

# Cambridge IGCSE<sup>™</sup>

CANDIDATE NAME					
CENTRE NUMBER			CANDIDATE NUMBER		

CHEMISTRY

Paper 4 Theorem

0620/41

Paper 4 Theory (Extended)

May/June 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.



1

Giv	re the name of the process that is used:	
(a)	to produce ammonia from nitrogen	
		[1]
(b)	to separate nitrogen from liquid air	
		[1]
(c)	to produce bromine from molten lead(II) bromide	
		[1]
(d)	to separate an undissolved solid from an aqueous solution	
		[1]
(e)	to produce amino acids from proteins	
		[1]
(f)	to separate a mixture of amino acids.	
` '		[1]
	[Total	l: 6]

## **2** Complete the table to:

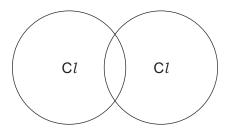
- deduce the number of protons, electrons and neutrons in the magnesium atom and copper ion shown
- identify the atom or ion represented by the final row.

	number of protons	number of electrons	number of neutrons
<sup>25</sup> Mg	12		
<sup>65</sup> Cu <sup>2+</sup>			36
	17	18	20

[Total: 5]

Pota	assium reacts with chlorine to form potassium chloride, KC <i>l</i> .	
(a)	Write a chemical equation for this reaction.	
		[2]
(b)	Potassium chloride is an ionic compound.	
	Complete the diagram to show the electron arrangement in the outer shells of the ions presin potassium chloride.	ent
	Give the charges on both ions.	
		[3]
(c)	Molten potassium chloride undergoes electrolysis.	
	(i) State what is meant by the term <i>electrolysis</i> .	
		[2]
(	(ii) Name the products formed at the positive electrode (anode) and negative electro (cathode) when molten potassium chloride undergoes electrolysis.	
	anode	
	cathode	
		[2]
(d)	Concentrated aqueous potassium chloride undergoes electrolysis.	
()	(i) Write an ionic half-equation for the reaction at the negative electrode (cathode).	
		[0]
(	(ii) Name the product formed at the positive electrode (anode).	[2]
		[1]
(	iii) Name the potassium compound that remains in the solution after electrolysis.	
		[1]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of chlorine,  ${\rm C} l_2$ . Show the outer electrons only.



[1]

(f) The melting points and boiling points of chlorine and potassium chloride are shown.

	melting point /°C	boiling point /°C
chlorine	-101	<b>–</b> 35
potassium chloride	770	1500

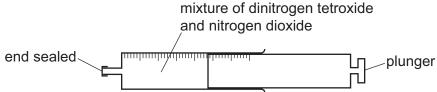
(i)	Deduce the physical state of chlorine at –75 °C. Use the data in the table to explain you answer.
	physical state
	explanation
	[2
(ii)	Explain, in terms of structure and bonding, why potassium chloride has a much higher melting point than chlorine.
	Your answer should refer to the:  • types of particle held together by the forces of attraction  • types of forces of attraction between particles  • relative strength of the forces of attraction.

[Total: 19]

	4	Dinitrogen tetroxide,	$N_2O_4$	decomposes	into nitrogen	dioxide, NO	ه. The	reaction	is reversible
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$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$
 colourless gas brown gas

A gas syringe containing a mixture of dinitrogen tetroxide and nitrogen dioxide gases was sealed and heated. After reaching equilibrium the mixture was a pale brown colour.



(a)	Sta	te what is meant by the term <i>equilibrium</i> .
		[2]
(b)	initi	plunger of the gas syringe is pushed in. The temperature does not change. The mixture ally turns darker brown. After a few seconds the mixture turns lighter brown because the illibrium shifts to the left.
		$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ colourless gas brown gas
	(i)	Explain why the mixture initially turns darker brown.
		[1]
	(ii)	Explain why the position of equilibrium shifts to the left.
		[1]
(c)	The	forward reaction is endothermic.
	(i)	State what happens to the position of equilibrium when the temperature of the mixture is increased.
		[1]
	(ii)	State what happens to the rate of the forward reaction and the rate of the backward reaction when the temperature of the mixture is increased.
		rate of the forward reaction
		rate of the backward reaction
		[2]

[Total: 7]

5 This question is about salts.
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- (a) Salts that are insoluble in water are made by precipitation.
  - $\mbox{Lead(II) iodide, PbI}_{\mbox{\scriptsize 2}}\mbox{, is insoluble in water.}$
  - All nitrates are soluble in water.
  - All sodium salts are soluble in water.

You are provided with solid lead(II) nitrate, Pb(NO<sub>3</sub>)<sub>2</sub>, and solid sodium iodide, NaI.

Describe how you would make a pure sample of lead(II) iodide by precipitation.

