Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

CHEMISTRY **5070/22**

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.

[Turn over

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 chlorides to answer the questions.

aluminium chloride

ammonium chloride

calcium chloride

hydrogen chloride

iron(III) chloride

silver chloride

sodium chloride

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

Which chloride:

(a) contains a cation with a 2+ charge

..... [1]

(b) reacts with warm aqueous sodium hydroxide to form a gas which turns damp red litmus paper blue

..... [1]

(c) is insoluble in water

..... [1]

(d) has a molecule which has only 18 protons

..... [1]

(e) is a coloured solid at room temperature and pressure?

..... [1]

[Total: 5]

2 Hydrogen reacts with oxygen as shown in the equation.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

A sample containing 1.00 mol of hydrogen, H_2, is completely combusted.

This sample releases 286 kJ of heat energy.

(a) Calculate the heat energy released when 25.0 g of hydrogen is completely combusted.

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

(b) Use ideas about bond breaking and bond forming to explain why this reaction is exothermic.

.....

.....

..... [2]

(c) The reaction shown also represents the overall process that occurs within a hydrogen-oxygen fuel cell.

(i) Describe one advantage of using a hydrogen-oxygen fuel cell to power a motor vehicle rather than burning gasoline.

.....

..... [1]

(ii) Complete the equations for the two electrode reactions that happen in a hydrogen-oxygen fuel cell.

$H_2 \rightarrow$ ..... $+ 2e^-$

$O_2 + 4H^+ + 4e^- \rightarrow$ .....

[2]

[Total: 7]

[Turn over

3 The table shows some properties of five esters.

name	structure	relative molecular mass	melting point / °C	boiling point / °C
methyl methanoate	$HCOOCH_3$	60	−100	32
methyl ethanoate	CH_3COOCH_3	74	−98	57
methyl propanoate	$CH_3CH_2COOCH_3$	88	−88	80
methyl butanoate	$CH_3CH_2CH_2COOCH_3$	102	−95	102
methyl pentanoate	$CH_3CH_2CH_2CH_2COOCH_3$			

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

(i) State the relative molecular mass of methyl pentanoate.

..... [1]

(ii) Predict the boiling point of methyl pentanoate

..... °C [1]

(iii) Explain why it is **not** possible to predict the melting point of methyl pentanoate.

.....

..... [1]

(b) At 35 °C methyl methanoate is a gas.

Explain how the data in the table shows this.

.....

..... [1]

(c) Methyl pentanoate is used to flavour food.

Suggest one **other** use for esters.

..... [1]

(d) Methyl propanoate is prepared by the reaction between propanoic acid and methanol.

$$CH_3CH_2CO_2H + CH_3OH \rightleftharpoons CH_3CH_2COOCH_3 + H_2O$$

The forward reaction is exothermic.

(i) Calculate the maximum mass of methyl propanoate that can be made from 11.0 g of propanoic acid and excess methanol.

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

mass of methyl propanoate ..... g [2]

(ii) The temperature of the reaction mixture is increased.

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

.....

.....

.....

.....

..... [3]

(iii) The temperature of the reaction mixture is increased.

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

.....

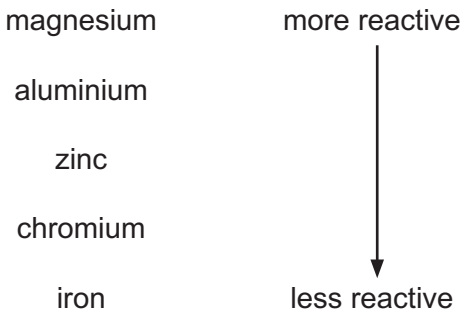
.....

..... [2]

[Total: 12]

[Turn over

4 Part of the reactivity series is shown.



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

.....

..... [1]

(b) Powdered zinc is added to aqueous chromium(III) ions, $Cr^{3+}(aq)$.

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

..... [2]

(c) Explain why aluminium does **not** react with water.

.....

.....

..... [2]

(d) Hydrogen peroxide, an oxidising agent, is added to aqueous potassium iodide in a test-tube.

Describe the colour change seen in the test-tube.

