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**DHANALAKSHMI SRINIVASAN COLLEGE OF ENGINEERING AND TECHNOLOGY**

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**DEPARTMENT OF MECHANICAL ENGINEERING**

**QUESTION BANK**

### Subject Code: ME8693 Year / Semester: III / 06

### Subject Name: Heat and Mass Transfer

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| **UNIT I - CONDUCTION** | |
| **PART \* A** | |
| **Q.No.** | **Questions** |
| 1. | **Define Heat Transfer.** BTL1  Heat transfer can be defined as the transmission of energy from one region to another region due to temperature difference. |
| 2 | **What are the modes of Heat Transfer?(Nov 2018, Dec 2016, May 2013)**BTL2  Conduction , Convection , Radiation |
| 3 | **Define Conduction.** BTL2  Heat conduction is a mechanism of heat transfer from a region of high temperature to a region of low temperature within a medium (solid, liquid or gases) or between different medium in direct physical contact.  In condition energy exchange takes place by the kinematic motion or direct impact of molecules. Pure conduction is found only in solids. |
| 4 | **Explain Convection (Apr 2012).** BTL1  Convection is a process of heat transfer that will occur between a solid surface and a fluid medium when they are at different temperatures.  Convection is possible only in the presence of fluid medium. |
| 5 | **Define Radiation.** BTL1  The heat transfer from one body to another without any transmitting medium is known as radiation. It is an electromagnetic wave phenomenon. |
| 6 | **State Fourier’s Law of conduction. (Dec 2019, May 2017, Dec 2016, May 2014)** BTL1  The rate of heat conduction is proportional to the area measured – normal to the direction of heat flow and to the temperature gradient in that direction. |

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|  | Q - A *dT* , *Q*  - KA dT , where A – are in m2 ,  *dx* dx  *dT* - Temperature gradient in K/m, K – Thermal conductivity W/mK.  *dx* |
| 7 | **Define Thermal Conductivity.(Dec 2016, May 2015)** BTL2  Thermal conductivity is defined as the ability of a substance to conduct heat. |
| 8 | **Write down the equation for conduction of heat through a slab or plane wall.** BTL3  Heat transfer *Q*  *Toverall* , Where  T = T1 – T2  *R*  *R*  *L* - Thermal resistance of slab , L = Thickness of slab  *KA*  K = Thermal conductivity of slab, A = Area |
| 9 | **State Newton’s law of cooling or convection law. (Nov 2018, Dec 2016, May 2013)**BTL2 Heat transfer by convection is given by Newton’s law of cooling  Q = hA (Ts - T) Where , A – Area exposed to heat transfer in m2  h - heat transfer coefficient in W/m2K, Ts – Temperature of the surface in K  T - Temperature of the fluid in K. |
| 10 | **Write down one dimensional, steady state conduction equation without internal heat generation.** BTL3  2*T*   *x*2 0 |
| 11 | **Write down the general equation for one dimensional steady state heat transfer in slab or plane wall without heat generation.** BTL3  2*T*  2*T*  2*T*  1 *T*  *x*2 *y*2 *z*2  *t*  Where, α thermal diffusivity, Temperature gradient |
| 12 | **Define overall heat transfer co-efficient. [April ’12]** BTL2  The overall heat transfer by combined modes is usually expressed in terms of an overall conductance or overall heat transfer co-efficient ‘U’.  Heat transfer Q = UA T. |

