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CHEMISTRY **0620/43**

Paper 4 Theory (Extended) **May/June 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.

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1 A list of substances is shown.

aluminium oxide	**carbon dioxide**	**carbon monoxide**	**chlorine**	**copper**
glucose	**iron(III) oxide**	**limestone**	**nitrogen**	**oxygen**

Answer the questions using the substances in the list.

Each substance may be used once, more than once or not at all.

State which substance is:

(a) a product of respiration

View solution

..... [1]

(b) the main constituent of hematite

View solution

..... [1]

(c) an element which has a sulfate that is used to test for water

View solution

..... [1]

(d) a colourless toxic gas

View solution

..... [1]

(e) a reactant in fermentation

View solution

..... [1]

(f) a reducing agent in the extraction of iron

View solution

..... [1]

(g) a conductor of electricity when solid

View solution

..... [1]

(h) a gas that is approximately 21% of clean, dry air.

View solution

..... [1]

[Total: 8]

2 **(a)** $^{32}_{16}S$ and $^{33}_{16}S$ are isotopes of sulfur.

View solution

Use your knowledge of protons, neutrons and electrons to answer the following questions.

(i) Describe how these isotopes of sulfur are the same and how they are different.

same .....

.....

different .....

.....

[3]

(ii) Explain why each of these isotopes have an overall charge of zero.

View solution

.....

..... [1]

(iii) Explain why both isotopes have the same chemical properties.

View solution

.....

..... [1]

(b) Sulfide ions, S^{2-}, have the electronic structure 2,8,8.

View solution

(i) Explain why sulfide ions have a charge of 2–.

.....

..... [1]

(ii) Give the formula of:

View solution

- an anion which has the same electronic structure as S^{2-}

.....

- a cation which has the same electronic structure as S^{2-}.

.....

[2]

[Total: 8]

3 This question is about nitrogen and compounds of nitrogen.

(a) Nitrogen molecules have the formula N_2.

View solution

Some properties of nitrogen are shown:

- melting point of –210 °C
- boiling point of –196 °C
- non-conductor of electricity when solid
- insoluble in water.

(i) Name the type of bonding between the atoms in an N_2 molecule.

..... [1]

(ii) Explain, in terms of attractive forces between particles, why nitrogen has a low melting point.

.....

..... [1]

(iii) Explain why nitrogen does **not** conduct electricity.

.....

..... [1]

(b) Nitrogen reacts with hydrogen to form ammonia, NH_3, in the Haber process.

View solution

State the essential conditions in the Haber process. Write an equation for the chemical reaction.

.....

.....

.....

.....

..... [4]

(c) Ammonia is made in the laboratory by heating ammonium chloride with calcium hydroxide.

View solution

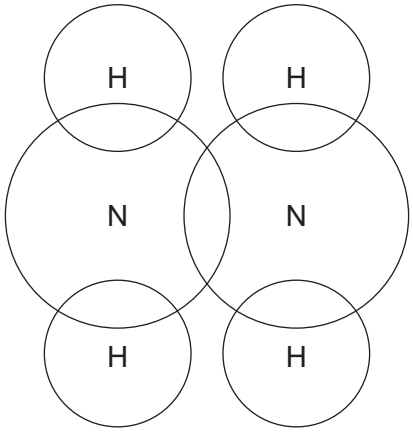
Balance the chemical equation for the reaction.

$$.....NH_4Cl + Ca(OH)_2 \rightarrow .....NH_3 + CaCl_2 + ...H_2O$$ [1]

(d) Hydrazine, N_2H_4, is another compound that contains nitrogen and hydrogen.

Complete the dot-and-cross diagram to show the electron arrangement in a molecule of hydrazine. Show outer electrons only.

View solution



[2]

View solution

(e) Ammonia and hydrazine are weak bases.

The chemical equation for the reaction between one molecule of ammonia and one molecule of water is shown.

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

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

..... [1]

(ii) Write a chemical equation for the reaction between one molecule of hydrazine, N_2H_4, and one molecule of water.

..... [1]

[Total: 12]

View solution

4 Ethanol is made industrially by the reaction of ethene with steam. The reaction occurs at a temperature of 300 °C and a pressure of 60 atmospheres.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

A catalyst is used in this reaction.

The forward reaction is exothermic.

(a) State what is meant by the term *catalyst*.

View solution

.....

..... [2]

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

View solution

	effect on the rate of the forward reaction	effect on the equilibrium yield of $C_2H_5OH(g)$
increasing the temperature		
decreasing the pressure		

[4]

(c) Ethanol is a member of the alcohol homologous series.

View solution

Members of the same homologous series have the same general formula.

(i) State the general formula of alcohols.

..... [1]

(ii) State two **general** characteristics, other than the same general formula, of all homologous series.

1 .....

2 .....

[2]

View solution

(iii) One alcohol containing three carbon atoms is propan-1-ol.

Draw the structure of one **other** alcohol containing three carbon atoms. Show all of the atoms and all of the bonds.

View solution

Name the alcohol you have drawn.

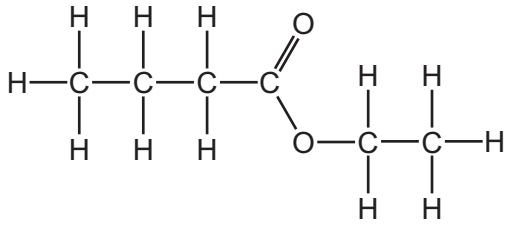
name .....

