Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V • EXAMINATION – SUMMER • 2014

Subject Code: 151403 Date: 13-06-2014

Subject Name: Food Refrigeration and Air Conditioning

Time: 10.30 am - 01.00 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)** Answer the following questions: **07**

(i) Differentiate between centrifugal & reciprocating compressors.
(ii)Write chemical formula of R134a and R22?
(iii) State the performance indices for vapour compression refrigeration systems.
(iv) What is the function of expansion valve in VCS?
(v) Why is Carnot COP greater than actual COP in VCS?
(vi) Define azetropes with an example.
(vii) State most important safety criteria for selecting refrigerants.

(b) Name different components of vapour absorption refrigeration system that replace the compressor of a vapour compression refrigeration system. What is the function of hydrogen gas in Electrolux refrigeration system? In a vapour absorption system, heating, cooling and refrigeration takes place at temperatures of 107^0C, 27^0C & - 37^0C respectively. Calculate the maximum theoretical COP of the system. **07**

Q.2 **(a)** A 30 TR ice plant is working on simple vapour compression cycle with R-22 as refrigerant : The operating conditions are: **07**
Evaporating temperature = -5^{o}C, Condensing temperature = 40^{o}C and Refrigeration efficiency = 78%. Calculate the following:

(a) Mass flow rate of the refrigerant in kg/s
(b) Condenser heat rejection in kW
(c) Rated compressor power (Nominal) in HP if it is 90 % efficient
(d) Actual COP of the system
(e) Compressor suction volume in LPS
(f) Quality of the refrigerant entering the evaporator in %
(g) Power consumption in HP/TR

Properties or R-22							
t (^{o}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)
-5	4.2135	194.176	403.496	0.9787	1.7593	$0.768x10^{-3}$	0.055
40	15.335	249.686	416.561	1.1666	1.6995	$0.884x10^{-3}$	0.01513

Take average specific heat of R-22 vapours in superheated region = 0.85 kJ/kg K.

(b) Explain the principle and operation of vapour compression based refrigeration system. Draw P-h, T-s and h-s phase diagrams of a simple vapour compression cycle showing all the state points. Write down expressions for refrigeration effect, compressor power, condenser heat rejection and throttling process in terms of usual notations using P-h diagram as a reference. If the condensed refrigerant liquid exiting the condenser is slightly sub-cooled, how will it affect the volumetric efficiency and COP of the system? **07**

OR

(b) State and explain the functions of different components of a simple vapour compression refrigeration system with the help of a neat flow diagram. Also draw P-h & T-s phase diagrams for the process. Explain the effect of the following on performance of a simple vapour compression refrigeration system: **07**

(i) Drop in evaporator pressure (ii) Increase in condenser pressure
(iii) Suction vapour superheat. (iv) Liquid sub-cooling

Q.3 **(a)** State fan laws. A fan driven by an 80% efficient constant speed motor delivers 6.2 m^3/s of air against a static head of 66 mm WC at a location where the specific gravity of air is 0.95. The same fan is now operated at a place where the specific gravity of the air is 1.15. Calculate **04**

(i) air flow rate in cmm.
(ii) static head in mm WC
(iii) motor shaft power in HP

(b) Name different types of supply air outlets used in air-conditioning. Room air from an air- conditioned space is being exhausted into atmosphere in a laminar flow pattern through a register installed at the top side-wall of the room. The duct leading to the register has cross-sectional size 45cm x 36cm and carries an air flow @ 27cmm. Calculate the effective area of the register section outlet if the static pressure drop just behind the register is 3 m WC. Assume no losses. **04**

(c) Explain the following: **06**

(i) Electronic air filters (ii) Humidistat
(iii)Slot Diffusers (iv) Solenoid valves
(v) Radial flow fans (vi) Limit Switches

OR

Q.3 **(a)** Explain fan characteristics. Show that the equation for fan power "$W = k \rho D^5 N^3$" is dimensionally consistent, where k is a unit-less constant. An axial fan running at 720 RPM, consumes 80W power and delivers 12 cmm air at 110 Pa static pressure. If the fan speed is increased by 100%, calculate **04**

(i) The power required in HP.
(ii) Static pressure in Pa.
(iii) Air flow rate in cmm.

(b) Explain the working of the following briefly: **04**

(i) Centrifugal dust collectors
(ii) Room thermostat
(iii) Automatic humidity controller
(iv) Time switches

(c) State the general requirements of optimal room air distribution and control for a cold room designed for storage of low moisture dry fruits. Explain the terms (a) Draft (b) induction ratio (c) Spread (d) Aspect ratio (e) Air washer (f) Radiator. **06**

Q.4 **(a)** Ten tonnes of potatoes are to be cooled from 25 ^{0}C and 10 ^{0}C in 24 hours. The consolidated heat of respiration of potatoes per 24 hours is 800 kcal. Four men will work for 4 hours and lighting load is estimated to be 100 Watt. The Cold storage measures 6 X 6 X 4 m from inside and is constructed of bricks laid in cement mortar. The wall thickness is 40 cm and there is 10 cm thick cork insulation on the inside of the four walls. The cement plaster is 1 cm thick. The heat transfer coefficient for the ceiling is 10% more than that of the walls. The outside temperature is 27 ^{0}C and the inside is maintained at 4 ^{0}C. Calculate the refrigeration capacity needed in TR. Assume that there is no heat transfer through the floor. **07**

The following data are given:

Specific heat of potatoes = 0.82 kcal/kg ^{0}C
Thermal conductivity of brick = 0.45 kcal h^{-1} m^{-1}.$^0C^{-1}$
Thermal conductivity of cork = 0.025 kcal h^{-1}.m^{-1}.$^0C^{-1}$
Thermal conductivity of cement plaster = 0.25 kcal h^{-1} m^{-1} $^0C^{-1}$
Rate of respiration for one man = 150 kcal/h
Air infiltration load = 1000 kcal/24 hours.

(b) Define and differentiate between freezing, refrigeration and chilling. Draw a typical freezing curve for foods and explain in detail the path followed. **07**

OR

Q.4 **(a)** Briefly explain the different components of a cold storage and name different types of safety devices and the purpose for which they are used. What do you mean by sensible heat and latent heat? 400 kg of an assorted food is first cooled from 30 ^{0}C to 4 ^{0}C and thereafter it is further cooled and frozen to -18 ^{0}C. Calculate the total heat load. **07**

Freezing point of assorted food = -2 ^{0}C
Latent heat of fusion = 246 kJ/kg.
Specific heat of assorted food above freezing point = 3.2 kJ/kg.^{0}C
Specific heat of assorted food below freezing point = 1.7 kJ/kg.^{0}C.

(b) Enumerate different types of freezers used in Food Industry. Explain in detail the immersion freezing technique with the help of a neat diagram. Also state its advantages. **07**

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

(b) What do you mean by hermetically sealed compressors? State its advantages over open type compressors? Classify and list commonly used expansion valves in refrigeration system. **07**

OR

Q.5 **(a)** Differentiate between: **07**

i. Plate surface evaporator & Finned tube evaporator
ii. Thermostatic expansion valve & solenoid expansion valve
iii. Air cooled condenser & water cooled condenser
iv. Rotary compressor and reciprocating compressor

(b) How are compressors classified? Differentiate between positive and non- positive displacement type compressors citing advantages and disadvantages of each with examples. **07**

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