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Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **5070/21**

Paper 2 Theory **May/June 2020**

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **three** 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 75.
- 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. Blank pages are indicated.

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Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the following oxides to answer the questions.

calcium oxide

carbon monoxide

copper(II) oxide

nitrogen dioxide

nitrogen monoxide

silicon dioxide

sulfur dioxide

water

zinc oxide

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

Which oxide:

(a) is used as a food preservative

..... [1]

(b) is amphoteric

..... [1]

(c) has a molecule that contains only 15 protons

..... [1]

(d) has a high melting point because it has a giant covalent structure

..... [1]

(e) reacts with dilute sulfuric acid to make a blue solution?

..... [1]

[Total: 5]

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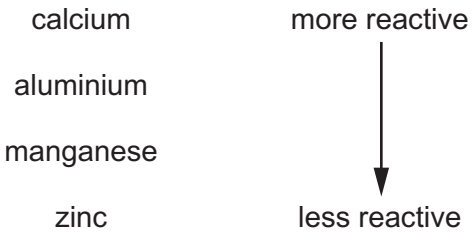
2 Part of the reactivity series is shown.



(a) Predict the names of the products formed when manganese reacts with dilute hydrochloric acid.

.....

..... [1]

(b) A sample of manganese(II) carbonate, $MnCO_3$, is heated strongly.

Construct the equation for this reaction.

..... [1]

(c) Powdered manganese is added to aqueous zinc sulfate to form aqueous manganese(II) sulfate, $MnSO_4$.

Construct an ionic equation, with state symbols, for this reaction.

..... [2]

(d) Zinc powder, a reducing agent, is added to acidified aqueous potassium manganate(VII).

Describe the colour change during this reaction.

..... [1]

(e) Aluminium is extracted by the electrolysis of aluminium oxide dissolved in molten cryolite.

(i) Write the electrode equation for the formation of aluminium atoms at the cathode.

..... [1]

(ii) Write the electrode equation for the formation of oxygen molecules at the anode.

..... [1]

(f) State one advantage of recycling aluminium.

..... [1]

[Total: 8]

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3 The equation for the decomposition of hydrogen peroxide is shown.

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

A sample containing 1.00 mol of hydrogen peroxide is completely decomposed.

This sample releases 98.0 kJ of heat energy.

(a) Calculate the heat energy released when 680 g of hydrogen peroxide is completely decomposed.

heat energy released ..... kJ [2]

(b) Use ideas about bond breaking and bond forming to explain why the decomposition of hydrogen peroxide is exothermic.

.....

.....

..... [2]

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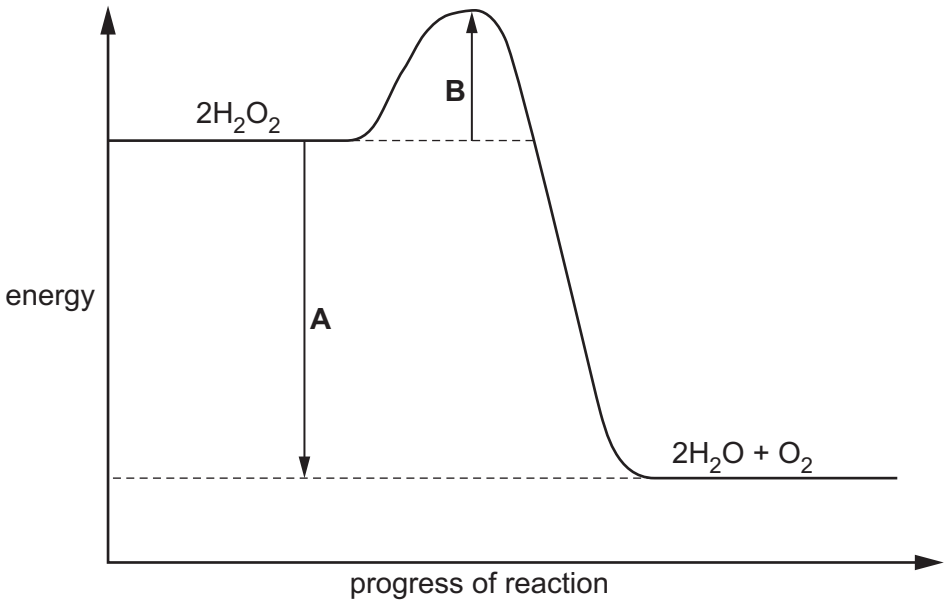
(c) The energy profile diagram for the decomposition of hydrogen peroxide is shown.



Identify the energy changes.

change **A** .....

change **B** .....

[2]

(d) The rate of decomposition of hot H_2O_2 is greater than that of cold H_2O_2.

Use ideas about particles to explain why.

.....

.....

