BITS Pilani, Dubai Campus

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

IV Year I Semester 2011-2012

COMPREHENSIVE EXAMINATION [CLOSED BOOK]

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

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

Date: 11-01-2012 **Duration:** 3HRS

Notes:

- Answer all the questions
- Draw neat sketches wherever necessary
- Make suitable assumptions if required and clearly state them

1. Compare the different air Refrigeration systems used in Air craft :- **[4M]**
2. Enumerate different ways of producing refrigeration:- **[4M]**
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. What modifications are necessary in a simple absorption refrigeration system in order to improve the performance of the system? **[4M]**
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. An air conditioning system is designed for `cinema hall of 1000 seating capacity with following conditions:

    Outdoor conditions ---- 11 DBT and 70% R.H

    Required conditions -------- 20 DBT and 60 % R.H.

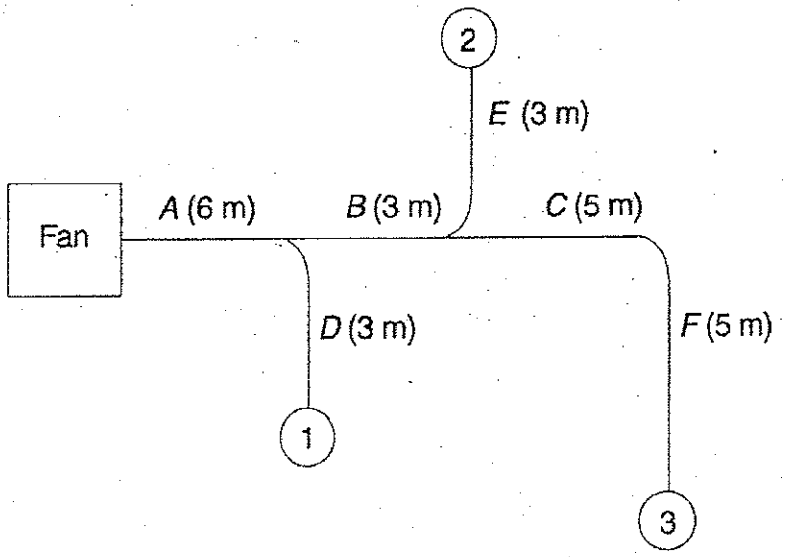
    Amount of air circulated ------ 0.25 m^3/min/person

The required condition is achieved first by heating, then adiabatic humidifying and finally by heating. The condition of air coming out of the humidifier is 755 R.H. Find the following:-

(a) Heating capacity of the first heating coil in kW and surface temperature of the heating coil if the bypass factor is 0.30

(b) The heating capacity of the second heater in kW and bypass factor if the surface temperature of the coil is maintained at 22°C. **[10M]**

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

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.

