KUMARAGURU
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Register Number: ……..

B.E DEGREE EXAMINATIONS: MAY 2015

(Regulation 2009)

Sixth Semester

MECHANICAL ENGINEERING

MEC118: Heat and Mass Transfer

(Instructions: Use of approved Heat and Mass Transfer Data Book is permitted)

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Unit of overall heat transfer coefficient is
   a) W/m^3K b) W/m^2K
   c) W/m^2 d) W/mK
2. Heat is transferred by conduction, convection and radiation in
   a) refrigerator freezer coils b) melting of ice
   c) boiler tubes d) steam condenser
3. Free convection heat transfer is influenced by
   a) buoyant and inertia forces only b) viscous and buoyant forces only
   c) viscous and inertia forces only d) viscous, inertia and buoyant forces
4. With increase of fluid viscosity the boundary layer thickness will
   a) decrease b) increase
   c) not change d) first increase and then decrease
5. Radiator of an automobile is a heat exchanger of
   a) parallel flow type b) counter flow type
   c) cross flow type d) open type
6. In pool boiling, the heat flux becomes maximum towards the end of
   a) free convection boiling regime b) nucleate boiling regime
   c) unstable film boiling regime d) stable film boiling regime
7. A black body is one which
   a) is black in colour b) absorbs all incident radiation
   c) reflects all incident radiation d) absorbs most of the incident radiation

8. Which of the following terms does not pertain to radiation heat transfer?

a) solid angle
b) configuration factor
c) Reynolds analogy
d) spectral distribution

9. Unit of diffusivity is

a) m^2/s
b) $kg\ m/s^2$
c) s/m^2
d) $kg\ s/m^2$

10. Driving force for mass transfer to take place is

a) concentration difference
b) potential difference
c) temperature difference
d) electromagnetic force difference

PART B (10 x 2 = 20 Marks)

11. State Fourier's law of heat conduction.
12. Write the formula to determine the critical thickness of insulation for a cylinder and sphere.
13. Define Prandtl number.
14. List out the types of boundary layer.
15. Differentiate between film wise and drop wise condensation.
16. What do you mean by the term effectiveness of a heat exchanger?
17. Express Stefan Boltzmann law of radiation in mathematical form.
18. Two circular discs of diameter 20 cm each are placed 2 m apart. Calculate the shape factor if the corresponding emissivity of these plates are 0.3 and 0.5.
19. Helium diffuses through a plane, plastic membrane 1 mm thick. The concentration of helium in the membrane is 0.02 $kmol/m^3$ at the inner surface and 0.005 $kmol/m^3$ at the outer surface. If the binary diffusion coefficient of helium with respect to the plastic is 10^{-9} m^2/s, what is the diffusion flux of helium through the plastic?
20. What is Reynolds analogy?

PART C (5 x 14 = 70 Marks)

21. a) Derive an expression for a plane wall with internal heat generation.

(OR)

b) (i) A wall of 0.5 m thickness is to be constructed from a material which has an average thermal conductivity of 1.4 W/mK. The wall is to be insulated with a material having an average thermal conductivity of 0.35 W/mK so that the heat loss per square metre will not exceed 1450 W. Assuming the inner and outer surface temperatures are 1200ºC and 15ºC respectively, calculate the thickness of insulation required. (7)

(ii) Circumferential aluminium fins (k=200 W/mk) of rectangular profile (1.5 cm wide and 1 mm thick) are fitted onto a 2.5 cm diameter tube. The fin base temperature is 170ºC and the ambient fluid temperature is 25 ºC. Estimate the heat loss per fin. Assume the heat transfer coefficient to be 130 W/m^2K. (7)

22. a) Using dimensional analysis, obtain an expression for Nusselt number in terms of Reynolds number and Prandtl number.

(OR)

b) (i) An air stream at 0ºC is flowing along a heated plate at 90ºC at a velocity of 75 m/s. The plate is 45cm long and 60 cm wide. Assuming the transition from boundary layer to take place at $Re_{x,c} = 5x10^5$, calculate the average values of friction coefficient for the full length of the plate. Also, calculate the rate of energy dissipation from the plate. (10)

(ii) An air stream at 27ºC is moving at 0.3 m/s across a 100 W electric bulb at 127ºC. If the bulb is approximated by a 60 mm diameter sphere, estimate the heat transfer coefficient. (4)

23. a) Water is boiled at a rate of 30 kg/h in a copper pan, 30 cm in diameter at atmospheric pressure. Estimate the temperature of the bottom surface of the pan assuming nucleate boiling conditions.

(OR)

b) Water enters a cross flow heat exchanger (both fluids unmixed) at 5ºC and flows at the rate of 4600 kg/h to cool 4000 kg/h of air that is initially at 40ºC. Assume the overall heat transfer coefficient to be 150 W/m^2K. For an exchanger surface area of $25m^2$, calculate the exit temperature of air and water.

24. a) A brick wall of emissivity 0.8, 6m wide x 4m high is located at a distance of 4m from an opening of size 20cm x 20cm in a furnace wall. The centre lines of the opening lies 1m lower and 1m left of the centre of the wall. If the furnace operates at a temperature of 1523ºC and the wall temperature is 37ºC, calculate the radiant heat exchange between the opening and the wall.

(OR)

b) The outlet header of a high pressure steam super heater consists of pipe (€ = 0.8) of diameter 27.5 cm. Its surface temperature is 500ºC. Calculate the heat loss per unit length by radiation if it is placed in an enclosure at 30ºC.

If the header is now enveloped in a steel screen of diameter 32.5 cm and emissivity 0.7 and the temperature of the screen is 240ºC, find the reduction in heat by radiation due to the provision of this screen.

25. a) (i) Estimate the diffusion rate of water at 27ºC from the bottom of a test tube 20 mm in diameter and 4 cm long into dry air at 27ºC. Take the diffusion coefficient of water into air as 0.26×10^{-4} m^2/s. (7)

(ii) An open pan 20 cm in diameter and 8 cm deep contains water at 25ºC and is exposed to dry atmospheric air. If the rate of diffusion of water vapour is 8.54 $\times 10^{-4}$ kg/h, estimate the diffusion coefficient of water in air. (7)

(OR)

b) Write the convective mass transfer correlations for a parallel flow over a flat plate.

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