SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur– 603203

DEPARTMENTOF MECHANICAL ENGINEERING

QUESTION BANK

VI-SEMESTER

1909602 -Heat and Mass Transfer

Regulation–2019

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Prepared by

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QUESTION BANK

SUBJECT : 1909602-Heat and Mass Transfer

SEM / YEAR: VI / III

UNIT – I CONDUCTION			
SYLLABUS General Differential equation – Cartesian, Cylindrical and Spherical Coordinates – One Dimensional Steady State Heat Conduction — plane and Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite Solids –Use of Heisler's charts.			
PART- A (2 Marks)			
Q.No	**Questions**	**BT Level**	**Competence**
1.	What is meant by lumped heat capacity analysis? When is it used?	BTL-1	Remembering
2.	Point out Fourier's Law of heat conduction.	BTL-2	Understanding
3.	what is a thermal symmetry boundary condition?	BTL-1	Remembering
4.	Define heat transfer. And write the different types.	BTL-1	Remembering
5.	Define the term thermal conductivity. Also list the behavior of metal, liquid and gases thermal conductivity for increase in temperature.	BTL-1	Remembering
6.	Define efficiency and fin effectiveness.	BTL-1	Remembering
7.	Write any two examples of heat conduction with heat generation.	BTL-1	Remembering
8.	Define critical thickness of insulation with its significance.	BTL-3	Applying
9.	Write the three dimensional heat transfer Poisson and Laplace equations in Cartesian co-ordinates.	BTL-1	Remembering
10.	What is meant by transient heat conduction ? Also give any two example.	BTL-2	Understanding
11.	Define thermal diffusivity. Explain its importance in heat conduction problems.	BTL-1	Remembering
12.	What are Biot and Fourier numbers? Explain their physical significance.	BTL-1	Remembering
13.	What are boundary and initial conditions?	BTL-1	Remembering
14.	Differentiate between steady and transient heat conduction.	BTL-2	Understanding

15.	What is Newtonian heating or cooling process?	BTL-1	Remembering
16.	Difference between conductivity and conductance. What are their units?	BTL-2	Understanding
17.	What is meant by thermal resistance?	BTL-2	Understanding
18.	Write a note on electrical analogy for conduction problems.	BTL-2	Understanding
19.	Describe about Heisler Charts.	BTL-1	Remembering
20.	Explain semi-infinite body and Define the error function in transient state.	BTL-4	Analyzing
21.	What is the difference between fin effectiveness and fin efficiency?	BTL-2	Understanding
22.	Give a few specific examples of use of fins.	BTL-3	Applying
23.	What is lumped system analysis?	BTL-2	Understanding
24.	Define conduction shape factor.	BTL-1	Remembering
25.	What is non periodic heat flow?	BTL-2	Understanding
PART- B(13 Marks)			
1.	A furnace wall consists of three layers. The inner layer of 10 cm thickness is made of firebrick (k =1.04 W/mK). The intermediate layer of 25 cm thickness is made of masonry brick (k = 0.69 W/mK) followed by a 5 cm thick concrete wall (k = 1.37 W/mK). When the furnace is in continuous operation the inner surface of the furnace is at 800°C while the outer concrete surface is at 50°C. Calculate the rate of heat loss per unit area of the wall, the temperature at the interface of the firebrick and masonry brick and the temperature at the interface of the masonry brick and concrete. (6)	BTL-2	Understanding
2.	A furnace wall is made up of three layer of thicknesses 25 cm, 10 cm and 15 cm with thermal conductivities of 1.65W/mK , 4.83W/mK and 9.2 W/mK respectively. The inside is exposed to gases at 1250°C with a convection coefficient of 25 W/m^2°C and the inside surface is at 1100°C, the outside surface is exposed to air at 25°C with convection coefficient of 12 W/m^2°C.Determine (i) The unknown thermal conductivity (ii) The overall heat transfer coefficient (iii) All the surface temperature.	BTL-2	Understanding

3.	The walls of a house, 4 m high, 5 m wide and 0.3 m thick are made from brick with thermal conductivity of 0.9 W/m.K. The temperature of air inside the house is 20°C and outside air is at –10°C. There is a heat transfer coefficient of 10 W/m^2K on the inside wall and 30 $W/m^2.K$ on the outside wall. Calculate the inside and outside wall temperatures, heat flux and total heat transfer rate through the wall.	BTL-3	Applying
4.	Derive the heat conduction equation in plane walls.	BTL-1	Remembering
5.	Derive the dissipation equation through pin fin with insulated end(5)	BTL-5	Evaluating
	(ii) 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/mK and heat transfer co efficient is 7 W/m^2K. Determine the amount of heat transferred through shaft assume that the shaft is a rod of infinite length. (8)	BTL-1	Remembering
6.	An aluminium rod (k = 204 W/mK) 2 cm in diameter and 20 cm long protrudes from a wall which is maintained at 300°C. The end of the rod is insulated and the surface of the rod is exposed to air at 30°C. The heat transfer coefficient between the rod's surface and air is 10 W/m^2K. Calculate the heat lost by the rod and the temperature of the rod at a distance of 10 cm from the wall.	BTL-1	Remembering
7.	A wall is constructed of several layers. The first layer consists of brick (k = 0.66 W/mK), 25 cm thick, the second layer 2.5 cm thick mortar (k = 0.7 W/mK), the third layer 10 cm thick limestone (k = 0.66 W/mK) and outer layer of 1.25 cm thick plaster (k = 0.7 W/mK). The heat transfer coefficients on interior and exterior of the wall fluid layers are 5.8 $W/m^2.K$ and 11.6 W/m^2K, respectively. Find : (i) Overall heat transfer coefficient, (ii) Overall thermal resistance per m^2, (iii) Rate of heat transfer per m^2 , if the interior of the room is at 26°C while outer air is at – 7°C, (iv) Temperature at the junction between mortar and limestone.	BTL-5	Evaluating

8.	The door of an industrial furnace is 2 m × 4 m in surface area 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 10 mm and 7 mm thick steel sheets (k = 25 W/mK). Between these two sheets, a suitable thickness of insulation material is to be placed. The effective gas temperature inside the furnace is 1200°C and the 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.	BTL-2	Understanding
9.	Circumferential aluminium fins of rectangular profile (1.5 cm wide and 1 mm thick) are fitted to a 90 mm engine cylinder with a pitch of 10 mm. The height of the cylinder is 120 mm.The cylinder base temperature before and after fitting the fins are 200°C and 150°C respectively. Take ambient at 30°C and $h_{(average)}$ = 100 W/m^{2}K. Estimate the heat dissipated from the finned and the unfinned surface areas of cylinder body.	BTL-5	Evaluating
10.	A hollow cylinder with inner radius 30 mm and outer radius 50 mm is heated at the inner surface at a rate of 10^5 W/m^2 and dissipated heat by convection from outer surface into a fluid at 80°C with heat transfer coefficient of 400 W/m^{2}K. There is no energy generation and thermal conductivity of the material is constant at 15 W/mK. Calculate the temperatures of inside and outside surfaces of the cylinder.	BTL-5	Evaluating
11.	A hollow sphere of inside radius 30 mm and outside radius 50 mm is electrically heated at its inner surface at a constant rate of 10^5 W/m^2. The outer surface is exposed to a fluid at 30°C, with heat transfer coefficient of 170 W/m^{2}K. The thermal conductivity of the material is 20 W/mK. Calculate inner and outer surface temperatures.	BTL-4	Analyzing
12.	A steel fin (k = 54 W/mK) with a cross section of an equilateral triangle, 5 mm in side is 80 mm long. It is attached to a plane wall maintained at 400°C. The ambient air temperature is 50°C and unit surface conductance is 90 W/m^{2}K. Calculate the heat dissipation rate from the rod.	BTL-2	Understanding
13.	A rectangular steel billet, measuring 500 x 400 x 200 mm in size	BTL-3	Applying

