DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT CODE & NAME: ME3691-HEAT AND MASS TRANSFER

QUESTION BANK

UNIT-1 CONDUCTION

PART-A

1. State Fourier's Law of conduction. [NOV-DEC 13][NOV-DEC 14][NOV/DEC 2016]
2. Define Thermal Conductivity.
3. Write down the equation for conduction of heat through a slab or plane wall
4. Write down the equation for conduction of heat through a hollow cylinder.
5. State Newton's law of cooling or convection law.
6. Write down the general equation for one dimensional steady state heat transfer in slab or plane wall with and without heat generation.
7. Define overall heat transfer co-efficient.
8. Write down the equation for heat transfer through composite pipes or cylinder.
9. Define critical thickness of insulation with its significance.[MAY-JUN14]
10. Define fins (or) extended surfaces.
11. State the applications of fins.
12. Define Fin efficiency.
13. Define Fin effectiveness. [APRIL MAY 16]
14. Write any two examples of heat conduction with heat generation.[MAY JUN 14]
15. How does transient heat transfer differ from steady heat transfer?
16. What is heat generation in a solid?
17. Write down the one-dimensional transient heat conduction equation for a plane wall with constant thermal conductivity and heat generation in its simplest form, andindicate what each variable represents.
18. Consider one-dimensional heat conduction through a cylindrical rod of diameter D and length L. What is the heat transfer area of the rod if (a) the lateral surfaces of the rod are insulated and (b) the top and bottom surfaces of the rod are insulated?
19. What does the thermal resistance of a medium represent? Andwhy are the convection and the radiation resistances at a surface in parallel instead of being in series?
20. Distinguish between the fin effectiveness and the fin efficiency?[NOV DEC 15]

PART B

1. A wall is constructed of several layers. The first layer consists of masonry brick 20 cm. thick of thermal conductivity 0.66 W/mK, the second layer consists of 3 cm thick mortar of thermal conductivity 0.6 W/mK, the third layer consists of 8 cm thick lime stone of thermal conductivity 0.58 W/mK and the outer layer consists of 1.2 cm thick plaster of thermal conductivity 0.6 W/mK. The heat transfer coefficient on the interior and exterior of the wall are 5.6 W/m^2K and 11

W/m^2K respectively. Interior room temperature is 22°C and outside air temperature is -5°Calculate

i) Overall heat transfer coefficient

ii) Overall thermal resistance

iii) The rate of heat transfer

iv) The temperature at the junction between the mortar and the limestone.

2. A furnace wall made up of 7.5 cm of fire plate and 0.65 cm of mild steel plate. Inside surface exposed to hot gas at 650°C and outside air temperature 27°C. The convective heat transfer co-efficient for inner side is 60 W/m^2K.The convective heat transfer co-efficient for outer side is $8W/m^2K$. Calculate the heat lost per square meter area of the furnace wall and also find outside surface temperature. [APRIL MAY 16]
3. A steel tube (K = 43.26 W/mK) of 5.08 cm inner diameter and 7.62 cm outer diameter is covered with 2.5 cm layer of insulation (K = 0.208 W/mK) the inside surface of the tube receivers heat from a hot gas at the temperature of 316°C with heat transfer co-efficient of 28 W/m^2K. While the outer surface exposed to the ambient air at 30°C with heat transfer co-efficient of 17 W/m^2K. Calculate heat loss for 3 m length of the tube.
4. An aluminum alloy fin of 7 mm thick and 50 mm long protrudes from a wall, which is maintained at 120°C. The ambient air temperature is 22°C. The heat transfer coefficient and conductivity of the fin material are 140 W/m^2K and 55 W/mK respectively. Determine

   i) Temperature at the end of the fin

   ii) Temperature at the middle of the fin.

   iii) Total heat dissipated by the fin.
5. a) A furnace wall consists of 200 mm layer of refractory bricks, 6mm layer of steel plate and a 100 mm layer of insulation bricks. The maximum temperature of the wall is 1150 °C on the furnace side and the minimum temperature is 40 °C on the outer side of the wall. An accurate energy balance over the furnace shows that the heat loss from wall is 400 W/m^2K. It is known that there is thin layer of air between the layers of refractory bricks and steel plate. Thermal conductivities for the three layers are 1.52, 45 and 0.138 W/m °C respectively. Find

   1) To how may millimeters of insulation brick is the air layer equivalent?

   2) What is the temperature of the outer surface of the steel plate?

b) Find out the amount of heat transferred through an iron fin of length 50 mm, width 100mm and thickness 5mm. Assume k= 210 kJ/mh°C and h = 42 $kJ/m^2h°C$ for the material of the fin and the temperature at the base of the fin as 80 °C. Also determine and temperature at tip of the fin, if atmosphere temperature is 20°C[NOV DEC 14]

6. a) Derive general heat conduction equation in Cartesian coordinates.

   b) Compute the heat loss per square meter surface area of 40 cm thick furnace wall having surface temperature of 300°C and 50 °C if the thermal conductivity k of the wall material is given by $k = 0.005T - 5\times10^{-6} T^2$ where T= Temperature in °C[NOV DEC 14]
7. Alloy steel ball of 2 mm diameter heated to 800°C is quenched in a bath at 100°C. The material properties of the ball are K = 205 kJ/m hr K, $\rho = 7860\ kg/m^3$, $C_\rho = 0.45$ kJ/kg K, h = 150 KJ/ hr m^2 K. Determine (i) Temperature of ball after 10 second and (ii) Time for ball to cool to 400°C.

