Cambridge Assessment International Education

Cambridge IGCSE™ (9 – 1)

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

* 8 9 2 1 4 6 7 8 4 3 *

CHEMISTRY **0971/42**

Paper 4 Theory (Extended) **May/June 2020**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION
- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Blank pages are indicated.

1 **(a)** Give the name of the process that:

(i) occurs when a gas turns into a liquid

.... [1]

(ii) occurs when a solid turns into a gas without first forming a liquid

.... [1]

(iii) is used to separate a mixture of liquids with different boiling points

.... [1]

(iv) is used to extract aluminium from aluminium oxide

.... [1]

(v) is used to separate a mixture of amino acids.

.... [1]

(b) The symbols of the elements in Period 2 of the Periodic Table are shown.

Li Be B C N O F Ne

For each of the following, give the symbol of an element from Period 2 which matches the description.

Each element may be used once, more than once or not at all.

Which element:

(i) combines with hydrogen to produce ammonia

.... [1]

(ii) makes up approximately 21% of clean, dry air

.... [1]

(iii) has atoms with only two electrons in the outer shell

.... [1]

(iv) has atoms with only seven protons

.... [1]

(v) is a monoatomic gas

.... [1]

(vi) is a soft metal stored in oil?

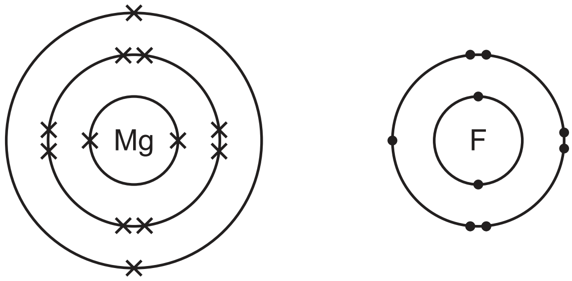
.... [1]

[Total: 11]

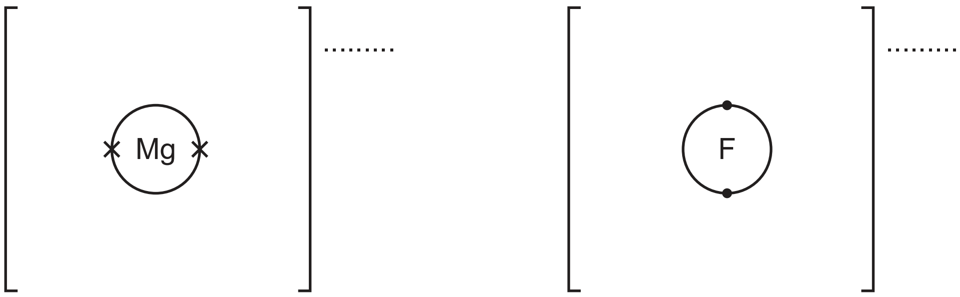
2 Fluorine forms both ionic and covalent compounds.

(a) Magnesium reacts with fluorine to form the ionic compound magnesium fluoride.

The electronic structures of an atom of magnesium and an atom of fluorine are shown.



(i) Complete the dot-and-cross diagrams to show the electronic structures of one magnesium ion and one fluoride ion. Show the charges on the ions.



[3]

(ii) What is the formula of magnesium fluoride?

.... [1]

(iii) Magnesium fluoride does **not** conduct electricity when it is solid.

What can be done to solid magnesium fluoride to make it conduct electricity?

In your answer explain why magnesium fluoride conducts electricity when this change is made.

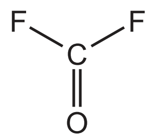
....

....

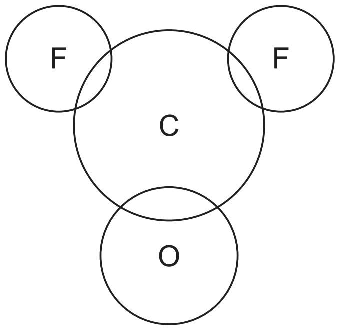
....

.... [2]

(b) Carbonyl fluoride, COF_2, is a covalent compound. The structure of a molecule of COF_2 is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of carbonyl fluoride. Show outer shell electrons only.



[3]

(c) The melting points of magnesium fluoride and carbonyl fluoride are shown.

	melting point / °C
magnesium fluoride	1263
carbonyl fluoride	–111

(i) Explain, using your knowledge of structure and bonding, why magnesium fluoride has a high melting point.