	with an initial temperature of 30°C is heated in a furnace to a temperature of 1000°C. Calculate the temperature at the centre of the billet 90 minutes after being put into the furnace. The thermal conductivity of steel is 37.0 W/mK and its thermal diffusivity is 0.025 m^2/h. The local coefficient of heat transfer is 185 W/m^2K.		
14.	It is better to use 10 fins of 5 cm length than 5 fins of 10 cm length. State and prove correctness of the statement. Take properties as follows : Diameter of fin = 10 mm Thermal conductivity = 45 W/mK Heat transfer coefficient = 95 W/m^2K.	BTL-1	Remembering
15.	A solid steel ball 5 cm in diameter and initially at 450°C is quenched in a controlled environment at 90°C with convection coefficient of 115 W/m^2K. Determine the time taken by centre to reach a temperature of 150°C. Take thermophysical properties as C = 420 J/kgK, ρ = 8000 kg/m^3, k = 46 W/mK.	BTL-5	Evaluating
16.	A titanium alloy blade of an axial compressor for which k = 25 W/mK, ρ = 4500 kg/m^3 and C = 520 J/kgK is initially at 60°C. The effective thickness of the blade is 10 mm and it is exposed to gas stream at 600°C, the blade experiences a heat transfer coefficient of 500 W/m^2K. Use low Biot number approximation to estimate the temperature of blade after 1, 5, 20 and 100 s.	BTL-4	Analyzing
17.	An aluminium sphere weighing 6 kg and initially at temperature of 350°C is suddenly immersed in a fluid at 30°C with convection coefficient of 60 W/m^2K. Estimate the time required to cool the sphere to 100°C. Take thermophysical properties as C = 900 J/kgK, ρ = 2700 kg/m^3,k = 205 W/mK.	BTL-1	Remembering
18.	A long aluminium cylinder 5.0 cm in diameter and initially at 200°C is suddenly exposed to a convection environment at 70°C with heat transfer coefficient of 525 W/m^2K. Calculate the temperature at the radius of 1.25 cm 1 minute after the cylinder exposed to the environment.	BTL-4	Analyzing
	PART- C (15 Marks)		
1.	The temperature of the inner side of a furnace wall is 640°C and that of on other side is 240°C and it is exposed to an atmosphere at 40°C.	BTL-1	Remembering

	In order to reduce the heat loss from the furnace, its wall thickness is increased by 100%. Calculate the percentage decrease in the heat loss due to increase in wall thickness. Assume no change in properties except temperature.		
2.	A steam pipe of 5 cm inside diameter and 6.5 cm outside diameter is covered with a 2.75 cm radial thickness of high temperature insulation (k = 1.1 W/mK). The surface heat transfer coefficient for inside and outside surfaces are 4650 W/m^2K and 11.5 W/m^2K, respectively. The thermal conductivity of the pipe material is 45 W/mK. If the steam temperature is 200°C and ambient air temperature is 25°C, determine : (i) Heat loss per metre length of pipe. (ii) Temperature at the interface. (iii) Overall heat transfer coefficient.	BTL-3	Applying
3.	One end of a copper rod (k = 380 W/mK), 300 mm long is connected to a wall which is maintained at 300°C. The other end is firmly connected to other wall at 100°C. The air is blown across the rod so that the heat transfer coefficient of 20 W/m^2K is maintained. The diameter of the rod is 15 mm and temperature of air is 40°C. Determine : (i) Net heat transfer rate to air, (ii) The heat conducted to other end which is at 100°C.	BTL-4	Analyzing
4.	A load of peas at a temperature of 25 C is to be cooled down in a room at a constant air temperature of 1 C. (a) How long the peas will require to cool down to 2 C when the surface heat transfer coefficient of the peas is 5.81 W/m^2 K ? (b) What is the temperature of the peas after a lapse of 10 min from the start of cooling ? (c) What air temperature must be used if the peas were to be cooled down to 5 C in 30 min? The peas are supposed to have an average diameter of 8 mm. Their density is 750 kg/m^3 and specific heat 3.35 kJ/kg K.	BTL-2	Understanding
5.	In a quenching process, a copper plate of 3 mm thick is heated upto 350°C and then suddenly, it is dropped into a water bath at 25°C. Calculate the time required for the plate to reach the temperature of 50°C.The heat transfer coefficient on the surface of the plate is	BTL-3	Applying

	28 W/m^2K. The plate dimensions may be taken as length 40 cm and width 30 cm. Also calculate the time required for infinite long plate to cool to 50°C. Other parameters remain same. Take the properties of copper as C = 380 J/kgK, ρ = 8800 kg/m^3,k = 385 W/mK.		

UNIT – II CONVECTION			
SYLLABUS Conservation Equations - Hydrodynamics and Thermal Boundary layer - Forced Convection: External Flow – Flow over Plates, Cylinders and Bank of tubes and Internal Flow through tubes. Free Convection: – Flow over Vertical Plate, Horizontal Plate, Inclined Plate, Cylinders and internal flow through tubes.			
PART- A (2 Marks)			
1.	What is meant by a hydrodynamically well-developed flow in a pipeline?	BTL-1	Remembering
2.	What is meant by convective heat transfer?	BTL-1	Remembering
3.	Define the velocity and thermal boundary layers.	BTL-1	Remembering
4.	Define bulk temperature.	BTL-1	Remembering
5.	Classify the dimensionless parameters used in forced and free convection heat transfer analysis.	BTL-3	Applying
6.	Define grashoff number and prandtl number.	BTL-1	Remembering
7.	Differentiate viscous sublayer and buffer layer.	BTL-1	Remembering
8.	State Newton's law of cooling.	BTL-1	Remembering
9.	Air at 27°C and 1 atmospheric flows over a flat plate at a speed of 2 m/s. Calculate boundary layer thickness at distance 40 cm from leading of plate. at 27°C viscosity(air)=1.85 x 10^{-5} kg/ms.	BTL-3	Applying
10.	A square plate 40 x 40 cm maintained at 400 K is suspended vertically in atmospheric air at 300 K. Determine the boundary layer thickness at trailing edge of the plate.	BTL-5	Evaluating
11.	What is colburnand Reynolds analogy?	BTL-2	Understanding
12.	Define Nusselt and Stanton numbers.	BTL-1	Remembering
13.	Distinguish between laminar & turbulent flow.	BTL-2	Understanding
14.	Diffrence between Biot and prandtl numbers.	BTL-2	Understanding
15.	What is Dittus-Boelter Equation?	BTL-1	Remembering
16.	Define momentum thickness.	BTL-1	Remembering
17.	Define critical Reynolds number. What is its typical value for flow over a flat plate and flow through a pipe?	BTL-1	Remembering
18.	Why heat transfer coefficient for natural convection is much lesser than that for forced convection?	BTL-1	Remembering
19.	What are the different methods of determining heat transfer	BTL-1	Remembering

