NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

## FACULTY OF ENGINEERING

**InSTEM**

| | |
|---|---|
| **QUALIFICATION: INTRODUCTION TO SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS** | |
| **QUALIFICATION CODE: 04STEM** | **LEVEL:** 4 |
| **COURSE CODE:** ICH401S | **COURSE NAME:** INTRODUCTION TO CHEMISTRY A |
| **SESSION:** NOVEMBER 2019 | **PAPER:** N/A |
| **DURATION:** 3 HOURS | **MARKS:** 100 |

| **FIRST OPPORTUNITY EXAMINATION QUESTION PAPER** | |
|---|---|
| **EXAMINER(S)** | **Mr Victor Uzoma** |
| **MODERATOR:** | **Prof Habauka M Kwaambwa** |

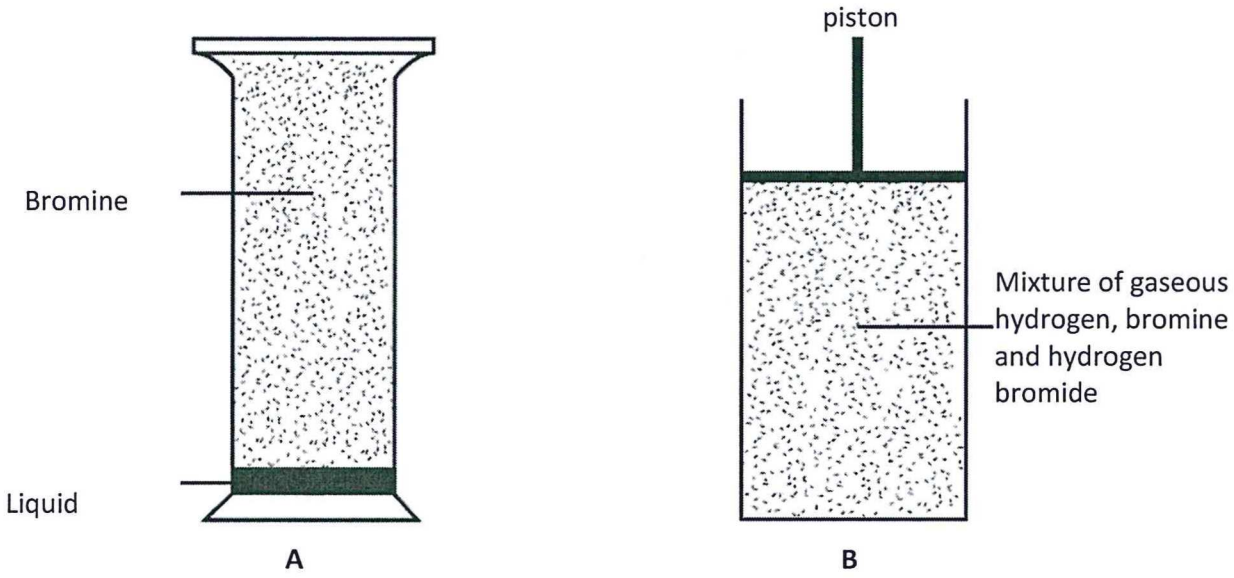
**INSTRUCTIONS**

1. Answer all questions.
2. Write all the answers in ink.
3. No books, notes, correction fluid (Tippex) or cell phones allowed.
4. Pocket calculators are allowed.
5. You are not allowed to borrow or lend any equipment or stationary.
6. All **FINAL ANSWERS** must be rounded off to **TWO DECIMAL PLACES** unless otherwise stated.
7. Periodic table on page 10.

**THIS QUESTION PAPER CONSISTS OF 10 PAGES (Excluding this front page)**

**Question 1** **[19]**

Consider the two equilibrium systems involving bromine gas illustrated below.




1.1 State equations to represent the equilibria in **A** and **B** with $Br_2$ (g) on the left-hand side in both equilibria. (2)

1.2.1 Describe what you would observe if a small amount of liquid bromine is introduced into **A**. (1)

1.2.2 Predict what happens to the position of equilibrium if a small amount of hydrogen is introduced into **B**. (1)

1.2.3 State and explain the effect of increasing the pressure in B on the position of equilibrium. (2)

1.3.1 Write the equilibrium constant expression, $K_c$, for the equilibrium in **B**. (1)

1.3.2 State the effect of increasing $[H_2]$ in B on the value of $K_c$. (1)

1.4 When bromine dissolves in water, 1 % of the original bromine molecules react according to the following equation:

$$Br_2\ (aq) + H_2O(l) \rightarrow HOBr\ (aq) + HBr\ (aq)$$

1.4.1 Find the oxidation numbers of bromine in the reactant and products. (3)

1.4.2 Explain the changes in the oxidation numbers of bromine. (1)

1.4.3 Estimate the magnitude of $K_c$ for this reaction. Choose your value from the following options:

$K_c = 0 \quad K_c < 1 \quad K_c = 1 \quad K_c > 1$ (1)

