SF-354

Total No. of Pages : 3

Seat No.	

S.E. (Chemical Engg.) (Semester - IV) (Revised) Examination, November - 2017

CHEMICAL ENGINEERING THERMODYNAMICS - I

Sub. Code : 63431

Day and Date : Tuesday, 07-11-2017 **Total Marks : 100**

Time : 10.00 a.m. to 1.00 p.m.

Instructions :
1) **Answer any three questions from each section.**
2) **Assume suitable data if necessary.**
3) **Draw neat diagrams wherever necessary.**

SECTION - I

Q1) a) Define & State Phase Rule? How many degree has each of the following system? **[8]**

i) Liquid water in equilibrium with it's vapour?

ii) Liquid water in equilibrium with a mixture of water vapour & nitrogen?

iii) Liquid solution of alcohol in water in equilibrium with it's water.

b) An astronaut weighs 730 N in Houston, Texas, where the local acceleration of gravity is g = 9.792 m/sec^2. What are astronaut's mass & weight on the moon, where g = 1.67 m/sec^2? **[8]**

Q2) a) Derive an expression for first law of thermodynamics for a steady - state steady - flow process. **[8]**

b) Calculate ΔU & ΔH for 1 kg of water. When it is vapourised at a constant temp. of 100°C & constant pressure 101.33 kPa. The sp. volume of liquid & vapour water at this conditions are 0.00104 & 1.673 $\frac{m^3}{kg}$ for this change heat in the amount of 2256.9 kJ is added to the water. **[8]**

P.T.O.

Q3) a) Explain in brief the PVT Behaviour of pure substances? **[8]**

b) Derive an expression for Vander Waals equation of state? **[8]**

Q4) Write short notes on : (Any three). **[18]**

a) Units & Dimensions.

b) Scope of Thermodynamics.

c) State function & path function.

d) Reversible & Irreversible function.

SECTION- II

Q5) a) Using Maxwell's equation prove that: **[8]**

$dH = Cp\ dT + V\ (1 - \beta\ T)\ dP$

$dS = Cp\ dT/T - \beta\ V\ dP.$ Where β = Volume expansivity.

b) A heat exchanger uses 5000 kg/hr of water to cool hydrocarbon oil from 140°C to 65°C. The oil is flowing at the rate of 2500 kg/hr has an average specific heat of 2.51 kJ/kg.°C. **[8]**

The water enters at 20°C. Determine

i) The entropy change of the oil.

ii) Entropy change of water.

iii) The total entropy change as a result of this heat exchange process.

Q6) a) What is residual property? Derive fundamental property relation for residual properties applied to fluids of constant composition. **[8]**

b) Derive first of the four Maxwell's Equations and state its application in thermodynamics. **[8]**

Q7) a) Estimate the fugacity of iso-butane at 15atm and 87°C using the compressibility factor correlation $Z = 1 + (BP/RT)$, given that the second virial coefficient $B = -0.00043\ m^3/mol$. **[8]**

b) Explain the air refrigeration cycle in detail with advantage and disadvantage. Also derive the equation for coefficient of performance in terms of temperature. **[8]**

Q8) Write short notes (Any Three) on the following **[18]**

a) Thermodynamic Temperature scales

b) Kelvin - Planck Statement.

c) Third law of thermodynamics.

d) Choice of refrigerant.

e) Heat Engines.

SF-352

Total No. of Pages : 4

Seat No.	

S.E. (Chemical) (Part-II) (Semester-IV) Examination, November - 2017
PROCESS CALCULATIONS
Sub. Code : 63429

Day and Date : Friday, 03-11-2017 **Total Marks : 100**

Time : 10.00 a.m. to 1.00 p.m.

Instructions : **1) Answer any three questions from each section.**
2) Assume suitable data, if necessary.

SECTION-I

Q1) a) The mass flow rate of n-hexane (S = 0.659 kg/m^3) in a pipe is 6.59 g/s [gram/second]. What is volumetric flow rate of n-hexane in m^3/s. **[8]**

b) How many of each of the following are contained in 100.0 gram of CO_2. **[9]**

i) Moles of CO_2
ii) g.atom C
iii) g.atom Oxygen
iv) wt. of O_2
v) molecules of CO_2
vi) moles of Oxygen

Q2) a) An industrial strength drain cleaner contains 5.0 kg water and 5.0 kg of NaOH. Calculate

i) mass and mole fraction of each component.
ii) % mass and % mole of each component. **[8]**

b) A natural gas has the following composition, all being volumetric percentage(% volume) CH_4=83.5%, C_2H_6=12.5% and N_2=4.0%. Calculate **[8]**

i) Comosition on % mole
ii) Composition on % weight
iii) Avg. mole. wt.
iv) Density of gas mix

P.T.O.

