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SARDAR PATEL UNIVERSITY

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EXTERNAL EXAMINATION, APRIL 2014

M.Sc INDUSTRIAL CHEMISTRY-SEMESTER 2

UNIT OPERATIONS II & STOICHIOMETRY- PS02CICH01

18<sup>th</sup> April, 2015

Max.Marks:70

Time:10.30 a.m-1.30 p.m

Answer all the questions.

Figures to the right side indicate marks

Q1 .Write the number of the correct statement. All questions carry 1 mark each. (8 \*1=8marks)

- a. In a shell & tube heat exchanger,
- square pitch gives more heat transfer area than triangular pitch.
  - triangular pitch gives more heat transfer area than square pitch.
  - both square & triangular pitch give same heat transfer area
  - cleaning facility is same in both square & triangular pitch
- b. Identify the correct relation.
- $1 \text{ W} = 1 \text{ J/s}$
  - $1 \text{ W} = 1 \text{ kcal/s}$
  - $1 \text{ W} = 1 \text{ cal/s}$
  - $1 \text{ W} = 1 \text{ cal/hr}$
- c. The -----component is always present in less than its stoichiometric proportion with respect to other reacting components.
- excess reactant
  - stoichiometric reactant
  - limiting reactant
  - none of these
- d. Heat transfer occurs by natural convection because change in temperature causes difference in----
- viscosity
  - thermal conductivity
  - heat capacity
  - density
- e. Fouling factor of a heat exchanger depends on
- length of fins
  - thickness of fins
  - scales formed
  - density of cold fluid
- f. The overall resistance for heat transfer through a series of flat resistance is the ----- of the resistances
- average
  - Product
  - geometric mean
  - sum
- g. The temperature average used in heta exchanger calculation is -----temperature difference
- arithmetic mean
  - geometric mean
  - Logarithmic mean
  - None of these
- h. Multipass heat exchangers are used -----
- Because of simplicity of fabrication
  - For low heat load
  - To obtain high heat transfer co-efficient & shorter tube
  - To reduce pressure drop

**Q2. Answer any seven ( each question carry two marks)**

**(7\*2=14 marks)**

- a. Define white body and opaque body
- b. In which side (tube/shell) will you take viscous fluid in a shell & tube exchanger? Justify your answer.
- c. Distinguish between triangular and square pitch
- d. Why are extended surfaces used in heat transfer?
- e. Enlist the conditions when maximum heat transfer rate occurs in a heat exchanger
- f. Define effectiveness of a heat exchanger
- g. Define adiabatic flame temperature
- h. Distinguish between sensible heat and latent heat
- i. Define % conversion and yield of reaction

**Q3.**

a. Discuss the significance of the following dimensionless numbers (06)

- Nusselts Number
- Grashoffs Number
- Prandtl's Number

b. With the help of neat diagrams, distinguish between parallel and counter flow heat exchangers. (06)

**OR**

b. Citing examples, distinguish between free and forced convection (06)

**Q4.**

a. A fluid ( $C_p=4$  kJ/kg K) flowing at 23000 kg/hr passes through a counter current heat exchanger at 130°C. Water ( $C_p=4.18$  kJ/kg K) flowing at 52000 kg/hr and entering at 25°C is used to cool the fluid. If the heat transfer area is 11 m<sup>2</sup> and the overall heat transfer co-efficient is 3500 kJ/hr m<sup>2</sup>K, find the exit temperatures of fluid and water using NTU method. (06)

b. A multi pass Shell & Tube heat exchanger is required to heat 25000 kg/hr of cold water entering at 25 °C using 20,000 kg/hr of hot water entering at 100°C and leaving the exchanger at 80 °C. The cold water flow through 10 tubes each of OD 0.01m and ID 0.008 m. The hot water flows through the annulus between tubes and a shell of dia 0.25 m. The thermal conductivity of the tube material is 60 kJ/hr m K. The properties of water are given below (06)

$$\rho=1000 \text{ kg/m}^3$$

$$C_p =4.18 \text{ kJ/kg K}$$

$$\mu=3.6 \text{ kg/hr m}$$

$$k=2.9 \text{ kJ/hr mK}$$

calculate the length of the heat exchanger if it is

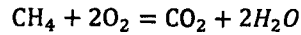
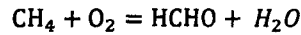
A parallel exchanger

**OR**

A counter exchanger

**Q5.**

a. Methane undergoes the following oxidation reactions.



100 kmol of methane is charged to the reactor and the product stream contains 10 kmol Carbondioxide and 40 kmol formaldehyde. Calculate the % conversion of methane and % yield of formaldehyde. (06)

b. 2000 kg of wet solids containing 70 % solids by weight are fed to a tray drier where it is dried by hot air. The product obtained is found to contain 1 % moisture by weight. Calculate (06)

- kg of water removed from wet solids
- kg of product obtained

**OR**

b. An evaporator is fed with 15000 kg/h of a solution containing 10 % NaCl, 15 % NaOH and rest water. During the process, water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving the evaporator contains 45 % NaOH, 2 % NaCl and the rest water. Calculate (06)

- kg/h of water evaporated
- kg/h of salt precipitated
- kg/h of thick liquor

**Q6.**

a. Calculate the heat to be transferred to a liquid stream of ethanol at its normal boiling point to generate 100 kg/h of saturated ethanol vapour.  $\lambda = 842.3 \text{ kJ/kg}$  (06)

b. A stream flowing at the rate of 15 kmol/h containing 25 %  $\text{N}_2$  and 75 %  $\text{H}_2$  is to be heated from 298 K to 473 K. Calculate the heat that must be transferred using the  $C_p$  data given below. (06)

Gas	a	b	c	d
$\text{N}_2$	29.59	$-5.41 \times 10^{-3}$	$13.183 \times 10^{-6}$	$-4.97 \times 10^{-9}$
$\text{H}_2$	28.61	$1.019 \times 10^{-3}$	$-0.147 \times 10^{-6}$	$0.769 \times 10^{-9}$

**OR**

b. Chlorine is manufactured using the reaction  $4\text{HCl} + \text{O}_2 \rightarrow 2\text{Cl}_2 + 2\text{H}_2\text{O}$  where 35 % excess air is used. If the feed contains 4 kmol HCl and if the oxidation is 80 % complete, calculate the heat that must be removed so that the products emerge at 600 K. The dry air and HCl enter at 560 K.  $\Delta H_R^\circ = -28600 \text{ kJ/mol}$  (06)

$C_p$ (KJ/mol K)	HCl	$\text{O}_2$	$\text{N}_2$	$\text{Cl}_2$	$\text{H}_2\text{O}$
(560- 298 K)	24.85	25.98	29.08		
(600-298 K)	30.31	26.02	29.59	28.08	31.05