



**Cambridge Assessment International Education**  
Cambridge International General Certificate of Secondary Education (9–1)

CANDIDATE  
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**CHEMISTRY**

**0971/42**

Paper 4 Theory (Extended)

**October/November 2019**

**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 12.

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 **12** printed pages.

1 The Periodic Table is very useful to chemists.

Refer only to elements with atomic numbers 1 to 36 in the Periodic Table provided when answering **Question 1**.

(a) Use information from the Periodic Table provided to identify **one** element which:

- (i) has atoms with exactly 9 protons ..... [1]
- (ii) has atoms with 0 neutrons ..... [1]
- (iii) has atoms with exactly 23 electrons ..... [1]
- (iv) has atoms with an electronic structure of 2,8,6 ..... [1]
- (v) forms ions with a charge of 3<sup>-</sup> containing 18 electrons ..... [1]
- (vi) forms ions with a charge of 2<sup>+</sup> containing 10 electrons ..... [1]
- (vii) has a relative atomic mass that shows it has at least two isotopes. .... [1]

(b) State which metal in the first 36 elements:

- (i) is the Group I element which reacts most vigorously with water ..... [1]
- (ii) reacts with air to form lime. .... [1]

(c) One element in the first 36 elements is used as the fuel in a fuel cell.

(i) Name this element.

..... [1]

(ii) Write the overall chemical equation for the reaction which occurs when the element in (c)(i) reacts in a fuel cell.

..... [2]

[Total: 12]

2 The gases Ar, CO<sub>2</sub>, N<sub>2</sub> and O<sub>2</sub> are in clean, dry air.

CO, NO, NO<sub>2</sub> and SO<sub>2</sub> are gases commonly found in polluted air.

(a) What percentage of clean, dry air is N<sub>2</sub>?

Give your answer to the nearest whole number.

..... % [1]

(b) Name the process used to separate O<sub>2</sub> from clean, dry air.

..... [2]

(c) State **one** major adverse effect of the pollutant SO<sub>2</sub>.

..... [1]

(d) NO and NO<sub>2</sub> are produced in car engines.

Describe how oxides of nitrogen form in a car engine.

.....  
 .....  
 ..... [2]

(e) Many cars have catalytic converters in their exhaust systems. In a catalytic converter, most of the CO and NO formed in a car engine is changed into less harmful products.

Identify these products and state the metal catalyst used.

products .....

catalyst .....

[3]

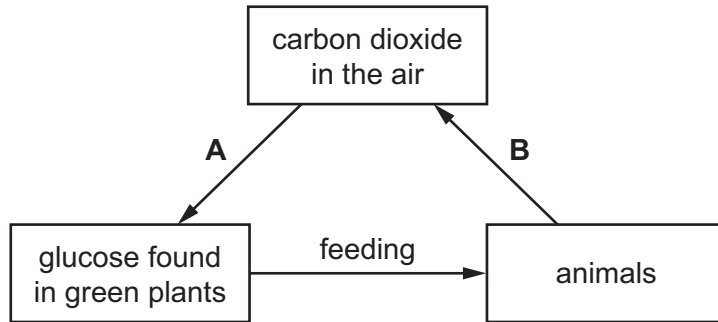
(f) CO is formed from the incomplete combustion of fossil fuels such as methane.

Write a chemical equation to show the incomplete combustion of methane.

..... [2]

(g) The CO<sub>2</sub> in air is part of the carbon cycle.

The scheme shows a simple representation of part of the carbon cycle.



(i) State the scientific terms for each of process **A** and process **B**.

**A** .....

**B** .....

[2]

(ii) Plants convert glucose into complex carbohydrates.

A unit of glucose can be represented as HO——OH.

Complete the diagram to show the complex carbohydrate formed from **three** units of glucose. Show all of the atoms and all of the bonds in the linkages.



[2]

(iii) Complex carbohydrates break down to form simple sugars.

State **two** ways that complex carbohydrates can be broken down into simple sugars.

1 .....

2 .....

[2]

(iv) Name a suitable technique for separating and identifying the individual sugars formed when complex carbohydrates are broken down.

..... [1]

[Total: 18]

3 Ammonia is an important chemical.

(a) Ammonia is manufactured by the Haber process. The reaction is reversible.

(i) What is the sign for a reversible reaction?

..... [1]

(ii) State the essential conditions for the manufacture of ammonia by the Haber process starting from hydrogen and nitrogen. Include a chemical equation to show the reaction which occurs.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [5]

(iii) Name **one** raw material which is a source of the hydrogen used in the Haber process.

..... [1]

(b) Ammonia is a base and reacts with sulfuric acid to form the salt, ammonium sulfate.

(i) What is meant by the term *base*?

