Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

2346499710

CHEMISTRY **0620/33**

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.

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1 A list of substances is shown.

ammonia
calcium oxide
carbon monoxide
cobalt(II) chloride
ethane
ethanol
ethene
oxygen
potassium oxide
sodium sulfate
sulfuric acid
water

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) is a product of photosynthesis

..... [1]

(b) is a member of the alkene homologous series

..... [1]

(c) has an ion with a charge of 1–

..... [1]

(d) is used to remove sulfur dioxide in flue gas desulfurisation

..... [1]

(e) is the product formed in a hydrogen–oxygen fuel cell

..... [1]

(f) is used to test for water.

..... [1]

[Total: 6]

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2 Hydrocarbons are compounds of carbon and hydrogen.

(a) State the meaning of the term compound.

.....

..... [2]

(b) Fig. 2.1 shows a fractionating column for separating petroleum into different hydrocarbon fractions.

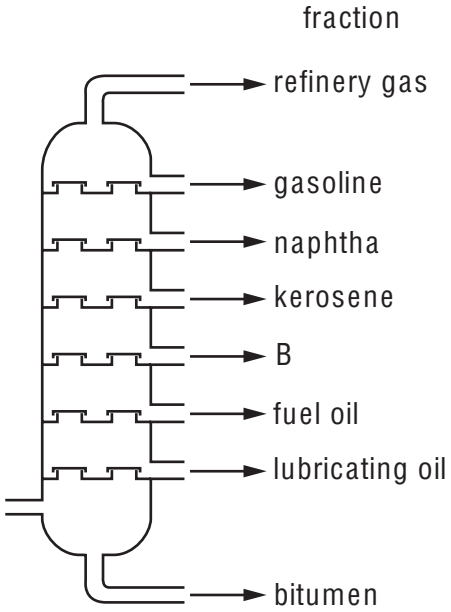


Fig. 2.1

(i) On Fig. 2.1, draw an **X** inside the column to show where the hydrocarbon with the highest boiling point collects. [1]

(ii) Name the fraction labelled **B** in Fig. 2.1.

..... [1]

(iii) State the name of the fraction which has hydrocarbons with the shortest chain length.

..... [1]

(iv) State **one** use of the naphtha 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				
	carbon monoxide	hydrocarbons	oxides of nitrogen	particulates	sulfur dioxide
2019	5.3	22.0	15.6	19.0	20.0
2020	4.1	13.5	14.8	20.1	18.2
2021	5.8	14.8	22.7	23.5	16.2
2022	2.6	18.0	10.9	26.2	14.0

(i) Name the pollutant which has the highest 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 hydrocarbons in a 200 cm^3 sample of polluted air in 2019.

mass = ... ng [1]

(b) **(i)** State **one** source of oxides of nitrogen in the air.

..... [1]

(ii) Oxides of nitrogen contribute to acid rain.

Give one **other** effect of oxides of nitrogen in the air.

..... [1]

(iii) Unpolluted water has a neutral pH.

Choose from the list the pH value of a neutral substance.

Draw a circle around your chosen answer.

pH 1 **pH 6** **pH 7** **pH 14** [1]

(c) Nitrogen dioxide is an acidic oxide.

Choose an oxide from the list which is also an acidic oxide.

Tick (✓) **one** box.

copper(II) oxide	☐
magnesium oxide	☐
phosphorus(V) oxide	☐
sodium oxide	☐

[1]

(d) Sulfur dioxide reacts with oxygen to produce sulfur trioxide.

(i) Complete the symbol equation for this reaction.

$$.....SO_2 + ... \rightleftharpoons 2SO_3$$ [2]

(ii) State the meaning of the symbol $\rightleftharpoons$.

..... [1]

(iii) Sulfur trioxide reacts with calcium oxide to produce calcium sulfate.

Describe a test for sulfate ions.

test .....

observations .....

[2]

[Total: 12]

4 Nitrogen is a gas at room temperature.

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

1 .....

.....

2 .....

.....

[2]

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

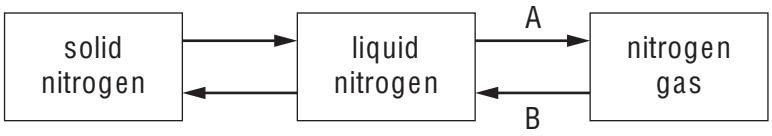


Fig. 4.1

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

A .....

B .....

[2]

(c) Describe solid nitrogen and nitrogen gas in terms of the arrangement and separation of the particles.

solid nitrogen

arrangement .....

.....

separation .....

.....

nitrogen gas

arrangement .....

.....

separation .....

.....

[4]

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

State how increasing the pressure affects the volume of nitrogen gas in the gas syringe when the temperature remains constant.

