University of Technology
Mechanical Engineering Department
Final Examination 2015/2016

Subject: Air Conditioning
Division: Air Conditioning& Refrigeration
Examiner: ا.د. وحيد شاتي محمد

Year: 2015/2016
Exam. Time : 3.0 Hrs.
Date: 29 /05/ 2016

Note: Answer 4 Questions Only.

Q1: The air-handling unit of an air conditioning plant supplies a total of 300 m^3/min of dry air which comprises by volume 20% fresh air at DBT=40 °C , WBT=29 °C and 80% return air at DBT=25 °C, RH=50% . The air conditioned space has a sensible and latent heat loads of 58 kW and 14.5 kW respectively. Calculate: i) air supply temperature (T_s), ii) apparatus dew point temperature (T_{ADP}) , iii) BPF, iv) The cooling coil load in TR, v) plot the processes psychometrically. [20 Marks]

Q2: It is required to air condition a factory building (27m x 18m x 4m) . The 27m wall is type B and faces south. The following data is available : Two glass windows in south wall 3m x 1.5m each with internal shade, Lighting load is 20 Watt fluorescent per m^2 floor area ; Infiltration is one air change per hour. The inside air conditions are, DBT=24 °C and RH=50%. The outside air conditions are, DBT=40 °C, WBT=30°C. Other related data are: DR=18.0 °C, U_{wall} = 1.4 W/m^2 K, U_{glass} = 3.5 W/m^2 K, Sc_{glass} = 0.7 , occupancy = 8 persons doing light bench work and, $CLF_{occupancy}$ = 0.85. The building is of heavy construction with light color located at 40 N . Calculate the building cooling load from the South wall , windows , lighting, infiltration and occupancy on August at 4.0 p.m. [20 Marks]

Q3: A 135 TR refrigeration capacity system works with ammonia as a refrigerant . It operates in a single stage saturation cycle at temperatures of 36 °C and -24 °C for condenser and evaporator respectively . A liquid vapor regenerative heat exchanger is installed in the system, with the temperature of the vapor leaving the heat exchanger at -10 °C. The volumetric efficiency is 78%. The temperature after the compressor is 90 °C. Calculate using table only: i) mass flow rate of refrigerant , ii) compressor work, iii) heat rejected from the condenser, iv) COP, and v) volume displacement. [20 Marks]

Q4: A) What are the advantage of the reverse return over the direct return in closed piping system ? Sketch both of them. [4 Marks]

B) A closed water piping system carried (5 L/s) of water at (8 °C) flowing at a discharge velocity of (1.5 m/s) through (60m) long steel pipe with $D_{discharg}/D_{suction}$=0.9 . The steel pipe is fitted with (10) elbows St. , (10) gate valves , (4) check valve and (3) cooling coils with pressure drop of (20 kPa) each . The pressure drop through the chiller is (50 kPa) . The height of the expansion tank is (6 m) above the center line of the pump suction side . Calculate i) $V_{suction}$ (m/s) , ii) $P_{discharg}$ (kPa) , iii) $P_{suction}$ (kPa), and iv) the pumping power in the piping system given η_{pump}=60%. [16 Marks]

Q5: A) What are the function of the evaporative cooling in the air refrigeration system? Plot the T-S diagram for the system as it used in an aircraft. [10 Marks]

B) What are the four thermodynamic steps of the magnetic refrigeration cycle (MRC)? State five advantages for this system over the vapor compression refrigeration system. [10 Marks]

Good Luck

2016 - 2015 تكييف هواء الدور الاول

Q1

$$SHR = \frac{Q_s}{Q_T} = \frac{58}{72.5} = 0.8$$

$$\dot{V}_s = \frac{300}{60} = 5 \ m^3/s$$

$$\dot{V}_r = 0.8 \times 5 = 4 \ m^3/s$$

$$\dot{V}_o = 0.2 \times 5 = 1 \ m^3/s$$

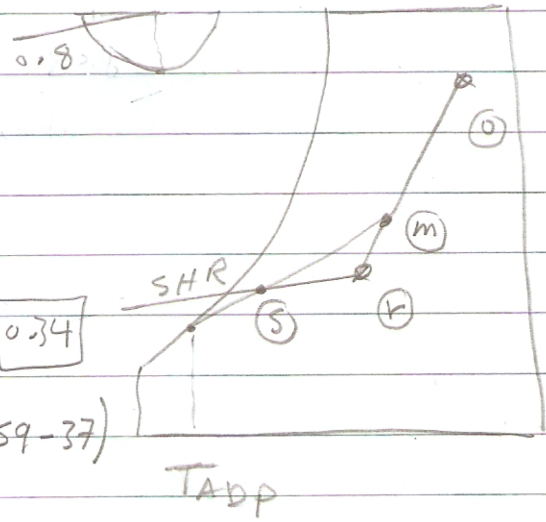
$$Q_s = 1.22 \dot{V}_s (T_r - T_s)$$

$$\therefore T_s = T_r - \frac{Q_s}{1.22 \dot{V}_s}$$

$$= 25 - \frac{58}{1.22 \times 5} = \boxed{15.5 \ ^\circ C}$$

$$T_m = \frac{\dot{V}_r . T_r + \dot{V}_o . T_o}{(V_r + V_o)} = \frac{V_r}{V_s} T_r + \frac{V_o}{V_s} T_o = 0.8 T_r + 0.2 T_o$$

$$= 20 + 8 = 28 \ ^\circ C$$



From psychrometric chart:

$$T_{ADP} = \boxed{9 \ ^\circ C}$$

$$B.P.F = \frac{T_s - T_{ADP}}{T_m - T_{ADP}} = \frac{15.5 - 9}{28 - 9} = \boxed{0.34}$$

$$Q_{coil} = 1.2 \dot{V}_s (h_m - h_s) = 1.2 \times 5 (59 - 37)$$

$$= 132 \ kW = \boxed{37.5 \ TR}$$

Q_2

$$Q_{wall} = A_{wall} \cdot U_{wall} \cdot CLTD_c \Big|_{wall}$$

$$CLTD_c = (CLTD + LM)K + (25.5 - t_r) + (t_o - 29.4)$$

$$= (9.0 + 2.2) \times 0.65 + (25.5 - 24) + (31 - 29.4)$$

$$= 10.38\ ^{\circ}C \qquad \text{where } t_o = T_o - \frac{DR}{2} = 40 - \frac{18}{2} = 31$$

$$A_{wall} = 27 \times 4 - 2 \times \underbrace{[3 \times 1.5]}_{A_{window}} = 99\ m^2$$

$$Q_{wall} = 99 \times 1.4 \times 10.38 = \boxed{1438.6\ \text{Watt}}$$

$$Q_{window} = Q_{rad} + Q_{cond}$$

$$Q_{rad} = A_{window} \cdot SHG \cdot S_c \cdot CLF$$

$$= 9 \times 470 \times 0.7 \times 0.35$$

$$= \boxed{1036.35\ \text{Watt}}$$

$$Q_{cond} = A_{wind} \cdot U_{wind} \cdot CLTD_c \Big|_{wind}$$

$$CLTD_c = 8 + 1.5 + 1.6 = 11.1\ ^{\circ}C$$

$$Q_{cond} = 9 \times 3.5 \times 11.1$$

$$= \boxed{349.65\ \text{Watt}}$$

$$Q_{window} = 1036.35 + 349.65 = \boxed{1386\ \text{Watt}}$$

$$Q_{light} = A_{floor} \times 1.25 \times 20 = (27 \times 18) \times 1.25 \times 20$$

