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| STUDENT ENROLMENT NUMBER (SEN) |  |  |  |  |  |  |  |  |  |
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# TONGA NATIONAL FORM SEVEN CERTIFICATE

## 2023

## CHEMISTRY

### QUESTION AND ANSWER BOOKLET

Time allowed: 3 Hours

#### INSTRUCTIONS:

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

| SECTION      | STRANDS                                                  | TOTAL SKILL LEVEL |
|--------------|----------------------------------------------------------|-------------------|
| <b>ONE</b>   | ATOMIC STRUCTURE, BONDING, SOLIDS AND RELATED PROPERTIES | 9                 |
| <b>TWO</b>   | KINETIC AND NUCLEAR CHEMISTRY                            | 17                |
| <b>THREE</b> | INORGANIC CHEMISTRY                                      | 13                |
| <b>FOUR</b>  | QUANTITATIVE CHEMISTRY AND REDOX CHEMISTRY               | 19                |
| <b>FIVE</b>  | ORGANIC CHEMISTRY                                        | 12                |
| <b>Total</b> |                                                          | <b>70</b>         |

- Answer ALL QUESTIONS. Write your answers in the spaces provided in this booklet.
- Use a **BLUE** or **BLACK** ball point pen only for writing. Use a pencil for drawing if required.
- 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.  
NOTE: A **Periodic Table** is provided at the back of this booklet in page 15.
- Check that this booklet contain pages **2-15** in the correct order and that none of the pages is blank.

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

**SECTION ONE:                      ATOMIC STRUCTURE, BONDING,  
SOLIDS AND RELATED PROPERTIES**

1. Define the **second ionization energy** of the element Sodium, Na.

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| Skill level 1 |  |
|---------------|--|
| 1             |  |
| 0             |  |
| NR            |  |

2. Write the corresponding **balanced equation** for the *second ionization energy* of the element Sodium, Na.

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

3. The melting points of selected elements in the Periodic Table including Sodium are given in the table below:

| Element   | Melting Point (°C) |
|-----------|--------------------|
| Sodium    | 98                 |
| Aluminium | 660                |
| Chlorine  | -101               |

- a. Account for the **differences in the melting points** of the elements: Sodium, Aluminum and Chlorine.

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| Skill level 3 |  |
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| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

- b. Relative to the melting points in the Table in **a.** (*page 2*), predict by **circling** the **best** possible melting point for the element, **Potassium**, and justify your choice.

**Melting point (°C):**        **1464**        **181**        **63**        **-7**  
**(Circle best possible)**

**Justification:**

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| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

## SECTION TWO: KINETIC AND NUCLEAR CHEMISTRY

### Nuclear Chemistry

1. Nuclear reaction differs from a chemical reaction.

a. Define 'nuclear reaction'.

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| Skill level 1 |  |
|---------------|--|
| 1             |  |
| 0             |  |
| NR            |  |

b. Americium-241 decays to form Neptunium-237 and an alpha particle.  
Write the **complete nuclear equation** representing this decay.  
(Word Equation is **NOT** acceptable)

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

c. Use the data given below to determine the **amount of energy in Joules** released during the following nuclear decay:

