# 17560

**21718**

**3 Hours / 100 Marks** Seat No. | | | | | | | | |

*Instructions* – (1) All Questions are *Compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Use of Non-programmable Electronic Pocket Calculator is permissible.

(7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

(8) Use of Steam tables, logarithmic, Mollier's chart is permitted.

**Marks**

**1.** a) **Attempt any THREE of the following:** **12**

(i) What is thermal conductivity? Derive its unit by using Fourier's law equation.

(ii) Define heat transfer coefficient. Write the relationship of overall heat transfer coefficients based on Inside and Outside diameters including foulling factor.

(iii) State Steafan-Boltzmann law and give its mathematical expression and explain the terms.

(iv) Give classification of shell and tube heat exchanger.

**Marks**

b) **Attempt any ONE of the following:** **6**

(i) A steel pipe with an outside diameter of 115 mm and wall thickness 5mm is covered with 50 mm thickness of insulation. Inside surface temperature and outside surface temperature is 423 K and 303 K respectively. Calculate Rate of heat flow per metre length of pipe and temperature at the interface.

k-for steel → 43.03 w/mk k-for insulation → 0.07 W/mk

(ii) What are the methods of increasing the economy of the evaporator? Explain thermal recompression of vapours.

**2. Attempt any FOUR of the following:** **16**

a) What is optimum thickness of insulation? How is it determined?

b) State Fourier's law of heat transfer. Write its Mathematical expression and explain the terms.

c) State and prove Kirchoff's law of radiation.

d) State the application of finned tube heat exchanger. Give any two examples where finned tube heat exchangers are used.

e) Draw a neat sketch of U-tube shell and tube heat exchanger and lable it's part.

**3. Attempt any TWO of the following:** **16**

a) A heat exchanger is required to cool 20kg/sec of water from 360 K to 340 K by mean of 25 kg/sec of water entering at 300 K and leaving at 316 K calculate heat transfer area required in countercurrent flow arrangement specific heat of water is = 4.187 KJ/kgK overall heat transfer coefficient is = 2000W/$m^2$K.

b) Differentiate between film wise and drop wise condensation. (any four points)

c) Compare square pitch and triangular pitch arrangement of tubes in shell and tube heat exchanger (four points) What is the use of baffles in a shell and tube heat exchanger?

**Marks**

**4.** a) **Attempt any <u>THREE</u> of the following:** **12**

(i) Derive an expression to find out rate of heat transfer through a single flat furnace wall.

(ii) Compare forward feed and backward feed arrangement for a multiple effect evaporator. (Atleast four points)

(iii) Calculate the net radiant heat exchange per square metre for very large planes at temperatures of 703K and 513 K respectively. Emissivity of hot and cold planes are 0.85 and 0.75 respectively. $\sigma = 5.67 \times 10^{-8}$ W/($m^2k^4$)

(iv) Explain with neat sketch construction and working of graphite block heat exchanger.

b) **Attempt any <u>ONE</u> of the following:** **6**

(i) A furnace wall is made up of 0.23 m of fire brick 0.075 m of insulating brick and 0.089 m of red brick. The temperature at the inner surface of the wall is 1073 K and that of the outer surface is 333 K. Average thermal conductivity values of the three types of bricks, i.e. fire brick, insulating brick and the red brick are 1.21, 0.121 and 0.865 w/(m.k) respectively. Calculate the temperature at the interface between different kinds of bricks.

(ii) With neat sketch explain working of long tube vertical evaporator.

**5.** **Attempt any <u>TWO</u> of the following:** **16**

a) Write assumptions and derive an expression for log mean temperature difference.

b) Derive material and energy balance equation for a single effect evaporator.

**Marks**

c) Calculate the inside heat transfer coefficient using Sieder-Tate equation for turbulent flow

Data Given

Inside diameter of tube = 20 mm

Raynold's number - $N_{Re}$ = 15745

Prandtl number - $N_{pr}$ = 36

Viscosity of fluid at bulk mean temperature = $550 \times 10^{-6}$ pa.S

Viscosity of fluid at average wall temperature = $900 \times 10^{-6}$ pa.S

Thermal conductivity of fluid - K = 0.25 W/mk.

**6. Attempt any <u>TWO</u> of the following:** **16**

a) What is dimensional analysis? Write Dittus Bolter and Sieder. Tate equation and explain the terms.

b) Water enters a heat exchanger at 328 K and leaves at 358 K. Hot gasses enters at 578 K and leaves at 433 K if the total heat transfer area is $500m^2$, The overall heat transfer coefficient is 700 $W/m^2K$. Determine the total heat transferred for co-current and counter current flow.

c) An evaporator is to be fed with 5000 kg/hr solution containing 10% solute by weight. The feed at 313 K is to be concentrated to the solution containing 40% solute by weight under an absolute pressure of 101.325 Kpa steam is available at an absolute pressure of 303.975 Kpa. [Saturation temperature of 407 K] The overall heat transfer coefficient is 1750 $W/(m^2.K)$

Data given:

Latent heat of condensation of steam – $\lambda_s$ = 2162 KJ/kg

Boiling point of solution – 373 K

Enthalpy of water vapours at 373 K = $\lambda_v$ = 2676 KJ/kg

Enthalpy of product at 373 K = 419 KJ/kg

Enthalpy of feed at 313 K = 170 KJ/kg

Calculate the economy of the evaporator heat transfer area that should be provided.

———