TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology
Department of Medical Engineering
UNIVERSITY EXAMINATION FOR:
BSc. Medical Engineering
EME 4355 **:** Engineering Thermodynamics II
END OF SEMESTER EXAMINATION
SERIES: SEPTEMBER 2018
TIME: 2 HOURS
DATE: Pick Date **Sep 2018**

Instruction to Candidates:

You should have the following for this examination

- *Answer booklet*
- *Non-Programmable scientific calculator*

This paper consists of **FIVE** questions. Attempt question **ONE** and any other **TWO** questions.

Maximum marks for each part of a question are as shown.

Do not write on the question paper.

Question ONE

a) Describe the various operations of Rankine cycle and derive the expression of its efficiency. (8 marks)

b) Define a reversible process and give the restrictions it is subjected with (6 marks)

c) Define the term availability and give an expression (2 marks)

d) For thermodynamic process for mixture define the following

i) The Mole Fraction y

ii) The Mass Fraction m_f

(4 marks)

Question TWO

a) Molar analysis of air indicates that it is composed primarily of nitrogen (78%) and oxygen (22%). Determine (i) the mole fractions, (ii) the gravimetric analysis, (iii) its molecular weight, and (iv) its gas constant.

(4 marks)

b) A rigid tank contains 2 kg of N, and 4 kg of CO, at a temperature of 25 ^{o}C and 2 MPa. Find the partial pressures of the two gases and the gas constant of the mixture.

(3 marks)

c) A mixture is composed of 2 mol CO_2 and 4 mol N_2. It is compressed adiabatically in a cylinder from 100 kPa and 20°C to 2 MPa. Assuming constant specific heats, calculate (i) the final temperature, (ii) the work required, and (iii) the change in entropy.

(4 marks)

d) The air at 25 ^{o}C and 100 kPa in a 150-m^3 room has a relative humidity of 60%. Calculate (i) the humidity ratio, (ii) the mass of water vapor in the air, and (iii) the mole fraction of the water vapor.

(4 marks)

e) Outside air at 5°C and 40% relative humidity is heated to 25°C and the final relative humidity is raised to 40% while the temperature remains constant by introducing steam at 400 kPa into the airstream. (i) Find the needed rate of heat transfer if the incoming volume flow rate of air is 60 m^3/min. (ii) Calculate the rate of steam supplied. (iii) Calculate the state of the steam introduced.

(5 marks)

Question THREE

a) Derive and expression for reversible work and irreversibility

(10 marks)

b) A steam turbine is supplied with steam at 12 MPa and 700"C, and exhausts at 0.6 MPa.

i) Determine the reversible work and irreversibility if the turbine is an ideal turbine.

ii) If the turbine has an adiabatic efficiency of 0.88, what is the reversible work, irreversibility, and second-law efficiency? (10 marks)

Question FOUR

a) A steam power plant is proposed to operate between the pressures of 10 kPa and 2 MPa with a maximum temperature of 400^0C. What is the maximum efficiency possible from the power cycle?

Saturated liquid
$h_1 = hf = 191.8$ kJ/kg

Superheat
$h_3 = 3248$kJ/kg
$S_3 = 7.1279$ kJ/kg * K

(6 marks)

b) Increase the boiler pressure of (Question Four a) to 4 MPa while maintaining the maximum temperature and the minimum pressure. Calculate the percentage increase in the thermal efficiency. (7 marks)

c) A Rankine cycle operates between pressures of 2 MPa and 10 kPa with a maximum temperature of 600°C. If the insulated turbine has an efficiency of 80 percent, calculate the cycle efficiency and the temperature of steam at the turbine outlet. (7 marks)

Question FIVE

a) Freon 12 is used in an ideal vapor refrigeration cycle operating between saturation temperatures of -20°C in the evaporator and 41.64^oC in the condenser. Calculate the rate of refrigeration, the coefficient of performance, if the refrigerant flows at 0.6 kg/s. Also, determine the coefficient of performance if the cycle is operated as a heat pump.

(6 marks)

b) A heat pump using Freon 12 is proposed for heating a home that requires a maximum heating load of 300 kW. The evaporator operates at -10 "C and the condenser at 900 kPa. Assume an ideal cycle.

i) Determine the COP.

ii) Determine the cost of electricity at $0.07/kWh.

iii) Compare the Freon 12 system with the cost of operating a furnace using natural gas at $0.50/therm if there are 100,000 kJ/therm of natural gas.

(6 marks)

c) The steam of a Rankine cycle, operating between 4 MPa and 10 kPa, is reheated at 400 kPa to 400 ^{o}C. Determine the cycle efficiency if the maximum temperature is 600 ^{o}C.

(8 marks)