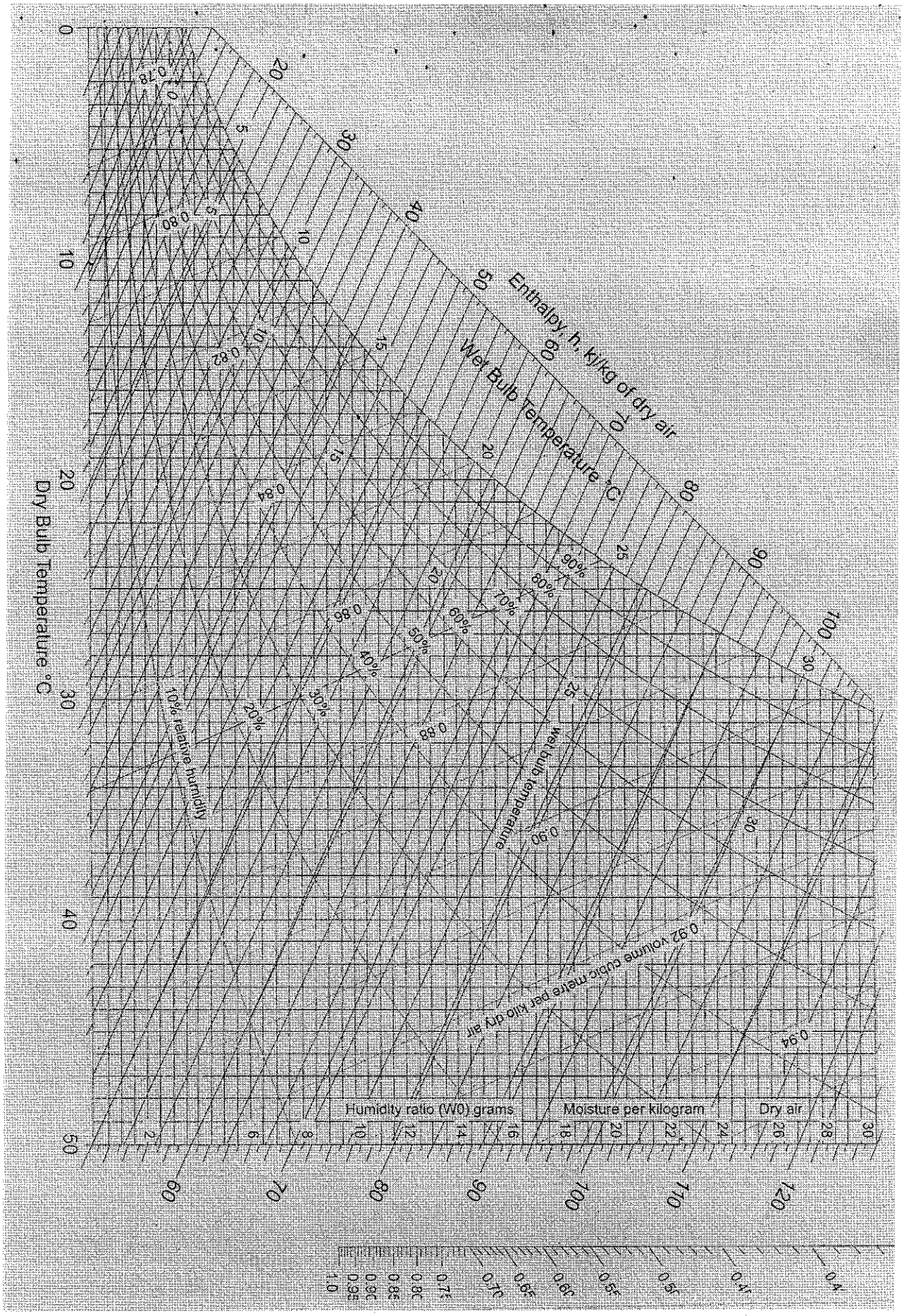
(ii) Room latent heat gain.

[16 M]

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

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


Dry Bulb Temperature °C
Enthalpy, h, kj/kg of dry air
Wet Bulb Temperature °C
10% relative humidity
Humidity ratio (W0) grams
Moisture per kilogram
Dry air
0.92 Volume cubic metre per kilo dry air

P-h Chart for Ammonia

Note: The datum for chart and table are different, use only chart or only table.

