

**MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES**

**FACULTY OF ENGINEERING**

**Chemical and Processing Engineering Department**

**METALLURGICAL CHEMISTRY**

**CODE: HMME 212**

**SESSIONAL EXAMINATIONS**

**JANUAURY 2021**

**DURATION: 3 HOURS**

**EXAMINER: K. NYENYAYI (MR)**

**INSTRUCTIONS**

1. Answer *all questions in Section A and any three from Section B.*
2. Each question carries 20 marks.
3. Total marks 100

**ADDITIONAL MATERIALS**

Calculators, Periodic table

This question paper consists of 7 printed pages

## SECTION A

### QUESTION ONE

- a) Define the following terms *heterogeneous* and *homogeneous mixtures*. [2]
- b) Differentiate between *weight*, *density* and *specific gravity*. [3]
- c) With aid of chemical equations, compare the reactions of Potassium, Magnesium and Copper with water clearly stating conditions under which reaction may occur. [9]
- d) Define the following terms giving examples: [6]
- i. Ionic bonds.
  - ii. Van der Waals forces.
  - iii. Metallic bonds.

### QUESTION TWO

- a) Calculate the Molarity of a solution of 81.1 grams of  $\text{MgCl}_2$ , Magnesium Chloride, in 1.0 Liter of deionized water. [3]
- b) Define pH and list any three mineral processes that are affected by pH. [4]
- c) What is meant by *standard enthalpy change of reaction*? [2]
- d) State the *collision theory* of molecules.

[2]

e) With reference to Le Chatelier's principle, outline the effects changing *concentrations of reactants* and *temperature* on the position of equilibrium and equilibrium constant.

[5]

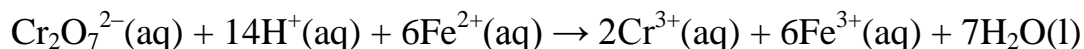
f) Illustrating with a simple electrolysis cell, briefly explain the process of electrolysis.

[9]

## SECTION B

### QUESTION THREE

a) Spathose is an iron ore that contains iron(II) carbonate,  $\text{FeCO}_3$ . The percentage of iron(II) carbonate in spathose can be determined by titration with acidified potassium dichromate(VI) solution using a suitable indicator. The ionic equation is shown below.



A 5.00 g sample of spathose was reacted with excess concentrated hydrochloric acid and then filtered. The filtrate was made up to  $250 \text{ cm}^3$  in a volumetric flask with distilled water. A  $25.0 \text{ cm}^3$  sample of the standard solution required  $27.30 \text{ cm}^3$  of  $0.0200 \text{ mol dm}^{-3}$  dichromate (VI) solution for complete reaction.

- i. Calculate the amount, in moles, of dichromate (VI) ions used in the titration.
- ii. Use your answer to (i) to calculate the amount, in moles, of  $\text{Fe}^{2+}$  present in the  $25.0 \text{ cm}^3$  sample.
- iii. Use your answer to (ii) to calculate the amount, in moles, of  $\text{Fe}^{2+}$  present in the  $250 \text{ cm}^3$  volumetric flask.

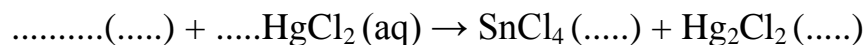
- iv. Use your answer to (iii) to calculate the mass of iron (II) carbonate present in the sample.
- v. Calculate the percentage of iron (II) carbonate in the sample of spathose.

[12]

**b)** Iron ores containing iron (III) compounds can be analysed using a similar method. A standard solution of an aqueous iron (III) compound is reacted with aqueous tin (II) chloride. Aqueous tin (IV) chloride and aqueous iron (II) chloride are the products of this reaction.

- i. Write a balanced ionic equation for this reaction. Do not include state symbols.
- ii. Any excess tin (II) chloride can be removed by reaction with  $\text{HgCl}_2(\text{aq})$ . A white precipitate of  $\text{Hg}_2\text{Cl}_2$  is produced.

Complete the equation for this reaction.



[8]

#### QUESTION FOUR

**a)** Give an explanation for each of the following statements.

- i. The atomic radius decreases across Period 3 (Na to Ar).
- ii. The first ionisation energy of sulfur is lower than that of phosphorus.
- iii. Sodium is a better electrical conductor than phosphorus.
- iv. Magnesium is a better electrical conductor than sodium.
- v. The radius of the most common ion of Mg is much smaller than the radius of the most common ion of S. Identify both ions.

[12]

**b)** Cerium is a lanthanoid metal that shows similar chemical reactions to some elements in the third period. Most of Cerium's compounds contain  $\text{Ce}^{3+}$  or  $\text{Ce}^{4+}$  ions.

i. Cerium shows the same structure and bonding as a typical metal.

Draw a labelled diagram to show the structure and bonding in cerium.

ii. Cerium (IV) oxide,  $\text{CeO}_2$ , is a ceramic. Suggest two physical properties of cerium (IV) oxide.

[8]

### QUESTION FIVE

**a)** Calcium and its compounds have a large variety of applications. Calcium metal reacts readily with most acids.

i. Write an equation for the reaction of calcium with dilute nitric acid. State symbols are not required.

[2]

ii. When calcium metal is placed in dilute sulfuric acid, it reacts vigorously at first. After a short time, a crust of calcium sulfate forms on the calcium metal and the reaction stops. Some of the calcium metal and dilute sulfuric acid remain unreacted. Suggest an explanation for these observations.

[5]

**b)** When calcium is placed in water, aqueous calcium hydroxide is formed and hydrogen is given off.

i. Write the equation for the reaction of calcium with water.

ii. When 1.00 g of calcium is placed in 200 g of water, the temperature

increases by 12.2 °C when the reaction is completed. The specific heat capacity of water,  $C$ , is 4.2 J g<sup>-1</sup>K<sup>-1</sup>.

Calculate the heat released in the experiment.

- iii. Calculate the standard enthalpy change of reaction in k J mol<sup>-1</sup> for your equation in (b)(i).
- iv. State Hess' Law.

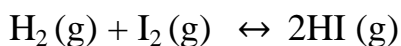
[13]

### QUESTION SIX

- a) i. What is meant by the standard enthalpy change of formation,  $\Delta H_f^\circ$ , of a compound. Explain what is meant by the term standard.
- ii. Write an equation, with state symbols, for the  $\Delta H_f^\circ$  of water.
- iii. Explain why the  $\Delta H_f^\circ$  for water is identical to the standard enthalpy change of combustion of hydrogen.

[7]

- b) In an experiment, 2.00 mol of hydrogen and 3.00 mol of iodine were heated together in a sealed container and allowed to reach equilibrium at a fixed temperature. The container had a fixed volume of 1.00 dm<sup>3</sup>. At equilibrium, there were 2.40 mol of iodine present in the mixture.



- i. What is the value of the equilibrium constant,  $K_c$ ?
- ii. The reaction exists as a dynamic equilibrium. Explain what is meant by the term dynamic equilibrium.
- iii. State and explain how the amounts of the chemicals present in the equilibrium mixture will change when the pressure is increased.

[8]

- c) The process uses a platinum catalyst, which increases the rate of reaction. Sketch a Boltzmann distribution on the axes given below and use your diagram to explain how the platinum catalyst increases the rate of the reaction.

[5]

THE END