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:

i. Ionic bonds.

ii. Van der Waals forces.

iii. Metallic bonds.

[6]

QUESTION TWO

a) Calculate the Molarity of a solution of 81.1 grams of $MgCl_2$, 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, FeCO3. 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.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

A 5.00 g sample of spathose was reacted with excess concentrated hydrochloric acid and then filtered. The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water. A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 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 Fe^{2+} present in the 25.0 cm^3 sample.

iii. Use your answer to (ii) to calculate the amount, in moles, of Fe^{2+} present in the 250 cm3 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 $HgCl_2$ (aq). A white precipitate of Hg_2Cl_2 is produced.

Complete the equation for this reaction.

.....(.....) + ...$HgCl_2$ (aq) → $SnCl_4$ (.....) + Hg_2Cl_2 (.....)

[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 Ce^{3+} or 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, CeO, 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–1K–1.

Calculate the heat released in the experiment.

iii. Calculate the standard enthalpy change of reaction in k J mol^{-1} 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, ΔH_f°, of a compound. Explain what is meant by the term standard.

ii. Write an equation, with state symbols, for the ΔH_f° of water.

iii. Explain why the ΔH_f° 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^3. At equilibrium, there were 2.40 mol of iodine present in the mixture.

$H_2(g) + I_2(g) \leftrightarrow 2HI(g)$

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