OR iii. Derive the expression for effectiveness of a counter flow heat exchanger, in terms of capacity ratio and number of heat transfer units. **7**

Q.6 i. Write a short note on Stefan-Boltzman Law, stating the expression and also the value of radiation constant. **3**

ii. A small black body has a total emissive power of 4.5 kW/m^2. Determine its surface temperature and the wavelength at which the emissive power would be maximum. Also state that in which range of spectrum does this wavelength will fall. **7**

OR iii. Describe shape factor algebra with the help of its salient features and also describe various computation rules. **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-2018

ME3CO13 Heat and Mass Transfer

Programme: B.Tech. Branch/Specialisation: ME

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

Note: (i) 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.

(ii) Use of Heat and Mass Transfer data book is permitted.

Q.1 i. The units of thermal resistance are **1**

(a) deg-m/W (b) deg/W (c) m^2/deg-W (d) m/deg-W

ii. The critical radius of insulation for a sphere is given by **1**

(a) k/h_o (b) $2k/h_o$ (c) $3k/h_o$ (d) $4k/h_o$

iii. The ratio of the fin heat transfer rate to the heat transfer rate with no fin at all is known as **1**

(a) Fin index (b) Characteristic length

(c) Fin effectiveness (d) None of these

iv. The heat transfer or heat dissipation through a fin does not depend on **1**

(a) Perimeter

(b) Convective heat coefficient

(c) Conductivity of fin material

(d) Mass of fin

v. The Nusselt number is given by **1**

(a) hl/k (b) hk/l (c) kl/h (d) k/hl

vi. Prandtl number is independent of **1**

(a) Dynamic viscosity (b) Specific heat

(c) Thermal conductivity (d) Depends on all three

	vii.	In an evaporator, the temperature of (a) Colder fluid is assumed constant (b) Hotter fluid is assumed constant (c) Both fluids are assumed constant (d) Both fluids varies	**1**
	viii.	The heat transfer rate in a heat exchanger is directly proportional to (a) Arithmetic mean temperature difference (b) Logarithmic mean temperature difference (c) Exponential mean temperature difference (d) Harmonic mean temperature difference	**1**
	ix.	According to Kirchoff's law, emissivity is equal to (a) Transmissivity (b) Reflectivity (c) Absorptivity (d) None of these	**1**
	x.	A perfectly black body (a) Absorbs all the incident radiations (b) Reflects all the incident radiations (c) Allows all the incident radiations to pass through (d) Is necessarily coated with graphite.	**1**
Q.2	i.	What is the utility of critical thickness of insulation in case of insulation sheeting of electrical wires carrying high current?	**2**
	ii.	An industrial freezer is designed to operate with an internal air temperature of -20°C, when the ambient air is at 25°C. The internal and external heat transfer coefficients are 12 W/m^2-deg and 8 W/m^2-deg, respectively. The wall of the freezer consists of an inner layer of plastic (k = 1 W/m-deg and 3 mm thick) and an outer layer of steel (k = 16 W/m-deg and 1 mm thick). A layer of insulation material (k= 0.07 W/m-deg) is sandwiched between these two layers. Find the thickness of insulation required if the heat transfer through walls is 15 W/m^2.	**8**
OR	iii.	Give a detailed explanation and derivation of temperature distribution by Lumped parameter analysis. Also state that in which conditions should it be carried out, and what check should be performed before applying this analysis. Finally describe the utility of time constant hence derived.	**8**

Q.3	i.	Is it advisable to provide fins of excessive lengths for enhancing heat transfer from a surface subjected to high temperatures? Justify your answer by proper reasoning.	**2**
	ii.	A steel fin, whose conductivity is 54 W/m-deg, has a cross section of an equilateral triangle, with 5 mm side and 100 mm length. It is attached to a plane wall maintained at 400°C. the ambient air temperature is 50°C and convective coefficient is 90 W/m^2-deg. Calculate the heat dissipation rate by the fin, considering it as very long.	**8**
OR	iii.	Derive the expression for temperature distribution and total heat transfer from a fin of finite length and insulated at tip, along with suitable diagrams.	**8**
Q.4	i.	Define free and forced convection, with examples.	**2**
	ii.	Show by dimensional analysis that data for forced convection may be correlated by an equation of the form: $Nu = f\,(Re, Pr)$ Where Nusselt number, Reynolds number and Prandtl number have usual formulae. Use Buckingham's Pi theorem and M-L-T-θ-H dimensions.	**8**
OR	iii.	Estimate the heat transfer from a 40 W bulb, which may be assumed as 50 mm diameter sphere at 130°C, to 20°C ambient air. What percentage of power is lost by the free convection?	**8**
Q.5	i.	Briefly explain Fick's Law for mass transfer. Support your answer with diagram.	**3**
	ii.	In a condenser, 8 kg/s of a certain fluid is condensed liberating 600 kJ/kg of latent heat. The cooling water is available at 15°C at a flow rate of 60 kg/s. The saturation temperature of the fluid to be condensed is 80°C. The overall heat transfer coefficient is 480 W/m^2-deg. Determine the number of tubes required in the condenser for heat exchange, if a single tube has an outer diameter of 25 mm and 4.85 m length.	**7**