	coefficient in forced convection.		
20.	Define skin friction coefficient.	BTL-1	Remembering
21.	What is the modified Grashof number ? Where does it use ?	BTL-2	Understanding
22.	Define Rayleigh number.	BTL-1	Remembering
23.	Define drag coefficient and drag force.	BTL-1	Remembering
24.	What is critical Reynolds number for flow over a flat plate?	BTL-3	Applying
25.	What do you mean by critical value of Rayleigh number?	BTL-2	Understanding
	PART- B (13 Marks)		
1.	(i) Sketch the boundary layer development of a flow over a flat plate and explain the significance of the boundary layer. (4)	BTL-4	Understanding
	(ii) Atmospheric air at 275 K and a free stream velocity of 20 m/s flows over a flat plate 1.5 m long that is maintained at a uniform temperature of 325 K. Calculate the average heat transfer coefficient over the region where the boundary layer is laminar, the average heat transfer coefficient over the entire length of the plate and the total heat transfer rate from the plate to the air over the length 1.5 m and width 1 m. Assume transition occurs at Re = 2 x 10^5. (9)	BTL-3	Applying
2.	Air at 27°C and 1 atm flows over a heated plate with a velocity of 2 m/s. The plate is at uniform temperature of 60°C. Calculate the heat transfer rate from (i) first 0.2 m of the plate, (ii) first 0.4 m of the plate.	BTL-2	Understanding
3.	Caster oil at 25°C flows at a velocity of 0.1 m/s part a flat plate, in a certain process. If the plate is 4.5 m long and is maintained at a uniform temperature of 95°C, calculate the following (i) The hydrodynamic and thermal boundary layer thicknesses on one side of the plate. (ii) The total drag force per unit width on one side of the plate. (iii) The local heat transfer coefficient at the trailing edge and (iv) The heat transfer rate ; properties of oil at 60°C are ρ = 956.8 kg/m^3, ∞= 7.2 x 10 -8m^2/s ; k = 0.213 W/mK ; ν = 0.65 x 10-4m^2/s.	BTL-3	Applying
4.	Air at 10°C and at a pressure of 100 kPa is flowing over a plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60°C. Calculate the following quantities at x = 0.3 m. (i) Boundary layer thickness, (ii) Local friction coefficient,	BTL-3	Applying

	(iii) Local shearing stress, (iv) Total drag force, (v) Thermal boundary layer thickness, (vi) Local convective heat transfer coefficient, (vii) The heat transfer from the plate.		
5.	Air at velocity of 3 m/s and at 20°C flows over a flat plate along its length. The length, width and thickness of the plate are 100 cm, 50 cm, and 2 cm respectively. The top surface of the plate is maintained at 100°C. Calculate the heat lost by the plate and temperature of bottom surface of the plate for the steady state conditions. The thermal conductivity of the plate may be taken as 23 W/mK.	BTL-1	Remembering
6.	An air stream at 0°C is flowing along a heated plate at 90°C at a speed of 75 m/s. The plate is 45 cm long and 60 cm wide. Assuming the transition of boundary layer takes plate at $Re_{cr} = 5 \times 10^5$. Calculate the average value of friction coefficient and heat transfer coefficient for full length of the plate. Also calculate the heat dissipation from the plate.	BTL-5	Evaluating
7.	Air at 27°C is flowing across a tube with a velocity of 25 m/s. The tube could be either a square of 5 cm side or a circular cylinder of 5 cm dia. Compare the rate of heat transfer in each case, if the tube surface is at 127°C. Use the correlation : $Nu = C\, Re^n\, Pr^{1/3}$ where, C = 0.027, n = 0.805 for cylinder C = 0.102, n = 0.675 for square tube.	BTL-5	Evaluating
8.	Air at 200 kPa and 200°C is heated as it flows through a tube with a diameter of 25 mm at a velocity of 10 m/sec. The wall temperature is maintained constant and is 20°C above the air temperature all along the length of tube. Calculate: (i) The rate of heat transfer per unit length of the tube. (ii) Increase in the bulk temperature of air over a 3 m length of the tube.	BTL-3	Applying
9.	Air stream at 27°C moving at 0.3 m/s across 100 W incandescent bulb, glowing at 127°C. If the bulb is approximated by a 60 mm diameter sphere, estimate the heat transfer rate and the percentage of power lost due to convection.	BTL-3	Applying

	Use correlation $Nu = 0.37\ Re_D^{0.6}$.		
10.	Water at 20°C enters a 2 cm diameter tube with a velocity of 1.5 m/s. The tube is maintained at 100°C. Find the tube length required to heat the water to a temperature of 60°C.	BTL-5	Evaluating
11.	A plate 20 cm in height and 1 m wide is placed in air at 20°C. If the surface of the plate is maintained at 100°C , Calculate the boundary layer thickness and local heat transfer coefficient at 10 cm from the leading edge. Also calculate the average heat transfer coefficient over the entire length of the plate.	BTL-5	Evaluating
12.	A vertical plate 15 cm high and 10 cm wide is maintained at 140°C. Calculate the maximum heat dissipation rate from the both sides of the plate in an ambient of at 20°C. The radiation heat transfer coefficient is 9.0 W/m^2K. For air at 80°C, take $\nu = 21.09 \times 10^{-6}\ m^2/s$, Pr = 0.692, $k_f = 0.03$ W/mK.	BTL-6	Creating
13.	Consider a rectangular plate 0.2 m × 0.4 m is maintained at a uniform temperature of 80°C. It is placed in atmospheric air at 24°C. Compare the heat transfer rates from the plate for the cases when the vertical height is (a) 0.2 m and (b) 0.4 m.	BTL-4	Applying
14.	The surface temperature of a steel wall (k = 0.213 W/mK) 0.3 m thick are maintained at 100°C and 40°C . Water at a temperature of T_∞= 20°C flows over the surface at 40°C. Calculate the convection coefficient associated with the water flow.	BTL-3	Applying
15.	Estimate the heat transfer rate from a 100 W incandescent bulb at 140°C to an ambient at 24°C.Approximate the bulb as 60 cm diameter sphere. Calculate the percentage of power lost by natural convection. Use following correlation and air properties ; $Nu = 0.60\ (GrPr)^{1/4}$ The properties of air at 82°C are $\nu = 21.46 \times 10^{-6}\ m^2/s$, $k_f = 30.38 \times 10^{-3}$ W/mK, Pr = 0.699.	BTL-5	Evaluating
16.	A hot plate 1 m × 0.5 m at 180°C is kept in still air at 20°C. Find : (i) The heat transfer coefficient.	BTL-3	Applying