$$= \boxed{12150\ \text{watt}}$$

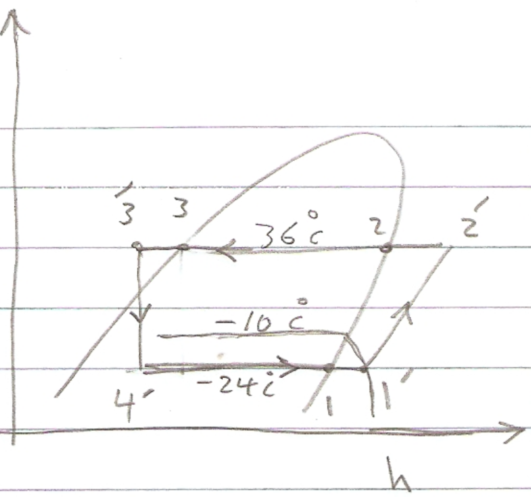
$$Q_{inf} = 1.2 \times \forall_{inf} \times (h_o - h_r) \quad \text{where } \forall_{inf} = \frac{\text{Volume ACH}}{3600}$$

$$= 1.2 \times 0.54\ (99 - 48) = \qquad\qquad = \frac{1944 \times 1}{3600} = 0.54\ m^3/s$$

$$= \boxed{33\ \text{KWatt}}$$

$$Q_{occup} = n(CLF \cdot Q_s + Q_L) = 8\,(0.85 \times 100 + 130) = \boxed{1720\ \text{Watt}}$$

Q3



$h_1 = h_g|_{-24} = 1432.17$ kJ/kg

$h_1' = h_1 + Cp|_g (T_1' - T_1)$

$= 1432.17 + 2.33(-10-(-24))$
$= 1464.82$ kJ/kg

$h_2' = h_2 + cp|_g (T_{2'} - T_2)$ where $h_2 = h_g|_{36} = 1488$ kJ/kg

$= 1488 + 3.405(90-36)$ $Cp_g|_{36} = 3.405$ kJ/kg.K
$= 1671.87$ kJ/kg

$h_3 = h_f|_{36} = 371.38$ kJ/kg

Heat exchanger
$h_3 - h_3' = h_1' - h_1$
$h_3' = h_3 - (h_1' - h_1)$
$= 338.73$ kJ/kg

$h_4' = h_3' = 338.73$ kJ/kg

$\dot m_R = \frac{\text{Refrigeration Capacity}}{q_{evap}} = \frac{135 * 3.517}{h_1 - h_4'} = \frac{474.8}{1432.17 - 338.73}$
$= \boxed{0.431 \text{ kg/s}}$

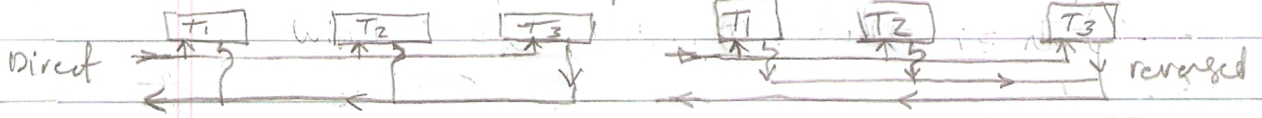
$Q_{comp} = \dot m_R (h_2' - h_1') = 0.431 (1671.87 - 1464.82)$
$= \boxed{89.0 \text{ kW}}$

$Q_{cond.} = \dot m_R (h_2' - h_3) = 0.431 (1671.87 - 371.38) = 559$ kW

$COP = \frac{Q_e}{W_{comp}} = \frac{474.8}{89.01} = \boxed{5.3}$ & $V_p = \frac{\dot m_R . \overset{0.418}{v_1}}{\eta} = \boxed{0.23 \text{ m}^3/\text{s}}$

Q 4

(A) The reversed return is better in giving almost equal pressure drop for all terminal unit lines



(B)

$$D_{disch} = \sqrt{\frac{4 \cdot Q}{\pi \cdot V_{dis}}} = \sqrt{\frac{4 * 5 * 10^{-3}}{3.14 * 1.5}} = 0.065 \text{ m}$$

$$D_{suction} = \frac{D_{disch}}{0.9} = 0.072 \text{ m}$$

$$V_{suction} = \frac{Q}{\frac{\pi}{4} D^2_{suction}} = \frac{4 * 5.0 * 10^{-3}}{3.14 * (0.072)^2} = 1.23 \text{ m/s}$$

chart Q & V_{disch} $\Rightarrow$ $\Delta P_{friction} = 320$ Pa/m

$$C_f = 1.13$$

$$\Delta P_{cor} = 1.13 * 320 = 361.6 \text{ Pa/m}$$

$$L_{elbow} = 10 * 1.8 = 18 \text{ m} \quad , \quad L_{gate valve} = 10 * 0.9 = 9 \text{ m}$$

$$L_{check valve} = 4 * 7.6 = 30.4 \text{ m}$$

$$L_{total} = 60 + 18 + 9 + 30.4 = 117.4 \text{ m}$$

$$\Delta P_{disch} = 3 * 20 + 50 + \frac{117.4 * 361.6}{1000} = \boxed{152.5 \text{ kPa}}$$

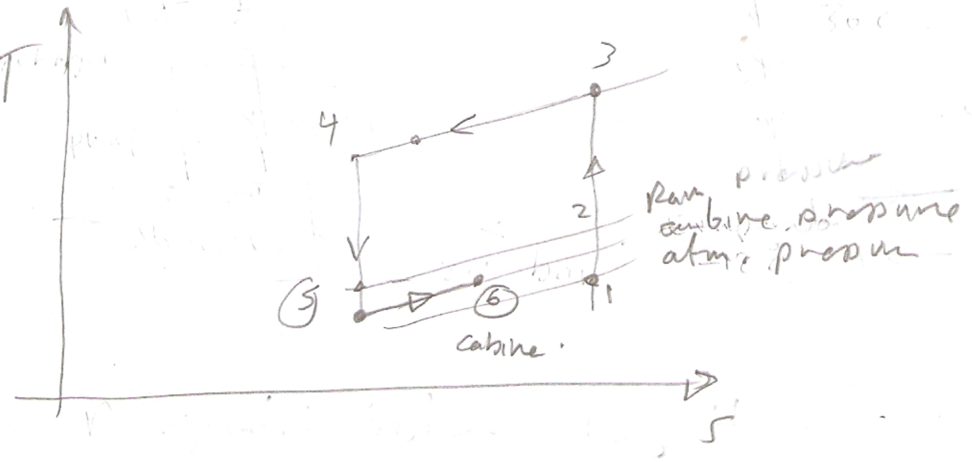
$$P_{suction} = \rho \cdot g \cdot H = \frac{1000 * 9.81 * 6}{1000} = \boxed{58.86 \text{ kPa}}$$

$$\Delta P_{pump} = \left[P_{dis} + \rho \frac{V_d^2}{2}\right] - \left[P_{suct} - \rho \frac{V_{suct}^2}{2}\right] = \boxed{94.0 \text{ kPa}}$$

$$\text{Power} = \frac{Q \, \Delta P_{pump}}{\eta} = \boxed{0.78 \text{ kwatt}}$$

Q5

(A) The function of the evaporative cooling is to produce more cooling to the air before expanding it in the turbine to improve the performance of the air refrigeration system.



(B) MRC steps

1. Adiabatic magnetization
2. Isomagnetic enthalpic transfer
3. Adiabatic demagnetization
4. Isomagnetic entropic transfer

Advantages

1. High eff
2. Reduced cost
3. Compactness
4. Reliability
5. Low capital cost
6. Competition in global market.
7. Environmental friendly
8. key factor to new tech.

