HEAT TRANSFER
(CHEN 2201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Thermal resistance of composite wall is maximum when slabs of different materials are arranged in
(a) Parallel (b) partly parallel & partly series
(c) random (d) Series

(ii) An increase in fin effectiveness is caused by high value of
(a) convective coefficient (b) thermal conductivity
(c) cross-section area (d) circumference

(iii) Drop wise condensation takes place on
(a) smooth surface (b) rough and contaminated surface
(c) gray surface (d) none of these

(iv) Lieden-frost effect is associated with
(a) evaporation of a solution (b) boiling liquid on a hot surface
(c) exchange of heat between two fluids (d) condensation of vapour on a cold surface

(v) Reynolds analogy states that
(a) $S_t = f/2$ (b) $S_t = f/4$
(c) $S_t = 4f$ (d) $S_t = \sqrt{f}$

(vi) In Wien's displacement law the value of $\lambda_{max} T$ is
(a) 2898 micron K (b) 5200 micron ^oR
(c) both (a) & (b) (d) 300 micron ^oR

(vii) The Sieder and Tate equation is used for the determination of heat transfer co-efficient of fluid
(a) Flows through a circular tube when flow is laminar
(b) Flows through a circular tube when flow is turbulent
(c) Flows over a flat plate when flow is laminar
(d) Flows over a flat plate when flow is turbulent

(viii) Thermal boundary layer is almost equal to hydrodynamic boundary layer for
(a) Gas (b) Solid
(c) Liquid metal (d) Oil

(ix) The rate of heat transfer between two large parallel planes with one radiation shield is
(a) Double
(b) Half
(c) Equal
(d) Logarithmic value of the radiation heat transfer between them in absence of radiation shield

(x) For a 2-4 exchanger where steam is condensing outside the tubes, the value of LMTD correction factor is
(a) 0 (b) 0.5
(c) 1 (d) Infinity

Group – B

2. (a) Derive a governing differential equation for steady state radial heat conduction with uniform heat generation in a cylindrical body.

(b) Show that in a long cylinder of radius R with uniformly distributed heat source, the temperature distribution is prescribed by the relation $\frac{T-T_w}{T_{\max}-T_w}=1-\left(\frac{r}{R}\right)^2$ where, T_w is the temperature at the outer surface of the cylinder and T_{max} is the maximum temperature in the cylinder.

5 + 7 = 12

3. (a) Define fin efficiency for heat transfer from extended surface. Determine an expression for the efficiency of a finite length fin having its tip perfectly insulated.

(b) During a heat treatment process, alloy steel spherical ball of 12mm diameter are initially heated to 800°C in a furnace. Subsequently, these are cooled in an oil bath at 35°C with convective coefficient 20 W/m^2-K. Determine the time required for the cooling process. Also calculate the convective coefficient if it is desired to complete the cooling process in 10 minutes. The thermo-physical properties of steel ball are: Density 7750 kg/m^3; specific heat 520 J/kg-K; conductivity 50 W/m-K.

(2 + 4) + 6 = 12

Group – C

4. (a) Derive the Reynold's analogy.

(b) Hot air flows with a mass rate of 0.050 kg/s through an uninsulated sheet metal duct of diameter of 0.25m. The hot air enters at 120^{o}C and after a distance of 5 m, cools to 77^{o}C. The heat transfer coefficient between the duct outer surface

and the ambient air at 0^oC is known to be outer heat transfer coefficient is 6 W/m^2k. Determine the heat flux and the duct surface temperature at x = L.
Air properties
at 363K , C_p = 1010 J/kg-K
at 350K, k =0.030 W/m-K, $\mu = 208.2 \times 10^{-7}$ N-s/m^2, Pr = 0.70

6 + 6 = 12

5. (a) Write a short note on thermal boundary layer.

   (b) Determine the average convection heat transfer coefficient for the 2.5-m-high vertical walls of a home having respective interior air and wall surface temperatures of (a) 20 and 10°C and (b) 27 and 37°C.
   Thermo-physical properties of Air at 288K, 1 atm are, $\beta = 1/T_f = 3.472 \times 10^{-3}$ K^{-1}, $\nu = 14.82 \times 10^{-6}$ m^2/s, k = 0.0253 W/m-K, $\alpha = 20.9 \times 10^{-6}$ m^2/s, Pr = 0.710
   Thermo-physical properties of Air at 305K, 1 atm are, $\beta = 1/T_f = 3.279 \times 10^{-3}$ K^{-1}, $\nu = 16.39 \times 10^{-6}$ m^2/s, k = 0.0267 W/m-K, $\alpha = 23.2 \times 10^{-6}$ m^2/s, Pr = 0.706.
   (Symbols bear usual significance).

4 + (4 + 4) =12

Group – D

6. (a) Discuss the detail the various regimes in pool boiling and explain the condition for the growth of bubbles. What is the effect of bubble size on boiling

   (b) Saturated steam at atmospheric pressure condenses on the outer surface of vertical tube of length 1 m and outer diameter 75 mm. the tube wall is maintained at a uniform surface temperature of 40°C by the flow of cooling water inside the tube. Estimate the steam condensation rate and the heat transfer rate to the tube. What water flow rate will result in a 5°C temperature difference between the outlet and inlet of the pipe? Also calculate the flow Reynolds number to check the assumption of laminar flow conditions. Given, the thermo-physical properties of saturated water are as follows: latent heat of vaporization = 2258.76 kJ/kg; density = 977.8 kg/m^3; thermal conductivity = 2.403 kJ/m-hr-K; viscosity = 4.06×10^{-4} kg/m-s.

(4 + 2) + 6 = 12

7. (a) State Kirchhoff's law. What is radiation shield?

   (b) (i) Calculate the net radiant heat exchange per m^2 area for two large parallel planes at temperatures of 427°C and 27°C respectively. ε (hot plane) = 0.9 and (cold plane) = 0.6.
   (ii) If an aluminum shield (ε = 0.04) is placed between them, find the percentage reduction in the heat transfer.

(2 + 2) + 8 =12

Group – E

8. (a) Describe the 2-4 pass heat exchanger with the help of schematic diagram. What is LMTD correction factor?

   (b) What are the main functions of baffles in a shell and tube exchanger? Draw the temperature profile of a parallel flow and counter flow for different heat capacity rate of fluid.

(3 + 3) + (3 + 3) = 12

9. (a) (i) How can you explain the increase in steam economy for a multiple effect evaporator as compared to a single effect evaporator?
   (ii) When is backward feed mode of operation more suitable than forward feed mode for a multiple effect evaporator? Explain.

   (b) A triple effect forward feed evaporator is used to concentrate a liquid which has marginal elevation in boiling point. The temperature of the stream to the first effect is 105°C, and the boiling point of the solution within third effect is 45°C. The overall heat transfer coefficients are 2200 W/m^2, 1800 W/m^2 and 1500 W/m^2 in the I-effect, II-effect and III-effect respectively. Find out at what temperatures the fluid boils in the I and II effects.

(3 + 3) + 6 = 12

Department & Section	Submission Link
CHE(Regular)	https://classroom.google.com/c/MzEyNTM2NjA2MzU1/a/MzcxNjU1NzIwNTUw/details
CHE(Backlog)	https://classroom.google.com/c/MzcxNjU1NzIwNjMz/a/MzcxNjU1NzIwNjQx/details