	(ii) Initial rate of cooling of the plate in °C/min. Mass of the plate is 20 kg and specific heat is 400 J/kg.K. Assume that the 0.5 m sides is vertical.		
17.	Explain the development of hydrodynamic and thermal boundary layers with suitable figure.	BTL-6	Creating
18.	A circular disc heater 0.2 m in diameter is exposed to ambient air at 25°C. One surface of the disc is insulated and other surface is maintained at 130°C. Calculate the amount of heat transferred from the disc when it is horizontal with hot surface facing up.	BTL-3	Applying
	PART- C (15 Marks)		
1.	A block 10 cm × 10 cm × 10 cm in size is suspended in still air at 10°C with one of its surface in horizontal position. All surfaces of the block are maintained at 150°C. Determine the total heat transfer rate from the block.	BTL-1	Remembering
2.	A 15 cm outer diameter steel pipe lines 2 m vertically and 8 m horizontally in a large room with an ambient temperature of 30 C. If the pipe surface is at 250 C and emissivity of steel is 0.60, Calculate the total rate of heat loss from the pipe to the atmosphere. Properties of air at 140 C are ρ = 0.854 kg/m^3, c_p= 1.01 kJ/kg K, k=0.035 W/m K, Pr=0.684 and v=27.8x$10^{-6}$$m^2$/s.	BTL-3	Applying
3.	Air at 20 C and a pressure of 1 bar is flowing over a flat plate at a velocity of 3 m/s. If the plate is 280 mm wide and at 56 C, estimate the following quantities at x= 280 mm, given that the properties of air at the bulk mean temperature of 38 C are : ρ = 1.1374 kg/m^3, k =0.02732 W/m K, c_p= 1.005 kJ/Kg K, and v = 16.768 x 10^{-6} m^2/s: (i) boundary layer thickness, (ii) local friction coefficient, (iii) average friction coefficient, (iv) shearing stress due to friction, (v) thickness of thermal boundary layer, (vi) local convective heat transfer coefficient, (vii) average convective heat transfer coefficient, (viii) rate of heat transfer by convection, (ix) total drag force on the plate, and (x) local mass flow rate through the boundary.	BTL-4	Analyzing
4.	Beer cans (diameter 65 mm, length 150 mm) are to be cooled from an initial temperature of 20°C by placing them in a bottle cooler with an ambient air temperature of 1°C. Compare the initial cooling	BTL-2	Understanding

	rates, when the cans are laid horizontally, to when they are laid vertically.		
5.	A pipe carrying steam runs in a large room and is exposed to air at a temperature of 30°C. The pipe surface temperature is 200°C. The pipe diameter is 20 cm. If total heat loss rate from the pipe per metre length is 1.9193 kW/m, determine the pipe surface emissivity.	BTL-4	Analyzing

UNIT – III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS			
SYLLABUS Nusselt's theory of condensation- Regimes of Pool boiling and Flow boiling, correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient - Fouling Factors- Analysis - LMTD and NTU methods.			
PART- A (2 Marks)			
1.	Explain the assumptions made in Nusselt theory of condensation.	BTL-5	Evaluating
2.	Explain fouling. How does it affect the rate of heat transfer?	BTL-5	Evaluating
3.	Compare subcooled or local boiling and saturated boiling.	BTL-4	Analyzing
4.	Explain the advantage does NTU method have over the LMTD method.	BTL-4	Analyzing
5.	Describe the different regimes involved in pool boiling.	BTL-4	Analyzing
6.	Develop the relation for overall heat transfer coefficient in heat exchanger without fouling factor.	BTL-6	Creating
7.	Define pool boiling . Give an example for it.	BTL-1	Remembering
8.	Distinguish fin efficiency and fin effectiveness .	BTL-1	Remembering
9.	Define LMTD of a heat exchanger.	BTL-1	Remembering
10.	Distinguish pool boiling from forced convection boiling.	BTL-1	Remembering
11.	Describe the limitation of LMTD method. How is ε-NTU method superior to LMTD method.	BTL-2	Understanding
12.	Differentiate boiling and condensation.	BTL-2	Understanding
13.	Show the temperature distribution graph for condensers & evaporators.	BTL-3	Applying
14.	Explain the excess temperature in boiling.	BTL-5	Evaluating
15.	What are the factors are involved in designing heat exchangers?	BTL-1	Remembering
16.	Define flow boiling.	BTL-1	Remembering
17.	Give an example of non mixing type heat exchangers.	BTL-2	Understanding
18.	Show the heat flux curve for various regions of flow boiling.	BTL-3	Applying
19.	Define Film wise condensation.	BTL-1	Remembering
20.	Define Drop wise condensation.	BTL-1	Remembering
21.	What is nucleate boiling? Why is it important?	BTL-3	Applying
22.	Define critical heat flux.	BTL-1	Remembering

23.	What is condensation number?	BTL-1	Remembering
24.	What do you mean by fouling factor?	BTL-2	Understanding
25.	Define compact heat exchanger.	BTL-1	Remembering
	PART- B (13 Marks)		
1.	The outer surface of a vertical tube 80 mm in outer diameter and 1 m long is exposed to saturated steam at atmospheric pressure. The tube surface is maintained at 50°C by flow of water through the tube. What is the rate of heat transfer to coolant and what is the rate of condensation of steam ?	BTL-4	Analyzing
2.	Dry saturated steam at a pressure of 2.45 bar condenses on the surface of a vertical tube of height 1 m. The tube surface temperature is kept at 117°C. Estimate the thickness of condensate film and local heat transfer coefficient at a distance of 0.2 m from the upper end of the tube.	BTL-3	Applying
3.	A horizontal tube 50 mm in diameter with a surface temperature of 34°C is exposed to steam at 0.2 bar. Estimate the condensation rate and heat transfer rate per unit length of the tube.	BTL-2	Understanding
4.	Compare the values of heat transfer coefficient for laminar film wise condensation, when a pipe 6.25 cm in diameter and 1 m long is used asmcondenser ; when it (i) vertical, (ii) horizontal.	BTL-6	Creating
5.	Point out the nucleate boiling and solve the following. A wire of 1 mm diameter and 150 mm length is submerged horizontally in wire at 7 bars. A wire carries a current of 131.5 ampere with an applied voltage of 2.15 volt. If the surface of the wire maintained at a temperature of 180°C, calculate the heat flux and boiling heat transfer coefficient.	BTL-4	Analyzing
6.	A steam condenser consist of 16 tubes arranged in 4 × 4 array. The tubes are 25 mm in diameter and 1.2 m long. Water flows through the tube at 65°C while steam condenses at 75°C over the tube surface. Find the rate of condensation, if tubes are horizontal. Take latent heat of steam as 2300 kJ/kg and properties of water at 70°C	BTL-4	Analyzing
7.	A vertical tube of 50 mm outside diameter and 2 mm long it exposed to steam at atmospheric pressure. The outer surface of the tube is	BTL-4	Analyzing

