

MARKER CODE

STUDENT ENROLMENT NUMBER (SEN)

TONGA NATIONAL FORM SEVEN CERTIFICATE

2021

CHEMISTRY

QUESTION AND ANSWER BOOKLET

Time allowed: 3 Hours

INSTRUCTIONS:

1. Write your **Student Enrolment Number (SEN)** on the top right-hand corner of this page.
2. This paper consists of **FIVE QUESTIONS** and is out of 70 Weighted scores.

QUESTION	STRANDS	TOTAL SKILL LEVEL
ONE	ATOMIC STRUCTURE, BONDING, SOLIDS AND RELATED PROPERTIES	16
TWO	KINETIC ENERGY AND NUCLEAR CHEMISTRY	11
THREE	INORGANIC AND REDOX CHEMISTRY	18
FOUR	QUANTITATIVE CHEMISTRY	17
FIVE	ORGANIC CHEMISTRY	8
TOTAL		70

3. Answer ALL QUESTIONS. Write your answers in the spaces provided in this booklet.
4. Show all workings.
5. A **Periodic Table** is provided in page 23
6. Use a **BLUE** or **BLACK** ball point pen only for writing. Use a pencil for drawing if required.
7. If you need more space for answers, ask the supervisor for extra paper. Write your **Student Enrolment Number (SEN)** on each additional sheet, number the questions clearly and insert them in the appropriate places in this booklet.
8. Check that this booklet contain pages **2 - 23** in the correct order and that page **22** has been deliberately left blank.

YOU MUST HAND IN THIS BOOKLET TO THE SUPERVISOR BEFORE YOU LEAVE THE EXAMINATION ROOM.

QUESTION ONE: ATOMIC STRUCTURE, BONDING, SOLIDS AND RELATED PROPERTIES

Part A: Atomic Structure and Bonding

Group 17 elements include fluorine F, chlorine Cl, bromine Br and iodine I.

They form compounds amongst themselves like iodine trifluoride, IF_3 and Cl_2 .

a. Name the shape of an IF_3 molecule.

Name of the shape: _____

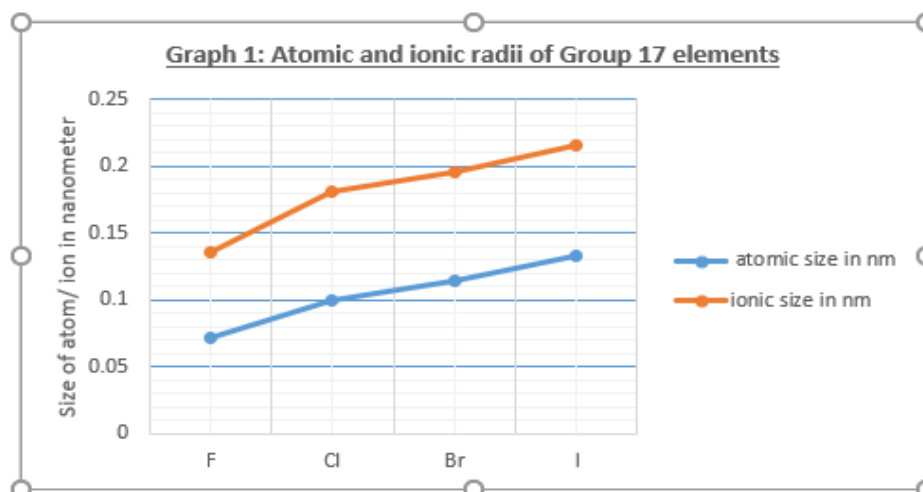
Skill level 1	
1	
0	
NR	

b. IF_3 is a polar molecule. Describe the **factors** that contribute to IF_3 being polar.

Skill level 2	
2	
1	
0	
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Use **Graph 1** below to answer c.

Graph 1 shows the atomic and ionic radius of the Group 17 elements.



[illegible]

Skill level 3	
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HF HCl HBr HI

HF HCl HBr HI

Skill level 1	
1	
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- d. **Circle** the hydride above that will **form hydrogen bonds** in solid form.
- e. Explain why solid hydrogen iodide, HI will have a **higher melting point** than solid hydrogen bromide, HBr.

