Cambridge IGCSE

**Cambridge International Examinations**
Cambridge International General Certificate of Secondary Education

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CENTER NUMBER | | | | | | CANDIDATE NUMBER | | | |

*6195714683*

**CHEMISTRY (US)** **0439/41**

Paper 4 Theory (Extended) **October/November 2016**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Center 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.

This document consists of **16** printed pages.




CAMBRIDGE International Examinations

**1** The table gives some information about five substances.

| substance | melting point / °C | boiling point / °C | solubility in water | electrical conductivity when molten | electrical conductivity when solid |
|---|---|---|---|---|---|
| **F** | –97 | 65 | very soluble | does not conduct | does not conduct |
| **G** | 1600 | 2230 | insoluble | does not conduct | does not conduct |
| **H** | 801 | 1413 | soluble | conducts | does not conduct |
| **I** | –57 | 126 | insoluble | does not conduct | does not conduct |
| **J** | 1085 | 2562 | insoluble | conducts | conducts |

**(a)** Which substance in the table has ionic bonding?

..... [1]

**(b)** Which substance in the table has a giant covalent structure?

..... [1]

**(c)** Name a method you could use to separate a mixture of substance **J** and water.

..... [1]

**(d)** Name a method you could use to obtain substance **F** from a mixture of substance **F** and water.

..... [2]

**(e)** Describe how you could obtain a solid sample of substance **H** from a mixture of substance **H** and substance **G**.

.....

.....

.....

.....

.....

..... [3]

**(f)** Substance **J** is a metal.

Describe how substance **J** is able to conduct electricity when it is a solid.

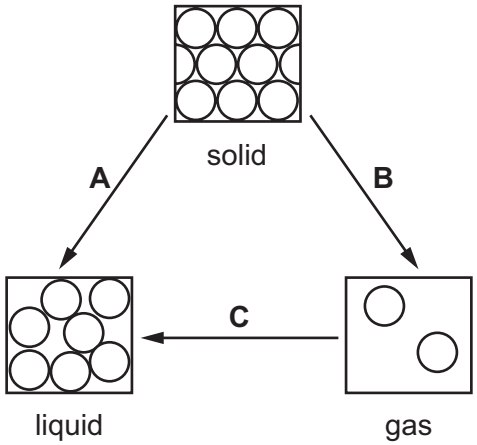
.....

.....

..... [2]

[Total: 10]

**2** Matter can exist as solid, liquid or gas. The arrows show some changes of state.




**(a)** Name the changes of state represented on the diagram.

**(i)** **A** ..... [1]

**(ii)** **B** ..... [1]

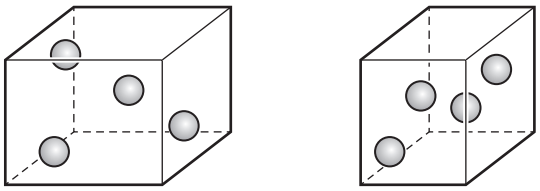
**(iii)** **C** ..... [1]

**(b)** Explain why energy has to be supplied to turn a liquid into a gas.

.....

..... [1]

**(c)** The diagrams represent the same number of particles of a gas in two containers, **D** and **E**, which have different volumes. The two containers are at the same temperature.




In which container will the pressure be higher? Explain your answer.

.....

.....

..... [1]

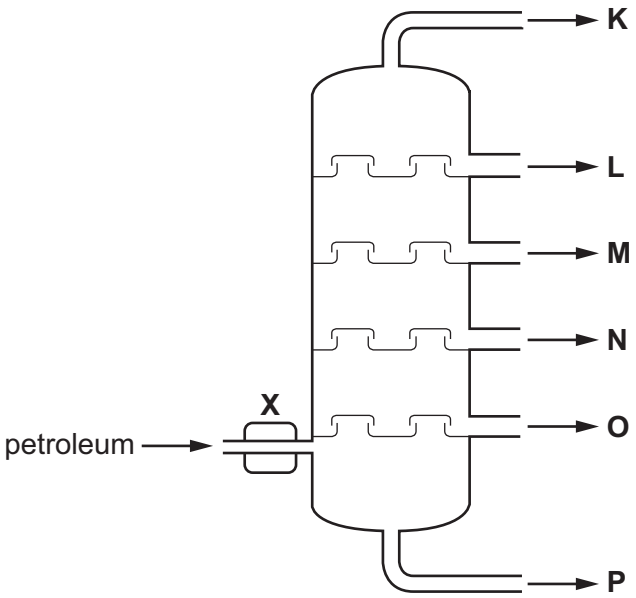
[Total: 5]





