

Cambridge IGCSE[™]

CANDIDATE NAME					
CENTRE NUMBER			CANDIDATE NUMBER		

CHEMISTRY 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	e 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	
	[10tal	. 0]

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
²⁵ Mg	12		
⁶⁵ Cu ²⁺			36
	17	18	20

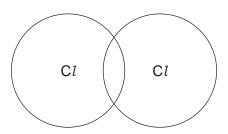
[Total: 5]

Potassium reacts with chlorine to form potassium chloride, KC1.

3

(a)	Wri	te a chemical equation for this reaction.	[2]
			[4]
(b)	Pot	assium chloride is an ionic compound.	
		nplete the diagram to show the electron arrangement in the outer shells of the ions present otassium chloride.	ent
	Giv	e the charges on both ions.	
			[2]
(-)	N / - I		[3]
(c)		ten potassium chloride undergoes electrolysis.	
	(i)	State what is meant by the term <i>electrolysis</i> .	
			[0]
	(ii)	Name the products formed at the positive electrode (anode) and negative electro (cathode) when molten potassium chloride undergoes electrolysis.	[2] ode
		anode	
		cathode	[2]
(d)	Cor	ncentrated 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)	omplete the dot-and-cross diagram to show the electron arrangement in a molecule of)
	nlorine, Cl_2 .	
	how 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	-35
potassium chloride	770	1500

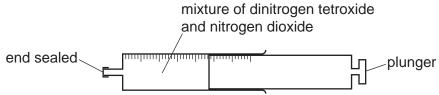
(1)	answer.	our
	physical state	
	explanation	
		 [2]
(ii)	Explain, in terms of structure and bonding, why potassium chloride has a much high melting point than chlorine.	
	Your answer should refer to the: • types of particle held together by the forces of attraction • types of forces of attraction between particles • relative strength of the forces of attraction.	
		[3]

[Total: 19]

4	Dinitrogen tetroxide,	N ₂ O ₄ , decom	poses into nitroger	n dioxide, NO ₂	. 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 ilibrium 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.
	(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]

[2]

5 This question is about salts	5	This	question	is	about	salts
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(b)

- (a) Salts that are insoluble in water are made by precipitation.
 - Lead(II) iodide, PbI₂, 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, $Pb(NO_3)_2$, and solid sodium iodide, NaI.

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

Your	answer	should	include:

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

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

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

observations

(c) Some sulfates are hydrated.

When hydrated sodium sulfate crystals, Na₂SO₄•**x**H₂O, are heated, they give off water.

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

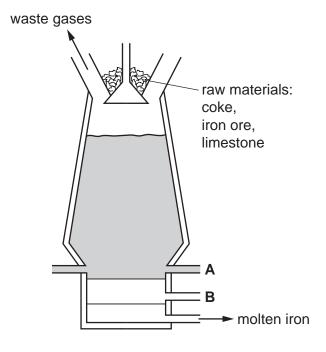
A student carries out an experiment to determine the value of $\textbf{\textit{x}}$ in Na₂SO₄• $\textbf{\textit{x}}$ H₂O.

- **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 ₂ SO ₄ • x H ₂ O is heated until all the mass of Na ₂ SO ₄ remaining is 0.71g.	water is given off. The
	[<i>M</i> _r : Na ₂ SO ₄ ,142; H ₂ O,18]	
	Determine the value of x using the following steps.	
	 Calculate the number of moles of Na₂SO₄ remaining. 	
		mol
	 Calculate the mass of H₂O given off. 	
		_
		g
	 Calculate the number of moles of H₂O given off. 	
		mol
	 Determine the value of x. 	
		X =
		[4]
		[Total: 15]

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



	(1)	Name the main ore of iron used in the blast furnace.	
			[1]
	(ii)	Name the substance that enters the blast furnace at A .	
			[1]
((iii)	Name the substance that leaves the blast furnace at B .	
			[1]
((iv)	Give two 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⁺ .	

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Deduce the formula of the negative ion in FeS_2 .

[2]

(c)	Iron	is a	transition	element.
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A list of properties of iron is shown.

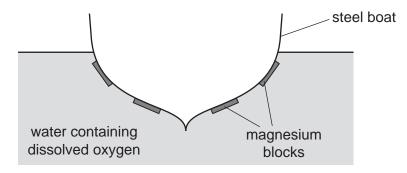
- Iron is a good conductor of electricity.
- Iron forms soluble salts.
- Iron forms coloured compounds.
- Iron has variable oxidation states.
- Iron acts as a catalyst.
- Iron forms a basic oxide.

(i)	Give two properties from the list in which iron differs from Group I elements.	
	1	
	2	
		[2
(ii)	Give two properties from the list in which iron is similar to Group I elements.	

(d) Steel consists mainly of iron.

