**TECHNICAL UNIVERSITY OF MOMBASA**

**Faculty of Engineering and Technology**

**DEPARTMENT OF MECHANICAL AND AUTOMOTIVE ENGINEERING**

**UNIVERSITY EXAMINATIOS FOR:**

THE DEGREE IN BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

(BSME)

**EMG 2302: ENGINEERING THERMODYNAICS II**

**END OF SEMESTER EXAMINATION**

**SERIES: MAY 2016 (SUPPLEMENTARY)**

**TIME: 2 HOURS**

**INSTRUCTIONS TO CANDIDATES**

1. You should have the following for this examination:
   - **Answer Booklet**
   - **A Non-Programmable Scientific Calculator**
   - **Thermodynamic and Transport Properties of Fluids (SI Edition) by Y.R Mayhew and G.F.C Rogers**
   - **P-h diagram for R-134a**
   - **Psychrometric Chart**
2. This paper consists of **FIVE** Questions.
3. Answer **ANY THREE** Questions.
4. All questions carry equal marks.
5. **This paper consists of SIX printed pages.**

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**Question 1**

a) A refrigeration system operates on the basic reversed Carnot Cycle using a condensable working fluid.

i. Show the cycle on T – s and p – h diagrams on which the exit from the evaporator is State 1.
(7 Marks)

ii. Show that the $COP_{REF} = \frac{T_1}{T_2 - T_1}$ (14 Marks)

iii. Show that the $COP_{HP} = \frac{T_2}{T_2 - T_1}$ (5 Marks)

iv. Show that the $COP_{HP} - COP_{REF} = 1.0$ (3 Marks)

b) A refrigerator operating on the basic reversed Carnot Cycle has working temperatures in the evaporator and condenser of -30$^0$C and 32$^0$C, respectively. What are the maximum $COP_{REF}$ and $COP_{HP}$?

If the actual refrigerator has a $COP_{REF}$ of 0.75 of the maximum $COP_{REF}$, calculate the refrigeration effect in kW per kW power input.

(11 Marks)

**Question 2**

Steam leaves a boiler at 2.5 MPa and 300$^0$C and is expanded in the HP Turbine to 0.10MPa at which pressure the liquid and vapour phases are completely separated. The vapour phase is reheated at constant pressure to 250$^0$C and then expanded in the LP Turbine to 4.0kPa after which the LP Turbine exhaust is completely condensed and under cooled by 3.0$^0$C and discharged into a hot well using a condensate pump. The separated liquid phase from the HP Turbine is used in a heat exchanger to heat process water from 40$^0$C to 65$^0$C. This stream is then discharged into the hot well.

A feed pump then transfers water from the hot well to the boiler.

a) Show the layout of the plant on a labelled diagram. (8 Marks)
b) Show the processes on a T – s diagram. Show the layout of the plant on a labelled diagram. (8 Marks)

c) Calculate the boiler steam output (kg/sec) required for a total turbine work output of 2MW.
All assumptions made must be stated.
(24 Marks)

**Question 3**

a) State Avogadro's Law and use it to show that the product of molecular mass and gas constant for all gases is a constant.
(8 Marks)

b) State Dalton's Law and use it to show the following:
   i. $V_i = (P_i/P)V$
   ii. $C_p = \sum x_i . C_{pi}$
   Where subscript *i* denotes property of individual gas in a mixture and x is the mass fraction
(15 Marks)

a) Stating form the definition of $C_p$ and $C_v$, show that:
$C_p - C_v = R$ where R is the gas constant
(5 Marks)

b) A vessel of volume 0.4 $m^3$ contains 0.45 kg of Carbon Monoxide (molecular weight 28) and 1.0 kg of air at $15^0$C. The gravimetric analysis of air is 23.3% oxygen and 76.7% nitrogen. The molecular weights of oxygen and nitrogen are 32 and 28 respectively.
Calculate the partial pressure of each gas and the total pressure inside the vessel.
(12 Marks)

**Question 4**

a) Give concise definitions of the following terms used in psychrometry and the symbol for each definition.

i. Saturated vapour
ii. Superheated vapour
iii. Specific humidity
iv. Relative humidity
v. Dew point temperature
vi. Percentage saturation

(20 Marks)

b) Show that the specific humidity ($\omega$) is given by:

$\omega = (0.622)\ (P_s) / (P - P_s)$

Where $P_s$ is the partial pressure off the vapour in the mixture, P is the total pressure and 0.622 is a constant derived from the properties of air and vapour.

(7 Marks)

c) Air at a barometric pressure of 1.01325 bar and temperature of $17^0$C has a relative humidity of 60%. Calculate the specific humidity and dew point temperature.

(13 Marks)

**Question 5**

a) Give concise definitions/meaning of the following terms as used in psychrometry:

i. Adiabatic mixing process
ii. Sensible heating process
iii. Sensible cooling process
iv. Dehumidification
v. Humidification

(10 Marks)

b) A mixture of vapour and air at State 1 ($\omega_1$, $m_{a1}$. $t_1$, $h_1$) is adiabatically mixed with a mixture of vapour and air at State 2 ($\omega_2$, $m_{a2}$. $t_2$, $h_2$) to form a mixture at State 3 ($\omega_3$, $m_{a3}$. $t_3$, $h_3$).

i. Show that $(h_1 - h_3) / (h_3 - h_2) = m_{a2}/m_{a1}$)
ii. Show that $(h_1 - h_3) / (h_3 - h_2) = (\omega_1 - \omega_3)/ (\omega_3 - \omega_2)$

(16 Marks)

c) Show the above processes on a labelled hand-drawn psychrometric chart.

d) Given that $t_1 = 40^0C$, $\omega_1 = 0.020$ kg/kg air, and that $t_2 = 25^0C$, $\omega_2 = 0.01$ kg/kg air, and $m_{a2}/ m_{a1} = 0.05$.

Show the processes and final state 3 on the psychrometric chart provided and hence obtain the final specific humidity, relative humidity and enthalpy.

(12 Marks)