

## **Cambridge IGCSE**<sup>™</sup>

CANDIDATE NAME					
CENTRE NUMBER			CANDIDATE NUMBER		

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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[Turn over

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

		copper	
(a)		swer the questions using the list of elements. Each element may be used once, more that be or not at all.	an
	Ide	ntify:	
	(i)	a non-metal	
	(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]
			[1]
(b)	Nar	me the main ores of:	
	(i)	zinc	[1]
	(ii)	aluminium	[1]
(c)		an experiment, a sample of aluminium appeared less reactive than expected.	
		······································	
			[1]

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2	(d)		me <b>two</b> metals from the list which are extracted by reduction of their ores using carbon.
(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.  (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		1	
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	
(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			
(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		(i)	Name the red-pink solid.
(iii) Explain, in terms of particles, why the rate of this reaction increases when the temperature is increased.  [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			[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		(ii)	Name the colourless solution.
is increased.			[1]
(iv) Suggest two other ways of increasing the rate of this reaction.  1	(	iii)	
(iv) Suggest two other ways of increasing the rate of this reaction.  1			
(iv) Suggest two other ways of increasing the rate of this reaction.  1			
(iv) Suggest two other ways of increasing the rate of this reaction.  1			
(iv) Suggest two other ways of increasing the rate of this reaction.  1			
(iv) Suggest two other ways of increasing the rate of this reaction.  1			
1			[3]
2[2]	(	iv)	Suggest two <b>other</b> ways of increasing the rate of this reaction.
[2]			1
HOIAL IOI			[Total: 18]

2	This qu	estion is about co	opper and its co	ompounds.			
	(a) Co	pper has two diffe	erent naturally o	occurring atom	s, <sup>63</sup> Cu and <sup>65</sup> C	u.	
	(i)	State the term u	sed for atoms	of the same el	ement with diff	erent nucleon number	rs.
							[1]
	(ii)	The atomic num	ber of copper i	s 29.			
		Complete the ta of copper show		number of pro	otons, neutrons	and electrons in the	particles
				<sup>63</sup> Cu	<sup>65</sup> Cu <sup>2+</sup>		
			protons				
			neutrons				
			electrons				
							[3]
	(iii)	Relative atomic	mass is the av	erage mass of	naturally occu	rring atoms of an eler	nent.
		The percentage	of the naturally	y occurring ato	ms in a sample	e of copper is shown.	
			6	65Cu 65Cu			
				70% 30%			
		Deduce the rela	tive atomic ma	ss of copper in	this sample.		
		Give your answ	er to <b>one</b> decin	nal place.			
				re	lative atomic n	nass =	[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					
	(ii)	Complete the chemical equation to show the reaction that takes place.					
		$CuSO_4 + \dots \Leftrightarrow CuSO_4 \circ 5H_2O$ [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)	Aqu	ueous copper(II) sulfate contains Cu²+(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 ( $\mathrm{II}$ ) 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.										

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

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

Use the following steps:

•	calculate	the mass	of one	mole o	of Cu	$I(NO_3)_3$
---	-----------	----------	--------	--------	-------	-------------

.....g

 $\bullet \quad \text{calculate the number of moles of } \mathrm{Cu}(\mathrm{NO_3})_2 \, \mathrm{used} \\$ 

..... moles

determine the number of moles of nitrogen dioxide formed

..... moles

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

..... dm³

(e) Write the chemical equation to show the action of heat on sodium nitrate, NaNO<sub>3</sub>.

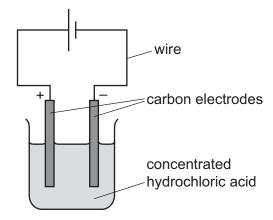
.....[2]

[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.

......C
$$l^{-}(aq) \rightarrow ......(g) + .....e^{-}$$
 [2]

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

	 [1 <sup>-</sup>

(b) Describe what is seen at the cathode.

[1]
-----

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

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 141

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

<b>(!)</b>	0		-4.41	
(1)	Suggest the pr	i of the electrolyte	e at the beginning	of the experiment.

۲1	11
ין	η,

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

Explain your answer.

(e)	The electrolysis is repeated using molten lead(II) bromide.
	Describe what is seen at the:
	• cathode
	• anode.
	[2]
(f)	State <b>two</b> properties of graphite (carbon) which make it suitable for use as an electrode.
	1
	2[2]
	[ <sup>2</sup> ]
	[Total: 13]

- 4 Chalcopyrite, FeCuS<sub>2</sub>, 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<sub>2</sub>, iron(III) oxide and copper(II) oxide.

