Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

4433508277

CHEMISTRY **5070/21**

Paper 2 Theory **October/November 2017**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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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.

A1 (a) Choose from the following elements to answer the questions.

calcium
chlorine
chromium
copper
krypton
nitrogen
oxygen
sodium
sulfur

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

Which element:

(i) is a monatomic gas,

.....[1]

(ii) makes up 78% of dry air,

.....[1]

(iii) has an oxide which reacts with the impurities in a blast furnace to form slag,

.....[1]

(iv) forms aqueous ions with a 2+ charge which give a dark blue solution on addition of excess aqueous ammonia,

.....[1]

(v) reacts with propane in the presence of ultraviolet light by a substitution reaction?

.....[1]

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(b) Complete the table to show the number of electrons and number of neutrons in the sulfur atom and in the magnesium ion.

	number of electrons	number of neutrons
$^{33}_{16}S$		
$^{25}_{12}Mg^{2+}$		

[4]

[Total: 9]

A2 Copper(II) sulfate is an ionic compound.

(a) Describe the arrangement of the ions and the type of attractive forces between the ions in solid copper(II) sulfate.

arrangement .....

type of attractive forces .....
[2]

(b) Explain why solid copper(II) sulfate does not conduct electricity but aqueous copper(II) sulfate does conduct.

.....

.....

.....[2]

(c) When aqueous copper(II) sulfate is electrolysed using platinum electrodes, copper(II) ions are reduced to copper at the negative electrode. Oxygen is formed at the positive electrode by loss of electrons from hydroxide ions.

(i) State the source of the hydroxide ions.

.....[1]

(ii) Complete the equation for the reaction at the positive electrode.

$$\ldots\ldots OH^- \rightarrow O_2 + \ldots\ldots H_2O + \ldots\ldots$$ [1]

(iii) Suggest why hydroxide ions and **not** sulfate ions are discharged at the positive electrode.

.....

.....[1]

(d) **(i)** Give the formulae of the four ions present in aqueous copper(II) sulfate.

.....[1]

(ii) Suggest why the solution becomes acidic as the electrolysis proceeds.

.....

.....[2]

(iii) Suggest why the blue colour of the aqueous copper(II) sulfate fades as the electrolysis proceeds.

.....

.....[1]

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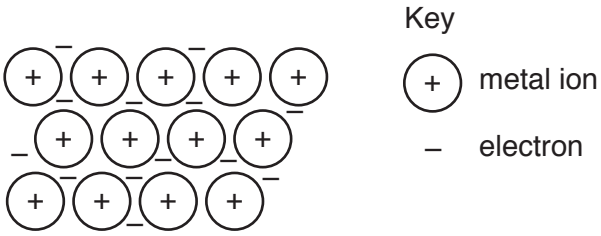
(e) Draw a 'dot-and-cross' diagram of an oxygen molecule.

Show only the outer shell electrons.

[2]

[Total: 13]

A3 The diagram shows the structure of a metal.



(a) Refer to this structure to explain why

(i) metals are malleable,

.....

.....[2]

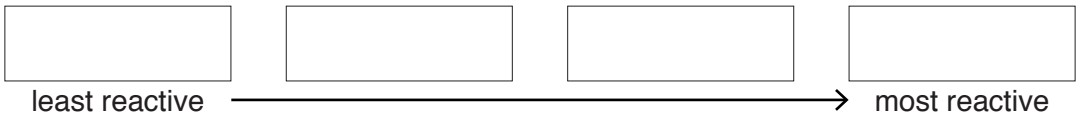
(ii) metals conduct electricity.

.....[1]

(b) The table shows the ease with which different metal oxides can be reduced.

metal oxide	ease of reduction
calcium oxide	**not** reduced by carbon at 1800 °C
iron(III) oxide	reduced by carbon at 650 °C
silver oxide	reduced by heating without carbon
titanium(IV) oxide	reduced by carbon at 1800 °C but **not** at 650 °C

Use the information in the table to place the metals calcium, iron, silver and titanium in order of their reactivity.



[1]

(c) Iron(III) oxide can be reduced by carbon monoxide.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

(i) Calculate the maximum mass of iron that can be formed when 14.4 g of iron(III) oxide is reduced by excess carbon monoxide.

Give your answer to three significant figures.

