Cambridge Assessment International Education

# Cambridge IGCSE™

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| CANDIDATE NAME | | | | | | | | | |
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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.

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**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.

View solution

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:

View solution

**(i)** zinc ..... [1]

**(ii)** aluminium. ..... [1]

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

View solution

Explain why.

.....

..... [1]

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

1 .....

2 .....

View solution [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.

View solution

**(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 $^{65}Cu$.

View solution

**(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.

View solution

| | $^{63}Cu$ | $^{65}Cu^{2+}$ |
|---|---|---|
| protons | | |
| neutrons | | |
| electrons | | |

[3]

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

View solution

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.

View solution

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

from ..... to ..... [2]

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

$CuSO_4$ + ..... $\rightleftharpoons$ $CuSO_4 \cdot 5H_2O$ [1]

**(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 $Cu^{2+}(aq)$ ions.

View solution

**(i)** Describe what is seen when aqueous copper(II) sulfate is added to aqueous sodium hydroxide, NaOH(aq).

..... [1]

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

Include state symbols.

View solution

..... [3]

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

View solution

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

Calculate the volume of nitrogen dioxide formed at room temperature and pressure when 4.7 g of $Cu(NO_3)_2$ is heated.

Use the following steps:

- calculate the mass of one mole of $Cu(NO_3)_2$

..... g

- calculate the number of moles of $Cu(NO_3)_2$ 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, $NaNO_3$.

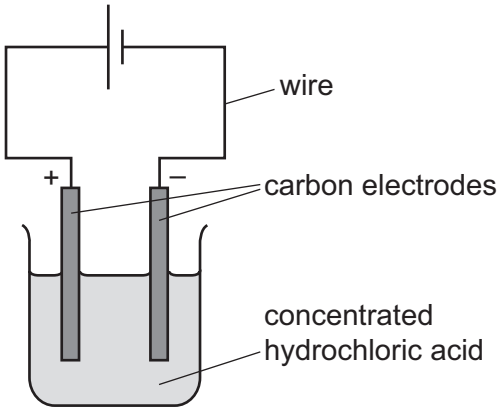
..... [2]

[Total: 22]

View solution

**3** This question is about electrolysis.

Concentrated hydrochloric acid is electrolysed using the apparatus shown.




**(a)** Chloride ions are discharged at the anode.

View solution

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

.....$Cl^-$(aq) → .....(g) + .....$e^-$ [2]

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

View solution

.....

..... [1]

**(b)** Describe what is seen at the cathode.

View solution

..... [1]

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

View solution

..... [2]

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

View solution

**(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.

View solution

Explain your answer.

.....

..... [2]

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

View solution

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.

View solution

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.

View solution

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

$$4FeCuS_2 + 13O_2 \rightarrow \text{.....} + \text{.....} + \text{.....}$$ [2]

View solution

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

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

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]

View solution

**(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, $C_6H_{12}O_6$.

$$C_6H_{12}O_6 \rightarrow \text{.....}C + \text{.....}$$ [2]

[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.

View solution

..... [1]

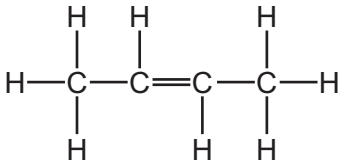
**(b)** State the general formula of alkenes.

View solution

..... [1]

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

View solution



**(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*.

View solution

..... [1]

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

View solution

..... [2]

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

View solution

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

..... [1]

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

View solution

Show all of the atoms and all of the bonds.

name .....

structure

[2]

**(d)** Butanoic acid, $CH_3CH_2CH_2COOH$, is a carboxylic acid.

View solution

**(i)** Deduce the empirical formula of butanoic acid.

..... [1]

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

$2CH_3CH_2CH_2COOH + Na_2CO_3 \rightarrow$ ..... + ..... + ..... [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 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.).