

SEAT No. _____

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[59]

SARDAR PATEL UNIVERSITY
EXTERNAL EXAMINATION, APRIL 2017

M.Sc. INDUSTRIAL CHEMISTRY-SEMESTER 2

HEAT TRANSFER OPERATIONS & STOICHIOMETRY- PS02CICH09

13th April, 2017

Max. Marks: 70

Time: 10.00 a.m-1.00 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 = 8 marks)

a. Identify the correct relation.

- i. $1 \text{ W} = 1 \text{ J/s}$ ii. $1 \text{ W} = 1 \text{ kcal/s}$ iii. $1 \text{ W} = 1 \text{ cal/s}$ iv. $1 \text{ W} = 1 \text{ cal/hr}$

b. The ----- component is always present in less than its stoichiometric proportion.

- i. excess reactant ii. stoichiometric reactant iii. limiting reactant iv. none of these

c. Natural Convection is characterized by

- i. Peclet number ii. Grashoffs number iii. Reynolds number iv. Stanton Number

d. The centre-centre distance between 2 tubes is called

- i. tube clearance ii. tube pitch iii. tube sheet iv. tie rods

e. ----- increases turbulence in a heat exchanger

- i. fins ii. baffles iii. Tube sheet iv. None of these

f. The effect of scale formation is to ----- the heat transfer co-efficient

- i. increase ii. decrease iii. rotate iv. none of these

g. Grashoffs number is defined as

- i. $L^2 \rho^2 g \beta \Delta T / \mu^2$ ii. $L^3 \rho g \beta \Delta T / \mu^2$ iii. $L^3 \rho^2 g \beta \Delta T / \mu$ iv. $L^3 \rho^2 g \beta \Delta T / \mu^2$

h. Which is most suitable for the evaporation of cold viscous feed?

- i. Forward feed ii. Backward feed iii. Mixed feed iv. Parallel feed

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

(7 * 2 = 14 marks)

- Define fouling factor in heat exchanger
- Distinguish between individual and overall heat transfer co-efficient
- Distinguish between pitch and clearance
- Why are tie rods and spacers used in heat exchangers?
- Enlist the conditions when maximum heat transfer rate occurs in a heat exchanger
- Define the term NTU used in heat exchanger calculations
- Define LMTD of parallel & counter flow heat exchangers
- Distinguish between limiting reactant and excess reactant
- Define selectivity and yield of reaction

Q3.

a. A fluid of density 13500 kg/m^3 and at 80°C is pumped through a pipe of 0.02 m ID kept at 30°C at 15000 m/hr . At the average temperature of 55°C , the properties of fluid are as follows. Calculate the heat transfer co-efficient.

(06)

C_p (kJ/kg K): 0.14	k (kJ/hr m K): 29	μ (kg/ hr m K): 3
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- b. A pipe 0.15 m dia & 1 m length and at temperature of 573 K is covered with 2 layers of insulation. The first layer is 0.05 m thick with a k value of 0.062 W/m K and the second layer is 0.06 m thick with a k value of 0.8 W/m K. The outer surface of second layer covering is at a temperature of 330 K. Calculate the heat loss and the interface temperature.

(06)

OR

- b. A horizontal cylinder 0.025 m dia and 0.6 m long is suspended in water at 20 °C. Calculate the heat transfer co-efficient if the cylinder surface is at 55 °C.

(06)

ρ (kg/m ³)	Npr	k (kJ/hr mK)	β (K ⁻¹)	μ (kg/hr m)
992	4.64	2.376	3.96×10^{-4}	2.47

Q4.

- a. A fluid ($C_p = 3.3$ kJ/kg K) flowing at 20000 kg/hr enters a parallel flow heat exchanger of 40 % efficiency at 120 °C. Water ($C_p = 4.186$ kJ/kg K) flowing at 50000 kg/hr which is used as the coolant enters at 20 °C. If a heat transfer area of 10 m² is available, what will be the heat transfer co-efficient?

(06)

- b. Find the length of a double pipe exchanger required to heat 4000 kg/hr of oil from 10 °C to 20 °C using hot water at 70 °C flowing at 690 kg/hr. The hot water flows through the inner pipe of ID 0.018 m and OD 0.021 m. The ID of the outer pipe is 0.03 m. k for pipe = 0.008 kJ/hr m K.

(06)

	C_p (kJ/kgK)	k (kJ/hr mK)	ρ (kg/m ³)	μ (kg/hr m)
Water	4.18	2.376	1000	1.458
Oil	1.885	0.504	850	2.163

Do the calculation for

A parallel flow exchanger

OR

A counter flow exchanger

Q5.

- a. 100 kg of a solution containing 55 % benzene, 28 % toluene, and 17 % xylene by weight is in contact with its vapour at 373 K. Calculate the total pressure and molar composition in liquid phase.

(06)

	Benzene (MW:78)	Toluene (MW:92)	Xylene (MW:106)
Vap. Pr (kpa)	178.6	74.6	28

- b. A combustion reactor is fed with 50 kmol/h of butane and 2000 kmol/h of air.
 $C_4H_{10} + 6.5 O_2 \rightarrow 4CO_2 + 5H_2O$.

Calculate the % excess air and the composition of gases leaving the combustion reactor assuming complete combustion.

(06)

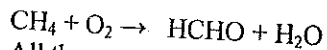
OR

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

(06)

Q6.

a. 100 moles of methane is oxidized with 50 % excess air to produce formaldehyde as per the reaction

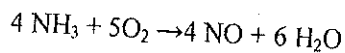


All the reactants enter at 311 K with 60 % conversion of methane. Calculate the heat that must be removed for the product stream to emerge at 478 K.

Component	Cp (311- 298 K) J/mol K	Cp (478-298 K) J/mol K	Std. heat of reaction = - 283000 J/mol
CH ₄	36.044	40.193	
O ₂			
N ₂			
HCHO		41.2902	
H ₂ O		34.2396	

(06)

b .Calculate the standard heat of reaction of the following reaction



(06)

Component	NH ₃	NO	H ₂ O
ΔH_f (kJ/mol)	-45.94	90.25	-241.82

OR

b. 100 kg/h of methanol liquid at 303 K is to be obtained by removing heat from saturated methanol vapour. Find the amount of heat to be removed

(06)

Boiling point of methanol = 337.8 K,
Cp of methanol = 2.7235 kJ/kg K

Latent heat of condensation = 1101.7 kJ/kg

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