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Department of Petrochemical Engineering

Subject: Unit Operation - II **Subject Code: BTPCC 402**

Class: Second Year **Semester: Fourth**

Question Bank

Unit No 01		
Qu. No.	**Questions**	**Marks**
1	Derive the expression for heat transfer through furnace wall made up of three different materials in series.	**6**
2	Derive the expression for heat flow through thick walled cylinder by conduction .	**6**
3	Derive the expression for heat flow through thick walled cylinder lagged with a layer of insulation.	**6**
4	What do you mean by thermal conductivity and write in brief on its variation with temperature?	**6**
5	What do you mean by critical radius of insulation and obtain critical radius of insulation for insulated cylinder.	**6**
6	Explain the significance of fin effectiveness and fin efficiency.	**6**
7	What are biot and fouriers numbers? Explain their physical significance.	**6**
8	Derive the expression for steady state conduction through plane wall.	**6**
9	Derive the expression for heat flow through hollow sphere.	**6**
10	Write note on thermal insulation.	**4**
11	What is transient heat conduction (Unsteady state)?	**2**
12	Define: a) Thermal conductivity b) Conduction c) Critical radius of insulation	**3**
13	What is meant by heat transfer process? Write its 3 types.	**6**
14	Write any 2 important differences between conduction and convection.	**4**
15	Write Fourier law of heat conduction and explain the terms in it.	**4**
16	Define Fourier number, Biot number in heat conduction problems and state their physical significance.	**6**
17	State Fourier's law of heat conduction and explain why negative sign is present before ‘k’.	**6**
18	Derive the one-dimensional steady state heat conduction for a hollow cylinder.	**6**
19	What is Fourier number and explain its significance?	**4**

20	A furnace wall is made up of brick wall of 15 cm thickness (k = 4.6 W /m 0C) lined on inside with silica brick 25 cm thick (k = 1.2 W /m 0C) & next layer of magnesite brick 35 cm thick (k = 1.8 W /m 0C). Inside temp of wall is 2600C & on outside 300C. Calculate a) Rate of heat flow through wall. b). Interface temp	**6**
21	A furnace wall made up of steel plate 7 cm thickness (k= 40 W /m 0C) lined on inside with fire clay brick 25 cm thick (k1 = 0.270 W /m 0 C) & on outside magnesite brick 35 cm thick (k2= 1.6 W /m 0C). Inside temp of wall is 7500C & on outside 400C Calculate, A) Rate of heat flow through wall. B) Interface temp. C)If the heat flow is to be reduced to 60% by means of air gap between steel plate and magnesite brick, calculate width of air gap required. Data: Thermal conductivity of air is 0.028 W/ m^{O}C	**6**
22	A steam pipe 150 mm ID & 164 mm OD is covered with two layers of insulation. The thickness of first layer is 50 mm (k= 0.75 w /m 0C). & that of second layer is 40mm (k = 0.450 w /m 0C). The inside temp is 320 0C & outside temp is 40 0C. Calculate heat loss and interface temp. Thermal conductivity of pipe is k = 15. W /m 0C	**6**
	Unit No 02	
1	Define Convection and gives two examples.	**3**
2	What do you mean by natural convection? Give example of heat transfer by natural convection.	**3**
3	What do you mean by heat transfer coefficient? Also give unit.	**3**
4	Define forced convection and give a suitable example of it.	**3**
5	Compare natural convection with forced convection.	**4**
6	Write a note on drop wise condensation and film wise condensation.	**6**
7	Give physical significance of a) Reynolds Number b) Nusselt Number c) Prandtle Number d) Grashoff Number	**4**
8	Give the Dittus Boelter equation for turbulent flow for heating and cooling.	**6**
9	Give the Sieder Tate equation for calculation of film coefficient in case of laminar flow and turbulent flow.	**6**
10	What are film coefficients? Why they are important in heat transfer by convection?	**6**
11	Explain two distinct mechanism of condensation.	**6**
12	Draw only neat labeled figures for different flow arrangements in heat exchangers.	**4**
13	Write down comparison between co-current flow and counter current flow in heat exchanger.	**4**
14	Explain the concept of log mean temperature difference and derive expression to calculate LMTD.	**8**
15	Write a note on flow arrangement in heat exchanger.	**6**
16	Define	**3**

