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CHEMISTRY

0620/41

Paper 4 Theory (Extended)

October/November 2021

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 **12** pages.

1 Some elements are shown in the order they appear in the reactivity series. The most reactive element is at the top.

- sodium
- calcium
- magnesium
- aluminium
- zinc
- iron
- hydrogen
- copper

(a) Answer the questions using the list of elements. Each element may be used once, more than once or not at all.

Identify:

(i) a non-metal

..... [1]

(ii) a metal which is stored under oil

..... [1]

(iii) the main component of steel

..... [1]

(iv) a metal with three electrons in the outer shell of its atoms

..... [1]

(v) a metal found in brass

..... [1]

(vi) a metal that forms chlorides of the type XCl_2 and XCl_3 .

..... [1]

(b) Name the main ores of:

(i) zinc [1]

(ii) aluminium. [1]

(c) In an experiment, a sample of aluminium appeared less reactive than expected.

Explain why.

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

(d) Name **two** metals from the list which are extracted by reduction of their ores using carbon.

1

2

[2]

(e) When zinc granules are added to aqueous copper(II) sulfate, a reaction occurs. During the reaction, a red-pink solid is formed and the solution becomes colourless.

(i) Name the red-pink solid.

..... [1]

(ii) Name the colourless solution.

..... [1]

(iii) Explain, in terms of particles, why the rate of this reaction increases when the temperature is increased.

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

(iv) Suggest two **other** ways of increasing the rate of this reaction.

1

2

[2]

[Total: 18]

2 This question is about copper and its compounds.

(a) Copper has two different naturally occurring atoms, ^{63}Cu and ^{65}Cu .

(i) State the term used for atoms of the same element with different nucleon numbers.

..... [1]

(ii) The atomic number of copper is 29.

Complete the table to show the number of protons, neutrons and electrons in the particles of copper shown.

	^{63}Cu	$^{65}\text{Cu}^{2+}$
protons		
neutrons		
electrons		

[3]

(iii) Relative atomic mass is the average mass of naturally occurring atoms of an element.

The percentage of the naturally occurring atoms in a sample of copper is shown.

^{63}Cu	^{65}Cu
70%	30%

Deduce the relative atomic mass of copper in this sample.

Give your answer to **one** decimal place.

relative atomic mass = [2]

(b) Anhydrous copper(II) sulfate is used to test for the presence of water. When this test is positive, hydrated copper(II) sulfate is formed.

(i) State the colour change seen during this test.

from to [2]

(ii) Complete the chemical equation to show the reaction that takes place.



(iii) State how hydrated copper(II) sulfate can be turned back into anhydrous copper(II) sulfate.

..... [1]

(iv) Describe a test for pure water.

.....
 [2]

(c) Aqueous copper(II) sulfate contains $\text{Cu}^{2+}(\text{aq})$ ions.

(i) Describe what is seen when aqueous copper(II) sulfate is added to aqueous sodium hydroxide, $\text{NaOH}(\text{aq})$.

..... [1]

(ii) Write the ionic equation for the reaction between aqueous copper(II) sulfate and aqueous sodium hydroxide.

Include state symbols.

..... [3]

- (d) When solid copper(II) nitrate is heated copper(II) oxide, nitrogen dioxide and oxygen are formed.



Calculate the volume of nitrogen dioxide formed at room temperature and pressure when 4.7 g of $\text{Cu}(\text{NO}_3)_2$ is heated.

Use the following steps:

- calculate the mass of one mole of $\text{Cu}(\text{NO}_3)_2$

..... g

- calculate the number of moles of $\text{Cu}(\text{NO}_3)_2$ used

..... moles

- determine the number of moles of nitrogen dioxide formed

..... moles

- calculate the volume of nitrogen dioxide formed at room temperature and pressure.

..... dm^3
[4]

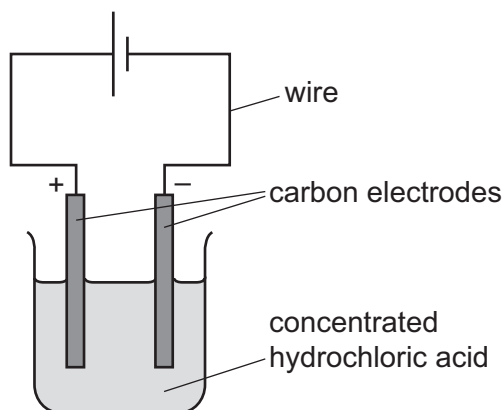
- (e) Write the chemical equation to show the action of heat on sodium nitrate, NaNO_3 .