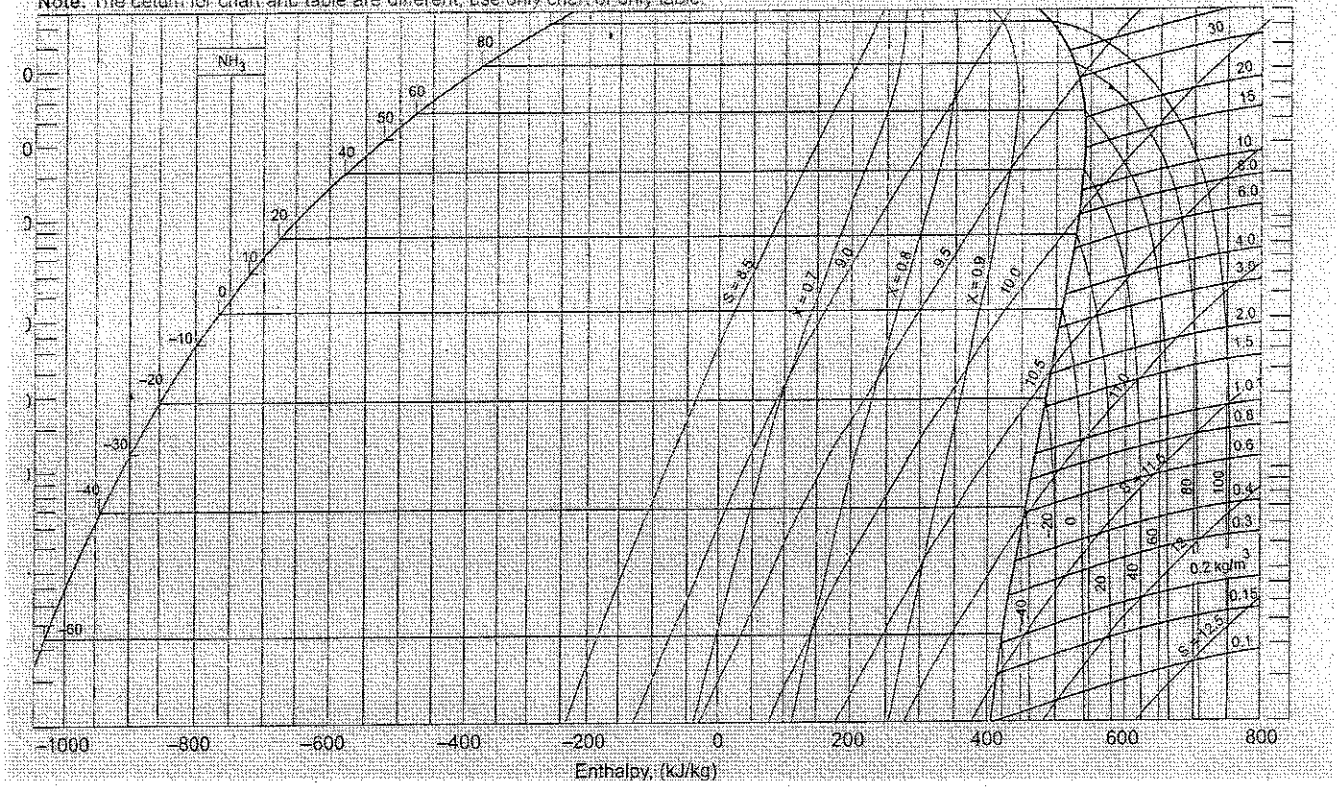


Table 3

Properties of Saturated Liquid and Saturated Vapour

R717, Ammonia, NH_3

Temp, T °C	*Pressure P, bar*	*Volume, v_g* m^3/kg	*Enthalpy, kJ/kg*		*Entropy, kJ/kg K*		*Sp Heat, kJ/kg K*	
			Liquid h_f	*Vapour* h_g	*Liquid* s_f	*Vapour* s_g	*Liquid* c_l	*Vapour* c_g
– 40	0.7168	1.5535	19.60	1408.41	0.2885	6.2455	4.396	2.175
– 38	0.7970	1.4068	28.41	1411.54	0.3260	6.2082	4.406	2.192
– 36	0.8844	1.2765	37.24	1414.62	0.3634	6.1717	4.417	2.210
– 34	0.9795	1.1603	46.09	1417.66	0.4005	6.1359	4.427	2.229
– 32	1.0826	1.0566	54.97	1420.65	0.4374	6.1008	4.437	2.248
– 30	1.1944	0.96377	63.86	1423.60	0.4741	6.0664	4.448	2.268
– 28	1.3153	0.88062	72.78	1426.51	0.5105	6.0327	4.458	2.289
– 26	1.4459	0.80595	81.72	1429.36	0.5467	5.9997	4.469	2.310
– 24	1.5866	0.73877	90.68	1432.17	0.5828	5.9672	4.479	2.332
– 22	1.7382	0.67822	99.66	1434.93	0.6186	5.9354	4.490	2.355
– 20	1.9011	0.62356	108.67	1437.64	0.6542	5.9041	4.501	2.379
– 18	2.0760	0.57413	117.69	1440.30	0.6896	5.8734	4.512	2.404
– 16	2.2634	0.52936	126.74	1442.91	0.7248	5.8433	4.523	2.429
– 14	2.4640	0.48874	135.82	1445.47	0.7599	5.8137	4.534	2.455
– 12	2.6785	0.45182	144.91	1447.97	0.7947	5.7846	4.545	2.482
– 10	2.9075	0.41823	154.03	1450.42	0.8294	5.7559	4.556	2.510
– 8	3.1517	0.38761	163.18	1452.81	0.8638	5.7278	4.568	2.538
– 6	3.4117	0.35966	172.35	1455.15	0.8981	5.7001	4.580	2.567
– 4	3.6862	0.33411	181.54	1457.43	0.9323	5.6728	4.592	2.597
– 2	3.9821	0.31073	190.76	1459.65	0.9662	5.6460	4.604	2.628
0	4.2941	0.28929	200.00	1461.81	1.0000	5.6196	4.617	2.660
2	4.6248	0.26962	209.27	1463.91	1.0336	5.5936	4.630	2.692
4	4.9749	0.25154	218.57	1465.94	1.0671	5.5679	4.643	2.726
6	5.3454	0.23491	227.89	1467.91	1.1004	5.5426	4.656	2.760
8	5.7370	0.21959	237.24	1469.82	1.1335	5.5177	4.670	2.795
10	6.1504	0.20545	246.62	1471.66	1.1666	5.4931	4.683	2.831
12	6.5865	0.19240	256.03	1473.43	1.1994	5.4688	4.698	2.868
14	7.0461	0.18034	265.46	1475.13	1.2321	5.4448	4.712	2.906
16	7.5301	0.16917	274.93	1476.75	1.2647	5.4212	4.727	2.945
18	8.0392	0.15882	284.43	1478.30	1.2972	5.3977	4.742	2.985

