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CHEMISTRY

0620/43

Paper 4 Theory (Extended)

October/November 2021

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. Any blank pages are indicated.



1 A list of substances is shown.

ammonia
bauxite
carbon dioxide
carbon monoxide
ethanol
hematite
oxygen
sodium chloride
sulfur dioxide

Answer the questions using the list of substances.

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

State which substance is:

- (a) an element [1]
- (b) an ore of aluminium [1]
- (c) a gas that causes acid rain [1]
- (d) used as a fuel [1]
- (e) an ionic compound [1]
- (f) produced in the Haber process [1]
- (g) a product of respiration [1]
- (h) a toxic product of the incomplete combustion of hydrocarbons
 [1]
- (i) a gas produced in the test for nitrate ions. [1]

[Total: 9]

2 This question is about electrolysis.

(a) State the meaning of the term *electrolyte*.

.....
 [2]

(b) The table gives information about the electrolysis of two electrolytes. Carbon (graphite) electrodes are used in each experiment.

(i) Complete the table to show the observations and products of electrolysis.

electrolyte	positive electrode (anode)		negative electrode (cathode)	
	observations	name of product	observations	name of product
aqueous copper(II) sulfate	colourless bubbles			
concentrated aqueous sodium bromide			colourless bubbles	hydrogen

[5]

(ii) Hydrogen is produced at the negative electrode (cathode) during the electrolysis of concentrated aqueous sodium bromide.

Write the ionic half-equation for this reaction.

..... [2]

(iii) State **two** reasons why carbon (graphite) is suitable to use as an electrode.

1

2 [2]

(iv) Name the particle responsible for the conduction of electricity in the metal wires used in a circuit.

..... [1]

[Total: 12]

4

- 3 Lead is a metallic element in Group IV. One of the ores of lead is galena, which is an impure form of lead(II) sulfide, PbS.

Lead also occurs in the ore cerussite, which contains lead(II) carbonate, PbCO₃.

- (a) Calculate the relative formula mass, M_r , of PbCO₃.

$$M_r \text{ of PbCO}_3 = \dots\dots\dots [1]$$

- (b) The M_r of PbS is 239.

Calculate the percentage of lead by mass in PbS.

$$\text{percentage of lead by mass in PbS} = \dots\dots\dots [1]$$

- (c) The percentage of lead by mass in PbCO₃ is 77.5%.

Use this information and your answer to (b) to suggest whether it would be better to extract lead from PbCO₃ or PbS.

Give a reason for your answer.

.....
 [1]

- (d) When lead(II) carbonate is heated it decomposes into lead(II) oxide, PbO, and carbon dioxide.

Write a chemical equation for this reaction.

..... [1]

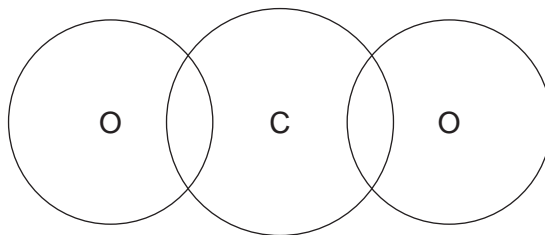
- (e) Lead(II) carbonate reacts with dilute nitric acid. One of the products is aqueous lead(II) nitrate, Pb(NO₃)₂.

Write a chemical equation for this reaction.

..... [2]

(f) Lead(II) oxide and carbon dioxide are oxides of Group IV elements.

- (i) Complete the diagram to show the electron arrangement in one molecule of CO_2 . Show only the outer electrons.



[2]

- (ii) The melting points of lead(II) oxide and carbon dioxide are shown.

	melting point/ $^{\circ}\text{C}$
lead(II) oxide	886
carbon dioxide	-56

Use your knowledge of structure and bonding to explain why lead(II) oxide has a much higher melting point than carbon dioxide.

Your answer should refer to:

- the types of particles involved
- the relative strength of the forces of attraction between the particles.

.....

.....

.....

..... [3]

(g) Part of the reactivity series is shown.

magnesium	most reactive
lead	↑
copper	least reactive

Aqueous lead(II) nitrate contains Pb^{2+} ions.

Two experiments are carried out.

In Experiment 1, magnesium is added to aqueous lead(II) nitrate.

In Experiment 2, copper is added to aqueous lead(II) nitrate.

Write an ionic equation for any reaction that occurs in each experiment. If no reaction occurs write 'no reaction'.

Experiment 1

Experiment 2

[2]

(h) When lead(II) nitrate is heated it decomposes to produce the same gaseous products as when copper(II) nitrate is heated.

(i) One of the gaseous products is oxygen.

Describe a test for oxygen.

test

observations

[2]

(ii) Name the other gaseous product.

