

ST JOSEPH'S INSTITUTION PRELIMINARY EXAMINATION 2022 (YEAR 4)

CANDIDATE NAME		
CLASS	INDEX NUMBER	
CHEMISTRY		6092/02
Paper 2		19 August 2022

Candidates answer on the Question Paper. No Additional Materials are required. 1 hour 45 minutes (10:40 – 12:25)

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in. Write in dark blue or black fluid ink pen. You may use a soft pencil for any diagrams, graphs or rough working. Do not use staples, paper clips, glue or correction fluid.

Section A

Answer all questions in the spaces provided.

Section B

Answer all **three** questions. The last question is in the form either/or. Answer **all** questions in the spaces provided.

The number of marks is given in brackets [] at the end of each question or part question.

The use of an approved scientific calculator is expected, where appropriate.

A copy of the Periodic Table is printed on **page 2**.

For Examiner's Use							
Section A	/ 50						
Section B	/ 30						
Total	/ 80						

The Periodic Table of Elements

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	0	2	не	helium	4	10	Ne	neon	R	18	Å	argon	40	36	고	krypton	8	54	×	xenon	131	86	R	radon	I				
	١١٨					6	LL.	fluorine	19	17	ci	chlorine	35.5	35	Б	bromine	8	53	I	iodine	127	85	At	astatine	I				
	М					8	0	oxygen	10	16	თ	sulfur	32	34	Se	selenium	62	52	Чe	tellurium	128	84	ይ	polonium	I	116	2	ivermorium	'
	>					7	z	nitrogen	14	15	۵.	hosphorus	31	33	As	arsenic	75	51	с	antimony	122	83	ö	bismuth	209			_	
	\geq					9	U	carbon	72	14	ល	silicon	28	32	9 0	germanium	73	20	S	tin	119	82	Ч	lead	207	114	F,	flerovium	1
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	_					33	-	lithium		,	Na	sodium	23	19	¥	potassium	39	37	å	rubidium	85	55	ပိ	caesium	133	87	Ŀ	francium	I
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02	₽ 2	ytterbi	173	102	Ž	um nobeli	I
69	۳	thulium	169	101	Md	mendelevi	I
89	ш	erbium	167	100	E	fermium	I
67	ደ	holmium	165	66	ы	einsteinium	I
99	6	dysprosium	163	86	້ວ	californium	I
65	đ	terbium	159	67	贸	berkelium	I
64	B	gadolinium	157	96	с С	curium	I
63	⊒	europium	152	95	Am	americium	I
62	Sm	samarium	150	94	Ы	plutonium	I
61	Pa	promethium	I	93	dN	neptunium	I
09	PN	neodymium	144	92	⊃	uranium	238
20	ዾ	praseodymium	141	91	Ра	protactinium	231
28	ပီ	cerium	140	6	F	thorium	232
22	La	lanthanum	139	88	Ac	actinium	I
anoids				inoids			

The volume of one mole of any gas is 24 \mbox{dm}^3 at room temperature and pressure (r.t.p.).

Section A (50 marks)

Answer all questions in this section in the spaces provided.

A1 Study the flowchart below and answer the following questions.



A2 Silicon tetrachloride, SiCl₄, and ethoxyethane, (C₂H₅)₂O, are both liquids at room temperature and pressure.

An experiment is performed to react silicon tetrachloride with ethoxyethane to produce two oxochlorides, Si_2OCl_6 and $Si_3O_2Cl_8$.

(a) (i) The temperature of the experiment is increased.

State the effect of increasing temperature on the rate of reaction. Explain your answer in terms of reacting particles.

(ii) A student suggested that the rate of reaction of the experiment can be increased by increasing the pressure.

Do you agree? Explain your answer.

.....[1]

- (b) The oxochlorides that are formed can be reacted with water to convert all the chlorine atoms in the oxochlorides into chloride ions.
 - (i) Calculate the number of moles of chloride ions produced when 1.00 g of the oxochloride, Si_2OCl_6 , completely reacts with water.

