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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?

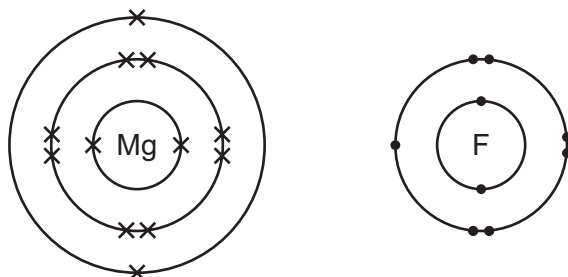
..... [1]

[Total: 11]

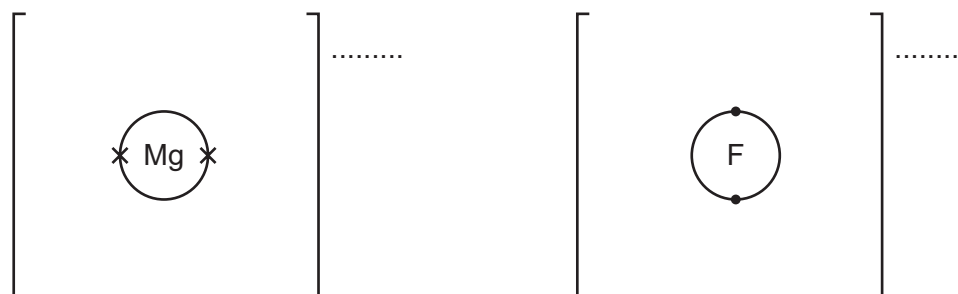
2 Fluorine forms both ionic and covalent compounds.

(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.

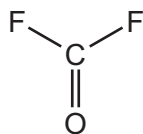
What can be done to solid magnesium fluoride to make it conduct electricity?

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

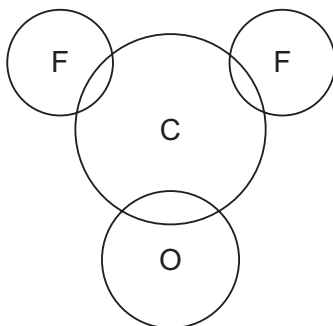
.....

 [2]

- (b) Carbonyl fluoride, 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/ $^{\circ}\text{C}$
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]

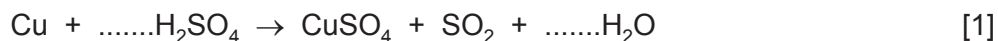
(c) Oleum is converted into sulfuric acid in **stage 4**.

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.

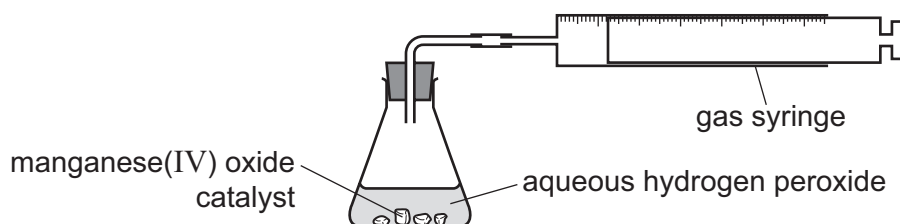
(a) What is meant by the term *catalyst*?

.....

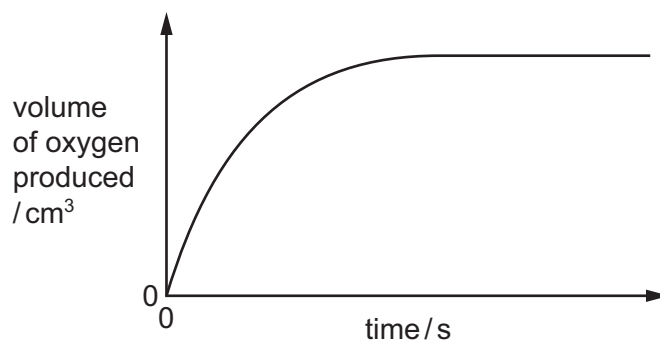
.....

..... [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 cm³ of aqueous hydrogen peroxide forms 48.0 cm³ 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/dm³.

..... mol/dm³
[3]

- (f) Oxygen can also be produced by the decomposition of potassium chlorate(V), KClO₃.

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.

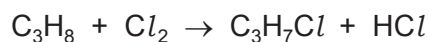
..... [2]

(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.



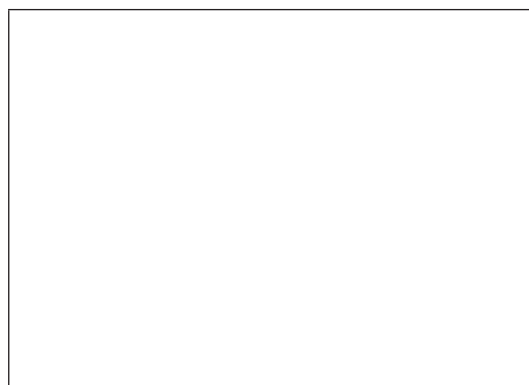
- (i) What type of reaction is this?

..... [1]

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

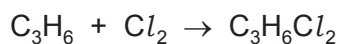
..... [1]

- (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]

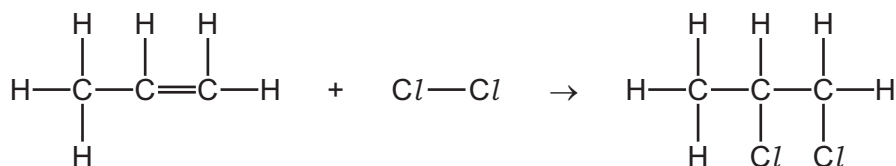
- (b) Propene reacts with chlorine in an addition reaction as shown.



- (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 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.

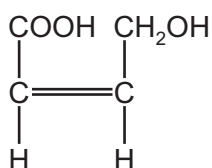
..... kJ

- 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	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20										
11	12	13	14	15	16	17	18										
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										
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
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
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
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
55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs caesium 133	Ba barium 137	lanthanoids	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 —
87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Fl flerovium —	Lv livermorium —	—	—	—	—

1
H
hydrogen
1

Key
atomic number
atomic symbol
name
relative atomic mass

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

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).