8. Derive the general heat conduction equation in cylindrical coordinate and solve the following. Hot air at a temperature of 65 °C is flowing through steel pipe of 120 mm diameter. The pipe is covered with two layers of different insulating materials of thickness 60 mm and 40 mm and their Corresponding thermal conductivities are 0.24 and 0.4 W/ m K. The inside and outside heat transfer coefficients are 60 W/m^2 K and 12 W/m^2 K respectively. The atmosphere is at 20°C. Find the rate of heat loss from 60 m length of pipe. [MAY-JUN 14]

9. Steam in a heating system flows through tubes whose outer diameter is D_1= 3 cm and whose walls are maintained at a temperature of 120°C. Circular aluminum fins (k =180 W/m · °C) of outer diameter D_2 = 6 cm and constant thickness t = 2 mm are attached to the tube. The space between the fins is 3 mm, and thus there are 200 fins per meter length of the tube. Heat is transferred to the surrounding air at T_∞= 25°C, with a combined heat transfer coefficient of h = 60 W/m^2 °C. Determine the increase in heat transfer from the tube per meter of its length as a result of adding fins.[APRIL MAY 16]
10. Copper plate fins of rectangular cross section having thickness t = 1mm, height L = 10 mm and thermal conductivity k = 380 W/ mK are attached to a plane wall maintained at a temperature T_0 = 230°C. Fins dissipate heat by convection in to ambient air at T = 30 °C with a heat transfer coefficient h= 40 W/ m^2 K. Fins are spaced at 8mm (that is 125 fins per meter). Assume negligible heat loss from the tip.
    a) Determine the fin efficiency
    b) Determine the fin effectiveness.
    c) Determine the net rate of heat transfer per square meter of plane surface
    d) What would be heat transfer rate from the plane wall if there were no fins attached?
11. Derive the heat dissipation equation through pin fin with insulated end and solve the following. A temperature rise of 50 C in a circular shaft of 50 mm diameter is caused by the amount of heat generated due to friction in the bearing mounted on the crankshaft. The thermal conductivity of shaft material is 55 W/m K and heat transfer coefficient is 7 W/m^2 K. Determine the amount of heat transferred through shaft assume that the shaft is a rod of infinite length. [MAY-JUN 14]
12. The door of an industrial furnace is 2 m × 4 m in surface and is to be insulated to reduce the heat loss to not more than 1200 W/m^2. The interior and exterior walls of the door are 10mm7mm thick steel sheets (k = 25 W/m K). Between these two sheets, suitable thickness of insulation material is to be placed. The effective gas temperature inside the furnace is 1200 °C and overall heat transfer coefficient between the gas and door is 20 W/m^{2}K. The heat transfer coefficient outside the door is 5 W/m^2 °C. The surrounding air temperature is 20 °C. Select suitable insulation material and its size. [NOV-DEC 13]
13. (i) A turbine blade 6 cm long and having a cross sectional area 4.65 cm^2 and perimeter 12 cm is made of stainless steel (k = 23.3 W/m K). The temperature at the root is 500 °C. The blade is exposed to a hot gas at 870 °C. The heat transfer coefficient between the blade surface and gas is 442 W/m^2 K. Determine the temperature distribution and rate of heat flow at the root of the blade. Assume the tip of the blade to be insulated.
    (ii)An ordinary egg can be approximated as 5cm diameter sphere. The egg in initially at a uniform temperature of 5°C and is dropped in to boiling water at 95 °C. Taking the convection

SANCET

heat transfer coefficient to be h = 1200 W/m^2°C. Determine how long it will take for the center of the egg to reach 70 °C. [NOV-DEC 13]

14. (i) consider 1.2m high and 2m wide double pane window consisting of two 3mm thick layers of glass (k=0.78 W/m K) separated by a 12mm wide stagnant air space (k=0.026W/m K).determine the steady rate of heat transfer through this double pane window and temperature of its inner surface when the room is maintained at 24^0C. While the temperature of outdoor is -5^oC. take the convection heat transfer co-efficient of inner and outer surface of the window to be 10W/m^2 K and 25 W/m^2 K respectively.(ii) derive the general three dimensional heat conduction equation Cartesian co-ordinate.[NOV DEC 15]
15. A cylinder 1m long and 5cm in diameter is placed in an atmosphere at 450C. It is provided with 10 longitudinal straight fins of materialhaving k=120 W/m K. The height of 0.76 mm thick fin is 1.27cm from the cylinder surface. The heat transfer co-efficient between the cylinder and atmospheric air is 17 W/m2 K. Calculate the rate of heat transfer and the temperature at the end of the fins with the surface temperature of cylinder is 150^0C.[NOV DEC 15]

