BITS Pilani, Dubai Campus

Dubai International Academic City, Dubai, U.A.E

IV Year II Semester 2012-2013

COMPREHENSIVE EXAMINATION [CLOSED BOOK]

Course No. CHE C471 / ME C461 **Course Title:** REFRIGERATION &A/C

Max.Marks: 80 **Weightage:** 40%

Date: 03-06-2013 **Duration:** 3HRS

Notes:

- Answer all the questions
- Draw neat sketches wherever necessary
- Make suitable assumptions if required and clearly state them
- ***Refrigeration charts and Tables*** are permitted

1. Enumerate the difference between refrigeration and air conditioning :- **[3M]**
2. What is the standard rating of a refrigeration machine ? **[3M]**
3. Explain the **BELL-COLEMAN AIR REFRIGERATION** system:- **[5M]**
4. Explain the different methods of improving the **COP** of a simple vapor compression refrigeration cycle :- **[4M]**
5. Explain **Flash chamber** in a **Multi compression** refrigeration systems with help of P-H diagram **[5M]**
6. An ammonia refrigerator produces 20 tons of ice per day from and at 0^0C. The condensation and evaporation takes at 20^0C and -20^0C respectively. The temperature of vapour at the end of isentropic compression is 50^0C and there is no under-cooling of the liquid. The actual C.O.P is 70 % of the theoretical C.O.P. Determine:
   a. The **rate** of ammonia circulation
   b. The **size** of the single acting compressor when running at 240 rpm assuming L= D and volumetric efficiency of 80%

   Take latent fusion of ice = 335kJ/kg. **[10M]**
7. In an **Absorption type** refrigerator, the heat is supplied to NH_3 generator by condensing steam at 2 bar and 90% dry. The temperature to be maintained in the refrigerator is -5^0C. The temperature of the atmosphere is 30^0C.Find the **maximum C.O.P** possible of the refrigerator.

   If the refrigeration load is 20 tons and actual C.O.P is 70% of maximum COP, find the **mass** of steam required per hour. **[8M]**
8. Explain ***comfort*** *Air conditioning* and ***metabolic rate*** **[4M]**
9. Find the nomenclature for the Methane base Refrigerant $\mathbf{C_2Cl_2F_4}$ **[4M]**

10. 30 m^3 of air at 15°C DBT and 13°C WBT are mixed with 12 m^3 of air at 25°C DBT and 18°C WBT. Assuming the barometric pressure of one std atmosphere, determine the DBT and WBT of the resulting mixture. **[8M]**

11. In the duct layout shown in Fig. below, outlets 1 and 2 deliver 20 cmm each and outlet 3 delivers 28 cmm. Select a velocity of 8 m/s in section A. Size the duct system using the equal friction method. Also assume dynamic los coefficient in elbow K = 0.22 and static regain factor in fitting R =0.75(1-R = 0.25). Static pressure at each outlet is 3 mm of water. **[10M]**

12. **[16M]**

A space to be conditioned has the following data.

Size of space	: 30 m × 30 m × 4 m high
West glass	: 15 m^2
South glass	: 15 m^2
Solar gain through west glass	: 508 W/m^2 at 4 p.m
Solar gain through south glass	: 38 W/m^2 at 4 p.m.
Overall heat-transfer coefficient of roof	: 2.5 W/m^2K
Overall heat-transfer coefficient of wall	: 3.5 W/m^2K
Overall heat-transfer coefficient of glass	: 6 W/m^2K
Door in E-wall	: 3 m × 2.5 m
Overall heat-transfer coefficient of door	: 1.5 W/m^2K
Equivalent temperature differentials at 4 p.m.	
E-wall	: 15°C
W-wall	: 10.5°C
N-wall	: 6.1°C
S-wall	: 10.5°C
Roof	: 17.8°C
Infiltration through window cracks	: 5.3 $m^2/h/m$
Infiltration through door openings	: 3 cmm/m^2
Occupancy	: 100
Sensible heat gain per occupant	: 75 W
Latent heat gain per occupant	: 55 W
Lighting	: 33.5 W/m^2 fluorescent
Outside design conditions	: 43°C DB, 27°C WB
Inside design conditions	: 25°C DB, 50% RH
Ventilation air	: 0.24 cmm/person.