..... [1]

[Total: 9]

5 This question is about metals.

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

Table 5.1

metal	melting point in °C	boiling point in °C	atomic volume in cm^3 / mol	observations on reaction with water
lithium	181	1342	12.9	bubbles form slowly but no flame
sodium	98	883	23.7	
potassium	63	760		bubbles form very rapidly and flame seen
rubidium		686	55.8	explodes

Use the information in Table 5.1 to predict:

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

(ii) the atomic volume of potassium ..... [1]

(iii) the observations when sodium reacts with water .....

..... [1]

(iv) the physical state of sodium at 1300 °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.

(i) In the first step, carbon burns in air to form carbon dioxide.

State the percentage of oxygen in clean, dry air.

..... [1]

(ii) In the second step, carbon monoxide is produced by the reaction of carbon dioxide with carbon.

$$CO_2 + C \rightarrow 2CO$$

Choose the correct statement about this reaction.

Tick (✓) **one** box.

the carbon dioxide is oxidised and the carbon is reduced	☐
both carbon dioxide and carbon are oxidised	☐
the carbon dioxide is reduced and the carbon is oxidised	☐
both carbon dioxide and carbon are reduced	☐

[1]

(iii) In the third step, iron(III) oxide is reduced by carbon monoxide.
The reaction is exothermic.

State the meaning of the term exothermic.

.....

..... [2]

(c) Calcium carbonate is added to the blast furnace.
The calcium carbonate breaks down as shown.

$$\text{calcium carbonate} \xrightarrow{\text{high temperature}} \text{calcium oxide + carbon dioxide}$$

(i) Name the type of chemical reaction that takes place.

..... [1]

(ii) Complete this sentence about the calcium oxide that is produced in the blast furnace.

Calcium oxide reacts with impurities in the iron ore to form ..... . [1]

(d) Table 5.2 gives the observations when four different metals react with air.

Table 5.2

metal	observations
cerium	forms an oxide layer slowly without heating
copper	forms an oxide layer only when heated
gold	does not form an oxide layer even when heated
rubidium	forms an oxide layer quickly without heating

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

least reactive ⟶ most reactive

[2]

[Total: 13]

6 Hydrogen peroxide, H_2O_2, breaks down slowly at 40 °C to produce oxygen gas and water.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

A student investigates the breakdown of hydrogen peroxide at 40 °C in the presence of a catalyst.

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

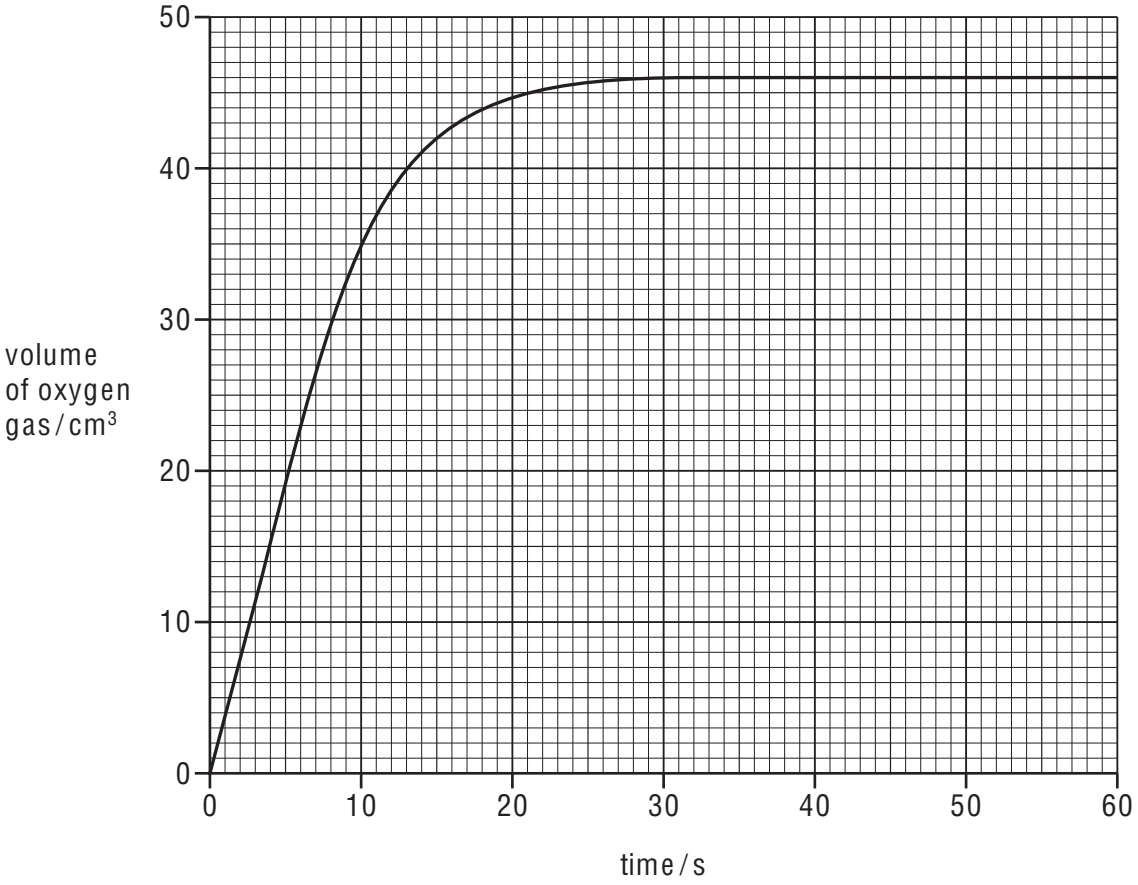


Fig. 6.1

(i) Deduce the volume of oxygen gas released after 15 seconds.

volume of oxygen = ... cm^3 [1]

(ii) The student repeats the experiment at 20 °C.