UNIT-2 CONVECTION

PART-A

1. Define convection.
2. What is difference between free convection and forced convection?[NOV/DEC 2016]
3. Define Reynolds number (Re) & Prandtl number (Pr). [APRIL MAY 16]
4. Define Nusselt number (Nu).
5. Define Grashoff number (Gr) & Stanton number (St).[NOV-DEC 14]
6. What is meant by Newtonian and non – Newtonian fluids? [APRIL MAY 16]
7. What is meant by laminar flow and turbulent flow?[APRIL MAY 15]
8. What is meant by hydrodynamic boundary layer and thermal boundary layer?
9. Define boundary layer thickness.
10. What is the form of equation used to calculate heat transfer for flow through cylindrical pipes?

11Differentiate viscous sub layer and buffer layer.[MAY JUN 14]

12. Define grashoff number and prandtl number.[MAYJUN 14]
13. Define the thermal boundary layer. [NOV-DEC 13]
14. Why heat transfer coefficient for natural convection is much lesser than that of forcedconvection? [NOV-DEC 13]
15. Consider laminar natural convection from a vertical hot plate. Will the heat flux be higher at the top or at the bottom of the plate? Why?
16. What is meant by velocity boundary layer thickness?[APRILMAY 15]
17. When is natural convection negligible and when is it not negligible in forced convection heat transfer?
18. Under what conditions does natural convection enhance forced convection, and underwhat conditions does it hurt forced convection?
19. What is drag? What causes it? Why do we usually try to minimize it?
20. What is the difference between the upstream velocity and the free-stream velocity? For what types of flow are these two velocities equal to each other?

SANCET

.

PART B

1. Air at 20°C, at a pressure of 1 bar is flowing over a flat plate at a velocity of 3 m/s. if the plate maintained at 60°C, calculate the heat transfer per unit width of the plate. Assuming the length of the plate along the flow of air is 2m.
2. Air at 30°C flows over a flat plate at a velocity of 2 m/s. The plate is 2 m long and 1.5 m wide. Calculate the following:
   i) Boundary layer thickness at the trailing edge of the plate,
   ii) Total drag force,
   iii) Total mass flow rate through the boundary layer between x = 40 cm and x = 85 cm.
3. In a surface condenser, water flows through staggered tubes while the air is passed in cross flow over the tubes. The temperature and velocity of air are 30°C and 8 m/s respectively. The longitudinal and transverse pitches are 22mm and 20mm respectively. The tube outside diameter is 18mm and tube surface temperature is 90°C. calculate the heat transfer coefficient.
4. 250 Kg/hr of air are cooled from 100°C to 30°C by flowing through a 3.5 cm inner diameter pipe coil bent in to a helix of 0.6 m diameter. Calculate the value of air side heat transfer coefficient if the properties of air at 65°C are K = 0.0298 W/mK , Pr = 0.7 μ = 0.003 Kg/hr – m, ρ = 1.044 Kg/m^3
5. a) Explain about velocity boundary layer on a flat plate[APRIL MAY 16]
   b) Assuming that a man can be represented by a cylinder 30 cm in diameter and 1.7 m high with surface temperature of 30 °C, calculate the heat he would lose while standing in a 36 kmph wind at 10 °C[NOV DEC 14]
6. a) A metal plate 0.609 m high forms the vertical wall of an oven and is at a temperature of 161 °C. Within the oven air at a temperature of 93 °C and one atmosphere. Assuming that natural convection conditions hold near the plate, estimate the mean heat transfer coefficient and rate of heat transfer per unit width of the plate.
   b) A 10 mm diameter spherical steel ball at 260°C is immersed in air at 90°C. Estimate the rate of convective heat loss.[NOV DEC 14]
7. Engine oil flows through a 50 mm diameter tube at an average temperature of 147°C. The flow velocity is 80 cm/s. Calculate the average heat transfer coefficient if the tube wall is maintained at a temperature of 200°C and it is 2 m long.
8. A thin 100 cm long and 10 cm wide horizontal plate is maintained at a uniform temperature of 150°C in a large tank full of water at 75°C. Estimate the rate of heat to be supplied to the plate to maintain constant plate temperature as heat is dissipated from either side of plate.
9. a) Explain in detail about boundary layer concept.
   b) An aero plane flies with a speed of 450 km/h at a height where the surrounding air has a temperature of 1°C and pressure of 65 cm of Hg. The aeroplane wing idealized as a flat plate 6m long, 1.2m wide is maintained at 19 °C. If the flow is made parallel to the 1.2 m width calculate 1) Heat loss from the wing 2) Drag force on the wing. [NOV- DEC 13]
10. Explain development of hydrodynamic and thermal boundary layers with suitable figure and solve the following. In a straight tube of 50mm diameter, water is flowing at 15 m/s. The