**[Turn over**

**3** **(a)** Petroleum is a mixture of hydrocarbons. It is separated into useful fractions by fractional distillation. This can be done using the fractionating column shown.




**(i)** What happens to the petroleum at point **X**, before it enters the fractionating column?

.....

..... [1]

**(ii)** State **two** ways in which fraction **O** differs from fraction **L**.

.....

.....

..... [2]

**(b)** Most of the hydrocarbons obtained from petroleum are alkanes. The alkanes are an homologous series of saturated hydrocarbons with the general formula $C_nH_{2n+2}$.

Give **two** characteristics, other than having the same general formula, of members of an homologous series.

.....

.....

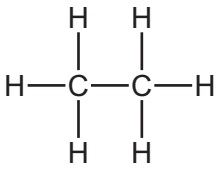
..... [2]

**(c)** The alkane with the molecular formula $C_5H_{12}$ can exist as a number of structural isomers.

Draw the structures of **two** isomers with the formula $C_5H_{12}$.

[2]

**(d)** The alkane ethane has the structure shown.



When a mixture of ethane and chlorine is exposed to ultraviolet light a substitution reaction takes place.

Draw the structure of **one** organic product from this substitution reaction.

[1]

**(e)** Isoprene is a naturally occurring hydrocarbon.

**(i)** Explain how the name of isoprene suggests that it contains a C=C double bond.

..... [1]

**(ii)** A sample of isoprene had the following composition by mass: C, 88.24%; H, 11.76%.

Calculate the empirical formula of isoprene. Show all your working.

empirical formula = ..... [3]

**(iii)** What additional information would be required to calculate the molecular formula of isoprene?

..... [1]

[Total: 13]

**4** **(a)** Ammonia, $NH_3$, is made by reacting nitrogen with hydrogen in the Haber process.

**(i)** Write a chemical equation for the formation of ammonia in the Haber process.

..... [2]

**(ii)** Name the raw materials from which nitrogen and hydrogen are obtained.

nitrogen .....

hydrogen .....
[2]

**(iii)** State the temperature and pressure used in the Haber process. Include the units.

temperature .....

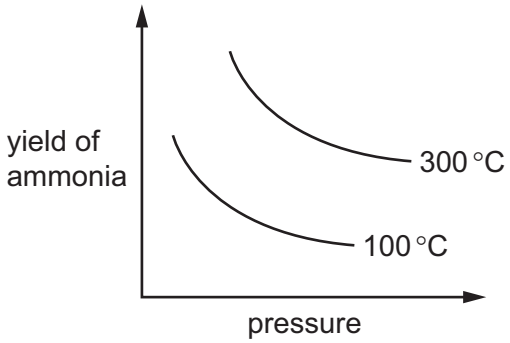
pressure .....
[2]

**(b)** Ammonia is also made when ammonium carbonate decomposes.

$$(NH_4)_2CO_3(s) \rightleftharpoons 2NH_3(g) + H_2O(g) + CO_2(g)$$

The reaction is reversible and can reach a position of equilibrium.

The graph shows how the yield of ammonia at equilibrium changes with temperature and pressure.




**(i)** What is meant by the term *equilibrium* for a reversible reaction?

.....

.....

..... [2]

**(ii)** Using information from the graph, explain whether the reaction is endothermic or exothermic.

.....

..... [1]

**(iii)** State and explain the effect of increasing the pressure on the yield of ammonia in this reaction.

.....

.....

.....

.....

