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CHEMISTRY

0620/43

Paper 4 Theory (Extended)

October/November 2020

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. Blank pages are indicated.



1 The names of nine substances are shown.

aluminium oxide
ammonia
carbon monoxide
anhydrous cobalt(II) chloride
hydrated copper(II) sulfate
iron(III) oxide
nitrogen dioxide
silver
steel

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

Name the substance that is:

- (a) the main constituent of hematite [1]
- (b) a gas produced in car engines which causes acid rain [1]
- (c) an alkaline gas [1]
- (d) an element [1]
- (e) a gas formed by the incomplete combustion of fossil fuels [1]
- (f) used to test for the presence of water. [1]

[Total: 6]

2 The table gives information about five particles, **A**, **B**, **C**, **D** and **E**.

particle	number of electrons	number of neutrons	number of protons
A	10	13	11
B	18	20	18
C	18	18	18
D	10	12	8
E	10	10	10

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

..... [1]

(b) State the nucleon number of **B**.

..... [1]

(c) Write the electronic structure of **C**.

..... [1]

(d) Give the letters of all the particles which are:

(i) atoms [1]

(ii) positive ions [1]

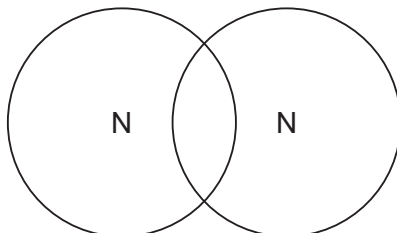
(iii) negative ions [1]

(iv) isotopes of each other. [1]

[Total: 7]

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

- (a) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of nitrogen, N_2 .
Show the outer shell electrons only.



[2]

- (b) Nitrogen can be converted into ammonia by the Haber process.

- (i) Describe how nitrogen is obtained for the Haber process.

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

- (ii) Give the essential reaction conditions and write a chemical equation for the reaction occurring in the Haber process.

chemical equation:

.....

reaction conditions:

.....

.....

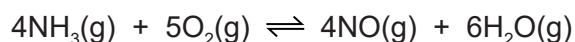
.....

.....

[5]

- (c) Some of the ammonia made by the Haber process is converted into nitric acid.

The first stage of this process is the oxidation of ammonia to make nitrogen monoxide.



The process is carried out at 900 °C and a pressure of 5 atmospheres using an alloy of platinum and rhodium as a catalyst.

The forward reaction is exothermic.

- (i) State the meaning of the term *catalyst*.

.....
 [2]

- (ii) State the meaning of the term *oxidation*.

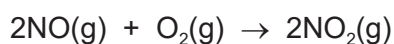
..... [1]

- (iii) Complete the table using the words **increase**, **decrease** or **no change**.

	effect on the rate of the forward reaction	effect on the equilibrium yield of NO(g)
increasing the temperature		
increasing the pressure		

[4]

- (d) Nitrogen monoxide, NO, is converted into nitrogen dioxide, NO₂.



The nitrogen dioxide reacts with oxygen and water to produce nitric acid as the only product.

Write a chemical equation for this reaction.

..... [2]

- (e) Ammonium nitrate, NH_4NO_3 , is a fertiliser.

Calculate the percentage by mass of nitrogen in ammonium nitrate.

..... % [2]

[Total: 20]

- 4 Zinc is manufactured from zinc blende. Zinc blende is an ore which consists mainly of zinc sulfide, ZnS.

(a) Zinc blende is roasted in air. One of the products is zinc oxide.

Name the **other** product formed in this reaction.

..... [1]

(b) Zinc oxide is then converted into zinc.

Zinc oxide and coke, a source of carbon, are heated in a furnace. Hot air is blown into the furnace.

(i) Give **two** reasons why coke is needed.

1

2

[2]

(ii) Write a chemical equation for the formation of zinc in the furnace.

..... [1]

(iii) Zinc has a melting point of 420°C and a boiling point of 907°C . The temperature inside the furnace is 1200°C .

Explain how this information shows that the zinc produced inside the furnace is a gas.

..... [1]

(iv) The gaseous zinc is converted to molten zinc.

Name this change of state.

..... [1]

(c) Zinc reacts with dilute sulfuric acid to produce aqueous zinc sulfate.



Hydrated zinc sulfate crystals are made from aqueous zinc sulfate.

Step 1 Solid zinc is added to dilute sulfuric acid until zinc is in excess.

Step 2 Excess zinc is separated from aqueous zinc sulfate by filtration.

Step 3 Aqueous zinc sulfate is heated until the solution is saturated.

Step 4 The saturated solution is allowed to cool and crystallise.

Step 5 The crystals are removed and dried.