..... [1]

[Total: 16]

4 Carbon is an important element.

(a) Carbon exists as the isotopes $^{12}_6\text{C}$ and $^{13}_6\text{C}$.

Complete the table.

isotope	number of protons in one atom	number of electrons in one atom	number of neutrons in one atom
$^{12}_6\text{C}$			
$^{13}_6\text{C}$			

[2]

(b) Name **two** forms of the element carbon which have giant covalent structures.

..... and [1]

(c) The Avogadro constant is the number of particles in 1 mole.

The numerical value of the Avogadro constant is 6.02×10^{23} .

(i) Calculate the number of molecules in 22.0 g of carbon dioxide, CO_2 .

..... molecules [2]

(ii) Calculate the number of molecules in 6.00 dm^3 of carbon dioxide gas at room temperature and pressure.

..... molecules [1]

[Total: 6]

- (c) Sodium hydrogensulfate, NaHSO_4 , dissolves in water to produce an aqueous solution, **X**, containing Na^+ , H^+ and SO_4^{2-} ions.

State the observations when the following tests are done.

- (i) A flame test is carried out on **X**.

..... [1]

- (ii) Copper(II) oxide is warmed with an excess of **X**.

.....

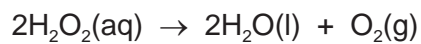
..... [2]

- (iii) Acidified aqueous barium nitrate is added to **X**.

..... [1]

[Total: 11]

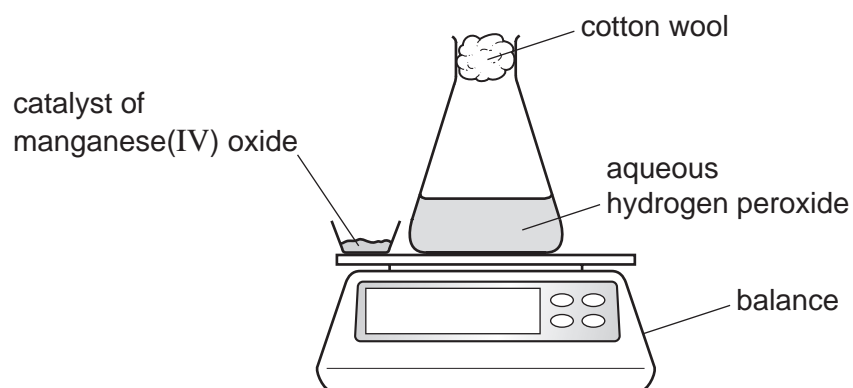
- 6 A student investigates the decomposition of hydrogen peroxide in the presence of a catalyst of manganese(IV) oxide.



- (a) State the meaning of the term *catalyst*.

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

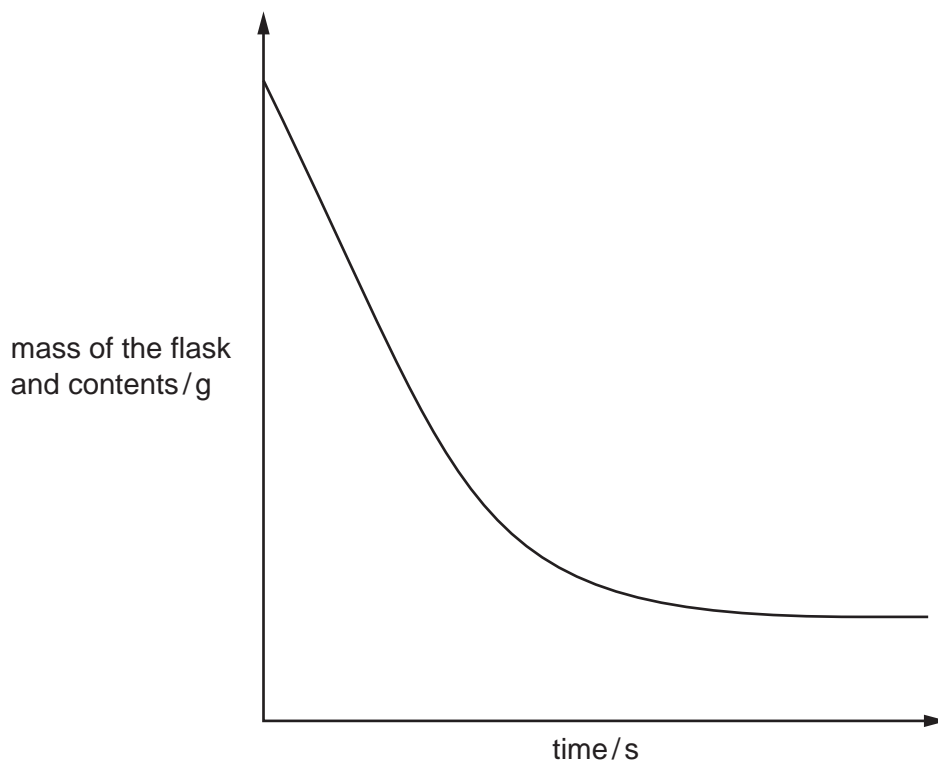
- (b) The diagram shows the equipment the student uses.