[2]

View solution

(d) When alcohols react with carboxylic acids, esters are produced.

(i) The structure of ester **X** is shown.



Name ester **X**.

..... [1]

(ii) Give the name of the alcohol and the carboxylic acid that react together to produce ester **X**.

alcohol .....

carboxylic acid .....

[2]

View solution

(e) Ester **Y** has the following composition by mass:

C, 58.82%; H, 9.80%; O, 31.37%.

Calculate the empirical formula of ester **Y**.

empirical formula = ... [3]

(f) Ester **Z** has the empirical formula C_3H_6O and a relative molecular mass of 116.

Calculate the molecular formula of ester **Z**.

View solution

molecular formula = ... [1]

[Total: 18]

5 This question is about copper and its compounds.

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

View solution

You may include a diagram as part of your answer.

.....

.....

..... [3]

(b) A metal spoon is electroplated with copper.

View solution

State what is used as:

the positive electrode (anode) .....

the negative electrode (cathode) .....

the electrolyte. .....

[3]

(c) The formula for crystals of hydrated copper(II) sulfate is $CuSO_4 \cdot 5H_2O$.

View solution

Hydrated copper(II) sulfate is made by reacting copper(II) oxide with dilute sulfuric acid.

The overall equation is shown.

$$CuO + H_2SO_4 + 4H_2O \rightarrow CuSO_4 \cdot 5H_2O$$

The crystals are made using the following steps:

step 1 50.0 cm^3 of 0.200 mol/dm^3 dilute sulfuric acid is heated in a beaker. Powdered copper(II) oxide is added until the copper(II) oxide is in excess. Aqueous copper(II) sulfate is formed.

step 2 The excess copper(II) oxide is separated from the aqueous copper(II) sulfate.

step 3 The aqueous copper(II) sulfate is heated until a saturated solution is formed.

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

step 5 The crystals are removed and dried.

Calculate the maximum mass of copper(II) sulfate crystals, $CuSO_4 \cdot 5H_2O$, that can form using the following steps.

- Calculate the number of moles of H_2SO_4 in 50.0 cm^3 of 0.200 mol/dm^3 H_2SO_4.

..... mol

- Deduce the number of moles of $CuSO_4 \cdot 5H_2O$ that can form.

..... mol

- The M_r of $CuSO_4 \cdot 5H_2O$ is 250.

  Calculate the maximum mass of $CuSO_4 \cdot 5H_2O$ that can form.

..... g
[3]

(d) State **one** observation that indicates the copper(II) oxide is in excess in **step 1**.

..... [1]

(e) **Step 1** is repeated without heating the dilute sulfuric acid.

View solution

All other conditions are kept the same.

The rate of reaction decreases.

Give a reason why the rate of reaction decreases. Explain your answer in terms of particles.

.....

.....

.....

.....

..... [3]

(f) Name a substance, other than copper(II) oxide, that can be added to dilute sulfuric acid to produce copper(II) sulfate in **step 1**.

..... [1]

(g) Name the process used to separate excess copper(II) oxide from aqueous copper(II) sulfate in **step 2**.

..... [1]

(h) Suggest what is meant by the term *saturated solution* in **step 3**.

View solution

.....

.....

..... [2]

(i) The phrase 'heating to dryness' means heating until no more water is given off.

View solution

Explain why aqueous copper(II) sulfate is **not** heated to dryness in **step 3**.

.....

..... [1]

[Total: 18]

6 The Periodic Table can be used to classify elements.

(a) The Group I metals react with cold water. Transition elements do not react with cold water.

(i) Describe two **other** differences in the **chemical** properties between Group I metals and transition elements.

1 .....

2 .....

[2]

(ii) Describe the observations when potassium is added to cold water. Write a balanced equation for the reaction. Include state symbols.

observations .....

.....

.....

.....

equation .....

[5]

View solution

(b) Transition elements are stronger than Group I metals.

View solution

Describe two **other** differences in the **physical** properties of Group I metals and transition elements.

1 .....

2 .....

[2]

(c) Some Group VII elements react with aqueous solutions containing halide ions.

View solution

When aqueous bromine is added to aqueous potassium iodide a reaction occurs.

The ionic half-equations for the reaction are shown.

$$Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)$$

$$2I^-(aq) \rightarrow I_2(aq) + 2e^-$$

(i) Describe the colour change of the solution.

original colour of potassium iodide solution .....

final colour of reaction mixture .....

[2]

(ii) State the name of the general term given to the type of reaction in which electrons are transferred from one species to another.

..... [1]

(iii) Identify the oxidising agent in this reaction. Give a reason for your answer.

oxidising agent .....

reason .....

[2]

(d) Use the key to complete the table to show the results of adding aqueous halogens to aqueous solutions of halides. One has been completed for you.

View solution

		halides		
		KCl(aq)	KBr(aq)	KI(aq)
halogens	Cl_2(aq)			
	Br_2(aq)			✓
	I_2(aq)			

key
✓ = reaction
✗ = no reaction

[2]

[Total: 16]

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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 –		114 Fl flerovium –		116 Lv livermorium –		

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.).