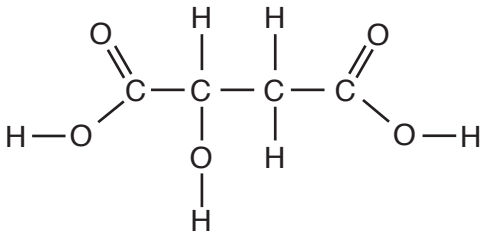
mass of iron = ... g [3]

(ii) Calculate the maximum volume of carbon dioxide, in dm^3, produced by this reaction, at room temperature and pressure.

volume of carbon dioxide = ... dm^3 [2]

[Total: 9]

A4 The structure of malic acid is shown.



(a) Malic acid is a carboxylic acid because it contains a –COOH group.

Malic acid also contains an –OH group.

Name the homologous series of compounds which contain the –OH group.

.....[1]

(b) A diester of malic acid has the formula shown.

$$H_7C_3OOC–CH(OH)–CH_2–COOC_3H_7$$

What reagent and conditions are needed to make this diester from malic acid?

reagent .....

conditions .....
[2]

(c) When heated, malic acid forms fumaric acid.

$$\underset{\text{malic acid}}{HOOC–CH(OH)–CH_2–COOH} \longrightarrow \underset{\text{fumaric acid}}{HOOC–CH=CH–COOH} + H_2O$$

How can aqueous malic acid and aqueous fumaric acid be distinguished when aqueous bromine is added to a sample of each?

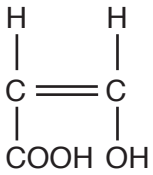
.....

.....

.....[2]

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(d) The structure of compound **A** is shown.



Compound **A** can undergo two types of polymerisation.

(i) Name these two types of polymerisation.

1. .....

2. .....

[2]

(ii) For one of these types of polymerisation, draw a section of the polymer to show two repeat units.

[2]

[Total: 9]

A5 Hydrocarbons undergo complete combustion to form carbon dioxide and water.

(a) Construct the equation for the complete combustion of butane, C_4H_{10}.

.....[2]

(b) The combustion of butane is exothermic.

Explain in terms of bond making and bond breaking why this reaction is exothermic.

.....

.....

.....

.....[2]

(c) Petroleum (crude oil) fractions contain hydrocarbons.

Give one use of the paraffin (kerosene) fraction.

.....[1]

[Total: 5]

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Section B

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

The total mark for this section is 30.

B6 Ethanoic acid is a weak acid.

(a) What is meant by the term *weak acid*?

.....

.....[1]

(b) Ethanoic acid reacts with ethanol to form ethyl ethanoate.

The reaction is exothermic.

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

Describe and explain the effect, if any, on the position of equilibrium when

(i) the concentration of ethanol is increased,

.....

.....

.....[2]

(ii) the temperature is increased.

.....

.....

.....[2]

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(c) The table shows some properties of four carboxylic acids.

carboxylic acid	formula	melting point / °C	boiling point / °C	density in the liquid state in g / cm^3
methanoic acid	HCOOH	8.5	100.7	1.22
ethanoic acid	CH_3COOH	16.7	118.0	1.05
propanoic acid	C_2H_5COOH	–20.7	141.1	
butanoic acid	C_3H_7COOH	–4.4	165.6	0.96

(i) How does the boiling point change as the number of carbon atoms in the formula of the carboxylic acids increases?

.....[1]

(ii) Estimate the density, in g / cm^3, of liquid propanoic acid.

density ..... g / cm^3 [1]

(iii) What is the physical state of ethanoic acid at 15.0 °C? Explain your answer.

.....

.....[1]

(iv) Why is it difficult to predict the melting point of pentanoic acid, C_4H_9COOH, using only the information from the table?

.....[1]

(v) Draw the structure of propanoic acid showing all of the atoms and all of the bonds.

[1]

[Total: 10]

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[Turn over

B7 Some properties of the Group IV elements are shown in the table.

element	melting point /°C	relative electrical conductivity
carbon (diamond)	3550	non-conductor
silicon	1410	poor conductor
germanium	937	poor conductor
tin	232	conductor
lead	328	conductor

(a) (i) Explain in terms of structure and bonding why diamond has such a high melting point.

.....

.....

.....[2]

(ii) Use the information in the table to suggest how the type of structure and bonding in carbon (diamond) differs from the type of structure and bonding in tin. Explain your answer.

.....

.....

.....

.....[2]

(iii) Lead oxide is an amphoteric oxide.

What is the meaning of the term *amphoteric oxide*?

.....[1]

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(b) A sample containing 64.5 g of a chloride of germanium contains 42.6 g of chlorine.

(i) Deduce the empirical formula of this chloride.

empirical formula .....[3]

(ii) This chloride of germanium has a boiling point of 87 °C.

Predict the structure and bonding of this chloride.

.....