..... [1]

(e) Chromium is extracted by the reaction of aluminium with chromium(III) oxide, Cr_2O_3.

(i) Write the equation for this reaction.

..... [1]

(ii) Suggest a **compound** that can reduce chromium(III) oxide to chromium metal.

..... [1]

(f) State one advantage of recycling metals.

..... [1]

[Total: 9]

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5 Sulfuric acid, H_2SO_4, reacts with sodium hydroxide, NaOH, as shown.

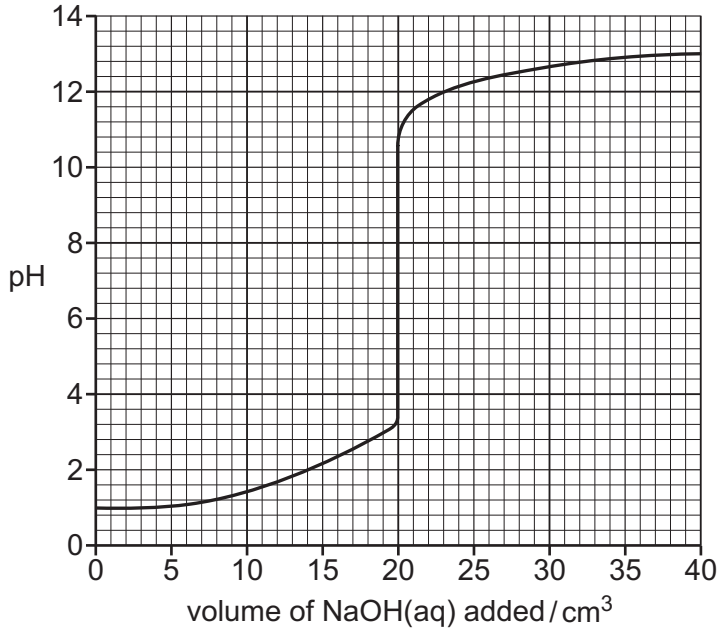
$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

A sample of 25.0 cm^3 of 0.0500 mol/dm^3 H_2SO_4 is placed in a beaker.

NaOH(aq) is added slowly, from a burette, to the H_2SO_4 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 NaOH(aq) is added.

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



(a) Explain, in terms of the ions present, why the pH of the solution in the beaker changes from 1.0 to 13.0.

.....

.....

.....

..... [2]

(b) Use the graph to state the volume of NaOH(aq) that just neutralises all of the H_2SO_4.

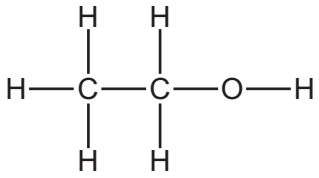
volume of NaOH(aq) ..... cm^3 [1]

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

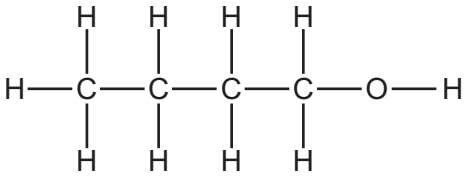
concentration of NaOH(aq) ..... mol/dm^3 [3]

[Total: 6]

6 The structures of two alcohols are shown.



ethanol



alcohol **B**

(a) What is the name of alcohol **B**?

..... [1]

(b) Draw the structure of one other alcohol which is an isomer of **B**.

Show all of the atoms and all of the bonds.

[1]

(c) Ethanoic acid is produced by the oxidation of ethanol.

State the reagent for this reaction.

..... [1]

(d) Ethanol is a simple molecular compound.

Explain why liquid ethanol does **not** conduct electricity.

.....

..... [1]

(e) Ethanol can be dehydrated to form ethene, C_2H_4.

Describe, using a dot-and-cross diagram, the bonding in a molecule of ethene.

Only include the outer shell electrons.

[2]

[Total: 6]

Section B

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

The total mark for this section is 30.

7 This question is about some of the oxides of the elements in Period 3.

(a) State the electronic configuration of the negative ion in sodium oxide, Na_2O.

..... [1]

(b) Magnesium oxide is an insoluble base that can be used to prepare pure magnesium sulfate crystals.

