THE ASSAM ROYAL GLOBAL UNIVERSITY GUWAHATI

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MEE024104

Roll No. of candidate:

2017

End Semester M.TECH. Examination

1st Semester

ADVANCED HEAT & MASS TRANSFER

Full Marks: 70 Pass Marks: 21 Time: 3 hours

Use of 'Heat and Mass Transfer Data Book' is permitted

Figures in the margin indicate full marks.

PART – A

Answer all questions

Q.1. **1 x 16 = 16**

a) Write the Diffusion Equation related to conduction heat transfer.
b) Define fin efficiency.
c) What is meant by 'lumped system analysis'?
d) Define the Biot and Fourier numbers used in study of heat transfer.
e) Define thermal boundary layer thickness.
f) Write the relation between thermal and hydrodynamic boundary layer thicknesses.
g) Write meaningfully the one-seventh power law for velocity distribution in turbulent boundary layer of a fluid.
h) Write mathematical expression for Colburn Analogy, with reference to flow over a flat plate.
i) State the main difference between boiling and condensation.
j) Name the regimes of boiling.
k) State the difference between LMTD and AMTD.
l) Sketch a single-shell pass and two-tube pass heat exchanger.
m) Define Schmidt number.
n) Define Sherwood number.
o) Define the mass transfer coefficient.
p) For flow of a fluid over a flat plate, what conclusions can be drawn if the thermal diffusivity α is equal to the mass diffusivity D?

PART – B

Answer all questions

Q.2. **3.5 x 4 = 14**

a) Uses of fins are more justified when the medium is a gas and heat transfer is by natural convection. Justify.
b) Explain in detail the Reynolds Analogy between momentum and heat transfer, with reference to flow over a flat plate.
c) Differentiate, with figures and examples, between pool boiling and film boiling.

d) A steel rectangular container having walls 16 *mm* thick is used to store gaseous hydrogen at elevated pressure. The molar concentrations of hydrogen in the steel at the inside and outside surfaces are 1.2 $kg\ mole/m^3$ and zero respectively. Assuming the diffusion coefficient for hydrogen in steel as 0.248×10^{-12} m^2/s, calculate the molar diffusion flux for hydrogen through the steel.

PART – C

Answer all questions

Q.3.

a) For a very long fin having its end temperature same as the surrounding, derive an expression for the heat loss. **(10)**

OR

b) A 15 *mm* diameter mild steel sphere ($k = 42\ W/m°C$) is exposed to cold air at 20°*C* resulting in the convective coefficient $h = 120\ W/m^2°C$.

Determine:

i. Time required to cool the sphere from 550°*C* to 90°*C*.
ii. Instantaneous heat transfer rate 2 minutes after the start of cooling.
iii. Total energy transferred from the sphere during the first 2 minutes.

For mild steel, take: $\rho = 7850\ kg/m^3$, $c = 475\ J/kg°C$ and $\alpha = 0.045\ m^2/h$. **(10)**

Q.4.

a) A barge with a rectangular surface, 30 *m* long and 10 *m* wide, is travelling down a river with a velocity of 0.6 *m/s*. A laminar boundary layer exists upto a Reynolds number equivalent to 5×10^5 and subsequently abrupt transition occurs to turbulent boundary layer. Calculate,

i. The maximum distance from the leading edge upto which laminar boundary layer persists and the maximum boundary layer thickness at that point,
ii. The total drag force on the flat bottom surface of the barge, and
iii. The power required to push the bottom surface through the water at the given velocity.

For water: $\nu = 1 \times 10^{-6} m^2/s$. **(10)**

OR

b) In a straight tube of 60 *mm* diameter, water is flowing at 12 *m/s*. The tube surface temperature is maintained at 70°*C* and the flowing water is heated from 15°*C* to 45°*C*. Calculate the following,

i. The heat transfer coefficient from the tube surface to the water,
ii. The heat transferred, and
iii. The length of the tube.

The thermo-physical properties of water at mean bulk temperature 30°*C* are,
$c_p = 4.174\ kJ/kg°C$, $k = 61.718 \times 10^{-2}\ W/m°C$, $\nu = 0.805 \times 10^{-6} m^2/s$ and $Pr = 5.42$. **(10)**

Q.5.

a) Draw and explain the boiling curve for water at 1 atm pressure. **(10)**

OR

b) Derive the expression for Logarithmic Mean Temperature Difference (LMTD) for a parallel flow heat exchanger. **(10)**

Q.6.

a) For mass diffusion in a stationary medium, derive the general mass diffusion equation in Cartesian coordinates. **(10)**

OR

b) State Fick’s law of diffusion with assumptions made during its analysis. Derive the expression for the diffusion rate for steady state diffusion through a plain membrane. **(3+7)**