SANCET

tube surface temperature is maintained at 60°C and the flowing water is heated from the inlet temperature 15 °C to an outlet temperature of 45°C. Calculate the heat transfer coefficient from the tube surface to the water and length of the tube. [MAY-JUN 14]

11. A two stroke motor cycle petrol engine cylinder consists of 15 annular fins. If outside and inside diameters of each fin are 200 mm and 100 mm respectively. The average fin surface temperature is 475 °C and they are exposed in air at 25 °C. Calculate the heat transfer rate from the fins for the following condition (i) when motor cycle is at rest. (ii) When motor cycle is running at a speed of 60 km/h. The fin may be idealized as a single horizontal flat plate of same area.[NOV - DEC 13]
12. Using dimensional analysis find dimensionless group involved in free convection and solve the following.A horizontal heated plate measuring 1.5 m × 1.1 m and 215 °C, facing upwards is placed in still air at 25 °C. Calculate the heat loss by natural convection. Use the relation H= 3.05 (T_f) 0.25, Tf = Mean film temperature [MAY-JUN 14]
13. (i) A long 10cm diameter steam pipe whose external surface temperature is 110^0C passes through some open area that is not protected against the winds. Determine the rate of heat loss from the pipe per unit length when the air is at 1atm and 10^0C and the wind blowing across the pipe at a velocity of 8 m/s.(ii) An air stream at 0^0C flowing along the heated plate at 90^0C at a speed of 75 m/s. The plate is 45cm long and 60 cm wide. Calculate the average values of friction co-efficient for the full length of the plate. Also calculate the rate of energy dissipation from the plate. [NOV DEC 15]
14. (i) Explain the concept of hydrodynamic and thermal boundary layers (ii) A 6m long section of an 8cm diameter horizontal hot water pipe passes through a large room whose temperature is 20^0C. If the outer surface temperature and emissivity of the pipe are 70^0C and 0.8 respectively, determine the rate of heat loss from the pipe by(1) Natural convection (2) Radiation [NOV DEC 15]
15. (i). Explain the velocity boundary layer profile on a flat plate and mention its significance
(ii). Engine oil at 20^0C is forced over a 20 cm square plate at a velocity of 1.2 m/s. The plate is heated to a uniform temperature of 60^0C. Find the heat loss of the plate. [APRIL MAY 2015]

UNIT-3 PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS

PART-A

1. What is meant by Boiling and condensation?
2. Give the applications of boiling and condensation.
3. What is meant by pool boiling?[NOV DEC 14]
4. What is meant by Film wise and Drop wise condensation? [APRIL MAY 16]
5. Give the merits of drop wise condensation?
6. What is heat exchanger?
7. What are the types of heat exchangers?[APRIL MAY 2015]
8. What is meant by direct heat exchanger (or) open heat exchanger?
9. What is meant by indirect contact heat exchanger?
10. What is meant by Regenerators? [APRIL MAY 16]

SANCET

11. What is meant by Recuperater (or) surface heat exchangers?
12. What is meant by parallel flow and counter flow heat exchanger?
13. What is meant by shell and tube heat exchanger?
14. What is meant by compact heat exchangers?
15. What is meant by LMTD?
16. What is meant by Fouling factor? [NOV DEC 16]
17. What is meant by effectiveness?[NOV DEC 14]
18. Distinguish the pool boiling from forced convection boiling.[NOV-DEC 13]
19. What are the limitations of LMTD method? How is ε-NTU method superior to LMTD method?[NOV- DEC 13] [NOV-DEC 15] [APRIL MAY 2015].
20. Write down the relation for overall heat transfer coefficient in heat exchanger with fouling factor. [MAY-JUN 13]

PART B

1. Water is boiled at the rate of 24 kg/h in a polished copper pan, 300 mm in diameter, at atmospheric pressure. Assuming nucleate boiling conditions calculate the temperature of the bottom surface of the pan.
2. i) Explain about fouling factors.
   ii) Hot oil with a capacity rate of 2500 W/K flows through a double pipe heat exchanger. It enters at 360 °C and leaves at 300 °C. Cold fluid enters at 30 °C and leaves at 200 °C. If the overall heat transfer coefficient is 800 W/m^2K, determine the heat exchanger area required for
   1) parallel flow and 2) Counter flow.[NOV DEC 14]
3. a) A vertical tube of 50 mm outside diameter and 2 m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 84 °C by circulating cold water through the tube. Determine the rate of heat transfer and also the condensate mass flow rate.[NOV DEC 14]
4. A Nickel wire carrying electric current of 1.5 mm diameter and 50 cm long, is submerged in a water bath which is open to atmospheric pressure. Calculate the voltage at the burn out point, if at this point the wire carries a current of 200A.
5. Water is boiling on a horizontal tube whose wall temperature is maintained ct 15°C above the saturation temperature of water. Calculate the nucleate boiling heat transfer coefficient. Assume the water to be at a pressure of 20 atm. And also find the change in value of heat transfer coefficient when
   i) The temperature difference is increased to 30°C at a pressure of 10 atm.
   ii) The pressure is raised to 20 atm at $\Delta T = 15°C$[APRIL MAY 16]
6. A vertical flat plate in the form of fin is 500m in height and is exposed to steam at atmospheric pressure. If surface of the plate is maintained at 60°C. calculate the following.
   i) The film thickness at the trailing edge ii). Overall heat transfer coefficient iii). Heat transfer rate iv).The condensate mass flow rate. Assume laminar flow conditions and unit width of the plate.

