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CHEMISTRY **0620/43**

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

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1 Give the name of the process that is used:

(a) to produce large molecules from monomers

View solution

..... [1]

(b) to separate oxygen from liquid air

View solution

..... [1]

(c) to make ethanol from glucose

View solution

..... [1]

(d) to separate water from aqueous sodium chloride

View solution

..... [1]

(e) to produce aluminium from aluminium oxide in molten cryolite

View solution

..... [1]

(f) to separate the products of hydrolysis of long chain carbohydrates

View solution

..... [1]

(g) to separate an aqueous solution from an undissolved solid.

..... [1]

[Total: 7]

View solution

2 Complete the table to:

- deduce the number of protons, electrons and neutrons in the boron atom and chloride ion shown
- identify the atom or ion represented by the final row.

View solution

formula	number of protons	number of electrons	number of neutrons
$^{11}_{5}B$		5	
$^{35}_{17}Cl^{-}$	17		
	24	21	30

[Total: 5]

3 Sodium reacts with fluorine to form sodium fluoride, NaF.

(a) Write a chemical equation for this reaction. View solution

..... [2]

(b) Sodium fluoride is an ionic compound. View solution

Complete the diagram to show the electron arrangement in the outer shells of the ions present in sodium fluoride.

Give the charges on both ions.



[3]

(c) Aqueous sodium fluoride undergoes electrolysis. View solution

(i) State what is meant by the term *electrolysis*.

.....

..... [2]

(ii) Name the products formed at the positive electrode (anode) and the negative electrode (cathode) when dilute aqueous sodium fluoride undergoes electrolysis.

anode .....

cathode .....

[2]

(d) Molten sodium fluoride undergoes electrolysis. View solution

(i) Name the products formed at the positive electrode (anode) and the negative electrode (cathode) when molten sodium fluoride undergoes electrolysis.

anode .....

cathode .....

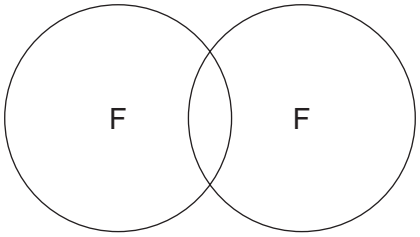
[2]

(ii) Write the ionic half-equation for the reaction at the negative electrode (cathode). View solution

..... [1]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of fluorine, F_2.
Show the outer electrons only.

View solution



[1]

(f) The melting points and boiling points of fluorine and sodium fluoride are shown.

View solution

	melting point / °C	boiling point / °C
fluorine	–220	–188
sodium fluoride	993	1695

(i) Deduce the physical state of fluorine at –195 °C. Use the data in the table to explain your answer.

physical state .....

explanation .....

.....

[2]

(ii) Explain, in terms of structure and bonding, why sodium fluoride has a much higher melting point than fluorine.

View solution

Your answer should refer to the:

- types of particle held together by the forces of attraction
- types of forces of attraction between particles
- relative strength of the forces of attraction.

.....

.....

.....

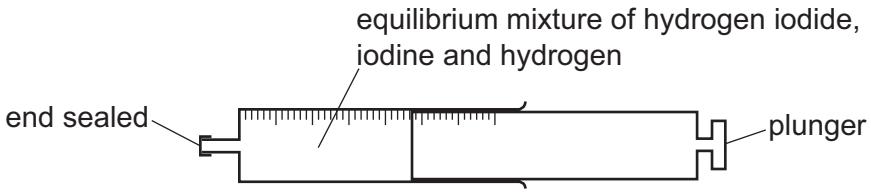
..... [3]

[Total: 18]

4 Hydrogen iodide, HI, decomposes into iodine and hydrogen. The reaction is reversible.

$$\underset{\text{colourless gas}}{2HI(g)} \rightleftharpoons \underset{\text{purple gas}}{I_2(g)} + \underset{\text{colourless gas}}{H_2(g)}$$

A gas syringe containing a mixture of hydrogen iodide, iodine and hydrogen gases was sealed. After reaching equilibrium the mixture was a pale purple colour.



