GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

METALLURGICAL THERMODYNAMICS

EMG 2105

Part II First Semester Examination Paper

November 2023

This examination paper consists of 4 printed pages

Time Allowed: **3 hours**

Total Marks: **100**

INSTRUCTIONS

1. Answer any **FIVE** questions
2. Each question carries 20 marks
3. Use of calculators is permissible

Additional Requirements

1. Periodic table
2. Thermodynamics Property tables
3. Calculator
4. Graph paper

MARK ALLOCATION

Part Questions	As shown in each part question
Total Attainable	100

Question 1

(a) Explain three causes of irreversibility in reactions **[6]**

(b) Differentiate between isothermal and adiabatic system **[4]**

(c) Find the change in internal energy when 100 kg of steam at constant pressure P = 1 bar has its temperature reduced from 300 °C to 100 °C. **[4]**

(d) To a closed system 150 kJ of work is supplied. If the initial volume is 0.6 m^3 and pressure of the system changes as P = 8 - 4V, where P is pressure in bars and V is volume in m^3, determine:

i. the final volume **[4]**

ii. Pressure of the system**.** **[2]**

Question 2

(a) Explain three similarities between work and heat **[6]**

(b) Explain the following thermodynamics terms with examples **:**

i. State, **[2]**

ii. Process, **[2]**

iii. Cycle. **[3]**

(c) A gas mixture consists of 2 kg of O_2, 5 kg of N_2, and 7 kg of CO_2. Determine

i. the mass fraction of each component, **[2]**

ii. the average molar mass **[2]**

iii. gas constant of the mixture **[3]**

Question 3

(a) Explain the first law of thermodynamics using an example **[6]**

(b) Water at 120 ^oC with a quality of 25% has its temperature raised 20 ^oC in a constant volume system. What is the new quality and pressure? **[6]**

(c) A vessel of 0.35 m capacity contains 0.4 kg of carbon monoxide (molecular

weight = 28) and 1 kg of air at 20°C. The gravimetric analysis of air is to be taken as 23.3% oxygen (molecular weight = 32) and 76.7% nitrogen (molecular weight = 28).Calculate :

i. The partial pressure of each constituent, **[4]**

ii. The total pressure in the vessel, **[4]**

Question 4

(a) What do you understand by intensive properties **[3]**

(b) You are a metallurgical process engineer for company X with mines and processes gold Identify and explain the following types of systems in your plant.

i. Open system **[3]**

ii. Isothermal **[4]**

(c) An iron cube at a temperature of 400 °C is dropped into an insulated bath containing 10 kg water at 25°C. The water finally reaches a temperature of 50°C at steady state. Given that the specific heat of water is equal to 4186 J/kg K.

i. Find the entropy changes for the iron cube and the water. **[6]**

ii. Is the process reversible? Explain your answer **[4]**

Question 5

(a) Explain the relationship between free- energy change and spontaneity of reactions. **[4]**

(b) An ideal gas is enclosed in a cylinder which has a movable piston. The gas is heated, resulting in an increase in temperature of the gas, and work is done by the gas on the piston so that the pressure remains constant.

i. Is the work done by the gas positive, negative or zero? Explain **[4]**

ii. From a microscopic view, how is the internal energy of the gas molecules affected? **[4]**

iii. Is the heat less than, greater than or equal to the work? Explain. **[3]**

(c) A rigid tank contains 5 kg of refrigerant-134a initially at 20 ^{o}C and 140 kPa. The refrigerant is now cooled while being stirred until its pressure drops to 100 kPa. Determine the entropy change of the refrigerant during this process **[5]**

Question 6

(a) A metal is melted in a furnace, which type of system is this, discuss with the aid of a diagram. **[6]**

(b) A piston-cylinder device initially contains 50 L of liquid water at 40 ^{o}C and 200 kPa. Heat is transferred to the water at constant pressure until the entire liquid is vaporized.

i. What is the mass of the water? **[3]**

ii. What is the final temperature? **[3]**

iii. Determine the total enthalpy change. **[4]**

(c) In an internal combustion engine, during the compression stroke the heat rejected to the cooling water is 50 kJ/kg and the work input is 100 kJ/kg. Calculate the change in internal energy of the working fluid stating whether it is a gain or loss. **[4]**

END OF QUESTION PAPER