ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA

DEPARTMENT OF
MECHANICAL, AUTOMOTIVE AND PRODUCTION ENGINEERING

FIRST SEMESTER EXAMINATIONS

2017/2018 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE: MEE 411 – Applied Thermodynamics I (2 Units)

CLASS: 400 Level Mech. & Automotive Engineering

TIME ALLOWED: 2 Hours

INSTRUCTIONS: Answer any **FOUR** questions

Date: March, 2018

Question 1

(a) What are the applications of thermodynamics relations? **(3 Marks)**

(b) Starting from laws of thermodynamics, show that the following Maxwell relations are valid.

$$\left(\frac{\partial T}{\partial v}\right)_s = -\left(\frac{\partial P}{\partial s}\right)_v, \quad \left(\frac{\partial s}{\partial P}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_P$$

$$\left(\frac{\partial T}{\partial P}\right)_s = +\left(\frac{\partial v}{\partial s}\right)_P, \left(\frac{\partial s}{\partial v}\right)_T = +\left(\frac{\partial P}{\partial T}\right)_v \quad \textbf{(12 Marks)}$$

Question 2

(a) Given that $h_{fg} = TV_{fg}\left(\frac{dP}{dT}\right)_{sat,@\ 20\ ^\circ C}$ estimate h_{fg} of R-134a at 20 °C **(5 Marks)**

(b) Given that $U_j = \frac{1}{C_P}\left[T\left(\frac{\partial v}{\partial T}\right)_P - v\right]$; Find Joule-Thomson Coefficient for steam at 500^0 C and 2 MPa. Hence, comments on your answer **(5 Marks)**

(c) Given that $\left(\frac{\partial P}{\partial T}\right)_v = \left(\frac{\partial S}{\partial v}\right)_T$, Show that Clausius- Clapeyron equation is $\frac{\partial P}{\partial T} = \frac{h_{fg}}{T_o V_{fg}}$ **(5 Marks)**

Question 3

(a) 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 ^{0}C to 2 MPa. Assuming constant specific heats, calculate

(i) The final temperature

(ii) The work required, and

(iii) The change in entropy **(7 Marks)**

(b) The air at 25 ^{0}C and 100 kPa in a 150 m^3 room has a relative humidity of 60%. Calculate

(i) The humidity ratio,
(ii) The dew point
(iii) The mass of water vapour in the air. **(8 Marks)**

Question 4

(a) The dry- and wet-bulb temperatures of atmospheric air at 1 atm (101.325 kPa) pressure are measured with sling psychrometer and determined to be 25 and 15 ^{0}C, respectively. Determine.
(i) The specific humidity,
(ii) The relative humidity, and
(iii) The enthalpy of the air. **(7 Marks)**

(b) Consider a room that contains air at 1 atm, 35 ^{0}C and 40 percent relative humidity. Using the psychrometric chart, determine.
(i) The specific humidity
(ii) The enthalpy (in kJ/kg dry air)
(iii) The wet-bulb temperature, the dew-point temperature, and
(iv) The specific volume of the air (in m^3/kg dry air) **(8 Marks)**

Question 5

(a) List 4 basic air-conditioning processes **(4 Marks)**

(b) Water is used to remove the heat from the condenser of a power plant. 10000 kg per minute of 40 ^{0}C water enters a cooling tower, as shown in fig. Q5b. Water leaves at 25 ^{0}C. Air enters at 20 ^{0}C and leaves at 32 ^{0}C. Estimate
(i) The volume flow rate of air into the cooling tower, and
(ii) The mass flux of water that leaves the cooling tower from the bottom. **(11 Marks)**

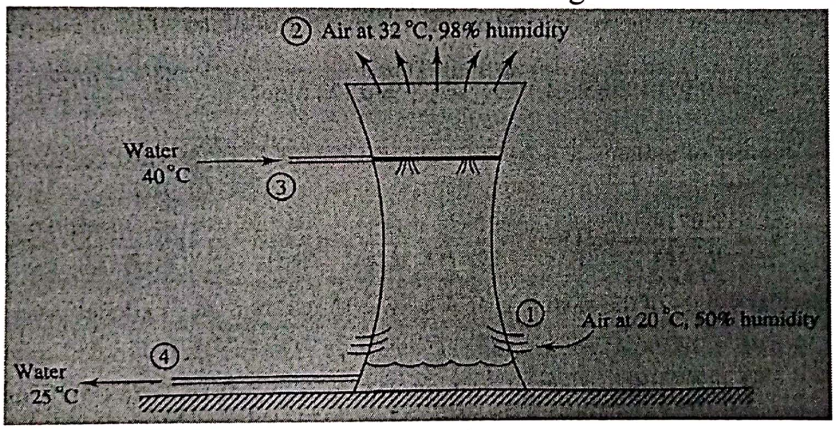

Fig. Q5b

Formulae

(1) $C_p = T\left(\frac{\partial s}{\partial T}\right)_P$ (2) $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{k-1/k}$ (3) $\Delta s = C_p ln\frac{T_2}{T_1} - R\, ln\frac{P_2}{P_1}$

(4) $\omega_1 = \frac{C_p(T_2-T_1)+\omega_2 h_{fg2}}{h_{g1}-h_{f2}}$ (5) $\omega_2 = \frac{0.622P_{g2}}{P_2-P_{g2}}$ (6) $\emptyset_1 = \frac{\omega_1 P_2}{(0.622+\omega_1)P_{g1}}$

(7) $\omega = 0.622\frac{P_v}{P_a}$