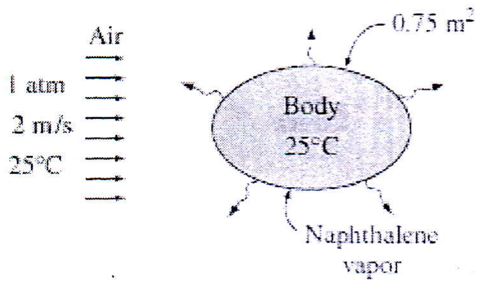
Menoufia University
Mech. Power Eng. Dept.
Subject: Mass transfer
Total mark: 100 (mark)

Faculty of Engineering
Post-graduate (Master)
Final Exam: 2017/2018
Time allowed: 3 hours.

Answer the following questions:
Assuming any missing data.

Question (1) (20 +20 = 40 mark)

1-a) The average heat transfer coefficient for air flow over an odd-shaped body is to be determined by mass transfer measurements and using the Chilton–Colburn analogy between heat and mass transfer. The experiment is conducted by blowing dry air at 1 atm at a free stream velocity of 2 m/s over a body covered with a layer of naphthalene. The surface area of the body is 0.75 m^2, and it is observed that 100 g of naphthalene has sublimated in 45 min. During the experiment, both the body and the air were kept at 25°C, at which the vapor pressure and mass diffusivity of naphthalene are 11 Pa and D_{AB} = 0.61 x 10^{-5} m^2/s, respectively. Determine the heat transfer coefficient under the same flow conditions over the same geometry.
For naphthalene: M = 128.2 kg/kmol. ρ = 1.184 kg/m^3, C_P = 1007 J/kg · K, and α = 2.141x 10^{-5} m^2/s



1 –b) The roof of a house is 15 m x 8 m and is made of a 20-cm-thick concrete layer. The interior of the house is maintained at 25°C and 50 percent relative humidity and the local atmospheric pressure is 100 kPa. Determine the amount of water vapor that will migrate through the roof in 24 h if the average out- side conditions during that period are 3°C and 30 percent relative humidity. The permeability of concrete to water vapor is 24.7 x 10^{-12} kg/s · m · Pa.
In order to reduce the migration of water vapor, the inner surface of the wall is painted with vapor retarder latex paint whose permeance is
26 x 10^{-12} kg/s · m^2 · Pa. Determine the amount of water vapor that will diffuse through the roof in this case during a 24-h period.
Take P_{sat} *@ 3°C = 768Pa, and* P_{sat} *@ 25 °C = 3169 Pa*

Question (2):

(40 mark)

Hot water baths with open tops are commonly used in manufacturing facilities for various reasons. In a plant that manufactures spray paints, the pressurized paint cans are temperature tested by submerging them in hot water at 50°C in a 40-cm-deep rectangular bath and keeping them there until the cans are heated to 50°C to ensure that the cans can withstand temperatures up to 50°C during transportation and storage . The water bath is 1 m wide and 3.5 m long, and its top surface is open to ambient air to facilitate easy observation for the workers. If the average conditions in the plant are 92 kPa, 25°C, and 52 percent relative humidity, determine the rate of heat loss from the top surface of the water bath by (*a*) radiation, (*b*) natural convection, and (*c*) evaporation. Assume the water is well agitated and maintained at a uniform temperature of 50°C at all times by a heater, and take the average temperature of the surrounding surfaces to be 20°C.

Treating the water vapor and the air as ideal gases and take the following properties:

For liquid water:

$\varepsilon = 0.95$, $h_{fg} = 2383$ kJ/kg, $P_v = 12.35$ kPa, and $R = 0.4615$ kJ/kg.K

For air:

$K = 0.02644$ w/m.^{0}C, $Pr = 0.7262$, $\alpha = 2.546 \times 10^{-5}$ m^2/s , and $\nu = 1.849 \times 10^{-5}$ m^2/s

For natural convection:

$$Nu = 0.15\,(Gr.Pr)^{1/3} \quad \text{where} \quad Gr = \frac{g\,(\rho_\infty - \rho_s)\,L_c^3}{\rho_{ave}\,\nu^2}$$

For mass transfer:

$$Sh = 0.15\,(Gr.Sc)^{1/3} \quad \text{where} \quad Sc = \frac{\nu}{D_{AB}}$$

Question (3):

(5 + 7 +8 = 20 mark)

For the cooling tower:

i) - Discuss the following items:

Range, Make-up, Approach, Fill, Head

ii) - Mention the Merkel Equation and define each parameter in these equation.

iii) - Explain by net diagram, the Graphical representation of the cooling tower characteristic.

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مع اطيب الامنيات بالنجاح و التوفيق