..... [2]

[Total: 22]

3 This question is about electrolysis.

Concentrated hydrochloric acid is electrolysed using the apparatus shown.



(a) Chloride ions are discharged at the anode.

(i) Complete the ionic half-equation for this reaction.



(ii) State whether oxidation or reduction takes place. Explain your answer.

.....
 [1]

(b) Describe what is seen at the cathode.

..... [1]

(c) Write the ionic half-equation for the reaction at the cathode.

..... [2]

(d) The pH of the electrolyte is measured throughout the experiment.

(i) Suggest the pH of the electrolyte at the beginning of the experiment.

..... [1]

(ii) State how the pH changes, if at all, during the experiment.

Explain your answer.

.....
 [2]

(e) The electrolysis is repeated using molten lead(II) bromide.

Describe what is seen at the:

- cathode
- anode.

[2]

(f) State **two** properties of graphite (carbon) which make it suitable for use as an electrode.

1

2

[2]

[Total: 13]

4 Chalcopyrite, FeCuS_2 , is used in the manufacture of sulfuric acid in the Contact process.

- (a) In the first stage of the process, chalcopyrite reacts with oxygen in the air to produce sulfur dioxide, SO_2 , iron(III) oxide and copper(II) oxide.

Complete the chemical equation for the reaction of FeCuS_2 with oxygen.



- (b) Sulfur dioxide is then converted to sulfur trioxide.



The reaction is exothermic. It is also an equilibrium.

- (i) State **two** features of an equilibrium.

1

2

[2]

- (ii) State the temperature and pressure used in this reaction. Include units.

• temperature

• pressure

[2]

- (iii) Name the catalyst used.

..... [1]

- (iv) Explain why a catalyst is used.

..... [1]

- (v) Describe and explain, in terms of equilibrium, what happens when the temperature is increased.

.....

..... [2]

- (c) Concentrated sulfuric acid is a dehydrating agent.

When glucose is dehydrated, carbon and one other product are formed.

Complete the equation to show the dehydration of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$.



[Total: 12]

- 5 Alkenes and carboxylic acids are both families of similar compounds with similar chemical properties. Alkenes and carboxylic acids have different reactions.

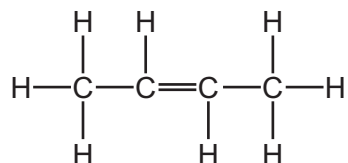
(a) State the term used for a 'family' of similar compounds.

..... [1]

(b) State the general formula of alkenes.

..... [1]

(c) The structure of but-2-ene is shown.



(i) But-2-ene reacts with aqueous bromine in an addition reaction.

Describe the colour change seen when but-2-ene is added to aqueous bromine.

from to [1]

(ii) State what is meant by the term *addition reaction*.

..... [1]

(iii) Write the chemical equation for the reaction between but-2-ene and bromine.

..... [2]

(iv) But-2-ene forms a polymer.

Suggest the name of the polymer formed from but-2-ene.

..... [1]

(v) Name and draw a structural isomer of but-2-ene.

Show all of the atoms and all of the bonds.

name

structure

[2]

(d) Butanoic acid, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$, is a carboxylic acid.

(i) Deduce the empirical formula of butanoic acid.

..... [1]

(ii) Complete the chemical equation for the reaction of butanoic acid and sodium carbonate, Na_2CO_3 .

$2\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{Na}_2\text{CO}_3 \rightarrow \dots + \dots + \dots$ [2]

(iii) Butanoic acid reacts with methanol to form an organic compound and water.

- Name the organic compound formed.

..... [1]

- Draw the structure of the organic compound formed.

Show all of the atoms and all of the bonds.

[2]

[Total: 15]

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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	13	14	15	16	17	18																																																																				
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	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	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	Cs caesium 133	Ba barium 137	La lanthanum 139	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 —	Fr francium —	Ra radium —	Ac actinium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Fl flerovium —	Lv livermorium —	Uu ununoctium —	Og oganesson —

Key

atomic number
atomic symbol
name
relative atomic mass

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La lanthanum 139	Ce cerium 140	Pr praseodymium 141	Nd neodymium 144	Pm promethium —	Sm samarium 150	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —

lanthanoids

actinoids

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