Your answer should include	Your	answer	should	include
----------------------------	------	--------	--------	---------

•	practical	details
-	practical	actanc

(b)

•	practical details a chemical equation for the precipitation reaction.
	[5]
Nitra	ates decompose when heated.
(i)	When hydrated zinc nitrate is heated, oxygen gas is given off.
	Describe a test for oxygen.
	test
	observations[2]

(ii) Complete the equation for the decomposition of hydrated zinc nitrate.

$$2Zn(NO_3)_2 \cdot 6H_2O \rightarrow .....ZnO + .....NO_2 + O_2 + .....H_2O$$
 [2]

When hydrated sodium sulfate crystals, Na<sub>2</sub>SO<sub>4</sub>•**x**H<sub>2</sub>O, are heated, they give off water.

$$Na_2SO_4$$
• $\textbf{x}H_2O(s) \rightarrow Na_2SO_4(s) + \textbf{x}H_2O(g)$ 

A student carries out an experiment to determine the value of  ${\it x}$  in Na $_2$ SO $_4$ • ${\it x}$ H $_2$ O.

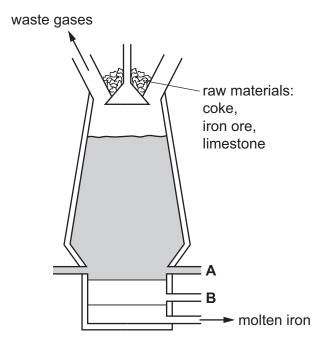
- **step 1** Hydrated sodium sulfate crystals are weighed.
- **step 2** The hydrated sodium sulfate crystals are then heated.
- **step 3** The remaining solid is weighed.

(i)	Describe how the student can check that all the water has been given off.
	[2]

(ii)	In an experiment, 1.61g of $Na_2SO_4 \cdot xH_2O$ is heated until all the mass of $Na_2SO_4$ remaining is 0.71g.	water is given off. The
	$[M_r: Na_2SO_4, 142; H_2O, 18]$	
	Determine the value of $\boldsymbol{x}$ using the following steps.	
	<ul> <li>Calculate the number of moles of Na<sub>2</sub>SO<sub>4</sub> remaining.</li> </ul>	
	• Calculate the mass of $H_2O$ given off.	mol
		g
	<ul> <li>Calculate the number of moles of H<sub>2</sub>O given off.</li> </ul>	
	Determine the value of <i>x</i> .	mol
		<b>x</b> =[4]

- 6 This question is about iron.
  - (a) Iron is extracted from its main ore in a blast furnace.

(i) Name the main ore of iron used in the blast furnace.



	(ii)	Name the substance that enters the blast furnace at <b>A</b> .	[1]
			[1]
(	(iii)	Name the substance that leaves the blast furnace at <b>B</b> .	[1]
(	(iv)	Give <b>two</b> reasons for using coke in the blast furnace.	
		1	
		2	
			[2]
(b)	And	other ore of iron is iron pyrites, $FeS_2$ . Iron pyrites contains the positive ion, $Fe^{2+}$ .	
	Dec	duce the formula of the negative ion in FeS <sub>2</sub> .	

......[1]

(c) Iron is a transition element.

A list of properties of iron is shown.

- Iron is a good conductor of electricity.
- Iron forms soluble salts.
- Iron forms coloured compounds.
- Iron has variable oxidation states.
- Iron acts as a catalyst.
- Iron forms a basic oxide.

(i)	Give <b>two</b> properties from the list in which iron differs from Group I elements.	

1	
2	
	[2]
Give <b>two</b> properties from the list in which iron is similar to Group I elements.	
1	

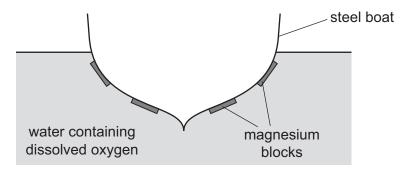
[2]

(d) Steel consists mainly of iron.

(ii)

Iron forms rust when it reacts with water and oxygen.

Magnesium blocks can be attached to the bottom of steel boats. The magnesium does not completely cover the steel.



(i)	Explain how the magnesium blocks prevent iron from rusting.

	Explain wottom of	_	_	sium	blocks	with	copper	blocks	will	not	prevent	the
-		 	 									[1]
											[Total:	131

7

Ma	ny organic compounds contain carbon, hydrogen and oxygen only.	
(a)	An organic compound ${f V}$ has the following composition by mass.	
	C, 48.65%; H, 8.11%; O, 43.24%	
	Calculate the empirical formula of compound <b>V</b> .	
	empirical formula =	[2]
	empincariornidia –	[၁]
(b)	Compound ${\bf W}$ has the empirical formula ${\rm CH_4O}$ and a relative molecular mass of 32.	
	Calculate the molecular formula of compound <b>W</b> .	
	molecular formula =	[4]
	molecular lormula –	ניו
(c)	Compounds <b>X</b> and <b>Y</b> have the same general formula.	
	<b>X</b> and <b>Y</b> are both carboxylic acids.	
	Compound <b>X</b> has the molecular formula $C_2H_4O_2$ .	
	Compound $\mathbf{Y}$ has the molecular formula $\mathrm{C_4H_8O_2}$ .	
	(i) Deduce the general formula of compounds <b>X</b> and <b>Y</b> .	
		[1]

