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(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 4054 Roll No. | | | | | | | | | | |

B.Tech.

SIXTH SEMESTER EXAMINATION, 2005-2006

REFRIGERATION AND AIR-CONDITIONING

Time : 3 Hours *Total Marks : 100*

Note : *(i) Attempt ALL questions.*
(ii) All questions carry equal marks.
(iii) In case of numerical problems assume data wherever not provided.
(iv) Use of steam tables, refrigerant's properties tables and charts, specially P-H chart for R-22 is permitted.
(v) Be precise in your answer.

1. Attempt ***any four*** parts of the following : **(5x4=20)**

(a) What is a refrigerant ? Enumerate the desired chemical, physical and thermodynamic properties of refrigerants used in vapour compression refrigeration cycle. Write a short note on the effects of release of CFC class of refrigerants into the atmosphere.

(b) Describe all the processes (on a T-s and P-h diagram) which constitute a simple Carnot refrigeration system. What are the limitations of this cycle and how is the cycle modified to get a vapour compression cycle ?

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(c) What do you understand by Dry Air Rated Temperature (DART) ? What are the limitations of Carnot Cycle with a gas as the working fluid ? What are the advantages of an air cycle with regards to its application in aircraft refrigeration ?

(d) Describe the operation of a Bootstarp air-cycle system for aircraft applications with the help of its block diagram and a Temperature - Entropy diagram.

(e) A Carnot refrigerator has working temperatures of - 30°C and 35°C. If it operates with R-12 as a working fluid, calculate :

(i) isentropic compression work

(ii) refrigeration effect

(iii) heat rejected per unit mass of the refrigerant

(iv) COP of the cycle

If an actual refrigerator has a COP which is 75% of that of the ideal Carnot cycle, calculate the power consumption and heat rejected to the surroundings per ton of refrigeration.

THERMODYNAMIC PROPERTIES OF R-12

Saturation Temp.	Saturation Pressure	Saturated Liquid and Vapour					
t	p	vf	vg	hf	hg	sf	sg
°C	bar	1/kg	m3/kg	kJ/kg	kJ/kg	kJ/kg K	kJ/kg K
−40	0.641	0.66	0.2421	0	169.6	0	0.7274
−35	0.806	0.67	0.1950	4.4	171.9	0.0187	0.7220
−30	1.003	0.67	0.1595	8.9	174.2	0.0371	0.7171
−25	1.236	0.68	0.1313	13.3	176.5	0.0552	0.7127
−20	1.508	0.69	0.1089	17.8	178.7	0.0731	0.7088
−15	1.825	0.69	0.0911	22.3	181.0	0.0906	0.7052
−10	2.19	0.70	0.0767	26.9	183.2	0.1080	0.7020
−5	2.61	0.71	0.0650	31.4	185.4	0.1251	0.6991
0	3.08	0.72	0.0554	36.1	187.5	0.1420	0.6966
5	3.62	0.72	0.0475	40.7	189.7	0.1587	0.6942
10	4.23	0.73	0.0409	45.4	191.7	0.1752	0.6921
15	4.91	0.74	0.0354	50.1	193.8	0.1915	0.6902
20	5.67	0.75	0.0308	54.9	195.8	0.2078	0.6885
25	6.51	0.76	0.0269	59.7	197.7	0.2239	0.6869
30	7.45	0.77	0.0235	64.6	199.6	0.2399	0.6854
35	8.47	0.79	0.0206	69.5	201.5	0.2559	0.6839
40	9.6	0.80	0.0182	74.6	203.2	0.2718	0.6825

(f) In the air cooling system of a jet aircraft, air is bled from the engine compressor at 3 bar, and is cooled in a heat exchanger to 105°C. It is expanded to 0.69 bar in an air turbine, the isentropic efficiency of the process being 85%. The air is then delivered to the cockpit and leaves the aircraft at 27°C. Calculate the temperature at which the air enters the cockpit and the mass flow of air required for a refrigerating effect of 4 kW. If the air turbine is used to help to drive the auxiliaries, calculate its contribution in power.

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2. Attempt *any two* parts of the following : **(10x2=20)**

(a) Explain the differences between throttling and isentropic expansion ? Although some work can be extracted from the isentropic expansion process after the refrigerant leaves the condenser, an irreversible isenthalpic process is generally preferred. Explain the reasons. Briefly describe the term 'flashing' of refrigerants ?