[illegible]

Skill level 3	
3	
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[illegible]

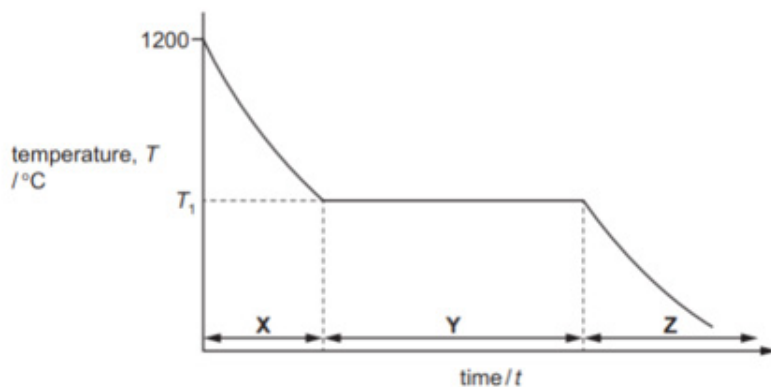
Skill level 4	
4	
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2	
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QUESTION TWO: KINETIC ENERGY AND NUCLEAR CHEMISTRY

Part A: Kinetic Chemistry

Graph 2 below shows how the temperature of a sample of substance B (with **melting point at 620°C** and **boiling point at 1298°C**) changes over time, t , as it is slowly cooled.

Graph 2



- a. Give the **states of matter** of substance B at stages **X** and **Y** of the processes shown in **Graph 2**.

X: _____

Y: _____

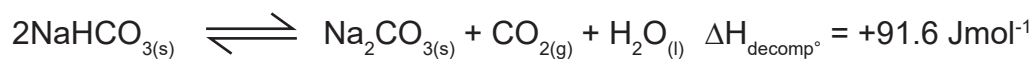
Skill level 2	
2	
1	
0	
NR	

- b. What **type of thermochemical reaction** takes place at stage Z?

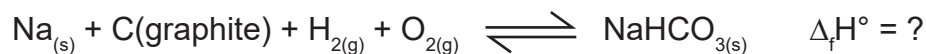
Skill level 1	
1	
0	
NR	

Part B: Thermochemistry

If solid sodium hydrogen carbonate, $\text{NaHCO}_{3(s)}$ decomposes as follows:



Apply Hess's Law to **calculate the standard enthalpy change of formation of solid sodium hydrogen carbonate**, $\Delta_f H^\circ(\text{NaHCO}_{3(s)})$



given the following standard enthalpies of formation:

$$\Delta_f H^\circ (\text{Na}_2\text{CO}_{3(s)}) = -1130.7 \text{ kJmol}^{-1}$$

$$\Delta_f H^\circ (\text{CO}_{2(g)}) = -393.5 \text{ kJmol}^{-1}$$

$$\Delta_f H^\circ (\text{H}_2\text{O}_{(l)}) = -285.8 \text{ kJmol}^{-1}$$

Skill level 3	
3	
2	
1	
0	
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Part C: Nuclear Chemistry

1. Polonium-218 is radioactive. It decays to form lead, Pb and an alpha particle.

Write a **balanced nuclear equation** that shows this decay of Polonium-218.

Skill level 2	
2	
1	
0	
NR	

2. Substance D is also radioactive.

If a sample of radioactive Substance D has an initial mass of 12 g and after 40,110 years the radioactive mass remaining is 0.09375 g, determine the **half-life** in years of Substance D.

Skill level 3	
3	
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1	
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QUESTION THREE: INORGANIC AND REDOX CHEMISTRY

Part A: Inorganic Chemistry

1. Write the chemical formula of ammonium sulphide.

Skill level 1	
1	
0	
NR	

2. Chlorine water, $\text{Cl}_{2(aq)}$, is mixed with a solution of potassium iodide, $\text{KI}_{(aq)}$ in a test tube and 2mL of chloroform, $\text{CH}_3\text{Cl}_{(l)}$ is added to the mixture.

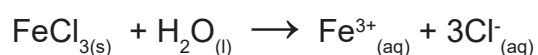


Chlorine water + Potassium iodide

Describe the **observed results**.