	a) Heat flux b) Sensible heat c) Latent heat	
17	State the relationship between overall heat transfer coefficient and individual heat transfer coefficient.	**12**
18	Write in brief on fouling factor or dirt factor with respect to heat transfer.	**6**
19	Explain in brief heat transfer to boiling liquids.	**6**
20	Write the relationship between U and h_i, h_o x_w / k and Rd.	**6**
21	Give physical significance of a) Reynolds number b) Nusselt number c) Prandtl number	**6**
22	Define the number of transfer units and discuss its importance in rating heat exchanger performance.	**6**
23	What is thermal boundary layer? How its thickness is changing with Prandtl number?	**6**
24	Write the equation giving the individual heat transfer coefficients as a function of relevant variables in the case of natural convection	**6**
25	Is a counter flow heat exchanger more efficient than a parallel heat exchanger? If so, why?	**6**
26	How does a scale deposit affect the heat transfer rate?	**6**
27	State Dittus-Boelter equation and Colburn equation for heat transfer and discuss their application.	**6**
28	How heat transfer coefficient is calculated in forced convection for laminar flow, turbulent flow and in transition region.	**6**
29	Calculate overall coefficient based on outside area required to heat water from 25 oC to 70oC, which is flowing in 20 mm ID tube with 2 mm thickness. The saturated steam is condensing on outside surface at 105 oC. Water velocity 2m/sec. Calculate amount of steam required. Data: hi = 1950 W/m2 OC, ho = 2100W/m2 OC, hdi = 17300 W/m2 OC, hdo = 2100 W/m2 OC, Cp=4180 J/Kg OC, km = 37 W/m, λ= 2200KJ/kg	**6**
30	A light oil in a tank is maintained at 80 0C by means of condensing steam inside a 100 mm OD tube having length 5 m . Steam maintains pipe surface temp. at 1200C. Assuming that pipe is kept horizontal calculate outside heat transfer coefficient and heat transfer rate. If tube is kept vertical calculate % change in heat transfer rate. Properties of oil: = 880 kg / m3, = 6.9 cp , k = 0.25 W / k , Cp= 2110 J/Kg0C	**6**
	<u>Unit No 03</u>	
1	Define a) Radiation b) Absorptivity c) Emissivity	**3**
2	Define a) Black body b) Grey Body c) Opaque Material	**3**

3	Define a) Emissive Power b) Monochromatic Emissive Power c) Radiation Shape Factor d) Radiation Shield	**4**
4	Explain following term with neat diagram a) Absorptivity b) Reflectivity c) Transmissivity	**3**
5	State and derived the expression for Kirchhoff's law of radiation.	**6**
6	State Stefan- Boltzmann law of radiation.	**2**
7	Write in brief on concept of black body.	**4**
8	Derive the expression for exchange of energy between two parallel plates.	**6**
9	Define Radiation Shield and derive the expression for it.	**6**
10	Write a note on Radiation Shape Factor.	**6**
11	State Wien's displacement law.	**3**
12	Define radiation and examples.	**3**
13	Derive an expression for view factor between an elemental surface and finite surface.	**6**
14	State and explain Stefan Boltzmann Law and Planks Law and Wien's displacement law.	**6**
15	Calculate the heat loss by radiation from an unlagged horizontal steam pipe 50 mm o.d. at 377 k to air at 283 k.	**3**
16	Estimate the total heat loss by convection and radiation from an unlagged steam pipe 50 mm o.d. at 415 k to 290 k.	**4**
17	Determine the net radiant interchange between two parallel oxidized iron plates placed at a distance of 25 mm having sides 3 *3 m. The surface temperature of two plates is 373 k and 313 k respectively. Emissivities of the plates are equal. $e_1 = e_2 =$ 0.736.	**6**
18	The inner sphere of a diwar flask is 30 cm diameter and outer sphere is 36 cm diameter. Both spheres are coated with a material for which emissivity is 0.05. Determine the rate at which liquid oxygen (Latent Heat = 21.44 kj/kg) would evaporate at 90 k when the outer sphere temperature is 293 k. Assume that the outer modes of heat transfer are absent.	**6**
19	Calculate the rate of heat loss from a thermoflask if the polished silvered surfaces have Emissivities of 0.05 the liquid in the flask is at 368 k and the casing is at 293 k. Calculate the loss if both surfaces were black.	**6**
20	Calculate the loss of heat by radiation from a steel tube of diameter 70 mm and 3 m long at a temperature of 550 k if the tube is located in asquare brick conduit 0.3 m sidew at 300 k. Assume e for steel as 0.79 and for brick conduit as 0.93.	**6**
21	Calculate the rate of heat transfer by radiation from an unlagged steam pipe 50 mm o.d. at 393 k to air at 293 k.	**3**
	Unit No 04	
1	Explain film boiling, nucleate boiling and sub-cooled boiling.	**6**

