Determine the rate of heat exchange. Take c_p of oil as 2131 J/kgK and that of sea water as 4178 J/kgK.

Q.6	i.	List any three salient features of a black body.	**3**
	ii.	A room is 3 m by 4.8 m with a 2.4 m high ceiling. The ceiling contains heating elements and may be assumed as a black body. What percentage of the radiant energy leaving the ceiling strikes all four walls?	**7**
OR	iii.	Explain and derive Kirchoff's law. Support your answer with suitable diagram.	**7**

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Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No.....

Faculty of Engineering

End Sem (Odd) Examination Dec-2019

ME3CO13 Heat and Mass Transfer

Programme: B.Tech. Branch/Specialisation: ME

Duration: 3 Hrs. **Maximum Marks: 60**

Note: 1. All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.
2. Use of Heat and Mass Transfer data-book permitted.

Q.1	i.	For a current carrying electrical wire, the insulation is purposely kept at (a) Half the value of critical radius (b) Equal to the value of critical radius (c) Double the value of critical radius (d) Critical radius does not play any role here.	**1**
	ii.	For successful implementation of Lumped parameter analysis, the essential condition is (a) Bi > 100 (b) Bi < 0.1 (c) Bi = Fo (d) None of these	**1**
	iii.	The fins attached to a surface are having effectiveness of 0.9. The rate of heat transfer from the surface as a result of addition of these fins (a) Remains the same (b) Becomes negligible (c) Decreases (d) Increases	**1**
	iv.	In order to achieve maximum heat dissipation, the fin should be designed in such a way that has a (a) Maximum lateral surface towards the tip side of fin (b) Minimum lateral surface near the center line (c) Maximum lateral surface at the root side of fin (d) Maximum lateral surface near the center of fin	**1**
	v.	Free convection flow depends on all of the following except (a) Density (b) Coefficient of viscosity (c) Gravitational force (d) Velocity	**1**

P.T.O.

vi. The dimensions of heat transfer coefficient in HMLT θ dimensions are **1**
(a) HLT θ (b) $HL^{-2}T^{-1}\theta^{-1}$ (c) $HML^{2}\theta$ (d) $ML^{-1}T^{-1}$

vii. In a condenser, the temperature of **1**
(a) Colder fluid is assumed constant
(b) Hotter fluid is assumed constant
(c) Both fluids are assumed constant
(d) Both fluids varies

viii. Counter flow shell and tube heat exchangers fall under which category? **1**
(a) Regenerators
(b) Recuperators
(c) Direct contact heat exchangers
(d) None of these

ix. For a perfectly black body, the values of absorptivity, reflectivity and transmissivity are **1**
(a) 1, 0 and 0 respectively (b) 0, 1 and 0 respectively
(c) 0, 0 and 1 respectively (d) 0.33 each

x. Which parameter should be highest for a radiation shield? **1**
(a) Absorptivity (b) Reflectivity
(c) Transmissivity (d) Emissivity

Q.2 i. Define thermal diffusivity. **2**

ii. A 100 mm diameter pipe carrying a hot chemical at 250ºC is covered with two layers of insulation, each 50 mm thick. The length of the pipe is 5 m. The outer surface temperature of the composite is 35ºC. The rate of heat loss through the pipe is 270 W. If the thickness of the outer insulation is increased by 25%, the heat loss is reduced to 260 W. Calculate the thermal conductivities of both insulating materials. Ignore the effect of convective environment on inner and outer sides. **8**

OR iii. A steel strip (ρ = 7900 kg/m^3, C_p = 0.64 kJ/kgK, and k = 30 W/mK), of characteristic length 2.475 mm, coming out of a rolling mill is passed through a cooling chamber maintained at 50ºC. How long should the strip stay in the chamber so as to attain a temperature of 100ºC. Take initial temperature of strip as 300ºC. The surface heat transfer coefficient is 95 W/m^{2}K. **8**

Q.3 i. Define fin efficiency. **2**

ii. Derive the expression for heat dissipation through a fin of finite length, and not insulated at tip. Also provide the temperature distribution for such arrangement. Support your answer with suitable diagram. **8**

OR iii. Two long rods of the same diameter, one made of copper (k = 375 W/mK) and other of brass (k = 85W/mK), have an end inserted into a hot surface. At a section 22.05 cm away from the surface in copper rod, the temperature is 120ºC. At what distance from the same surface, the same temperature would be reached in brass rod? Both rods are exposed to same environment. **8**

