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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.

1 Give the name of the process that is used:

(a) to produce large molecules from monomers

..... [1]

(b) to separate oxygen from liquid air

..... [1]

(c) to make ethanol from glucose

..... [1]

(d) to separate water from aqueous sodium chloride

..... [1]

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

..... [1]

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

..... [1]

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

..... [1]

[Total: 7]

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.

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

[Total: 5]

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

(a) Write a chemical equation for this reaction.

..... [2]

(b) Sodium fluoride is an ionic compound.

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.

(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.

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

anode

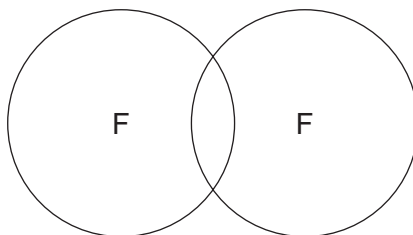
cathode

[2]

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

..... [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.



[1]

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

	melting point / $^{\circ}C$	boiling point / $^{\circ}C$
fluorine	-220	-188
sodium fluoride	993	1695

- (i) Deduce the physical state of fluorine at $-195^{\circ}C$. 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.

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.

.....

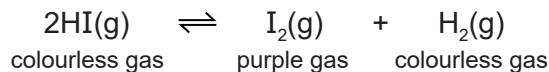
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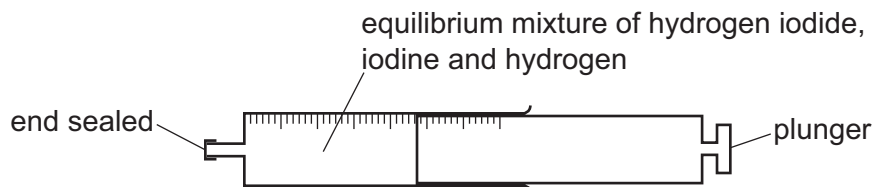
..... [3]

[Total: 18]

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



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.



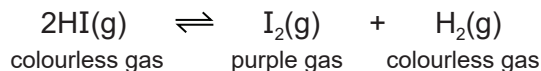
- (a) State what is meant by the term *equilibrium*.

.....

 [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.

The temperature remains constant.



- (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.

- (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]

(c) Some chlorides are hydrated.

When hydrated barium chloride crystals, $\text{BaCl}_2 \cdot x\text{H}_2\text{O}$, are heated they give off water.



A student carries out an experiment to determine the value of x in $\text{BaCl}_2 \cdot x\text{H}_2\text{O}$.

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 $\text{BaCl}_2 \cdot x\text{H}_2\text{O}$ is heated until all the water is given off. The mass of BaCl_2 remaining is 4.16 g.

[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

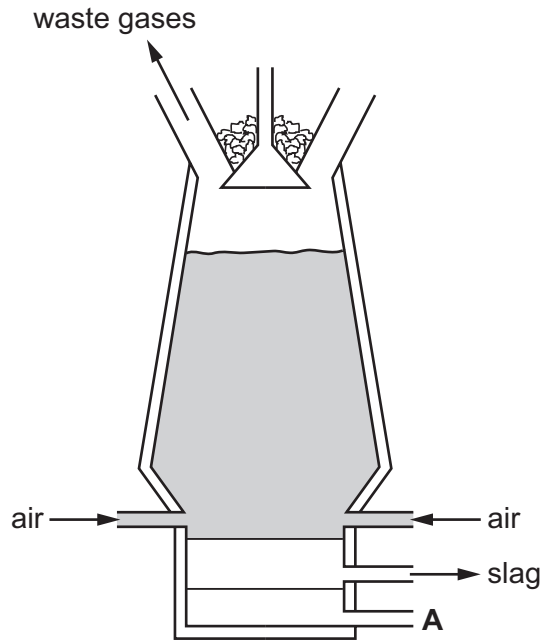
- Determine the value of x .

$x = \dots\dots\dots$
 [4]

[Total: 15]

6 This question is about metals.

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



(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**.

..... [1]

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

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 .

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.

1

2

[2]

(b) Zinc is extracted from zinc blende.

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

..... [1]

(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]

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

..... [1]

(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]

(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.

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.

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

molecular formula = [2]

(c) Compounds **T** and **V** have the same molecular formula, $\text{C}_3\text{H}_6\text{O}_2$.

- Compound **T** is an ester.
- Compound **V** contains a $-\text{COOH}$ 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]

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

Name compound **T**.

name [3]

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

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.



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	2	3	4	5	6	7	8	9	10
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
Key									
atomic number atomic symbol name relative atomic mass									
3	4	5	6	7	8	9	10	11	12
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20	Na sodium 23	Mg magnesium 24
11	12	13	14	15	16	17	18	19	20
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	K potassium 39	Ca calcium 40
19	20	21	22	23	24	25	26	27	28
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
37	38	39	40	41	42	43	44	45	46
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
55	56	57–71	72	73	74	75	76	77	78
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
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Fr francium —	Ra radium —	Ac actinium —	Th thorium 232
91	92	93	94	95	96	97	98	99	100
Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —
101	102	103	104	105	106	107	108	109	110
Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
111	112	113	114	115	116	117	118	119	120
Rg roentgenium —	Cn copernicium —	Nh nihonium —	Fl flerovium —	Lv livermorium —	Ts tennessine —	Og oganesson —	Uue unbinilium —	Uuh ununhexium —	Uuo ununoctium —

lanthanoids

actinoids

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 —

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