			Marks	BL	PO	CO	PSO
OR	iii.	A steel rod (k = 30 W/m-deg) 1 cm in diameter and 5 cm long protrudes from a wall which is maintained at 100°C.The rod is insulated at its tip and is exposed to an environment with h = 50 W/m^2-deg and t_a = 30°C. Calculate the fin efficiency, temperature at the tip of fin and the rate of heat dissipation.	**8**	4	3	3	3
Q.5	i.	Explain Fick's law of diffusion.	**2**	1	2	4	2
	ii.	What is the limitation of LMTD method? How effectiveness – NTU method superior to it.	**3**	1	3	4	2
	iii.	A heat exchanger is to be designed to condense 8 kg/s of an organic liquid (t_{sat} = 80°C ; h_{fg} = 600 kJ/kg) with cooling water available at 15°C and at a flow rate of 60 kg/s. The overall heat transfer coefficient is 480 W/m^2-deg. Calculate the number of tubes required. The tubes are to be of 25 mm outer diameter, 2 mm thickness and 4.85 m length.	**5**	4	3	4	3
OR	iv.	Derive the expression for the LMTD for the parallel flow arrangement.	**5**	3	2	4	2
Q.6	i.	What is mean by fouling factor? How does it affect the performance of a heat exchanger?	**4**	2	2	5	3
	ii.	A black body of total area 0.045 m^2 is completely enclosed in a space bounded by 5 cm thick walls. The walls have a surface area 0.5 m^2 and thermal conductivity 1.07 W/m-deg. If the inner surface of the enveloping wall is to be maintained at 215°C and the outer wall surface is at 30°C, calculate the temperature of the black body. Neglect the difference between inner and outer surface areas of enveloping material.	**6**	4	3	5	2
OR	iii.	The flat floor of a hemispherical furnace is at 800 K and has an emissivity of 0.5. The corresponding values for the hemispherical roof are 1200 K and 0.25. Determine the net radiation heat transfer from the roof to floor.	**6**	4	3	5	2

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

Enrollment No......................................

Faculty of Engineering
End Sem Examination Dec 2024
ME3CO32 Heat & Mass Transfer

Programme: B.Tech. Branch/Specialisation: ME

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

Note: 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. Assume suitable data if necessary. Notations and symbols have their usual meaning.

			Marks	BL	PO	CO	PSO
Q.1	i.	A composite plane wall is made up of two different materials of the same thickness and having thermal conductivities of k1 and k2 respectively. The equivalent thermal conductivity of the slab is: (a) k1 + k2 (b) k1 k2 (c) (k1 + k2) / k1 k2 (d) 2 k1 k2 / (k1 + k2)	**1**	1	1	1	3
	ii.	Heat is conducted through a 10 cm thick wall at the rate of 30 W/m^2 when the temperature difference across the wall is 10°C. What is the thermal conductivity of the wall? (a) 0.03 W/mK (b) 0.3 W/mK (c) 3.0 W/mK (d) 30.0 W/mK	**1**	2	1	1	3
	iii.	The ratio of energy transferred by convection to that by conduction is called- (a) Stanton number (b) Nusselt number (c) Biot number (d) Preclet number	**1**	1	2	2	2
	iv.	Air at 20°C blows over a hot plate of 50 × 60 cm made of carbon steel maintained at 220°C. The convective heat transfer coefficient is 25 W/m^2K. What will be the heat loss from the plate? (a) 1500W (b) 2500 W (c) 3000 W (d) 4000 W	**1**	2	3	2	3
	v.	Which one of the following is correct?	**1**	1	1	3	3

The effectiveness of a fin will be maximum in an environment with
(a) Free convection
(b) Forced convection
(c) Radiation
(d) Convection and radiation

vi. Addition of fin to the surface increases the heat transfer if hA/KP is: **1** 2 2 3 3
(a) Equal to one
(b) Greater than one
(c) Less than one
(d) Greater than one but less than two

vii. In a heat exchanger, the hot liquid enters with a temperature of 180ºC and leaves at 160ºC. The cooling fluid enters at 30ºC and leaves at 110ºC. The capacity ratio of the heat exchanger is: **1** 2 3 4 2
(a) 0.25 (b) 0.40
(c) 0.50 (d) 0.55

viii. In case of liquids, what is the binary diffusion coefficient proportional to? **1** 1 2 4 3
(a) Pressure only (b) Temperature only
(c) Volume only (d) All of these

ix. In radiative heat transfer, a gray surface is one- **1** 1 1 5 3
(a) Which appears gray to the eye
(b) Whose emissivity is independent of wavelength
(c) Which has reflectivity equal to zero
(d) Which appears equally bright from all directions.

x. If the temperature of a solid state changes from 27°C to 627°C, then emissive power changes which rate? **1** 2 3 5 2
(a) 6 : 1 (b) 9 : 1
(c) 27 : 1 (d) 81: 1