(a) State what is meant by the term *equilibrium*.

View solution

.....

.....

..... [2]

(b) The plunger of the gas syringe is pushed in. The position of equilibrium does not change. The colour of the gaseous mixture turns darker purple.

View solution

The temperature remains constant.

$$\underset{\text{colourless gas}}{2HI(g)} \rightleftharpoons \underset{\text{purple gas}}{I_2(g)} + \underset{\text{colourless gas}}{H_2(g)}$$

(i) Explain why the position of equilibrium does **not** change.

..... [1]

(ii) Suggest why the colour of the gaseous mixture turns darker purple even though the position of equilibrium does not change.

..... [1]

(c) The forward reaction is endothermic.

View solution

(i) State what happens to the position of equilibrium when the temperature is decreased.

.....

..... [1]

(ii) State what happens to the rate of the forward reaction and the rate of the backward reaction when the temperature of the mixture is decreased.

rate of the forward reaction .....

rate of the backward reaction .....

[2]

[Total: 7]

View solution

5 This question is about salts.

(a) Salts that are soluble in water can be made by the reaction between insoluble carbonates and dilute acids. Zinc sulfate is soluble in water.

View solution

You are provided with solid zinc carbonate, $ZnCO_3$, and dilute sulfuric acid, H_2SO_4.

Describe how you would make a pure sample of zinc sulfate crystals.

Your answer should include:
- practical details
- how you would make sure that all the dilute sulfuric acid has reacted
- a chemical equation for the reaction.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(b) Some sulfates decompose when heated.

View solution

When hydrated iron(II) sulfate is heated strongly, sulfur dioxide gas is given off.

(i) Describe a test for sulfur dioxide.

test .....

observations .....
[2]

(ii) Complete the equation for the decomposition of hydrated iron(II) sulfate.

$$.....FeSO_4 \bullet 7H_2O \rightarrow Fe_2O_3 + SO_2 + SO_3 + ...H_2O$$ [2]

View solution

(c) Some chlorides are hydrated.

View solution

When hydrated barium chloride crystals, $BaCl_2 \cdot xH_2O$, are heated they give off water.

$$BaCl_2 \cdot xH_2O(s) \rightarrow BaCl_2(s) + xH_2O(g)$$

A student carries out an experiment to determine the value of ***x*** in $BaCl_2 \cdot xH_2O$.

step 1 Hydrated barium chloride crystals are weighed.

step 2 The hydrated barium chloride crystals are then heated.

step 3 The remaining solid is weighed.

(i) Describe how the student can be sure that all the water is given off.

.....

.....

..... [2]

(ii) In an experiment, 4.88 g of $BaCl_2 \cdot xH_2O$ is heated until all the water is given off. The mass of $BaCl_2$ remaining is 4.16 g.

View solution

[M_r: $BaCl_2$, 208; H_2O, 18]

Determine the value of ***x*** using the following steps.

- Calculate the number of moles of $BaCl_2$ remaining.

..... mol

- Calculate the mass of H_2O given off.

..... g

- Calculate the number of moles of H_2O given off.

..... mol

- Determine the value of ***x***.