Q3) a) The gas acetylene is produced according to the following reaction

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

Calculate the number of hours of services that can be delivered from 1kg of calcium carbide in acetylene lamp burning capacity 100 liter/hr of gas at T = 25°C and P = 743 mm Hg

Atomic wt of Ca = 40.0 **[8]**

b) A compound whose mole. wt. 103, analyses C = 81.5%, H = 4.9% and N = 13.6%. What is its formula? **[8]**

Q4) a) A sample of coal is found to be contain 67.2% carbon and 22.3% ash(by wt). The refuse obtained at the end of combustion is analysed to contain 7.5% carbon and rest ash. Compute the % original carbon remain unburnt in the furnace. **[9]**

b) For carrying out Nitration reaction, it is desired to have a mixed acid containing 39% HNO_3, 42% H_2SO_4 and 19% H_2O (by wt.). Nitric acid of 68.3% (wt.) is readily available calculate: **[8]**

i) Required strength of H_2SO_4 to obtain above mixed acid.

ii) The weight ratio of HNO_3 to H_2SO_4 to be mixed.

SECTION-II

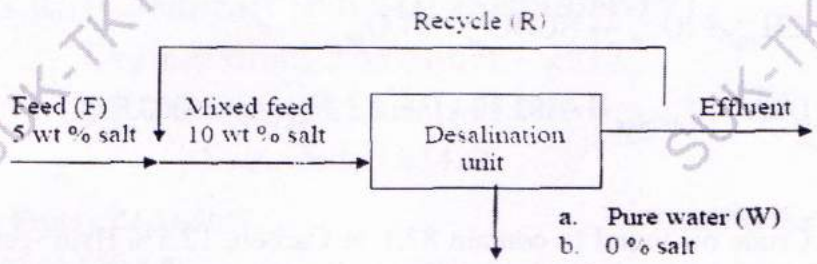
Q5) a) In manufacturing of chlorine, feed containing hydrochloric acid gas & air are fed to an oxidizer. The product gases leaving the oxidizer are found to contain 13.2% HCI, 6.3% O_2, 42.9% N_2, 30% Cl_2, & 7.6% H_2O (by weight) Calculate: **[8]**

i) the percent excess air used

ii) composition by weight of gases entering the oxidizer &

iii) degree of completion of oxidation

b) Pure water (stream W) is to be obtained from a feed containing 5 wt % salt using a desalination unit as shown below:



If the overall recovery of pure water (stream W) is 0.75 kg/kg feed, then find recycle ratio(R/F). **[8]**

Q6) a) Heat capacity of air can be approximately expresses as $Cp = 26.693 + 7.365 \times 10^{-3} T$ where Cp is in J/(mol)(K) and T is in K. Calculate heat given off by 1 mole of air when cooled at 1 atmospheric pressure from 500°C to −100°C. **[8]**

b) 100 kg/h of methanol liquid at a temperature of 303 K(30°C) is to obtained by removing heat from saturated methanol vapour. Find out the amount of heat to be removed in this case. **[8]**

Data: Boiling point of methanol = 337.8 (64.8°C)

Latent heat of condensation of methanol = 1101.7kJ/kg

Specific heat of methanol = 2.7235kJ/(kg.K)

Q7) a) Calculate the standard heat of formation of n-propanol liquid using the following data. **[8]**

Standard heat of formation of $CO_2(g)$ = −393.51 kJ/mol

Standard heat of formation of $H_2O(l)$ = −285.83 kJ/mol

Standard heat of combustion of n-propanol liquid = −2028.19 kJ/mol

b) Calculate enthalpy change between reactant & products if both are at 298 K & if 10 mol of formaldehyde is produced due to following reaction:

$$CH_{4(g)} + O_{2(g)} \rightarrow HCHO_{(g)} + H_2O_{(g)}$$

Data : $H^{\circ}_{c(HCHO)g} = -563.46$ kJ/mol : $H^{\circ}_{c(CH_4)g} = -890.65$ kJ/mol **[8]**

Q8) a) Crude oil found to contain 87.1 % Carbon, 12.5% Hydrogen & 0.4% Sulphur (by mass). Its GCV at 298.15 K is measured to be 45071 kJ/kg oil. Calculate its NCV at 298.15K. **[8]**

b) A sample of natural gas containing 80% Methane (CH_4) and the rest Nitrogen (N_2) is burnt with 20% excess air. With 80% of the combustibles producing CO_2 and the remainder going to CO find Orsat analysis in volume percent. **[10]**

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SF - 353

Total No. of Pages :3

Seat No.	

