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CHEMISTRY

0620/43

Paper 4 Theory (Extended)

October/November 2022

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 Atoms and ions are made from small particles called electrons, neutrons and protons.

(a) Complete the table.

particle	relative charge	relative mass
electron	-1	$\frac{1}{1840}$
neutron		
proton		

[2]

(b) Information about atoms and ions, **A**, **B** and **C**, is shown in the table.

Complete the table.

atom or ion	number of electrons	number of neutrons	number of protons	symbol
A	18		20	${}_{20}^{42}\text{Ca}^{2+}$
B		18		${}_{17}^{35}\text{Cl}$
C	18	16	16	

[6]

[Total: 8]

- 2 The table shows the melting points, boiling points and electrical conductivities of six substances, **D**, **E**, **F**, **G**, **H** and **I**.

substance	melting point /°C	boiling point /°C	conducts electricity when solid	conducts electricity when liquid
D	1083	2567	yes	yes
E	-117	79	no	no
F	3550	4827	no	no
G	119	445	no	no
H	-210	-196	no	no
I	801	1413	no	yes

- (a) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which is:

(i) a liquid at 25°C [1]

(ii) a gas at 25°C [1]

(iii) a solid consisting of simple molecules at 25°C. [1]

- (b) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which is a metal. Give a reason for your choice.

substance

reason [2]

- (c) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which has a macromolecular structure. Give **two** reasons for your choice.

substance

reason 1

reason 2 [3]

- (d) Identify the substance, **D**, **E**, **F**, **G**, **H** or **I**, which is an ionic solid. Give a reason for your choice.

substance

reason

..... [2]

[Total: 10]

3 Aluminium is extracted from its ore by electrolysis.

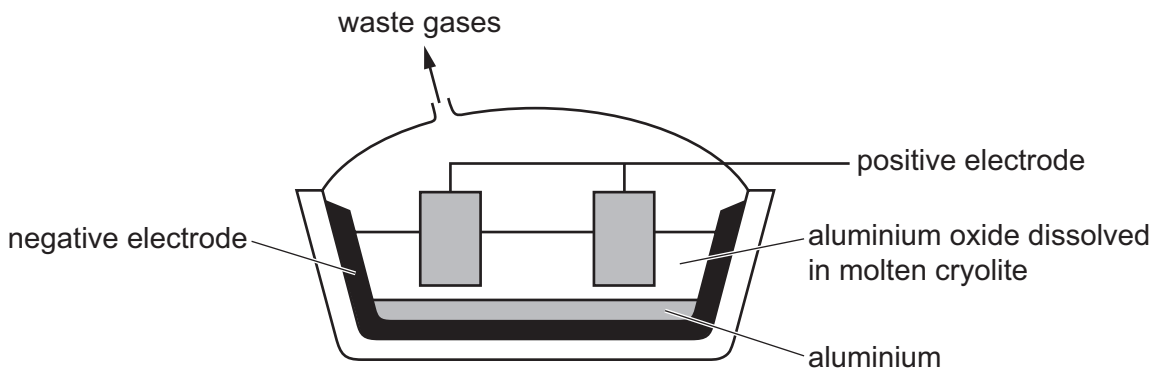
(a) Name the ore of aluminium which consists mainly of aluminium oxide.

..... [1]

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

.....
 [2]

(c) Electrolysis is carried out on aluminium oxide dissolved in molten cryolite.



(i) Give **two** reasons why the electrolysis is carried out on aluminium oxide dissolved in molten cryolite instead of electrolysis molten aluminium oxide only.

1

2 [2]

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

..... [2]

(iii) The positive electrodes are made of carbon.

Explain why the positive carbon electrodes are replaced regularly.

.....
 [2]

(d) Aluminium is more reactive than copper.

When aluminium is added to aqueous copper(II) sulfate, no immediate reaction is seen.

Explain why.

..... [1]

(e) Aluminium reacts with oxygen to form an amphoteric oxide.

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

.....
..... [1]

(ii) The reaction between aluminium oxide and aqueous sodium hydroxide forms a salt containing the negative ion AlO_2^- . The only other product is water.

