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Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

* 4 9 8 4 1 5 8 8 8 1 *

CHEMISTRY **0620/41**

Paper 4 Theory (Extended) **October/November 2018**

1 hour 15 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.

Answer **all** questions.
Electronic calculators may be used.
A copy of the Periodic Table is printed on page 16.
You may lose marks if you do not show your working or if you do not use appropriate units.

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.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **15** printed pages and **1** blank page.

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CAMBRIDGE International Examinations

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1 The following formulae represent different substances.

Al Ag $CaCO_3$ CH_4 Cl_2 Cu SO_2

Answer the following questions using only these substances.
Each substance may be used once, more than once or not at all.

State which substance is:

(a) used to make food containers ..... [1]

(b) added to a blast furnace to remove impurities during the production of iron ..... [1]

(c) the main constituent of natural gas ..... [1]

(d) a cause of acid rain ..... [1]

(e) a gas which bleaches damp litmus paper ..... [1]

(f) a gas which contributes to climate change. ..... [1]

[Total: 6]

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2 The table gives some information about four different particles, **A**, **B**, **C** and **D**.

particle	number of electrons	number of neutrons	number of protons	electronic structure	charge on particle
A	11	12	11	2,8,1	0
B		14	11	2,8,1	0
C	18	20		2,8,8	0
D	18	20	17		

(a) Complete the table. The first row has been done for you. [4]

(b) Give **two** particles from the table which are isotopes of each other.

..... [1]

(c) Element **Z** is in the same group of the Periodic Table as **A** and is less reactive than **A**.

State the identity of element **Z**.

..... [1]

(d) **C** is unreactive.

Use information from the table to explain why.

..... [1]

[Total: 7]

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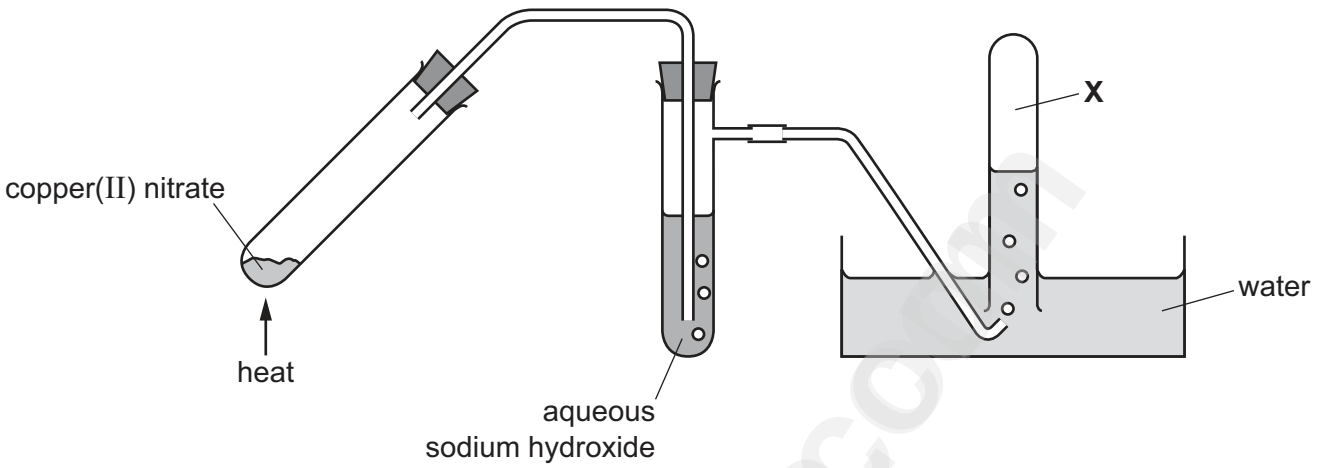
3 **(a)** Copper(II) nitrate decomposes when heated. Two gases, oxygen and nitrogen dioxide, and a solid are made in the reaction.

A sample of copper(II) nitrate was decomposed using the apparatus shown.



(i) Complete the chemical equation for the reaction.

$$2Cu(NO_3)_2 \rightarrow O_2 + \text{.....}NO_2 + \text{.....}$$ [2]

(ii) Only oxygen gas is collected at **X**.

Explain why.

.....

..... [1]

(b) Nitrogen dioxide and other oxides of nitrogen are formed in car engines.

Explain how nitrogen dioxide is formed in car engines.

.....

.....

.....

..... [2]

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(c) A teacher heated 18.8 g of copper(II) nitrate.

(i) Calculate the number of moles of copper(II) nitrate present in the 18.8 g.

..... mol [2]

(ii) Calculate the maximum number of moles of oxygen that can be made by heating 18.8 g of copper(II) nitrate.

..... mol [1]

(iii) Calculate the maximum volume of oxygen at room temperature and pressure, in cm^3, that can be made by heating 18.8 g of copper(II) nitrate.

