Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **0620/42**

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 **14** printed pages and **2** blank pages.

1 **(a)** Dust particles in the air move around in a random way.

(i) What term describes the random movement of the dust particles?

..... [1]

(ii) Identify the particles in the air which cause the random movement of the dust particles.

..... [2]

(iii) Explain why the dust particles move in this way.

.....

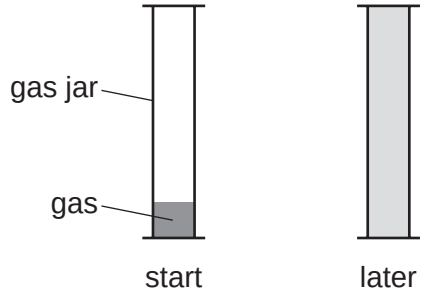
.....

..... [2]

(b) When chlorine gas, Cl_2, is put into a gas jar, it spreads out to fill the gas jar.

When bromine gas, Br_2, is put into a gas jar, it also spreads out to fill the gas jar.

The process takes longer for bromine gas than for chlorine gas.



(i) What term describes the way that the gas particles spread out?

..... [1]

(ii) Use **data** from the Periodic Table to explain why bromine gas takes longer to fill a gas jar than chlorine gas.

.....

.....

..... [2]

(iii) Explain why increasing the temperature increases the rate at which the gas particles spread out.

.....

..... [1]

[Total: 9]

2 **(a)** Complete the table to show the electronic structure of the atoms and ions.

	electronic structure
F	2,7
Si	
Ca^{2+}	
N^{3-}	

[3]

(b) Predict the formula of the compound formed between Ca^{2+} and N^{3-}.

..... [1]

(c) Draw a dot-and-cross diagram to show the electron arrangements in the **two** ions present in lithium chloride, LiC*l*.
Show outer shell electrons only. Include the charges on the ions.

[3]

(d) Sulfur dichloride, S$C*l*_2$, is a covalent compound. It has the structure C*l*–S–C*l*.

Draw a dot-and-cross diagram to show the electron arrangement in a molecule of sulfur dichloride.
Show outer shell electrons only.

[3]

(e) In terms of attractive forces, explain why LiCl has a higher melting point than SCl_2.

.....

.....

.....

.....

..... [3]

(f) Suggest the identity of a **covalent compound** with a higher melting point than LiCl.

..... [1]

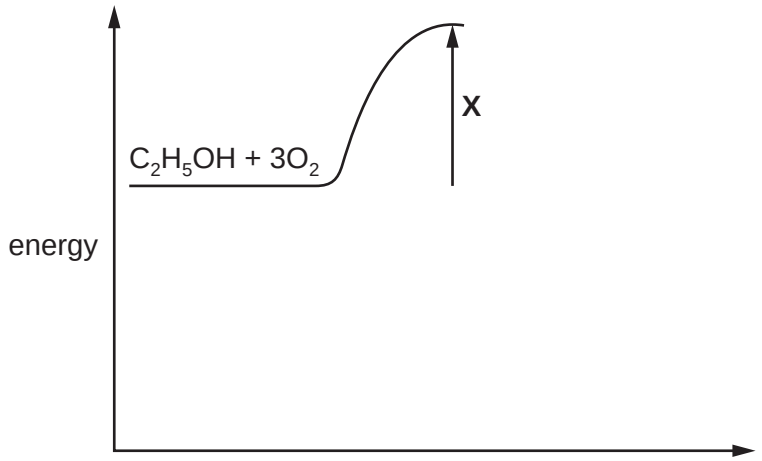
[Total: 14]

3 The chemical equation for the complete combustion of ethanol, C_2H_5OH, is shown.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

The energy released when one mole of ethanol undergoes complete combustion is 1280 kJ.

Part of the energy level diagram for this reaction is shown.



(a) Complete the energy level diagram to show
- the products of the reaction,
- the overall energy change of the reaction.

[3]

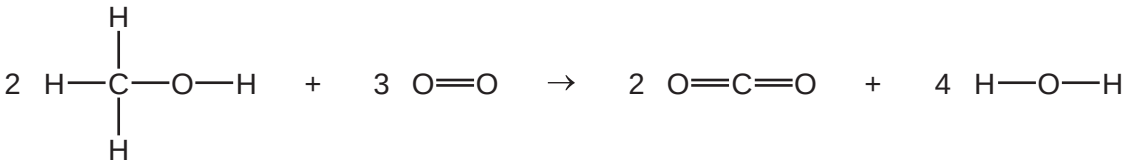
(b) What does **X** represent?