Describe the essential practical details for the preparation of pure magnesium sulfate crystals from magnesium oxide.

.....

.....

.....

.....

.....

.....

..... [4]

(c) An oxide of phosphorus contains 43.7% by mass of phosphorus.

(i) Show that the empirical formula for this oxide is P_2O_5.

[2]

(ii) A sample of this oxide has a mass of 2.56 g.

The sample contains 0.00901 mol of the oxide.

Calculate the relative molecular mass and hence the molecular formula for this oxide of phosphorus.

relative molecular mass .....

molecular formula .....

[2]

(d) State the structure and bonding in silicon dioxide, SiO_2.

..... [1]

[Total: 10]

8 Copper is a transition element.

(a) State two properties that are typical of the compounds of a transition element.

1 .....

2 .....
[2]

(b) Aqueous copper(II) sulfate reacts with aqueous potassium iodide.

The ionic equation for this reaction is shown.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \longrightarrow 2CuI(s) + I_2(aq)$$

Explain how this equation shows that the reaction involves oxidation.

.....

..... [1]

(c) Anhydrous copper(II) sulfate decomposes when heated strongly.

$$CuSO_4(s) \longrightarrow CuO(s) + SO_3(g)$$

A sample of 6.40 g of $CuSO_4$ is heated until all of the sample has thermally decomposed.

Calculate the volume of sulfur trioxide formed, in dm^3, measured at room temperature and pressure.

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

(d) Iron reacts with aqueous copper(II) sulfate to make aqueous iron(II) sulfate and copper.

(i) Construct the ionic equation for this reaction.

..... [1]

(ii) Suggest one observation that would be seen during this reaction.

.....

..... [1]

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

chemical test .....

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

result with copper(II) sulfate .....

[2]

[Total: 10]

9 Sulfur dioxide is a colourless gas which can be found in air.

(a) State one environmental problem caused by the presence of sulfur dioxide in air.

..... [1]

(b) When heated in air iron pyrite, FeS_2, reacts with oxygen.

Sulfur dioxide and iron(III) oxide, Fe_2O_3, are the products of this reaction.

Construct the equation for this reaction.

..... [2]

(c) Give one use for sulfur dioxide.

..... [1]

(d) Liquid sulfur dioxide is stored in cylinders.

When the cylinder is opened the liquid quickly changes into a gas.

Use the kinetic particle theory to describe the changes in **movement** and **arrangement** of the particles when liquid sulfur dioxide becomes a gas.

.....

.....

.....

.....

..... [2]

(e) Sulfur dioxide has a low melting point.

Suggest, in terms of structure and bonding, why sulfur dioxide has a low melting point.

.....

.....

.....

.....

..... [2]

(f) Describe the chemical test for sulfur dioxide.

test .....

observation .....
[2]

[Total: 10]

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

(a) Fractional distillation separates petroleum (crude oil) into fractions such as bitumen and naphtha.

(i) Which physical property allows the petroleum (crude oil) to be separated into fractions?

..... [1]

(ii) Describe the separation of petroleum (crude oil) by fractional distillation.

.....

.....

.....

..... [2]

(iii) Give one use of the bitumen fraction.

..... [1]

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

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

Use the general formula for an alkane to show that $C_{10}H_{22}$ is an alkane.

.....

.....

..... [2]

(c) In an experiment $C_{10}H_{22}$ is cracked to form products **A**, **B** and **C**.

(i) Product **A** gives a squeaky pop when ignited with a burning splint.

Identify product **A**.

..... [1]

(ii) Product **B** has a relative molecular mass of 98 and decolourises aqueous bromine.

Suggest the molecular formula for **B**.

Explain your answer.

molecular formula .....

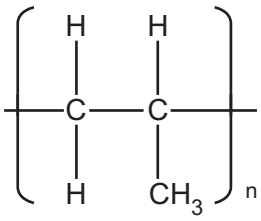
explanation .....

.....

.....

[2]

(iii) Product **C** can be polymerised to give the polymer shown.



Draw the structure of product **C**.

[1]

[Total: 10]

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.).