[1]

(ii) Calculate the number of moles of chloride ions produced when 1.00 g of the oxochloride, $Si_3O_2Cl_8$, completely reacts with water.

[1]

- (c) Excess aqueous silver nitrate is added separately to the solutions formed by the two different oxochlorides, Si₂OC*l*₆ and Si₃O₂C*l*₈. This helps to remove the chloride ions by forming a precipitate.
 - (i) Write an ionic equation for the formation of the precipitate.

[1]

(ii) Using your answers in (b) and (c)(i), identify the oxochloride that will produce 3.03 g of precipitate. Explain how you arrived at your answer.

.....[2]

[Total: 8]

- A3 (a) The Medupi Power Station is a coal-fired power station in South Africa. When coal is burnt in the power station, one of the pollutants formed is nitrogen dioxide.
 - (i) Describe how nitrogen dioxide is formed in the power station.

.....[1]

(ii) Analysis of soil samples in the region in close proximity to the power station showed a high nitrate ion content.

Suggest the reason for the above.

(iii) Over a period of time, marble structures near the power station were observed to be corroding.

Write the chemical equation for the reaction which resulted in the corrosion of the marble structures.

[1]

(b) The following message was displayed on the side of a bus in Singapore.

This bus is more environmentally friendly than a car.

40 cars = 230 000 kg of carbon dioxide per year

This bus = 3200 kg of carbon dioxide per year

(i) Describe the environmental problem caused by carbon dioxide.

 (ii) Using the information provided, explain how the environmental problem caused by carbon dioxide in (b)(i) can be reduced.

(c) The Haber Process is used to manufacture ammonia in the chemical industry.
 (i) State the optimum conditions used in the Haber Process.
 [1]
 (ii) Explain why the yield of ammonia produced in the Haber Process can never be 100 %.
 [1]
 [1] [Total: 10]

A4 Zinc can be obtained from zinc blende (ZnS) in a two-step process.

In Step 1, zinc blende is roasted in air and converted into zinc oxide according to the equation shown below.

 $2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$

In Step 2, the zinc oxide formed in Step 1 is then converted into zinc by reacting zinc oxide with the same gaseous reducing agent used in the extraction of iron.

(a) Explain, in terms of oxidation states, why the reaction shown in Step 1 is a redox reaction.

(b) Write the chemical equation with state symbols for the reaction in Step 2.

[2]

(c) Two iron rods are coated, one with zinc and the other with copper.

Both rods were damaged with their coating scratched when they were piled into the ground to construct a structure. The damaged iron rods were exposed to the wet ground and air.

(i) Describe what will be observed on the exposed iron surfaces of both rods after a few days.

.....[2]

(ii) Explain your answer in (c)(i).

[Total: 8]

A5 Transition metals are a block of elements in the centre of the Periodic Table. Some information about the transition metals in Period 4 are shown in the tables below.

element	Sc	Ti	V	Cr	Mn	Fe	Со	Ni	Cu	Zn
density / g/cm ³	2.99	4.50	5.96	7.20	7.20	7.86	8.90	8.90	8.92	7.14
melting point / °C	1541	1660	1890	1857	1244	1535	1495	1455	1083	420

Table 5.1

Table 5.	2
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element	Sc	Ti	V	Cr	Mn	Fe	Со	Ni	Cu	Zn
common oxidation states that occur in compounds	+3	+4 +3 +2	+5 +4 +3 +2	+6 +5 +4 +3 +2	+7 +6 +5 +4 +3 +2	+6 +5 +4 +3 +2	+4 +3 +2	+4 +3 +2	+2 +1	+2

(a) State one characteristic property of a transition metal that is not shown in both Tables 5.1 and 5.2.

.....[1]

- (b) Some scientists do not consider two of the metals found in Period 4 as transition metals.
 - (i) Name the two metals.

.....[1]

(ii) Explain your answer in (b)(i), using relevant information to support your answer.

