2.2 which has the lowest boiling point.

..... [1]

(iv) State **one** use of the bitumen fraction.

..... [1]

[Total: 6]

3 **(a)** Table 3.1 shows the average concentrations, in ng / 1000 cm^3, of air pollutants in four different years.

Table 3.1

year	concentration of air pollutant in ng / 1000 cm^3				
	ammonia	hydrocarbons	oxides of nitrogen	particulates	sulfur dioxide
2019	10.6	12.0	15.3	30.1	20.5
2020	11.2	13.0	21.6	28.2	20.0
2021	14.3	15.2	23.5	26.5	25.0
2022	15.5	9.0	14.0	25.2	18.2

(i) Name the pollutant that has the lowest concentration in 2019.

..... [1]

(ii) Name the pollutant that shows a continuous decrease in concentration from 2019 to 2022.

..... [1]

(iii) Calculate the average mass, in ng, of sulfur dioxide in a 250 cm^3 sample of polluted air in 2020.

mass = ... ng [1]

(b) **(i)** State **one** source of sulfur dioxide in the atmosphere.

..... [1]

(ii) State **one** adverse effect of sulfur dioxide in the atmosphere.

..... [1]

[Turn over

(iii) Choose the compound used to remove sulfur dioxide in flue gas desulfurisation.

Tick (✓) **one** box.

aluminium chloride	☐
calcium oxide	☐
methane	☐
sulfuric acid	☐

[1]

(iv) Hydrochloric acid reacts with sodium sulfite.

The products are sodium chloride, sulfur dioxide and a liquid which turns anhydrous cobalt(II) chloride pink.

Complete the symbol equation for this reaction.

$$Na_2SO_3 + ...HCl \rightarrow 2NaCl + SO_2 + ...$$ [2]

(v) Name the acidified solution used to test for sulfur dioxide gas and state the observations.

acidified solution .....

observations .....

[2]

(c) Ammonia forms an alkaline solution in water.

(i) Give the formula of the ion that is present in all alkaline solutions.

..... [1]

(ii) Choose from the list the pH value for an alkaline solution.

Draw a circle around your chosen answer.

pH 1 **pH 4** **pH 7** **pH 13** [1]

[Total: 12]

4 Bromine is a liquid at room temperature.

(a) State **two** general properties of a liquid.

1 .....

.....

2 .....

.....
[2]

(b) Fig. 4.1 shows the physical states of bromine.

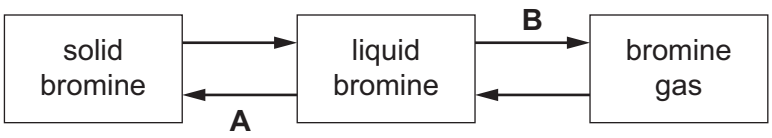


Fig. 4.1

Name the changes of physical states **A** and **B**.

A .....

B .....
[2]

(c) Describe liquid bromine and bromine gas in terms of the arrangement and motion of the particles.

liquid bromine

arrangement .....

.....

motion .....

.....

bromine gas

arrangement .....

.....

motion .....

.....
[4]

[Turn over

(d) A sealed gas syringe contains 80 cm^3 of bromine gas.

State how decreasing the pressure affects the volume of bromine gas in the gas syringe when the temperature remains constant.

..... [1]

[Total: 9]

5 This question is about metals and metal compounds.

(a) Table 5.1 shows some properties of some Group I metals.

Table 5.1

metal	melting point in °C	boiling point in °C	observations on reaction with water	solubility of metal hydroxide in g/dm^3 at room temperature
sodium	98	883	bubbles form rapidly but no flame	
potassium	63	760		1130
rubidium		686	explodes	1980
caesium	29	669	explodes	3860

Use the information in Table 5.1 to predict:

(i) the melting point of rubidium ..... [1]

(ii) the solubility of sodium hydroxide at room temperature ..... [1]

(iii) the observations when potassium reacts with water

.....

..... [1]

(iv) the physical state of caesium at 20 °C. Give a reason for your answer.

physical state .....

reason .....

..... [2]

(b) Iron is extracted in a blast furnace by reduction of iron(III) oxide, Fe_2O_3, with carbon monoxide.

Carbon monoxide is produced by the reaction of carbon with carbon dioxide.

$$C + CO_2 \rightarrow 2CO$$

(i) Explain how this equation shows that carbon dioxide is reduced.

.....

..... [1]

(ii) Name the type of chemical reaction where oxidation and reduction take place simultaneously.

..... [1]

(iii) Calcium carbonate is added to the blast furnace.

The calcium carbonate undergoes thermal decomposition.

State the meaning of the term thermal decomposition.

.....