2	Write a note on maximum heat flux and critical temperature drop.	**6**
3	Derive Nusselt equation for condensation of pure saturated vapors on a vertical tube.	**6**
4	Discuss briefly the difference between film-wise and drop-wise condensation. What are the methods employed to promote drop-wise condensation?	**6**
5	Discuss briefly the phenomenon of nucleate and film boiling. Explain with a neat diagram the various zones of boiling.	**6**
6	Condensing equipments are always designed for film-wise condensation - why?	**6**
7	Explain Pool Boiling curve and comment on difference in curve of flux verses temperature drop and heat transfer coefficient verses temperature drop.	**6**
8	Explain the various types of evaporators used in chemical industry. Give figures wherever possible.	**6**
9	Indicate the various methods of improving the overall efficiency of evaporators	**6**
10	Discuss the operation and advantages of a multiple effect evaporator.	**6**
11	What is 'Boiling Point Elevation'? How will your account it during evaporator design?	**6**
12	Define 'Capacity' and 'Economy, of a steam-heated tubular evaporator.	**6**
13	Why is multiple effect evaporation preferred over a single effect operation?	**4**
14	Explain different feeding methods of multiple effect evaporators.	**6**
15	It is desired to concentrate 6500 kg/hr of an organic solution from 10% to 50% solids in a single effect evaporator. Steam is available at 110 oC and vapor space is maintained at 415 mm of Hg. The boiling point of water at this pressure is 85 oC and solution has 11 oC BPR. The enthalpy of feed liquor and concentrated solution are, 370 kJ/kg and 555 kJ/kg, enthalpy of vapor is 2735 kJ/kg and latent heat of condensation is 2255 kJ/kg. Feed enters at its boiling point. Calculate, I. Steam consumption per hour and economy. II. Heating surface area required if overall coefficient is 1200 W/m2 oC .	**6**
16	It is desired to concentrate 6000 kg/hr of an NaOH solution from 10% to 50% solids in a single effect evaporator. Steam is available at 128 oC with latent heat of 2140 kJ/kg. The boiling point of solution is 82 oC. The enthalpy of feed liquor and concentrated solution are, 135KJ/kg & 575 kJ/kg, enthalpy of vapor is 2700 kJ/kg and latent heat of condensation is 2240 kJ/kg. Feed enters at its boiling point. Calculate, a. Steam consumption per hour and economy. b. Heating surface area required if overall coefficient is 2005 W/m2 oC	**6**
	Unit No 05	
1	Give the following terms: a) Condenser b) Cooler c) Vaporizer d) Heater e) Reboiler f) Chiller g) Evaporator	**6**
2	Write a note on shell and tube heat exchanger.	**6**
3	Write in brief on plate heat exchanger.	**6**

4	Write in brief on scrapped surface heat exchanger.	**6**
5	Write in brief on fined tube heat exchanger.	**6**
6	State the advantages of double pipe heat exchanger and its drawbacks.	**4**
7	Define heat exchanger and give examples.	**3**
8	Describe double pipe heat exchanger with neat sketch.	**4**
9	Define a) Tube Pitch b) Clearance	**4**
10	Write down the difference between single pass and multipass shell and tube heat exchanger.	**4**
11	Give the classification of shell and tube heat exchanger.	**4**
12	Draw a neat sketch of U-tube heat-exchanger and explain briefly its construction.	**4**
13	Draw a neat sketch of kettle reboiler and explain in brief it's working.	**4**
14	Draw a neat sketch of 1-2 shell and tube heat exchanger and label its parts.	**4**
15	State the advantages of a floating head heat exchanger.	**4**
16	State the advantages of a double pipe heat exchanger and its drawbacks.	**4**
17	List out the various types of heat exchangers	**4**
18	What is use of baffles in shell and tube heat exchangers? What is minimum and maximum baffle spacing?	**6**
19	What patterns of arranging tubes in shell and tube exchanger? What is tube pitch?	**6**
20	A horizontal water heater is required to heat 17 tons/hr of water from 35 oC to 86 oC by means of condensing steam at 110 oC in shell. The heater is to consist 16. mm ID and 19 mm OD tubes 3.5 m long. The velocity of water is not to exceed 1 m/s through the tubes. The shell side coefficient for steam is 6500 w / m2 o C and latent heat of steam at 110 oC is 2230 KJ / Kg. If the tube side coefficient is 3200 w / m2 o C, determine number of passes and number of tubes in each pass neglecting tube wall resistance. density of water is 996 Kg/ m3 and specific heat of water is 4180 J/Kg o C, LMTD correction factor is 0.95.	**6**
21	Define LMTD and explain the reason for which this concept is introduced in heat exchanger design. Explain why correction factors are being used when applying this technique for the design of multi-pass heat exchangers.	**6**