(i) Name the residue in **step 2**.

..... [1]

(ii) In **step 3**, a saturated solution is produced.

Describe what a saturated solution is.

.....

 [2]

(iii) Name **two** compounds each of which react with dilute sulfuric acid to produce aqueous zinc sulfate.

1
 2
 [2]

(d) When hydrated magnesium sulfate crystals, $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$, are heated they give off water.



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

Step 1 Hydrated magnesium sulfate crystals were weighed.

Step 2 Hydrated magnesium sulfate crystals were heated.

Step 3 The remaining solid was weighed.

(i) Describe how the student can ensure that all the water is given off.

.....

 [2]

(ii) In an experiment, all the water was removed from 1.23 g of $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$. The mass of MgSO_4 remaining was 0.60 g.

M_r : $\text{MgSO}_4 = 120$; M_r : $\text{H}_2\text{O} = 18$

Determine the value of x using the following steps.

- Calculate the number of moles of MgSO_4 remaining.

moles of $\text{MgSO}_4 = \dots\dots\dots$

- Calculate the mass of H_2O given off.

mass of $\text{H}_2\text{O} = \dots\dots\dots \text{g}$

- Calculate the moles of H_2O given off.

moles of $\text{H}_2\text{O} = \dots\dots\dots$

- Determine the value of x .

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

[Total: 17]

- 5 Group I elements, Group VII elements and transition elements are found in different parts of the Periodic Table.

(a) Describe the trend in the reactivity of Group I elements.

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

(b) When potassium is added to water a chemical reaction occurs.

(i) State **two** observations that can be made when potassium is added to water.

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

(ii) Write a chemical equation for the reaction of potassium with water.

..... [2]

(c) Excess aqueous potassium iodide is added to chlorine.

(i) Write a chemical equation for the reaction that occurs when aqueous potassium iodide is added to chlorine.

..... [2]

(ii) State the final colour of the reaction mixture.

..... [1]

(d) Sodium is extracted from sodium chloride by electrolysis.

(i) State the meaning of the term *electrolysis*.

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

(ii) State what must be done to sodium chloride before it can be electrolysed to produce sodium.

..... [1]

(iii) Write an ionic half-equation for the change that occurs at the cathode during this electrolysis.

..... [1]

(e) Chromium is a transition element.

- Chromium has a high melting point.
- Chromium is a good conductor of electricity.
- Many chromium compounds are soluble in water.
- Hydrated chromium(III) sulfate is green.
- Chromium forms the chlorides CrCl_2 and CrCl_3 .
- Oxides of chromium act as catalysts in the manufacture of poly(ethene).

(i) Use this information to give **two** properties of chromium which are different from properties of Group I elements such as sodium.

1

2 [2]

(ii) Use this information to give **two** properties of chromium which are similar to properties of Group I elements such as sodium.

1

2 [2]

[Total: 16]

6 (a) A carboxylic acid and an ester are structural isomers.

(i) State the meaning of the term *structural isomers*.

..... [2]

(ii) Draw the structures of the carboxylic acid and the ester which both contain two carbon atoms.

Show all of the atoms and all of the bonds.

Name the carboxylic acid and the ester.

carboxylic acid

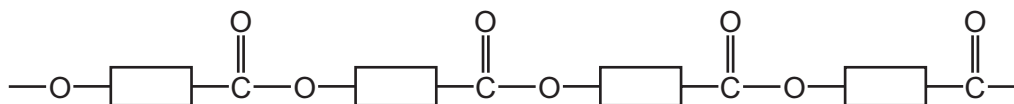
name

ester

name

[4]

(b) Part of a polyester chain is shown. This polyester is made from one monomer.

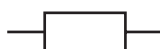


(i) **On the diagram** draw a ring around one unit of the polymer that is repeated. [1]

(ii) Name the type of polymerisation that produces polyesters.

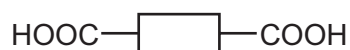
..... [1]

(iii) Complete the diagram to show the structure of the monomer used to produce this polyester. Show all of the atoms and all of the bonds in the functional groups.



[2]

(c) A polyamide is made from the two monomers shown.



Complete the diagram to show a section of the polyamide made from the two monomers. Show all of the atoms and all of the bonds in the linkages.



[2]

(d) Naturally occurring polyamides are constituents of food.

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

..... [1]

(ii) Name the monomers which form naturally occurring polyamides.

..... [1]

[Total: 14]

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The Periodic Table of Elements

Group																		
I	II	Key										III	IV	V	VI	VII	VIII	
		atomic number atomic symbol name relative atomic mass										1 H hydrogen 1						
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 —		114 Fl flerovium —		116 Lv livermorium —		

lanthanoids

actinoids

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