Skill level 2	
2	
1	
0	
NR	

3. When solid iron(III) chloride, FeCl_3 dissolves in water, a large amount of **heat is released**.



Explain how **enthalpy** and **entropy changes** drive this dissolving process.

Skill level 3	
3	
2	
1	
0	
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Part B: Transition Metals

- a. Tetrachlorocopper(II) is a complex ion.

Write a balanced equation for the formation of tetrachlorocopper(II) ion from chloride ions and copper ions.

Skill level 2	
2	
1	
0	
NR	

- b. Chloride ion, Cl^- is the **ligand** in the complex ion, tetrachlorocopper(II).

Describe the **nature** of a ligand using the chloride ion as the example.

Skill level 2	
2	
1	
0	
NR	

- c. Copper is a **transition metal** that has an oxidation number or oxidation state of +2.

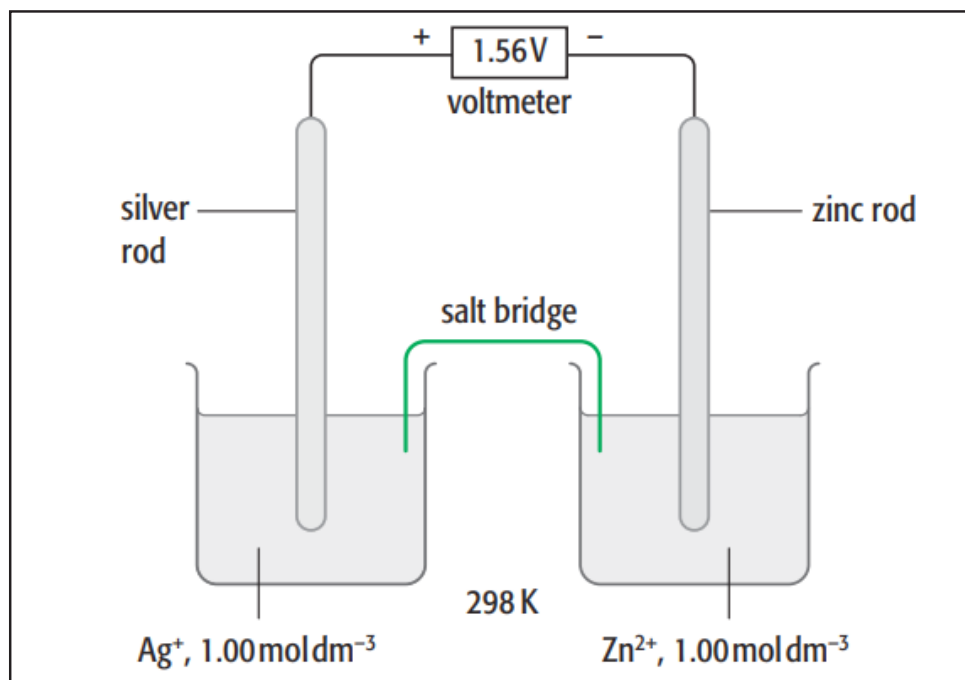
Explain why the transition metals, with the exception of Scandium, Sc, have an oxidation state of +2.

Skill level 3	
3	
2	
1	
0	
NR	

Part C: Redox Chemistry

Study and use data from **Figure 1** below and the given information to answer **a.** and **b.**

Figure 1: Electrochemical cell of two half cells, Ag/Ag⁺ and Zn/Zn²⁺ at standard conditions.



The standard electrode potential, E^0 value for the Ag/Ag⁺ half-cell, $E^0_{(\text{Ag}/\text{Ag}^+)}$ is +0.80V.

- a. Determine the **standard electrode potential** of the Zn/Zn²⁺ half-cell, $E^0_{(\text{Zn}/\text{Zn}^{2+})}$.

Include in your answer the appropriate unit.

