

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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0620/41

October/November 2021

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- 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.

- 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]

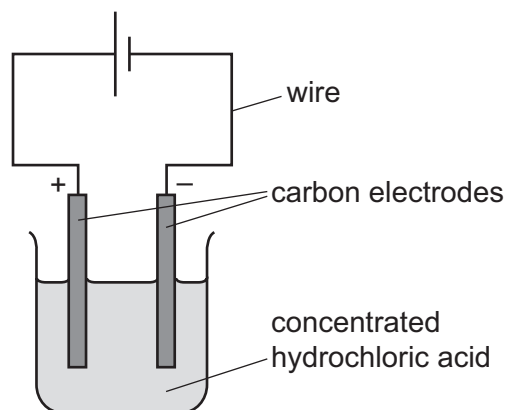
- (e) Write the chemical equation to show the action of heat on sodium nitrate, NaNO_3 .

..... [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.

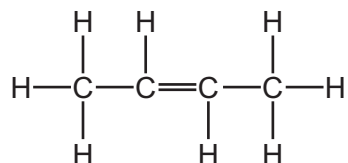
(a) State the term used for a 'family' of similar compounds.

..... [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

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3 Li lithium 7	4 Be beryllium 9	Key atomic number atomic symbol name relative atomic mass										9 F fluorine 19	10 Ne neon 20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
11 Na sodium 23	12 Mg magnesium 24	1 H hydrogen 1	5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	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 —	118 Og oganesson —	119 Uu ununennium —	120 Uub ununbium —	121 Uut ununtrium —	122 Uuq ununquadium —	123 Uubh ununhexium —	124 Uuhc ununheptium —	125 Uuhf ununfluctium —	126 Uuis ununseptium —	127 Uuql ununquadium —	128 Uuqo ununoctium —	129 Uus ununseptium —	130 Uuql ununquadium —	131 Uuqo ununoctium —	132 Uus ununseptium —	133 Uuql ununquadium —	134 Uuqo ununoctium —	135 Uus ununseptium —	136 Uuql ununquadium —	137 Uuqo ununoctium —	138 Uus ununseptium —	139 Uuql ununquadium —	140 Uuqo ununoctium —	141 Uus ununseptium —	142 Uuql ununquadium —	143 Uuqo ununoctium —	144 Uus ununseptium —	145 Uuql ununquadium —	146 Uuqo ununoctium —	147 Uus ununseptium —	148 Uuql ununquadium —	149 Uuqo ununoctium —	150 Uus ununseptium —	151 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ununquadium —	509 Uuqo ununoctium —	510 Uus ununseptium —	511 Uuql ununquadium —	512 Uuqo ununoctium —	513 Uus ununseptium —	514 Uuql ununquadium —	515 Uuqo ununoctium —	516 Uus ununseptium —	517 Uuql ununquadium —	518 Uuqo ununoctium —	519 Uus ununseptium —	520 Uuql ununquadium —	521 Uuqo ununoctium —	522 Uus ununseptium —	523 Uuql ununquadium —	524 Uuqo ununoctium —	525 Uus ununseptium —	526 Uuql ununquadium —	527 Uuqo ununoctium —	528 Uus ununseptium —	529 Uuql ununquadium —	530 Uuqo ununoctium —	531 Uus ununseptium —	532 Uuql ununquadium —	533 Uuqo ununoctium —	534 Uus ununseptium —	535 Uuql ununquadium —	536 Uuqo ununoctium —	537 Uus ununseptium —	538 Uuql ununquadium —	539 Uuqo ununoctium —	540 Uus ununseptium —	541 Uuql ununquadium —	542 Uuqo ununoctium —	543 Uus ununseptium —	544 Uuql ununquadium —	545 Uuqo ununoctium —	546 Uus ununseptium —	547 Uuql ununquadium —	548 Uuqo ununoctium —	549 Uus ununseptium —	550 Uuql ununquadium —	551 Uuqo ununoctium —	552 Uus ununseptium —	553 Uuql ununquadium —	554 Uuqo ununoctium —	555 Uus ununseptium —	556 Uuql ununquadium —	557 Uuqo ununoctium —	558 Uus ununseptium —	559 Uuql ununquadium —	560 Uuqo ununoctium —	561 Uus ununseptium —	562 Uuql ununquadium —	563 Uuqo ununoctium —	564 Uus ununseptium —	565 Uuql ununquadium —	566 Uuqo ununoctium —	567 Uus ununseptium —	568 Uuql ununquadium —	569 Uuqo ununoctium —	570 Uus ununseptium —	571 Uuql ununquadium —	572 Uuqo ununoctium —	573 Uus ununseptium —	574 Uuql ununquadium —	575 Uuqo ununoctium —	576 Uus ununseptium —	577 Uuql ununquadium —	578 Uuqo ununoctium —	579 Uus ununseptium —	580 Uuql ununquadium —	581 Uuqo ununoctium —	582 Uus ununseptium —	583 Uuql ununquadium —	584 Uuqo ununoctium —	585 Uus ununseptium —	586 Uuql ununquadium —	587 Uuqo ununoctium —	588 Uus ununseptium —	589 Uuql ununquadium —	590 Uuqo ununoctium —	591 Uus ununseptium —	592 Uuql ununquadium —	593 Uuqo ununoctium —	594 Uus ununseptium —	595 Uuql ununquadium —	596 Uuqo ununoctium —	597 Uus ununseptium —	598 Uuql ununquadium —	599 Uuqo ununoctium —	600 Uus ununseptium —	601 Uuql ununquadium —	602 Uuqo ununoctium —	603 Uus ununseptium