..... [1]

(c) The chemical equation for the complete combustion of methanol, CH_3OH, is shown.

$$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$$

The equation can be represented as shown.



Use the bond energies in the table to determine the energy change, ΔH, for the complete combustion of **one** mole of methanol.

bond	bond energy in kJ / mol
C–H	410
C–O	360
O–H	460
O=O	500
C=O	805

- energy needed to break bonds

..... kJ

- energy released when bonds are formed

..... kJ

- energy change, ΔH, for the complete combustion of **one** mole of methanol

..... kJ / mol
[4]

(d) Dodecane is an alkane containing 12 carbon atoms. Ethanol can be manufactured from dodecane in a two-stage process.

In **stage 1**, each molecule of dodecane is converted into three molecules of ethene and one molecule of another hydrocarbon.

(i) Name the process which occurs in **stage 1**.

..... [1]

(ii) Write a chemical equation for the reaction which occurs in **stage 1**.

..... [2]

In **stage 2**, ethene reacts with steam to produce ethanol.

(iii) State **two** conditions needed for **stage 2**.

1 .....

2 .....
[2]

(iv) Name the type of reaction which occurs in **stage 2**.

..... [1]

(v) Suggest how to test the purity of the ethanol produced.

.....

..... [2]

(e) Ethanol can also be manufactured by the fermentation of glucose, $C_6H_{12}O_6$.

(i) State **two** conditions needed for the fermentation of glucose.

1 .....

2 .....
[2]

(ii) Complete the chemical equation for the fermentation of glucose.

$$C_6H_{12}O_6 \rightarrow .....C_2H_5OH + ...$$
[2]

(iii) One disadvantage of fermentation is that the maximum concentration of ethanol produced is about 15%.

Suggest why the concentration of ethanol produced by fermentation does **not** exceed 15%.

.....

..... [1]

(iv) Give **one** other disadvantage of manufacturing ethanol by fermentation.

..... [1]

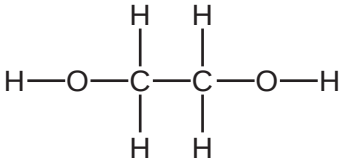
(v) Give **one** advantage, other than cost, of manufacturing ethanol by fermentation.

..... [1]

(vi) Suggest the name of a process to obtain ethanol from a mixture of ethanol and water.

..... [1]

(f) Ethane-1,2-diol has the following structure.



(i) Write the empirical formula of ethane-1,2-diol.

..... [1]

(ii) Ethane-1,2-diol can undergo condensation polymerisation but cannot undergo addition polymerisation.

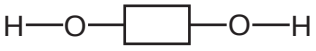
Explain why ethane-1,2-diol **cannot** undergo addition polymerisation.

.....

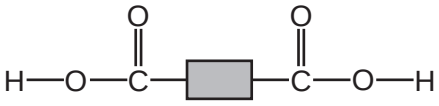
..... [1]

(iii) Ethane-1,2-diol undergoes condensation polymerisation with molecule **Y**.

The diagrams represent the structures of ethane-1,2-diol and molecule **Y**.



ethane-1,2-diol



molecule **Y**

Draw the condensation polymer formed between ethane-1,2-diol and molecule **Y**.
Show **one** repeat unit. Show all of the atoms and all of the bonds in the linkage.

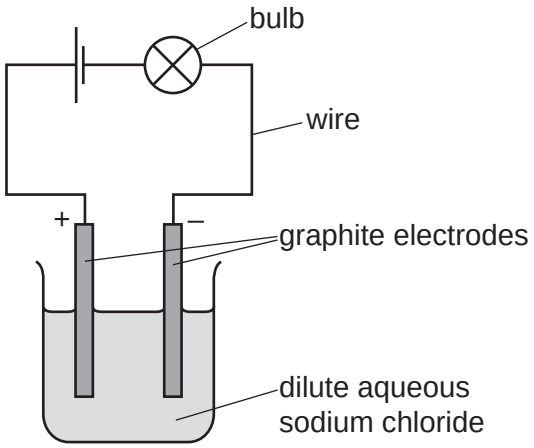
[3]

(iv) Name the type of condensation polymer formed between ethane-1,2-diol and molecule **Y**.

..... [1]

[Total: 30]

4 A student sets up the following electrolysis experiment.



(a) Define the term *electrolysis*.

.....

..... [2]

(b) The student observes bubbles of colourless gas forming at each electrode.

(i) Name the main gas produced at the positive electrode (anode).