SANCET

7. A condenser is to design to condense 600 kg/h of dry saturated steam at a pressure of 0.12 bar. A square array of 400 tubes, each of 8 mm diameters is to be used. The tube surface is maintained at 30°C. Calculate the heat transfer coefficient and the length of each tube.
8. Steam at 0.080 bar is arranged to condense over a 50 cm square vertical plate. The surface temperature is maintained at 20°C. Calculate the following. i) Film thickness at a distance of 25 cm from the top of the plate. ii) Local heat transfer coefficient at a distance of 25 cm from the top of the plate. iii) Average heat transfer coefficient. iv) Total heat transfer v) Total steam condensation rate. What would be the heat transfer coefficient if the plate is inclined at 30°C with horizontal plane.
9. Explain nucleate boiling and solve the following. A wire of 1mm diameter and 150 mm length is submerged horizontally in water at 7 bar. The wire carries current of 131.5 ampere with an applied voltage of 2.15 Volt. If the surface of the wire is maintained at 180 °C, calculate the heat flux and boiling heat transfer coefficient.[MAY-JUN 14]
10. Classify heat exchangers, draw temperature distribution in a condenser and evaporator and derive the Expression for effectiveness of parallel flow heat exchanger by NTU method. [MAY-JUN14]
11. (i) Explain the various regions of flow boiling in detail.[APRIL MAY 2015]
    (ii) The outer surface of a vertical tube, which is 1m long and has an outer diameter of 80mm, is exposed to saturated steam at atmospheric pressure and is maintained at 50 °C by the flow of cool water through the tube. What is the rate of heat transfer to coolant and what is the rate at which steam is condensed at the surface? [NOV-DEC 13]
    (ii) A counter- flow concentric tube heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water through the inner tube (di=20 mm) is 0.18 kg/s while the flow rate of oil through the outer annulus (do=40 mm) is
    0.12 kg/s. The inlet and outlet temperatures of oil are 95 °C and 65 °C respectively. The water enters at 30 °C to the heat exchanger, neglecting the tube wall thermal resistance, fouling factors and heat loss to the surroundings, calculate the length of the tube. Take the following properties at the bulk mean temperature: Engine oil at 80 °C; Cp= 2131 J/kg °C, μ= 0.0325 N- s/m^2 ; k = 0.138 W/m °C Water at 35 °C; Cp = 4174 J/kg °C, μ = 725 × 10 -6 N-s/m^2 ; k = 0.625 W/m °C, Pr = 4.85[NOV-DEC 13]
12. Water is boiled at atmospheric pressure by horizontal polished copper heating element of diameter D=5 mm and emissivity 0.05 immersed in water. If the surface temperature of heating wire is 3500C, determine the ratio of heat transfer from wire to the water per unit length of the wire. [NOV DEC 15]
13. Hot coil (C_p=2200 J/kg K) is to be cooled by water (C_p=4180 J/kg K) in a 2-shell pass and 12 tube pass heat exchanger. The tubes are thin walled and made of copper with diameter of 1.8cm. the length of each tube pass in the heat exchanger is 3m, and the overall heat transfer co-efficient is 340 W/m^2 K. Water flows through the tube at a total rate of 0.1 kg/s and the oil through the shell at a rate of 0.2 kg/s. The water and oil enters at temperatures 18^0C and 160^0C respectively. Determine the rate of heat transfer in the heat exchanger and outlet temperatures of water and oil. [NOV DEC 15] [APRIL MAY 16]

SANJCET

14. A 10 X 10 array of horizontal tubes of 1.27 cm diameter is exposed to pure steam at atmospheric pressure. If the tube wall temperature is 98^0C, find the mass of steam condensed assuming a length of tube of 1.5 m. [APRIL MAY 2015].
15. (i). What are the different types of fouling in heat exchangers?
    (ii). Water enters a cross flow heat exchanger (both fluid mixed) at 5^0C and flows at the rate of 4600 kg/hr to cool 4000 kg/hr of air that is initially at 40^0C. The surface area of heat exchanger is 25 m^2. And overall heat transfer coefficient is 150 W/m^2K. Find the exit temperature of air and water [APRIL MAY 2015].

