Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Sem-Vth Examination December 2010

Subject Code: 151403

Subject Name: Food Refrigeration and Air Conditioning

Date: 15 /12 /2010 **Time: 03.00 pm - 05.30 pm**

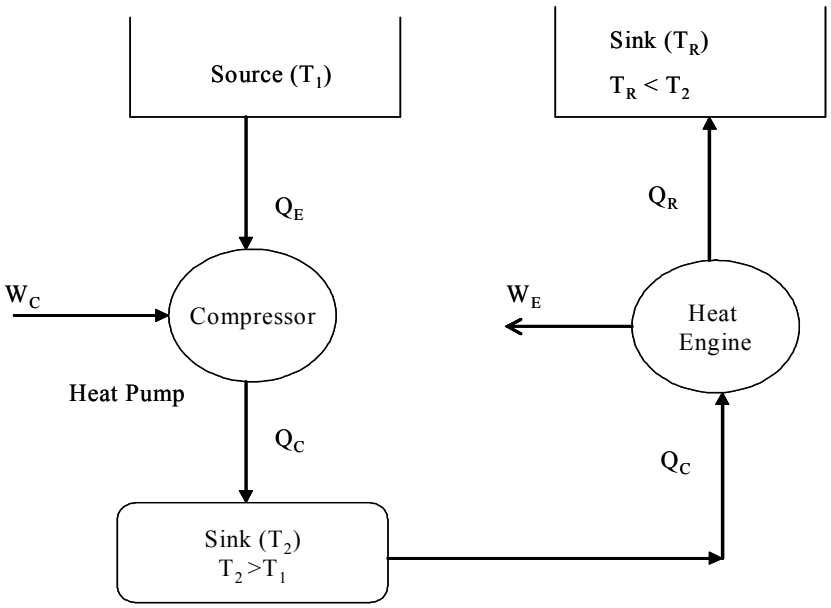
Total Marks: 70

Instructions

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** State the desirable thermodynamic properties of refrigerants. Find out the international designation 'R' for the following refrigerants: $C_2Cl_3F_3$, C_2H_6, $C_2Cl_2F_4$, and NH3. **07**

A heat pump and a heat engine are operating together as depicted in the block diagram below:



The net heat delivered by the heat pump is 7 kW and its COP is 4. The heat engine operates at an efficiency of 15%. Write individual and combined energy balance accounts for the system and calculate the work inputs W_C and W_E.

(b) "An ideal vapour absorption refrigeration system may be considered as a heat-operated refrigerating machine combining a heat engine and a mechanical refrigerator working together to produce the desired refrigeration effect". Justify the statement with help of schematic diagram and mathematical relations. **07**

Q.2 **(a)** Explain the operation of a simple vapour compression cycle with the help of a neat labelled block diagram supplementing your answer with sketches of P-h and T-s diagrams indicating various state points the refrigerant undergoes. State why is it desirable to have a slight vapour superheat at he compressor suction and liquid sub-cooling at the condenser outlet? **07**

(b) A simple vapour compression refrigeration system operating on R-22 develops 15 TR refrigeration when the evaporating and condensing temperatures are set at -10°C and 35 °C respectively. Calculate the following: **07**

(i) Refrigeration effect in kJ/kg
(ii) Mass flow rate of refrigerant in kg/s
(iii) Compressor power required in kW
(iv) COP of the system
(v) Compressor suction volume flow rate in m^3/s
(vi) Power consumed per TR of refrigeration in kW/TR
(vii) Compressor discharge temperature in °C

Properties or R-22							
t (°C)	P (bar)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)	v_f (m^3/kg)	v_g (m^3/kg)
-10	3.543	188.426	401.555	0.95725	1.76713	$0.76x10^{-3}$	0.065
35	13.548	243.114	415.627	1.1459	1.7057	$0.86x10^{-3}$	0.017

Specific heat of refrigerant vapours in the superheated region C_{pv} = 0.88kJ/kg K

OR

(b) A 22 TR refrigeration plant is operating on simple vapour compression cycle using R-12. The evaporating and condensing temperatures are set at -8 °C and 42 °C respectively. Calculate the following: **07**

(i) Compressor discharge temperature
(ii) Refrigeration effect in kJ/kg
(iii) Mass flow rate of the refrigerant in kg/s
(iv) Dryness fraction of refrigerant entering evaporator
(v) Specific volume of the refrigerant entering evaporator, m^3/kg
(vi) Compressor power required in kW to run the cycle
(vii) COP of the system

Properties or R-12							
t (°C)	P (bar)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)	v_f (m^3/kg)	v_g (m^3/kg)
- 8	2.3519	192.647	348.012	0.973	1.56	$0.703x10^{-3}$	0.0716
42	10.088	240.574	367.825	1.1362	1.54	$0.803x10^{-3}$	0.0173

Take specific heat of refrigerant vapours in superheated region =0.64 kJ/kg K.

