Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

3185438732

CHEMISTRY **5070/21**

Paper 2 Theory **May/June 2023**

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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[Turn over

1 Choose from the following oxides to answer the questions.

Al_2O_3
CO
CO_2
CaO
Fe_2O_3
H_2O
Na_2O
SO_2
SiO_2

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

State which oxide:

(a) is a solid made during the thermal decomposition of limestone in the blast furnace

..... [1]

(b) reacts with both acids and alkalis

..... [1]

(c) has a giant covalent structure

..... [1]

(d) has an ion with an oxidation number of +2

..... [1]

(e) turns white anhydrous copper(II) sulfate blue

..... [1]

(f) is made during the fermentation of aqueous glucose to make ethanol.

..... [1]

[Total: 6]

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2 Group I includes the elements lithium, sodium and potassium.

(a) State **two** physical properties of lithium.

1 .....

2 .....
[2]

(b) Potassium reacts with cold water.

The ionic equation for the reaction is shown.

$$2K(s) + 2H_2O(l) \longrightarrow 2K^+(aq) + 2OH^-(aq) + H_2(g)$$

(i) State, in terms of electrons, why potassium is a reducing agent in this reaction.

.....

..... [1]

(ii) State the oxidation number of hydrogen in H_2.

..... [1]

(iii) Describe what is observed during this reaction.

.....

.....

..... [3]

(c) A sample of sodium chloride is tested using a flame test.

State the colour of the flame seen in this test.

..... [1]

[Total: 8]

3 This question is about the preparation of salts.

(a) Zinc chloride is a soluble salt.

It is prepared by the reaction of an insoluble base with a dilute acid.

The equation for this reaction is shown.

$$ZnO(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2O(l)$$

A sample of 3.50 g of zinc oxide is added to 50.0 cm^3 of 1.20 mol / dm^3 hydrochloric acid.

(i) Show by calculation that the zinc oxide is in excess.

[3]

(ii) State why it is important to use an excess of zinc oxide in this preparation.

.....

..... [1]

(iii) Suggest how the excess zinc oxide is removed from the reaction mixture to leave only aqueous zinc chloride.

..... [1]

(b) Barium sulfate is an insoluble salt.

It is prepared using a precipitation reaction.

Name **two** aqueous solutions that react together to give a barium sulfate precipitate.

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

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(c) Sodium nitrate is a soluble salt.

It is prepared by the reaction of an acid and an alkali.

(i) Name the acid and the alkali used.

acid .....

alkali .....

[1]

(ii) Name the experimental technique used to make neutral aqueous sodium nitrate.

..... [1]

[Total: 8]

4 This question is about compounds that contain phosphorus.

(a) The formula for a phosphide ion can be written as $^{31}_{15}P^{3-}$.

Complete Table 4.1 to show the number of particles in this phosphide ion.

Table 4.1

particle	number of particles
electron	
neutron	
proton	

[3]

(b) State why the formula for a phosphide ion is P^{3-} rather than P^{2-} or P^{4-}.

.....

..... [1]

(c) The formula for a calcium ion is Ca^{2+}.

Deduce the formula for calcium phosphide.

..... [1]

(d) Calcium phosphate, $Ca_3(PO_4)_2$, is an ionic compound.

Explain why calcium phosphate has a high melting point.

.....

.....

..... [2]

(e) Calculate the percentage by mass of phosphorus in calcium phosphate.

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

percentage by mass ..... [2]

[Total: 9]

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5 Ammonium chloride decomposes when heated to make hydrogen chloride and ammonia.

This reaction is reversible. The forward reaction absorbs thermal energy.

$$NH_4Cl(s) \rightleftharpoons HCl(g) + NH_3(g)$$

(a) An equilibrium mixture is formed when the reversible reaction happens in a closed system.

(i) State what is meant by the term equilibrium.

Include ideas about rate of reaction and the concentrations of the reactant and products in your answer.

.....

.....

.....

..... [2]

(ii) Predict what happens to the **position of equilibrium** when the temperature is increased and the pressure remains constant.

Explain your answer.

prediction .....

explanation .....

.....

.....

[2]

(iii) Predict what happens to the **position of equilibrium** when the pressure is increased and the temperature remains constant.

Explain your answer.

prediction .....

explanation .....