..... [2]

[Total: 8]

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4 The table shows some properties of five esters.

name	structure	relative molecular mass	melting point / °C	boiling point / °C
methyl ethanoate	CH_3COOCH_3	74	–98	57
ethyl ethanoate	$CH_3COOCH_2CH_3$	88	–84	77
propyl ethanoate	$CH_3COOCH_2CH_2CH_3$	102	–95	102
butyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_3$	116	–78	126
pentyl ethanoate	$CH_3COOCH_2CH_2CH_2CH_2CH_3$	130	–71	148

(a) These esters are part of a homologous series.

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

1. .....

.....

2. .....

.....

[2]

(b) The next member of the homologous series is hexyl ethanoate.

Explain why it is more difficult to predict the melting point than the boiling point of hexyl ethanoate.

.....

.....

..... [1]

(c) At 25 °C ethyl ethanoate is a liquid.

Explain how the data in the table shows this.

.....

..... [1]

(d) State one use for an ester.

..... [1]

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(e) Propyl ethanoate is prepared by the reaction between ethanoic acid and propanol.

$$CH_3CO_2H + CH_3CH_2CH_2OH \rightleftharpoons CH_3COOCH_2CH_2CH_3 + H_2O$$

(i) Calculate the maximum mass of propyl ethanoate that can be made from 7.20 g of ethanoic acid and excess propanol.

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

mass of propyl ethanoate ..... g [2]

(ii) The concentration of ethanoic acid is increased.

State and explain, in terms of particles, what happens to the rate of the forward reaction.

.....

.....

.....

..... [3]

(iii) The water formed in the reaction is removed.

State and explain what happens to the position of the equilibrium.

.....

.....

..... [2]

[Total: 12]

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5 Hydrochloric acid, HC*l*, reacts with barium hydroxide, $Ba(OH)_2$, as shown.

$$2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$$

A sample of 25.0 cm^3 of 0.0500 mol / dm^3 $Ba(OH)_2$ is placed in a beaker.

Dilute HC*l* is added slowly, from a burette, to the $Ba(OH)_2(aq)$ in the beaker.

A pH probe is used to measure the pH of the solution in the beaker until a total of 40.0 cm^3 of dilute HC*l* is added.

The table shows how the pH of the solution in the beaker changes.

volume of dilute HC*l* added / cm^3	pH of the solution in the beaker
0.0	13.0
5.0	12.9
10.0	12.5
15.0	11.6
20.0	7.0
25.0	3.0
30.0	1.6
35.0	1.1
40.0	0.9

(a) Explain, in terms of the ions present, why the pH of the solution in the beaker changes from 13.0 to 0.9.

.....

.....

.....

..... [2]

(b) Use the data in the table to state the volume of dilute HC*l* that just neutralises all of the sample of $Ba(OH)_2(aq)$.

volume of dilute HC*l* ..... cm^3 [1]

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(c) Use your answer to **(b)** to calculate the concentration, in mol / dm^3, of the dilute HC*l*.

concentration of dilute HC*l* ..... mol / dm^3 [3]

[Total: 6]

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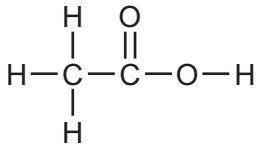
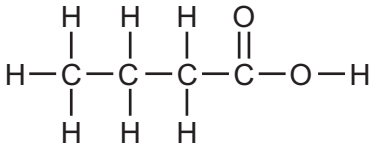
6 The structures of two carboxylic acids are shown.



ethanoic acid



carboxylic acid **B**

(a) An isomer of carboxylic acid **B** has the name methylpropanoic acid.

(i) What is the name of carboxylic acid **B**?

..... [1]

(ii) What is the meaning of the term *isomer*?

.....

.....

..... [1]

(b) Vinegar contains ethanoic acid.

Describe the formation of vinegar from ethanol.

.....

.....

..... [2]

(c) Ethanoic acid reacts with calcium carbonate.

(i) Give the formula of the calcium salt formed in this reaction.

..... [1]

(ii) Name the other **two** products formed in this reaction.

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

[Total: 6]

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Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

7 Carbon dioxide is a colourless gas found in air.

(a) The percentage of carbon dioxide in the air is increasing.

State one environmental problem caused by this increase.

..... [1]

(b) Carbon dioxide is a product of the complete combustion of octane, C_8H_{18}.

Construct the equation for this reaction.

..... [2]

(c) Fermentation of glucose produces carbon dioxide.

(i) Give the equation for the fermentation of glucose.

..... [1]

(ii) State **two** essential conditions needed for fermentation.

.....

..... [2]

(d) When warmed, solid carbon dioxide changes directly into a gas. It does **not** become a liquid.

Use the kinetic particle theory to describe the changes in **movement** and **arrangement** of the particles during this change of state.

.....

.....

.....

.....

..... [3]

(e) Explain why solid carbon dioxide does not conduct electricity.

.....

..... [1]

[Total: 10]

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8 This question is about the chlorides of the elements in Period 3.