	maintained at a temperature of 84°C by circulating cold water through the tube. Determine the rate of heat transfer and also condensate mass flow rate.		
8.	Hot oil with a capacity rate of 2500 W/K flows through the 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.	BTL-1	Remembering
9.	Describe about the pool boiling regimes of water at atmospheric pressure.	BTL-1	Remembering
10.	Steam in a condenser of a steam power plant is to be condensed at a temperature of 30°C with cooling water from a nearby lake, which enters the tubes of condenser at 14°C and leaves at 22°C. The surface area of the tubes is 45 m^2 and overall heat transfer coefficient is 2100 W/m^2K. Calculate the mass flow rate of cooling water needed and rate of steam condensation in the condenser.	BTL-2	Understanding
11.	Steam enters a counter flow heat exchanger, dry saturated at 10 bar and leaves at 350°C.The mass flow rate of the steam is 720 kg/min. The hot gas enters the exchanger at 650°C with mass flow rate of 1320 kg/min. If the tubes are 30 mm in diameter and 3 m long, determine the number of tubes required. Neglect the resistance offered by metallic tubes. Use following data: For steam T_{sat} = 180°C (at 10 bar), $C_{p,s}$ = 2.71 kJ/kgK, h_i = 600 W/m^2K For gas $C_{p,g}$ = 1 kJ/kgK, h_o = 250 W/m^2K.	BTL-2	Understanding
12.	A counter flow concentric 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 (d_i = 20 mm) is 0.18 kg/s while the flow rate of oil through the outer annulus (d_o = 40 mm) is 0.12 kg/s. The inlet and outlet temperature of the oil are 95°C and 65°C respectively. The water enters at 30°C to the exchanger. Neglecting tube wall thermal resistance, fouling factors and heat loss to the surroundings, calculate the length of the tube. Take the	BTL-5	Evaluating

	following properties at the bulk mean temperature: Engine oil at 80°C; C_p=2131 J/kg°C; μ=0.0325 N-s/m^2; k=0.138w/m °C. Water at 35°C; C_p=4174 J/kg °C; μ=725×10^{-6} N-s/m^2; k=0.625w/m°C; pr = 4.85.		
13.	A one tonne window air conditioner removes 3.5 kW heat from a room and in process, it rejects 4.2 kW heat in an air cooled condenser. The ambient temperature is 30°C, whereas, the refrigerant condenser at 45°C. For the condenser, the product of overall heat transfer coefficient and corresponding area is 350 W/K. Calculate the temperature rise of air as it flows over the condenser tubes.	BTL-4	Analyzing
14.	Hot oil (C_p=2200 J/kg K) is to be cooled by water (C_p=4180 J/kg K) in a 2shell pass and 12 tube pass heat exchanger. The tubes are thin walled and are made of copper with a diameter of 1.8 cm. The length of the each tube pass in the heat exchanger is 3m, and the overall heat transfer coefficient 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 the oil enter at 18°C and 160°C, respectively. Determine the rate of heat transfer in the heat exchanger and the outlet temperature of the water and the oil.	BTL-4	Analyzing
15.	A chemical having specific heat of 3.3 kJ/kgK at a rate of 20,000 kg/h enters a parallel flow heat exchanger at 120°C. The flow rate of cooling water is 50,000 kg/h with an inlet temperature of 20°C. The heat transfer area is 10 m^2 and overall heat transfer coefficient is 1050 W/m^2K. Find (i) The effectiveness of the heat exchanger,(ii) Outlet temperature of water and chemical. Take C_p of water as 4.186 kJ/kgK.	BTL-5	Evaluating
16.	In an open heart surgery, under hypothermic conditions, the patient blood is cooled before the surgery and rewarmed afterwards. It is proposed that a concentric tube, counter flow heat exchanger of length 0.5 m be used for this purpose with the thin walled inner tube having a diameter of 55 mm. If the water at 60°C and 0.10 kg/s is used to heat the blood entering the exchanger at 18°C and 0.05 kg/s, what is the temperature of blood leaving the exchanger ? The overall	BTL-2	Understanding

	heat transfer coefficient is 500 W/m^{2}K and specific heat of the blood is 3500 J/kgK.		
17.	List out the classification of heat exchangers and draw the temperature distribution in a condenser and evaporator and drive the expression for effectiveness of parallel flow heat exchanger by NTU method.	BTL-1	Remembering
18.	Calculate for the following cases, the surface area required for the heat exchanger which is required to cool 3200 kg/hr of benzene (C_p=1.74 kJ/kg K) from 72°C to 42°C. The cooling water (C_P=4.18 kJ/kg °C) at 15°C has a flow rate of 2200 kg/hr. (i) single pass counter flow (ii) 1-4 heat exchanger (one-shell pass and four -tube passes) and (iii) Cross flow single pass with water mixed and benzene unmixed. Assume all the cases U=0.28 kW/m^{2}K.	BTL-1	Remembering
PART- C (15 Marks)			
1.	A condenser is designed to condense 500 kg/h of dry and saturated steam at 0.1 bar. A square array of 400 tubes, 6 mm in diameter is used. The tube surface is maintained at 24°C by flowing water. Calculate the heat transfer coefficient and length of the each tube.	BTL-2	Understanding
2.	A vertical plate 2.8 m high is maintained at 54°C in the presence of saturated steam at atmospheric pressure. Estimate the heat transfer rate per unit width.	BTL-3	Applying
3.	A 1-shell-2-tube steam condenser consists of 3000 brass tubes of 20 mm diameter. Cooling water enters the tube at 20°C with a mean flow rate of 3000 kg/s. The heat transfer coefficient for condensation on the outer surfaces of the tube is 15500 W/m^{2}K. If the heat load of the condenser is 2.3x10^8 W when the steam condenses at 50°C determine (a) the outlet temperature of the cooling water. (b) the overall heat transfer coefficient. (c) the tube length per pass using the NTU method.	BTL-4	Analyzing

	(d) the rate of condensation of steam if h_{fg} = 2380 kJ/kg.		
4.	A simple heat exchanger consisting of two concentric flow passages is used for heating 1110 kg/h of oil (sp. heat = 2.1 kJ/kgK) from a temperature of 27°C to 49°C. The oil flows through the inner pipe made of copper (O.D. = 2.86 cm, I.D. = 2.54 cm) and the surface heat transfer coefficient on the oil side is 635 W/m^2K. The oil is heated by hot water supplied at the rate of 390 kg/h and at an inlet temperature of 93°C. The water side heat transfer coefficient is 1270 W/m^2K. Take the thermal conductivity of copper to be 350 W/mK and the fouling factors on the oil and water sides to be 0.0001 and 0.0004 m^2K/W. What is the length of the heat exchanger for : (i) parallel flow, and (ii) counter flow ?	BTL-4	Analyzing
5.	A counter flow heat exchanger is used to heat air entering at 400°C with a flow rate of 6 kg/s by exhaust gas entering at 800°C with a flow rate of 4 kg/s. The overall heat transfer coefficient is 100 W/m^2K and the outlet temperature of air is 551.5°C. The specific heat at constant pressure for both air and exhaust gas can be taken as 1100 J/kgK. Calculate :(i) Heat transfer area needed,(ii) Number of transfer units.	BTL-1	Remembering