(b) What are the principal factors which make the actual vapour compression cycles deviate from ideal cycle ? With the help of a P-h diagrams, explain the effect of the following parameters on the performance of a vapour compression refrigerant cycle :

(i) Evaporator pressure
(ii) Condenser pressure
(iii) Suction vapour superheat
(iv) Liquid subcooling

(c) The pressure in the evaporator of an ammonia refrigerator is 1.902 bar the pressure in the condenser is 12.37 bar. Calculate the refrigeration effect per unit mass of the refrigerant and the COP_{ref} for the following cycles.

(i) the ideal reversed Carnot cycle,
(ii) dry saturated vapour delivered to the condenser after isentropic compression, and no undercooling of the condensed liquid ;

Given :

For ammonia at 1.902 bar, $T_{sat} = -20°C$
$s_g = 5.623$ kJ/kg K, $h_g = 1420.0$ kJ/kg
$s_f = 0.363$ kJ/kg K, $h_f = 89.8$ kJ/kg
at 12.37 bar, $T_{sat} = 32°C$
$s_g = 4.962$ kJ/kg K, $h_g = 1469.9$ kJ/kg
$s_f = 1.235$ kJ/kg K, $h_f = 332.8$ kJ/kg

3. Attempt *any two* parts of the following : **(10x2=20)**

(a) Draw a neat and labelled schematic of a typical vapour absorption refrigeration system. Draw and explain an equivalent system with a combination of a reversible heat engine and reversible refrigerator, thereby determine the maximum COP of a vapour absorption refrigeration cycle. In a vapour absorption refrigeration system, the refrigeration temperature is - 15°C. The generator is operated by solar heat where the temperature reached is 110°C. The temperature of the heat sink is 55°C. What is the maximum possible COP of the system ?

(b) With respect to a binary mixture, write short notes on :

(i) Homogeneous and Heterogeneous mixtures

(ii) Miscibility

(iii) Temperature - Concentration diagram

(iv) Enthalpy - Concentration diagram

If two fluid streams with mass flow rates m_1 and m_2, having different concentrations, C_1 and C_2 and specific enthalpies h_1 and h_2, are adiabatically mixed together in a mixing chamber, derive the expressions for the resultant concentration and enthalpy, explaining the process with an Enthalpy-Concentration diagram.

(c) Describe the operation of a Lithium Bromide - Water absorption refrigeration system with the help of a neat labelled diagram. Comment on the possibility of utilizing Solar Energy for the purpose of refrigeration coupled with this system.

4. Attempt *any two* parts of the following : **(10x2=20)**

(a) Define the following terms, with the help of Temperature Entropy diagram :

(i) Dew point temperature of air

(ii) Degree of saturation of air

(iii) Wet bulb temperature

If the total atmospheric pressure remains constant at a location, prove that the specific humidity is approximately a linear function of the partial pressure of the vapour in the atmosphere.

(b) Explain the term 'Temperature of Adiabatic Saturation'. Moist unsaturated air having temperature T, specific enthalpy h, and specific humidity ω, enters an adiabatic chamber where pure water having temperature T* and specific enthalpy h* already exists. The air leaves the chamber in a saturated state with temperature T*, specific enthalpy h* and specific humidity ω^*. Assuming the humid specific heats of inlet and exit streams to be equal (=Cp), prove that :

$T^* = T - \frac{h^*_{fg}}{Cp}(\omega^* - \omega)$, where h^*_{fg} is the latent heat of vapour corresponding to T*.

(c) Calculate (i) relative humidity, (ii) humidity ratio, (iii) dew point temperature (iv) density and enthalpy of atmospheric air when the DBT is 35°C, WBT is 23°C and the barometer reads 750 mm of mercury (Use Carrier Equation for determining the partial pressure of vapour). Use properties of water from steam tables.

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5. Attempt *any four* parts of the following : **(5x4=20)**

(a) What do you understand by thermal resistance ? With respect to a building wall, what is meant by surface conductance and overall heat transfer coefficient ?

(b) With respect to the passive heating and cooling of buildings, explain the following concepts :

(i) Direct gain principle

(ii) Indirect gain principle

(iii) Isolated gain principle

(c) With the help of a neat diagram, explain the working of an automatic expansion valve used for refrigerant flow control.

(d) Write short notes on frictional losses and dynamic losses in a flow through a duct. Write the expression for frictional pressure drop in ducts with proper nomenclature.

(e) Explain two types of refrigeration systems used in trucks/trailers during road transport ?

(f) Explain the factors which affect human comfort. What use of 'comfort charts' for comfort air-conditioning ?

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