1.5 A mixture of 5.0 mol $H_{2(g)}$ and 10.0 mol $I_{2(g)}$ are placed in a 5 L container at 450°C and allowed to come to equilibrium. At equilibrium the concentration of $HI_{(g)}$ is 1.87 mol $L^{-1}$. Calculate the value for $K_c$ for this reaction. (6)

**Question 2** **[15]**

2.1 Explain why certain elements in the Periodic Table are classified as p-block elements. Illustrate your answer with an example of the first p-block element and give its electronic configuration. (3)

2.2 Explain why electrical conductivity decreases across Period 3 from sodium to phosphorus. (3)

2.3 The table below shows the melting temperatures, $T_m$, of the Period 3 elements.

| Element | Na | Mg | Al | Si | P | S | Cl | Ar |
|---|---|---|---|---|---|---|---|---|
| $T_m$/K | 371 | 923 | 933 | 1680 | 317 | 392 | 172 | 84 |

Explain the following in terms of structure and bonding:

2.3.1 Magnesium has a higher melting temperature than sodium. (2)

2.3.2 Silicon has a very high melting temperature. (2)

2.3.3 Sulphur has a lower melting temperature than magnesium. (2)

2.3.4 Argon has a lower melting temperature than chlorine. (3)

**Question 3** **[8]**

3.1 Chlorine and bromine are both oxidising agents. Define an *oxidising agent* in terms of electrons. (1)

3.2 In aqueous solution, bromine oxidises sulphur dioxide, $SO_2$, to sulphate ions, $SO_4^{2-}$.

3.2.1 Determine the oxidation state of sulphur in $SO_2$ and in $SO_4^{2-}$. (2)

3.2.2 Give a half-equation for the reduction of bromine in aqueous solution. (2)

3.2.3 Give a half-equation for the oxidation of $SO_2$ in aqueous solution forming $SO_4^{2-}$ and $H^+$ ions. (2)

3.2.4 Use these two half-equations to construct an overall equation for the reaction between aqueous bromine and sulphur dioxide. (1)

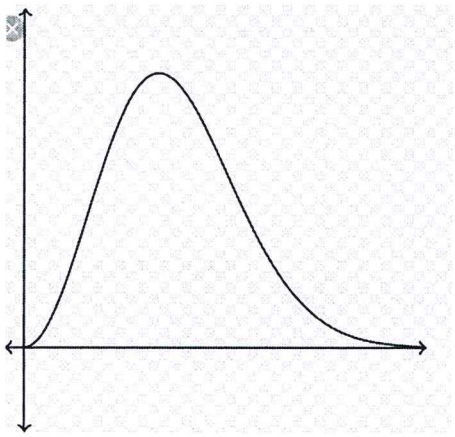
**Question 4** **[9]**

4.1 Define the term *activation energy* for a reaction. (1)

4.2 Give the meaning of the term *catalyst*. (1)

4.3 Explain in general terms how a catalyst works. (1)

4.4 The diagram below represents a Maxwell–Boltzmann distribution curve for the particles in a sample of a gas at a given temperature. The questions below refer to this sample of particles.



4.4.1 Redraw the diagram above in your answer booklet and label the axes. (2)

4.4.2 On the diagram in your answer booklet, draw a curve to show the distribution for this sample at a lower temperature. (2)

4.4.3 In order for two particles to react, they must collide. Explain why most collisions do not result in a reaction. (1)

4.4.4 State one way in which the collision frequency between particles in a gas can be increased without changing the temperature. (1)

**Question 5** **[13]**

5.1 Balance the following equation:

$$B_2O_3\ (s) + HF\ (l) \rightarrow BF_3\ (g) + H_2O\ (l) \quad (2)$$

5.2 Butane is a hydrocarbon fuel similar to gasoline, but lighter. It is sold as "bottled gas" and is used in cigarette lighters. The chemical formula of butane is $C_4H_{10}$. Consider the complete combustion of butane. Write a balanced equation for the complete combustion of butane. Show the phases. (2)

5.3 When chlorine gas is bubbled into an aqueous solution of sulfur dioxide, hydrogen ions, sulfate ions and chloride ions are formed.