.....

.....

[2]

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(b) Predict what happens to the **rate of the backward reaction** when the temperature is increased and the pressure remains constant.

Explain your answer.

prediction .....

explanation .....

.....

.....

.....

[2]

(c) Predict what happens to the **rate of the backward reaction** when the pressure is increased and the temperature remains constant.

Explain your answer.

prediction .....

explanation .....

.....

.....

.....

[2]

[Total: 10]

6 This question is about the energy changes that take place during chemical reactions.

(a) Methane reacts with chlorine to make chloromethane.

The reaction is exothermic.

$$CH_4(g) + Cl_2(g) \longrightarrow CH_3Cl(g) + HCl(g)$$

Draw, on the axes provided in Fig. 6.1, the reaction pathway diagram for this reaction.

Include labels for the:

- axes
- reactants
- products
- enthalpy change of reaction, ΔH
- activation energy, E_a.

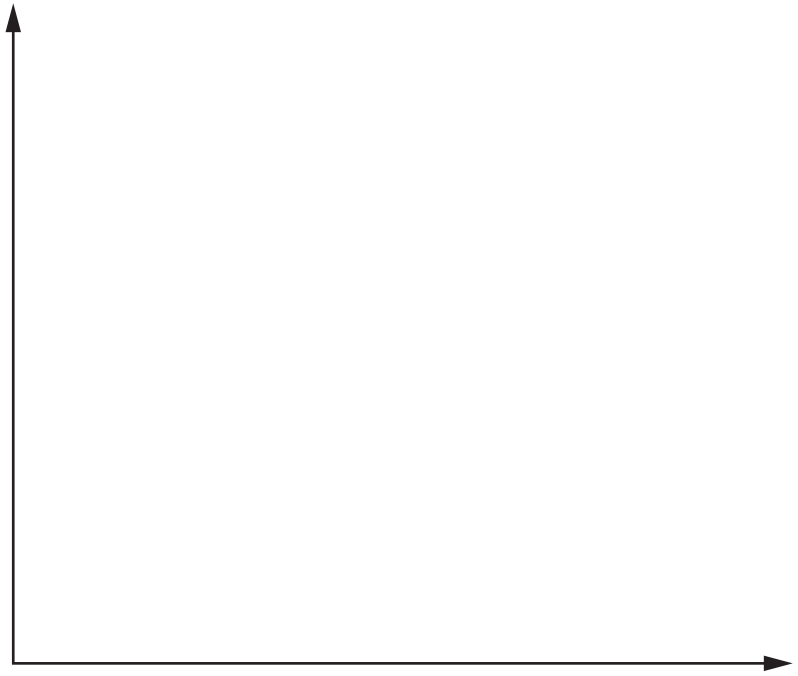


Fig. 6.1

[5]

(b) Hydrogen iodide decomposes to make hydrogen and iodine.

$$2H—I \rightarrow H—H + I—I$$

Calculate the enthalpy change of this reaction.

Use the bond energies in Table 6.1.

Table 6.1

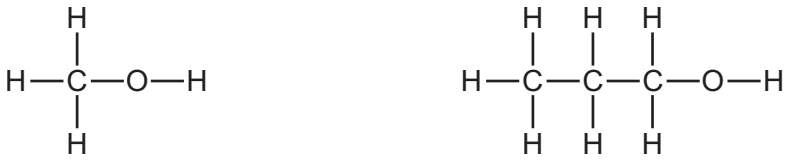
bond	bond energy in kJ / mol
H—H	436
I—I	151
H—I	298

enthalpy change of reaction ..... kJ / mol [3]

[Total: 8]

7 Methanol, propan-1-ol and propan-2-ol are alcohols.

The displayed formulae of methanol and propan-1-ol are shown in Fig. 7.1.



methanol propan-1-ol

Fig. 7.1

(a) State the general formula of the homologous series of alcohols.

..... [1]

(b) Propan-1-ol and propan-2-ol have the same molecular formula but different structural formulae.

(i) State the name given to compounds that have the same molecular formula but different structural formulae.

..... [1]

(ii) Draw the structural formula for propan-2-ol.

[1]

(c) State why propan-1-ol is a saturated compound.

.....

..... [1]

(d) State why propan-1-ol is **not** a hydrocarbon.

