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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.

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

..... [1]

(b) the main constituent of hematite

..... [1]

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

..... [1]

(d) a colourless toxic gas

..... [1]

(e) a reactant in fermentation

..... [1]

(f) a reducing agent in the extraction of iron

..... [1]

(g) a conductor of electricity when solid

..... [1]

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

..... [1]

[Total: 8]

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

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.

.....

..... [1]

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

.....

..... [1]

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

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

.....

..... [1]

(ii) Give the formula of:

- 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 .

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.

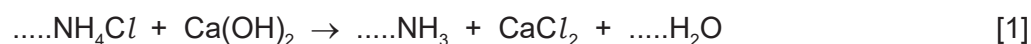
State the essential conditions in the Haber process. Write an equation for the chemical reaction.

.....

 [4]

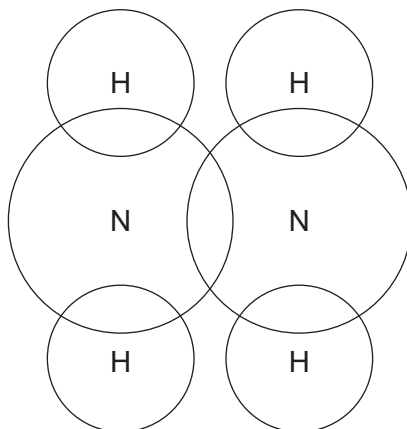
(c) Ammonia is made in the laboratory by heating ammonium chloride with calcium hydroxide.

Balance the chemical equation for the reaction.



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

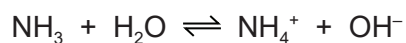
Complete the dot-and-cross diagram to show the electron arrangement in a molecule of hydrazine. Show outer electrons only.



[2]

(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.



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

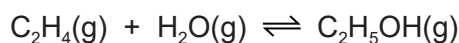
..... [1]

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

..... [1]

[Total: 12]

- 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.



A catalyst is used in this reaction.

The forward reaction is exothermic.

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

.....
 [2]

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

	effect on the rate of the forward reaction	effect on the equilibrium yield of C ₂ H ₅ OH(g)
increasing the temperature		
decreasing the pressure		

[4]

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

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]

- (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.

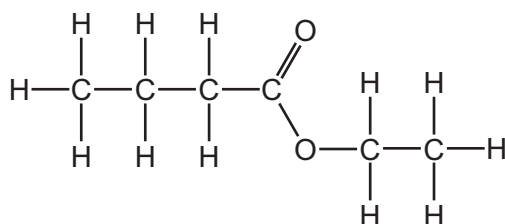
Name the alcohol you have drawn.

name

[2]

- (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]

- (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**.

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.

You may include a diagram as part of your answer.

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

(b) A metal spoon is electroplated with copper.

State what is used as:

the positive electrode (anode)

the negative electrode (cathode)

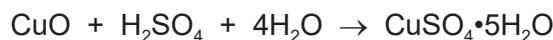
the electrolyte.

[3]

(c) The formula for crystals of hydrated copper(II) sulfate is $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

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

The overall equation is shown.



The crystals are made using the following steps:

- step 1** 50.0 cm³ of 0.200 mol/dm³ 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, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, that can form using the following steps.

- Calculate the number of moles of H_2SO_4 in 50.0 cm³ of 0.200 mol/dm³ H_2SO_4 .

..... mol

- Deduce the number of moles of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ that can form.

..... mol

- The M_r of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is 250.

Calculate the maximum mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ 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.

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**.

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

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

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]

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

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

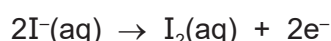
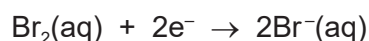
1

2 [2]

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

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

The ionic half-equations for the reaction are shown.



(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.

		halides		
		KCl(aq)	KBr(aq)	KI(aq)
halogens	Cl ₂ (aq)			
	Br ₂ (aq)			✓
	I ₂ (aq)			

key
 ✓ = reaction
 X = no reaction

[2]

[Total: 16]

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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
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
11	12	13	14	15	16	17	18		
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
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
37	38	39	40	41	42	43	44	45	46
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
55	56	57–71	72	73	74	75	76	77	78
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
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Cn copernicium —	Hg mercury 201	Au gold 197	Pt platinum 195
113	114	115	116	117	118	119	120	121	122
In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131	Pb lead 207	Hg mercury 201	Au gold 197	Pt platinum 195
151	152	153	154	155	156	157	158	159	160
Fl flerovium —	Lv livermorium —	Cn copernicium —	Rg roentgenium —	Ds darmstadtium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —
167	168	169	170	171	172	173	174	175	176
Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	Ho holmium 165	Er erbium 167	Dy dysprosium 163	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
101	102	103	104	105	106	107	108	109	110
Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Ho holmium 165	Dy dysprosium 163	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
99	100	101	102	103	104	105	106	107	108
Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Ho holmium 165	Dy dysprosium 163	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids

actinoids

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