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| 13 | **Write down the general equation for one dimensional steady state heat transfer in slab with heat generation. [Oct. ’16]** BTL3  2*T*  2*T*  2*T*  *q*  1 *T*  *x*2 *y*2 *z*2 *K*  *t* |
| 14 | **What is critical radius of insulation (or) critical thickness? [Oct. ’17]** BTL2 Critical radius = rc Critical thickness = rc – r1  Addition of insulating material on a surface does not reduce the amount of heat transfer rate always. In fact under certain circumstances it actually increases the heat loss up to certain thickness of insulation. The radius of insulation for which the heat transfer is maximum is called critical radius of insulation, and the corresponding thickness is called critical thickness. |
| 15 | **Explain fins (or) Extended surfaces.** BTL2  It is possible to increase the heat transfer rate by increasing the surface of heat transfer. The surfaces used for increasing heat transfer are called extended surfaces or sometimes known as fins. |
| 16 | **Define Fin efficiency. [Nov. ’16, Oct. ’17]** BTL4  The efficiency of a fin is defined as the ratio of actual heat transfer by the fin to the maximum possible heat transferred by the fin. |
| 17 | **Define Fin effectiveness. [Apr. 2012]** BTL2  Fin effectiveness is the ratio of heat transfer with fin to that without fin  *Q*  Fin effectiveness = *with fin*  *Qwithout fin* |
| 18 | **What is meant by Transient heat conduction or unsteady state conduction?** BTL2  If the temperature of a body varies with time, it is said to be in a transient state and that type of conduction is known as transient heat conduction or unsteady state conduction. |
| 19 | **Explain Lumped heat analysis?[Oct. 16]** BTL2  In a Newtonian heating or cooling process the temperature throughout the solid is considered to be uniform at a given time. Such an analysis is called Lumped heat capacity analysis. |
| 20 | **What is the significance of Biot number? [Nov.12]** BTL2  Biot number is used to find Lumped heat analysis, semi-infinite solids and infinite solids  If Bi< 0.1 L  Lumped heat analysis Bi = Semi infinite solids  < Bi< 100  Infinite solids. |
| 21 | **What are Heisler charts? (Dec 2019, May 2017, Dec 2016, May 2014)**BTL1  In Heisler chart, the solutions for temperature distributions and heat flows in plane walls, long cylinders and spheres with finite internal and surface resistance are presented. Heisler’s charts are nothing but a analytical solutions in the form of graphs. |
| **Part B** | |
| 1 | A wall of 0.6m thickness having thermal conductivity of 1.2 W/mK. The wall is to be insulated with a material having an average thermal conductivity of 0.3 W/mK. Inner and outer surface temperatures are 100º C and 10º C. Heat transfer rate is 1400 W/m2 calculate the thickness of insulation. **(Nov ‘12)**(13 M)**-**BTL5 |
| 2 | An external wall of a house is made up of 10 cm common brick (K = 0.7 W/mK) followed by a 4 cm layer of zibsum plaster (K = 0.48 W/mK). What thickness of loosely packed insulation (K  = 0.065 W/mK) should be added to reduce the heat loss through the wall by 80%. **(13 M)** **(May 12) -BTL5** |
| 3 | A thick walled tube of stainless steel [K = 77.85 kJ/hr mC] 25 mm ID and 50 mm OD is covered with a 25 mm layer of asbestos [K = 0.88 kJ/hr mC]. If the inside wall temperature of the pipe is maintained at 550C and the outside of the insulator at 45C. Calculate the heat loss per meter length of the pipe. **(13 M)(Nov 2018, Dec 2016, May 2013)-BTL5** |
| 4 | A hollow sphere (K = 65 W/mK) of 120 mm inner diameter and 350 mm outer diameter is covered 10 mm layer of insulation (K = 10 W/mK). The inside and outside temperatures are 500C and 50C respectively. Calculate the rate of heat flow through this sphere**.** (13 M) **– (Oct ’15) BTL5** |
| 5 | A wire of 6 mm diameter with 2 mm thick insulation (K = 0.11 W/mK). If the convective heat transfer co-efficient between the insulating surface and air is 25 W/m2L, find the critical thickness of insulation. And also find the percentage of change in the heat transfer rate if the critical radius is used. **(13 M)(Dec 2019, May 2017, Dec 2016, May 2014)-BTL5** |
| 6 | A current of 200 A is passed through a stainless steel wire (K = 19 W/mK) 3 mm in diameter. The resistivity of the steel may be taken as 70  cm and the length of the wire is submerged in a liquid at 110C with heat transfer co-efficient h = 4 kW/m2C. Calculate the centre temperature of the wire. (13 M) **– (May 2013) BTL5** |
| 7 | Ten thin brass fins (K = 100 W/mK), 0.75 mm thick are placed axially on a 1 m long and 60 mm diameter engine cylinder which is surrounded by 35C. The fins are extended 1.5 cm from the cylinder surface and the heat transfer co-efficient between cylinder and atmospheric air is 15 W/m2K. Calculate the rate of heat transfer and the temperature at the end of fins when the cylinder surface is at 160C. **(13M)(May 2019, Dec 2015)-BTL5** |
| 8 | An aluminium 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/m2K and 55 W/mK respectively. Determine   1. Temperature at the end of the fin. 2. Temperature at the middle of the fin.   Total heat dissipated by the fin. **(13M) -BTL5** |