Write a chemical equation for the reaction between aluminium oxide and aqueous sodium hydroxide.

..... [2]

(f) Gallium is in the same group as aluminium and forms similar compounds.

Predict the formulae of:

gallium(III) chloride

gallium(III) sulfate.

[2]

[Total: 15]

4 This question is about compounds of phosphorus.

- (a) Gaseous phosphorus(V) chloride decomposes into gaseous phosphorus(III) chloride and gaseous chlorine.

When the three gases are present in a closed container the system reaches equilibrium.



- (i) Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the forward reaction	effect on the equilibrium yield ($\text{PCl}_3(\text{g})$ and $\text{Cl}_2(\text{g})$)
increasing the temperature		increases
decreasing the pressure		
adding a catalyst		no change

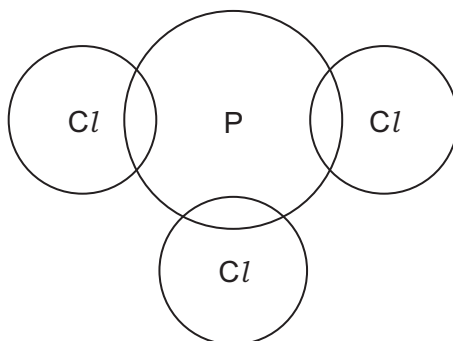
[4]

- (ii) The table shows that when the temperature increases, the equilibrium yields of $\text{PCl}_3(\text{g})$ and $\text{Cl}_2(\text{g})$ increase.

State what conclusion can be made from this.

..... [1]

- (b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphorus(III) chloride, PCl_3 . Show outer shell electrons only.



[2]

(c) Phosphorus oxychloride has the formula POCl_3 .

Phosphorus oxychloride is the only product of the reaction between phosphorus(V) chloride, PCl_5 , and phosphorus(V) oxide, P_4O_{10} .

Write a chemical equation for the reaction between phosphorus(V) chloride and phosphorus(V) oxide.

..... [2]

(d) Compound **X** has the following composition by mass.

H, 3.66%; P, 37.80%; O, 58.54%

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

empirical formula = [2]

(e) Compound **Y** has the empirical formula H_3PO_4 and a relative molecular mass of 98.

Deduce the molecular formula of compound **Y**.

molecular formula = [1]

[Total: 12]

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5 This question is about sulfuric acid, H_2SO_4 , and salts that can be made from sulfuric acid.

(a) Sulfuric acid is manufactured by the Contact process.

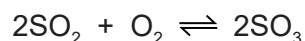
stage 1 Molten sulfur burns in air to produce sulfur dioxide.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide, SO_3 .

stage 3 Sulfur trioxide reacts with concentrated sulfuric acid to form oleum, $\text{H}_2\text{S}_2\text{O}_7$.

stage 4 Oleum is converted into sulfuric acid.

(i) The equation for the reaction in **stage 2** is shown.



State the temperature and pressure used in **stage 2**.

Name the catalyst used in **stage 2**.

temperature °C

pressure atm

catalyst [3]

(ii) Write the chemical equation for the reaction in **stage 3**.

..... [1]

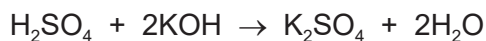
(iii) Name the substance that reacts with oleum in **stage 4**.

..... [1]

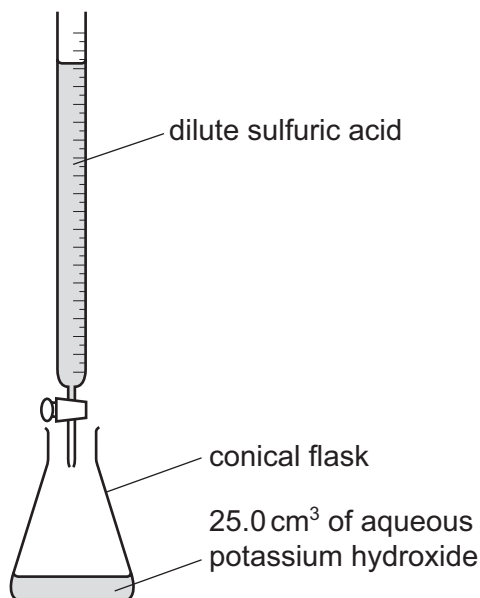
(b) Name the black solid that is produced when concentrated sulfuric acid is added to sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$.

