FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

METALLURGICAL THERMODYNAMICS

EMG 2105

Final Examination Paper

November 2024

This paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner: Dr L. Mugwagwa

INSTRUCTIONS

1. This paper contains ONE section with **SIX (6)** questions.
2. Answer any **FIVE (5)** questions.
3. Each question carries 20 marks.
4. Where a question contains subdivisions, the mark value of each subdivision is shown in brackets.
5. Illustrate your answer, where appropriate, with clearly labeled diagrams.
6. Started each question on a new page.
7. This paper comprises of 4 printed pages

Additional requirements:

1. Periodic table
2. Property tables- saturated water
3. Calculator
4. Graph paper

Question 1

a) Explain how the second law of thermodynamics address the limitations of the first law of thermodynamics **[6]**

b) Describe using examples three differences between work and heat **[6]**

c) With the aid of a rankine cycle explain what you understand by an open system **[4]**

d) A reactor with the following dimensions 3 m x 2 m x 1 m contain 32 kg of an ideal gas at a pressure of 101 k Pa. Find the temperature of the gas assuming R= 0.287 KJ/KgK **[4]**

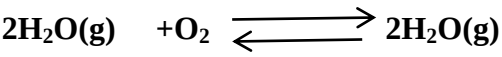
Question 2

(a) Define thermodynamic equilibrium **[3]**

(b) With the aid of a diagram describe the carnot cycle **[5]**

(c) State and explain the Clausius statement **[2]**

(d) Explain three factors that disturbs the equilibrium state of the process below **[6]**



(e) A system consisting of some fluid is stirred in a tank. The rate of work done on the system by the stirrer is 2.25 hp. The heat generated due to stirring is dissipated to the surroundings. If the heat transferred to the surroundings is 3400 kJ/h, determine the change in internal energy **[4]**

Question 3

(a) With the aid of P-V-T diagrams and examples explain the following processes

i. Isochoric process **[3]**

ii. Isobaric process **[4]**

(b) Calculate the standard heat of formation of the solid WO_3 from the solid W and O_2 gas at 25 ^oC (298 K) and 1 atm pressure from the following data at 25 ^oC and 1 atm pressure **[5]**

W	+	O_2	=	WO_2	$:\Delta H^o_{298}$ = -134 kcal
$3WO_2$	+	O_2	=	W_3O_8	$:\Delta H^o_{298}$ = -131.5 kcal

$W_3O_8 + 1/2O_2 = 3WO_3 \quad :\Delta H^o_{298} = -66.5$ kcal

(c) A mixture of gases consists of 40% nitrogen, 25% hydrogen and 35% carbon dioxide by mass. If the mixture is at a pressure of 100 kPa and temperature of 17 ^oC, Calculate:

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

ii. The specific volume of the mixture **[4]**

Question 4

(a) Define enthalpy **[2]**

(b) Explain what you understand by thermal efficiency of heat engines and explain three factors that affect it **[6]**

(c) Distinguish between an Isothermal and adiabatic process **[5]**

(d) Water at 120 ^oC with a quality of 25% has its temperature raised 20 ^oC in a constant volume. What is the new quality and pressure? **[4]**

(e) A heat engine operates between a heat source at 700 K and a heat sink at 300 K. What is the maximum efficiency of the engine? **[3]**

Question 5

(a) Distinguish between extensive and intensive properties, giving examples **[5]**

i. Air in a closed vessel of fixed volume 0.15 m^3 exerts pressure of 12 bar at 250 ^oC. If the vessel is cooled so that the pressure falls to 3.5 bar, Assume specific heat capacity is 1.005 J /kgK and R is 0.287 KJ/Kg K. Determine

i. Final pressure **[3]**

ii. Heat transfer **[4]**

iii. Change in entropy **[4]**

Question 6

(a) Explain with a neat diagram the Rankine cycle, describing how it is applied in the production of electricity **[5]**

(b) Explain two cause of irreversibility in the reduction of iron oxides to iron in a blast furnace **[4]**

(c) An 80L vessel contains 4 kg of regrigerant-134a at a pressure of 160 kPa. Determine

i. Temperature of the refrigerant **[3]**

ii. The quality of the refrigerant **[2]**

iii. Enthalpy of the refrigerant **[3]**

END OF EXAMINATION PAPER