The student uses this method:

- the catalyst is added to the aqueous hydrogen peroxide
- the stop-clock is started
- the mass of the flask and contents is recorded at regular time intervals.

A graph of the mass of the flask and contents against time is shown.



- (i) Suggest why the mass of the flask and contents decreases as time increases.

..... [1]

- (ii) Describe what happens to the rate of the reaction as time increases.

.....
 [2]

- (c) The student repeats the experiment at a higher temperature. All other conditions stay the same. The rate of reaction increases.

- (i) Explain, in terms of collisions between particles, why the rate of reaction increases at a higher temperature.

.....

 [3]

- (ii) Draw a line on the graph in (b) for the experiment at a higher temperature. [2]

[Total: 10]

7 (a) Ethanol is a member of the homologous series of alcohols.

Give **two** characteristics of members of a homologous series.

1

2

[2]

(b) Ethanol can be manufactured from ethene.

Ethene can be made from long chain hydrocarbons such as decane, $C_{10}H_{22}$.

Ethene is then converted into ethanol.

(i) Name the process used to obtain ethene from long chain hydrocarbons such as decane, $C_{10}H_{22}$.

..... [1]

(ii) Complete the chemical equation to show the formation of ethene from decane, $C_{10}H_{22}$.



(iii) Write the chemical equation for the conversion of ethene into ethanol.

..... [1]

(iv) Name the type of reaction occurring when ethene is converted into ethanol.

..... [1]

(v) Give **one** condition for the reaction in which ethene is converted into ethanol.

..... [1]

(c) Ethanol can also be produced by fermentation of carbohydrates such as glucose.

Give **two** advantages of manufacturing ethanol by fermentation compared to manufacturing ethanol from ethene.

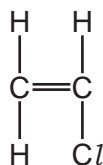
1

2

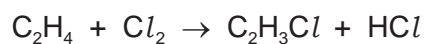
[2]

- (d) (i) Under certain conditions ethene can react with chlorine to produce chloroethene.

The structure of chloroethene is shown.



The equation for the chemical reaction is shown.



State the type of chemical reaction between ethene and chlorine that this equation shows.

..... [1]

- (ii) Chloroethene monomers can be converted into a polymer called poly(chloroethene).

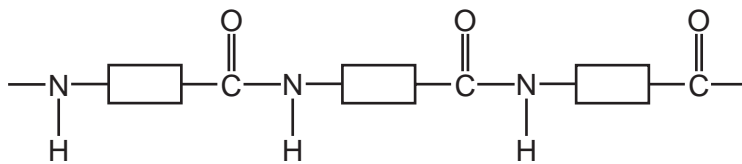
State the type of polymerisation that produces poly(chloroethene) from chloroethene.

..... [1]

- (iii) Draw a section of the poly(chloroethene) molecule made from **two** monomer molecules.

[2]

(e) The structure of part of a polymer is shown.



This polymer is made from one type of monomer only.

Complete the diagram to show the structure of the monomer used to produce this polymer. Show all of the atoms and all of the bonds in the functional groups.



[2]

[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	Al aluminium 13	Si silicon 14	P phosphorus 15	S sulfur 16	Cl chlorine 17	Ar argon 18	K potassium 19	Ca calcium 20	Sc scandium 21	Ti titanium 22	V vanadium 23	Cr chromium 24	Mn manganese 25	Fe iron 26	Co cobalt 27	Ni nickel 28	Cu copper 29	Zn zinc 30	Ga gallium 31	Ge germanium 32	As arsenic 33	Se selenium 34	Br bromine 35	Kr krypton 36										
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57-71 lanthanoids	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 90	Nb niobium 91	Mo molybdenum 92	Tc technetium 93	Ru ruthenium 94	Rh rhodium 95	Pd palladium 96	Ag silver 97	Cd cadmium 98	In indium 99	Sn tin 100	Sb antimony 101	Te tellurium 102	I iodine 103	Xe xenon 104	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 210	At astatine 210	Rn radon 222		
87	88	89-103 actinoids	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138
Fr francium —	Ra radium —	Ac actinium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Nh nihonium —	Fl flerovium —	Lv livermorium —	Ts tennessium —	Og oganeson —	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	

Group

1
H
hydrogen
1

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 dm³ at room temperature and pressure (r.t.p.).