(a) State the electronic configuration of the positive ion in sodium chloride, NaC*l*.

..... [1]

(b) Magnesium chloride crystals can be prepared by reacting an insoluble base with an acid.

(i) Name an insoluble base and the acid that can be used.

insoluble base .....

acid .....
[1]

(ii) Describe the essential practical details for the preparation of pure magnesium chloride crystals.

.....

.....

.....

.....

..... [3]

(c) Anhydrous aluminium chloride contains 20.2% by mass of aluminium.

(i) Show that the empirical formula for anhydrous aluminium chloride is A*l*Cl_3.

[2]

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(ii) A sample of anhydrous aluminium chloride has a mass of 2.34 g.

The sample contains 0.00876 mol of anhydrous aluminium chloride.

Calculate the relative molecular mass and give the molecular formula for anhydrous aluminium chloride.

relative molecular mass .....

molecular formula .....
[2]

(d) Silicon(IV) chloride, $SiCl_4$, has a simple molecular structure.

Predict **one** physical property of silicon(IV) chloride at room temperature.

..... [1]

[Total: 10]

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9 Iron is a transition element.

(a) State two physical properties of iron that are typical of a transition element.

1. .....

2. .....
[2]

(b) Name an industrial process that uses iron as a catalyst.

..... [1]

(c) Iron(II) sulfate thermally decomposes to form iron(III) oxide, sulfur dioxide and sulfur trioxide.

$$2FeSO_4(s) \longrightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

(i) Explain how the equation shows that this reaction involves oxidation.

.....

..... [1]

(ii) A sample of 6.08 g of $FeSO_4$ is heated until all the sample has thermally decomposed.

Calculate the volume of sulfur dioxide formed, $SO_2(g)$, in dm^3, measured at room temperature and pressure.

volume of sulfur dioxide ..... dm^3 [3]

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(d) Iron(III) oxide reacts with dilute sulfuric acid to make iron(III) sulfate, $Fe_2(SO_4)_3$.

Construct the equation for this reaction.

..... [1]

(e) Describe a chemical test that can be used to distinguish between aqueous solutions of iron(II) sulfate and iron(III) sulfate.

chemical test .....

result with iron(II) sulfate .....

result with iron(III) sulfate .....
[2]

[Total: 10]

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10 Fractional distillation and cracking are important processes in the conversion of petroleum (crude oil) into useful substances.

(a) Complete the sentence about petroleum (crude oil).

Choose from the list.

an alloy	**a compound**	**an element**
a mixture	**a polymer**	**a salt**

Petroleum (crude oil) is ..... of hydrocarbons. [1]

(b) Fractional distillation separates petroleum (crude oil) into fractions such as paraffin (kerosene) and naphtha.

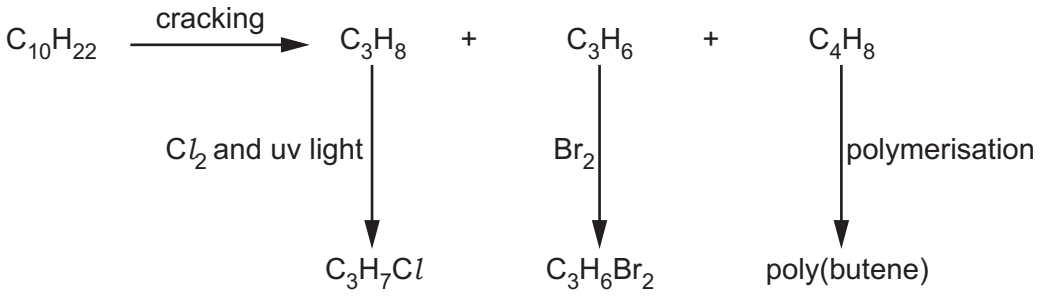
Give one use for the paraffin (kerosene) fraction.

..... [1]

(c) The naphtha fraction is used as a chemical feedstock.

One of the hydrocarbons in naphtha has the molecular formula $C_{10}H_{22}$.

The flow chart shows some compounds that can be made from $C_{10}H_{22}$.



(i) C_3H_8 is an alkane and C_3H_6 is an alkene.

Explain why, in terms of their general formulae, C_3H_8 is an alkane and C_3H_6 is an alkene.

.....

.....

.....

..... [2]

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(ii) In the presence of uv light chlorine reacts with C_3H_8.

Two of the products formed are HC*l* and C_3H_7C*l*.

What type of reaction takes place when C_3H_8 reacts with chlorine?

.....

Give the formula of one other product of this reaction.

.....

[2]

(iii) Describe the colour change when C_3H_6 reacts with bromine.

.....

..... [1]

(d) (i) Suggest a possible structure for C_4H_8.

[1]

(ii) Draw the partial structure of poly(butene) that shows at least two repeat units.

[2]

[Total: 10]

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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 –		114 Fl flerovium –		116 Lv livermorium –		

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.).

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