Assume a suitable fan heat and bypass factor of the air-conditioning apparatus. Calculate:

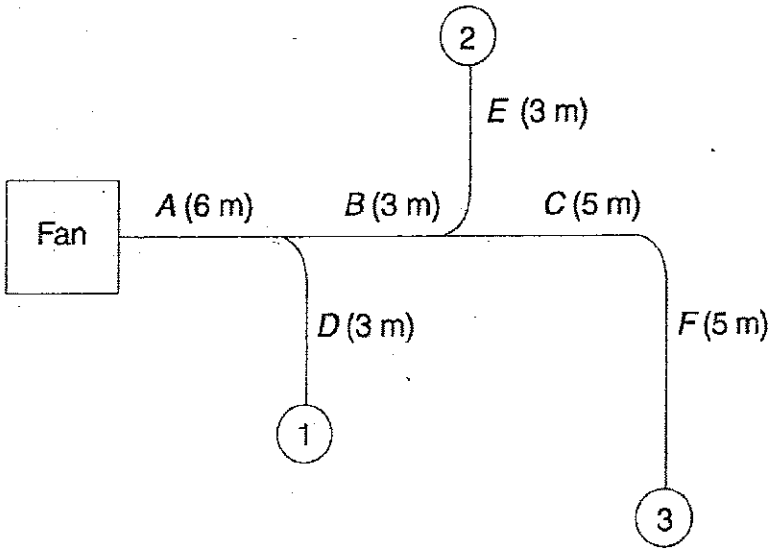
(i) Room sensible heat gain.

(ii) Room latent heat gain.

$$\frac{\Delta p_f}{L} = \frac{0.002268\,\dot{Q}_v^{1.852}}{D^{4.973}} \qquad \Delta p = 0.00047\,(C)^2 \qquad p_{V_A} = \left(\frac{C}{4.04}\right)^2$$

Table 19.1 Heat Liberated due to Occupancy

Activity	*Metabolic Rate* W	*Heat Liberated,* W *Room Dry Bulb Temperature,* °C							
		20		22		24		26	
		S	*L*	*S*	*L*	*S*	*L*	*S*	*L*
Seated at rest	115	90	25	80	35	75	40	65	50
Office work	140	100	40	90	50	80	60	70	70
Standing	150	105	45	95	55	82	68	72	78
Eating in restaurant	160	110	50	100	60	85	75	75	85
Light work in factory	235	130	105	115	120	100	135	80	155
Dancing	265	140	125	125	140	105	160	90	175



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IV Year II Semester 2012-2013

COMPREHENSIVE EXAMINATION [CLOSED BOOK]

Course No. CHE C471 /ME C461 **Course Title:** REFRIGERATION &A/C

Max.Marks: 40 **Weightage:** 40%

Date: 03-06-2013 **Duration:** 3HRS

SOLUTION KEY

1. Write at least 3 difference **3 marks**

2. Write the std.rating (about Tonn of Refrigeration) **3 marks**

3. Explain with block diagram & P-H chart **5 marks**

4. Write at least 3 methods **4 marks**

5. Explain with figure. **5 marks**

6. P-H/T-S diagram **2 marks**

Actual COP = 6.33 **2 marks**

Compressor power = 12.25 kW. **2 marks**

Mass flow rate = 0.097 kg/sec. **2 marks**

D= L= 28.8 cm **2 marks**

7. Max. C.O.P = 1.75. **2 marks**

Actual COP = 1.225 **2 marks**

Actual heat supplied = 57.15 kJ/s **2 marks**

Steam requirement/ hr = 104 kg/hr **2 marks**

8. Explain comfort and metabolic rate **4 marks**

9. Number is 022 and designated as 22 **4 marks**

10. Representation in Psychrometric chart **1 marks**

m_{a1} = 36.2 kg of dry air **1.5 marks**

m_{a2} = 14 kg of dry air **1.5 marks**

w_3 = 8.85 grams /kg **2 marks**

h_3 = 40.8 kJ/kg **2 marks**

11. $Q_A = 1.13\ m^3/s$, $C_A = 8\ m/s$

$A_A = 0.14125\ m^2$

$D_A = 0.424\ m$

$\frac{\Delta P_f}{L}$ = 0.2027 mm of water.