..... cm^3 [1]

(d) A sample of copper(II) nitrate was dissolved in water to form an aqueous solution.

The aqueous solution was split into three portions. A separate test was done on each portion as shown.

test	reagent added	result
1	aqueous sodium hydroxide	light blue precipitate forms
2	zinc powder	solution changes from blue to colourless and a brown solid forms
3		ammonia gas is produced

(i) Give the formula of the light blue precipitate formed in **test 1**.

..... [1]

(ii) Explain the changes seen in **test 2**.

.....

.....

.....

..... [3]

(iii) Identify the **two** reagents that must be added to the aqueous copper(II) nitrate in **test 3**.

1 .....

2 .....

[2]

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(e) Copper(II) nitrate can be made by reacting copper(II) carbonate with nitric acid. One of the products is carbon dioxide.

(i) Write a chemical equation for the reaction of copper(II) carbonate with nitric acid.

..... [2]

(ii) Carbon dioxide is added to the air by living things.

Name the chemical process by which living things add carbon dioxide to the air.

..... [1]

(iii) Carbon dioxide is removed from the air by plants.

Name the chemical process by which plants remove carbon dioxide from the air.

..... [1]

[Total: 19]

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4 **(a)** Sulfuric acid is made industrially by a four-step process.

step 1 Sulfur is burned in air to produce sulfur dioxide.

step 2 Sulfur dioxide is converted into sulfur trioxide.

step 3 Sulfur trioxide is reacted with concentrated sulfuric acid to produce oleum.

step 4 Oleum is reacted with water to produce concentrated sulfuric acid.

(i) Some sulfur is obtained by mining.

Name **one** other major source of sulfur.

..... [1]

(ii) What is the name of the process by which sulfuric acid is made industrially?

..... [1]

(iii) Describe the conversion of sulfur dioxide into sulfur trioxide in **step 2**.

In your answer, include:
- a chemical equation for the reaction
- the essential reaction conditions.

.....

.....

.....

.....

.....

.....

..... [5]

(b) When concentrated sulfuric acid is added to glucose, $C_6H_{12}O_6$, a black solid is produced. The concentrated sulfuric acid acts as a dehydrating agent.

(i) What is removed from the glucose in this reaction?

..... [1]

(ii) Name the black solid produced in this reaction.

..... [1]

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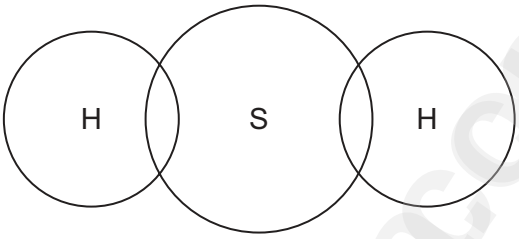
(c) The gas hydrogen sulfide, H_2S, is produced when concentrated sulfuric acid is added to solid potassium iodide.

The reaction involves oxidation.

(i) Define the term *oxidation* in terms of electron transfer.

..... [1]

(ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of hydrogen sulfide. Show outer shell electrons only.



[2]

(iii) Hydrogen sulfide has a simple molecular structure.

Explain why hydrogen sulfide has a low boiling point.

.....

.....

..... [2]

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(d) Dilute sulfuric acid reacts with aqueous sodium hydrogencarbonate in a neutralisation reaction.

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$$

In a titration, 0.200 mol / dm^3 aqueous sodium hydrogencarbonate was used to neutralise 20.0 cm^3 of dilute sulfuric acid of concentration 0.150 mol / dm^3.

(i) Calculate the number of moles of dilute sulfuric acid used in the titration.

..... mol [1]

(ii) Calculate the number of moles of sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

..... mol [1]

(iii) Calculate the volume, in cm^3, of 0.200 mol / dm^3 aqueous sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

..... cm^3 [1]

[Total: 17]

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5 Hydrogen gas reacts with iodine gas. The equation is shown.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The reaction is reversible and can reach equilibrium.

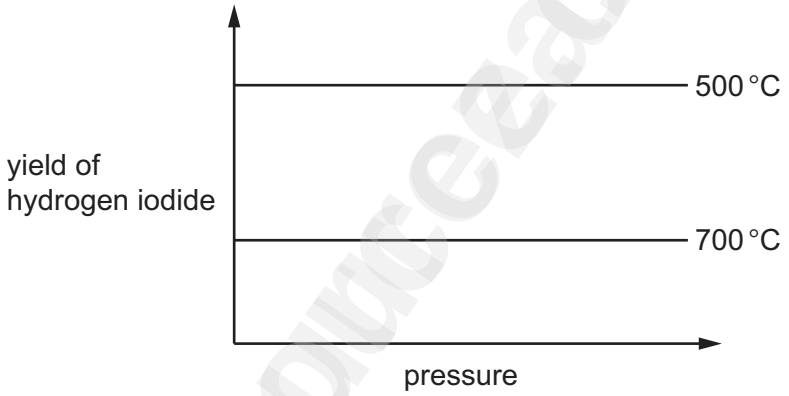
(a) What is meant by the term *equilibrium*?

