Cambridge Assessment International Education

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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.

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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

View solution

..... [1]

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

..... [1]

(c) is an acidic oxide

View solution

..... [1]

(d) is an unsaturated hydrocarbon

View solution

..... [1]

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

View solution

..... [1]

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

..... [1]

[Total: 6]

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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:

View solution

(i) atoms

..... [1]

(ii) ions with a charge of 2–

..... [1]

(iii) cations.

..... [1]

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

View solution

..... [1]

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

View solution

..... [1]

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

View solution

..... [1]

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

View solution

..... [1]

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

View solution

..... [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.

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(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.

View solution

..... [1]

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

View solution

Show the outer shell electrons only.

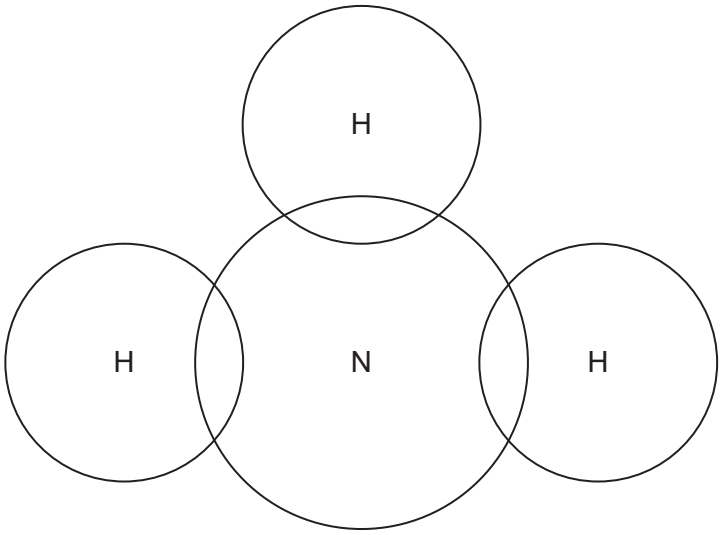

Fig. 3.1

[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:

View solution

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.

View solution

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

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:

NH_3 .....

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.

View solution

Balance the symbol equation for this reaction.

$$.....NO + ...O_2 + ...H_2O \rightarrow .....HNO_3$$ [1]

[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.

View solution

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

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.

View solution

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

.....

..... [2]

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

..... [1]

View solution

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

View solution

When nickel(II) sulfate crystals, $NiSO_4 \cdot \mathbf{x}H_2O$, are heated, they give off water.

$$NiSO_4 \cdot \mathbf{x}H_2O(s) \rightarrow NiSO_4(s) + \mathbf{x}H_2O(g)$$

A student carries out an experiment to determine the value of **x** in $NiSO_4 \cdot \mathbf{x}H_2O$.

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.

View solution

..... [1]

(iii) In an experiment, 0.454 g of nickel(II) sulfate crystals, $NiSO_4 \cdot \mathbf{x}H_2O$, is used. The mass of anhydrous nickel(II) sulfate, $NiSO_4$, remaining is 0.310 g.

View solution

[M_r: $NiSO_4$, 155; H_2O, 18]

Determine the value of **x** in $NiSO_4 \cdot \mathbf{x}H_2O$.

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 = ...
[4]

[Total: 15]

5 This question is about iron.

(a) (i) Describe the bonding in a metallic element such as iron.

View solution

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

.....

.....

..... [3]

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

..... [1]

View solution

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

View solution

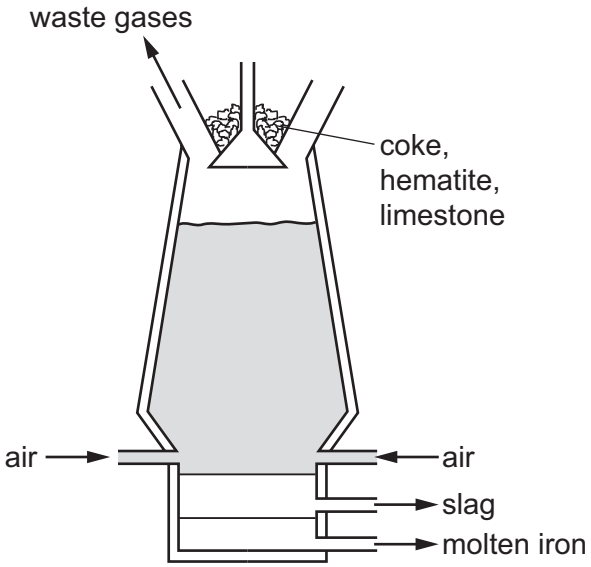

Fig. 5.1

(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.

View solution

.....

.....

..... [2]

(iii) Hematite contains iron(III) oxide.

View solution

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]

View solution

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

View solution

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.

View solution

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. View solution

..... [1]

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

..... [1]

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

View solution

Explain how the zinc continues to prevent rusting.

.....

.....

..... [2]

[Total: 18]

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

View solution

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.

View solution

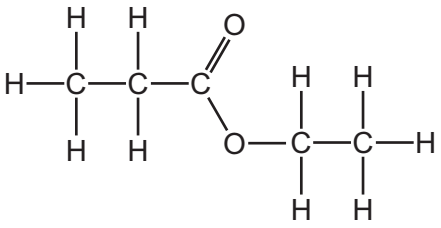

Fig. 6.1

Name ester **X**.

..... [1]

(c) **(i)** Ester **Y** has the structural formula $HCOOCH_2CH_2CH_3$.

View solution

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

alcohol .....

carboxylic acid .....

[2]

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

View solution

..... [1]

(d) Ester **Z** has the molecular formula $C_4H_8O_2$.

View solution

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

..... [1]

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

View solution

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

The structure of nylon is shown in Fig. 6.2.

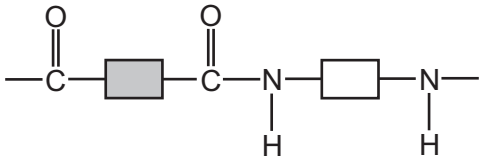

Fig. 6.2

(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.

View solution

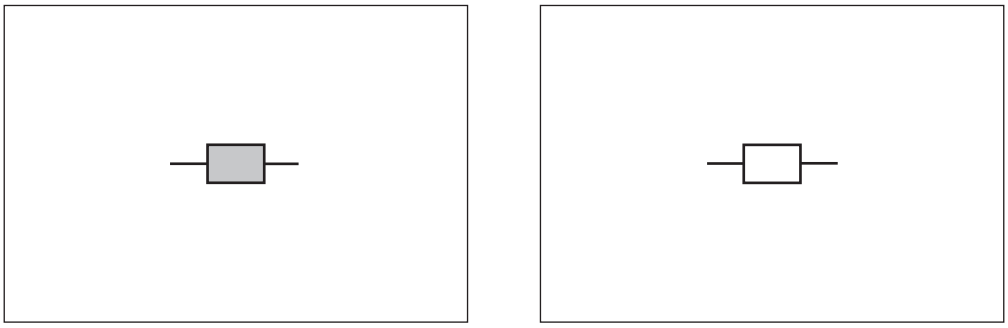

Fig. 6.3

[2]

(f) Naturally occurring polyamides are found in food.

View solution

(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 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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).