..... [1]

(ii) Name the industrial process used to manufacture sulfuric acid.

..... [1]

(iii) Write a chemical equation for the reaction between ammonia and sulfuric acid.

..... [2]

(c) When aqueous ammonia is added to aqueous iron(II) sulfate a green precipitate is seen. This green precipitate turns red-brown at the surface.

(i) Name the green precipitate.

..... [1]

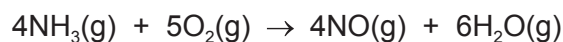
(ii) Suggest why the green precipitate turns red-brown at the surface.

.....  
..... [2]

(iii) State what happens when an excess of aqueous ammonia is added to the green precipitate.

..... [1]

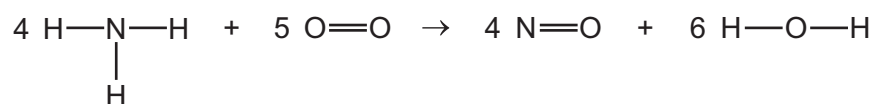
(d) Ammonia reacts with oxygen as shown.



- (i) Calculate the volume of oxygen at room temperature and pressure, in  $\text{dm}^3$ , that reacts with  $4.80 \text{ dm}^3$  of ammonia.

volume = .....  $\text{dm}^3$  [3]

- (ii) The chemical equation for the reaction can be represented as shown.



Use the bond energies in the table to calculate the energy change, in  $\text{kJ/mol}$ , which occurs when **one** mole of  $\text{NH}_3$  reacts.

bond	N–H	O=O	N=O	O–H
bond energy in $\text{kJ/mol}$	391	498	587	464

- Energy needed to break bonds.

.....  $\text{kJ}$

- Energy released when bonds are formed.

.....  $\text{kJ}$

- Energy change when **one** mole of  $\text{NH}_3$  reacts.

energy change = .....  $\text{kJ/mol}$   
[4]

[Total: 22]

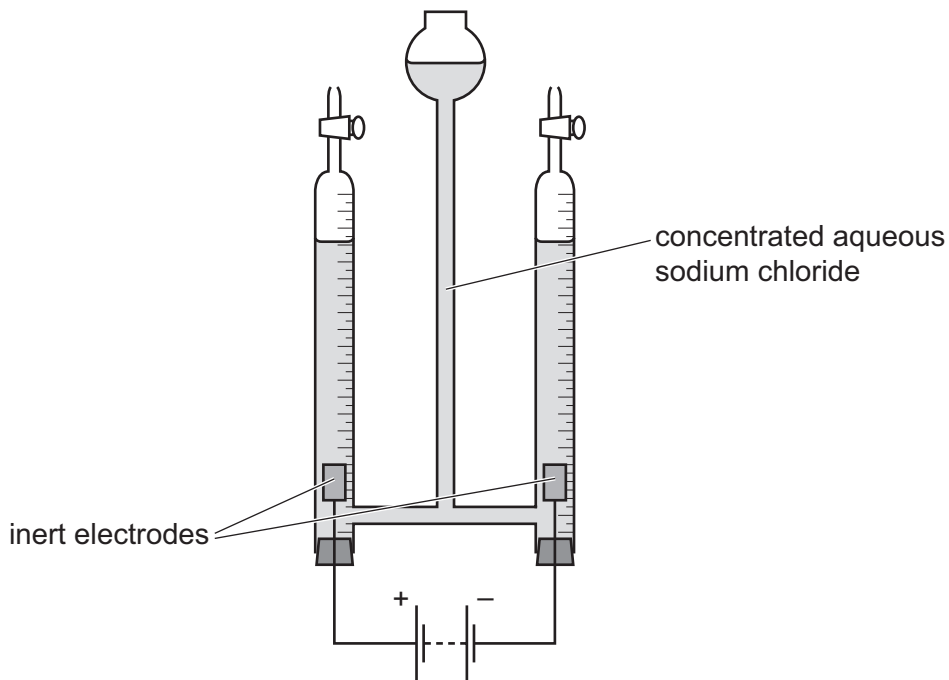
4 Many substances conduct electricity.

(a) Identify all the particles responsible for the passage of electricity in:

- graphite .....
- magnesium ribbon .....
- molten copper(II) bromide. ....

[4]

(b) A student used the following apparatus to electrolyse concentrated aqueous sodium chloride using inert electrodes.



(i) Suggest the name of a metal which could be used as the inert electrodes.

..... [1]

(ii) Name the gas formed at the positive electrode.

..... [1]

(iii) Write an ionic half-equation for the reaction occurring at the negative electrode. Include state symbols.

..... [3]

(iv) How, if at all, does the pH of the solution change during the electrolysis? Explain your answer.