UNIT – IV RADIATION			
SYLLABUS Radiation laws - Black Body and Gray body Radiation - Shape Factor - Electrical Analogy. Radiation Shields- Radiation through gases.			
PART- A (2 Marks)			
1.	What are the factors involved in radiation by a body.	BTL-1	Remembering
2.	List out the use of radiation shield.	BTL-1	Remembering
3.	What is thermal radiation? What is its wavelength band?	BTL-2	Understanding
4.	How a radiation gas differs from solids?	BTL-2	Understanding
5.	Differentiate Opaque body & perfectly transparent surface.	BTL-3	Applying
6.	Explain black body radiation.	BTL-5	Evaluating
7.	Explain emissive power and monochromatic emissivity.	BTL-5	Evaluating
8.	Compare irradiation and radiosity.	BTL-4	Analyzing
9.	Write down the heat transfer equation for Radiant exchange between infinite parallel gray planes.	BTL-4	Analyzing
10.	List out any two shape factor algebra.	BTL-1	Remembering
11.	Define Planck's distribution law.	BTL-1	Remembering
12.	Define Wien's distribution law.	BTL-1	Remembering
13.	Describe Emissivity of a surface.	BTL-2	Understanding
14.	Define Reflectivity.	BTL-1	Remembering
15.	What is Radiation Shield?	BTL-1	Remembering
16.	Define Radiation heat transfer.	BTL-1	Remembering
17.	What is Intensity of radiation?	BTL-3	Remembering
18.	Explain Shape factor.	BTL-5	Evaluating
19.	Formulate the equation for radiation between two gray bodies.	BTL-6	Creating
20.	Distinguish between Absorptivity &Transmitivity of radiation.	BTL-2	Understanding
21.	Define infrared and ultraviolet radiation.	BTL-1	Remembering
22.	State Lambert's cosine law.	BTL-1	Remembering
23.	Discuss the radiation characteristics of carbon dioxide and water vapour.	BTL-6	Creating

24.	What does the view factor represent? When is the view factor from a surface to itself is not zero?	BTL-2	Understanding
25.	Define electrical analogy.	BTL-1	Remembering
	PART- B (13 Marks)		
1.	Determine (a) the wavelength at which the spectral emissive power of a tungsten filament at 1400 K is maximum, (b) the spectral emissive power at that wavelength, and (c) the spectral emissive power at 5 μm.	BTL-3	Applying
2.	(i) What is view factor and shape factor? (4)	BTL-4	Analyzing
	(ii) State laws of black body radiation? (4)	BTL-2	Understanding
	(iii) Two large parallel plates are at temperatures T_1 = 500 K and T_2 = 300 K. The emissivity's are ε_1= 0.85 and ε_2= 0.90. What is the radiation flux between the plates? (5)	BTL-5	Evaluating
3.	Two very large parallel plates are maintained at a uniform temperature of T_1 = 1000 K and T_2 = 800 K and have emissivity's of $\varepsilon_1 = \varepsilon_2$ = 0.2, respectively. It is desire to reduce the net rate of radiation heat transfer between the two plates to one-fifth by placing the thin aluminium sheets with an emissivity of 0.15 on both sides between the plates. Determine the number of sheets that need to be inserted.	BTL-2	Understanding
4.	(i) The spectral emissivity function of an opaque surface at 1000 K is approximated as $\varepsilon_{\lambda 1}$=0.4, $0\leq \lambda$ 2μm; $\varepsilon_{\lambda 2}$=0.7, 2 μm $\leq \lambda$ 6μm; $\varepsilon_{\lambda 3}$=0.3, 6 μm $\leq \lambda$ ∞. Determine the average emissivity of the surface and the rate of radiation emission from the surface, in W/m^2. (6)	BTL-6	Creating
	(ii) Emissivity's of two large parallel plates maintained at 800°C and 300°C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per meter for these plates? (7)	BTL-2	Understanding
5.	A window glass 0.3 cm thick has a monochromatic transmissivity of 0.9 in the range of 0.3 μm to 2.5 μm and nearly zero elsewhere. Estimate the total transmissivity of the window for (a) near black solar radiation at 5800 K, and (b) black room radiation at 300 K.	BTL-4	Analyzing
6.	Two large parallel planes with emissivity 0.6 are at 900 K and	BTL-2	Understanding

	300 K. A radiation shield with one side polished and having emissivity of 0.05,while the emissivity of other side is 0.4 is proposed to be used. Which side of the shield to face the hotter plane, if the temperature of shield is to be kept minimum ? Justify your answer.		
7.	A gray, diffuse opaque surface (α = 0.8) is at 100°C and receives an irradiation 1000 W/m^2. If the surface area is 0.1 m^2. Calculate (i) Radiosity of the surface, and (ii) Net radiative heat transfer rate from the surface. (iii) Calculate above quantities, if surface is black.	BTL-3	Applying
8.	Two parallel plate of size 1.0 m by 1.0 m 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 temperature of 900°C and the other at 400°C. Theiremissivities 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 the room. Consider only the plate surfaces facing each other.	BTL-2	Understanding
9.	Two parallel, infinite gray surfaces are maintained at temperature of 127°C and 227°C respectively. If the temperature of the hot surface is increased to 327°C. By what factor is the net radiation exchange per unit area increased ? Assume the emissivities of colder and hotter surfaces to be 0.9 and 0.7, respectively.	BTL-1	Remembering
10.	A cubical room 4 m by 4 m by 4 m is heated through the floor by maintaining it at uniform temperature of 350 K, while side walls are well insulated. The heat loss takes place through the ceiling at 300 K. Assuming that the all surfaces have an emissivity of 0.8, determine the rate of heat loss by radiation through the ceiling.	BTL-4	Analyzing
11.	Two parallel discs 50 cm in diameter are spaced 40 cm apart with one disc located directly above the other disc. One disc is maintained at 500°C and other at 227°C. The emissivities of the discs are 0.2 and 0.4, respectively. The curved cylindrical surface approximates a black body and is maintained at a temperature of 67°C. Determine the rate of heat loss by radiation from the inside surfaces of each disc, and explain how these surfaces can be maintained at specified temperatures.	BTL-3	Applying

