



# Cambridge IGCSE™

CANDIDATE  
NAME

CENTRE  
NUMBER

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## CHEMISTRY

0620/42

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?

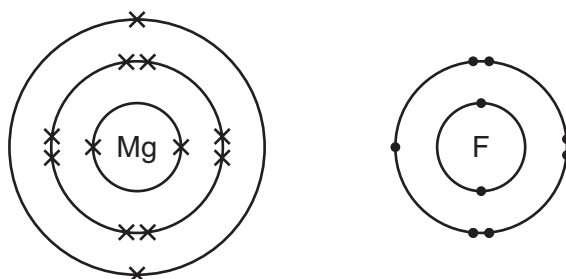
..... [1]

[Total: 11]

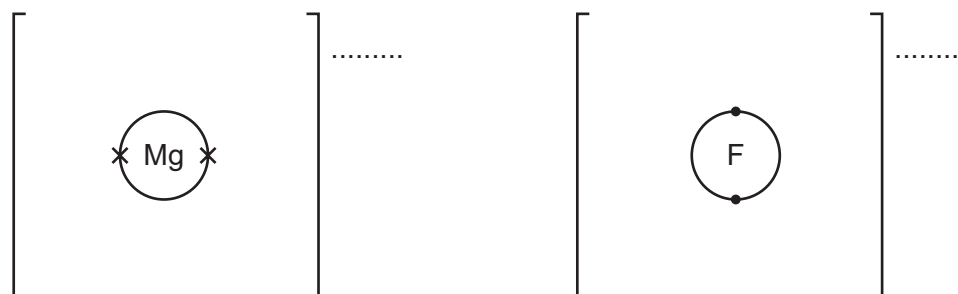
2 Fluorine forms both ionic and covalent compounds.

(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]

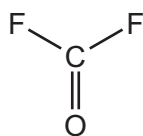
(iii) Magnesium fluoride does **not** conduct electricity when it is solid.

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

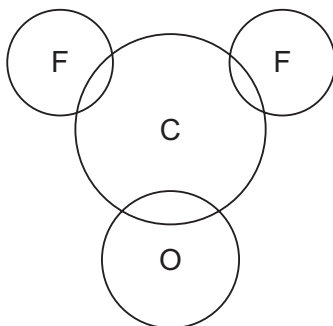
In your answer explain why magnesium fluoride conducts electricity when this change is made.

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

- (b) Carbonyl fluoride,  $\text{COF}_2$ , is a covalent compound. The structure of a molecule of  $\text{COF}_2$  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/ $^{\circ}\text{C}$ |
|--------------------|-----------------------------------|
| 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,  $\text{H}_2\text{S}_2\text{O}_7$ , in **stage 3**.

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

..... [1]

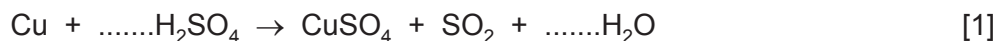
(c) Oleum is converted into sulfuric acid in **stage 4**.

Write a chemical equation for the conversion of oleum,  $\text{H}_2\text{S}_2\text{O}_7$ , 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.



- (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.

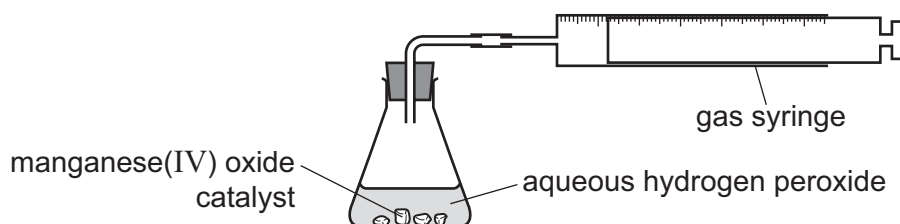
(a) What is meant by the term *catalyst*?

.....

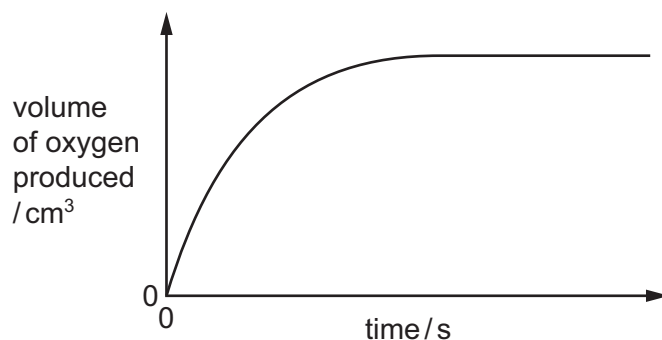
.....

..... [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]

- (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.



