Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

1311966589

CHEMISTRY **0620/41**

Paper 4 Theory (Extended) **October/November 2017**

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 **16** printed pages.

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1 The table gives information about five particles. The particles are all atoms or ions.

particle	number of protons	number of neutrons	number of electrons
A	6	8	6
B	12	12	12
C	13	14	10
D	8	8	10
E	11	12	11

Answer the following questions using the information in the table.
Each particle may be used once, more than once or not at all.

(a) Which particle, **A**, **B**, **C**, **D** or **E**,

(i) is an atom with atomic number 12,

..... [1]

(ii) is an atom with nucleon number 14,

..... [1]

(iii) is an ion with a positive charge,

..... [1]

(iv) has only **one** electron in its outer shell?

..... [1]

(b) **D** is an ion of an element.

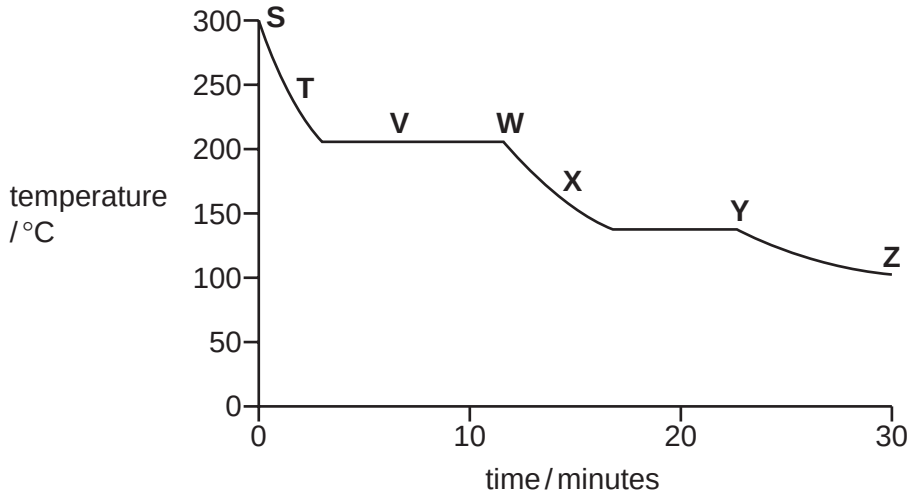
Identify the element and write the formula of **D**.

..... [2]

[Total: 6]

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2 The graph shows how the temperature of a substance changes as it is cooled over a period of 30 minutes. The substance is a gas at the start.



Each letter on the graph may be used once, more than once or not at all.

(a) Which letter, **S**, **T**, **V**, **W**, **X**, **Y** or **Z**, shows when

(i) the particles in the substance have the most kinetic energy,

..... [1]

(ii) the particles in the substance are furthest apart,

..... [1]

(iii) the substance exists as both a gas and a liquid?

..... [1]

(b) Use the graph to estimate the freezing point of the substance.

..... °C [1]

(c) Name the change of state directly from a solid to a gas.

..... [1]

(d) When smoke is viewed through a microscope, the smoke particles in the air appear to jump around.

(i) What term describes this movement of the smoke particles?

..... [1]

(ii) Explain why the smoke particles move in this way.

.....

.....

..... [2]

[Total: 8]

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[Turn over

3 **(a)** When magnesium is added to aqueous copper(II) sulfate a reaction occurs.
The ionic equation for the reaction is shown.

$$Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$$

(i) Give **one** change you would observe during this reaction.

..... [1]

(ii) Explain why this is a redox reaction.

.....

..... [1]

(iii) Identify the oxidising agent in this reaction. Give a reason for your answer.

.....

..... [2]

(iv) A redox reaction occurs when magnesium is heated with iron(III) oxide.

Write a chemical equation for the reaction between magnesium and iron(III) oxide.

..... [2]

(b) The metal iron and the alloy steel are commonly used materials. A problem with them is that they rust.

(i) How does painting iron and steel prevent rusting?

.....

..... [1]

(ii) Magnesium blocks can be attached to the bottom of steel boats.

Explain how the magnesium blocks prevent the whole of the bottom of the boat from rusting.

.....

.....

.....

..... [2]

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(iii) Replacing the magnesium blocks with copper blocks does not prevent rusting.

Explain why the copper blocks do **not** prevent rusting.

.....

..... [1]

[Total: 10]

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[Turn over

4 **(a)** Ethanol, C_2H_5OH, can be made by fermentation.

(i) Complete the chemical equation for the formation of ethanol by fermentation.

$$C_6H_{12}O_6 \rightarrow \text{.....}C_2H_5OH + \text{.....}$$

[2]

(ii) State **two** conditions required for fermentation.

1 .....

2 .....

[2]

(b) Ethanol can also be made by the catalytic hydration of ethene. The equation for the reaction is shown.

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

(i) Name a suitable catalyst for this reaction.

..... [1]

(ii) Calculate the maximum mass of ethanol that can be made from 56 g of ethene.

maximum mass of ethanol = ... g [2]

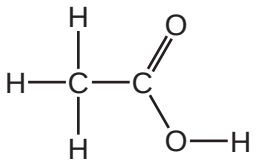
(c) Ethanol can be oxidised to form ethanoic acid.

