SNS COLLEGE OF TECHNOLOGY

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COIMBATORE-641 035, TAMIL NADU

B.E/B.Tech.- Internal Assessment – III
Academic Year 2024-2025 (EVEN Semester)
Sixth Semester
Mechanical Engineering
19MEB302-HEAT & MASS TRANSFER

ANSWER KEY

PART- A (2×5 = 10 Marks)

1. Radiative heat transfer is the transfer of energy in the form of electromagnetic waves. It does not require a medium and is governed by the Stefan-Boltzmann law. The formula is: $q = \varepsilon\sigma T^4$, where ε is emissivity, σ is Stefan-Boltzmann constant (5.67×10^{-8} W/m^2K^4), and T is absolute temperature.

2. The shape factor (view factor) F_ij is the fraction of radiation leaving surface i that directly reaches surface j. It depends only on geometry. The summation rule: $\Sigma F_{ij} = 1$.

3. Given: T = 900 K, ε = 0.85

$E = \varepsilon\sigma T^4 = 0.85 \times 5.67\times10^{-8} \times (900)$^4

$= 0.85 \times 5.67\times10^{-8} \times 6.561\times10$^11

= 31,338 W/m^2 (approx)

4. Mass concentration is defined as the mass of a component per unit volume of mixture. Formula: $\rho_i = m_i / V$

5. Given: $D = 1.6\times10^{-5}$ m^2/s, dc/dx = 3 kg/m^4

Mass flux $J = -D \times (dc/dx) = -1.6\times10^{-5} \times 3 = -4.8\times10^{-5}$ $kg/m^2\cdot s$

PART – B (2×13 = 26 Marks) & (1×14 = 14 Marks)

6(a). Two infinite parallel plates:

$T1 = 1000$ K, $\varepsilon1 = 0.9$

$T2 = 600$ K, $\varepsilon2 = 0.6$

$q = \sigma(T1^4 - T2^4)/[(1-\varepsilon1)/\varepsilon1 + 1 + (1-\varepsilon2)/\varepsilon2]$

$= 5.67\times10^{-8} \times (1000^4 - 600^4)/[(1-0.9)/0.9 + 1 + (1-0.6)/0.6]$

$= 5.67\times10^{-8} \times (1\times10^{12} - 1.296\times10^{11})/[0.111 + 1 + 0.667]$

$= 5.67\times10^{-8} \times 8.704\times10^{11} / 1.778$

$\approx 27,770$ W/m²

With radiation shield ($\varepsilon = 0.1$): Total resistance increases as one more term is added, reducing the net heat transfer.

6(b). Given: Incident = 800 W/m², Absorbed = 300 W/m², Reflected = 100 W/m²

Transmitted = 800 - 300 - 100 = 400 W/m²

Absorptivity = 300/800 = 0.375

Reflectivity = 100/800 = 0.125

Transmissivity = 400/800 = 0.5

7(a). Given:

$dx = 2$ mm $= 0.002$ m,

$C1 = 0.025$ kg.mol/m³,

$C2 = 0.007$ kg.mol/m³,

$D = 1\times10^{-9}$ m²/s

$J = -D(C1 - C2)/dx = -1\times10^{-9} \times (0.025 - 0.007)/0.002 = -9\times10^{-6}$ kg.mol/m²·s

7(b). Case 1: Drying of food products - Moisture is removed using heat (conduction, convection) aiding mass transfer.

Case 2: Cooling towers - Hot water releases heat to air, while water vapor diffuses (mass transfer with heat interaction).

8(a). Given:

$A = 0.02\ m^2$,

$\varepsilon = 0.75$,

$T = 1100\ K$,

$T_{surr} = 300\ K$

$Q = \varepsilon\sigma A(T^4 - T_{surr}^4) = 0.75\times5.67\times10^{-8}\times0.02\times(1100^4 - 300^4)$

$= 0.75\times5.67\times10^{-8}\times0.02\times(1.4641\times10^{12} - 8.1\times10^9)$

$\approx 100.9\ W$

Using a radiation shield reduces the net heat loss due to increased thermal resistance.

8(b). Given:

$Re = 5\times10^{-5}$,

$Sc = 0.6$,

$\nu = 1.4\times10^{-5}\ m^2/s$,

$L = 1\ m$

Use: $Sh = 0.664 \times Re^{0.5} \times Sc^{0.33}$

$Sh \approx 0.664 \times (5\times10^{-5})^{0.5} \times 0.6^{0.33} \approx 0.029$

$D = \nu / Re = 1.4\times10^{-5} / 5\times10^{-5} = 0.28\ m^2/s$

$h_m = Sh \times D / L \approx 0.029 \times 0.28 / 1 = 0.0081\ m/s$