Complete the chemical equation for the reaction of FeCuS<sub>2</sub> with oxygen.

$$4FeCuS_2 + 13O_2 \rightarrow \dots + \dots + \dots + \dots$$
 [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	f an ed	quilibrium.
-----	-----------	-------------	---------	-------------

1	l	• •
2		

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

  - pressure ......[2]
- (iii) Name the catalyst used.

(iv) Explain why a catalyst is used.

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

ro

(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<sub>6</sub>H<sub>12</sub>O<sub>6</sub>.

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

[Total: 12]

[2]

	s and carboxylic acids are both families of similar compounds with similar chemical properties. s and carboxylic acids have different reactions.
(a) Sta	te the term used for a 'family' of similar compounds.
	[1]
(b) Sta	te the general formula of alkenes.
	[1]
( <b>c</b> ) The	e structure of but-2-ene is shown.
	H H H 
(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
(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.

structure

(d)	But	anoic acid, CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> 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, $Na_2CO_3$ .
		$2CH_3CH_2COOH + Na_2CO_3 \rightarrow \dots + \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

	<b>=</b>	2 He	helium 4	10	Ne	neon 20	18	Ā	argon 40	36	궃	krypton 84	54	Xe	xenon 131	98	R	radon			
	=			6	ш	fluorine 19	17	ľ	chlorine 35.5	35	Ŗ	bromine 80	53	Н	iodine 127	85	¥	astatine -			
	5			8	0	oxygen 16	16	ഗ	sulfur 32	34	Se	selenium 79	52	<u>e</u>	tellurium 128	84	Ъ	molod –	116	^	livemorium –
	>			7	z	nitrogen 14	15	₾	phosphorus 31	33	As	arsenic 75	51	Sb	antimony 122	83	<u>.</u>	bismuth 209			
	≥			9	ပ	carbon 12	14	S	silicon 28	32	Ge	germanium 73	50	Sn	tin 119	82	Pb	lead 207	114	Εl	flerovium -
	≡			5	Δ	boron 11	13	Αſ	aluminium 27	31	Ga	gallium 70	49	In	indium 115	81	11	thallium 204			
										30	Zn	zinc 65	48	පි	cadmium 112	80	Ĥ	mercury 201	112	ű	copernicium -
										59	J.	copper 64	47	Ag	silver 108	79	Αn	gold 197	111	Rg	roentgenium -
Group										28	Z	nickel 59	46	Pd	palladium 106	78	£	platinum 195	110	Ds	damstadtium -
ğ				,						27	ပိ	cobalt 59	45	몬	rhodium 103	77	i	iridium 192	109	Μ̈́	meitnerium -
		- I	hydrogen 1							26	Pe	iron 56	44	Ru	ruthenium 101	9/	Os	osmium 190	108	Hs	hassium -
							1			25	Mn	manganese 55	43	ပ	technetium -	75	Re	rhenium 186			bohrium –
				_	loqu	lass				24	ပ်	chromium 52	42	Mo	molybdenum 96	74	≥	tungsten 184	106	Sg	seaborgium -
			Key	atomic number	atomic symbo	name relative atomic mass				23	>	vanadium 51	41	g	niobium 93	73	<u>⊐</u>	tantalum 181	105	Вр	dubnium –
					atc	ē				22	i=	titanium 48	40	Zr	zirconium 91	72	Ξ	hafnium 178	104	峜	rutherfordium -
										21	Sc	scandium 45	39	>	yttrium 89	57–71	lanthanoids		89–103	actinoids	
	=			4	Be	beryllium 9	12	Mg	magnesium 24	20	Ca	calcium 40	38	ഗ്	strontium 88	56	Ba	barium 137	88	Ra	radium -
	_			8	=	lithium 7	11	Na	sodium 23	19	×	potassium 39	37	&	rubidium 85	92	CS	caesium 133	87	ъ́	francium

7.1	Γn	lutetium	175	103	۲	lawrencium	ı
	ХÞ					_	
69	H	thulium	169	101	Md	mendelevium	ı
89	ш	erbinm	167	100	Fm	ferminm	1
29	웃	holmium	165	66	Es	einsteinium	ı
99	Dy	dysprosium	163	86	ర్	californium	ı
99	Tp	terbium	159	26	Ř	berkelium	ı
64	В	gadolinium	157	96	Cm	curium	ı
63	En	europium	152	92	Am	americium	ı
62	Sm	samarium	150	94	Pu	plutonium	ı
61	Pm	promethium	ı	93	ď	neptunium	ı
09	ρN	neodymium	144	92	$\supset$	uranium	238
59	Ā	praseodymium	141	91	Ра	protactinium	231
58	Ce	cerium	140	06	Ч	thorium	232
57	Га	lanthanum	139	68	Ac	actinium	ı

lanthanoids

actinoids

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