.....

..... [1]

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(e) Propan-1-ol reacts in the same way as ethanol.

(i) Draw the displayed formula of the product of the reaction of propan-1-ol with acidified aqueous potassium manganate(VII).

[1]

(ii) Draw the displayed formula of the product of the reaction of propan-1-ol with ethanoic acid in the presence of a catalyst.

[1]

(f) Methanol is a covalent substance.

(i) Draw a dot-and-cross diagram to show the bonding in a molecule of methanol.

Include only the outer shell electrons of each atom.

[2]

(ii) State why methanol does **not** conduct electricity.

.....

..... [1]

(g) Methanol is used as a solvent.

State the meaning of the term solvent.

.....

..... [1]

[Total: 11]

8 This question is about electrolysis.

(a) The table shows some information about the electrolysis of three different electrolytes using graphite electrodes.

Complete Table 8.1 with the names of the products at each electrode.

Table 8.1

electrolyte	product at anode	product at cathode
dilute aqueous potassium chloride		
aqueous copper(II) sulfate		
molten lead(II) iodide		

[3]

(b) The electrolysis of aqueous copper(II) sulfate gives different products when copper electrodes are used instead of graphite electrodes.

Describe the observations during the electrolysis with copper electrodes.

.....

.....

..... [2]

(c) Magnesium is manufactured by the electrolysis of molten magnesium chloride.

At the anode, chloride ions react to make chlorine molecules.

Construct the ionic half-equation for this electrode reaction.

..... [1]

[Total: 6]

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9 Oxides of nitrogen such as nitrogen monoxide, NO, are atmospheric pollutants.

The exhaust gas from a car engine contains 0.00200% by volume of nitrogen monoxide.

(a) Calculate the number of molecules of nitrogen monoxide in 960 dm^3 of exhaust gas at room temperature and pressure.

One mole of any gas contains 6.02×10^{23} molecules.

number of molecules ..... [3]

(b) Nitrogen and oxygen react to make nitrogen monoxide inside a car engine.

Construct the equation for this reaction.

..... [1]

(c) State **one** adverse effect of oxides of nitrogen as pollutants in the air.

..... [1]

(d) Describe how oxides of nitrogen formed in a car engine are removed by a catalytic converter.

.....

..... [1]

(e) The rate of diffusion of nitrogen dioxide, $NO_2(g)$, is less than that of nitrogen monoxide, NO(g), under the same conditions of temperature and pressure.

(i) Explain why the rate of diffusion of $NO_2(g)$ is less than that of NO(g) under the same conditions.

.....

.....

..... [1]

(ii) The rate of diffusion of nitrogen monoxide decreases as the temperature decreases.

Suggest why using ideas about kinetic particle theory.

.....

..... [1]

[Total: 8]

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10 PVC and poly(propene) are polymers made by a reaction called addition polymerisation.

(a) The diagram in Fig. 10.1 shows the structure of PVC.

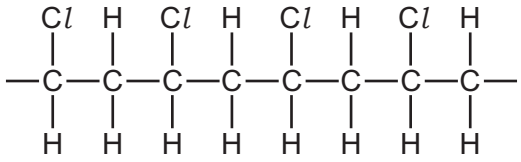


Fig. 10.1

Draw the structure of the monomer used to make PVC.

[1]

(b) Poly(propene) is a polymer used to make plastic food containers.

The diagram in Fig. 10.2 shows the structure of poly(propene).

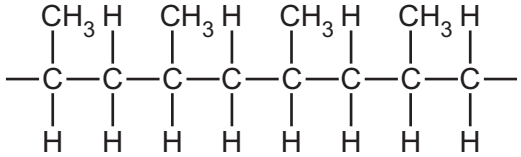


Fig. 10.2

(i) Some waste poly(propene) plastic is disposed of by burning.

This makes a toxic gas because of incomplete combustion.

Name this toxic gas.

..... [1]

(ii) State one **other** environmental challenge caused by the disposal of waste poly(propene) plastic.

Explain how this challenge is related to the properties of poly(propene).

environmental challenge .....

.....

explanation .....

.....

[2]

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(c) Name one **condensation** polymer.

Draw the displayed formula of the linkage between the repeat units in this polymer.

name .....

linkage

[2]

[Total: 6]

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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.).