Pv_A = 3.92 mm of water.

	A	B	C	D	E	F
Q	1.13	0.8	0.466	0.33	0.33	0.466
L	6	3	3	3	5	5
D	0.424	0.373	0.305	0.268	0.268	0.305
A	0.142	0.1092	0.073	0.0564	0.0564	0.073
C	8	7.324	6.37	5.84	5.84	6.37
Pv	3.92	3.28	2.49	2.09	2.09	2.49

= 0.2027 X 19 = 3.85 MMOF WATER.

Dynamic pressure drops in A to F :

(Fitting) $_{AB}$ = 0.25(3.92 -3.28) = 0.16

(Fitting) $_{BC}$ = 0.25(3.28 -2.49) = 0.19

Elbow = 0.22 x 2.49 = 0.54

Total = 0.8978

\+ VP at out let F = 2.49

\+ SP at outlet F = 3.0

Total = 6.38 mm of water

Total pressure at fan outlet :

PT = ΔP_F + ΔP_D = 3.85 + 6.38 = **10.23 mm of water**

BITS Pilani, Dubai Campus

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IV Year II Semester 2012-2013

Test No.2 (Open Book)

Course No. CHE C471 /ME C461 **Course Title:** REFRIGERATION &A/C

Max.Marks: 20 **Weightage:** 20%

Date: 1-05-2013 **Duration:** 50 min.

Notes:

- Answer all the questions
- Draw neat sketches wherever necessary
- Make suitable assumptions if required and clearly state them
- ***Refrigeration charts and Tables*** are permitted

1. An air conditioning system is to be designed for cinema hall of 1000 seating capacity when the following data is known:

   Outdoor conditions--- 11^0C and 70% R.H.

   Indoor conditions -- 20^0C and 60% R.H.

   Amount of air supplied --- 0.3 m3/min/person

   The required conditions are achieved first by heating then by adiabatic humidifying and finally by heating. The condition of air coming out of the humidifier is 75% R.H. Then find the following:

   (a) Heating capacity of the first heater in kW and condition of the air coming out of the first heating coil. Also find the surface temperature required if the by pass factor is 0.3

   (b) Heating capacity of the second heater in kW and by pass factor if the surface temperature of the coil is maintained at 22^0C. **[7M]**

2. In an absorption refrigeration system heating, cooling and refrigeration take place at the temperatures of 120^0C, 30^0C and -10^0C. Find the following;

   (a) Ideal C.O.P of the system

   (b) If the heating temperature is increased to 160^0C and refrigeration temperature is decreased to -20^0C find the percentage change in ideal C.O.P

   (c) If the heating is carried out in both cases by using the steam and assuming actual C.O.P is 70% of ideal C.O.P. Find the quantity of steam required per hour in both cases for 50 tons load on system **[7M]**

3. (a) What is the condition for DBT = WBT = DPT ? **[2M]**

(b) "For a given state of refrigerant, the pressure drop is inversely proportional to the length and directly proportional to the bore diameter of the Capillary tube." Is this statement is correct or not? Justify your answer **[2M]**

(d) Discuss the conditions of comfort you would prescribe for an office in a city like Mumbai where hot and wet climate prevails. **[2M]**

BEST OF LUCK

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IV Year II Semester 2012-2013

Test No.2 (Open Book)

Course No. CHE C471 /ME C461 **Course Title:** REFRIGERATION &A/C

Max.Marks: 20 **Weightage:** 20%

Date: 1-05-2013 **Duration:** 50 min

SOLUTION KEY

1 A. 103.678 kW

B. 0.3

2 a. 1.386

b. 3.7 %

c. 244.08 kg/hr

3 a. at saturated condition

b. Directly proportional

c. Mumbai hot and humid – cooling & Dehumidification

BITS Pilani, Dubai Campus

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IV Year II Semester 2012-2013

Test No.1 (Closed Book) -

Course No. CHE C471 /ME C461 **Course Title:** REFRIGERATION &A/C

Max.Marks: 25 **Weightage:** 25%

Date: 20-03-2013 **Duration:** 50 min.