**Polonium-218 form Lead-214 plus an alpha particle**

Initial mass of Polonium-218 =  $362.0124 \times 10^{-27}$  kg

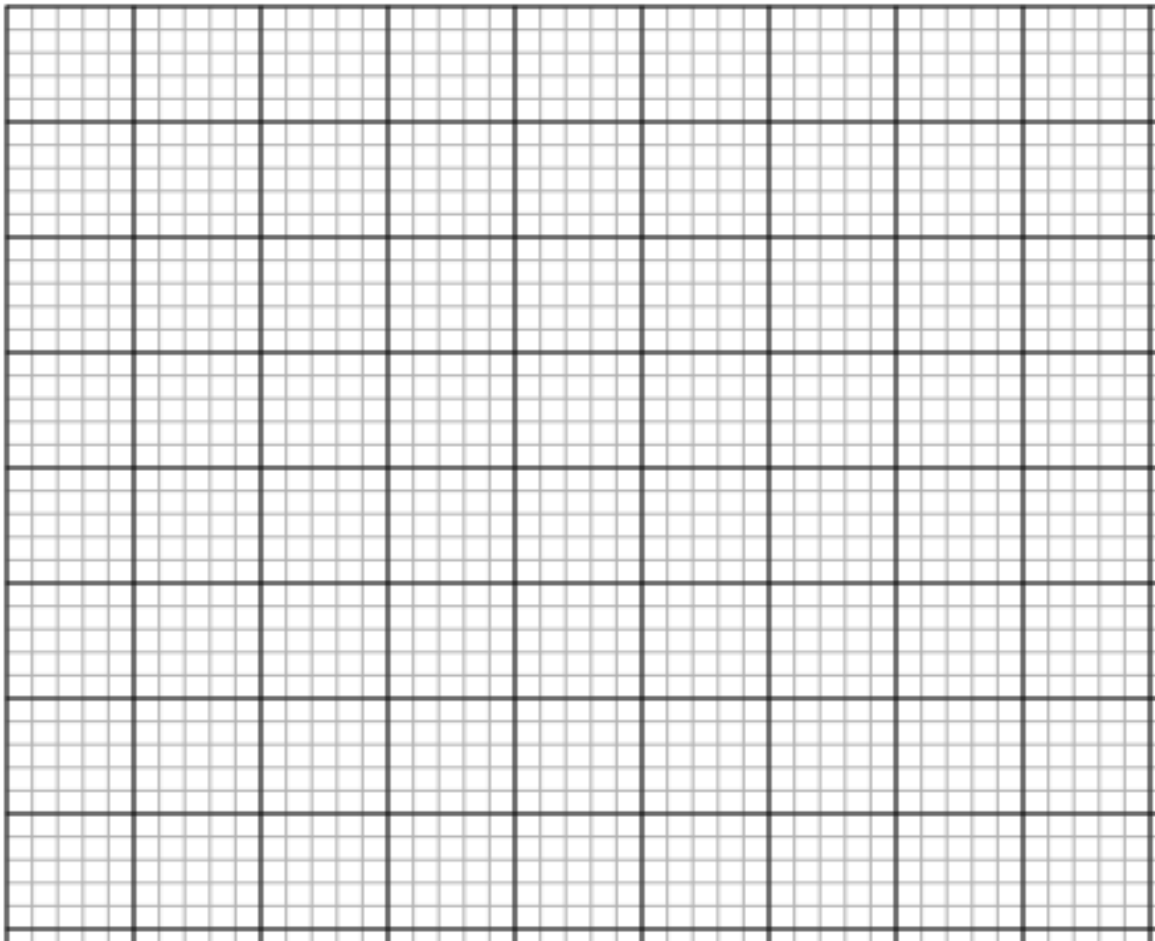
Mass of Lead-214 produced =  $355.3550 \times 10^{-27}$  kg,

Mass of an alpha particle =  $6.6460 \times 10^{-27}$  kg

Speed of light =  $3.00 \times 10^8$  ms<sup>-1</sup>

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

- d. Plot a graph on the axis below of the **decay of 40 grams of radioactive plutonium-239** that has a half-life of 24100 years.



| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

## Kinetic Chemistry

2. Define 'standard heat (or enthalpy) of combustion,  $\Delta_c H^\circ$ '.

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| Skill level 1 |  |
|---------------|--|
| 1             |  |
| 0             |  |
| NR            |  |

3. Consider these two standard heat or enthalpies of combustion of water:

$$\Delta_c H^\circ(\text{H}_2\text{O}_{(\text{g})}) = -242 \text{ kJmol}^{-1}$$

$$\Delta_c H^\circ(\text{H}_2\text{O}_{(\text{l})}) = -286 \text{ kJmol}^{-1}$$

Use the kinetic theory to **account** for the **differences** in these two standard enthalpies of combustion.

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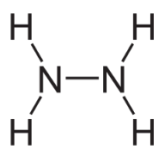
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| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

4. Hydrazine,  $\text{N}_2\text{H}_4$  is used in cancer researches, amongst many others. It has the following structure:



The **standard enthalpy of formation** of hydrazine liquid at  $25^\circ\text{C}$  is  $95.55 \text{ kJmol}^{-1}$ .

- a. Write the **balanced thermochemical equation** for the **standard enthalpy of formation** of hydrazine liquid.

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

b. Associated **bond energies** for the formation of hydrazine are given:

N-N is  $159 \text{ kJmol}^{-1}$

H-H is  $436 \text{ kJmol}^{-1}$

N-H is  $389 \text{ kJmol}^{-1}$

Apply Hess' Law to find the **NEN bond energy**.

| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

## SECTION THREE:

## INORGANIC CHEMISTRY

## Inorganic Compounds

1. Give the *chemical formula* of **ammonium phosphate**.

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|--|--|
|  |  |
|--|--|

| Skill level 1 |  |
|---------------|--|
| 1             |  |
| 0             |  |
| NR            |  |

2. Ammonium chloride is very soluble in water.  
Describe the **nature of species present in solution** when ammonium chloride dissolves in water.