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 why replacing the magnesium blocks with copper blocks will not prevent the bottom of the boat from rusting.	i)	(ii)
[1]		
[Total: 13]		

7

Mai	ny organic compounds contain carbon, hydrogen and oxygen only.	
(a)	An organic compound V has the following composition by mass.	
	C, 48.65%; H, 8.11%; O, 43.24%	
	Calculate the empirical formula of compound V.	
	and initial forwards	·01
	empirical formula = [3]
(b)	Compound W has the empirical formula CH ₄ O and a relative molecular mass of 32.	
	Calculate the molecular formula of compound W .	
	molecular formula = [41
	molecular lormula –	']
(c)	Compounds X and Y have the same general formula.	
	X and Y are both carboxylic acids.	
	Compound ${\bf X}$ has the molecular formula ${\bf C_2H_4O_2}$.	
	Compound \mathbf{Y} has the molecular formula $C_4H_8O_2$.	
	(i) Deduce the general formula of compounds X and Y.	
	[[1]

	17	
(ii)	Draw the structure of compound Y. 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]
(d) Pro	opene is an unsaturated hydrocarbon. The formula of propene is shown.	
	CH ₃ CH=CH ₂	
(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 ₁₅ H ₃₂ , is cracked to produce an alkane and propene in a 1:2 molar ratio	Э.
	Complete the chemical equation for this reaction.	
	$C_{15}H_{32} \rightarrow \dots + \dots$	[2]
(iii)	Propene can be converted into poly(propene).	
	Name the type of polymerisation that occurs when propene is converted into poly(propen	e).
		[1]

(iv) Complete the diagram to show a section of poly(propene).



[2]

[Total: 15]

15

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The Periodic Table of Elements

	=	2 He	helium 4	10	Ne	neon 20	18	Ar	argon 40	36	궃	krypton 84	54	Xe	xenon 131	98	Ru	radon			
	=			6	ш	fluorine 19	17	Cl	chlorine 35.5	35	ğ	bromine 80	53	Н	iodine 127	85	Ą	astatine -			
	5			80	0	oxygen 16	16	ഗ	sulfur 32	34	Se	selenium 79	52	<u>e</u>	tellurium 128	84	Ъ	moloud –	116		livermorium –
	>			7	z	nitrogen 14	15	۵	phosphorus 31	33	As	arsenic 75	51	Sp	antimony 122	83	Ξ	bismuth 209			
	≥			9	ပ	carbon 12	14	S	silicon 28	32	Ge	germanium 73	50	Sn	tin 119	82	Pb	lead 207	114	Fl	flerovium -
	=			2	В	boron 11	13	Αl	aluminium 27	31	Ga	gallium 70	49	In	indium 115	18	11	thallium 204			
										30	Zu	zinc 65	48	S	cadmium 112	80	Hg	mercury 201	112	ű	copernicium -
										59	Cn	copper 64	47	Ag	silver 108	62	Αu	gold 197	111	Rg	roentgenium -
dn										28	Z	nickel 59	46	Pq	palladium 106	78	Ŧ	platinum 195	110	Ds	darmstadtium -
Group										27	ပိ	cobalt 59	45	R	rhodium 103	77	Г	iridium 192	109	¥	meitnerium -
		- I	hydrogen 1							26	Ьe	iron 56	44	Ru	ruthenium 101	9/	Os	osmium 190	108	£	hassium
				,						25	Mn	manganese 55	43	ပ	technetium -	75	Re	rhenium 186	107	Bh	bohrium —
					loc	ISS				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>R</u>	tantalum 181	105	<u>6</u>	dubnium –
					ato	rela				22	ı=	titanium 48	40	Zr	zirconium 91	72	士	hafnium 178	104	꿒	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	Ва	barium 137	88	Ra	radium -
	_			က	:=	lithium 7	7	Na	sodium 23	19	¥	potassium 39	37	Rb	rubidium 85	55	Cs	caesium 133	87	Ē	francium -

r ₁	lutetium 175	103	۲	lawrencium -
oz Yb	ytterbium 173	102	2	nobelium –
ee Tm	thulium 169	101	Md	mendelevium —
68 Er	erbium 167	100	Fm	fermium —
67 Ho	holmium 165	66	Es	einsteinium —
°° Dy	dysprosium 163	86	₽	californium —
es Tb	terbium 159	97	Ř	berkelium —
⁵² Gd	gadolinium 157	96	Cm	curium —
e3 Eu	europium 152	92	Am	americium _
62 Sm	samarium 150	94	Pu	plutonium —
e1 Pm	promethium	93	ď	neptunium —
9N	neodymium 144	92	\supset	uranium 238
59 Pr	praseodymium 141	91	Ра	protactinium 231
Se Ce	cerium 140	06	Ч	thorium 232
57 La	lanthanum 139	88	Ac	actinium _

lanthanoids

actinoids

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

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