University of Technology
Mechanical Engineering Department
Final Examination 2013-2014

Subject: Air-conditioning 3rd Year
Examiner : د. وحيد شاتي محمد

Time: 3Hours
Date: 11/06/2014

Answer four questions

Q1: A winter air conditioning system maintain a building at 21°C and 40% RH . The out- door conditions are 0.0°C and 100% RH . The sensible load of the building is 100 kW , while the latent load is 25 kW . In this system 25% of the outdoor air is mixed with 75% of the return air. The mixed air is heated in a pre- heater to 25°C and then humidified at constant DBT by a humidifier . The humidified air is then heated to the supply temperature 35°C and supplied to the room . Find:- : a- the required volume flow rate of the supplied air ,b- the required heat input to the pre-heater , c- the required heat input to the re-heater ,d- mass (kg/s) of vapor added by the humidifier , and , e- plot the psychrometric processes of the system . [25 Marks]

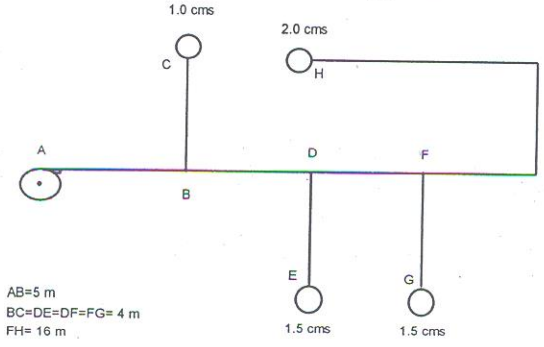
Q2:In alight color light weight building the south wall20m length , the east wall 10m length and the roof are exposed to sun . The roof has a suspending ceiling with mechanical ventilation .The height the building is 3.5 m . The U-value for the walls is 0.5 W/m^2K each, while it is 0.62 W/m^2K for the roof . The other two walls are exposed to air conditioned spaces . The outside design temperature is 45°C , while the indoor is maintained at 24°C. The daily range is 18.5°C . The lighting load may be calculated using 25 $Watt/m^2$ floor area .Calculate lighting and cooling loads for the building at 5 p.m. on August. The walls are E-type , the roof is of type 5 and the building is located at 40 N Latitude. [25 Marks]

Q3: A store room is refrigerated by vapor compression refrigeration machine using R-134a . The condenser of the machine is cooled by water with ΔT_{water}= 8°C . The refrigerant temperature in the condenser is 50°C and in the evaporator is at -30°C .The refrigeration capacity of the machine is 5.0 TR . Assume isentropic compression with the compressor outlet temperature equal to65 °C , determine : a- the refrigerant mass flow rate kg/s , b- the power consumed by the compressor in kW, c- C.O.P of the machine, d- $C.O.P_{Carnot}$ and ,e- the coolant water mass flow rate in kg/s . [25 Marks]

Q4 An absorption refrigeration system based on H_2O-LiBr has a refrigeration capacity of 80 TR . The system operates at an evaporator temperature of 8°C and a condensation temperature of 50 °C . The exit temperatures of absorber and generator are 40 °C and 110°C respectively . The concentration of the solution at the exit of absorber and generator are 0.55 and 0.60 respectively. Calculate : a- the mass flow rates of refrigerant ,weak and strong solutions, b- heat transfer rates at absorber ,generator and condenser, [25 Marks]

Q5: A) What are the types of the closed loop water piping systems ?Sketch only one of these types and express its advantages and dis-advantages . [5 Marks]

B) Design the following duct system using equal friction method and a velocity in the main duct 10 m/s. Assume a dynamic loss coefficient of 0.8 for bends . The pressure loss for the outlet opening is 25 Pa ,the duct height H=450 mm and BD=5m .Find the fan power where η_{fan} =0.9 . .[20 Marks]



Good Luck

University of Technology
Department of Machines and Equipment Engineering
Final Examination 2012/2013

Subject: Air conditioning & Refrigeration
Division: Air Condition & Refrigeration
Examiner : د وحيد شاتي محمد

Year: 2012-2013
Time: 3 Hours
Date:10 / 6 / 2013

Answer (4) Questions Only

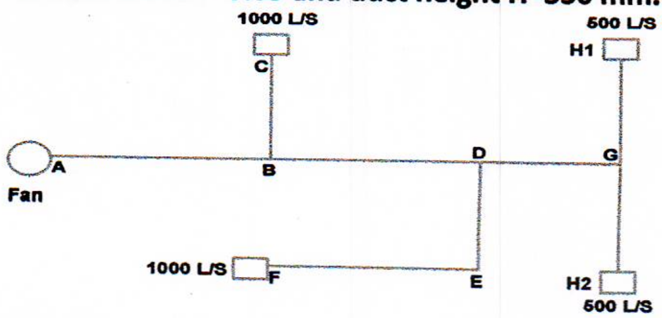
Q1: In a refrigeration machine R-134a leaves the compressor at 60°C and at a rate of 0.2 m^3/min . The refrigerant leaves the condenser at 50°C as a saturated liquid . The evaporator temperature is -20°C. The compressor has one cylinder and run with 1450 rpm . The volumetric efficiency is η_v=90% and L/D =1.15 . Assume simple saturated cycle , calculate : a) the mass flow rate of the refrigerant in kg/s , b) the power input to the compressor , c) the heat rejected by the condenser , d) the size of the compressor L and D in mm , and e) the coefficient of performance . 25 Marks

Q2: An air conditioned building has a sensible cooling load of 60 kW and latent load of 40 kW . The room is maintained at 24 ℃ (DBT) and 50% RH ,while the outside design conditions are : 34 ℃ (DBT) and 40% RH . To satisfy the ventilation requirement , outdoor air is mixed with recirculating air in the ratio of 1:3 by volume . Since the latent load on the building is high , a reheat coil is used along with a cooling and dehumidifying coil . If the B.P.F of the cooling coil is 0.15 and its T_{ADP} is 6.5 C , find : a) the supply air temperature T_s , b) the volume flow rate of the supply air m^3/s , c) required cooling capacity , d) the heating capacity of the reheat coil , and e) plot the psychrometric processes on a representative chart . 25 Marks

Q3: A single stage vapor absorption refrigeration system based on H_2O – LiBr has a refrigeration capacity of 300 kW . The system operates at an evaporator temperature of 5 ℃ (P_{sat} =8.72 mbar) and a condensing temperature of 50 C (P_{sat} =123.3 mbar) .The exit temperatures of absorber and generator are 40 ℃ and 110 ℃ respectively . The concentration of the solution at the exit of absorber and generator are 57.8% and 66% respectively . Assume exit condition at condenser and evaporator are to be saturated , calculate : a) the mass flow rate of the refrigerant weak and strong solutions in the system , b)the condenser heat , c) the absorber heat , d) the heat added to the generator , and e) the COP of the system . 25 Marks

Q4: A gymnasium room (قاعة العاب رياضيه) measures (3mx6mx3m high) located at 40 N latitude . One of the two 3m walls is external of type D , faces west and contains a double glazed window of size (2mx2m) with no external shading . The other walls are internal . The inside design condition : 25 C DBT and 50% RH . The outside condition : 43 C (DBT) and 24 C WBT with a daily range of 18.0 C. The U value of the wall is 1.78 W/m^2K . The U value of the glass is 3.12 W/m^2 K . The internal shading coefficient of the glass (Sc)=0.86 . The lighting load is based on 33 W/m^2 . The occupancy is 14 athletics men . Determine the cooling load from the west wall , window, lighting , occupancy and infiltration at 3 p.m. on August 21st .The building is of medium construction with light color . $\boxed{CLF=1}$ 25 Marks