Contd

Properties of Saturated Liquid and Saturated Vapour

R717, Ammonia, NH_3 (Contd.)

Temp, T °C	*Pressure P, bar*	*Volume, v_g* m^3/kg	*Enthalpy, kJ/kg*		*Entropy, kJ/kg K*		*Sp Heat, kJ/kg K*	
			Liquid h_f	*Vapour* h_g	*Liquid* s_f	*Vapour* s_g	*Liquid* c_l	*Vapour* c_g
20	8.5744	0.14923	293.96	1479.78	1.3295	5.3746	4.758	3.027
22	9.1364	0.14032	303.52	1481.18	1.3617	5.3517	4.774	3.069
24	9.7262	0.13204	313.11	1482.49	1.3937	5.3290	4.791	3.113
26	10.345	0.12434	322.73	1483.72	1.4257	5.3066	4.808	3.158
28	10.993	0.11717	332.39	1484.87	1.4575	5.2844	4.825	3.204
30	11.671	0.11048	342.08	1485.93	1.4892	5.2623	4.843	3.252
32	12.381	0.10424	351.81	1486.90	1.5208	5.2405	4.862	3.301
34	13.123	0.09842	361.58	1487.78	1.5523	5.2188	4.881	3.352
36	13.898	0.09297	371.38	1488.56	1.5837	5.1972	4.901	3.405
38	14.708	0.08788	381.23	1489.24	1.6149	5.1759	4.922	3.459
40	15.553	0.08311	391.11	1489.82	1.6461	5.1546	4.943	3.516
42	16.434	0.07864	401.03	1490.30	1.6772	5.1334	4.966	3.574
44	17.352	0.07445	411.00	1490.67	1.7083	5.1124	4.989	3.635
46	18.308	0.07051	421.01	1490.92	1.7392	5.0914	5.013	3.698
48	19.303	0.06682	431.07	1491.07	1.7701	5.0705	5.039	3.764
50	20.339	0.06334	441.18	1491.09	1.8009	5.0497	5.066	3.832
52	21.415	0.06007	451.33	1491.00	1.8316	5.0289	5.095	3.903
54	22.534	0.05699	461.54	1490.78	1.8623	5.0082	5.124	3.977
56	23.696	0.05409	471.80	1490.43	1.8929	4.9875	5.156	4.055
58	24.903	0.05136	482.12	1489.94	1.9235	4.9667	5.190	4.136
60	26.154	0.04878	492.50	1489.32	1.9541	4.9460	5.225	4.221
62	27.452	0.04634	502.94	1488.55	1.9846	4.9252	5.263	4.310
64	28.798	0.04404	513.45	1487.63	2.0151	4.9044	5.303	4.404
66	30.193	0.04186	524.03	1486.56	2.0456	4.8836	5.346	4.502
68	31.637	0.03980	534.68	1485.33	2.0762	4.8626	5.392	4.606
70	33.133	0.03785	545.41	1483.94	2.1067	4.8416	5.441	4.716
75	37.103	0.03340	572.62	1479.67	2.1832	4.7884	5.581	5.019
80	41.418	0.02949	600.44	1474.20	2.2601	4.7342	5.749	5.374
85	46.099	0.02605	628.97	1467.38	2.3377	4.6785	5.955	5.794
90	51.167	0.02299	658.36	1459.01	2.4163	4.6209	6.211	6.302

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IV Year I Semester 2011-2012

Test No.2 (Open Book)

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

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

Date: 17-12-2011 **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 a **small Restaurant** when the following data is available:-

Transmission gain through Doors, Glass, Roof & Floor = 15000 kJ/hr

Solar transmission through Walls, Roof & Floor = 16000 kJ/hr

Solar Heat gain through glass = 7000 kJ/hr.