..... [2]

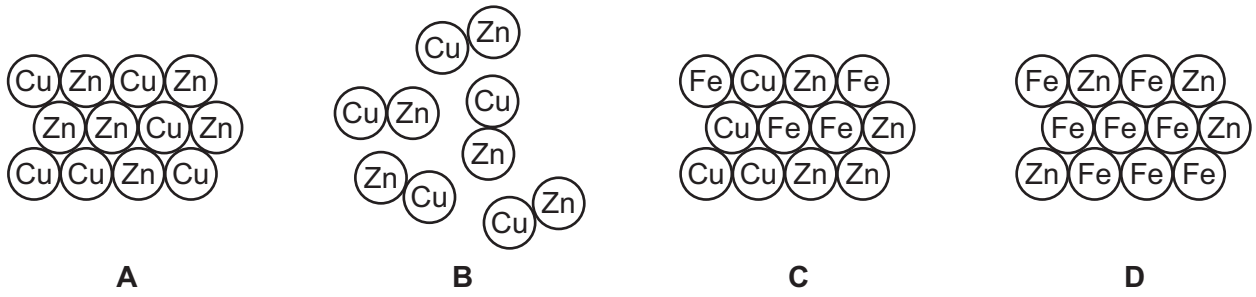
(c) Stainless steel is an alloy of iron.

(i) Give **one** reason why alloys are more useful than pure metals.

..... [1]

(ii) Brass is an alloy.

Choose the diagram, **A**, **B**, **C** or **D**, in Fig. 5.1 that best shows the structure of brass.



A **B** **C** **D**

Fig. 5.1

diagram ..... [1]

(d) Table 5.2 gives some observations about the reactivity of four metals with dilute hydrochloric acid.

Table 5.2

metal	observations
iron	bubbles form slowly
magnesium	bubbles form very quickly
mercury	no bubbles form
tin	bubbles form very slowly

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

[Total: 13]

6 A student investigates the reaction of large pieces of magnesium carbonate with dilute hydrochloric acid at 20 °C. The magnesium carbonate is in excess.

(a) Fig. 6.1 shows the volume of carbon dioxide gas released as the reaction proceeds.

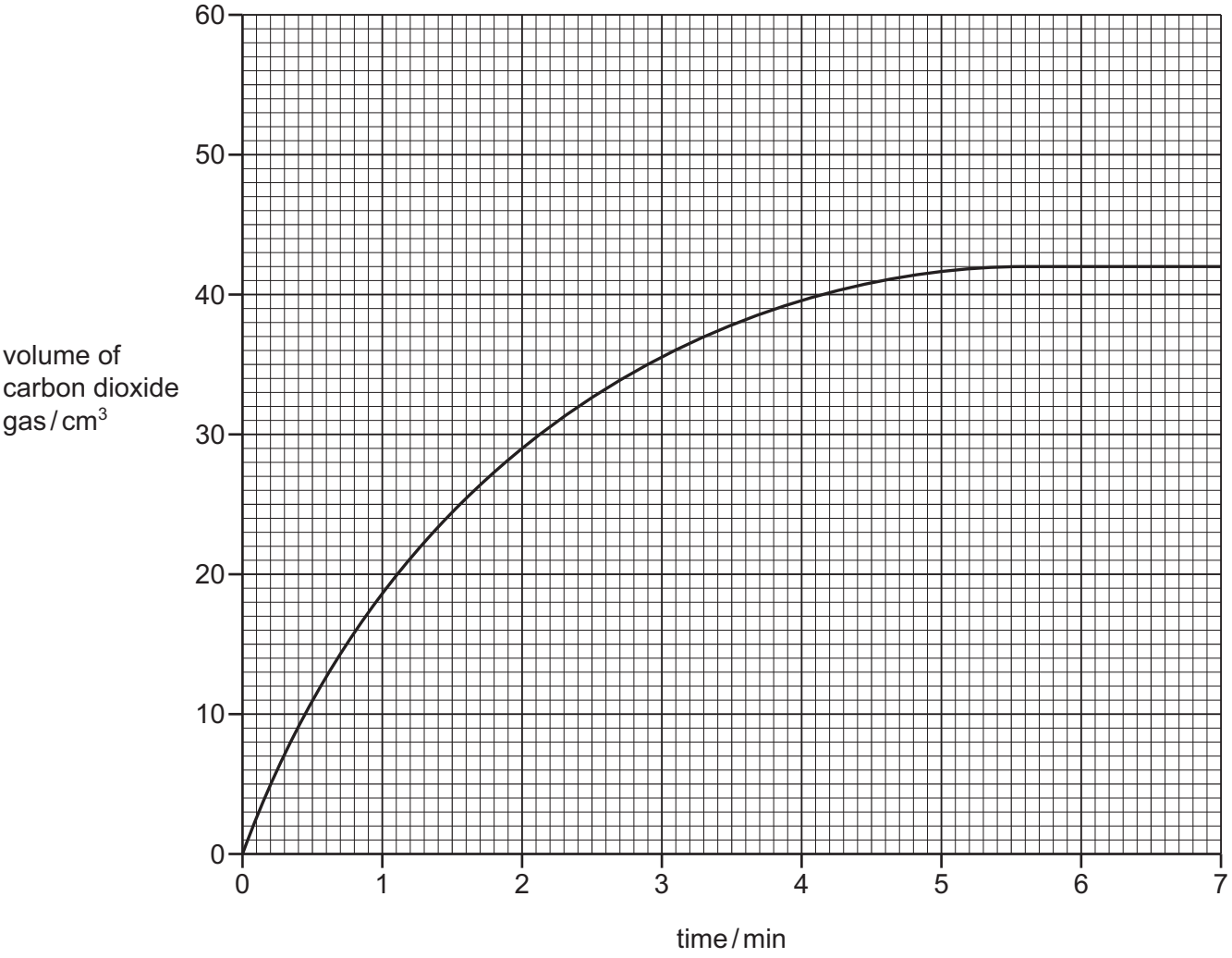


Fig. 6.1

(i) Deduce the volume of carbon dioxide gas released after 2 minutes.