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| **UNIT II - CONVECTION** | |
| **PART \* A** | |
| **Q.No.** | **Questions** |
| 1. | **Define Reynolds number (Re).** BTL1  It is defined as the ratio of inertia force to viscous force. Re  Inertia force  Viscous force |
| 2 | **Define Prandtl number (Pr).** BTL1  It is the ratio of the momentum diffusivity of the thermal diffusivity.  Pr  Momentum diffusivity  Thermal diffusivity |
| 3 | **Define Nusselt number (Nu).** BTL1  It is defined as the ratio of the heat flow by convection process under an unit temperature gradient to the heat flow rate by conduction under an unit temperature gradient through a stationary thickness (L) of metre.  Nusselt number (Nu) = Qconv .  Qcond |
| 4 | **What is Grashoff number?** BTL1  It is defined as the ratio of product of inertia force and buoyancy force to the square of viscous force.  Gr  Inertia force  Buyoyancy force  (Viscous force)2 |
| 5 | **Explain Newtonion and non – Newtonion fluids?** BTL2  The fluids which obey the Newton’s Law of viscosity are called Newtonion fluids and those which do not obey are called non – newtonion fluids. |
| 6 | **What is meant by laminar flow and turbulent flow?** BTL2  **Laminar flow:** Laminar flow is sometimes called stream line flow. In this type of flow, the fluid moves in layers and each fluid particle follows a smooth continuous path. The fluid particles in each layer remain in an orderly sequence without mixing with each other.  **Turbulent flow:** In addition to the laminar type of flow, a distinct irregular flow is frequency observed in nature. This type of flow is called turbulent flow. The path of any individual particle is zig – zag and irregular. Fig. shows the instantaneous velocity in laminar and turbulent flow. |
| 7 | **State Newton’s law of convection.** BTL2  Heat transfer from the moving fluid to solid surface is given by the equationQ = h A (Tw – T) **,**This equation is referred to as Newton’s law of cooling. Where , h – Local heat transfer coefficient in W/m2K, A – Surface area in m2,Tw – Surface (or) Wall temperature in K, T - Temperature of fluid in K. |

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| 8 | **Define free or natural convection.**(**AUMay2004,Dec2004,June 2006, May 2004**)BTL2  If the fluid motion is produced due to change in density resulting from temperature gradients, the mode of heat transfer is said to be free or natural convection. |
| 9 | **Define forced convection.(AU May 2004, Dec 2004, June 2006, May 2004)** BTL2  If the fluid motion is artificially created by means of an external force like a blower or fan, that type of heat transfer is known as forced convection. |
| 10 | **Define boundary layer thickness.** BTL2  The thickness of the boundary layer has been defined as the distance from the surface at which the local velocity or temperature reaches 99% of the external velocity or temperature. |
| 11 | **Give the form of equation used to calculate heat transfer for flow through cylindrical pipes.**  BTL3  Nu = 0.023 (Re)0.8 (Pr)n , n = 0.4 for heating of fluids, n = 0.3 for cooling of fluids |
| 12 | **Name the dimensionless parameters used in forced convection.** BTL2   1. Reynolds number (Re) 2. Nusselt number (Nu) 3. Prandtl number (Pr) |
| 13 | **Define hydrodynamic boundary layer.** BTL2  In hydrodynamic boundary layer, velocity of the fluid is less than 99% of free stream velocity. |
| 14 | **Explain thermal boundary layer.** BTL2  In thermal boundary layer, temperature of the fluid is less than 99% of free stream velocity. |
| 15 | **Define Stanton number (St).** BTL1  It is the ratio of Nusselt number to the product of Reynolds number and Prandtl number.  St  Nu RePr |
| 16 | **Indicate the significance of boundary layer.** BTL2  In boundary layer concept the flow field over a body is divided into two regions: (i) A thin region near the body called the boundary layer where the velocity and the temperature gradients are large.  (ii) The region outside the boundary layer where the velocity and the temperature gradients are very nearly equal to their free stream values. |
| 17 | **An electrically heated plate dissipates heat by convection at a rate of 8000 W/m2 in to the ambient air at 25ºC. If the surface of the hot plate is at 125ºC, calculate the heat transfer coefficient for convection between the plate and air. (Nov 2018, Dec 2016, May 2013)**BTL 4.  Heat Transfer Q=hA(Tw-Tα), 8000= h x 1 (398-298) = 80 W/m2K. |