12.	A 12 mm outside diameter pipe carries a cryogenic fluid at 90 K. another pipe of 15 mm outside diameter and 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 the both surface is 0.25. (ii) Calculate the percentage reduction in heat flow if a shield of 13.5mm diameter and 0.06 surface emissivity is placed between pipes.	BTL-3	Applying
13.	A heater of 1 m diameter is covered by a hemisphere of 4 m diameter. The surface of hemisphere is maintained at 400 K. The emissivity of the surface is 0.8. The heater surface is maintained at 1000 K. The remaining base area is open to surroundings at 300 K. The surroundings may be considered black. The emissivity of heater surface is also 0.8. Determine the heat exchange from heater to the hemisphere and to the surroundings.	BTL-1	Remembering
14.	Identify an expression for heat transfer rate using electrical analogy (i)Without any shield between two parallel plates. (ii)With shield in between two parallel plates.	BTL-1	Remembering
15.	A cubical room 4 m by 4 m by 4 m is heated through the ceiling by maintaining it at uniform temperature of 350 K, while walls and the floor are at 300 K. Assuming that the all surfaces have an emissivity of 0.8, determine the rate of heat loss from ceiling by radiation.	BTL-3	Applying
16.	A cryogenic fluid flows through a long tube of 20 mm diameter, the outer surface of which is diffuse and gray (ε_1 = 0.02) at 77 K. This tube is concentric with a larger tube of 50 mm diameter, the inner surface of which is diffuse and gray (ε_2 = 0.05) and at 300 K. The space between the surfaces is evacuated. Calculate the heat gain by cryogenic fluid per unit length of tubes. If a thin radiation shield of 35 mm diameter (ε_3 = 0.02) both sides is inserted midway between the inner and outer surfaces, calculate the percentage change in heat gain per unit length of the tube.	BTL-3	Applying
17.	A pipe carrying steam having an outside diameter of 20 cm runs in a large room and is exposed to air at a temperature of 30°C. The pipe surface temperature is 400°C. Calculate the heat loss to the surroundings per metre length of pipe due to thermal radiation. The	BTL-4	Analyzing

	emissivity of the pipe surface is 0.8. (i) What would be the loss of heat due to radiation, if the pipe is enclosed in a 50 cm diameter brick conduit of emissivity of 0.9 ? (ii) What would be the radiation heat transfer from the pipe, if it is enclosed within a square conduit of 0.5 m side of emissivity of 0.9 ?		
18.	A cylindrical rod (ε = 0.7) of 50 mm diameter is maintained at 1000°C by an electric resistance heating and is kept in a room, the walls (ε = 0.6) of which are at 15°C. Determine the energy which must be supplied per metre length of the rod. If an insulated half circular reflector of 0.45 m diameter is placed around the rod, determine the energy supplied to the rod per metre length.	BTL-1	Remembering
	PART- C (15 Marks)		
1.	Calculate the following quantities for an industrial furnace (black body) emitting radiation at 2650°C. (i) Spectral emissive power at λ = 1.2 μm, (ii) Wavelength at which the emissive power is maximum, (iii) Maximum spectral emissive power, (iv) Total emissive power, (v) Total emissive power of the furnace, if it is treated as gray and diffuse body with an emissivity of 0.9.	BTL-3	Applying
2.	Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperature of 427 °C and 27 °C respectively. ε (hot plate) = 0.9 and ε (cold plate) = 0.6. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer, ε (shield) = 0.4.	BTL-3	Applying
3.	A long square duct has its three surfaces 1, 2, and 3 maintained at uniform temperatures of 400 K,500 K and 600 K, respectively, their respective emissivities are 0.9, 1.0 and 0.1. The surface 4 is subjected to a uniform heat flux of 5000 W/m^2 and emissivity of 0.8. Determine the net radiative heat fluxes from surfaces 1, 2, and 3 and temperature of surface 4. Assume all surfaces are gray and diffuse.	BTL-3	Applying
4.	An oven is approximated as a long equilateral triangular duct, which heat surface maintained at a temperature of 1200 K. The other surface is insulated while the third surface is at 500 K. The duct has a width of a 1 m on a side and the heated and insulated surfaces have	BTL-4	Analyzing

	an emissivity of 0.8. The emissivity of the third surface is 0.4. For steady state operation find the rate at which energy must be supplied to the heated side per unit length of the duct to maintained at a temperature at 1200 K. What is the temperature of the insulated surface?		
5.	Two parallel plates 2 m x1m are spaced 1m apart. The plates are at temperatures of 727°C and 227°C and their emissivities are 0.3 and 0.5 respectively. The plates are located in a large room, the walls of which are at 27°C. Determine the rate of radiant heat loss from each plate and the heat gain by the walls.	BTL-4	Analyzing

UNIT – V MASS TRANSFER			
SYLLABUS			
Basic Concepts - Diffusion Mass Transfer - Fick's Law of Diffusion - Steady state Molecular Diffusion - Convective Mass Transfer - Momentum, Heat and Mass Transfer Analogy - Convective Mass Transfer Correlations.			
PART– A (2 Marks)			
1.	Define Molar concentration.	BTL-1	Remembering
2.	Explain Mass transfer co-efficient.	BTL-2	Understanding
3.	Define Fourier number &Biot number for mass transfer.	BTL-1	Remembering
4.	Define Mass concentration.	BTL-1	Remembering
5.	Define Mole fraction.	BTL-1	Remembering
6.	Evaluate free convective mass transfer.	BTL-5	Evaluating
7.	Give two examples of convective mass transfer.	BTL-3	Applying
8.	Write the physical meaning of Lewis number.	BTL-2	Understanding
9.	Show the analogy of Momentum transfer.	BTL-3	Applying
10.	Show the anology of Heat transfer.	BTL-3	Applying
11.	Define 'Sherwood Number' & Schmidt number.	BTL-1	Remembering
12.	Point out molecular diffusion.	BTL-4	Analyzing
13.	Point out eddy diffusion.	BTL-4	Analyzing
14.	Define forced convective mass transfer.	BTL-1	Remembering
15.	What are the factors considered in evaporation of water into air?	BTL-1	Remembering
16.	Summarize the mass transfer.	BTL-2	Understanding
17.	What is the governing equation for Transient Diffusion?	BTL-1	Remembering
18.	Classify the modes of mass transfer.	BTL-4	Analyzing
19.	State Fick's law of diffusion. Give its expression.	BTL-2	Understanding
20.	Evaluate the convective mass transfer.	BTL-5	Evaluating
21.	Define equimolar counter diffusion.	BTL-1	Remembering
22.	What do you understand by steady state molecular diffusion?	BTL-1	Remembering
23.	Define molar concentration and mass fraction.	BTL-1	Remembering