Q5: Design the ducting system shown below and calculate the fan power (η_{fan}=65%). The velocity at main duct AB =8.5 m/s .The duct lengths are : AB= BD=EF=8m , BC=DG=GH1=5m and DE=GH2=6m . Take dynamic loss coefficient for each bend k=0.65 and duct height H=350 mm. 25 Marks



Good Luck

University of Technology
Department of Machines and Equipment Engineering
First Term Examination 2012/2013

Subject: Air Conditioning | **Year:2012/2013**
Division: Air Conditioning | **Exam Time:1.5 Hr**
Examiner: د وحيد شاتي محمد | **Date:29/01/ 2013**

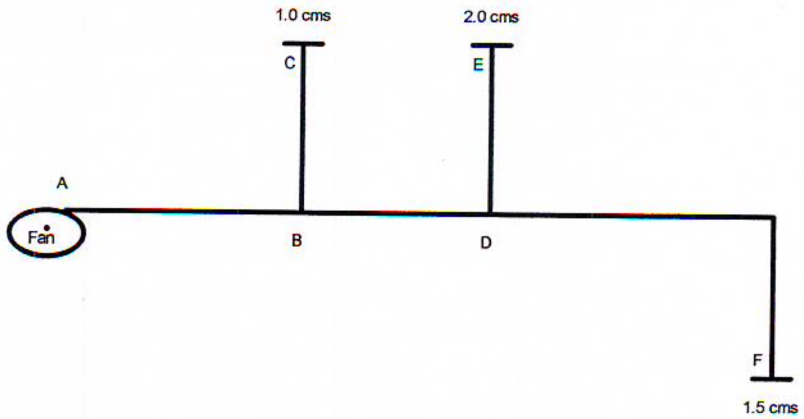
Answer (3) Questions , All Questions Have Equal Marks

Q1: The prayer hall of a mosque uses a package system with basic *mixed-air* system . The summer space sensible cooling load is 20 kW with latent load of 5 kW .Other design data are as follows: Outdoor design temperature DBT= 45 ċ and WBT=28 ċ. Indoor design conditions :DBT= 24 ċ and RH=50%. The relative humidity of the air leaving the cooling coil is Rh=90%. Fresh air requirements is 0.3 cms . Determine :
a) The supply temperature, b) Volume flow rate of supply air, c) Cooling coil load d) the BPF, e) plot all process on the Psychrometric Chart .

Q2: A computer classroom (8mx 8m x3m high) with light color and medium construction . It is located at 40 N latitude with an external east wall . There is two (2.5mx2m high) windows in the east wall .The wall is of type D and both windows with out internal shade . The overall heat transfer coefficients are U_{wall}=3.4 W/m^{2}K and, U_{window}=7.0 W/m ^{2}K . The window shade coefficient Sc_{window} =0.6 .The inside DBT=26 ċ and RH=50% with DR= 18.0 ċ . The outside design conditions are DBT = 43 ċ and WBT = 28 ċ . The occupancy is 28 students seated at rest with CLF=0.9 . The light is 30 W/m^2 of floor area . Calculate the cooling load at 9.0 am on July 21 from: a) The east wall , b Two east windows , c) Occupancy and d) Lighting

Q3: A library building has a roof with area (20mx 30m) .The sensible heat loss form the *roof* of building is 60 kW . The inside condition of the building is DBT = 22 ċ and RH=60% . The outside temperature is -2 ċ . An insulation of (3 mm) thickness is added to the building to reduce the heat losses by 40% . The inside convective heat transfer coefficient is f_i=9.0 W/m^2 K .
a) Calculate The inside surface temperature of the roof , b) Does condensation exist before the addition of insulate ? ,
b) Find The thermal conductivity of the added insulate c) Determine the volume flow rat of air supplied to the space after the use of insulate , use T_s= T_r + 10 ċ .

Q4 : The figure shows a typical duct layout . Design the duct system using Equal friction method . Take the velocity of air in the main duct A as (8 m/s) . Assume a dynamic loss coefficient of (k=0.6) for branch and for elbow (i.e. bend) . The outlet opening losses is (30 pas) . Find also fan power where η_{fan} = 0.69 . Given AB=BC=BD=DE=10m and DF=25m and the ducting system height H=500 mm .



Good Luck

University of Technology
Mechanical Engineering Department
Final Examination 2011-2012

Subject: Air-conditioning 3rd Year

Examiner : د. وحيد شاتي محمد

Time: 3Hours
Date: 06/06/2012

Answer four questions

Q1/ It is required to maintain an air conditioned hall at 28 °C DBT and 20 °C WBT . The sensible and latent heat load are 45.4 kW and 16.5 kW respectively . Outside air at 39°C DBT and 28°C WBT is mixed with the return in ratio of (1/4) by volume and then the mixture is passed through a cooling coil with apparatus dew point temperature of 9°C . Determine : a) The temperature of the air after the cooling coil, b) Volume flow rate of air supplied to the hall , c)The by-pass factor of the cooling coil , d) The cooling coil load, e) Plot the Psychrometric air processes of the system . (25 Marks)

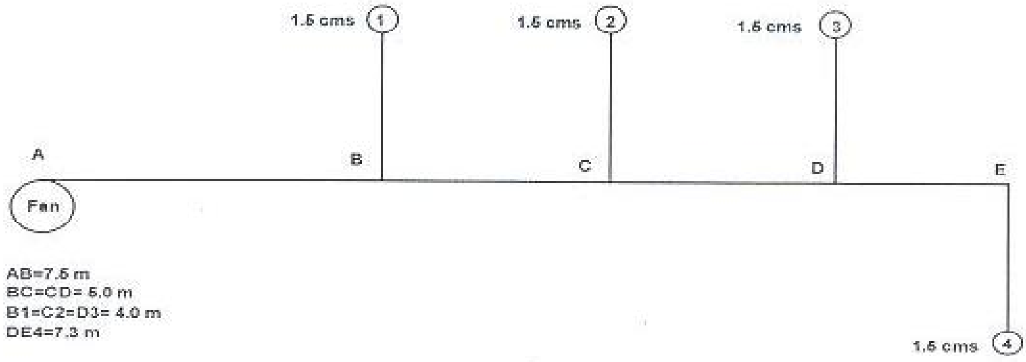
Q2/a) An office room at latitude (32N) with external west wall of (10m x 4m) area has inside design conditions of DBT =24°C and RH=40 %.The group of the wall is (D) ,U_{wall}=2.782 W/m^2°C and color is light . Calculate the cooling load from the wall and from 6 typists in the room at 1.0 p.m. on July . Take CLF_{person}=0.9 , DR= 18.0°C , and $T_{out\ side}$ = 45 °C. (13 Marks)

b) What is the Electrolux refrigerator ? How is it work ? What is the function of H_2 in this refrigerator ? Show all its components on a representative sketch . (12 Marks)

Q3/ For a vapor compression refrigeration system using R-134a as refrigerant , condenser outlet temperature is 40 °C and evaporator inlet temperature is -20 °C . In order to avoid flashing of refrigerant , a liquid –suction vapor heat exchanger is provided where the liquid is sub cooled to 26 °C . The compression process is isentropic . The refrigerant mass flow rate in the system is 0.06 kg/s and its temperature after the compressor is 60°C . Find : a) The refrigeration capacity in ton refrigeration (TR) , b) The COP of the cycle , c) Power required for the compressor , d) Plot the system T-S diagrams and e) Air mass flow rate required to cool the condenser if ΔT_{air}= 5 °C and $C_{p\ air}$ = 1.005 kJ/kg K . (25 Marks)