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| 18 | **Sketch the boundary development of a plate.** BTL 1  C:\Users\INTEL\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Word\New Doc 2018-07-21_1.jpg |
| 19 | **Define displacement thickness.** BTL 2  The displacement thickness is the distance, measured perpendicular to the boundary, by which the free stream is displaced on account of formation of boundary layer. |
| 20 | **Explain momentum thickness? (Dec 2019, May 2017, Dec 2016, May 2014)** BTL 2  The momentum thickness is defined as the distance through which the total loss of momentum per second is equal to if it were passing a stationary plate. |
| 21 | **Define energy thickness.** BTL 1  The energy thickness can be defined as the distance, measured perpendicular to the boundary of the solid body, by which the boundary should be displaced to compensate for the reduction in kinetic energy of the flowing fluid on account of boundary layer formation. |
| **Part-B & C** | |
| 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. **(13 M) *–* BTL5** |
| 2 | Air at 20C at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. if the plate is 1 m wide and 80C, calculate the following at x = 300 mm. 1. Hydrodynamic boundary layer thickness, 2. Thermal boundary layer thickness, 3. Local friction coefficient, 4.Average friction coefficient, 5. Local heat transfer coefficient, 6. Average heat transfer coefficient, 7. Heat transfer**. (13 M)BTL5** |
| 3 | Air at 30C, Flows over a flat plate at a velocity of 4 m/s. The plate measures 50  30 cm and is maintained at a uniform temperature of 90C. Compare the heat loss from the plate when the air flows (a) Parallel to 50 cm, (b) Parallel to 30 cm, Also calculate the percentage of heat loss. **(13 M) BTL5** |
| 4 | Air at 290C flows over a flat plate at a velocity of 6 m/s. The plate is 1m long and 0.5 m wide. The pressure of the air is 6 kN/m2. If the plate is maintained at a temperature of 70C, estimate the rate of heat removed from the plate. **(13 M)(Nov 2018, Dec 2016, May 2013)BTL5** |
| 5 | Air at 15C, 30 km/h flows over a cylinder of 400 mm diameter and 1500 mm height with surface temperature of 45C. Calculate the heat loss. **(13 M)(Dec 2019, May 2017, Dec 2016, May 2014) BTL5** |
| 6 | Air at 30C, 0.2 m/s flows across a 120W electric bulb at 130C. Find heat transfer and power lost due to convection if bulb diameter is 70 mm. **(13 M)(May 2019, Dec 2015) BTL5** |
| 7 | Air at 40C flows over a tube with a velocity of 30 m/s. The tube surface temperature is 120C. Calculate the heat transfer for the following cases. 1. Tube could be square with a side of 6 cm.2. Tube is circular cylinder of diameter 6 cm. **(13 M) BTL 5** |
| 8 | When 0.6 Kg of water per minute is passed through a tube of 2 cm diameter, it is found to be heated from 20C to 60C. The heating is achieved by condensing steam on the surface of the tube and subsequently the surface temperature of the tube is maintained at 90C. Determine the length of the tube required for fully developed flow. **(13 M) (Dec 2016) BTL5** |
| 9 | Water at 50C enters 50 mm diameter and 4 m long tube with a velocity of 0.8 m/s. The tube wall is maintained at a constant temperature of 90C. Determine the heat transfer coefficient and the total amount of heat transferred if exist water temperature is 70C. **(13 M) BTL5** |
| 10 | For a particular engine, the underside of the crank case can be idealized as a flat plat measuring 80 cm  20 cm. The engine runs at 80 km/hr and the crank case is cooled by air flowing past it at the same speed. Calculate the loss of heat from the crank case surface of temperature 75C to the ambient air temperature 25C. Assume the boundary layer becomes turbulent from the loading edge itself. **(15 M)(Nov 2018, Dec 2016, May 2013)BTL5** |
| 11 | A thin 100 cm long and 10 cm wide horizontal plate is maintained at a uniform temperature of 150ºC in a long tank full of water at 75ºC. Estimate the rate of heat to be supplied to the plate to maintain constant plate temperature as heat is dissipated from either side of the plate**. (15M) BTL4** |

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| **UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS** | |
| **PART \* A** | |
| **Q.No.** | **Questions** |
| 1. | **Define boiling.** BTL1  The change of phase from liquid to vapour state is known as boiling. |
| 2 | **What is meant by condensation?** BTL2  The change of phase from vapour to liquid state is known as condensation. |
| 3 | **Give the applications of boiling and condensation.** BTL2  Boiling and condensation process finds wide applications as mentioned below.   1. Thermal and nuclear power plant. 2. Refrigerating systems 3. Process of heating and cooling Air conditioning systems |
| 4 | **Define pool boiling.** BTL2  If heat is added to a liquid from a submerged solid surface, the boiling process referred to as pool boiling. In this case the liquid above the hot surface is essentially stagnant and its motion near the surface is due to free convection and mixing induced by bubble growth and detachment. |
| 5 | **What are the modes of condensation?** BTL2 There are two modes of condensation   1. Film wise condensation 2. Drop wise condensation |
| 6 | **What is meant by Film wise condensation?[(Dec 2016, May 2015)**BTL2  The liquid condensate wets the solid surface, spreads out and forms a continuous film over the entire surface is known as film wise condensation. |
| 7 | **Write short note on drop wise condensation. [April 2000 MU Oct 2000 MU]** BTL2  In drop wise condensation the vapour condenses into small liquid droplets of various sizes which fall down the surface in a random fashion. |
| 8 | **What is heat exchanger?** BTL2  A heat exchanger is defined as equipment which transfers the heat from a hot fluid to a cold fluid. |