..... [1]

- (c) Dilute sulfuric acid and aqueous potassium hydroxide are used to make aqueous potassium sulfate.



The method includes use of the following apparatus.



- (i) Calculate the volume of 0.0625 mol/dm³ dilute sulfuric acid, H₂SO₄, that completely reacts with 25.0 cm³ of 0.100 mol/dm³ potassium hydroxide, KOH, to produce aqueous potassium sulfate.

Use the following steps.

- Calculate the number of moles of KOH in 25.0 cm³ of 0.100 mol/dm³ KOH.

= mol

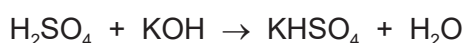
- Deduce the number of moles of H₂SO₄ that react with KOH.

= mol

- Calculate the volume of H_2SO_4 required.

volume = cm^3
[3]

- (ii) The experiment is repeated using the same volume and concentration of potassium hydroxide and the same concentration of dilute sulfuric acid. In this second experiment, the product is aqueous potassium hydrogensulfate, KHSO_4 .



Use your answer to (c)(i) and the equation to deduce the volume of H_2SO_4 required.

volume = cm^3 [1]

- (d) Aqueous potassium hydrogensulfate, $\text{KHSO}_4(\text{aq})$, contains the ions $\text{K}^+(\text{aq})$, $\text{H}^+(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$.

Describe the observations in the following tests.

- (i) A flame test is carried out on aqueous potassium hydrogensulfate.

..... [1]

- (ii) Solid copper(II) carbonate is added to aqueous potassium hydrogensulfate.

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

- (iii) An acidic solution containing aqueous barium ions, $\text{Ba}^{2+}(\text{aq})$, is added to aqueous potassium hydrogensulfate.

..... [1]

- (e) Write the ionic equation for the reaction in (d)(iii).

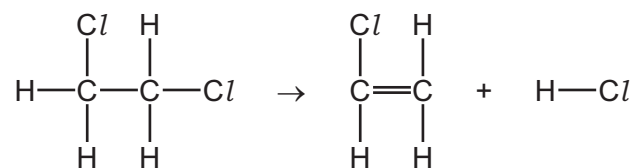
Include state symbols.

..... [3]

[Total: 17]

- 6 (a) Chloroethene ($\text{CH}_2=\text{CHCl}$) can be manufactured from 1,2-dichloroethane ($\text{CH}_2\text{ClCH}_2\text{Cl}$).

The equation can be represented as shown.



- (i) Some bond energies are given.

bond	bond energy in kJ/mol
C–C	350
C=C	610
C–Cl	340
C–H	410
H–Cl	430

Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

Use the following steps.

- Calculate the energy needed to break bonds.

energy = kJ

- Calculate the energy released when bonds form.

energy = kJ

- Calculate the energy change of the reaction.

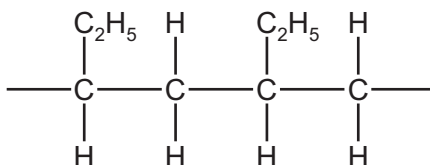
energy change of the reaction = kJ/mol
[3]

- (ii) Deduce whether the energy change for this reaction is exothermic or endothermic.

Give a reason for your answer.

.....
..... [1]

- (b) Part of a synthetic polymer is shown.



- (i) State the number of monomer units that are needed to make the part of the polymer shown.

..... [1]

- (ii) Name and draw the structure of the monomer used to make this polymer. Show all of the atoms and all of the bonds.

name

structure

[3]

- (iii) State the empirical formula of the polymer.

..... [1]

(c) Proteins are natural polymers.

Proteins are broken down into amino acids. The process is similar to how complex carbohydrates are broken down to give simple sugars.

(i) Name the type of reaction in which proteins are broken down into amino acids.

