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

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.**

Question 1

Figure Q1 shows the layout of a type of refrigeration plant.

a) Label each component and state its function.

(3 Marks)

b) Use the equilibrium states marked on the diagram, to draw T – s and p – h diagrams for the complete system.
(3 Marks + 3 Marks)

c) If the working fluid is R–134 a, and given the following data:

$P_1 = 10.163$ bar, $t_1 = 60^0C$

$t_2 = 20^0C$, $P_3 = 2.0$ bar

$p_6 = 0.40$ bar

$t_7 = -20^0C$

Determine the specific enthalpies at all points numbered on the diagram, and then:
(13 Marks)

d) Calculate the following per kg of fluid going through the condenser.

i. Total compressor work
(6 Marks)

ii. Evaporator load
(3 Marks)

iii. Condenser load.
(3 Marks)

iv. Coefficient of Performance for Refrigeration (COP_{REF})
(3 Marks)

v. Coefficient of Performance for Heat Pump (COP_{HP})
(3 Marks)

Any assumptions made must be stated.

Question 2

A steam power cycle is designed to operate at the following parameters:

- Maximum pressure = 30 bar
- Minimum pressure = 0.04 bar

Assuming the work transfer components have isotropic efficiencies of 1.0, calculate the net output, the work ratio, the specific steam consumption and the thermal efficiency of the cycle for the following two cases:

a) For the Carnot Cycle
   (20 Marks)
b) For the Basic Rankine Cycle
   (20 Marks)

In both cases, the fully labelled layout of the components of the plants and the T- s diagrams must be shown, on which the inlet to the work producing device is labelled "2".

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)

c) 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)

d) 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 15^0C. 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 (ω) 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 17^0C 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 (ω_1, m_{a1}. t_1, h_1) is adiabatically mixed with a mixture of vapour and air at State 2 (ω_2, m_{a2}. t_2, h_2) to form a mixture at State 3 (ω_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)

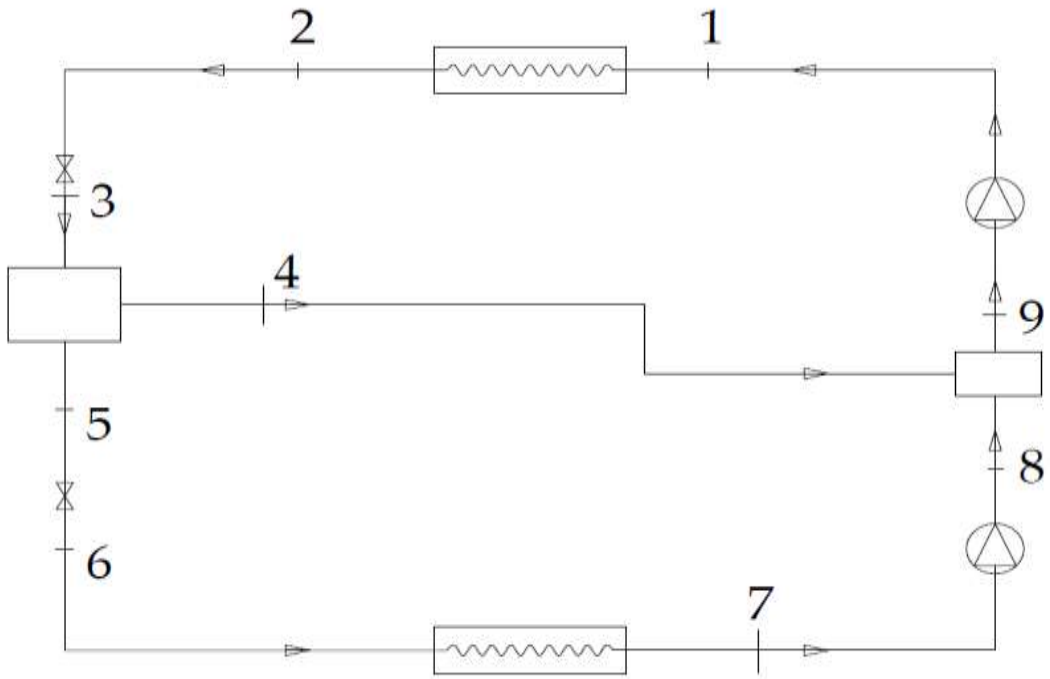

Figure Q1