..... [3]

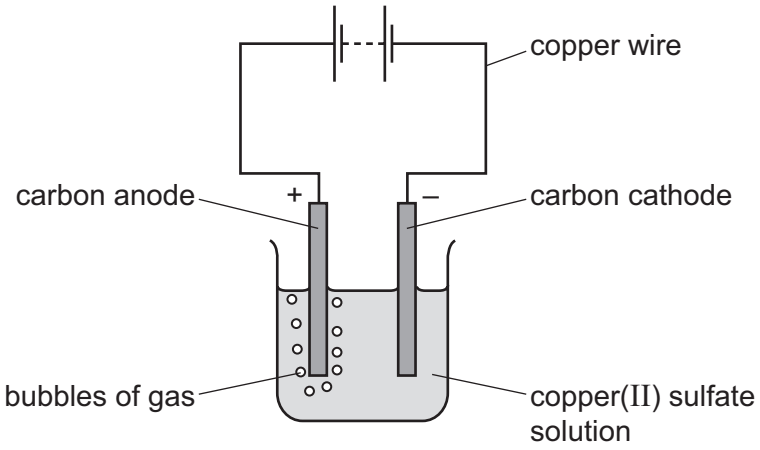
[Total: 12]





**[Turn over**

**5** Copper(II) sulfate solution was electrolyzed using the apparatus shown.




**(a)** A gas was formed at the anode.

Identify this gas and give the test for this gas.

gas .....

test .....

result of test .....

[3]

**(b)** During electrolysis, electricity passes through the copper(II) sulfate solution.

Solid copper(II) sulfate does not conduct electricity.

Explain **both** of these statements.

.....

.....

.....

.....

..... [3]

**(c)** The electrolysis was repeated using copper electrodes in place of carbon electrodes. The ionic half-equations for the reactions at the two electrodes are shown.

anode $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

cathode $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

**(i)** Which species is reduced during the electrolysis? Explain your answer.

.....

.....

..... [2]

**(ii)** The masses of the copper electrodes changed during the electrolysis.

State how **and** explain why the masses of the **two** copper electrodes changed.
Use the ionic half-equations to help you.

.....

.....

.....

.....

.....

.....

..... [3]

**(iii)** Explain why, during the electrolysis, the color of the copper(II) sulfate solution does **not** change.

.....

.....

..... [1]

[Total: 12]





**[Turn over**

**6** Nylon, *Terylene* and proteins are all polymers.

**(a)** What is a polymer?

.....

.....

..... [2]

**(b)** Proteins are natural polymers. Proteins are biodegradable.

**(i)** Name the type of linkage in proteins.

..... [1]

**(ii)** What is meant by the term *biodegradable*?

.....

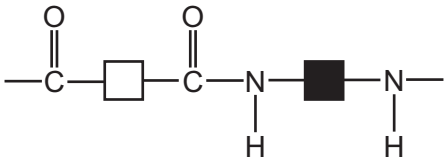
.....

..... [2]

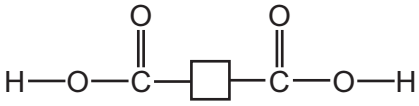
**(iii)** Name another natural polymer.

..... [1]

**(c)** Nylon and *Terylene* are synthetic polymers.
The repeat unit of nylon can be shown as



*Terylene* can be made from the monomers shown.



Draw a diagram to show the repeat unit of *Terylene*.

[3]

[Total: 9]

**7** Calcium chloride can be made by reacting calcium carbonate with hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

An excess of calcium carbonate was added to 50.0 $cm^3$ of 0.500 mol / $dm^3$ hydrochloric acid. The solution was filtered to remove the excess calcium carbonate.

**(a)** How many moles of HCl were used in this reaction?

..... mol [2]

**(b)** Deduce the number of moles of carbon dioxide gas made in this reaction.

..... mol [1]

**(c)** Calculate the mass of carbon dioxide made in this reaction.

..... g [2]

**(d)** Calculate the volume, in $dm^3$, of carbon dioxide made in this reaction at room temperature and pressure (r.t.p.).