.....

.....

..... [2]

(b) The graphs show how pressure affects the yield of hydrogen iodide, HI, at two different temperatures.



(i) Explain why the yield at 500 °C does **not** change as the pressure is increased.

.....

..... [1]

(ii) What can you conclude from the difference in the yield of hydrogen iodide at the **two** temperatures shown? Explain your answer.

.....

.....

..... [2]

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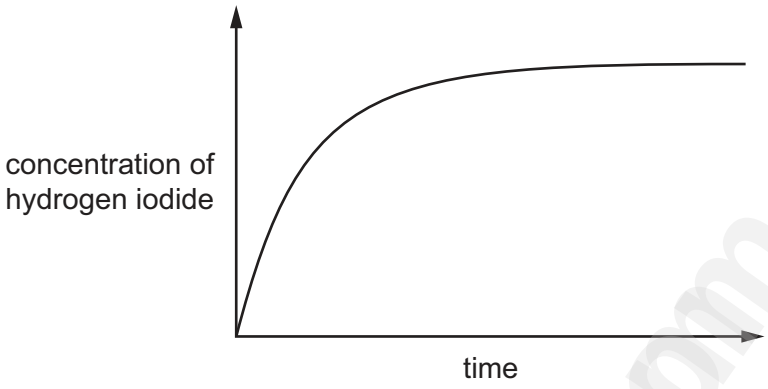
(c) The graph shows how the concentration of hydrogen iodide, HI, changes after hydrogen gas and iodine gas are mixed together in a sealed container.



(i) When is the rate of reaction fastest?

..... [1]

(ii) The reaction was repeated at the same temperature and pressure but in the presence of a catalyst.

Draw a graph on the same axes to show how the concentration of hydrogen iodide changes with time in the presence of a catalyst. [2]

(d) A mixture of hydrogen gas and iodine gas is allowed to reach equilibrium.

(i) Increasing the pressure of a gas increases its concentration.

State and explain the effect of increasing the pressure on the **rate** of the forward reaction.

.....

.....

..... [2]

(ii) State and explain the effect of increasing the temperature on the **rate** of the reverse reaction.

.....

.....

.....

.....

..... [3]

[Total: 13]

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6 **(a)** Ethane, C_2H_6, is a member of the homologous series called alkanes.
Ethanol, C_2H_5OH, is a member of the homologous series called alcohols.

(i) Alkanes are hydrocarbons.

What is meant by the term *hydrocarbon*?

.....

..... [2]

(ii) All members of a homologous series can be represented by a general formula.

State the general formula of:

- alkanes .....
- alcohols .....

[2]

(iii) State **two** characteristics, other than having the same general formula, of members of a homologous series.

1 .....

.....

2 .....

.....

[2]

(b) Ethane can react with chlorine in a substitution reaction.

(i) State **one** essential reaction condition.

..... [1]

(ii) Draw the structure of the organic product formed by substitution of **one** of the hydrogen atoms in ethane with chlorine. Show all of the atoms and all of the bonds.

[1]

(iii) Name the product of the substitution reaction between ethane and chlorine that does **not** contain carbon.

..... [1]

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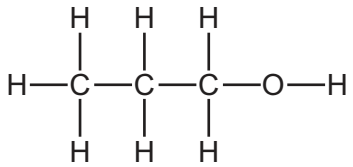
(c) Propan-1-ol is an alcohol.

The structure of propan-1-ol is shown.

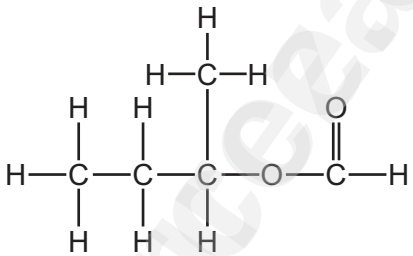


Propan-1-ol reacts with ethanoic acid to form an ester.

Give the name of the ester formed in this reaction.

..... [1]

(d) Ester **Y** has the structure shown.



ester **Y**

(i) Give the molecular formula of ester **Y**.

..... [1]

(ii) Draw the structures of the carboxylic acid and the alcohol used to make ester **Y**. Show all of the atoms and all of the bonds. Give the name of the carboxylic acid and the alcohol.

structure of the carboxylic acid

name of the carboxylic acid .....

structure of the alcohol

name of the alcohol .....

[4]

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(e) Nylon is a polyamide.

Complete the diagram to show the structure of nylon. Show all of the atoms and all of the bonds present in the linkages.

[3]

[Total: 18]

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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 –		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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