25.0 cm<sup>3</sup> of aqueous hydrogen peroxide forms 48.0 cm<sup>3</sup> 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<sup>3</sup>.

..... mol/dm<sup>3</sup>  
[3]

- (f) Oxygen can also be produced by the decomposition of potassium chlorate(V), KClO<sub>3</sub>.

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.

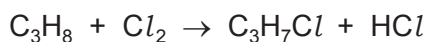
..... [2]

(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.



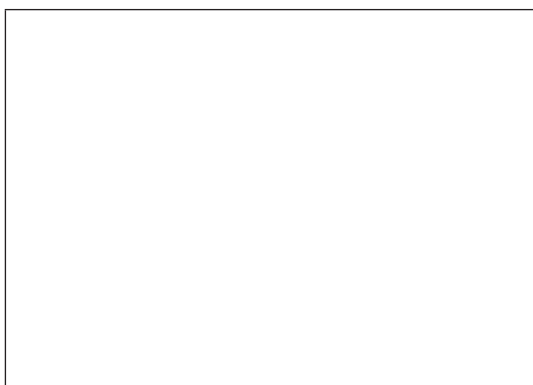
- (i) What type of reaction is this?

..... [1]

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

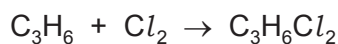
..... [1]

- (iii) Draw **two** structural isomers of compounds with the formula  $\text{C}_3\text{H}_7\text{Cl}$ .  
Show all of the atoms and all of the bonds.



[2]

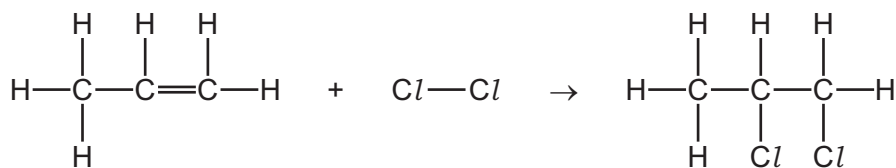
- (b) Propene reacts with chlorine in an addition reaction as shown.



- (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<br>in kJ/mol |
|-------|--------------------------|
| C–C   | 347                      |
| C=C   | 612                      |
| C–H   | 413                      |
| C–Cl  | 339                      |
| Cl–Cl | 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.