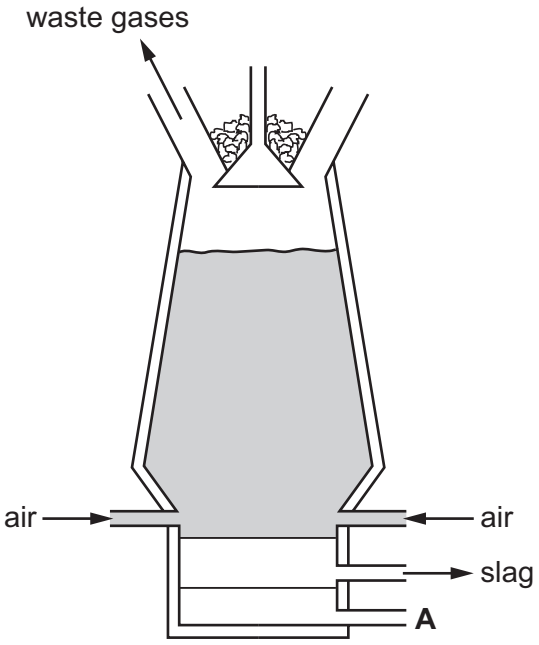
x = ...
[4]

[Total: 15]

6 This question is about metals.

(a) Iron is extracted from its main ore in a blast furnace.

View solution



(i) Coke and iron ore are added at the top of the blast furnace.

Name one **other** substance that is added at the top of the blast furnace.

..... [1]

(ii) Name the substance that leaves the blast furnace at **A**.

View solution

..... [1]

(iii) Iron ore is mainly iron(III) oxide, Fe_2O_3.

View solution

Name a substance that reduces iron(III) oxide to iron in the blast furnace.

..... [1]

(iv) Temperatures inside a blast furnace can reach 2000 °C.

View solution

Name **two** substances that react together, in the blast furnace, to produce this high temperature.

..... [1]

(v) Name **two** waste gases that leave the blast furnace.

View solution

1 .....

2 .....

[2]

(b) Zinc is extracted from zinc blende.

View solution

(i) Name the main zinc compound that is present in zinc blende.

..... [1]

View solution

(ii) When zinc is extracted, it is formed as a gas.

The gaseous zinc is then converted into molten zinc.

State the name of this physical change.

..... [1]

View solution

(c) Name the alloy that contains zinc and copper only.

..... [1]

View solution

(d) Copper has the following properties.

- It has a high melting point.
- It has a high density.
- It is a good conductor of electricity.
- It has variable oxidation states.
- It forms a basic oxide.
- It forms soluble salts.

(i) Give **two** properties from the list in which copper differs from Group I elements.

1 .....

2 .....

[2]

View solution

(ii) Give **two** properties from the list in which copper is similar to Group I elements.

1 .....

2 .....

[2]

[Total: 13]

7 Many organic compounds contain carbon, hydrogen and oxygen only.

(a) An organic compound **R** has the following composition by mass.

View solution

C, 69.77%; H, 11.63%; O, 18.60%

Calculate the empirical formula of compound **R**.

empirical formula = ... [2]

(b) Compound **S** has the empirical formula CH_2O and a relative molecular mass of 60.

View solution

Calculate the molecular formula of compound **S**.

molecular formula = ... [2]

(c) Compounds **T** and **V** have the same molecular formula, $C_3H_6O_2$.

View solution

- Compound **T** is an ester.
- Compound **V** contains a –COOH functional group.

(i) State the name given to compounds with the same molecular formula but different structures.

..... [1]

(ii) Name the homologous series that **V** is a member of.

..... [1]

View solution

(iii) Draw a structure of compound **T**. Show all of the atoms and all of the bonds.

View solution

Name compound **T**.

name .....

[3]

(iv) Draw the structure of compound **V**. Show all of the atoms and all of the bonds.

View solution

Name compound **V**.

name .....

[2]

(d) Ethanol can be produced from long chain alkanes such as decane, $C_{10}H_{22}$, in a two-step process.

View solution

$$\text{decane} \xrightarrow{\textbf{step 1}} \text{ethene} \xrightarrow{\textbf{step 2}} \text{ethanol}$$

For each of the two steps:

- name the type of chemical reaction that occurs
- write a chemical equation.

step 1: decane to ethene

type of reaction .....

chemical equation .....

step 2: ethene to ethanol

type of reaction .....

chemical equation .....

[4]

[Total: 15]

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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.).