....

....

....

.... [2]

(ii) Explain, using your knowledge of structure and bonding, why carbonyl fluoride has a low melting point.

....

....

....

.... [2]

[Total: 13]

3 (a) Sulfuric acid is made from sulfur in a four-stage process.

stage 1 Sulfur is converted into sulfur dioxide.

stage 2 Sulfur dioxide is converted into sulfur trioxide.

stage 3 Sulfur trioxide is converted into oleum.

stage 4 Oleum is converted into sulfuric acid.

(i) How is sulfur converted into sulfur dioxide in **stage 1**?

.... [1]

(ii) Describe how sulfur dioxide is converted into sulfur trioxide in **stage 2**.

Your answer should include:

- an equation for the reaction
- the temperature used
- the name of the catalyst used.

....

....

....

.... [3]

(iii) The reaction in **stage 2** can reach equilibrium.

What is meant by the term *equilibrium*?

....

....

.... [2]

(b) Sulfur trioxide is converted into oleum, $H_2S_2O_7$, in **stage 3**.

What is sulfur trioxide reacted with to convert it into oleum?

.... [1]

(c) Oleum is converted into sulfuric acid in **stage 4**.

Write a chemical equation for the conversion of oleum, $H_2S_2O_7$, into sulfuric acid.

.... [2]

(d) When copper is reacted with hot concentrated sulfuric acid, sulfur dioxide gas is formed.

Balance the chemical equation for this reaction.

$$Cu + ...H_2SO_4 \rightarrow CuSO_4 + SO_2 + ...H_2O$$ [1]

(e) Sulfur dioxide is a reducing agent.

Give the colour change that occurs when excess sulfur dioxide is bubbled into acidified aqueous potassium manganate(VII).

starting colour of the solution ....

final colour of the solution ....
[1]

(f) When sulfuric acid reacts with ammonia the salt produced is ammonium sulfate.

Write the chemical equation for this reaction.

.... [2]

(g) Barium sulfate is an insoluble salt.

Barium sulfate can be made from aqueous ammonium sulfate using a precipitation reaction.

(i) Name a solution that can be added to aqueous ammonium sulfate to produce a precipitate of barium sulfate.

.... [1]

(ii) Write an ionic equation for this precipitation reaction. Include state symbols.

.... [2]

[Total: 16]

4 Oxygen is produced by the decomposition of hydrogen peroxide. Manganese(IV) oxide is the catalyst for this reaction.

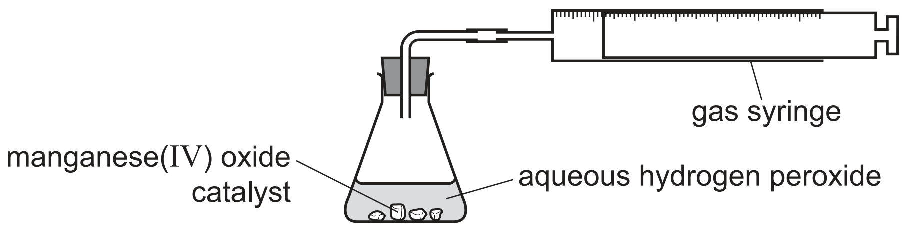
(a) What is meant by the term *catalyst*?

....

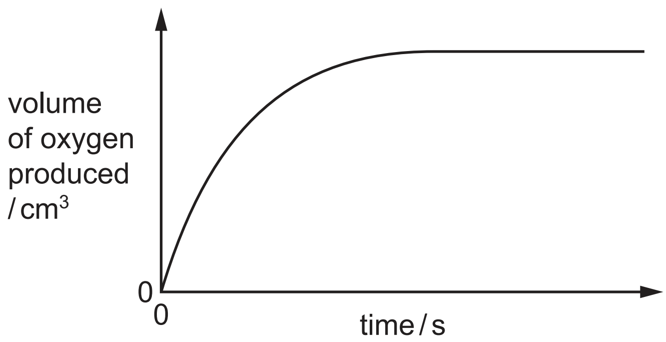
....

.... [2]

(b) A student measures the volume of oxygen produced at regular time intervals using the apparatus shown. Large lumps of manganese(IV) oxide are used.



A graph of the results is shown.