[Total: 5]

A6 Different electrolytes were electrolysed using different electrodes as shown in the table below.

experiment	electrolyte used	cathode	anode
1	concentrated copper(II) nitrate solution	electrode used: copper product formed:	electrode used: carbon product formed: oxygen
2		electrode used: platinum	electrode used:
	zinc nitrate solution	product formed:	product formed: zinc ions

(a) Complete the table above.

(b) State two observations in Experiment 1.

 	[2]

(c) Write an ionic equation with state symbols for the reaction at the anode for Experiment 1.

[2]

(d) In both Experiments 1 and 2, gases are produced as products of electrolysis.

By naming suitable apparatus and reagents, suggest how the gases can be dried and their volumes determined.

......[2] [Total: 9]

[3]

- A7 Propene is an unsaturated hydrocarbon which is widely used as a raw material for many plastic products.
 - (a) (i) Explain what is meant by unsaturated.

(ii) Describe a chemical test to show that propene is unsaturated.
[1]
(b) Propene can be used to produce propanol.
(i) Describe how propanol can be produced from propene.

(ii) Name and draw the full structural formula of the product formed when propanol reacts with ethanoic acid.

.....[2]

[Total: 6]

Section B (30 marks)

Answer all three questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Alcohols can be classified into primary, secondary or tertiary alcohols according to the number of alkyl groups on the carbon atom to which the hydroxyl group is attached to.

An alkyl group consists of carbon and hydrogen atoms and is formed by removing one hydrogen atom from the alkane chain. An alkyl group is usually attached to a carbon chain, forming a branch. An alkyl group can be represented using \mathbf{R} .

Examples of alkyl groups can be methyl ($-CH_3$), ethyl ($-C_2H_5$), propyl ($-C_3H_7$), butyl ($-C_4H_9$), etc.

Table 8.1 below shows the different types of alcohols and their structures.

type of alcohol	no. of alkyl groups attached to the carbon atom with hydroxyl group	structure
primary	1	H
secondary	2	R R – C – OH H
tertiary	3	R R – C – OH R

Table 8.1

Some examples of the different types of alcohols are shown below.





propan-2-ol

This alcohol contains one alkyl group attached to the carbon atom with hydroxyl group, hence it is a primary alcohol. This alcohol contains two alkyl groups attached to the carbon atom with hydroxyl group, hence it is a secondary alcohol.

The boiling point of an alcohol is affected by the number of alkyl groups attached to the carbon atom with the hydroxyl group.

Table 8.2 below shows the boiling points of three different alcohols with molecular formula $C_4H_{10}O$.

alcohol	butan-1-ol	butan-2-ol	2-methylpropan-2-ol
structure	H H H H H - C - C - C - OH H H H H H H H H	H H CH₃ OH H - C - C - C - OH H H H	H CH₃ H - C - OH H - C - OH H CH₃
boiling point / °C	118	99	82

Table 8.2

Alcohols can behave as weak acids and react with sodium metal to form alkoxides and hydrogen gas.

Some examples of the reactions between alcohols and sodium metal are shown below.

2C₂H₅OH ethanol	+	2Na	→ 2C ₂ H ₅ O ⁻ Na ⁺ + sodium ethoxide	H ₂
2C₃H⁊OH propanol	+	2Na	→ 2C ₃ H ₇ O ⁻ Na ⁺ + sodium propoxide	H ₂

The acidity of an alcohol is also affected by the number of alkyl groups attached to the carbon atom with the hydroxyl group.

The strength of an acid is indicated by pK_a . The smaller the value of pK_a , the stronger the acid. The larger the value of pK_a , the weaker the acid.

Table 8.3 below shows the pK_a values of the three alcohols from Table 8.2 and a few carboxylic acids.

substance	рКа
butan-1-ol	16.1
butan-2-ol	17.6
2-methylpropan-2-ol	19.2
ethanoic acid	4.77
butanoic acid	4.82

Table 8.3

(a) Which alcohol shown in Table 8.2 is a secondary alcohol? Explain your answer.

.....

.....[1]

(b) Draw the structure of a tertiary alcohol with the molecular formula $C_5H_{12}O$.