(i) Name a suitable oxidising agent for this reaction.

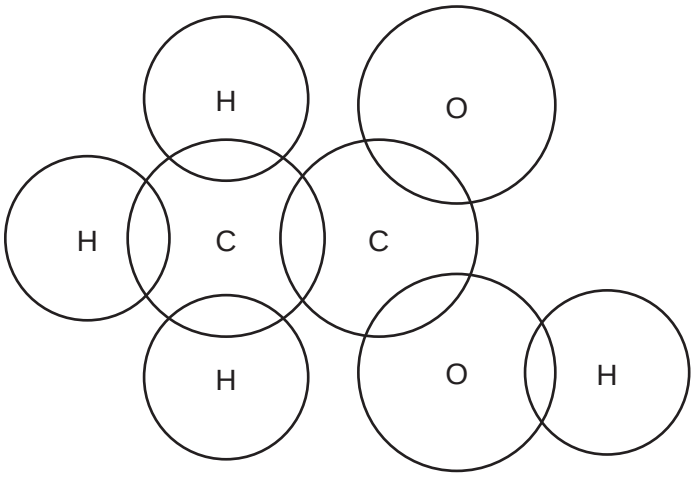
..... [1]

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(ii) A molecule of ethanoic acid has the structure shown.



Complete the dot-and-cross diagram to show the electron arrangement in ethanoic acid. Show outer shell electrons only.



[3]

(d) Ethanoic acid is a weak acid.

(i) When referring to an acid, what is meant by the term *weak*?

.....

..... [1]

(ii) Describe how you could show that ethanoic acid is a weaker acid than hydrochloric acid.

.....

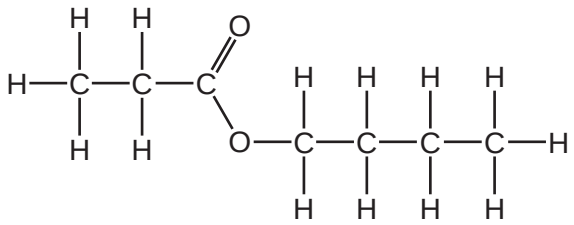
.....

.....

..... [3]

(e) Carboxylic acids react with alcohols to make esters.

The structure of an ester is shown.



Draw the structures of the carboxylic acid and alcohol from which this ester can be made.
Give the names of the carboxylic acid and alcohol.

structure of the carboxylic acid

name of the carboxylic acid .....

structure of the alcohol

name of the alcohol .....

[4]

[Total: 19]

5 **(a)** Solid copper(II) carbonate undergoes thermal decomposition. One of the products of the thermal decomposition is copper(II) oxide.

(i) State the colour change of the solid seen during the reaction.

start colour .....

end colour .....
[1]

(ii) Write a chemical equation for the thermal decomposition of copper(II) carbonate.

..... [1]

(b) Copper(II) carbonate reacts with dilute nitric acid. One of the products of the reaction is a solution of copper(II) nitrate.

(i) Describe tests for copper(II) ions and nitrate ions. Include the results of the tests.

copper(II) ions .....

.....

.....

nitrate ions .....

.....

.....
[4]

(ii) Copper(II) nitrate undergoes thermal decomposition.

Balance the chemical equation for the thermal decomposition of copper(II) nitrate.

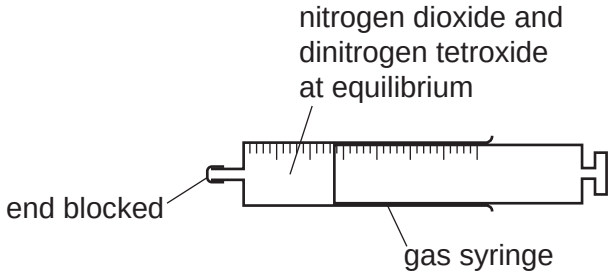
$$\text{.....}Cu(NO_3)_2 \rightarrow \text{.....}CuO + \text{.....}NO_2 + \text{.....}O_2$$
[1]

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(c) Nitrogen dioxide, NO_2, exists in equilibrium with dinitrogen tetroxide, N_2O_4.
Nitrogen dioxide is brown and dinitrogen tetroxide is colourless.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)}$$

(i) A sample of nitrogen dioxide and dinitrogen tetroxide at equilibrium was placed in a closed gas syringe.
The syringe plunger was pushed in. This increased the pressure in the gas syringe. The temperature was kept constant.



State how the colour of the gas in the syringe changed. Explain your answer in terms of the position of the equilibrium.

.....

.....

.....

..... [3]

(ii) A sealed tube containing nitrogen dioxide and dinitrogen tetroxide at equilibrium was cooled in an ice bath at constant pressure. The contents of the tube became paler.

Suggest an explanation for this observation in terms of the position of the equilibrium.

.....

.....

..... [2]

[Total: 12]

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6 Aluminium is extracted from aluminium oxide by electrolysis.