UNIT-4 RADIATION

PART-A

1. Define emissive power [E] and monochromatic emissive power. [$E_{b\lambda}$] [NOV DEC 16]
2. What is meant by absorptivity, reflectivity and transmissivity?
3. What is black body and gray body?
4. State Planck's distribution law.[NOV-DEC 13]
5. State Wien's displacement law. [APRIL MAY 16]
6. State Stefan – Boltzmann law.
7. Define Emissivity.
8. State Kirchhoff's law of radiation. [APRIL MAY 2015] [APRIL MAY 16]
9. Define intensity of radiation (I_b).
10. State Lambert's cosine law.
11. What is the use of radiation shield? [NOV DEC 14]
12. Define irradiation (G) and radiosity (J) [APRIL MAY 2015], [NOV DEC 15]
13. What is meant by shape factor?
14. How radiation from gases differs from solids? [NOV DEC13]
15. Define irradiation and emissive power.[MAY JUN 14]
16. What does the view factor represent? When is the view factor from a surface to itself not zero?
17. Write down any two shape factor algebra.[MAY-JUN 14]
18. What is a radiation shield? Why is it used?
19. What is a blackbody? Does a blackbody actually exist?
20. What are the factors involved in radiation by a body?[NOV DEC 14]

PART B

1. A Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500 °C (i) Monochromatic emissive power at 1.2 μm length. ii) Wave length at which the emission is maximum. iii) Maximum emissive power iv) Total emissive power, and v) Total emissive power of the furnace if it is assumed as a real surface with emissivity equal to 0.9 [NOV DEC 14]
2. Two parallel plates of size 1 m by 1m spaced 0.5 m apart are located in a very large room, the walls of which are maintained at temperature of 27 °C. One plate is maintained at a

SANCET

temperature of 900°C and other at 400 °C. Their emissivities are 0.2 and 0.5 respectively. If the plates exchange heat between themselves and surroundings, find the net heat transfer to each plate and to room. Consider only the plate surfaces facing each other.[NOV DEC 14]

3. Two black square plates of size 2 by 2 m are placed parallel to each other at a distance of 0.5 m. One plate is maintained at a temperature of 1000°C and the other at 500°C. Find the heat exchange between the plates.
4. A gas mixture contains 20% CO_2 and 10% H_2o by volume. The total pressure is 2 atm. The temperature of the gas is 927°C. The mean beam length is 0.3 m. Calculate the emissivity of mix [APRIL MAY 16]
5. a)A furnace of 2 m × 1.5 m × 1.5 m size contains gases at 1500 K while the walls are at 500 K. The gas contains 18% of CO_2 and 12% of water vapour by volume. Determine the heat exchange from the gases to the walls. The total pressure is 2 atm. Assume black surface.

   b)In a furnace of 2 × 1.5 × 1 m size, floor isat 1000 K and other surfaces are at 600 K. The surface emissivity for the floor is 0.8 and for theother surfaces it is 0.5. Determine the heat exchange by radiation from (i) floor to each of sidewalls and (ii) floor to roof.
6. Consider the 5m×5m×5m cubical furnace, whose surfaces closely approximate black surfaces. The base, top, and side surfaces of the furnace are maintained at uniform temperatures of 800 K, 1500 K, and 500 K, respectively. Determine (*a*) the net rate of radiation heat transfer between the base and the side surfaces, (*b*) the net rate of radiation heat transfer between the base and the top surface, and (*c*) the net radiation heat transfer from the base surface.
7. a) Two very large parallel plates are maintained at uniform temperatures T_1=800 K and T_2=500 K and have emissivities ε_1=0.2 and ε_2 =0.7 respectively. Determine the net rate of radiation heat transfer between the two surfaces per unit surface area of the plates.[APRIL MAY 16]

b) A thin aluminum sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T_1=800 K and T_2=500 K and have emissivities ε_1=0.2 and ε_2 =0.7 respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to without the shield.

8. a) Consider a cylindrical furnace with r =H=1m.The top (surface 1) and the base (surface 2) of the furnace has emissivities ε_1=0.8 and ε_2 =0.4 respectively, and are maintained at uniform temperatures T_1=700 K and T_2=500 K. The side surface closely approximates a blackbody and is maintained at a temperature of T_3 = 400 K. Determine the net rate of radiation heat transfer at each surface during steady operation and explain how these surfaces can be maintained at specified temperatures. [APRIL MAY 2015].

   b) A furnace is shaped like a long equilateral triangular duct. The width of each side is 1 m. The base surface has an emissivity of 0.7 and is maintained at a uniform temperature of 600 K. The heated left-side surface closely approximates a blackbody at 1000 K. The right-side surface is well insulated. Determine the rate at which heat must be supplied to the heated side externally per unit length of the duct in order to maintain these operating conditions.
9. (i) A truncated cone has top and bottom diameters of 10 and 20 cm and a height of 10 cm. Calculate the shape factor between the top surface and the side and also the shape factor between the side and itself.

