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

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3130393098

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– containing 18 electrons ..... [1]

(vi) forms ions with a charge of 2+ 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_2, N_2 and O_2 are in clean, dry air.

CO, NO, NO_2 and SO_2 are gases commonly found in polluted air.

(a) What percentage of clean, dry air is N_2?

Give your answer to the nearest whole number.

..... % [1]

(b) Name the process used to separate O_2 from clean, dry air.

..... [2]

(c) State **one** major adverse effect of the pollutant SO_2.

..... [1]

(d) NO and NO_2 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.

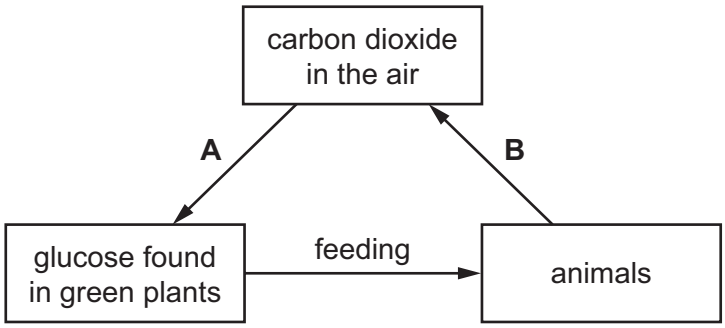
Write a chemical equation to show the incomplete combustion of methane.

..... [2]

[Turn over

(g) The CO_2 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]

[Turn over

(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]

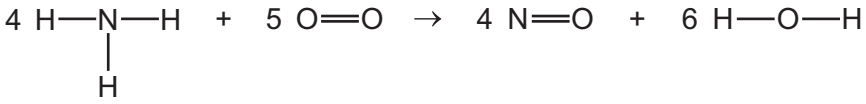
(d) Ammonia reacts with oxygen as shown.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

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

volume = ... 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 kJ / mol, which occurs when **one** mole of NH_3 reacts.

bond	N–H	O=O	N=O	O–H
bond energy in kJ / mol	391	498	587	464

- Energy needed to break bonds.

..... kJ

- Energy released when bonds are formed.

..... kJ

- Energy change when **one** mole of NH_3 reacts.

energy change = ... kJ / mol
[4]

[Total: 22]

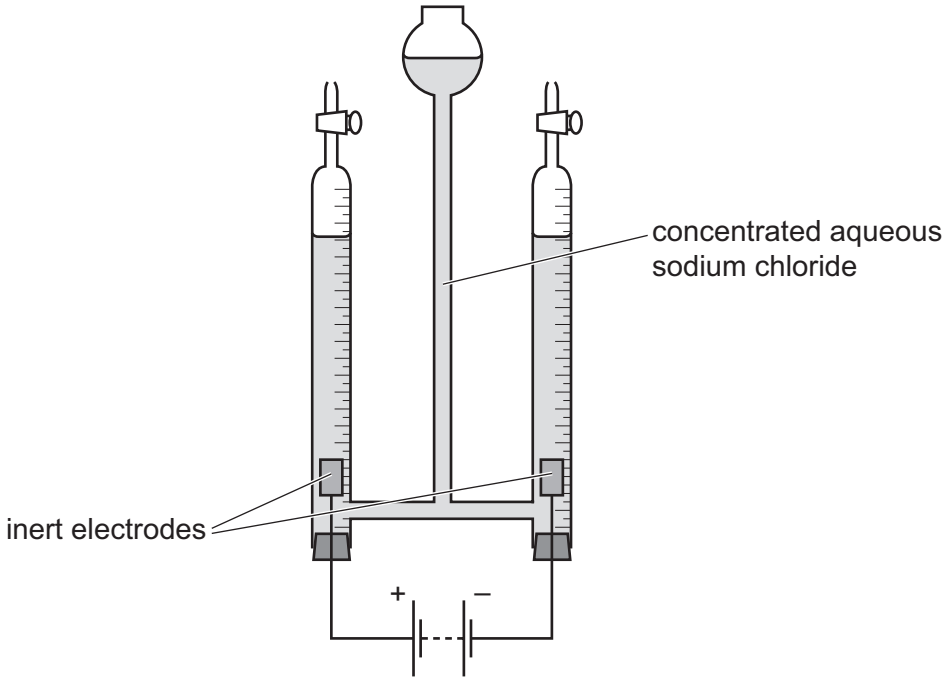
4 Many substances conduct electricity.

(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.

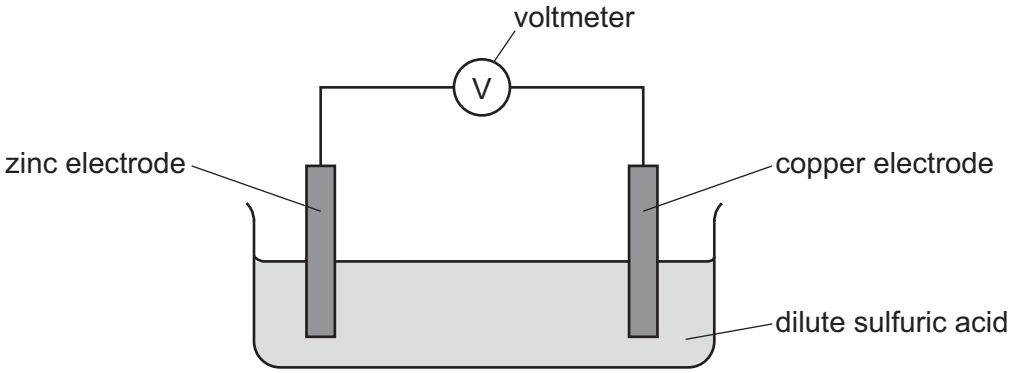
.....

.....

..... [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 V.

Suggest why the sign of the voltmeter reading became negative.

.....

..... [1]

[Total: 16]

5 Methanol, CH_3OH, 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, CH_3Cl.

step 2 CH_3Cl is reacted with sodium hydroxide to produce CH_3OH 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]

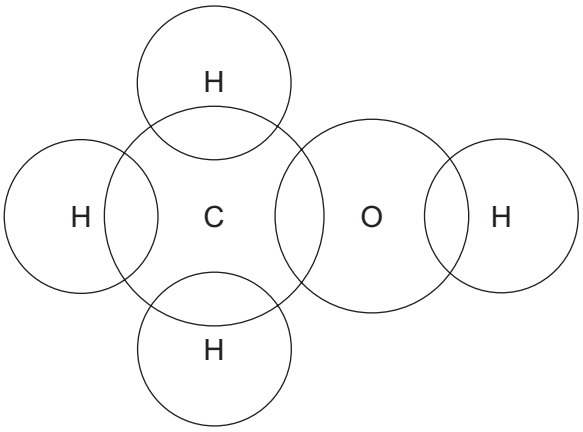
(iii) State the type of organic reaction occurring in **step 1**.

..... [1]

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

$$CH_3Cl + NaOH \rightarrow CH_3OH + ...$$ [1]

(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]

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.).