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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.

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]

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]

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.

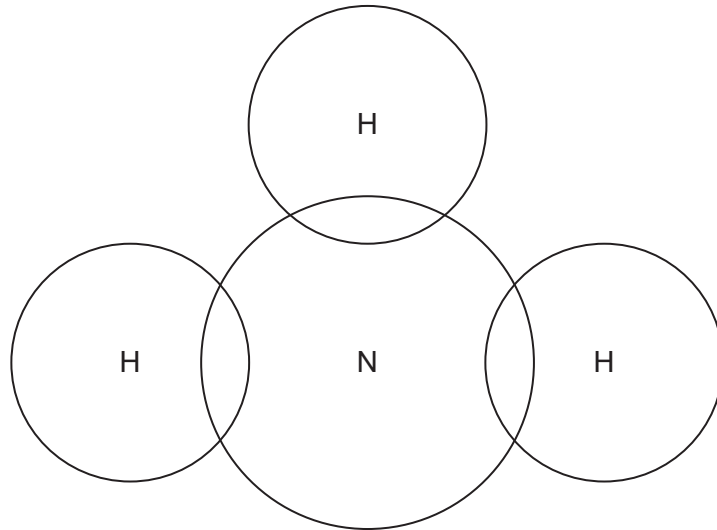


Fig. 3.1

[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

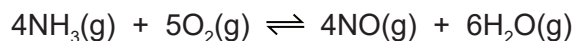
pressure

catalyst

[5]

(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]

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

Balance the symbol equation for this reaction.

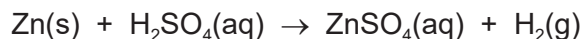


[Total: 21]

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 =

- Calculate the value of x .

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

[Total: 15]

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.

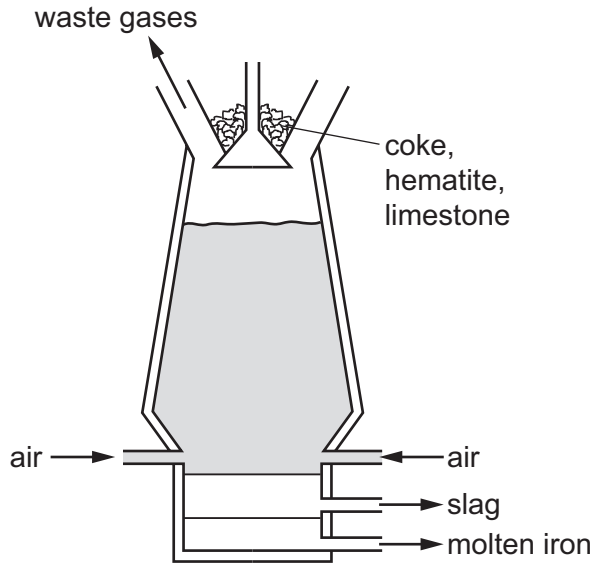


Fig. 5.1

(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]

(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]

- 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.

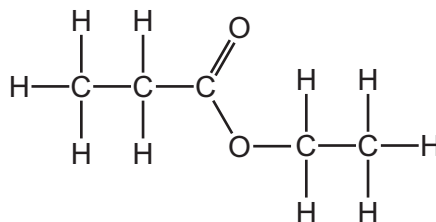


Fig. 6.1

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]

(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.

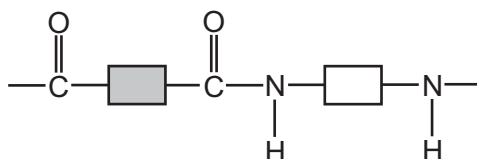


Fig. 6.2

(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.

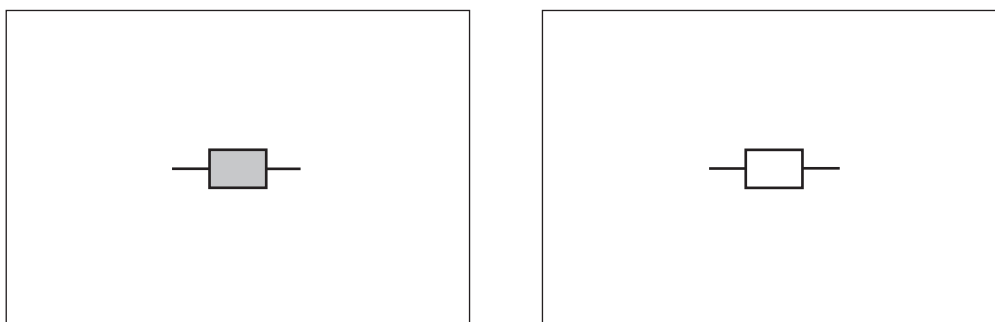


Fig. 6.3

[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										
1	2	3	4	5	6	7	8	9	10	11	12						
1	2	3	4	5	6	7	8	9	10	11	12						
H hydrogen 1	He helium 2	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20	Al aluminium 13	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40				
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	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40		
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
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	Cu copper 64	Zn zinc 65	Ga gallium 70	Ge germanium 73	As arsenic 75	Se selenium 79	Br bromine 80	Kr krypton 84
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
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	Ag silver 108	Cd cadmium 112	In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131
55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
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	Au gold 197	Hg mercury 201	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —
87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganeson —

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.).