5.3.1 Write a half-equation for the formation of chloride ions from chlorine. (2)

5.3.2 Complete the half-equation for the formation of hydrogen ions and sulfate ions from sulphur dioxide and water. (2)

5.3.3 A sample of zinc is heated in air to form zinc oxide. Assuming all of the zinc is converted to the oxide, use the data below to calculate the empirical formula of zinc oxide. (5)

| | |
|---|---|
| Mass of crucible | = 32.00 g |
| Mass of crucible + Zinc (before heating) | = 33.64 g |
| Mass of crucible + Oxide (after heating) | = 34.04 g |
| Mass of crucible + Oxide (after heating) | = 34.04 g |

**Question 6** **[13]**

6.1 What is the oxidation state of the elements bolded in the following compounds shown below?

6.1.1 $K_2Cr_2O_7$ (2)

6.1.2 $H_3PO_3$ (2)

6.1.3 $Ca(NO_2)_2$ (2)

6.2 In terms of gain and loss of electron(s) determine which element is oxidized and which element is reduced in the following reactions:

6.2.1 $Zn + 2H^+ \rightarrow Zn^{2+} + H_2$ (1)

6.2.2 $2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$ (1)

6.2.3 In terms of oxygen gain and loss, determine which element is oxidized and which element is reduced in the reaction below:

$$C + 2HgO \rightarrow CO_2 + Hg$$ (2)

6.3 The melting points of some of the oxides formed by Period 3 elements are given in a random order below:

| Oxide | A | B | C | D | E |
|---|---|---|---|---|---|
| $T_m$/ºC | 2852 | -73 | 1610 | 1275 | 300 |

Using the letters A to E, give two oxides which have simple molecular structures. Explain your answer. (3)

**Question 7** **[5]**

Consider the element with electron configuration $1s^2 2s^2 2p^6 3s^2 3p^5$.

7.1. What is the name of the element? (1)

7.2 What charge do you expect for a simple ion from this element? (1)

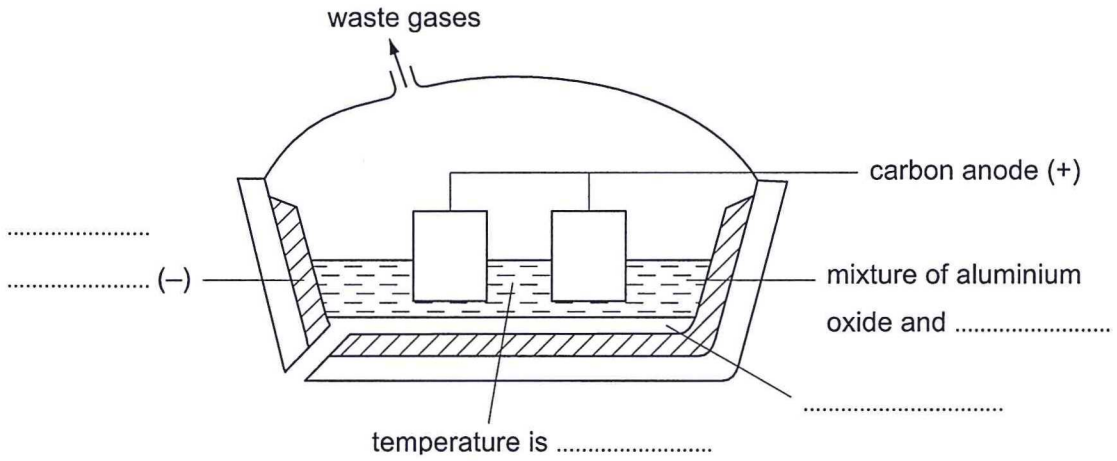
7.3 Write the electronic configuration of the ion (1)

7.4 Which of the electrons are the valence electrons? (1)

7.5 Give one example of another element with the same number and type of valence electrons. (1)

**Question 8** **[18]**

8.1 Aluminium is extracted by the electrolysis of a molten mixture that contains alumina, which is aluminium oxide, $Al_2O_3$. The ore of aluminium is bauxite. This contains alumina, which is amphoteric, and iron(III) oxide, which is basic. The ore is heated with aqueous sodium hydroxide. Complete the labeling of the diagram. (4)




8.2 The ions that are involved in the electrolysis are $Al^{3+}$ and $O^{2-}$.

8.2.1 Write an equation for the reaction at the cathode. (2)

8.2.2 Explain how carbon dioxide is formed at the anode. (2)

8.3 Give an explanation for each of the following:

8.3.1 Aluminium is used extensively in the manufacture of aircraft. (1)

8.3.2 Aluminium is used to make food containers. (2)

8.4 Three substances are added to a blast furnace during the extraction of iron from its ore. Haematite, $Fe_2O_3$, is the ore. Limestone, $CaCO_3$, and coke are the other substances needed. The main products are iron, slag and oxides of carbon.