volume of carbon dioxide = ... cm^3 [1]

(ii) The student repeats the experiment using the same volume of hydrochloric acid but with a higher concentration. The magnesium carbonate is still in excess.

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show the volume of carbon dioxide released when hydrochloric acid with a higher concentration is used. [2]

(b) (i) The student repeats the experiment using smaller pieces of magnesium carbonate.

All other conditions stay the same.

Describe how the rate of reaction differs when smaller pieces of magnesium carbonate are used.

..... [1]

(ii) The student repeats the experiment at 10 °C.

All other conditions stay the same.

Describe how the rate of reaction differs when the temperature is 10 °C.

..... [1]

(c) Hydrochloric acid reacts with iron.

Complete the word equation for this reaction.

hydrochloric acid	+	iron	→	....	+	.....

[2]

(d) Acids are used as catalysts in many chemical reactions.

State the meaning of the term catalyst.

.....

..... [2]

[Total: 9]

7 **(a)** Fig. 7.1 shows the displayed formula of compound **S**.

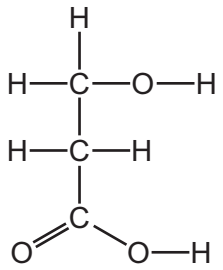


Fig. 7.1

(i) On Fig. 7.1, draw a circle around the carboxylic acid functional group. [1]

(ii) Deduce the molecular formula of compound **S**.

..... [1]

(b) Compound **S** can be converted to acrylic acid.
The molecular formula of acrylic acid is $C_3H_4O_2$.

(i) Complete Table 7.1 to calculate the relative molecular mass of acrylic acid.

Table 7.1

atom	number of atoms	relative atomic mass	
carbon	3	12	$3 \times 12 = 36$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

(ii) Acrylic acid is an unsaturated compound.

Describe a test for an unsaturated compound.

test .....

observations .....
[2]

(iii) When left in the air, acrylic acid forms a polymer.

State the meaning of the term polymer.

.....

..... [2]

(iv) Poly(ethene) is also a polymer.

Choose from the list the type of polymerisation that occurs when poly(ethene) is made.

Draw a circle around your chosen answer.

substitution **oxidation** **neutralisation** **addition** [1]

(c) Ethanoic acid is a carboxylic acid.

Complete the word equation for the reaction of ethanoic acid with sodium hydroxide.

ethanoic acid	+	sodium hydroxide	→	....	+	.....

[2]

(d) Ethanoic acid can be converted to ethanol.

Name the **two** products formed when ethanol undergoes complete combustion.

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

[Total: 13]

[Turn over

8 Lithium bromide is a compound with ionic bonding.

(a) State the meaning of the term ionic bond.

.....

..... [2]

(b) Complete Fig. 8.1 to show:

- the electronic configuration of a lithium ion
- the charge on the ion.

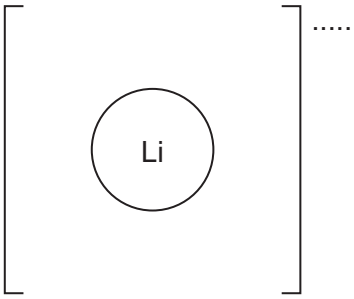


Fig. 8.1

[2]

(c) Deduce the number of protons and neutrons in the bromide ion shown.

$^{79}_{35}Br^-$

number of protons .....

number of neutrons .....

[2]

(d) Molten lithium bromide is electrolysed using graphite electrodes.

State the names of the product at each electrode and give the observations at the positive electrode.

product at the negative electrode .....

product at the positive electrode .....

observations at the positive electrode

.....

[3]

(e) Fig. 8.2 shows the structure of graphite.

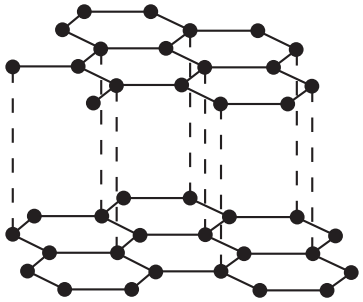


Fig. 8.2

(i) State the type of bonding in graphite.

..... [1]

(ii) Explain by referring to Fig. 8.2 why graphite is used as a lubricant.

..... [1]

(iii) Graphite and diamond are both forms of carbon.

State **one** use of diamond.

..... [1]

[Total: 12]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											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

lanthanoids	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
actinoids	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 –

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