What happens to the **rate** of this reaction as time increases?
In your answer, explain why the rate changes in this way.

....

....

....

....

.... [4]

(c) The experiment is repeated using the same mass of manganese(IV) oxide. Powdered manganese(IV) oxide is used instead of large lumps. All other conditions stay the same.

Sketch a graph on the axes in **(b)** to show how the volume of oxygen changes with time. [2]

  [Turn over

(d) In terms of particles, explain what happens to the rate of this reaction when the temperature is increased.

....

....

....

....

.... [3]

(e) The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

25.0 cm^3 of aqueous hydrogen peroxide forms 48.0 cm^3 of oxygen at room temperature and pressure (r.t.p.).

Calculate the concentration of aqueous hydrogen peroxide at the start of the experiment using the following steps.

- Calculate the number of moles of oxygen formed.

.... mol

- Deduce the number of moles of hydrogen peroxide that decomposed.

.... mol

- Calculate the concentration of hydrogen peroxide in mol / dm^3.

.... mol / dm^3
[3]

(f) Oxygen can also be produced by the decomposition of potassium chlorate(V), $KClO_3$.

The only products of this decomposition are potassium chloride and oxygen.

Write a chemical equation for this decomposition.

.... [2]

[Total: 16]

5 Electrolysis of concentrated aqueous sodium chloride using inert electrodes forms chlorine, hydrogen and sodium hydroxide.

(a) What is meant by the term *electrolysis*?

....

....

.... [2]

(b) Name a substance that can be used as the inert electrodes.

.... [1]

(c) Write an ionic half-equation for the formation of hydrogen during this electrolysis.

.... [1]

(d) Give the formulae of the **four** ions present in concentrated aqueous sodium chloride.

.... [2]

(e) Explain how sodium hydroxide is formed during this electrolysis.

....

....

.... [2]

[Total: 8]

6 (a) Propane reacts with chlorine in a photochemical reaction as shown.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

(i) What type of reaction is this?

.... [1]

(ii) What condition is needed for this photochemical reaction to occur?

.... [1]

(iii) Draw **two** structural isomers of compounds with the formula C_3H_7Cl.
Show all of the atoms and all of the bonds.

[2]

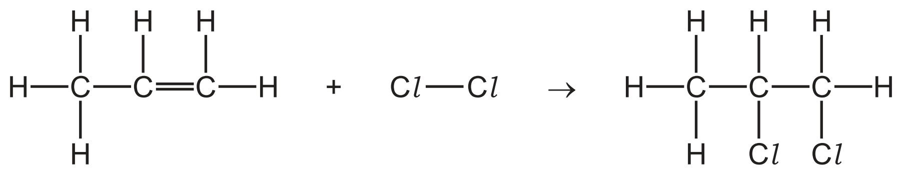
(b) Propene reacts with chlorine in an addition reaction as shown.

$$C_3H_6 + Cl_2 \rightarrow C_3H_6Cl_2$$

(i) State why this is an addition reaction.

.... [1]

(ii) The structures of the reactants and products of this reaction are shown.



Some bond energies are shown in the table.

bond	bond energy in kJ / mol
C–C	347
C=C	612
C–H	413
C–C*l*	339
C*l*–C*l*	242

Calculate the energy change for the reaction between propene and chlorine using the following steps.

- Calculate the energy needed to break the bonds.

.... kJ

- Calculate the energy released when bonds are formed.

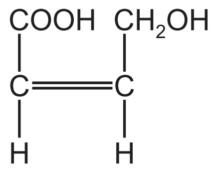
.... kJ

- Calculate the energy change for the reaction between propene and chlorine.

.... kJ / mol
[3]

(c) There are three functional groups in compound **A**.

compound **A**



(i) Name the homologous series of compounds that contains the following structures.

C=C ....

–OH ....

–COOH ....
[3]

(ii) What would you observe when compound **A** is added to:

aqueous bromine ....

aqueous sodium carbonate? ....
[2]

(d) Compound **A** can be used as a single monomer to produce two different polymers.

(i) Draw **one** repeat unit of the addition polymer formed from compound **A**.

[2]

(ii) What type of condensation polymer is formed from compound **A**?

.... [1]

[Total: 16]

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The Periodic Table of Elements

Key

atomic number atomic symbol name relative atomic mass

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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 –		

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.).