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CHEMISTRY**0620/43**

Paper 4 Theory (Extended)

October/November 2023**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.

2

1 A list of substances is shown.

barium nitrate
carbon monoxide
hydrated cobalt(II) chloride
copper(II) oxide
anhydrous copper(II) sulfate
ethane
potassium iodide
propene
sodium bromide
sulfur dioxide
zinc oxide

Answer the following questions using only the substances from the list.
Each substance may be used once, more than once or not at all.

Give the name of the substance that:

(a) gives a lilac colour in a flame test

..... [1]

(b) forms a cream precipitate when its aqueous solution reacts with acidified aqueous silver nitrate

..... [1]

(c) is an acidic oxide

..... [1]

(d) is an unsaturated hydrocarbon

..... [1]

(e) is a product of incomplete combustion of fossil fuels

..... [1]

(f) is used to test for the presence of water.

..... [1]

[Total: 6]

3

2 Table 2.1 gives information about particles **A**, **B**, **C**, **D**, **E** and **F**.

Table 2.1

particle	number of electrons	number of neutrons	number of protons
A	5	6	5
B	10	11	10
C	10	14	13
D	18	17	16
E	18	17	17
F	15	16	15

(a) Give the letters of **all** the particles which are:

(i) atoms

..... [1]

(ii) ions with a charge of 2–

..... [1]

(iii) cations.

..... [1]

(b) State the atomic number of **A**.

..... [1]

(c) Determine the number of nucleons in **D**.

..... [1]

(d) State the electronic configuration of **D**.

..... [1]

(e) State the group number of **F**.

..... [1]

(f) State the period number of **B**.

..... [1]

[Total: 8]

4

3 This question is about nitrogen and some of its compounds.

(a) Nitrogen is converted into ammonia, NH_3 , in the Haber process.

(i) Nitrogen is obtained from air.

State the percentage of nitrogen in clean, dry air.

..... [1]

(ii) State the source of hydrogen for the Haber process.

..... [1]

(iii) Complete the dot-and-cross diagram in Fig. 3.1 for a molecule of ammonia.

Show the outer shell electrons only.

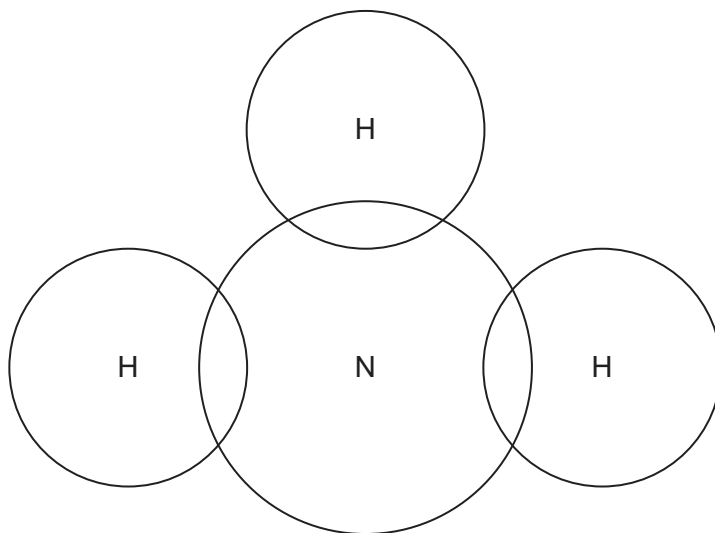


Fig. 3.1

[2]

(iv) Write a chemical equation for the reaction occurring in the Haber process and give the typical reaction conditions. Include units where appropriate.

chemical equation

reaction conditions:

temperature

pressure

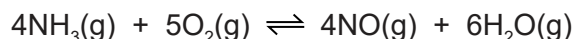
catalyst

[5]

5

(b) Ammonia is converted into nitric acid.

The first stage of this conversion uses a catalyst and occurs at a temperature of 900 °C and a pressure of 5 atmospheres.



The forward reaction is exothermic.

(i) Suggest which of the following elements is most likely to be used as a catalyst.
Draw a circle around your answer.

calcium lead platinum sodium sulfur [1]

(ii) State the oxidation number of nitrogen in:

NH₃

NO [2]

(iii) Use your answer to (ii) to explain whether the nitrogen in ammonia undergoes oxidation or reduction.

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

(iv) Complete Table 3.1 using the words **increases**, **decreases** or **no change**.

Table 3.1

	effect on the equilibrium yield of NO(g)	effect on the rate of the forward reaction
decreasing the pressure		
decreasing the temperature		decreases
removing the catalyst		decreases

[4]

(v) Decreasing the temperature causes the rate of the forward reaction to decrease.

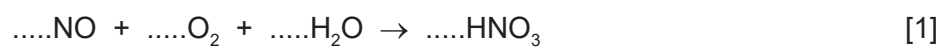
Explain, using collision theory, why the rate of the reaction is slower at the decreased temperature.

.....
.....
.....
..... [3]

6

(c) In the second stage, nitric acid is produced.

Balance the symbol equation for this reaction.