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show how the volume of oxygen changes when a temperature of 20 °C is used. [2]

(b) (i) The student repeats the experiment without a catalyst.

All other conditions stay the same.

Describe how the rate of reaction differs when no catalyst is used.

..... [1]

(ii) The student repeats the experiment using a lower concentration of hydrogen peroxide.

All other conditions stay the same.

Describe how the rate of reaction differs when a lower concentration of hydrogen peroxide is used.

..... [1]

(c) Hydrogen peroxide can act as a reducing agent in the presence of an alkali.

(i) State the meaning of the term alkali.

..... [1]

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

..... [1]

(iii) State the colour of methyl orange in an alkaline solution.

..... [1]

(iv) Aqueous ammonia is an alkali.

Complete the word equation for the reaction of aqueous ammonia with hydrochloric acid.

ammonia	+	hydrochloric acid	→	....

[1]

[Total: 9]

7 Ethanoic acid and methacrylic acid are both carboxylic acids.

(a) Complete the word equation for the reaction of ethanoic acid with calcium.

ethanoic acid	+	calcium	→	....	+	.....

[2]

(b) Ethanoic acid can be reduced to ethanol.

(i) Name the homologous series that includes ethanol.

..... [1]

(ii) Ethanol can be manufactured by fermentation.

Describe **two** conditions needed for fermentation.

1 .....

2 .....

[2]

(c) Fig. 7.1 shows the displayed formula of methacrylic acid.

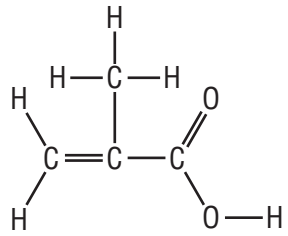


Fig. 7.1

(i) On Fig. 7.1, draw a circle around the functional group which reacts with aqueous bromine. [1]

(ii) State the colour of aqueous bromine.

..... [1]

(iii) Deduce the molecular formula of methacrylic acid.

..... [1]

(d) Methacrylic acid can be converted to methyl methacrylate.
The molecular formula of methyl methacrylate is $C_5H_8O_2$.

Complete Table 7.1 to calculate the relative molecular mass of methyl methacrylate.

Table 7.1

atom	number of atoms	relative atomic mass	
carbon	5	12	$5 \times 12 = 60$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

(e) Methyl methacrylate can be polymerised to produce a plastic.

Describe **two** environmental problems caused by plastics.

1 .....

2 .....
[2]

(f) Poly(ethene) is a polymer.

Draw the displayed formula of the monomer used to make poly(ethene).

[1]

[Total: 13]

8 Potassium chloride is an ionic compound.

(a) Complete Fig. 8.1 to show:

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

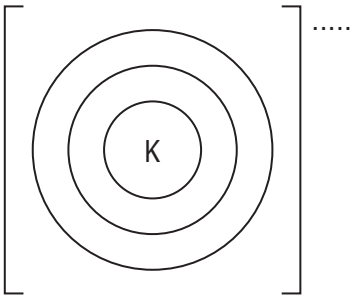


Fig. 8.1

[2]

(b) Deduce the number of protons and neutrons in the chloride ion shown.

$^{37}_{17}Cl^{-}$

number of protons .....

number of neutrons .....

[2]

(c) Molten potassium chloride is electrolysed using graphite electrodes.

(i) Define the term electrolysis.

.....

..... [2]

(ii) State the names of the products 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]

(d) Graphite electrodes are inert.

Name one **other** inert electrode.

..... [1]

(e) Graphite and diamond are two forms of carbon.

Fig. 8.2 shows the structure of diamond.

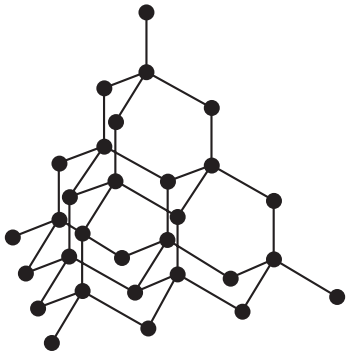


Fig. 8.2

(i) Name the type of bonding in diamond.

..... [1]

(ii) Use Fig. 8.2 to explain why diamond is used in cutting tools.

..... [1]

[Total: 12]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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.).

PMT