Q4/ An air craft moving with speed of 900 km/hr uses simple air refrigeration cycle of (90 TR) for air conditioning . The ambient pressure and temperature are 0.36 bar and -12 °C respectively . The pressure ratio of compressor is 5 . The temperature after the heat exchanger is 32 °C . The isentropic efficiencies of compressor and expander are 82% each . The cabin pressure and temperature are 1.05 bar and 27 °C respectively. Calculate : a) Temperatures and pressures at all points of the cycle, b) Volume flow rate through the compressor inlet, c) Volume flow rate through the expander outlet, d) C.O.P of the cycle, and e) Plot the T-S diagram of the cycle . Take :c_{pair}=1 kJ/kg K ,R_{air}= 0.287 kJ/kg Kand γ=1.4 . (25 Marks)

Q5/ An air conditioning system has volume flow rate of 6.0 m^3/s and fan outlet velocity is 10 m/s . The duct has four branches with 90° elbow as shown in the figure below . Design the ducting system using equal friction method and calculate the fan power where fan efficiency= 65% . Given that one side of the duct is 500mm, bend dynamic loss coefficient k=0.5 , and (cms=m^3/s). (25 Marks)



Good Luck

University of Technology
Mechanical Engineering Department

Subject : Air-conditioning 3^{rd} Year — Time: 3.0 Hours

Examiner : Dr. Wahid Sh. Mohammad — Date:13 / 9 /2011

Answer Four Questions Only

Q1: A laboratory room has an inside design conditions of DBT=25 ċ , RH= 50% . The outside design conditions are DBT= 3.0 ċ and RH=80 % [winter condition] . The sensible heat losses is 10 kW with sensible heat ratio SHR=0.8 . The fresh air is mixed with the return air at a ratio of (1/3) by volume . The mixed air is heated by a heating coil to a dry bulb temperature of 40 ċ then cooled adiabatically to RH=90% . The air is then heated by a reheat coil and supplied to the building . Calculate : (a) The supply air condition (b) The supply air volume flow rate in m^3/s , (c) The reheating coil capacity in kW , (d) The quantity of moisture added in kg/s , (e) Plot all the processes on a representative psychrometrics chart .

Q2: A vegetable store building of (4m) height has two external walls one facing south (30m x 4m) and the other facing east (10m x 4m) . The east wall has 30 % glassing area with internal shade . The overall heat transfer coefficients of the walls and glass are $U_{wall} = 1.98\ W/m^2$ ċ , $U_{glass} = 3.6\ W/m^2$ ċ respectively . The group of the two external walls are (C) . The building is located at 32 N latitude with outside design condition of DBT= 48 ċ and WBT= 28 ċ . The daily range is DR= 18 ċ . The inside conditions are DBT = 25 ċ and RH= 60% . The building is of medium construction with light color . There are 5 persons doing heavy (lifting) work in the building . The lighting load may assumed to be 20 W per m^2 floor area . Calculate the cooling load from the two external walls, glass , occupancy , lighting and infiltration on July at 10 a.m .
<u>Note</u> : Use a cooling load factor for occupancy CLF =1.0 and the shade factor for window Sc= 0.8 .

Q:3 An absorption system is used to air-conditioned a hospital building using LiBr-H_2O pairs . The temperatures of the system are as follows : Generator (110 ċ) , condenser (50 ċ) , evaporator (5 ċ) and absorber (40 ċ) . The pumping capacity is (m_1 =10 kg/s) . The concentrations at the absorber and generator are X1= 55% and X3=65% respectively . Calculate: (a) The mass flow rate of refrigerant in the evaporator , (b)The refrigeration capacity , (c) The heat input to the generator and, (d) The quantity of water (kg/s) required to cool the condenser . Given that ΔT_{water}= 6 ċ , Cp_{vapor} =1.84 kJ/kg.ċ ,and Cp_{water}=4.2 kJ/kg.ċ .

Q4:A food freezer of 5 TR capacity works with R134a as a refrigerant . It has a single cylinder compressor operating at 1740 r.p.m . The stroke to diameter ratio of the cylinder is 0.8 . The evaporator temperature is (-10 ċ) and the condenser temperature is (40 ċ) . A heat exchanger is installed in the system and gives (5 ċ) super heating after the evaporator . The gas temperature out of the compressor is (60 ċ) . Determine using Tables only : (a) The mass flow rate of R134a in the food freezer , (b) The stroke and diameter of the cylinder where the volumetric efficiency of the compressor is 90% , (c) The compressor work in kW.

Q5: A- Cold water piping system has a water flow rate of (6 L/s) . The water temperature is 8 °c . The discharge pipe diameter is (62.5 mm) and that for the suction side is (70mm) . The expansion tank is located at the suction side at a height of 5.0m above the centerline of the pump suction pipe . The discharge pipe is 40m long steel pipe fitted with 10 [90° elbows std.] , 4 gate valves , 1 globe valve and two cooling coils of (ΔP_{loss}=30 kPa) each . Calculate the power of the pump required to deliver the required water flow rate , assuming η_{pump} =85% . Given : $P_{pump}= (P_{discharge} + 0.5\ \rho\ V^2_{discharge}) - (P_{suction} + 0.5\ \rho\ V^2_{suction})$, where : $P_{discharge}= P_{discharge\ losses}$ (i.e the pressure losses in the discharge pipe + pressure losses in its fittings) .

B- Explain with aid of sketch the elements of the 4-pipe water system and state its advantages over the one-pipe system ?

Note : All questions have equal marks

Good Luck

University of Technology
Mechanical Engineering Department

Subject: Air-conditioning 3rd Year | Time: 3 Hours
Final Examination | Date: 21 / 06 /2011

Answer four questions

Q1: An air conditioned building has a sensible cooling load of 60 kW and latent load of 40 kW . The building is maintained at DBT= 24 c , RH= 50 % , while the outside design conditions are DBT= 34 c and RH= 40 % . To satisfy the ventilation requirement , outdoor air is mixed with re-circulated air in the ratio of 1:3 (by volume) . Since the latent load on the building is high , a reheat coil is used along with a cooling and dehumidifying coil . Air is exited from the cooling coil at DBT=14 c . If the by-pass factor of the cooling coil is 0.15 , find : i) Air supply temperature after reheat , ii) The cooling coil capacity in TR , iii) The reheat coil capacity in kW , iv) $\dot{m}_{w.v.}$ removed by cooling coil and , v) Plot all psychrometric processes .

Q2: In a R134a household refrigerator (ثلاجة منزلية) of 2 kW refrigeration capacity , located in the kitchen (المطبخ) , a liquid to suction heat exchanger is used . The evaporating and condensing temperatures are 8 c and 54 c respectively . The temperatures of the vapor entering and leaving the compressor are 14 c and 60 c respectively . Assuming isentropic compression process , find using table only : i) The mass flow rate of refrigerant $\dot{m}_{R134a}$, ii) The compressor work , iii) The heat rejected to the kitchen , iv) COP of the refrigerator and , v) Plot the p-h diagram .