Notes:

- Answer all the questions
- Draw neat sketches wherever necessary
- Make suitable assumptions if required and clearly state them
- ***Refrigeration charts and Tables*** are permitted

Q 1 Explain the necessity of cooling in aeroplane :- **[6M]**

Q 2.A. Describe Simple evaporative air refrigeration systems **[5M]**

B. Air craft is flying at an altitude of 8000 m at a speed of 900 km/hr. The pressure and temperature of air at this altitude are 0.34 bar and 263 k respectively. The air is compressed by an air compressor with a compression ratio of 5. The cabin pressure is 1.013 bar and the temperature is 300 K. Determine the power required for pressurization excluding ram work. Extra power required for refrigeration purpose and refrigeration capacity of the system if the air flow rate is 1 kg/s. **[6M]**

Q.3.A. Explain ice making test :- **[2M]**

B. .A vapour compression machine is used to maintain a temperature of -23^0C in a refrigerated space. The ambient temperature is 37^0C. The compression takes in dry saturated vapour of Freon 12. A minimum 10^0C temperature is required at the evaporator as well as at condenser. There is no sub cooling of liquid. If the refrigerant flow rate is 1 kg/ min. Find. **(i)** Tonnage of refrigeration (ii) Power requirement (iii) Ratio of the COP of this cycle to COP of Carnot cycle **[6M]**

BEST OF LUCK

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IV Year II Semester 2012-2013

Test No.1 (Closed Book) -

Course No. CHE C471 /ME C461 **Course Title:** REFRIGERATION &A/C

Max.Marks: 25 **Weightage:** 25%

Date: 20-03-2013 **Duration:** 50 min.

SOLUTION KEY

1.A. Write at least four differences --- 3 marks

1.B. Explain DART - Dry air Rated Temperature 2 marks

2.A. Explain with figure 5 marks

2.B. 1. Stagnation temperature - T_2 = 296.5 K 1.5 marks

Stagnation pressure P_2 = 0.57 bar 1.5 marks

2. COP = 0.3 3 marks

3.A Explain 0ne ton of refrigeration system. -- 2 marks

3.B. a. COP = Q_c/W = 53.12/18.88 = 2.814 3 marks

b. Capacity of the plant = $Q_c/210$

= 53.12/210

= 0.253 ton 3 marks

BITS PILANI, DUBAI CAMPUS

SECOND SEMESTER 2012 – 2013

QUIZ- II

Course Code: ME C461 / CHE C471 **FINAL YEAR** Date: 23-04- 2013

Course Title: REFRIGERATION & A/C Max Marks: 14

Duration: 20 minutes Weightage: 7%

Name: ..... **ID No:** ..... **Sec / Prog:** .....

Instructions: 1. Attempt all questions

1. Explain **Flash chamber** in a **Multi compression** refrigeration systems with help of P-H diagram **3 marks**

2. Explain the desirable properties of R11 refrigerant: **3 marks**

3. The color of the R500 & R40 are ---------- & ---------- **2 marks**

4 Explain alternate refrigerants **3 marks**

5. What are the different application of Cascading:- **3 marks**

BITS PILANI, DUBAI CAMPUS

SECOND SEMESTER 2012 – 2013

QUIZ- II

SOLUTION KEY

Course Code: ME C461 / CHE C471 **FINAL YEAR** Date: 23-04- 2013

Course Title: REFRIGERATION & A/C Max Marks: 14

Duration: 20 minutes Weightage: 7%

1. Explain **Flash chamber** in a **Multi compression** refrigeration systems with help of P-H diagram **3 marks**

- Flash is defined as the mass of vaporized refrigerant per kg. after leaving the throttle valve.
- This formed vapour refrigerant does not take part in the refrigeration effect.
- This vapour can be bypassed around the evaporator and supplied directly to the compressor.
- This is done by using a tank before evaporator which is known as Flash Chamber.
- No effect on thermodynamic cycle.
- It reduces the size of evaporator providing better conditions of heat transfer