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| 9 | **Give classifications of heat exchanger.**BTL2 The types of heat exchangers are as follows   1. Direct contact heat exchangers 2. Indirect contact heat exchangers 3. Surface heat exchangers 4. Parallel flow heat exchangers 5. Counter flow heat exchangers 6. Cross flow heat exchangers 7. Shell and tube heat exchangers 8. Compact heat exchangers. |
| 10 | **What is meant by Direct heat exchanger (or) open heat exchanger?** BTL2  In direct contact heat exchanger, the heat exchange takes place by direct mixing of hot and cold fluids. |
| 11 | **What is meant by Indirect contact heat exchanger?** BTL2  In this type of heat exchangers, the transfer of heat between two fluids could be carried out by transmission through a wall which separates the two fluids. |
| 12 | **What is meant by Regenerators?(Dec 2019, May 2017, Dec 2016, May 2014)** BTL2  In this type of heat exchangers, hot and cold fluids flow alternately through the same space. Examples: IC engines, gas turbines. |
| 13 | **Define recuperator (or) surface heat exchangers.**BTL2  This is the most common type of heat exchangers in which the hot and cold fluid do not come into direct contact with each other but are separated by a tube wall or a surface. |
| 14 | **What is meant by parallel flow heat exchanger?** BTL2  In this type of heat exchanger, hot and cold fluids move in the same direction. |
| 15 | **What is meant by counter flow heat exchanger?** BTL2  In this type of heat exchanger hot and cold fluids move in parallel but opposite directions. |
| 16 | **What is meant by cross flow heat exchanger?** BTL2  In this type of heat exchanger, hot and cold fluids move at right angles to each other. |
| 17 | **What is shell and tube heat exchanger?** BTL2  In this type of heat exchanger, one of the fluids move through a bundle of tubes enclosed by a shell. The other fluid is forced through the shell and it moves over the outside surface of the tubes. |

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| 18 | **Define compact heat exchangers. (Dec 2016, May 2015)** BTL2  There are many special purpose heat exchangers called compact heat exchangers. They are generally employed when convective heat transfer coefficient associated with one of the fluids is much smaller than that associated with the other fluid. |
| 19 | **What is meant by LMTD?** BTL2  We know that the temperature difference between the hot and cold fluids in the heat exchanger varies from point in addition various modes of heat transfer are involved. Therefore based on concept of appropriate mean temperature difference, also called logarithmic mean temperature difference, also called logarithmic mean temperature difference, the total heat transfer rate in the heat exchanger is expressed as  Q = U A (T)m , Where , U – Overall heat transfer coefficient W/m2K A – Area m2 , (T)m – Logarithmic mean temperature difference |
| 20 | **What is meant by Fouling factor?** BTL2  We know the surfaces of a heat exchangers do not remain clean after it has been in use for some time. The surfaces become fouled with scaling or deposits. The effect of these deposits the value of overall heat transfer coefficient. This effect is taken care of by introducing an additional thermal resistance called the fouling resistance. |
| **Part- B** | |
| 1 | Water is to be boiled at atmospheric pressure in a polished copper pan by means of an electric heater. The diameter of the pan is 0.38 m and is kept at 115C. Calculate the following, 1. Power required boiling the water, 2. Rate of evaporation, 3. Critical heat flux**. (13 M)BTL4** |
| 2 | 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**. (13 M) (Dec 2016) BTL4** |
| 3 | 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, The temperature difference is increased to 30C at a pressure of 10 atm, The pressure is raised to 20 atm at  T = 15C **(13 M) (Jun ’12) BTL4** |
| 4 | Dry saturated steam at a pressure of 3 bar, condenses on the surface of a vertical tube of height 1m. The tube surface temperature is kept at 110C. Calculate the following, 1. Thickness of the condensate film, 2. Local heat transfer coefficient at a distance of 0.25m**. (13 M) BTL4** |
| 5 | A vertical tube of 65 mm outside diameter and 1.5 m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 60C by circulating cold water through the tube. Calculate the following, 1. The rate of heat transfer to the coolant, 2. The rate of condensation of steam.**(13M) BTL4** |
| 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.1. The film thickness at the trailing edge,2. Overall heat transfer coefficient, 3. Heat transfer rate, 4. The condensate mass flow rate. Assume laminar flow conditions and unit width of the plate. **(13 M)(Dec 2019, May 2017, Dec 2016, May 2014)**BTL4 |
| 7 | A horizontal tube of outer diameter 2.2 cm is exposed to dry steam at 100C. The pipe surface is maintained at 62C by circulating water through it. Calculate the rate of formation of condensate per meter length of the pipe**.(13 M)** BTL4 |
| 8 | In a counter flow double pipe heat exchanger, oil is cooled from 85C to 55C by water entering at 25C. The mass flow rate of oil is 9,800 kg/h and specific heat of oil is 2000 j/kg K. the mass flow rate of water is 8,000 kg/h and specific heat of water is 4180 j/kg K. Determine the heat exchanger area and heat transfer rate for an overall heat transfer coefficient of 280 W/m2 K. **(13 M)(Dec 2016)** BTL4. |
| 9 | 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**. (15 M)(Dec 2016)** BTL4 |
| 10 | A heating element cladded with metal is 8 mm diameter and of emissivity is 0.92. The element is horizontally immersed in a water bath. The surface temperature of the metal is 260C under steady state boiling conditions. Calculate the power dissipation per unit length for the heater**. (15 M)(Dec 2016)** BTL4 |
| 11 | 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.   1. Film thickness at a distance of 25 cm from the top of the plate. 2. Local heat transfer coefficient at a distance of 25 cm from the top of the plate. 3. Average heat transfer coefficient. 4. Total heat transfer 5. Total steam condensation rate. 6. What would be the heat transfer coefficient if the plate is inclined at 30C with horizontal plane.**(15 M)-**BTL4 |