Q3: A) A vapor absorption refrigeration system working with (H2O-LiBr) has a refrigeration capacity of 300 kW . It operates at an evaporator temperature of 5 c and condensing temperature of 50 c . The temperatures of absorber and generator are 40 c and 110 c respectively . The concentration of solution at exit of absorber and generator are 0.58 and 0.66 respectively . Carry out a mass and energy balances to find :

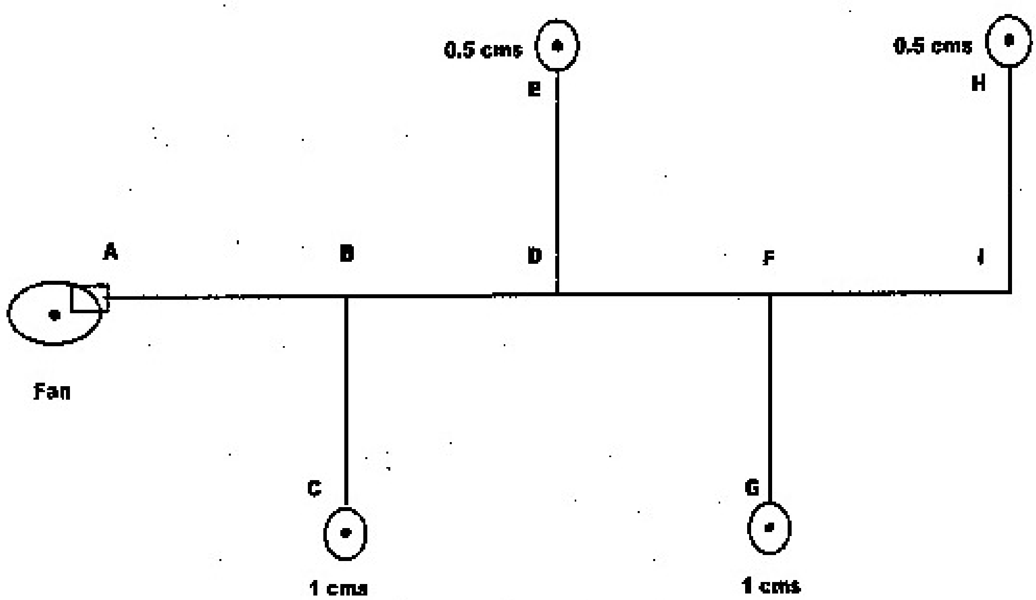
i) The mass flow rate of water vapor in the evaporator ,
ii) Mass flow rate of the strong solution ,
iii) Heat transfer rates at absorber , condenser and generator,
iv) System COP and , v) The amount of cooling water in (kg/s) required to cool the absorber if ΔT_{water} = 6 c and Cp_{water}=4.2 W/kg K .

B) Explain the working principals of the Electrolux absorption refrigerator (الثلاجه النفطيه) aiding your answer with sketch includes all its components .

Q4: Air conditioned office room measured 5m wide , 3m high and 6m deep . One of its walls (5m) faces south east (SE) and contains a double glazed window of size 1.5m by 1.5m with no external shade . The external heat gain is <u>only</u> from the SE wall (type D) and the roof .

Given the following information : Inside conditions DBT=25 c , RH=50%, outside conditions DBT= 43 c and WBT= 24 c , U_{wall} = 1.397 $W/m^2 K$, U_{roof}= 1.32 $W/m^2 K$, $CLTD_{c\ roof}$ = 30 c , U_{glass} = 3.1 $W/m^2 K$, Sc_{glass} = 0.86 , occupancy= 5 typist (طابعيات) and the manger , lighting load 33 W/m^2_{floor} , infiltration 0.5 air change per hour , $CLF_{occupancy}$ = 0.9 and CLF_{glass} = 0.31 . The office is located at 40 N latitude with medium construction and light color . The daily range is 18.8 c . Calculate the total cooling load in (TR) for the office room from SE wall , roof , window , occupancy , lighting and infiltration on June at 1.0 p.m .

Q5: The following figure shows a typical duct layout . Design the duct system using equal friction method . Take the velocity in the main duct AB equal to 8 m/s and the duct height for the system to be 0.4 m . Assume a dynamic loss coefficient of 0.5 for bends and a pressure loss for each outlet equal to 25 Pas . Ducts length for AB=BC=BD=DE=DF=FG=FI=IH= 10 m . Find also the fan power , where fan efficiency is 65% .



Good Luck

University of Technology

Mechanical Engineering Department

Subject : Air-conditioning | **Time: Three Hours**

Class: 3rd Air-Conditioning | **Date: 27/ 10 /2011**

Answer Four Questions

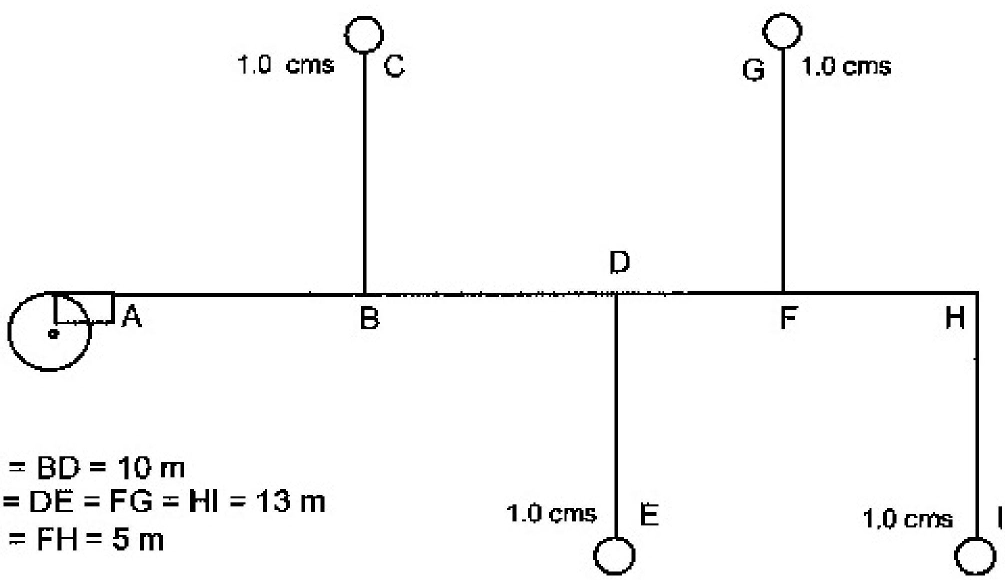
Q1: An operational theater room has a sensible load of 20 kW and a latent load of 5 kW. The space is to be maintained at DBT=24°C and RH=50% . The air supplied to the space is all outdoor air at DBT=45 °C and WBT =28 °C . Assume that the air is supplied to the space at RH = 90 % , calculate: i-The supply air flow rate (m^3 /s) , ii-The T_{ADP} and the B.P.F, iii-The water vapor removed by the cooling coil (kg_{wv} /s) , iv-The cooling coil load in TR v- Plot the psychometric processes on a representative chart.

Q2: In R134-a based refrigeration system a liquid-vapor heat exchanger is used . The refrigeration capacity of the system is 1.5 TR . The condenser temperature is 50 °C and the evaporator temperature is -10 °C with super-heating of 4 °C . The compressor of the machine is a reciprocating type with a cylinder of L/D=1.1 and 1450 rpm . Assume isentropic compression process in the compressor with outlet temperature of 60 °C and η_v =90% . Calculate using tables only : i- The mass flow rate of the refrigerant (kg/s) , ii- The work of the compressor in [kW] , iii- The stroke and diameter of the piston , iv- COP of the cycle , v- The heat rejected [kW] .