Q.2 i. Explain critical thickness of insulation taking example of steam carrying pipe. **4** 3 3 1 3

ii. A furnace wall is a made up of steel plate 10 mm thick (k = 62.8 kJ/m-hr-deg) lined on inside with

silica bricks 150 mm thick (k = 7.32 kJ/m-hr-deg) and on the outside with magnesia bricks 200 mm thick (k = 18.84 kJ/m-hr-deg). The inside and outside surfaces of the wall are at temperature 650°C and 125°C respectively. Make calculations for the heat loss from unit area of the wall. **6** 4 3 1 2

OR iii. Derive an expression of general heat conduction equation in Cartesian coordinate. **6** 3 3 1 3

Q.3 i. Distinguish between natural and forced convection heat transfer. **2** 2 2 2 3

ii. Calculate the rate of heat loss from a human body which may be considered as a vertical cylinder 30 cm in diameter, and 175 cm high while standing in a 30 km/hr wind at 15°C. The surface temperature of the human is 35°C. **8** 4 3 2 2
The thermo-physical properties of air at mean film temperature of 25°C are as follows:
$\upsilon = 15.33 \times 10^{-6}$ m^2/s; k = 0.0263 W/m-deg; Pr=0.7

OR iii. The oil pan of an engine approximates a flat plate 0.3 m wide by 0.45 m long and protrudes below the framework of the automobile. The engine oil is at 95°C and the ambient air temperature is 35°C. If the automobile runs at 36 km/hr, make calculations for the rate of heat transfer from the oil-pan surface. Assume negligible resistance to conduction through the oil pan. **8** 4 3 2 2
The thermo-physical properties of air at mean film temperature of 65°C are as follows:
$\upsilon = 18.46 \times 10^{-6}$ m^2/s; k = 0.0293 W/m-deg; Pr=0.695

Q.4 i. How does a fin enhance heat transfer at a surface? **2** 2 3 3 3

ii. Derive an expression for heat dissipation from a fin insulated at the tip. **8** 3 3 3 3

Marking Scheme

ME3CO32 (T) Heat & Mass Transfer (T)

Q.1	i)	(d) 2 k1 k2 / (k1 + k2)	**1**
	ii)	(b) 0.3 W/mK	**1**
	iii)	(b) Nusselt number	**1**
	iv)	(a) 1500W	**1**
	v)	(a) Free convection	**1**
	vi)	(c) Less than one	**1**
	vii)	(a) 0.25	**1**
	viii)	(b) Temperature only	**1**
	ix)	(b) Whose emissivity is independent of wavelength	**1**
	x)	(d) 81: 1	**1**
Q.2	i.	Definition of critical thickness with Rate of heat transfer vs length or radius diagram	**2**
		Explanation of condition for critical thickness of insulation for steam carrying pipe	**2**
	ii.	Calculation of thermal resistance in steel plate, silica bricks, and magnesia bricks Calculation of total thermal resistance of the composite wall Calculation of heat loss from the wall **(1*3M)**	**3**
OR	iii.	Heat influx and efflux in x, y, and z direction Total heat generated in control volume Energy balance and final expression **(1*3M)**	**3**
Q.3	i.	Brief but clear distinctions with examples	**2**
	ii.	Calculation of Reynolds number **2M** Calculation of Nusselt number **2M** Calculation of convective heat transfer coefficient **2M** Calculation of convective heat loss **2M**	**8**
OR	iii.	Calculation of Reynolds number **2M** Calculation of Nusselt number **2M** Calculation of convective heat transfer coefficient **2M** Calculation of convective heat flow **2M**	**8**
Q.4	i.	Clear and concise answer with an example	**2**
	ii.	Boundary conditions **2M** Stepwise derivation **4M** Final Expression **2M**	**8**
OR	iii.	Calculation of parameter 'm' **2M** Calculation of the fin efficiency **2M** Calculation of temperature at the tip of fin **2M** Calculation of rate of heat dissipation. **2M**	**8**
Q.5	i.	Statement of Fick's law of diffusion	**2**
	ii.	Explanation of LMTD limitations **1.5M** Advantages of effectiveness-NTU **1.5M**	**3**
	iii.	Calculation of outlet temperature of water **1M** Calculation of LMTD **2M** Calculation of no. of tubes **2M**	**5**
OR		Step-by-step derivation **3.5M** Correct final expression **1.5M**	**5**
Q.6	i.	Definition of fouling factor **2M** Explanation of its impact on performance **2M**	**4**
	ii.	Calculation of net heat radiated from black body to wall **2M** Calculation of heat conducted through wall **2M** Calculation of temperature of black body **2M**	**6**
OR	iii.	Calculation of grey body factor from floor to roof **4M** Calculation of net radiation heat transfer from the roof to floor **2M**	**6**

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