Q.3 **(a)** Draw a schematic layout of an air-conditioning system showing the location of all major components, direction of air and refrigerant flow and control devices employed. Briefly explain the thermodynamic function of each component. **05**

(b) What are fan laws? What can be interpreted if FVP = FTP? A fan was purchased and installed to run at 760 RPM and deliver the rated duty of 3.6 m^3/s air at FTP of 500 Pa to a room through a duct work. However, after installation of the fan, the ductwork was altered resulting in an increase in the total pressure drop in the ductwork to 650 Pa. Reason out if the fan will now be able to deliver the rated duty? What would you suggest so that the same fan is able to meet the rated duty? Provide mathematical justification for your answer. **05**

(c) Draw a labelled schematic diagram of air flow and control in a blow-through type air-conditioning system showing various components. State the general requirements of good room air distribution in a cold storage meant for storage of food grains. How would you control air volume flow rate within such a storage enclosure? **04**

OR

Q.3 **(a)** Differentiate between axial and centrifugal flow fans and mention their suitability for various duty requirements. A fan driven by a 70% efficient constant speed motor delivers 6 m^3/s of air against a static head of 60 mm WC at a location where the specific gravity of air is 0.92. Calculate the air flow rate in m^3/s , static head in mm WC and the required motor shaft power (HP) if the same fan is tested at a place where the specific gravity of the air is 1.2. **05**

(b) Write mass and energy balance equations for air flowing in a duct. An air duct of cross-sectional area 120 cm x 90 cm carrying 15 m^3/s air branches into two sub-ducts of size 80 cm x 80 cm and 80 cm x 64 cm. calculate the mean velocities of air in the main duct and the smaller of the branched ducts if the mean velocity of air in the sub-duct 80cm x 80 cm is 12 m/s. **05**

(c) Mention the sensing elements for temperature, pressure and humidity used in air-conditioning systems. Explain operation of an automatic temperature control device with the help of a schematic layout indicating feedback and locations of A/c room, amplifier, sensor, comparator, actuator indicator, controller etc. **04**

Q.4 **(a)** Briefly explain the different components of a cold storage and list out different type of safety device and write their functions and location in the cold storage. **07**

(b) In an absorption type refrigerator, the heat supplied to NH_3 generator by condensing steam at 2 bar and 85% dry. The temperature to be maintained in the refrigerator is -4 ^{0}C. The temperature of atmosphere is 32 ^{0}C. Find the maximum COP possible of the refrigerator. If the refrigeration load is 20 Tons and actual COP is 80% of the maximum COP, find the mass of steam required per hour.
Saturation temperature of steam at 2 bar = 120 ^{0}C.Assume that only Latent heat of steam is used for heating and h_{fg}= 2200 kJ/kg. **07**

OR

Q.4 **(a)** What do you mean by sensible heat and latent heat? 200 kg of lean poultry is first cooled from 30 to 4 ^{0}C, thereafter it is cooled and frozen to -18 ^{0}C. Calculate the total heat load. Freezing point of poultry is -2.8 ^{0}C and latent heat of fusion is 246.8 kJ/kg. Specific heat of poultry above freezing point is 3.21 kJ/kg.^{0}C and Specific heat of poultry below freezing point is 1.71 kJ/kg.^{0}C. **07**

(b) Explain the principle, construction and working of a Domestic Electrolux Refrigerator with neat sketch. **07**

Q.5 **(a)** Explain briefly Controlled atmosphere storage (CAS) and Modified atmosphere storage (MAS). **07**

(b) Mention the classification of compressors. Differentiate between positive and non- positive displacement type compressors with examples. **07**

OR

Q.5 **(a)** Explain with neat diagram the working of a flooded type evaporator. **07**

(b) What do you mean by a hermetically sealed compressor and what are its advantages over an open type compressor? Classify and list the commonly used expansion valves. **07**

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