SANCET

(ii)Emissivities of two large parallel plates maintained at 800 °C and 300 °C and 0.3 and 0.5 respectively. Find the net radiant heat exchange per square meter for these plates[NOVDEC13]

10. A 12 mm outside diameter pipe carries a cryogenic fluid at 90 K. Another pipe of 15 mm outside diameter and at 290 K surrounds it coaxially and the space between the pipes is completely evacuated (i) determine the radiant heat flow for 3.5 m length of pipe if the surface emissivity for both surface is 0.25 (ii) Calculate the percentage reduction in heat flow if a shield of 13.5 mm diameter and 0.06 surface emissivity is placed between pipes.[NOV- DEC 13]
11. State laws of radiation and solve the following.
    Assuming the sun to be black body emitting radiation with maximum intensity at λ = 0.5 μm, Calculate the surface temperature of the sun and the heat flux at its surface. [MAY-JUN 14]
12. Derive the relation for heat exchange between infinite parallel planes and solve.
13. Consider double wall as two infinite parallel planes. The emissivity of the wall is 0.3 and 0.8 respectively. The space between the walls is evacuated. Find the heat transfer/unit area when inner and outer surface temperatures are 300 K and 260 K. To Reduce the heat flow, a shield of polished aluminum with ε = 0.05 is inserted between the walls. Find the reduction in heat transfer.[MAY-JUN 14]
14. Determine the average emissivity of the surface and the rate of radiation emission from the surface in W/m^2.[NOV DEC 15]
15. Emissivities of two large parallel plates maintained at 800^o C. And 300 ^{o} C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per square meter for these plates. Find the % reduction in heat transfer when a polished aluminum radiation shield of emissivity of 0.05is placed between them. Also find the temperature of shield. [NOV DEC 15] [APRIL MAY 2015].

UNIT-5 MASS TRANSFER

PART-A

1. What is mass transfer? [APRIL MAY 16]
2. Give the examples of mass transfer.
3. List Out the various modes of mass transfer? [NOV DEC 14]
4. What is molecular diffusion?
5. What is Eddy diffusion?
6. What is convective mass transfer?
7. State Fick's law of diffusion. [APRIL MAY 2015][MAY JUN 14] [NOV DEC 13] [NOV DEC 14][NOV DEC 16]
8. What is free convective mass transfer?
9. Define forced convective mass transfer. [APRIL MAY 16]
10. Define Schmidt Number.[NOV DEC 16]
11. Define Sherwood Number.
12. Define Schmidt and Lewis number. What is the physical significance of each?
    [NOV DEC 13][NOV DEC 15]

SANCET

13. Write down the analogues terms in heat and mass transfer. [MAY-JUN 14]
14. Does a mass transfer process have to involve heat transfer? Describe a process that Involves both heat and mass transfer.
15. Express mass convection in an analogous manner to heat transfer on a mass basis, and Identify all the quantities in the expression and state their units.
16. What is permeability? How is the permeability of a gas in a solid related to the solubility of the gas in that solid?
17. How does the mass diffusivity of a gas mixture change with (*a*) temperature and (*b*) Pressure?
18. How does mass transfer differ from bulk fluid flow? Can mass transfer occur in a homogeneous medium?
19. How is the concentration of a commodity defined? How is the concentration gradient defined? How is the diffusion rate of a commodity related to the concentration gradient?
20. Give examples for (*a*) liquid-to-gas, (*b*) solid-to liquid, (*c*) solid-to-gas, and (*d*) gas-to liquid mass transfer.

PART B

1. Hydrogen gases at 3 bar and 1 bar are separated by a plastic membrane having thickness 0.25 mm. the binary diffusion coefficient of hydrogen in the plastic is 9.1×10^{-3} m^2/s. The solubility of hydrogen in the membrane is $2.1 \times 10^{-3} \frac{\text{kg} - \text{mole}}{\text{m}^3 \text{ bar}}$

   An uniform temperature condition of 20° is assumed. Calculate the following a) Molar concentration of hydrogen on both sides b) Molar flux of hydrogen c) Mass flux of hydrogen[APRIL-MAY 16]

2. a) Oxygen at 25°C and pressure of 2 bar is flowing through a rubber pipe of inside diameter 25 mm and wall thickness 2.5 mm. The diffusivity of O2 through rubber is 0.21×10^{-9} \ \$m^2/s$ and the solubility of O2 in rubber is $3.12 \times 10^{-3} \frac{\text{kg} - \text{mole}}{\text{m}^3 - \text{bar}}$. Find the loss of O_2 by diffusion per metre length of pipe.

   b) An open pan 210 mm in diameter and 75 mm deep contains water at 25°C and is exposed to dry atmospheric air. Calculate the diffusion coefficient of water in air. Take the rate of diffusion of water vapour is 8.52×10^{-4} kg/h.
3. a) An open pan of 150 mm diameter and 75 mm deep contains water at 25°C and is exposed to atmospheric air at 25°C and 50% R.H. Calculate the evaporation rate of water in grams per hour.

   b) Air at 10°C with a velocity of 3 m/s flows over a flat plate. The plate is 0.3 m long. Calculate the mass transfer coefficient.
4. Explain Reynold's number, Sherwood number, Schmidt number and solve the following. A vessel contains a binary mixture of oxygen and nitrogen with partial pressures in the ratio 0.21 and 0.79 at 15 C. The total pressure of the following mixture is 1.1 bar. Calculate the following. i) Molar concentrations ii) Mass densities iii) Mass fractions iv)Molar fractions of each species. [MAY-JUN 14]