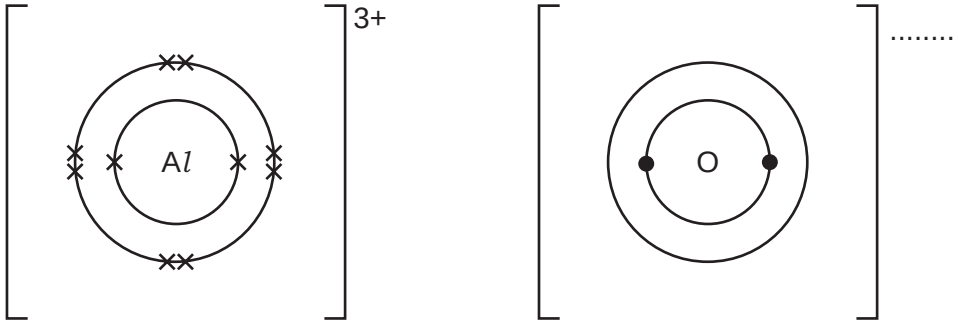
(a) Why is aluminium **not** extracted by heating aluminium oxide with carbon?

.....

..... [1]

(b) Aluminium oxide is an ionic compound with a high melting point.

(i) Complete the dot-and-cross diagram to show the electron arrangement in **one** of the oxide ions present in aluminium oxide. Include the charge on the oxide ion.
One of the aluminium ions is shown.



[2]

(ii) The melting point of aluminium oxide is above 2000 °C.

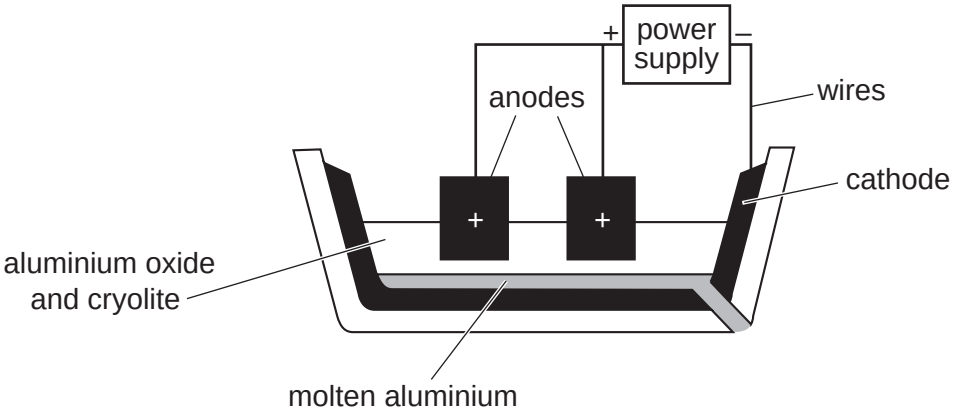
Explain why aluminium oxide has a high melting point.

.....

.....

..... [2]

(c) Aluminium can be extracted by electrolysis using the apparatus shown.



(i) Name the type of particle responsible for the transfer of charge in

the wires, ...

the electrolyte. .....
[2]

(ii) Give **two** reasons why cryolite is used.

1 .....

2 .....
[2]

(iii) Write the ionic half-equation for the formation of aluminium during the electrolysis.

..... [1]

(iv) Explain how carbon dioxide gas is formed at the anodes.

.....

.....

..... [3]

(d) When a piece of aluminium is placed in dilute hydrochloric acid, there is no immediate visible reaction.
If the aluminium is left in the dilute hydrochloric acid for several hours, bubbles start to form.

Explain why aluminium does **not** react immediately with dilute hydrochloric acid.

.....

..... [1]

[Total: 14]

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Question 7 starts on the next page.

7 Copper(II) oxide reacts with dilute hydrochloric acid.

$$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$$

6.00 g of copper(II) oxide were added to 50.0 cm^3 of 1.00 mol / dm^3 hydrochloric acid. This was an excess of copper(II) oxide.

(a) The rate of the reaction can be increased by increasing the concentration of the hydrochloric acid or by heating it.

(i) In terms of collisions, explain why increasing the concentration of the hydrochloric acid increases the rate of the reaction.

.....

.....

.....

..... [2]

(ii) In terms of collisions, explain why heating the hydrochloric acid increases the rate of the reaction.

.....

.....

.....

..... [2]

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(b) (i) Calculate the number of moles of copper(II) oxide added to the hydrochloric acid.

moles of copper(II) oxide = ... mol [2]

(ii) Calculate the number of moles of hydrochloric acid used.

moles of hydrochloric acid = ... mol [1]

(iii) Calculate the mass of copper(II) oxide that did **not** react.

mass of copper(II) oxide that did **not** react = ... g [2]

(c) Crystals of hydrated copper(II) chloride were obtained from the solution at the end of the reaction.

The crystals had the following composition by mass: C*l*, 41.52%; Cu, 37.43%; H, 2.34%; O, 18.71%.

Calculate the empirical formula of the crystals.

empirical formula = ... [2]

[Total: 11]

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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.).