Skill level 2	
2	
1	
0	
NR	

- b. Account for possible **observed changes** at the ANODE of the electrochemical cell.
(Use relevant equation to clarify the observed changes)

Anode half-cell reaction: _____

Observed changes: _____

Reasons for observed changes: _____

Skill level 3	
3	
2	
1	
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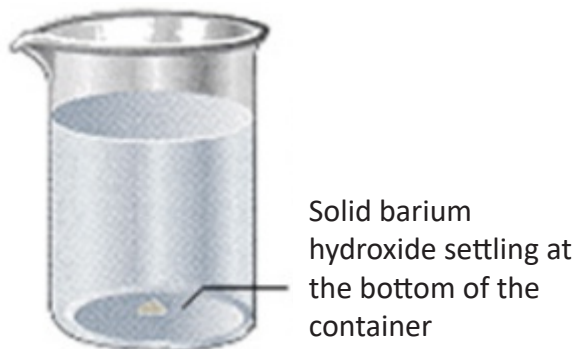
QUESTION FOUR:

QUANTITATIVE CHEMISTRY

Part A: Aqueous salt solutions

Barium hydroxide, $\text{Ba}(\text{OH})_2$ is a sparingly soluble salt.

It dissolves in water to form a saturated solution containing ions **and** a small amount of solid barium hydroxide, $\text{Ba}(\text{OH})_2$ settling at the bottom of the container.



- a. Write the solubility product expression, K_s , for $\text{Ba}(\text{OH})_2$.

Skill level 1	
1	
0	
NR	

- b. Calculate the solubility, s , in g L^{-1} of barium hydroxide, $\text{Ba}(\text{OH})_2$ in pure water given its solubility product, K_s is 5.07×10^{-3} . The molecular formula $M(\text{Ba}(\text{OH})_2) = 171 \text{ g mol}^{-1}$

Skill level 3	
3	
2	
1	
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- c. Explain the possible **observations** in the container if a small amount of concentrated hydrochloric acid, HCl is added to the saturated solution of $\text{Ba}(\text{OH})_2$.

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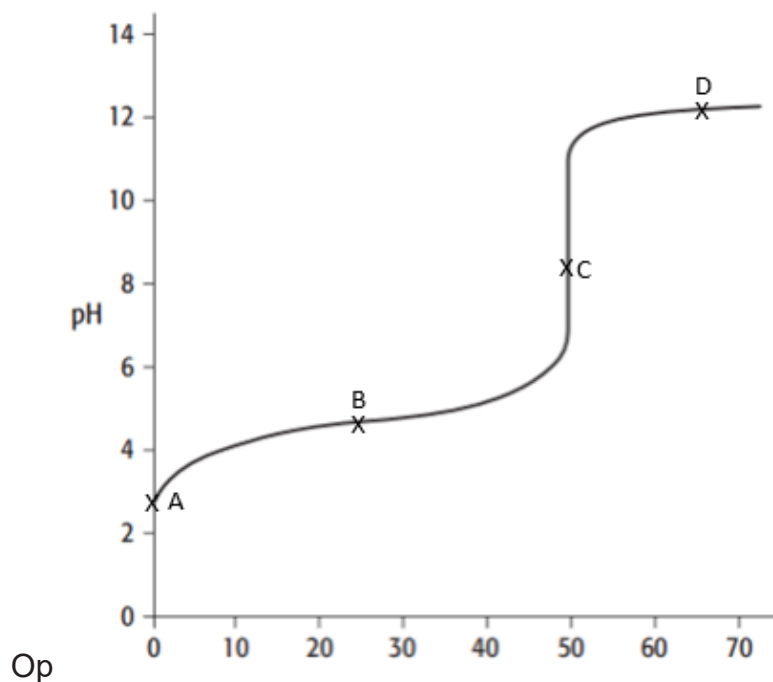
Skill level 3	
3	
2	
1	
0	
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Part B: Acid-base Titration Curve

Use **Graph 3** below to answer **a. - d.**

The titration curve below is a result of adding aqueous solution of sodium hydroxide, $\text{NaOH}_{(\text{aq})}$ to 50mL of ethanoic acid solution, $\text{CH}_3\text{COOH}_{(\text{aq})}$.

Graph 3: Titration curve for the addition of NaOH solution to CH_3COOH solution



- a. From **Graph 3**, calculate the initial concentration of the 50mL of ethanoic acid solution given its acid dissociation constant at 25°C , K_a is $1.75 \times 10^{-5} \text{ mol L}^{-1}$.

