Total No. of Questions : 8]

SEAT No. :

PA-1529

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[5926]-149

T.E. (Mechanical/Mechanical - Sandwich)

HEAT AND MASS TRANSFER

(2019 Pattern) (Semester - I) (302042)

Time : 2½ Hours] *[Max. Marks : 70*

Instructions to the candidates:

1) *Solve Q.1 or Q.2, Q.3 or Q.4, Q.5 or Q.6, Q.7 or Q.8.*
2) *Draw neat diagram wherever necessary.*
3) *Use of scientific calculator is allowed.*
4) *Assume suitable data if necessary.*
5) *Figures to the right indicate full marks.*

Q1) a) The crankcase of an IC Engine measuring 0.8 m × 0.2 m may be assumed as a flat plat. The engine runs at a speed of 25 m/s and the crankcase is cooled by the air flowing past it at the same speed. Calculate the heat loss from the crank surface maintained at 85°C to the ambient air at 15°C. Due to road induced vibration, the boundary layer becomes turbulent from the leading edge itself. **[10]**

Properties of the air 50°C,

$v = 17.95 \times 10^{-6}$ m²/s,

k = 0.02824 W/mK,

Pr = 0.698

Use $Nu = 0.036 (Re)^{0.8} (Pr)^{1/3}$

b) Explain the physical significance of Reynold's Number in case of Forced convection and Grashof's Number in case of Natural Convection. **[8]**

OR

Q2) a) A Nuclear reactor with its core constructed of parallel vertical plate 2.2 m high and 1.45 wide has been designed on free convection heating of liquid bismuth. The maximum temperature of the plate surfaces is limited to 960°C, while the lowest allowable temperature of bismuth is 340°C. Calculate the maximum possible heat dissipation from both sides of each plate. For the convection coefficient the correlation is $Nu = 0.13 (Gr.Pr)^{1/3}$ Where the properties evaluated at mean film temperature of 650°C for bismuth are : **[10]**

$\rho = 10^4$ kg/m³,

$\mu = 3.12$ kg/m-h,

Cp = 150.7 J/kgK,

k = 13.02 W/mK.

b) Mention difference between Boiling and Condensation. Explain pool boiling and Regimes of pool boiling. **[8]**

P.T.O.

Q3) a) Explain the following terminology of Radiation. **[12]**

i) Emissive Power

ii) Emissivity

iii) Wein's Displacement Law

iv) Stefan-Boltzmann law

b) Formulate the Radiation Heat flow equation for two concentric infinitely long Cylinders. Let r1 and r2 radii of inner and outer cylinder, T1 & T2 are surface temperature inner and outer cylinder with ε1 & ε2 be respective emissivity. Also consider shape factor if required. **[5]**

OR

Q4) a) Determine the heat transfer rate per unit area due to radiation between two infinite long parallel planes. The First plane has an emissivity = 0.4 & it is maintained at 200°C. The emissivity of second plane is 0.2 and it is maintained at 30°C. A radiation shield having $\varepsilon = 0.5$ is introduced between the given planes. Find the percentage reduction in the heat transfer rate & the steady state temperature attained by the radiation shield. **[10]**

b) Derive relation for radiation between two finite black surface and explain term shape factor. **[7]**

Q5) a) State Fick's Law of Diffusion and Explain Mass diffusion coefficient. **[6]**

b) Write Mass diffusion Equation in Cartesian coordinates deviation, cylindrical coordinates and Spherical Coordinates with Boundary and Initial Condition. **[8]**

c) Define following Terminology: **[4]**

i) Mass Diffusion velocity

ii) Molar Diffusion velocity

iii) Mass Diffusion Flux

iv) Molar Diffusion Flux

OR

Q6) a) Oxygen at 25°C and pressure of 2 bar is flowing through rubber of inside diameter 25mm and wall thickness 2.5mm. The diffusion of oxygen in rubber is 3.12×10^{-3} kgmol/m^3 bar. Find the loss of O^2 diffusion per meter length of pipe. **[8]**

b) Draw Phase Diagram and explain different phases. **[5]**

c) Write down the Physical origins of mass transfer and enlist the applications of mass transfer. **[5]**

Q7) a) Determine the area required in parallel flow heat exchanger to cool oil from 60°C to 30°C using water available at 20°C. The outlet temperature of the water is 26°C. The rate of flow of oil is kg/s. The specific heat of the oil is 2200 J/kgK. The overall heat transfer coefficient U = 300 W/m^2K. Compare the area required for a counter flow exchanger. **[10]**

b) Derive LMTD for parallel flow heat exchanger and mention assumptions considered for derivations. **[7]**

OR

Q8) a) A counter flow heat exchanger is used to cool 3600 kg/hrs of oil (Cp=2000 J/kg K) at 150°C with the help of water (Cp=4178 J/kg K) flowing at the rate of 3710 kg/Hr. Water enters at 298K. The overall heat transfer coefficient is 500 W/m^2 and the surface area is 4.872 m^2. Calculate the exit temperature of oil & water by using: **[12]**

i) LMTD Method

ii) NTU-effectiveness Method.

b) Explain Temperature and Radiation Effects in Heat Exchanger Design. **[5]**

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