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|  |  |
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|  |  |
|  |  |
|  |  |

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

3. Draw the **structure** of the chromate ion,  $\text{CrO}_4^{2-}$

|  |  |
|--|--|
|  |  |
|--|--|

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

4. **Explain why** the halogens listed below are **not found free in nature**, giving an example of the natural source of each.

Chlorine      Fluorine      Bromine

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|--|--|
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| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

## Complex Ions

5. Water forms a complex ion with Chromium (III) ion.  
Describe the **nature of the ligand** in this aquo complex ion.

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| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

6. Account for the **formation** of the chloro complex ion of Chromium (III).

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| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

## SECTION FOUR: QUANTITATIVE CHEMISTRY AND REDOX CHEMISTRY

### Equilibrium System

1. A beaker contains solid calcium hydroxide,  $\text{Ca(OH)}_{2(s)}$ , in equilibrium with its dissolved ions in aqueous solutions.

- a. Write the **balanced equation** for the **equilibrium** existing in the saturated solution of  $\text{Ca(OH)}_{2(s)}$ .

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

- b. Write the **solubility product expression,  $K_s$**  for the equilibrium in the saturated solution of  $\text{Ca(OH)}_{2(s)}$ .

| Skill level 1 |  |
|---------------|--|
| 1             |  |
| 0             |  |
| NR            |  |

- c. Calculate the **solubility in  $\text{mol L}^{-1}$**  of calcium hydroxide in water at  $25^\circ\text{C}$ .

$$K_s (\text{Ca(OH)}_2) = 5.02 \times 10^{-6} \text{ (at } 25^\circ\text{C)}$$

| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

- d. Describe **how the equilibrium system** in the beaker respond to an increase in the Ph of the solution.

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |



## Redox Chemistry

3. Consider the **standard electrode potential** of these two half-cells:

$$E^0_{(\text{Cu}/\text{Cu}^{2+})} \text{ is } +0.34\text{V}$$

$$E^0_{(\text{Zn}/\text{Zn}^{2+})} \text{ is } +0.80\text{V}$$

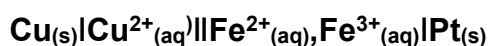
- a. Determine the **most** probable reaction that will occur.

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

- b. Determine the **cell potential**,  $E^\circ$  of the feasible reaction identified in a.

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

4. An electrochemical cell has different forms of representations.  
Shown below is the representation of an electrochemical cell using a **cell notation**.



Draw a **labelled diagram** of the electrochemical cell given above.

| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

## SECTION FIVE:

## ORGANIC CHEMISTRY

## Organic Compounds.

1. Circle the compound (s) below that is an **aldehyde**.



| Skill level 1 |  |
|---------------|--|
| 1             |  |
| 0             |  |
| NR            |  |

2. Deduce the **structural formula** of the **two reactants** that formed **butyl ethanoate**.

REACTANT 1:

REACTANT 2:

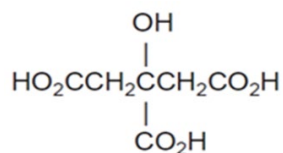
| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

3. Ethanol,  $\text{CH}_3\text{CH}_2\text{OH}$ , is rapidly formed when an aqueous solution of sodium hydroxide,  $\text{NaOH}_{(\text{aq})}$  is added to bromoethane,  $\text{CH}_3\text{CH}_2\text{Br}$ .

Describe the **reaction mechanism** that allows the formation of ethanol in this reaction.

| Skill level 2 |  |
|---------------|--|
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

4. Unripe fruits often contain **citric acid** as shown below:



Explain **why** citric acid can **or** cannot show **optical isomerism**.

[illegible]

| Skill level 3 |  |
|---------------|--|
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

5. Discuss the **effect of multiple bonding** of carbon atoms on the **tetrahedral nature** of bonding in alkanes.

Use ethane, ethene and ethyne as examples in your response.

[illegible]

| Skill level 4 |  |
|---------------|--|
| 4             |  |
| 3             |  |
| 2             |  |
| 1             |  |
| 0             |  |
| NR            |  |

## 18

Atomic numberMolar mass / g mol<sup>-1</sup>Lanthanide  
SeriesActinide  
Series