(c)	(i)	State the trend in the boiling point and the number of alkyl groups attached to the carbon atom with the hydroxyl group in Table 8.2.	
	(ii)	[1] Suggest a reason for your answer in (c)(i) .	
<i>(</i> 1)		[1]	
(d)	State	e one similarity and one difference between the reaction of an alcohol with um compared to the reaction of a carboxylic acid with sodium.	
	Simi	larity:	
	Diffe	rence:	
		[2]	
(e)	Wha carb	t is the relationship between the number of alkyl groups attached to the on atom with the hydroxyl group and the acidity of the alcohol?	
		[1]	
(f)	Whic	ch substance from Table 8.3 will react most vigorously with sodium?	
	Explain your answer using the information provided.		
		[2]	

15

(g) Write the chemical equation for the reaction between butanol and sodium.

		[1]
(h)	Buta	noic acid can be produced from butanol using a laboratory reagent.	
	(i)	Name a suitable reagent for the above reaction.	
		[1]
	(ii)	Describe the observations for (h)(i).	
		[1]
		[Total: 1]	2]

B9 Methylamine, CH₃NH₂, is a substance with similar properties to ammonia.

The equation below shows what happens when methylamine is dissolved in water.

 $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$

(a) According to the Brønsted-Lowry theory, an acid is a species that donates a proton (H⁺) and a base is a species that accepts a proton (H⁺).

Using the equation, state whether methylamine is acting as an acid or a base.

Explain your answer.

.....[1]

.....

- (b) An aqueous solution of sodium hydroxide has pH 13.
 - (i) Predict the pH of an aqueous solution of methylamine.
 -[1]
 - (ii) Explain your answer in (b)(i).

(c) Methylamine can react with acids to form soluble salts.

The equation below shows the reaction of methylamine with hydrochloric acid.

 $CH_3NH_2 + HCl \rightarrow CH_3NH_3Cl$ methylammonium chloride

(i) Suggest the method used to prepare methylammonium chloride salt.

.....[1]

(ii) Describe how a pure and dry sample of methylammonium chloride crystals can be obtained from the salt solution obtained in (c)(i).



.....[1]

[Total: 8]

EITHER

B10 Halogens can react with hydrogen to form hydrogen halides.

The following equations show the formation of the hydrogen halides, hydrogen chloride and hydrogen fluoride.

Reaction 1: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Reaction 2: $H_2(g) + F_2(g) \rightarrow 2HF(g)$

The energy profile diagrams for Reactions 1 and 2 are also shown below.



(a) Use the Kinetic Particle Theory to describe the arrangement and movement of the particles of hydrogen chloride formed in Reaction 1.



(c) (i) Explain why the activation energies for both reactions are different.

.....[2]

(ii) Calculate the energy released during the formation of bonds for both Reactions 1 and 2.

[2]

(iii) From your results in (c)(ii), state whether the hydrogen chloride bond or hydrogen fluoride bond is stronger.

.....[1]

 (iv) Draw a dotted line on the energy profile diagram for Reaction 2 to indicate the new energy level of the product if it is cooled to liquid state.

[Total: 10]

B10 The table below shows the melting points of some compounds formed between aluminium, phosphorus, chlorine and fluorine.

substance	melting point / °C
aluminium chloride	192
aluminium fluoride	1290
phosphorus trichloride	-94
phosphorus trifluoride	-152

(a) Which compounds are most likely to have simple molecular structures?

Explain your reasoning.

.....[2]

(b) (i) Draw a 'dot-and-cross' diagram to represent the bonding in aluminium fluoride, showing only the outermost electrons.

(ii) In which states can aluminium fluoride conduct electricity?

Explain your answer.

.....[2]

[2]

OR

(iii) Predict whether aluminium oxide has a higher or lower melting point than aluminium fluoride.

Explain your answer.

(c) Explain, in terms of structure and bonding, the difference in melting points between phosphorus trichloride and phosphorus trifluoride.

[2]	
[Total: 10]	

- End of Paper -