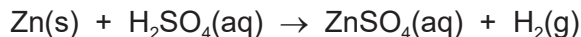


[Total: 21]

4 This question is about sulfuric acid and salts that are made from sulfuric acid.

(a) Zinc reacts with dilute sulfuric acid. Aqueous zinc sulfate is one of the products.

Powdered zinc is added to dilute sulfuric acid. The mixture is stirred. More zinc is added, with stirring, until the zinc is in excess.



The mixture is then filtered.

(i) Name the limiting reactant.

..... [1]

(ii) State two **observations** that indicate the zinc is in excess.

1

2 [2]

(iii) Name the filtrate.

..... [1]

(iv) Name **two** compounds which both react with dilute sulfuric acid to produce aqueous zinc sulfate.

1

2 [2]

(b) Zinc sulfate crystals are produced by heating aqueous zinc sulfate until a saturated solution is formed. When the saturated solution cools down, crystals of zinc sulfate start to form.

(i) State what is meant by the term saturated solution.

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

(ii) Explain why crystals form when the saturated solution cools down.

..... [1]

(c) Nickel(II) sulfate crystals contain water of crystallisation.

When nickel(II) sulfate crystals, $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$, are heated, they give off water.



A student carries out an experiment to determine the value of x in $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$.

step 1 Nickel(II) sulfate crystals are weighed.

step 2 Nickel(II) sulfate crystals are heated.

step 3 The remaining solid is allowed to cool and is then weighed.

step 4 The remaining solid is heated again, allowed to cool and is then weighed.

step 5 Step 4 is repeated until there is no change in mass.

(i) State the term used to describe crystals that contain water of crystallisation.

..... [1]

(ii) State why **step 4** is repeated until there is no change in mass.

..... [1]

(iii) In an experiment, 0.454 g of nickel(II) sulfate crystals, $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$, is used. The mass of anhydrous nickel(II) sulfate, NiSO_4 , remaining is 0.310 g.

[M_r : NiSO_4 , 155; H_2O , 18]

Determine the value of x in $\text{NiSO}_4 \cdot x\text{H}_2\text{O}$.

Use the following steps.

- Calculate the number of moles of NiSO_4 remaining.

moles of NiSO_4 =

- Calculate the mass of H_2O given off.

mass of H_2O = g

- Calculate the number of moles of H_2O given off.

moles of H_2O =

9

- Calculate the value of **x**.

x =

[4]

[Total: 15]

10**5** This question is about iron.**(a) (i)** Describe the bonding in a metallic element such as iron.

You may include a labelled diagram as part of your answer.

.....

.....

..... [3]

(ii) Explain why iron conducts electricity when it is solid.

..... [1]

(b) Iron is extracted from hematite in the blast furnace as shown in Fig. 5.1.

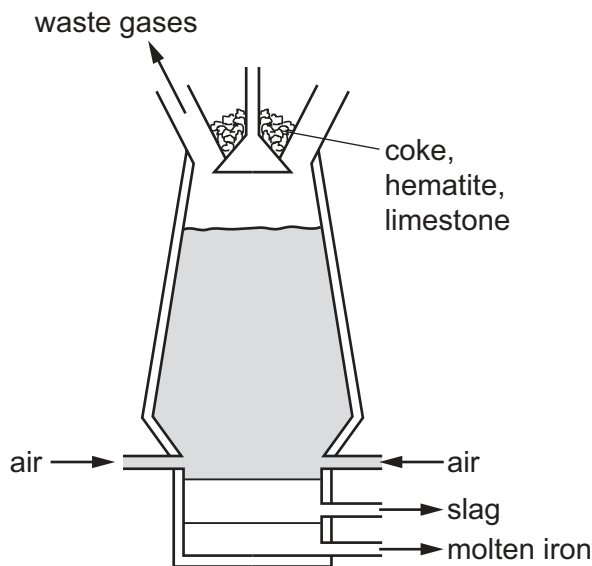


Fig. 5.1

(i) Give **two** reasons why coke is added to the blast furnace.

1

2 [2]

(ii) Explain how limestone removes the impurities in the hematite.

.....

.....

..... [2]

(iii) Hematite contains iron(III) oxide.

Write a symbol equation for the conversion of iron(III) oxide to iron in the blast furnace.

..... [2]

(iv) Suggest why the iron produced in the blast furnace is molten.

..... [1]

12

(c) Most iron is converted into steel. Steel is an alloy.

Steel is more useful than pure iron because it is harder and stronger.

Explain why the structure of alloys causes them to be harder and stronger than pure metals.

You may include a diagram as part of your answer.

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

(d) Iron forms rust.

Rusting is prevented by coating iron with zinc.

(i) Name the substances that react with iron to form rust.

..... [1]

(ii) Name the process in which zinc is used to coat iron to prevent rusting.

..... [1]

(iii) Explain how the coating of zinc prevents rusting if the zinc is **not** scratched.

..... [1]

(iv) When zinc is scratched the iron becomes exposed.

Explain how the zinc continues to prevent rusting.

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

[Total: 18]

13

- 6 (a) Esters are members of a homologous series of organic compounds.

Give **two** characteristics that are the **same** for all members of a homologous series.