2. Explain the desirable properties of R11 refrigerant: **3 marks**

6. R-11 (Trichloro monofluoro methane)

Properties :

(i) It is composed of one carbon, three chlorine and one fluorine atoms (or parts by weight) and is *non-corrosive, non-toxic* and *non-flammable.*

(ii) It dissolves natural rubber.

(iii) It has a boiling point of – 24°C.

(iv) It mixes completely with mineral lubricating oil under all conditions.

Uses :

It is employed for 50 tonnes capacity and over in small office buildings and factories. A centrifugal compressor is used in the plants employing this refrigerant.

• *Its leakage is detected by a halide torch.*

3. The color of the R500 & R40 are ---------- & ---------- **2 marks**

RED & ORANGE

4 Explain alternate refrigerants **3 marks**

Alternative refrigerants

R290 - Pure propane, a hydrocarbon (HC) an efficient naturally occurring refrigerant with similar properties to R22, but has no ozone depletion potential and an extremely low global warming potential. Whilst it is environmentally safe, it is also highly flammable and must only be used after careful consideration is given to safety. - ODP = 0, GWP = 3.

Ammonia - A highly efficient refrigerant, that has been used in industrial applications for many years and with success. It is however, highly toxic and very careful consideration must be given to any design or application.

5. What are the different application of Cascading:- **3 marks**

- Applications of *CASCADE SYSTEM:*
- There are many Industrial, Medical application where very low temperatures are required such as
- 1. Liquefaction of Petroleum vapours
- 2. Liquefaction of atmospheric gases.
- 3. Dry Ice manufacture
- 4. Blood storage – needs as low as -80°C
- 5. Precipitation hardening of alloy steel –needs -90°C.

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SECOND SEMESTER 2012 – 2013

QUIZ- I

Course Code: ME C461 / CHE C471 **FINAL YEAR** Date: 07-03- 2013

Course Title: REFRIGERATION & A/C Max Marks: 16

Duration: 20 minutes Weightage: 8%

Name: ..... **ID No:** ..... **Sec / Prog:** .....

1. A Freon 12 vapour compression system operating at a condenser temperature of 40^0C and an evaporator temperature of 0^0C develops 15 TR Calculate the discharge temperature and mass flow rate of the refrigerant circulated:- (5 Marks)

2. Explain the effect of **Suction & Delivery pressure** in a vapour compression refrigeration system (3 Marks)

3. What are the **merits & demerits** of Vapour compression Refrigeration system (3 Marks)

4. Explain Pull-Down characteristics :- (2 Marks)

5. Represent vapour compression refrigeration having **superheated vapor** & **liquid sub cooling** on a P-h diagram (3 Marks)

