MEBS6006 Environmental Services I

Try the questions and see if there is any additional data required or there exists any incorrect data. Hints to solve would be given later. If you do not know how to answer, just try to understand the questions at first.

Question 1

A cooling tower is found with following operating conditions: -

Entering condenser water temperature = 37°C

Leaving condenser water temperature = 32°C

Entering air temperature (wet bulb) is at 29 °C

Enthalpy of saturated air at 29 °C (wet bulb): 92.3 kJ/kg

Ratio of water and air mass flow rate is given as 1.2.

Height of each deck H_d = 0.6 m

The number of decks N and the height of the fill H are given by the following equations:-

$$\frac{K_a V}{m_w} = 0.0167 + 0.033N\left(\frac{m_w}{m_a}\right)^{-0.6}$$

$$H = N \times H_d$$

Determine the tower coefficient and height of the fill.

Water Temperature (°C)	Enthalpy of saturated film (kJ/kg)
32	111.0
33	116.8
34	123.0
35	129.4
36	136.2
37	143.2

Question 2

A car park with volume at 60m x 30m x 3m high was found with vehicle producing carbon monoxide at a total of 0.0024 m^3/s. The permissible concentration of it is only 0.01%.

Determine the number of air change per hour assuming that the car park is in continual use.

Question 3

A CAV AHU for one large office having a cooling load at 40kW (34kW sensible heat)

It is given that:-

Summer outdoor design dry bulb temperature is 33^{o}C

Summer outdoor design wet bulb temperature is 28 ^{o}C

Heat gain in supply fan and duct is 2 ^{o}C

Heat gain in return duct is 2.5 ^{o}C

Relative Humidity of the conditioned air leaving coil coil is 95%

Outdoor ventilation air required is 0.44 m^3/s

Determine:

(1) The condition of supply air (temperature, RH, enthalpy, humidity ratio)
(2) Supply air volume flow rate
(3) Enthalpy of the mixture of outdoor and return air

Question 4

A variable air volume (VAV) air conditioning system supplies air to two rooms. It is found that: -

Room Temperature setting (both rooms) = 22^{o}C

Temperature difference between supply air and room air = 8^{o}C

Specific humidity of air leaving cooling coil = 0.0076

Summer external design temperature = 27^{o}C db and 22 ^{o}C wb

Turn down ratio of the VAV air conditioning system = 3:1

Temperature rise across fan = 2^{o}C

Room	Minimum fresh air	Maximum sensible gain	Latent heat gain	Maximum simultaneous sensible gain
1	0.6 l/s	49 kW	7 kW	14 kW
2	0.8 l/s	49 kW	7 kW	49 kW

Calculate:

1. Recirculation Ratio (Ratio of mass flow rate of re-circulated to fresh air);
2. Temperature and percentage saturation in zone 2 during maximum simultaneous gains
3. Maximum Cooling Coil’s Load
4. The return air temperature (after mixing from the return from room 1 and 2).

Question 5

As a Technical Manager, you are going to suggest installation of an economizer at the fuel exhaust to preheat feed water and installation of variable speed drive (VSD) at the fan which blow air for combustion so as to save energy on the existing boiler using low sulphur oil.

You have to determine the following parameters in order to convince the CEO of your company on the investment.

i) The energy saving (in MJ/hr) on the using of economizer.
ii) The money saving in the first year and second year due to the use of VSD drive.

Given:-
Exhaust temperature of fuel gas = 185°C
Allowable exit stack temperature of low sulphur oil = 145°C
Consumption rate of low sulphur oil = 150 Litre/hour
Air Fuel Ratio = 1:14
Feed water flow rate (entering boiler) = 3800kg/hour
Feed water temperature (entering boiler) = 88°C

Specific heat capacity of fuel gas = 1.1kJ/kg/K
Density of low sulphur oil = 900kg/m^3
Annual Interest Rate is 3% per annum.

Loading	**Operation hours per day**	**Fan motor power (with damper)**
100%	3	15 kW
80%	4	14 kW
60%	10	12 kW
40%	7	11 kW

Fan motor with VSD drive rates at 15kW at 100% load.

Question 6

A centrifugal chiller at 1500kW cooling capacity operates at an ideal single stage vapor compression cycle. Enthalpies of refrigerants are found as follows: -

Leaving the evaporator = 188.2 kJ/kg

Leaving the compressor= 208.7 kJ/kg

Leaving the condenser = leaving the expansion valve = 76.3 kJ/kg

You are requested to find:

1) Refrigeration effect,

2) The work input to the compressor

3) The coefficient of performance

4) The mass flow rate of the refrigerant

5) Power input per kW refrigeration produced

If the liquid refrigerant is sub-cooled so that the enthalpy of refrigerant leaving the condenser is 74.2 kJ/kg , re-calculate the coefficient of performance of this refrigerant plant, power input per kW refrigeration produced and percentage of electric energy saved by sub-cooling.

Question 7

A chiller with a centrifugal compressor is operating as follows: -

Refrigerant enter centrifugal compressor = dry saturated at 0.4 bar

Isentropic efficiency = 0.8

Pressure ratio = 2.5

Rotational speed = 3600 rpm

Inside diameter of impeller = 65mm

Axial velocity of the refrigerant at impeller inlet = 85 m/s

Enthalpy of refrigerant leaving evaporator = 960 kJ/kg

Enthalpy of refrigerant leaving compressor (in an isentropic compression) = 977 kJ/kg

Enthalpy of refrigerant leaving condenser = 790 kJ/kg

Enthalpy of refrigerant leaving expansion valve = 790 kJ/kg

Specific volume of refrigerant at inlet of compressor = 0.4 m^3/kg

Calculate:

i) The Coefficient of Performance;

ii) The mass flow rate of the refrigerant at compressor inlet;

iii) The diameter of the impeller of the compressor;

iv) The outside diameter of the eye of the impeller inlet.

Question 8

A cooling coil has a face area of $0.8m^2$, outer surface area of the coil of $81m^2$ and inner surface area of the coil = $6.9m^2$.

The face area velocity is given as 3m/s and the chilled water flow rate = 2 lit/sec

Air entering dry bulb temperature = 30^oC

Chilled water temperature entering temperature = 12^oC

Outer surface heat transfer coefficient of the coil could be taken as $63W/m^2K$ and the inner surface heat transfer coefficient of the coil could be considered as $5993W/m^2K$

Other useful data:

R-value of fin = $4.32x10^{-3}m^2K/W$

Specific heat of moist air: 1.02 kJ/kg.K

Specific heat of water: 4.2 kJ/kg.K

Density of air: $1.2kg/m^3$

Density of water: $1000kg/m^3$

$$\left(\frac{A_f}{A_o}\right) = 0.9$$

Determine the sensible cooling coil's load.