.....[2]

[Total: 10]

B8 Concentrated aqueous ammonia is used to make fertilisers such as ammonium phosphate, $(NH_4)_3PO_4$.

(a) Calculate the percentage by mass of nitrogen in ammonium phosphate.

..... % by mass [2]

(b) Explain why farmers spread nitrogen-containing fertilisers on their fields.

.....[1]

(c) Describe a test for ammonia.

test .....

result .....
[2]

(d) Explain why adding calcium hydroxide to the soil at the same time as ammonium phosphate results in loss of nitrogen from the soil.

.....

.....[2]

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(e) Aqueous ammonia reacts with dilute sulfuric acid.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

A student titrates 20.0 cm^3 of aqueous ammonia with 0.150 mol/dm^3 sulfuric acid.

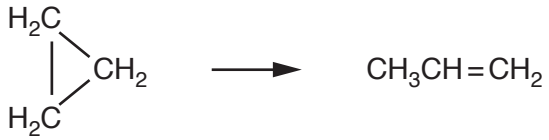
10.5 cm^3 of sulfuric acid is required to neutralise the aqueous ammonia.

Calculate the concentration, in mol/dm^3, of the aqueous ammonia.

concentration of aqueous ammonia = ... mol/dm^3 [3]

[Total: 10]

B9 Cyclopropane is converted to propene when heated.

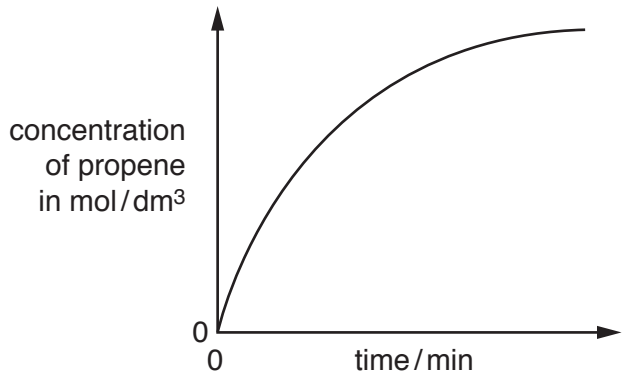


cyclopropane

(a) Explain why cyclopropane and propene are isomers.

.....[1]

(b) The graph shows how the concentration of propene in this reaction changes with time.



Describe how the rate of this reaction changes with time. Explain your answer by referring to the graph.

.....

.....[2]

(c) Describe and explain the effect of increasing the concentration of cyclopropane on the rate of this reaction.

.....

.....

.....[2]

(d) Describe and explain the effect of decreasing the temperature on the rate of this reaction.

.....

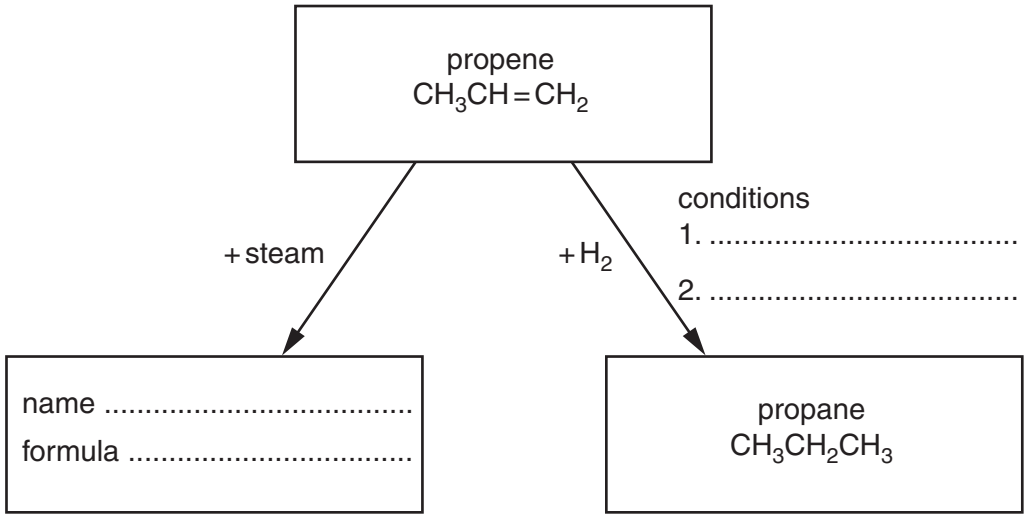
.....

.....[2]

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(e) Propene undergoes addition reactions. Two addition reactions of propene are shown in the diagram.

Complete the diagram to show the missing name, formula and conditions.



[3]

[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.).