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| **UNIT IV RADIATION** | |
| **PART \* A** | |
| **Q.No.** | **Questions** |
| 1 | **Define Radiation.** BTL1  The heat transfer from one body to another without any transmitting medium is known as radiation. It is an electromagnetic wave phenomenon. |
| 2 | **Define emissive power [E].(Nov 2018, Dec 2016, May 2013)**BTL1  The emissive power is defined as the total amount of radiation emitted by a body per unit time and unit area. It is expressed in W/m2. |
| 3 | **Define monochromatic emissive power. [Eb****]** BTL1  The energy emitted by the surface at a given length per unit time per unit area in all directions is known as monochromatic emissive power. |
| 4 | **What is meant by absorptivity?** BTL2  Absorptivity is defined as the ratio between radiation absorbed and incident radiation.  Absorptivity (α) = Radiation absorbed  Incident radiation |
| 5 | **What is meant by reflectivity?** BTL2  Reflectivity is defined as the ratio of radiation reflected to the incident radiation.  Reflectivity (γ) = Radiation Reelection  Incident radiation |
| 6 | **What is meant by Transmissivity?** BTL2  Transmissivity is defined as the ratio of radiation transmitted to the incident radiation.  Transmissivity (τ) = Radiation Transmission  Incident radiation |
| 7 | **What is black body? [April.97, April 99]** BTL2  Black body is an ideal surface having the following properties.  1. A black body absorbs all incident radiation, regardless of wave length and direction.  2. For a prescribed temperature and wave length, no surface can emit more energy than black body. |

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| 8 | **State Planck’s distribution law. (Dec 2019, May 2017, Dec 2016, May 2014)**BTL2  The relationship between the monochromatic emissive power of a black body and wave length of a radiation at a particular temperature is given by the following expression, by Planck.  C  5  Eb  1   C2    T   e  1  Where Eb = Monochromatic emissive power W/m2   = Wave length – m  c1 = 0.374  10-15 W m2 c2 = 14.4  10-3mK |
| 9 | **State Wien’s displacement law.** BTL2  The Wien’s law gives the relationship between temperature and wave length corresponding to the maximum spectral emissive power of the black body at that temperature.   mas T = c3  Where c3 = 2.9  10-3 [Radiation constant]    mas T = 2.9  10 mK  -3 |
| 10 | **State Stefan – Boltzmann law. [April 2002]** BTL2  The emissive power of a black body is proportional to the fourth power of absolute temperature.  Eb  T  4  Eb =  T  4  2  Where Eb = Emissive power, w/m   = Stefan. Boltzmann constant  = 5.67  10-8 W/m2 K4  T = Temperature, K |
| 11 | **Define Emissivity. [Oct. 2000, April 2002]** BTL1  It is defined as the ability of the surface of a body to radiate heat. It is also defined as the ratio of emissive power of any body to the emissive power of a black body of equal temperature.  Emissivity   E/ Eb |

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| 12 | **What is meant by gray body? [April, 2000, 2002]** BTL2  If a body absorbs a definite percentage of incident radiation irrespective of their wave length, the body is known as gray body. The emissive power of a gray body is always less than that of the black body. |
| 13 | **State Kirchoff’s law of radiation. [April 2001]** BTL2  This law states that the ratio of total emissive power to the absorbtivity is constant for all surfaces which are in thermal equilibrium with the surroundings. This can be written as  E1  E2  E3 ,  1 2 3  It also states that the emissivity of the body is always equal to its absorptivity when the body remains in thermal equilibrium with its surroundings.  1 = E1; 2 = E2 and so on. |
| 14 | **Define intensity of radiation (Ib). [Nov. 96, Oct. 98, 99]** BTL1  It is defined as the rate of energy leaving a space in a given direction per unit solid angle per unit area of the emitting surface normal to the mean direction in space.  I  Eb  n  |
| 15 | **State Lambert’s cosine law.** BTL1  It states that the total emissive power Eb from a radiating plane surface in any direction proportional to the cosine of the angle of emission  Eb cos |
| 16 | **What is the purpose of radiation shield? [Apr. 2012,Apr.2013]** BTL2  Radiation shields constructed from low emissivity (high reflective) materials. It is used to reduce the net radiation transfer between two surfaces. |
| 17 | **Define irradiation (G) [Nov. 17]** BTL1  It is defined as the total radiation incident upon a surface per unit time per unit area. It is expressed in W/m2. |
| 18 | **What is radiosity (J)? [April 2016]** BTL2  It is used to indicate the total radiation leaving a surface per unit time per unit area. It is expressed in W/m2. |