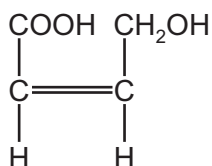
..... kJ

- 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

|  |                             | Group                      |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                               |                              |                               |                               |                              |                              |
|--|-----------------------------|----------------------------|---------------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|------------------------------|
| I  | II                          | III                        | IV                              | V                           | VI                           | VII                         | VIII                         |                              |                                |                               |                               |                             |                               |                              |                               |                               |                              |                              |
| 1<br>H<br>hydrogen<br>1  |                             |                            |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                               |                              |                               |                               |                              |                              |
| 2<br>He<br>helium<br>4   |                             |                            |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                               |                              |                               |                               |                              |                              |
| <b>Key</b>   |                             |                            |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                               |                              |                               |                               |                              |                              |
| atomic number<br>atomic symbol<br>name<br>relative atomic mass |                             |                            |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                               |                              |                               |                               |                              |                              |
| 3<br>Li<br>lithium<br>7  | 4<br>Be<br>beryllium<br>9   | 5<br>B<br>boron<br>11      | 6<br>C<br>carbon<br>12          | 7<br>N<br>nitrogen<br>14    | 8<br>O<br>oxygen<br>16       | 9<br>F<br>fluorine<br>19    | 10<br>Ne<br>neon<br>20       | 11<br>Na<br>sodium<br>23     | 12<br>Mg<br>magnesium<br>24    | 13<br>Al<br>aluminium<br>27   | 14<br>Si<br>silicon<br>28     | 15<br>P<br>phosphorus<br>31 | 16<br>S<br>sulfur<br>32       | 17<br>Cl<br>chlorine<br>35.5 | 18<br>Ar<br>argon<br>40       |                               |                              |                              |
| 19<br>K<br>potassium<br>39                                     | 20<br>Ca<br>calcium<br>40   | 21<br>Sc<br>scandium<br>45 | 22<br>Ti<br>titanium<br>48      | 23<br>V<br>vanadium<br>51   | 24<br>Cr<br>chromium<br>52   | 25<br>Mn<br>manganese<br>55 | 26<br>Fe<br>iron<br>56       | 27<br>Co<br>cobalt<br>59     | 28<br>Ni<br>nickel<br>59       | 29<br>Cu<br>copper<br>64      | 30<br>Zn<br>zinc<br>65        | 31<br>Ga<br>gallium<br>70   | 32<br>Ge<br>germanium<br>73   | 33<br>As<br>arsenic<br>75    | 34<br>Se<br>selenium<br>79    | 35<br>Br<br>bromine<br>80     | 36<br>Kr<br>krypton<br>84    |                              |
| 37<br>Rb<br>rubidium<br>85                                     | 38<br>Sr<br>strontium<br>88 | 39<br>Y<br>yttrium<br>89   | 40<br>Zr<br>zirconium<br>91     | 41<br>Nb<br>niobium<br>93   | 42<br>Mo<br>molybdenum<br>96 | 43<br>Tc<br>technetium<br>— | 44<br>Ru<br>ruthenium<br>101 | 45<br>Rh<br>rhodium<br>103   | 46<br>Pd<br>palladium<br>106   | 47<br>Ag<br>silver<br>108     | 48<br>Cd<br>cadmium<br>112    | 49<br>In<br>indium<br>115   | 50<br>Sn<br>tin<br>119        | 51<br>Sb<br>antimony<br>122  | 52<br>Te<br>tellurium<br>128  | 53<br>I<br>iodine<br>127      | 54<br>Xe<br>xenon<br>131     |                              |
| 55<br>Cs<br>caesium<br>133                                     | 56<br>Ba<br>barium<br>137   | 57-71<br>lanthanoids       | 72<br>Hf<br>hafnium<br>178      | 73<br>Ta<br>tantalum<br>181 | 74<br>W<br>tungsten<br>184   | 75<br>Re<br>rhenium<br>186  | 76<br>Os<br>osmium<br>190    | 77<br>Ir<br>iridium<br>192   | 78<br>Pt<br>platinum<br>195    | 79<br>Au<br>gold<br>197       | 80<br>Hg<br>mercury<br>201    | 81<br>Tl<br>thallium<br>204 | 82<br>Pb<br>lead<br>207       | 83<br>Bi<br>bismuth<br>209   | 84<br>Po<br>polonium<br>—     | 85<br>At<br>astatine<br>—     | 86<br>Rn<br>radon<br>—       |                              |
| 87<br>Fr<br>francium<br>—                                      | 88<br>Ra<br>radium<br>—     | 89-103<br>actinoids        | 104<br>Rf<br>rutherfordium<br>— | 105<br>Db<br>dubnium<br>—   | 106<br>Sg<br>seaborgium<br>— | 107<br>Bh<br>bohrium<br>—   | 108<br>Hs<br>hassium<br>—    | 109<br>Mt<br>meitnerium<br>— | 110<br>Ds<br>darmstadtium<br>— | 111<br>Rg<br>roentgenium<br>— | 112<br>Cn<br>copernicium<br>— | 114<br>Fl<br>flerovium<br>— | 116<br>Lv<br>livermorium<br>— | 118<br>Og<br>oganesson<br>—  | 119<br>Uue<br>unbinilium<br>— | 120<br>Uub<br>unbinilium<br>— | 121<br>Uut<br>ununilium<br>— | 122<br>Uuq<br>ununilium<br>— |

|             |                              |                            |                                 |                              |                             |                             |                             |                               |                            |                               |                              |                           |                               |                              |                              |
|-------------|------------------------------|----------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|------------------------------|---------------------------|-------------------------------|------------------------------|------------------------------|
| lanthanoids | 57<br>La<br>lanthanum<br>139 | 58<br>Ce<br>cerium<br>140  | 59<br>Pr<br>praseodymium<br>141 | 60<br>Nd<br>neodymium<br>144 | 61<br>Pm<br>promethium<br>— | 62<br>Sm<br>samarium<br>150 | 63<br>Eu<br>europium<br>152 | 64<br>Gd<br>gadolinium<br>157 | 65<br>Tb<br>terbium<br>159 | 66<br>Dy<br>dysprosium<br>163 | 67<br>Ho<br>holmium<br>165   | 68<br>Er<br>erbium<br>167 | 69<br>Tm<br>thulium<br>169    | 70<br>Yb<br>ytterbium<br>173 | 71<br>Lu<br>lutetium<br>175  |
| actinoids   | 89<br>Ac<br>actinium<br>—    | 90<br>Th<br>thorium<br>232 | 91<br>Pa<br>protactinium<br>231 | 92<br>U<br>uranium<br>238    | 93<br>Np<br>neptunium<br>—  | 94<br>Pu<br>plutonium<br>—  | 95<br>Am<br>americium<br>—  | 96<br>Cm<br>curium<br>—       | 97<br>Bk<br>berkelium<br>— | 98<br>Cf<br>californium<br>—  | 99<br>Es<br>einsteinium<br>— | 100<br>Fm<br>fermium<br>— | 101<br>Md<br>mendelevium<br>— | 102<br>No<br>nobelium<br>—   | 103<br>Lr<br>lawrencium<br>— |

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