Q.4 i. How is the number of π terms decided in Buckingham –pi procedure of dimensional analysis? **2**

ii. A car is travelling at a steady speed of 108 km/h in ambient air temperature of 18ºC. The hood of the vehicle may be approximated as a 1.2 m square plate. Determine the average heat transfer coefficient. The hood of the vehicle is at 42ºC. **8**

OR iii. Describe the significance of following dimensionless numbers in convection problems **8**
(a) Reynolds Number (b) Prandtl Number
(c) Grashoff Number (d) Nusselt Number

Q.5 i. Define Equimolar diffusion. **2**

ii. Derive the expression for LMTD for counter flow shell and tube heat exchanger. Support your answer with suitable diagrams. What is the advantage of counter flow heat exchangers over parallel flow heat exchangers? **8**

OR iii. A parallel flow heat exchanger is to be used to cool oil (0.25 kg/s at 115ºC), using sea water (0.5 kg/s at 15ºC). The area of the heat exchanger is 11.5 m^2 and overall heat transfer coefficient is 36.5 W/m^{2}K. **8**

Marking Scheme
ME3CO13 Heat and Mass Transfer

Q.1 i. For a current carrying electrical wire, the insulation is purposely kept at **1**
(b) Equal to the value of critical radius

ii. For successful implementation of Lumped parameter analysis, the essential condition is **1**
(b) $Bi < 0.1$

iii. The fins attached to a surface are having effectiveness of 0.9. The rate of heat transfer from the surface as a result of addition of these fins **1**
(c) Decreases

iv. In order to achieve maximum heat dissipation, the fin should be designed in such a way that has a **1**
(c) Maximum lateral surface at the root side of fin

v. Free convection flow depends on all of the following except **1**
(d) Velocity

vi. The dimensions of heat transfer coefficient in HMLT θ dimensions are **1**
(b) $HL^{-2}T^{-1}\theta^{-1}$

vii. In a condenser, the temperature of **1**
(b) Hotter fluid is assumed constant

viii. Counter flow shell and tube heat exchangers fall under which category? **1**
(b) Recuperators

ix. For a perfectly black body, the values of absorptivity, reflectivity and transmissivity are **1**
(a) 1, 0 and 0 respectively

x. Which parameter should be highest for a radiation shield? **1**
(b) Reflectivity

Q.2 i. Definition thermal diffusivity **2**

ii. Calculate the thermal conductivities of both insulating materials **8**
Formulation of two equation with two unknowns 4 marks
Calculation of both 2 marks for each (2 marks *2) 4 marks

OR iii. How long should the strip stay in the chamber so as to attain a temperature of 100ºC. **8**
Stepwise marking

Q.3 i. Definition of fin efficiency. **2**

ii. Expression for heat dissipation through a fin of finite length **8**
Diagram 1 mark
Implementing boundary conditions 2 marks
Derivation 2 marks
Temp distribution 1 mark
Expression for heat transfer 2 marks

OR iii. At what distance from the same surface, the same temperature would be reached in brass rod? **8**
Stepwise marking

Q.4 i. How is the number of π terms decided in Buckingham –pi procedure of dimensional analysis? **2**
Comment regarding subtraction of recurring and non recurring variables

ii. Determine the average heat transfer coefficient. **8**
Identifying the problem as forced convection 1 marks
Applying suitable formulae 2 marks
Air properties at mean temp 2 marks
$H=69.45\ W/m^2K$ approx.. 3 marks

OR iii. Describe the significance of following dimensionless numbers in convection problems 2 marks for each (2 marks * 4) **8**

Q.5 i. Definition of Equimolar diffusion. **2**

ii. Derive the expression for LMTD for counter flow shell and tube heat exchanger. **8**
Diagram 1 mark
Derivation 6 marks
Comment on last part 1 mark

OR iii. Heat capacity ratio = 0.255 2 marks **8**
NTU = 0.788 2 marks
Effectiveness = 0.5 2 marks
Q= 26637.5 W 2 marks

Q.6 i. Any three salient features of a black body **3**
1 mark for each (1 mark * 3)

ii. Calculation of four shape factors 4 marks **7**
Percentage 3 marks

OR iii. Kirchoff's law. **7**
Diagram 2 marks
Derivation 5 marks

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