Marking Scheme
ME3CO13 Heat and Mass Transfer

Q.1	i.	The units of thermal resistance are (b) deg/W		1
	ii.	The critical radius of insulation for a sphere is given by (b) $2k/h_o$		1
	iii.	The ratio of the fin heat transfer rate to the heat transfer rate with no fin at all is known as (c) Fin effectiveness		1
	iv.	The heat transfer or heat dissipation through a fin does not depend on (d) Mass of fin		1
	v.	The Nusselt number is given by (a) hl/k		1
	vi.	Prandtl number is independent of (d) Depends on all three		1
	vii.	In an evaporator, the temperature of (a) Colder fluid is assumed constant		1
	viii.	The heat transfer rate in a heat exchanger is directly proportional to (b) Logarithmic mean temperature difference		1
	ix.	According to Kirchoff's law, emissivity is equal to (c) Absorptivity		1
	x.	A perfectly black body (a) Absorbs all the incident radiations.		1
Q.2	i.	Utility of critical thickness of insulation Formula		2
	ii.	Diagram	1 mark	8
		Electrical analogy	1 mark	
		Fourier's law one dimension equation	2 marks	
		Computation and result : 195 mm	4 marks	
OR	iii.	Diagram	1 mark	8
		Derivation	4 marks	
		Condition for applying this analysis	1 mark	
		Check for application by Biot number	1 mark	
		Utility of time constant	1 mark	
Q.3	i.	Comment: No it is not advisable, as most of the heat transfer occurs near to the base temperature.	1 mark	2
		Reason with either diagram or mathematical expression	1 mark	
	ii.	Calculation of area and perimeter: 1.0825×10^{-5} m^2 and 0.015 m respectively	2 marks	8
		$m = 48.06\ m^{-1}$	2 marks	
		Applying appropriate formulae for infinitely long fin	2 marks	
		Q = 9.82 W	2 marks	
OR	iii.	Diagram	2 marks	8
		Derivation of general equation	2 marks	
		Applying correct boundary conditions	2 marks	
		Derivation of temp distribution and Q_{total}	2 marks	
Q.4	i.	Definition of free convection, with eg	2 marks	2
		Definition of free convection, with eg	2 marks	
	ii.	Formulation of a combined function involving parameters of all three numbers	2 marks	8
		Finalizing no. of π terms (i.e 3) and repeated variables	2 marks	
		Computation of each π term	2 marks	
		Reorganising the functional relationship and deriving the expected expression	2 marks	
OR	iii.	Calculation of mean temperature i.e 75°C, and for the same finding out various thermophysical properties of air like	4 marks	8
		$\nu = 20.55 \times 10^{-6}\ m^2/s$ k = 0.03W/m-deg Pr = 0.693 $\beta = 2.87 \times 10^{-3}$ per deg		
		Applying appropriate formulae of Nusselt number	2 marks	
		Calculation of h ≈ 9.823 W/m^2 deg approx.	1 mark	
		Calculation of heat transfer and hence the loss = 19.28%	1 mark	

Q.5	i.	Fick's law statement	2 marks	**3**
		Diagram	1 mark	
	ii.	Diagram of temp distribution	1 mark	**7**
		Calculation of $T_{co} = 34.11°C$	2 marks	
		Calculation of LMTD , $\theta_m = 54.91°C$	2 marks	
		No. of tubes = 478 approx	2 marks	
OR	iii.	Diagram	1 mark	**7**
		Derivation	4 marks	
		Final expression	2 marks	
Q.6	i.	Statement and mathematical expression	2 marks	**3**
		Value of σ	1 mark	
	ii.	Calculation of T = 530.77 K	3 marks	**7**
		Applying Wien's displacement law $\lambda_{max} = 5.46\ \mu m$	3 marks	
		Range: infrared region	1 mark	
OR	iii.	Aprrox 4-5 rules of radiation shape factor algebra		**7**

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