..... [1]

(ii) Describe a test for the gas produced in **(b)(i)**.

test .....

result .....
[2]

(iii) Write the ionic half-equation for the reaction taking place at the negative electrode (cathode).

..... [2]

(c) Charge is transferred during electrolysis.

Name the type of particle responsible for the transfer of charge in

the wires, ...

the electrolyte. .....
[2]

(d) The student replaces the dilute aqueous sodium chloride with **concentrated** aqueous sodium chloride.

Suggest **two** differences that the student observes.

1 .....

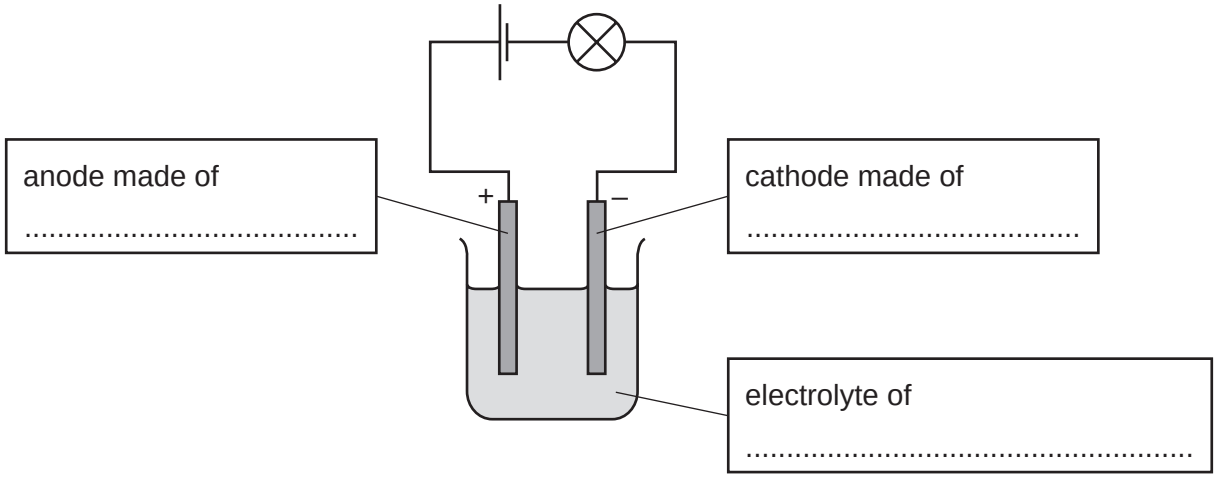
2 .....

[2]

(e) The student has a small piece of impure copper. The main impurities in the copper are small quantities of silver and zinc.

The student uses electrolysis to extract pure copper from the small piece of impure copper.

(i) Complete the labels on the diagram of the student's electrolysis experiment.



[3]

(ii) Use your knowledge of the reactivity series to suggest what happens to the silver and zinc impurities. Explain your answers.

silver impurities .....

.....

.....

zinc impurities .....

.....

.....

[3]

[Total: 17]

5 Some chemical reactions are reversible.

(a) Aqueous potassium chromate(VI), K_2CrO_4, is a yellow solution.

Aqueous potassium dichromate(VI), $K_2Cr_2O_7$, is an orange solution.

The two compounds interconvert when the pH of the solution changes.

$$\underset{\text{yellow}}{2K_2CrO_4} + H_2SO_4 \rightleftharpoons \underset{\text{orange}}{K_2Cr_2O_7} + K_2SO_4 + H_2O$$

Solution **Y** is a mixture of aqueous potassium chromate(VI) and aqueous potassium dichromate(VI) at equilibrium.

- Explain, in terms of the position of the equilibrium, what you would **see** if sulfuric acid were added to solution **Y**.

  .....

  .....

  .....

- Explain, in terms of the position of the equilibrium, what you would **see** if sodium hydroxide were added to solution **Y**.

  .....

  .....

  .....

  .....

[5]

(b) Hydrogen can be manufactured using a reversible reaction between methane and steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

At 900 °C, in the presence of a nickel catalyst, the yield of hydrogen is 70%.

(i) What volume of hydrogen is produced from 100 cm^3 of methane under these conditions?

..... cm^3 [2]

Under different conditions, different yields of hydrogen are obtained.

(ii) If the pressure is increased, the yield of hydrogen becomes less than 70%.

Explain why, in terms of the position of the equilibrium.

.....

..... [1]

(iii) If the temperature is decreased, the yield of hydrogen decreases.

What does this information indicate about the reaction between methane and steam?

..... [1]

(iv) Why is a catalyst used in this reaction?

..... [1]

[Total: 10]

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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.).