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| 19 | **What is meant by shape factor? (Dec 2016, May 2015)**BTL2  The shape factor is defined as the fraction of the radiative energy that is diffused from on surface element and strikes the other surface directly with no intervening reflections. It is represented by Fij. Other names for radiation shape factor are view factor, angle factor and configuration factor. |
| 20 | **What are the assumptions made to calculate radiation exchange between the surfaces?**  BTL2   1. All surfaces are considered to be either black or gray 2. Radiation and reflection process are assumed to be diffuse. 3. The absorptivity of a surface is taken equal to its emissivity and independent of temperature of the source of the incident radiation. |
| **Part\*B** | |
| 1 | A black body at 3000 K emits radiation. Calculate the following:   1. Monochromatic emissive power at 7 m wave length. 2. Wave length at which emission is maximum. 3. Maximum emissive power. 4. Total emissive power,   Calculate the total emissive of the furnace if it is assumed as a real surface having emissivity equal to 0.85. **(Nov 2018, Dec 2016, May 2013)(13 M)**BTL4 |
| 2 | A black body of 1200 cm2 emits radiation at 1000 K. Calculate the following:   1. Total rate of energy emission 2. Intensity of normal radiation 3. Wave length of maximum monochromatic emissive power.   Intensity of radiation along a direction at 60 to the normal**. (13 M)**BTL4 |
| 3 | Assuming sun to be black body emitting radiation at 6000 K at a mean distance of 12   1010 m from the earth. The diameter of the sun is 1.5  109 m and that of the earth is  13.2 x 106 m. Calculation the following. (i) Total energy emitted by the sun, (ii) The emission received per m2 just outside the earth’s atmosphere, (iii) The total energy received by the earth if no radiation is blocked by the earth’s atmosphere, (iv) The energy received by a 2  2 m solar collector whose normal is inclined at 45 to the sun. The energy loss through the atmosphere is 50% and the diffuse radiation is 20% of direct radiation**.(13 M) (Dec 2019, May 2017, Dec 2016, May 2014)BTL4** |
| 4 | A furnace wall emits radiation at 2000 K. Treating it as black body radiation, calculate,  (i) Monochromatic radiant flux density at 1m wave length, (ii) Wave length at which emission is maximum and the corresponding emissive power., (iii) Total emissive power  **(13 M)**BTL4 |
| 5 | The temperature of a black surface 0.25 m2 of area is 650C. Calculate, (i) 1. The total rate of energy emission, (ii) 2. The intensity of normal radiation, (iii) The wavelength of maximum monochromatic emissive power. **(13 M)**BTL4 |
| 6 | The sun emits maximum radiation at  = 0.52. Assuming the sun to be a black body, calculate the surface temperature of the sun. Also calculate the monochromatic emissive power of the sun’s surface. **(Dec 2016, May 2015)(15 M)**BTL4 |
| 7 | Two concentric spheres 30 cm and 40 cm in diameter with the space between them evacuated are used to store liquid air at - 130C in a room at 25C. The surfaces of the spheres are flushed with aluminium of emissivity  = 0.05. Calculate the rate of evaporation of liquid air if the latent heat of vaporization of liquid air is 220 kJ/kg.**(15 M)(Dec 2019, May 2017, Dec 2016, May 2014)**BTL4 |
| 8 | Emissivities 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 square meter of the plates. If a polished aluminium shield ( = 0.05) is placed between them. Find the percentage of reduction in heat transfer**. (15 M) (May 17)** BTL4 |
| 9 | The inner sphere of liquid oxygen container is 40 cm diameter and outer sphere is 50 cm diameter. Both have emissivities 0.05. Determine the rate at which the liquid oxygen would evaporate at -183C when the outer sphere at 20C. Latent heat of oxygen is 210 kJ/kg**.(15 M) May 2**BTL4 |

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| **UNIT V MASS TRANSFER** | |
| **PART \* A** | |
| **Q.No.** | **Questions** |
| 1 | **What is mass transfer?** BTL2  The process of transfer of mass as a result of the species concentration difference in a mixture is known as mass transfer. |
| 2 | **Give the examples of mass transfer.** BTL3 Some examples of mass transfer.   1. Humidification of air in cooling tower 2. Evaporation of petrol in the carburetor of an IC engine. 3. The transfer of water vapour into dry air. |
| 3 | **What are the modes of mass transfer?** BTL2 There are basically two modes of mass transfer,   1. Diffusion mass transfer 2. Convective mass transfer |
| 4 | **What is molecular diffusion? (Jun ’13)** BTL2  The transport of water on a microscopic level as a result of diffusion from a region of higher concentration to a region of lower concentration in a mixture of liquids or gases is known as molecular diffusion. |
| 5 | **What is Eddy diffusion?** BTL2  When one of the diffusion fluids is in turbulent motion, eddy diffusion takes place. |
| 6 | **What is convective mass transfer?** BTL2  Convective mass transfer is a process of mass transfer that will occur between surface and a fluid medium when they are at different concentration. |
| 7 | **State Fick’s law of diffusion. (AU June 06, May’05).**BTL2  The diffusion rate is given by the Fick’s law, which states that molar flux of an element per unit area is directly proportional to concentration gradient. |