..... $dm^3$ [1]

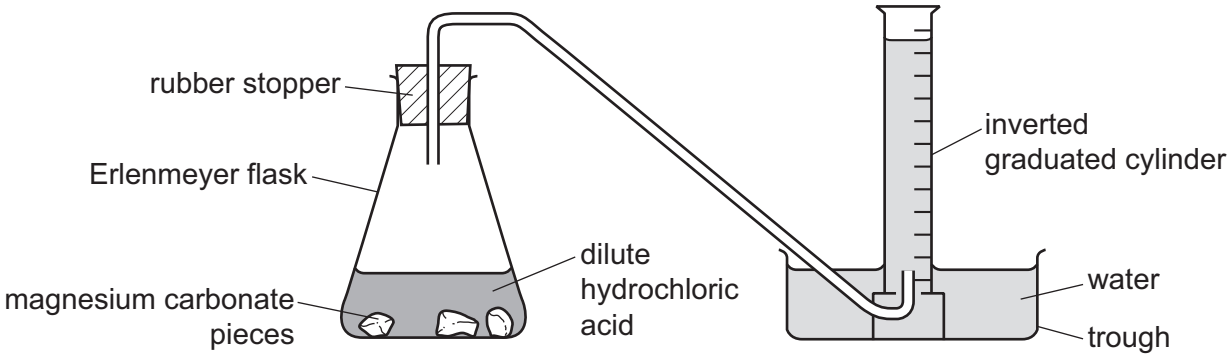
[Total: 6]

**Question 8 starts on the next page.**

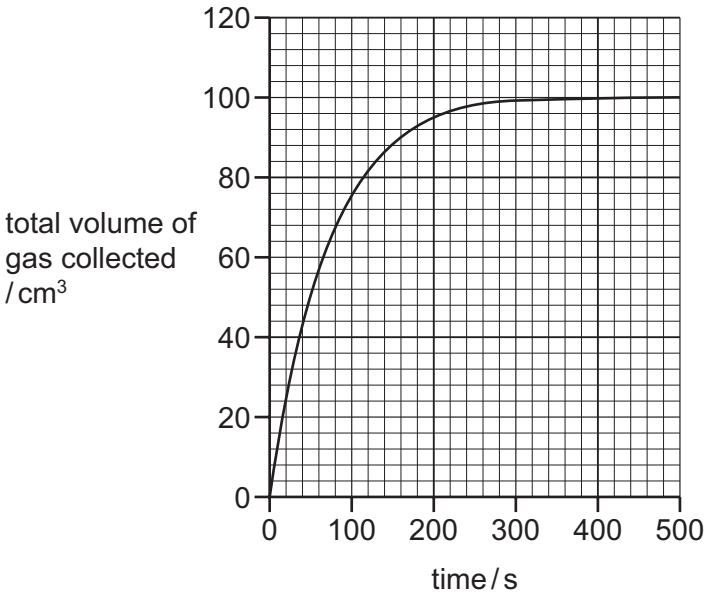
**8** Magnesium carbonate reacts with dilute hydrochloric acid.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

An excess of magnesium carbonate pieces was added to dilute hydrochloric acid. The apparatus in the diagram was used to measure the volume of gas produced. The total volume of gas collected was recorded every 20 seconds.




**(a)** The results obtained are shown on the graph.




**(i)** Describe how the rate of this reaction changed during the reaction. Explain why the rate changed in this way.

.....

.....

.....

.....

..... [4]

**(ii)** The experiment was repeated using the same mass of **powdered** magnesium carbonate with the same volume and concentration of dilute hydrochloric acid.

Explain how the initial rate of reaction and total volume of gas collected would compare to the first experiment.

initial rate of reaction .....

.....

.....

total volume of gas .....

.....

.....

[4]

**(b)** A piece of magnesium ribbon was cleaned. The experiment was repeated using this clean magnesium ribbon instead of magnesium carbonate.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

This reaction is exothermic.
The rate of the reaction gradually increased over the first 2 minutes.

Explain why the rate of the reaction increased.

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 13]

## 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 aluminum 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 cesium 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.)