SANCET

5. Air is contained in a tyre tube of surface area 0.5 m^2 and wall thickness 10 mm. The pressure of air drops from 2.2 bar to 2.18 bar in a period of 6 days. The solubility of air in the rubber is 0.72 m^3 of air per m^3 of rubber at 1 bar. Determine the diffusivity of air in rubber at the operating temperature of 300 K if the volume of air in the tube is 0.028 m^3. [NOV-DEC 13]
6. a) Dry air at atmospheric pressure blows across a thermometer that is enclosed in a dampened cover. This is the classical wet-bulb thermometer. The thermometer reads a temperature of 18°C. What is the temperature of the dry air? (Without using psychrometric chart)
   b) If the airstream in above problem is at 32°C, while the wet-bulb temperature remains at 18 °C, calculate the relative humidity of the airstream. (Without using psychrometric chart)
7. During a certain experiment involving the flow of dry air at 25°C and 1 atm at a free stream velocity of 2 m/s over a body covered with a layer of naphthalene, it is observed that 12 g of naphthalene has sublimated in 15 min. The surface area of the body is 0.3 m^2. Both the body and the air were kept at 25°C during the study. The vapor pressure of naphthalene at 25°C is 11 Pa and the mass diffusivity of naphthalene in air at 25°C is $D_{AB} = 0.61\times10^{-5}$ m^2/s. Determine the heat transfer coefficient under the same flow conditions over the same geometry.
8. Explain different modes of mass transfer and derive the general mass diffusion equation in stationary media. [MAY-JUN 14]
9. a) Discuss about steady state equimolar counter diffusion.
   b) Hydrogen gas is maintained at pressure of 2.4 bar and 1 bar on opposite sides of a plastic membrane 0.3 mm thick. The binary diffusion coefficient of hydrogen in the plastic is 8.6×10^{-8} m^2/s and solubility of hydrogen in the membrane is 0.00145 kg mole / m^3. Bar. Calculate under uniform temperature conditions of 24 °C the following (1) Molar concentration of hydrogen at the opposite faces of the membrane, and (2) Molar and mass diffusion flux of hydrogen through the membrane. [NOV-DEC 14]
10. a) Air at 20 °C ($\rho = 1.205$ kg/m^3, $\nu = 15.06 \times 10^{-6}$ m^2/s, D = 4.166×10^{-5} m^2/s), flows over a tray (length = 320 mm, width = 420 mm) full of water with a velocity of 2.8 m/s. The total pressure of moving air is 1 atm and the partial pressure of water present in the air is 0.0068 bar. If the temperature of the water surface is 15 °C, Calculate the evaporation rate of water.
    b) Dry air at 27 °C and 1 atm flows over a wet flat plate 50cm long at a velocity of 50 m/s. Calculate the mass transfer coefficient of water vapor in air at the end of the plate. [NOV-DEC 14] [APRIL MAY 2015].
11. i) A 3-cm diameter Stefan tube is used to measure the binary diffusion coefficient of water vapour in air at 20°C at an elevation of 1600 m where the atmospheric pressure is 83.5 kPa. The tube is partially filled with water, and the distance from the water surface to the open end of the tube is 40 cm. Dry air is blown over the open end of the tube so that water vapour rising to the top is removed immediately and the concentration of vapour at the top of the tube is 0 in 15 days of continuous operation at constant pressure and temperature, the amount of water vapour that has evaporated is measured to be 1.23 g. Determine the diffusion coefficient of water vapour in air at 20°C and 83.5 kPa .
    ii) State some analogies between heat and mass transfer.[NOV-DEC 15]

SANCET

12. A thin plastic membrane separates hydrogen from air. The molecular concentration of hydrogen in the membrane at the inner and outer surfaces is determined to be 0.045 and 0.002 $kmol/m^3$, respectively. The binary diffusion coefficient of hydrogen in plastic at the operation temperature is $5.3*10^{-10}$ m^2/sec. Determine the mass flow rate of hydrogen by diffusion through the membrane under steady condition if the thickness of the membrane is (1) 2mm and
(2) 0.5 mm . [NOV-DEC 15]

13. Dry air at 15°C and 92 kPa flows over a 2m long wet surface with a free stream velocity of 4m/sec. Determine the average mass transfer coefficient. [NOV-DEC 15] [APRIL MAY 16]

14.(i). What are the assumptions made in 1-D transient mass diffusion problems?
(ii). The dry bulb and wet bulb temperature recorded by a thermometer in moist air are 27°C and 17°C respectively. Find the specific humidity of air assuming that prandtl number = 0.74; Schimdt number = 0.6; specific heat at constant pressure = 1.004 kJ/kgK; pressure = 1.0132 bars. [APRIL MAY 2015].

15. Air at 35°C and 1 bar flows at a velocity of 60m/s (i). Flat plate of 0.5m long (ii). Sphere of 5cm diameter. Find the mass transfer coefficient of water in air. Neglect the concentration of

SANCET