BITS PILANI, DUBAI CAMPUS

SECOND SEMESTER 2012 – 2013

QUIZ- I

SOLUTION KEY

Course Code: ME C461 / CHE C471 **FINAL YEAR** Date: 07-03- 2013

Course Title: REFRIGERATION & A/C Max Marks: 16

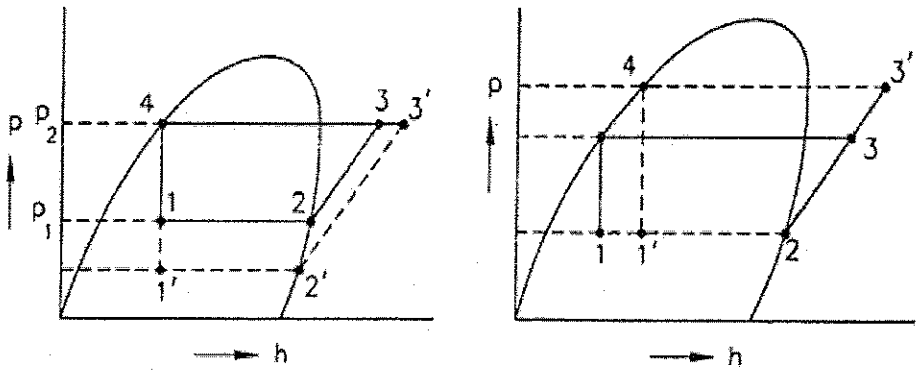
Duration: 20 minutes Weightage: 8%

1. A Freon 12 vapour compression system operating at a condenser temperature of 40^0C and an evaporator temperature of 0^0C develops 15 TR Calculate the discharge temperature and mass flow rate of the refrigerant circulated:- (5 Marks)

   Discharge Temperature = 46 0C

   Mass flow rate = 0.24 kg/s

2. Explain the effect of **Suction & Delivery pressure** in a vapour compression refrigeration system (3 Marks)



(a) Effect of suction pressure. (b) Effect of delivery pressure.

3. What are the **merits & demerits** of Vapour compression Refrigeration system (3 Marks)

- MERITS:

1. C.O.P. is quite high as the working of the cycle is very near to that of reversed Carnot cycle.
2. When used on ground level the running cost of vapour compression refrigeration system is only 1/5 of air refrigeration system.
3. For the same refrigeration effect the size of the evaporator is smaller.
4. The required temperature of the evaporator can be achieved simply by adjusting the throttle valve of the same unit.

- DEMERITS

- 1. Initial cost is high.
- 2. the major disadvantages are
- a) Inflammability
- b) Leakage of vapours
- c) Toxity.

4. Explain Pull-Down characteristics :- (2 Marks)

- *PURPOSE OF THE TEST* – COMPARE THE VALUES FOR DIFFERENT REFRIGERATORS FOR DIFFERENT REFRIGERENTS
- TESTING OF REFRIGERATORS ACCORDING TO ISI SPECIFICATIONS
- ENVIORNMENT TEMPERATURE – MAINTAINED AT 43^0C.
- NO-LOAD TEST
- ADJUST THERMOSTAT –CABNET TEMP. 7^0C.
- PURPOSE:
- FIND PULL –DOWN PERIOD
- NO LOAD POWER CONSUMPTION
- % RUNNING TIME
- PULL –DOWN PERIOD : TIME REQUIRED TO REACH THE SPECIFIED TEMP. INSIDE THE CABNET AFTER SWITCHING ON THE UNIT.

5. Represent vapour compression refrigeration having **superheated vapor** & **liquid sub cooling** on a P-h diagram (3 Marks)

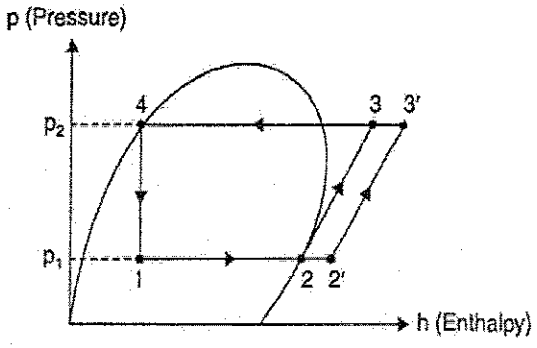


Fig. Effect of superheating.

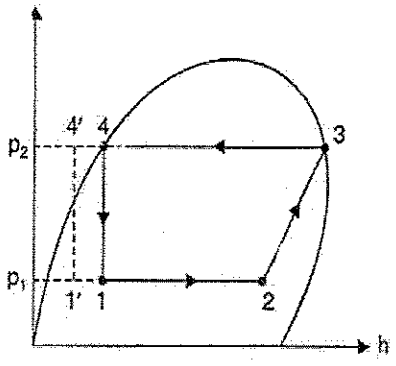


Fig. Effect of sub-cooling of liquid