8.4.1 State the reason for adding limestone to the furnace. (1)

8.4.2 Write balanced equations for the reactions that occur when:

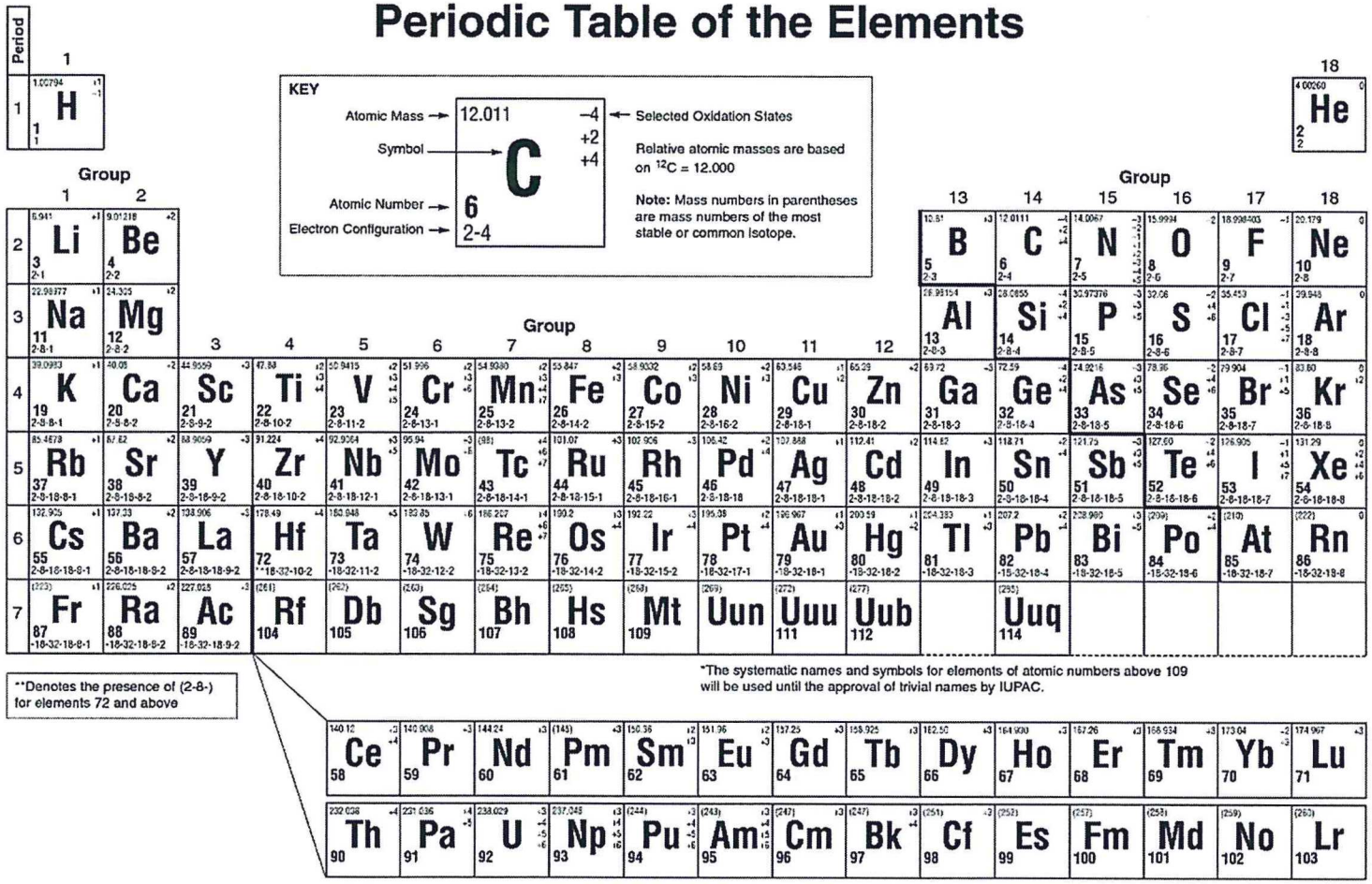
8.4.2.1 limestone decomposes (2)

8.4.2.1 Haematite is reduced. (2)

8.5 Iron and steel can be prevented from rusting by galvanising. When the covering is complete this prevents the iron being exposed to the air. However, unlike painting, galvanising continues to prevent rusting even when the coating is damaged. Explain this difference between painting and galvanising. (2)

**THE END**

# Periodic Table of the Elements




**Denotes the presence of (2-8-) for elements 72 and above

*The systematic names and symbols for elements of atomic numbers above 109 will be used until the approval of trivial names by IUPAC.



Reference Tables for Physical Setting/CHEMISTRY 