Q3: An absorption refrigeration system working with LiBr- H_2O has (0.5 kg/s) of the solution leaving the absorber . The generator temperature is (100 °C) and that of the evaporator is (10 °C) . The condenser and absorber temperatures are (40 °C) and (30 °C) respectively . The concentration out of the absorber is X1 = 50% and out of the generator is X3= 60% . Calculate:
i- The mass flow rate of refrigerant in the evaporator , ii- The refrigeration capacity in TR , iii- The heat input to the generator , iv- COP of the system , v- The energy balance .

Q4: A laboratory has a dimension of (6m x 10m x 4m) . The south west (sw) wall of the building contains two windows 3m x 2m each with no external shade . The external heat gain is from the SW wall (10m x 4m) type D and from the roof (6m x 10m) . The following information are available : Inside air conditions are DBT=25 °C , RH= 50% , outside conditions DBT= 43 °C , WBT= 24 °C , U_{wall} = 1.397 W/m^2 K , U_{roof}= 1.30 W/m^2K, $CLTD_{c\ roof}$ = 28 °C , U_{glass} = 3.6 W/m^2K , Sc_{glass} = 0.82 , occupancy = 10 students , lighting load 30 W/m^2_{floor} , infiltration rate is 0.5 air change per hour , $CLF_{occupancy}$ = 0.9 , CLF_{glass} = 0.31 and daily range of 18.8 °C . The building is of heavy construction with light color and located at 32 N . Calculate the total cooling load in (TR) for the building from the sw wall , roof , window , occupancy (light bench work) , lighting and infiltration on July at 4 .0 p.m .

Q5: Design the ducting system shown below using equal friction method . The velocity in the main duct AB is 9 m/s . A duct height of H = 0.4 m may be taken for the whole system. Assume a dynamic loss coefficient of 0.5 in bends and a pressure loss for each outlet opening equal to be 25 Pa .Calculate the maximum pressure in the system and the fan power (kW) assuming fan efficiency of 65% . Note : cms means m^3/s .



AB = BD = 10 m
BC= DE = FG = HI = 13 m
DF = FH = 5 m

GOOD LUCK

University of Technology
Mechanical Engineering Department

Subject: Air-conditioning 3rd Year — Time: 3 Hours

Final Examination — Date: 21 / 06 /2011

Answer four questions

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iii) Heat transfer rates at absorber, condenser and generator,
iv) System COP and, v) The amount of cooling water in (kg/s) required to cool the absorber if $\Delta T_{water} = 6$ c and $Cp_{water}=4.2$ W/kg K.

B) Explain the working principals of the Electrolux absorption refrigerator (الثلاجه النفطيه) aiding your answer with sketch includes all its components.

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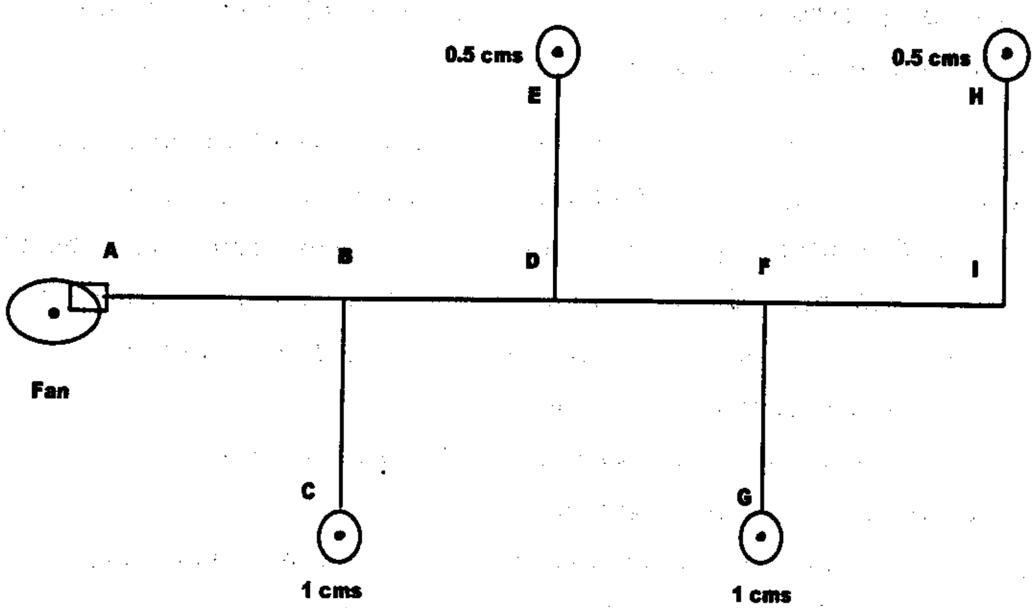


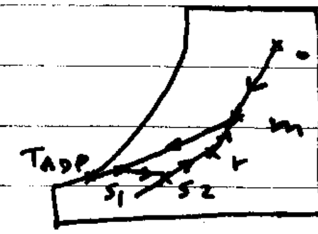
Good Luck

21-06-2011

Q1 $\quad SHF = \dfrac{Q_s}{Q_T} = \dfrac{60}{100} = 0.6$

$$T_{mixing} = \frac{\forall_o \cdot T_o + \forall_r \cdot T_r}{\forall_m} = \frac{1 * 34 + 3 * 24}{4} = 26.5\ ^\circ c$$

$$B.P.F = \frac{T_{s_1} - T_{ADP}}{T_m - T_{ADP}}$$



$$0.15 = \frac{14 - T_{ADP}}{26.5 - T_{ADP}} \qquad T_{ADP} = 11.8\ ^\circ c \qquad , T_{s_2} = 22.$$

1.22 (22.5 - 1

$$Q_s = 1.22 \forall_s \left(T_r - T_{s_4}\right) \implies \forall_s = \frac{Q_{s_{Room}} + Q_{s\ coil}}{1.22\ (24 - T_{s_4})}$$

$$\implies \forall_s = \frac{60 + 10.37}{1.22\ (24.0 - \underset{14.0}{\ldots})} \implies 5.76\ m^3/s$$

$$Q_{c.coil} = 1.2 \forall_s \left(h_m - h_{s_1}\right) = 1.2 * 5.76 (53 - 37)$$
$$= 110\ KW$$

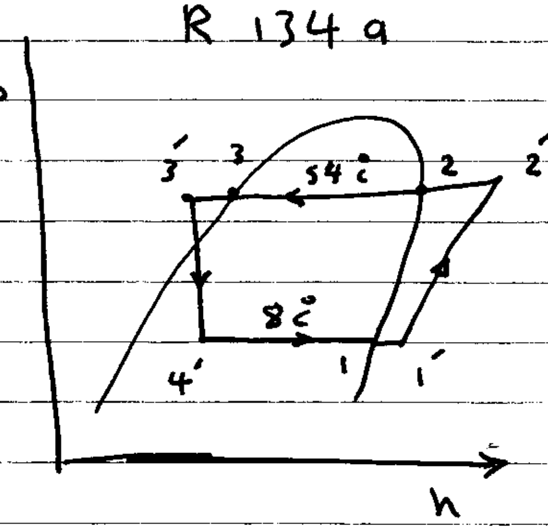
$$Q_{H.coil} = 1.2 \forall_s \left(h_{s_2} - h_{s_1}\right) = 1.2 * 5.76 (43 - 37)$$
$$= 41.5\ KW$$

$$\dot{m}_{vapor} = \dot{m}_a \left(W_m - W_{s_1}\right) \qquad \dot{m}_a = \frac{\forall_s}{v_{s_1}} = 7.0$$

$$= 7.0 \left(\frac{10.4 - 9.8}{1000}\right) = 0.0042\ kg/s$$

Q2

Heat exchanger



$h_3 - h_3' = h_1' - h_1$

$h_1 = h_g \Big]_{8^\circ c} = 403.27 \text{ kJ/kg}$

$h_3 = h_f \Big|_{54^\circ c} = 277.86 \text{ kJ/kg}$

$h_1' = h_1 + c_{p_g}\Big|_{8^\circ c} \Delta T = 403.27 + 0.92(14-8)$
$= 408.8 \text{ kJ/kg}$