24.	State the modes of mass transfer with suitable examples.	BTL-2	Understanding
25.	State the generalised mass diffusion equation.	BTL-2	Understanding
	PART– B (13 Marks)		
1.	A tank contains a mixture of CO_2 and N_2 in the mole proportion of 0.2 and 0.8 at 1 bar and 290 K. It is connected by a duct of cross-sectional area 0.1 m^2, 0.5 m long to another tank containing mixture of CO_2 and N_2 in the molar proportion of 0.8 and 0.2 respectively. Calculate the diffusion rates of CO_2 and N_2.Assume diffusivity coefficient $D_{AB} = 0.17 \times 10^{-4}$ m^2/s.	BTL-6	Creating
2.	(i) Analogy between heat and mass transfer. (7)	BTL-2	Understanding
	(ii) Analogy of Mass convection. (6)	BTL-2	Understanding
3.	A vessel contains binary mixture of O_2 and N_2 with partial pressure in the ratio of 0.21 and 0.79 at 15°C. The total partial pressure of the mixture is 1.1 bar. Calculate the following, Molar concentrations Mass densities Mass fractions & Molar fraction of each species.	BTL-3	Applying
4.	An open pan 20 cm in diameter 20 mm deep is filled with water to a level of 10 mm and is exposed to air at 25°C. Assuming mass diffusivity of 0.25×10^{-4} m^2/s, calculate the time required for all the water to evaporate.	BTL-4	Analyzing
5.	Paraphrase the followings.		
	(i) Fick's law of diffusion (4)	BTL-5	Evaluating
	(ii) Equimolar counter diffusion (4)	BTL-5	Evaluating
	(iii) Evaporation process in the atmosphere (5)	BTL-5	Evaluating
6.	An open pan 20 cm in diameter and 8 cm deep contains water at 25°C and is exposed to dry atmospheric air. If the rate of diffusion od water vapour is 8.54×10^{-4} kg/h estimate the diffusion coefficient of water in air.	BTL-5	Evaluating
7.	A well is 40 m deep and 9 m in diameter is exposed to atmosphere at 25°C. The air at the top has relative humidity of 50%. Calculate the rate of diffusion of water vapour through the wall. Take $D_{AB} = 2.58 \times 10^{-5}$ m^2/s, $M_w = 18$ kg/kg-mole.	BTL-1	Remembering
8.	Estimate the diffusion rate of water from the bottom of the test tube 1.5 cm in diameter and 15 cm long into dry atmospheric air at 25°C. Take diffusion coefficient of 25.6×10^{-6} m^2/s.	BTL-4	Analyzing
9.	A steel sphere of radius 60 mm which is initially at a uniform temperature of 325°C is suddenly exposed to an environment at	BTL-4	Analyzing

	25°C; with convection heat transfer coefficient 500 W/m^2K. Calculate the temperature at a radius 36 mm and the heat transferred 100 seconds after the sphere is exposed to the environment.		
10.	Air at 25°C and 1 atmospheric pressure, containing small quantities of iodine flows with a velocity of 5 m/s inside a 3 cm inner diameter tube. Determine the mass transfer coefficient from the air stream to the wall surface. Assume D_{AB} (iodine air) = 0.82 x 10^{-5} m^2/s.	BTL-3	Applying
11.	Air at 35°C and 1 atm flows at a velocity of 60 m/s over (i) a flat plate 0.5 m long (ii) a sphere 5 cm in diameter. Calculate the mass transfer coefficient of water vapour in air. Neglect the concentration of vapour in air.	BTL-1	Remembering
12.	(i) Dry air at 27°C and 1 atm flows over a wet flat plate 50 cm long at a velocity of 50 m/s. To find out the mass transfer coefficient of water vapour in air at the end of the plate. (10)	BTL-2	Understanding
	(ii) Summarize about equimolar diffusion. (3)	BTL-2	Understanding
13.	The water in a 5 m x 15 m outdoor swimming pool is maintained at a temperature of 27°C. The average ambient temperature and relative humidity are 27°C and 40 percent respectively. Assuming a wind speed of 2 m/s in the direction of the long side of the pool estimate the mass transfer coefficient for the evaporation of water from the pool surface.	BTL-1	Remembering
14.	Water is available at the bottom of well of 2.5 m diameter and 5 m deep. Estimation its diffusion rate in to dry air is 0.0925 m^2/h and the atmospheric pressure is 1.032 bar.	BTL-1	Remembering
15.	In a solar pond, the salt is placed at the bottom of the pond 1.5 m deep. The surface is flushed constantly, so that the concentration of salt at the top layer is zero. The salt concentration at the bottom layer is 5 kg-mole/m^3. Calculate the rate at which salt is washed off at the top at steady state condition per m^2.Take D_{AB} = 1.24 × 10^{-9} m^2/s. Total concentration = 55.55 kg-mole/m^3.	BTL-3	Applying
16.	Air at 50°C and 1 atm flow over the surface of a water reservoir at an average velocity of 2.3 m/s. The water surface is 0.65 m long and 0.65 m wide. The water surface temperature is estimated at 30°C. The relative humidity of air is 40%. The density of air is	BTL-4	Analyzing

	1.105 kg/m^3 and its viscosity is 1.943 × 10^{-5} kg/ms. Calculate the amount of water vapour evaporates per hour per sq.m of water surface and state the direction of diffusion.		
17.	Air at 1 atm, 25°C containing small quantity of iodine flows with a velocity of 4 m/s inside a 25 mm diameter tube. Calculate the mass transfer coefficient for iodine transfer from gas stream to the wall surface. If C_m is mean concentration of the iodine in kg-mole/m^3 in air stream, calculate the rate of deposition of iodine on the tube surface, where the iodine concentration is zero.	BTL-4	Analyzing
18.	Calculate the temperature of dry air at 1 atm, whose wet bulb temperature is 18.3°C. If air stream temperature is 32.2°C and wet bulb temperature remains 18.3°C, what would be the relative humidity of air stream ? Take D_{AB} = 0.26 × 10^{-4} m^2/s, α = 0.221 × 10^{-4} m^2/s for air, C_p = 1.004 kJ/kg.K.	BTL-1	Remembering
	PART– C (15 Marks)		
1.	A thermometer whose bulb is covered by a wetted cloth reads 20°C when dry air is blown over it. Determine the temperature of the air.	BTL-4	Analyzing
2.	A spherical tank of 0.18 m radius made of fused silica has a wall thickness of 2.5 mm. It is originally filled with helium at 6 bar gauge and 0°C. Determine the rate of pressure drop with time at this condition due to gas diffusion. D = 0.04 × 10^{-12} m^2/s, the density of gas at the solid surface is given by 18 × 10^{-9} kg/m^3 Pa. (also termed solubility).	BTL-4	Analyzing
3.	Water flows down on the surface of a vertical plate at a rate of 0.05 kg/s over a width of 1m. The water film is exposed to pure carbon dioxide. The pressure is 1.013 bar and the temperature is 25°C. Water is essentially CO_2 free initially. Determine the rate of absorption of CO_2. The molal concentration at this condition for CO_2 in water at the surface is 0.0336 kgmol/ m^3 of solution. D = 1.96 × 10^{-9} m^2/s, solution density = 998 kg/m^3, μ = 0.894 × 10^{-3} kg/ms, G=0.05 kg/ms, L = 1 m. The notation for convective mass transfer coefficient is h_m.	BTL-5	Evaluating
4.	A square plate of side 1 m has one of its sides coated with napthalene and stands vertically in still air at 53°C. Determine	BTL-4	Analyzing

	diffusion rate. M = 128, D = 6.11 × 10^{-6} m^2/s, kinematic visocity = 18.8 × 10^{-6}, Sc = 3.077. The vapour pressure at 53°C is 1.333×10^{-3}bar.R_v= 8315/128=64.91 J/kgK,T=53+273 = 326 K.		
5.	During an experimentation, the flow of dry air at 25°C and 1 atm at a free stream velocity of 2 m/s over a softdrink bottle covered with a layer of wet cloth. It is observed that 15 gram of water has evaporated in 15 minutes. The surface area of bottle is 0.3 m^2. Both the body and air are kept at 25°C during study. The vapour pressure of water at 25°C is 15 Pa and mass diffusivity of water in air at 25°C is 2.5 × 10^{-5} m^2/s. Calculate heat transfer coefficient under the same flow conditions over same geometry.	BTL-4	Analyzing