Bihar Engineering University, Patna
End Semester Examination - 2022

Course: B.Tech.	Semester: VII	Time: 03 Hours
Code: 102702	Subject: Refrigeration and Air-Conditioning	Full Marks: 70

Instructions:-
(i) The marks are indicated in the right-hand margin.
(ii) There are **NINE** questions in this paper.
(iii) Attempt **FIVE** questions in all.
(iv) Question No. **1** is compulsory.
(v) Use of steam table, refrigerant table and psychometric chart is allowed.

Q.1 Choose the correct answer of the following (any seven): [2 x 7 = 14]

(a) One ton of refrigeration is equal to
   (i) 3.5 kJ/min   (ii) 210 kJ/min
   (iii) 50 kJ/min   (iv) 4.2 kJ/min

(b) Refrigerant vapour enters into the compressor of a standard vapour compression cycle at 10^0C (h=402 kJ/kg) and leaves the compressor at 50^0C (h=432 kJ/kg). It leaves the condenser at 30^0C (h=237 kJ/kg). The COP of the cycle is :
   (i) 4.5   (ii) 5
   (iii) 5.5   (iv) 6

(c) In Electrolux refrigerator
   (i) Ammonia is absorbed in hydrogen   (ii) Ammonia is absorbed in water
   (iii) Ammonia evaporates in hydrogen   (iv) Hydrogen evaporates in Ammonia

(d) Which of the following are normally desired comfort conditions in an air-conditioning system?
   (i) 25^0C DBT and 50% RH   (ii) 15^0C DBT and 75% RH
   (iii) 22^0C DBT and 90% RH   (iv) 15^0C DBT and 40% RH

(e) A heat pump works on a reversed Carnot cycle. The temperature in the condenser coils is 27^0C and that in the evaporator coils is -23^0C. For a work input of 1kW, how much is the heat pumped?
   (i) 1 kW   (ii) 5 kW
   (iii) 6 kW   (iv) None of the above

(f) Environment friendly refrigerant R134a is used in the new generation domestic refrigerators. Its chemical formula is
   (i) $CHClF_2$ (ii) $C_2Cl_3F_3$
   (iii) $C_2Cl_2F_4$ (iv) $C_2H_2F_4$

(g) If the specific humidity of air remains same but its DBT increase, then DPT.
   (i) Remains Same   (ii) Increases
   (iii) Decreases   (iv) May increase or decrease

(h) During sensible cooling of air, the coil efficiency is given by
   (i) 1- BPF   (ii) 1+ BPF
   (iii) 1/BPF   (iv) None of the above

(i) The process used for winter air conditioning is
   (i) Cooling and dehumidification   (ii) Heating and dehumidification
   (iii) Heating and humidification   (iv) Evaporative Cooling

(j) The COP of a window air conditioner compared to the COP of domestic refrigerator is
   (i) Same   (ii) Lower

(iii) Higher   (iv) Unpredictable

Q.2 (a) A refrigerator working on Bell-Coleman cycle operates between pressure limits of   **[7]** 1.05 bar and 8.5 bar. Air is drawn from the cold chamber at 10^0C, compressed and then it is cooled to 30^0C before entering the expansion cylinder. The expansion and**P.T.O.** compression follows the law $pv^{1.3}$=constant. Determine the theoretical C.O.P. of the system.

(b) Derive an expression for COP of Reserved Brayton cycle in terms of pressure ratio   **[7]** and ratio of specific heat.

Q.3 (a) Discuss the effect of the change in the suction pressure and discharge pressure on the   **[7]** COP of the VCR with neat P-h diagram.

(b) A vapour compression works on a simple saturation cycle with R–12 as the   **[7]** refrigerant which operates between the condenser temperature of 40^0C and evaporation temperature of $- 5^0C$. For the modified cycle, the evaporative temperature is changed to $- 10^0C$ and other operating condition are the same as the original cycle. Compare the power requirement for the both the cycles. Both systems develop 15 Tons of refrigeration.

Q.4 (a) What are the advantages of absorption refrigeration system over compression   **[6]** refrigeration system?

(b) Under which circumstances the cascade refrigeration system is preferable?   **[8]**

Q.5 (a) With the help of line diagram showing each component, explain the working of   **[6]** vapour absorption refrigeration system.

(b) In an absorption-type refrigerator, the heat is supplied to NH_3 generator by   **[8]** condensing steam at 2 bar and 90% dry. The temperature in the refrigerator is to be maintained at -5^0C. Find the maximum COP possible. If the refrigeration load is 20 tons and actual COP is 10% of the maximum COP, find the mass of steam required per hour. Take the temperature of the atmosphere as 30^0C.

Q.6 A food storage locker requires a refrigeration capacity of 12 TR and works between the   **[14]** evaporating temperature of -8^0C and condensing temperature of 30^0C. The refrigerant R-12 is sub cooled by 5^0C before entry to expansion valve and the vapour is superheated to -2^0C before leaving the evaporator. Assume a 2 cylinder, single acting compressor operating at 1000rpm with stroke equal to 1.5 times the bore.
The specific heat of liquid R-12 is 1.235kJ/kg K and vapour R-12 is 0.733 kJ/kg K.
Determine:
(a) C.O.P.
(b) Theoretical power per Ton of refrigeration
(c) Bore and stroke of compressor when there is no clearance.

Saturation temperature,^0C	Pressure, bar	Enthalpy, KJ/kg		Entropy, kJ/kg K		Specific volume, m^3/kg
		Liquid	Vapour	Liquid	Vapour	
-8	2.345	28.72	184.07	0.1149	0.7007	0.0790
30	7.451	64.59	199.62	0.2400	0.6853	0.0235

Q.7 (a) Draw a neat diagram of Electrolux refrigerator and explain its working principle.   **[7]** What is the important role of hydrogen in this refrigeration in system?

(b) What are the advantages of air-refrigeration system, using aeroplane?   **[7]**

Q.8 (a) What are the factors that affect human comfort and effective temperature required for   **[5]**

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human comfort?

(b) An auditorium is to be air conditioned for a seating capacity of 2000 for the following [9] outdoor and indoor comfort conditions.
Outdoor = 34^0C DBT and 70% R.H. and Indoor=26^0C DBT and 50% R.H.
SH=480000kJ/hr., LH = 160000 kJ/hr.
The rise in temperature of the air inside the auditorium is limited to 7^0C. 70% of the room air going to exhaust is recirculate and mixed with 30% fresh air. The fan is located before all the cooling heating equipment and mixed air is passed through the fan. The motor capacity connected to the fan is 50kW. Assume 80% of the motor energy is given to the air passing through the fan. The required air-conditioning is achieved first by cooling and dehumidifying and then heating the air. The DPT of the cooling and humidifying coil=12^0C. Find the following:
(i) Quantity of air supplied at outdoor condition in m^3/hr per person.
(ii) The capacity of refrigeration system in TR
(iii) Capacity of heating coil in kW
(iv) The bypass factor of the cooling coil.

Q.9 (a) Prove that the enthalpy of the humid air remains constant along the wet-bulb [7] temperature line of a psychometric chart.

(b) The humidity ratio of atmospheric air at 28^0C dry-bulb temperature and 760 mm Hg [7] is 0.016 kg/kg of dry air. Using steam tables determine-
(i) Partial pressure of water vapour;
(ii) Dew point temperature;
(iii) Relative humidity;
(iv) Specific enthalpy;
(v) Vapour density.