..... [1]

(ii) Name **two** types of substance that are used to break down proteins into amino acids.

1

2

[2]

(iii) Amino acids are colourless.

A sample containing a mixture of amino acids is separated. Each amino acid is detected and identified.

- Name the process used to separate the amino acids.

.....

- Name the type of substance used to detect the amino acids.

.....

- Give the symbol of the value used to determine the identity of each amino acid after separation and detection.

.....

[3]

(d) Proteins are natural polymers. Proteins contain amide linkages.

Synthetic polyamides also contain amide linkages.

(i) Name a synthetic polyamide.

..... [1]

(ii) Identify the **two** functional groups present in the monomers used to produce synthetic polyamides.

1

2

[2]

[Total: 18]

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The Periodic Table of Elements

		Group								
I	II	III	IV	V	VI	VII	VIII			
		1 H hydrogen 1								
3 Li lithium 7	4 Be beryllium 9	Key atomic number atomic symbol name relative atomic mass						9 F fluorine 19	10 Ne neon 20	
11 Na sodium 23	12 Mg magnesium 24	5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	17 Cl chlorine 35.5	18 Ar argon 40			
19 K potassium 39	20 Ca calcium 40	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	35 Br bromine 80	36 Kr krypton 84			
37 Rb rubidium 85	38 Sr strontium 88	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	52 Te tellurium 128	54 Xe xenon 131			
55 Cs caesium 133	56 Ba barium 137	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	83 Bi bismuth 209	84 Po polonium —	85 At astatine —	86 Rn radon —	
87 Fr francium —	88 Ra radium —	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	116 Lv livermorium —				
		29 Cu copper 64	28 Ni nickel 59	27 Co cobalt 59	26 Fe iron 56	25 Mn manganese 55	24 Cr chromium 52	23 V vanadium 51	22 Ti titanium 48	
		47 Ag silver 108	46 Pd palladium 106	45 Rh rhodium 103	44 Ru ruthenium 101	43 Tc technetium —	42 Mo molybdenum 96	41 Nb niobium 93	40 Zr zirconium 91	
		79 Au gold 197	78 Pt platinum 195	77 Ir iridium 192	76 Os osmium 190	75 Re rhenium 186	74 W tungsten 184	73 Ta tantalum 181	72 Hf hafnium 178	
		111 Rg roentgenium —	110 Ds darmstadtium —	109 Mt meitnerium —	108 Hs hassium —	107 Bh bohrium —	106 Sg seaborgium —	105 Db dubnium —	104 Rf rutherfordium —	
		66 Dy dysprosium 163	65 Tb terbium 159	64 Gd gadolinium 157	63 Eu europium 152	62 Sm samarium 150	61 Pm promethium —	60 Nd neodymium 144	59 Pr praseodymium 141	
		98 Cf californium —	97 Bk berkelium —	96 Cm curium —	95 Am americium —	94 Pu plutonium —	93 Np neptunium —	92 U uranium 238	91 Pa protactinium 231	
		100 Fm fermium —	100 Es einsteinium —	99 Es einsteinium —	99 Es einsteinium —	94 Pu plutonium —	93 Np neptunium —	92 U uranium 238	91 Pa protactinium 231	
		68 Er erbium 167	67 Ho holmium 165	66 Dy dysprosium 163	65 Tb terbium 159	64 Gd gadolinium 157	63 Eu europium 152	62 Sm samarium 150	61 Pm promethium —	
		70 Yb ytterbium 173	69 Tm thulium 169	68 Er erbium 167	67 Ho holmium 165	66 Dy dysprosium 163	65 Tb terbium 159	64 Gd gadolinium 157	63 Eu europium 152	
		103 Lr lawrencium —	101 Md mendelevium —	100 No nobelium —	99 Es einsteinium —	98 Cf californium —	97 Bk berkelium —	96 Cm curium —	95 Am americium —	
		71 Lu lutetium 175	69 Tm thulium 169	68 Er erbium 167	67 Ho holmium 165	66 Dy dysprosium 163	65 Tb terbium 159	64 Gd gadolinium 157	63 Eu europium 152	

lanthanoids

actinoids

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