1

2

[2]

- (b) Ester **X** has the structure shown in Fig. 6.1.

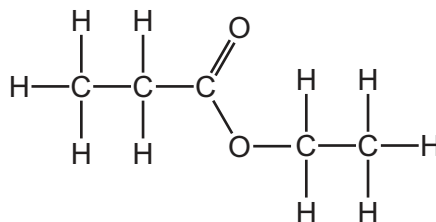


Fig. 6.1

Name ester **X**.

..... [1]

- (c) (i) Ester **Y** has the structural formula $\text{HCOOCH}_2\text{CH}_2\text{CH}_3$.

Name the alcohol and the carboxylic acid used to make ester **Y**.

alcohol

carboxylic acid

[2]

- (ii) State the molecular formula of ester **Y**.

..... [1]

- (d) Ester **Z** has the molecular formula $\text{C}_4\text{H}_8\text{O}_2$.

State the empirical formula of ester **Z**.

..... [1]

14

- (e) Polymers containing ester linkages are known as polyesters.

Polyamides are another type of polymer. Nylon is a polyamide.

The structure of nylon is shown in Fig. 6.2.

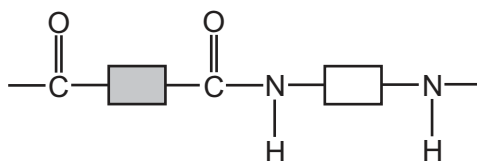


Fig. 6.2

- (i) State the term used to describe the type of polymerisation used to produce polyesters and polyamides.

..... [1]

- (ii) Complete Fig. 6.3 to show the structures of the monomers used to produce nylon. Show all of the atoms and all of the bonds.

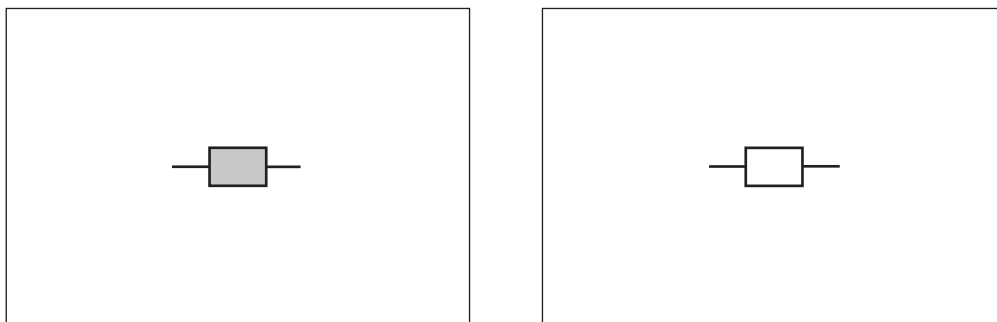


Fig. 6.3

[2]

- (f) Naturally occurring polyamides are found in food.

- (i) State the name given to naturally occurring polyamides.

..... [1]

- (ii) Name the type of monomer which forms naturally occurring polyamides.

..... [1]

[Total: 12]

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The Periodic Table of Elements

Group																		
I	II											III	IV	V	VI	VII	VIII	
1Hhydrogen1 atomic number atomic symbol name relative atomic mass																		
3Li lithium 7	4Be beryllium 9																	
11Na sodium 23	12Mg magnesium 24																	
19K potassium 39	20Ca calcium 40	21Sc scandium 45	22Ti titanium 48	23V vanadium 51	24Cr chromium 52	25Mn manganese 55	26Fe iron 56	27Co cobalt 59	28Ni nickel 59	29Cu copper 64	30Zn zinc 65	31Ga gallium 70	32Ge germanium 73	33As arsenic 75	34Se selenium 79	35Br bromine 80	36Kr krypton	
37Rb rubidium 85	38Sr strontium 88	39Y yttrium 89	40Zr zirconium 91	41Nb niobium 93	42Mo molybdenum 96	43Tc technetium —	44Ru ruthenium 101	45Rh rhodium 103	46Pd palladium 106	47Ag silver 108	48Cd cadmium 112	49In indium 115	50Sn tin 119	51Sb antimony 122	52Te tellurium 128	53I iodine 127	54Xe xenon 131	
55Cs caesium 133	56Ba barium 137	57–71 lanthanoids		72Hf hafnium 178	73Ta tantalum 181	74W tungsten 184	75Re rhenium 186	76Os osmium 190	77Ir iridium 192	78Pt platinum 195	79Au gold 197	80Hg mercury 201	81Tl thallium 204	82Pb lead 207	83Bi bismuth 209	84Po polonium —	85At astatine —	86Rn radon —
87Fr francium —	88Ra radium —	89–103 actinoids		104Rf rutherfordium —	105Db dubnium —	106Sg seaborgium —	107Bh bohrium —	108Hs hassium —	109Mt meitnerium —	110Ds darmstadtium —	111Rg roentgenium —	112Cn copernicium —	113Nh nihonium —	114Fl flerovium —	115Mc moscovium —	116Lv livermorium —	117Ts tennessine —	118Og oganeson —

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
	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.).