Equipment sensible heat gain = 10500 kJ/hr

Equipment Latent heat gain = 2500 kJ/hr

Infiltrated air flow = 400 m^3/hr

The Hall seating capacity = 50

Servants serving meals = 5

Sensible heat gain per diner : 250 kJ/ h

Latent heat gain per diner : 260 kJ/ h

Outside Design conditions: 35^{0}C DBT and 26^{0}C WBT

Inside design conditions : 25^{0}C and 55% RH, By pass factor of the coil is 0.15

Find the **Room Sensible heat & Latent load** in tons in the Restaurant **[11M]**

TABLE 16.2 VENTILATION AIR REQUIREMENT

Application	Smoking Status	Recommended cmm/Person	Minimum	
			cmm/ person	cmm/m floor area
Apartments	Some	0.56	0.28	—
Offices and factories	Occasional-Som	0.28–0.6	0.21	—
Restaurants	Some	0.4	—	—
Board rooms	Very heavy	1.4	0.56	0.03
Department stores	None	0.21	0.14	0.0015
Theatres	None	0.21	0.14	—
Hotel rooms	Heavy	0.84	0.7	—
Hospital wards	None	0.84	—	—
Hospital operation theatres	None	All outdoor	—	—

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

2. An air conditioning system is designed for industrial process for hot & wet summer conditions.

Outdoor conditions – 30 DBT and 75% RH

Indoor conditions - 22 DBT and 70% R.H.

Amount of free air circulated 200 m^3/min

Coil dew point temperature 14 ^{0}C.

The required condition is achieved first by cooling and dehumidifying and then heating. Find the following:-

(a) The cooling capacity of the cooling coil and its bypass factor.

(b) Heating capacity of the heating coil if the BF is 0.12 **[5 M]**

3 Discuss the conditions of comfort you would prescribe for an office in a city like Nagpur where hot and dry climate prevails. **[4 M]**

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IV Year I Semester 2011-2012

Test No.1 (Closed Book)

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

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

Date: 23-10-2011 **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 A. Explain ***DART.*** **[2M]**

B. Explain cascading Refrigeration systems **[3M]**

Q 2.A. Describe ***BOOT-STRAP AIR REFRIGERATION*** systems **[4M]**

B. A Bell-Coleman refrigeration cycle works between 1bar and 5 bar. The adiabatic efficiency of compression is 85% and expansion is 90%. Find out the ***COP*** of the system and its ***tonnage*** when the air flow rate is 1 kg/s. The ambient temperature is 27^0C and refrigerator temperature is 0^0C. **[6M]**

Q.3.A. Explain Flash Chamber in multi stage refrigeration systems **[3M]**

B. A simple R-12 plant is to develop 5 tonnes of refrigeration. The condenser and evaporator temperatures are to be 40^0C and -10^0C respectively. Determine **(a)** the refrigerant flow rate in kg/s, **(b)** the heat rejected to the condenser in kW, **(c)** the C.O.P **(d)** the power required to drive the compressor.

How does this COP compare with that of a Carnot refrigerator operating between 40^0C and -10^0C? **[7M]**

BITS PILANI, DUBAI CAMPUS

FIRST SEMESTER 2011 – 2012

QUIZ- II

A

Course Code: ME C461 / CHE C471 **FINAL YEAR** Date: 5-12- 2011

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 ***Apparatus Dew point*** temperature :- **3 marks**

2. What type of Load is if a building ***gains*** or ***losses moisture***, Explain :- **2 marks**

3. What is the significance of a lower value of SHF. Explain **3 marks**

4 100 cu.m of air per minute at 30^0C DBT and 60% R.H is cooled to 20^0C DBT by passing through a cooling coil. Find the capacity of cooling coil in tons of refrigeration **3 marks**

5. What is the difference Summer & Winter Air conditioning:- **3 marks**

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FIRST SEMESTER 2011 – 2012

QUIZ-I

A

Course Code: ME C461 / CHE C471 **FINAL YEAR** Date: 26-09- 2011

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

Duration: 20 minutes Weightage: 8%

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

Instructions: 1. Attempt all questions

1.Explain Bell-Coleman refrigeration system with ***T-s and Pv*** diagram 3 marks

2. Explain the difference between Refrigerator & Heat Pump 3 marks

3. Define 1 TR 3 marks

4 Show all thermal properties in a P-h diagram 4 marks

5. Expalin different causes for external heat sources:- 3 marks