Skill level 2	
2	
1	
0	
NR	

- b. On the titration curve in **Graph 3**, draw a rectangle, on the buffer region showing the pH limits. (i.e. maximum and minimum pH values)

Skill level 2	
2	
1	
0	
NR	

Skill level 2	
2	
1	
0	
NR	

d. Discuss the changes in pH along the titration curve at points A, B, C and D in terms of the species present in the solution.

- *Balanced equation for the titration reaction at each point*
- *Species present & their relative concentration in solution at each point*
- *Link species present to pH value at each point*
- *Reasons for the pH value at each point)*

1. pH value is already given in the graph. You do not have to calculate it.
2. You do not need to use exact concentrations at points **A**, **B** and **C**.
3. Concentration **MUST** be exact at point **D**.

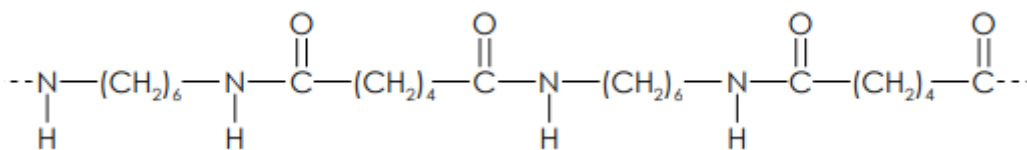
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QUESTION FIVE:

ORGANIC CHEMISTRY

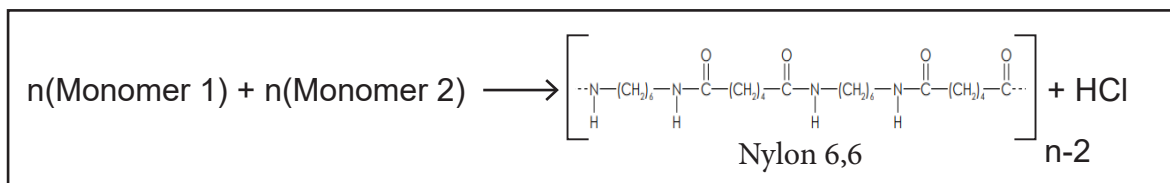
Part A: Polymer

Nylon 6,6 is a widely used polymer. It has the following structure:



Skill level 1	
1	
0	
NR	

- a. Identify by *circling ONE (1)* of the **peptide link** in the structure of nylon 6,6 above.
- b. TWO monomers, Monomer 1 and Monomer 2, react to form nylon 6,6 above and a by-product, hydrogen chloride, HCl.



Deduce the **structural formula** of the two monomers, Monomer 1 and Monomer 2, that formed the nylon 6,6 above.

Draw the **structural formula** in the space provided below.

Monomer 1	Monomer 2
-------------------------	-------------------------

Skill level 2	
2	
1	
0	
NR	

Part B: Organic reactions

Ammonia, hydroxide ions and water are examples of **nucleophiles**.

Describe the **mechanism** that leads to the attraction of the nucleophile (OH^-) in sodium hydroxide, NaOH) to the carbon-bromine bond, C-Br, in bromoethane, $\text{CH}_3\text{CH}_2\text{Br}$.

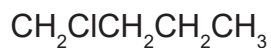
(Use arrows to show the attraction forces.)

[illegible]

Skill level 2	
2	
1	
0	
NR	

Part C: Isomers

Explain why 2-chlorobutane can exhibit optical isomerism but 1-chlorobutane cannot.



1-chlorobutane



2-chlorobutane

(Consider in your answer the:

- *Properties of an optical isomer,*
- *How each compound meet or does not meet the properties of an optical isomer*
- *Reason(s)*
- *Conclusive statement.)*

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Skill level 3	
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2	
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PERIODIC TABLE

Atomic number																	
1 H 1.0												Molar mass / g mol ⁻¹					
131415161718																	
1		2		3		4		5		6		7		8		9	
3	4																
Li	Be																
6.9	9.0																
11	12																
Na	Mg																
23.0	24.3																
				</													

Lanthanide Series	57	58	59	60	61	62	63	64	65	66	67	68	69	70	
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	
	139	140	141	144	147	150	152	157	159	163	165	167	169	173	
	Actinide Series	89	90	91	92	93	94	95	96	97	98	99	100	101	102
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
	227	232	231	238	237	239	241	244	249	251	252	257	258	259	