.....

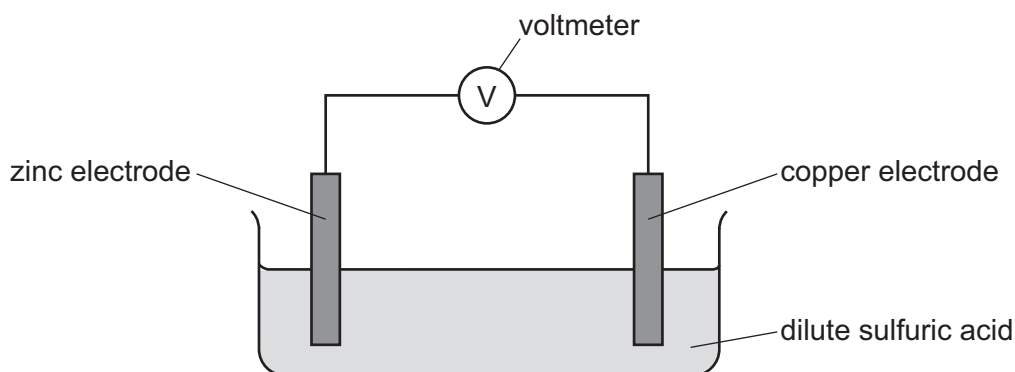
.....

..... [3]



(c) A student used the following electrochemical cell.

The reading on the voltmeter was +1.10 V.



- (i) Draw an arrow on the diagram to show the direction of electron flow. [1]
- (ii) Suggest the change, if any, in the voltmeter reading if the zinc electrode was replaced with an iron electrode. Explain your answer.

.....

..... [2]

- (iii) The zinc electrode was replaced with a silver electrode. The reading on the voltmeter was  $-0.46\text{ V}$ .

Suggest why the sign of the voltmeter reading became negative.

.....

..... [1]

[Total: 16]

5 Methanol,  $\text{CH}_3\text{OH}$ , is a member of the homologous series of alcohols.

(a) Methanol can be made from methane in a two-step process.

**step 1** Methane is reacted with chlorine gas to produce chloromethane,  $\text{CH}_3\text{Cl}$ .

**step 2**  $\text{CH}_3\text{Cl}$  is reacted with sodium hydroxide to produce  $\text{CH}_3\text{OH}$  and one other product.

(i) What conditions are needed in **step 1**?

..... [1]

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

..... [1]

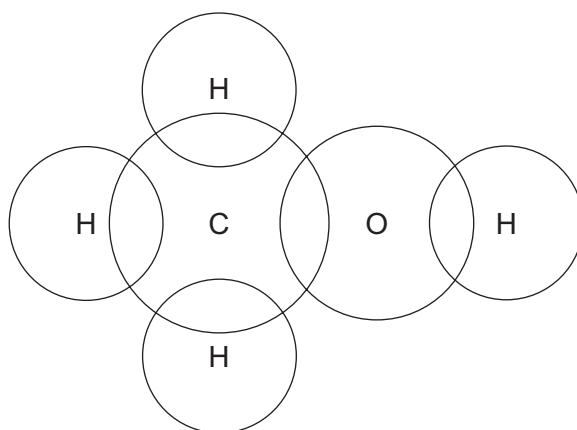
(iii) State the type of organic reaction occurring in **step 1**.

..... [1]

(iv) Complete the chemical equation for **step 2**.



(b) Draw a dot-and-cross diagram to show the electron arrangement in a molecule of methanol. Show outer shell electrons only.



[2]

(c) Methanol reacts with propanoic acid to form an ester with a molecular formula  $C_4H_8O_2$ .

(i) Name the ester formed when methanol reacts with propanoic acid.

..... [1]

(ii) Name **one** other substance formed when methanol reacts with propanoic acid.

..... [1]

(iii) Draw the structure of an ester which is a structural isomer of the ester named in (c)(i). Show all of the atoms and all of the bonds.

[3]

(iv) State the conditions needed to form an ester from a carboxylic acid and an alcohol.

..... [1]

[Total: 12]

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## The Periodic Table of Elements

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Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20	Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40	K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59	Cu copper 64	Zn zinc 65	Ga gallium 70	Ge germanium 73	As arsenic 75	Se selenium 79	Br bromine 80	Kr krypton 84	Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106	Ag silver 108	Cd cadmium 112	In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131	Cs caesium 133	Ba barium 137	La lanthanum 139	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Fr francium —	Ra radium —	Ac actinium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Fl flerovium —	Lv livermorium —	Uu ununoctium —	Og oganeson —																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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## Key

atomic number  
atomic symbol  
name  
relative atomic mass

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).