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CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

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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.

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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.

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]

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(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]

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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	$^{65}Cu^{2+}$
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]

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(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.

$$CuSO_4 + \text{.....} \rightleftharpoons CuSO_4{\bullet}5H_2O$$ [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.

(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.

..... [3]

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

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

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]

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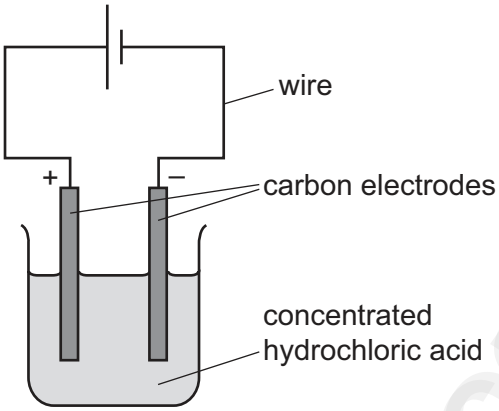
3 This question is about electrolysis.

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.

.....Cl^-(aq) → .....(g) + ...e^- [2]

(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]

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(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]

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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.

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

(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]

(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]

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

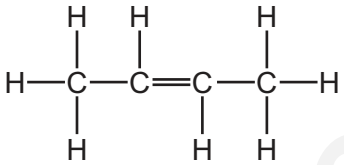
(a) State the term used for a 'family' of similar compounds.

..... [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]

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(d) Butanoic acid, $CH_3CH_2CH_2COOH$, 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.

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

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