$h_2 = h_g \Big|_{54^\circ c} = 425.03 \text{ kJ/kg}$

$h_2' = h_2 + c_{p_g}\Big|_{54^\circ c} \Delta T = 425.03 + 1.6(60-54)$
$= 434.6 \text{ kJ/kg}$

$h_3' = h_3 - (h_1' - h_1) = 277 - (408.8 - 403.27)$
$= 271.47$

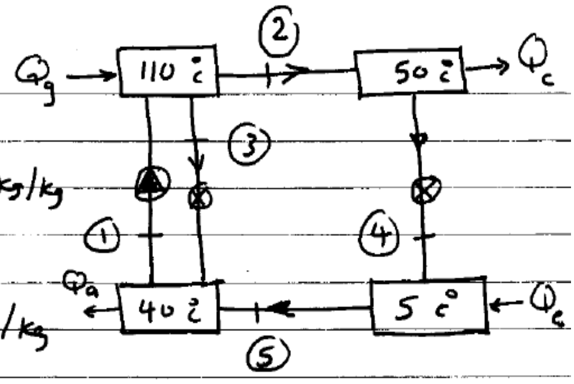
$\dot{m}_R = \dfrac{Q_{evap}}{h_1 - h_4'} = \dfrac{2.0}{403.27 - 271.47} = 0.0152 \text{ kg/}$

$W_{comp} = \dot{m}_R (h_2' - h_1') = 0.0152(434.6 - 408.8)$
$= 0.39 \text{ kW}$

$Q_{cond.} = \dot{m}_R (h_2' - h_3) = 0.0152(434.6 - 277.) = 2.38$ k

$C.O.P = h_1 - h_4' / (h_2' - h_1') = 5.1$

Q3



$h_5 = h_g \big|_{5°C} = 2509.96$ kJ/kg

$h_4 = h_f \big|_{50°C} = 209.3$ kJ/kg

$h_2 = h_g \big|_{50°C} + Cp_g \Delta T = 2591.27 + 1.84(110 - 50)$
$= 2701.7$ kJ/kg

$h_1 = 110$ kJ/kg & $h_3 = 270$ kJ/kg chart

mass balance $\dot{m}_1 = \dot{m}_2 + \dot{m}_3$ — ① $\dot{m}_1 X_1 = \dot{m}_3 X_3$ — ②

$\dot{m}_2 = \dfrac{Q_e}{h_5 - h_4} = \dfrac{300}{2509.96 - 209.3} = 0.13$ kg/s

substitute in equation 1 & 2 gives
$\dot{m}_3 = 0.94$ kg/s & $\dot{m}_1 = 1.07$ kg/s

$Q_c = \dot{m}_2 (h_2 - h_4) = 0.13(2701.7 - 209.33) = 324$ kW

$Q_g = \dot{m}_3 h_3 + \dot{m}_2 h_2 - \dot{m}_1 h_1 \Rightarrow 487.$ kW

$Q_a = \dot{m}_2 h_5 + \dot{m}_3 h_3 - \dot{m}_1 h_1 \Rightarrow 462.4$ kW

$Q_g + Q_e \simeq Q_a + Q_c$ check ✓

$C.O.P = \dfrac{Q_e}{Q_g} = 0.61$

$\dot{m}_w = Q_c / Cp_w \Delta T_w = \dfrac{324}{4.2 * 6} = 12.8$ kg/s

$$Q_{light} = A_{floor} * 33 = 5*6*33 = 990 \text{ watt}$$

$$Q_{vent} = \frac{\dot{V}}{v} * (h_o - h_i) \qquad \dot{V} = \frac{n \cdot V}{3600} = \frac{0.5*90}{3600}$$

$$= \frac{0.0125}{0.85}(64-51) * 1000 \qquad = 0.0125 \ m^3/s$$

$$= 191.2 \text{ watt}$$

$$Q_{occup} = n * q_s * CLF + n \, q_L$$

~~for typist~~ $q_s = q_L = 75$ watt

$$Q_{occup}\Big|_{Typist} = 5*75*0.9 + 5*75 = 712.5 \text{ Watt}$$

$$Q_{occup}\Big|_{manger} = 1*65*0.9 + 1*55 = 113.5 \text{ watt}$$

$$Q_{occup}\Big|_{total} = 825.5 \text{ watt}$$

$$Q_{total} = \sum Q_{wall + roof} + Q_{glass} + Q_{vent} + Q_{light} + Q_{occup}$$

$$= 3825 \text{ Watt}$$

Q_4 $\quad Q_{wall} = A_w \cdot U_w \; CLTD_c$ $\qquad$ CLTD from tables

$A_w = (5\times3) - (1.5\times1.5) = 12.75 \; m^2$

$CLTD_c = (CLTD + LM)K + (25.5 - t_r) + (t_o - 29.4)$

$CLTD = 14\,^\circ C \qquad LM = 0.0 \qquad K = 0.65$

$t_o = T_o - \frac{DR}{2} = 43 - \frac{18.8}{2} = 33.6\,^\circ C \quad \& \; t_r = 25\,^\circ C$

$CLTD = (14+0)\,0.65 + 0.5 + 4.2 = 13.8\,^\circ C$

$\therefore Q_{wall} = 245.8$ watt

$Q_{roof} = A_{roof} \cdot U_{roof} \cdot CLTD_c$

$= (5\times6) \times 1.32 \times 30 = 1188$ watt

$Q_{glass}\big|_{cond} = A_{glass} \cdot U_{glass} \times CLTD_c$ $\qquad CLTD_c = 7 + 4.7$

$= (1.5\times1.5) \times 3.1 \times 11.7 = 81.6$ watt

$Q_{glass}\big|_{rad} = A_{glass} \cdot SHGF \times S_c \times CLF$

Table $\Rightarrow$ $SHGF = 506 \; W/m^2$, $CLF = 0.31$, $S_c = 0.86$

$\therefore Q_{glass}\big|_{rad} = 303.5$ watt

$Q_{glass\ total} = 81.6 + 303.5 = 384.5$ watt

Q_5

Element	Q l/s	V m/s	f Pa/m	D mm	H mm	W mm	ΔP Pa
AB	3000	8.0	0.85	700	400	1100	8.5
BC	1000	6.2	0.85	450	400	425	–
BD	2000	7.2	0.85	600	400	800	8.5
DE	500	5.2	0.85	350	400	260	–
DF	1500	6.7	0.85	520	400	555	8.5
FG	1000	6.2	0.85	450	400	425	–
FH	500	5.2	0.85	350	400	260	17.
Bend I							8.0

$$\Delta P_{bend} = k\,\rho\frac{v^2}{2} = 0.5 \times 1.2 \frac{(5.2)^2}{2} = 8 \text{ Pa}$$

$$FSP = \Delta L * f + \Delta P_{bend} + \Delta P_{opening}$$

$$= 50 * 0.85 + 8 + 25 = 75.5 \text{ Pa}$$

$$FTP = FSP + P_v = 75.5 + 1.2 * (8)^2/2 = 114 \text{ Pa}$$

$$P_{ower} = \frac{Q * FTP}{\eta} = \frac{3 * 0.114}{0.65} = 0.53 \text{ kW}$$