S.E. (Chemical Engg.) (Part - II) (Semester - IV) Examination, November - 2017

HEAT TRANSFER

Sub. Code: 63430

Day and Date :Monday, 06 - 11 - 2017 **Total Marks : 100**

Time :10.00 a.m. to 1.00 p.m.

Instructions : 1) **Solve any three questions from each section.**

2) **Assume suitable data if any missing.**

3) **Draw figures wherever necessary.**

SECTION - I

Q1) a) Explain fouriers law of heat conduction & derive an equation for rate of HT through a sphere assuming $T_i > T_o$. **[8]**

b) A plane brick wall, 25 cm thick, is faced with 5 cm thick concrete layer. If the temperature of the exposed brick face is 70°C and that of the concrete is 25°C, find out the heat lost per hour through a wall of 15 m × 10 m. Also, determine the interface temperature. Thermal conductivity of the brick and concrete are 0.7 W /m.K and 0.95 W /m.K respectively. **[8]**

Q2) a) Air at 300°K and 101.325kPa flows over a flat plate at a velocity of 2 m/sec. The plate is heated over its entire length to a temperature of 333°K. Calculate the heat transferred in the first 20 cm of plate the plate is 1 m wide.

Given data:- ν for air = 17.36×10^{-6} m^2/sec

Thermal conductivity of air = k = 0.0275W/m°K

Specific heat of air = Cp = 1.006 KJ/kg°K

Npr for air = 0.7 **[8]**

b) Derive an equation for Forced convection by using dimensional analysis method. **[8]**

P.T.O.

Q3) a) Hot water at 90°C is flowing through a pipe having internal diameter 16 mm and 2 mm wall thickness. Pipe is coated with asbestos insulation having thermal conductivity 0.2 W /m°C. Surrounding air is at 30°C.

Thermal conductivity of pipe material is 40 W /m°C.

Heat transfer coefficient for water = 500 W /m^2 °C

Heat transfer coefficient for air = 10 W /m^2 °C

Calculate the heat loss due to surrounding air if the insulation thickness is 5 mm. **[8]**

b) Discuss Colburn Analogy, Reynold's Analogy and significance of Prandtl number. **[8]**

Q4) Write short notes on Any Three. **[18]**

a) Eddy diffusivity of heat.

b) Heat transfer to Semi-infinite solid.

c) Assumptions made in LMTD and cases in which LMTD is not valid.

d) Greatz and peclet numbers.

e) Laminar flow heat transfer to plate.

SECTION - II

Q5) a) An iron pipe of 50mm i.d. and 60 mm. o.d. at 150°C passes through a room in which the surrounding air at a temp. of 32°C. Calculate the net interchange of radiation per meter of the length of the pipe if the emissivity of the pipe metal is 0.8. **[8]**

b) What is compact heat exchanger? Explain in detail with neat diagram kettle type Reboiler. **[8]**

Q6) a) A SEE is used to concentrate an aqueous solution from 7% to 29% solid content by weight, using saturated steam at 2 bar gauge pressure. If U is 2kW/m^2 °C. Calculate capacity, steam consumption, economy and heat Transfer area required. Assume that feed is 4000 kg/hr at 50°C. Vapour space pressure remains constant at 1.013 bar absolute.

Data : $C_{pf} = 4.2$ KJ/kg $\quad T_s = 135.55°C \quad \lambda_s = 2163.9$KJ/kg

$T_{sat} = 100°C \quad \lambda_v = 2256$ KJ/kg **[8]**

b) Why the boiling equipment should be operated below critical temp. drop? Discuss the boiling phenomena with heat boiling curve. **[8]**

Q7) a) Why temperature correction factor 'F' is required in multipass heat exchanger? Discuss the finned tube heat exchanger with types of fins.**[8]**

b) Calculate the heat Transfer coefficient for condensation when the tube is kept horizontal and vertical of 0.0013m O.D. and 1.5m long is to be used to condense the steam at 40KN/m^2 and saturation temp. is 349 K, if the average temp of tube is 325K. **[8]**

Data : $K_l = 0.661$ w/mK $\quad \mu_l = 4.48 \times 10^{-4}$ N.s/m^2

$\rho_l = 980.9$ kg/m^3 $\quad C_{pl} = 4184$ J/kg K

$\lambda = 2.349 \times 10^6$ J/kg $\quad \sigma_v = 0.25$ kg/m^3

Q8) Write short notes on any Three : **[18]**

a) Effect of non - condensable gases on rate of condensation.

b) 2.4 pass Heat Exchanger.

c) Heat Transfer to packed Bed.

d) Laws of Radiation.

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