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| 8 | **What is free convective mass transfer?** BTL2  If the fluid motion is produced due to change in density resulting from concentration gradients, the mode of mass transfer is said to be free or natural convective mass transfer.  Example : Evaporation of alcohol. |
| 9 | **Define forced convective mass transfer.** BTL1  If the fluid motion is artificially created by means of an external force like a blower or fan, that type of mass transfer is known as convective mass transfer.  Example: The evaluation if water from an ocean when air blows over it. |
| 10 | **Define Schmidt Number.** BTL1  It is defined as the ratio of the molecular diffusivity of momentum to the molecular diffusivity of mass.  Sc  Molecular diffusivity of momentum Molecular diffusivity of mass |
| 11 | **Define Scherwood Number.** BTL1  It is defined as the ratio of concentration gradients at the boundary.  Sc  hmx  Dab  hm  Mass transfer coefficient, m/s  Dab  Diffusion coefficient, m / s  2  x  Length, m |
| 12 | **Give two examples of convective mass transfer.** BTL3.  Evaporation of alcohol, Evaporation of water from an ocean when air blows over it. |
| 13 | **Define Mass concentration and molar concentration.** BTL 1  Mass Concentration = Mass of component/Unit volume of mixture  Molar Concentration = Number of moles of component/ Unit volume of mixture. |
| 14 | **Define mass fraction and molar fraction.** BTL 1  Mass fraction=Mass concentration of a species/ Total mass density  Molar fraction = Mole concentration of a species/ Total molar concentration. |

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| **Part \* B** | |
| 1 | Explain steady diffusion through a plane membrane.(**13 M)(Dec 2016)** BTL2 |
| 2 | Helium diffuses through a plane membrane of 2 mm thick. At the inner side the concentration of helium is 0.25 kg mole/m3. At the outer side the concentration of helium is 0.007 kg mole/m3. What is the diffusion flux of helium through the membrane. Assume diffusion coefficient of helium with respect to plastic is 1  10-9 m2/s**. (Nov 2018, Dec 2016, May 2013)(8 M)**BTL4 |
| 3 | Gaseous hydrogen is stored in a rectangular container. The walls of the container are of steel having 25 mm thickness. At the inner surface of the container, the molar concentration of hydrogen in the steel is 1.2 kg mole/m3 while at the outer surface of the container the molar concentration is zero, calculate the molar diffusion flux for hydrogen through the steel. Take diffusion coefficient for hydrogen in steel is 0.24  10-12 m2/s. **(15 M)**BTL4 |
| 4 | 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 m2/s and the solubility of O2 in rubber is 3.12  10-3 kg  mole . Find the loss of O2 by diffusion per  m3  bar  metre length of pipe. **(13 M)**BTL4 |
| 5 | Determine the diffusion rate of water from the bottom of a test tube of 25 mm diameter and 35 mm long into dry air at 25C. Take diffusion coefficient of water in air is 0.28  10-4 m2/s. **(13 M)(Nov 2018, Dec 2016, May 2013)**BTL4 |
| 6 | Estimate the rate of diffusion of water vapour from a pool of water at the bottom of a well which is 6.2 m deep and 2.2 m diameter to dry ambient air over the top of the well. The entire system may be assumed at 30C and one atmospheric pressure. The diffusion coefficient is 0.24  10-4 m2/s. **(13 M)**BTL4 |
| 7 | Explain FICK’s Law of Diffusion. **(15 M)**BTL2 |
| 8 | 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 m2/s. The solubility of hydrogen in the membrane is 2.1  10-3 kg mole / m3 bar An uniform temperature condition of 20 Cis assumed**. (15 M)**BTL4 |
| 9 | Explain steady state Equimolar counter diffusion**. (15 M)**BTL2 |
| 10 | Ammonia and air in equimolar counter diffusion in a cylindrical tube of 2.5 mm diameter and 15m length. The total pressure is 1 atmosphere and the temperature is 25C. One end of the tube is connected to a large reservoir of ammonia and the other end of the tube is open to atmosphere. If the mass diffusivity for the mixture is 0.28  10-4 m2/s. Calculate the following,  a) Mass rate of ammonia in kg/h, b) Mass rate of air in kg/h. **(15 M)**BTL4 |