(ii)	Draw the structure of compound <b>Y</b> . Show all of the atoms and all of the bonds.	
	Name compound Y.	
	name	
		[3]
(iii)	Give the name used to describe a 'family' of similar compounds with the same gene formula, similar chemical properties and the same functional group.	ral
		[1]
( <b>d)</b> Pro	opene is an unsaturated hydrocarbon. The formula of propene is shown.	
	CH <sub>3</sub> CH=CH <sub>2</sub>	
(i)	State the colour change observed when propene is added to aqueous bromine.	
	from to	[1]
(ii)	Propene can be produced by cracking long chain alkanes.	
	Pentadecane, C <sub>15</sub> H <sub>32</sub> , is cracked to produce an alkane and propene in a 1:2 molar ratio	0.
	Complete the chemical equation for this reaction.	
		[2]
/iii\		[~]
(iii)	Propene can be converted into poly(propene).	,
	Name the type of polymerisation that occurs when propene is converted into poly(propen	,
		[1]
(iv)	Complete the diagram to show a section of poly(propene).	
	Ĭ Ĭ Ĭ	
		[2]

[Total: 15]

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The Periodic Table of Elements

								Gro	Group								
=												≡	2	>	5	=>	₹
							- エ										2 He
Key	Key	Key	Key				hydrogen 1										helium 4
4 atomic number	atomic number	atomic number	omic number									2	9	7	80	6	10
Be atomic symbol	atomic symbol	atomic symbol	nic symbol	$\overline{g}$								Ω	ပ	Z	0	ш	Ne
beryllium name 9 relative atomic mass	name relative atomic mass	name relative atomic mass	name ive atomic mass	SS								boron 11	carbon 12	nitrogen 14	oxygen 16	fluorine 19	neon 20
12												13	14	15	16	17	18
Mg												Αl	S	۵	ഗ	Cl	Ā
magnesium 24												aluminium 27	silicon 28	phosphorus 31	sulfur 32	chlorine 35.5	argon 40
21 22 23	22 23	23		24		25	26	27	28	29	30	31	32	33	34	38	36
>   i	> =	>		ပ်	_	Mn	Fe	ပိ	z	Cn	Zu	Ga	Ge	As	Se	ğ	궃
calcium         scandium         titanium         vanadium         chromium           40         45         48         51         52	titanium vanadium 6	vanadium 51		chromit 52	Ę	manganese 55	iron 56	cobalt 59	nickel 59	copper 64	zinc 65	gallium 70	germanium 73	arsenic 75	selenium 79	bromine 80	krypton 84
39 40 41	40 41	41		42		43	44	45	46	47	48	49	20	51	52	53	54
Y Zr Nb	Zr Nb	Q Q		Ĭ	0	ပ	R	格	Pd	Ag	g	In	Sn	Sb	<u>a</u>	н	Xe
strontium         yttrium         zirconium         niobium         molybdenum           88         89         91         93         96	zirconium niobium 91 93	niobium 93		molybde 96	mnu	technetium -	ruthenium 101	rhodium 103	palladium 106	silver 108	cadmium 112	indium 115	tin 119	antimony 122	tellurium 128	iodine 127	xenon 131
57–71 72 73	72 73	73		1/2	<u>_</u>	75	92	77	78	79	80	81	82	83	84	85	98
lanthanoids Hf Ta	HTTa	Та		>	>	Re	Os	Ľ	₹	Αn	Нg	ll L	Pp	<u>B</u>	Ъ	Ą	R
hafnium tantalum 178 181	tantalum 181	tantalum 181		tung	gsten 84	rhenium 186	osmium 190	iridium 192	platinum 195	gold 197	mercury 201	thallium 204	lead 207	bismuth 209	moloum —	astatine -	radon
89–103 104 105	104 105	105			90	107	108	109	110	111	112		114		116		
actinoids Rf Db	Rf	Db		0,	Sg	Bh	Hs	¥	Ds		ű		F1				
radium rutherfordium dubnium seab	dubnium	dubnium		seab	seaborgium	bohrium	hassium	meitnerium -	darmstadtium	0	copernicium		flerovium		livermorium		
ı	ı	_			_ 	ı	-	ı	ı		ı		ı		I		

71	Γn	lutetium	175	103	۲	lawrencium	I
	Υp	^				_	
69	Tm	thulium	169	101	Md	mendelevium	I
89	ш	erbinm	167	100	Fm	ferminm	1
29	웃	holmium	165	66	Es	einsteinium	ſ
99	۵	dysprosium	163	86	ర్	californium	1
65	q	terbium	159	97	BK	berkelium	1
64	Gd	gadolinium	157	96	Cm	curium	1
63	En	europium	152	92	Am	americium	1
62	Sm	samarium	150	94	Pu	plutonium	I
61	Pm	promethium	ı	93	d N	neptunium	1
09	pN	neodymium	144	92	$\supset$	uranium	238
29	Ā	praseodymium	141	91	Ра	protactinium	231
28	Ce	cerium	140	06	┖	thorium	232
57	Га	lanthanum	139	89	Ac	actinium	I

lanthanoids

actinoids

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