BITS-PILANI, DUBAI CAMPUS
I Semester 2013-'14 - Comprehensive Exam

CHE F213 Chemical Engineering Thermodynamics

Maximum Marks: 40 Weightage: 40%

Duration: 3 hr **(Closed Book)** 06.01.2013

Note: This question paper contains 2 pages.
Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

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1. Liquid water at 453.15 K (180 °C) and 1002.7 kPa has an internal energy (on an arbitrary scale) of 762.0 kJ kg^{-1} and a specific volume of 1.128 cm^3 g^{-1}. **(i)** What is its enthalpy? **(ii)** The water brought to the vapor state 573.15 K (300 °C) and 1500kPa, where its internal energy is 2784.4 kJ kg^{-1} and its specific volume is 169.7cm^3 g^{-1}. Calculate ΔU and ΔH for the process. **(4 M)**

2. Steam at 2100 kPa and 533.15 K (260 °C) expands at constant enthalpy (as in a throttling process) to 125 kPa. What is the temperature of the steam in its final state and what is its entropy change? What would be the final temperature and entropy change assuming steam as an ideal gas? **(4 M)**

3. 500 g of air at an initial state of 500 K and 2 bar pressure is heated reversibly at constant pressure until its volume changes to 5 times of initial volume. Calculate W, Q, ΔU and ΔH for the process. Assume for air PV/T = 83.14 bar cm^3 mol^{-1} K^{-1}, and C_p = 29 J mol^{-1} K^{-1}. **(4 M)**

4. A Carnot's engine operates between 600 K and 200 K produce a power of 6.7×10^7 Watts. Calculate the heat absorbed and rejected in the process. And also calculate the heat absorbed and rejected by a practical engine operating with the same condition whose efficiency is 40% of Carnot's engine. **(4 M)**

5. Determine Q, W, ΔU & ΔH for a mechanically reversible isothermal process in which one kg of water at 25 ^{o}C ($V_1 = 1.003x10^{3}\ cm^{3}\ kg^{-1}$) is compressed from 1 *bar* to 1500 *bar*. [Given that $\beta = 2.5x10^{-4}\ K$ *and* $\kappa = 4.5x10^{-5}$] **(4 M)**

6. Saturated vapor steam ($1.4x10^{-2}\ m^{3}$) and $2.1x10^{-2}\ m^{3}$ of saturated liquid water (100 ^{o}C) are in equilibrium in a rigid vessel. If heat is transferred to the vessel to make one phase just to disappear (single phase exists) determine the temperature and pressure and which phase will remain? Calculate the heat transferred in this process. **(4 M)**

7. Determine the BUBL point pressure for methane(1)/ethylene(2)/ethane(3) system at -50 ^{o}C [Given $x_1 = 0.10$ and $x_2 = 0.50$]. Also calculate the DEW point pressure for the same system at -51 ^{o}C [Given $y_1 = 0.50$ and $y_2 = 0.25$]. **(4M)**

8. (a). Discuss the liquefaction of gases by Linde's process with a neat sketch **(2 M)**

   (b). Discuss: Entropy and Spontaneity, Isentropic and Adiabatic process. **(2 M)**

9. An organic liquid of chemical formula $C_{10}H_{18}$ is combusted in a constant volume process in the presence of oxygen. At 25 ^{o}C the heat evolved is $43,960\ J\ g^{-1}$. Calculate the standard heat of combustion of the compound at 25 ^{o}C in the reaction giving H_2O *(g)* and CO_2 *(g)* as products. [Enthalpy of vaporization of water is $44012\ J\ mol^{-1}$]. **(4 M)**

10. Superheated steam at 700 kPa and 280 °C (mass flow rate is 50 kg s^{-1}), is mixed liquid water at 40 °C to produce steam at 700 kPa and 200 °C. Assuming adiabatic operation, determine the mass flow rate of liquid water to the mixer. Calculate the entropy generation rate and comment on the irreversible feature of the process. **(4 M)**

BITS PILANI, DUBAI CAMPUS

THIRD YEAR CHEMICAL ENGG. - FIRST SEMESTER, 2013-'14

TEST- 2 (Open Book)

Course Title : Chem. Engg. Thermodynamics **Course No: CHE F213**

Date: 31.10.2013 **MAXIMUM MARKS: 20**

Time: 50 min **Weightage: 20%**

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1. Calculate the heat of formation of n-Octane from the following data

   $C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$ $\Delta H^\circ = -5.5$ MJ/mol **(5 M)**

2. An engine having 35 % of the Carnot's efficiency operates between the temperatures 315 °C and 20 °C and generates 750 MW power. How much heat is discarded at the sink and what would be the efficiency of the engine? If it is a Carnot's engine, at what rate heat will be discarded to the sink. **(5 M)**

3. One kg of water at 0 °C is heated to 100 °C by contact with a heat reservoir at 100 °C. What is the entropy change of the water and the reservoir and both? If it is heated by a reservoir at 50 °C initially to 50 °C and then with a reservoir at 100 °C to 100 °C calculate the total change in entropy as well as in each stage. **(5 M)**

4. An ideal gas with $C_p = 7/2$ R enters in to a mixing chamber as three streams A (600 K), B (500 K) and C (400 K). Each at 1 atm pressure, has the molar flow rate of 1, 2 and 3 mol s^{-1} respectively. If the exiting stream is at 1 atm pressure and 450 K, calculate the rate of heat transfer and entropy of generation. Assume steady state flow, negligiblae KE and PE changes with the surrounding temperature of 300 K. **(5 M)**

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BITS PILANI, DUBAI CAMPUS

THIRD YEAR CHEMICAL ENGG. - FIRST SEMESTER, 2013-'14

TEST- 1 (Closed Book)

Course Title : Chem. Engg. Thermodynamics **Course No: CHE F213**

Date: 06.10.2013 **MAXIMUM MARKS: 25**

Time: 50 min **Weightage: 25%**

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1. An ideal gas from an initial state of 70 ^{o}C and 1 bar pressure is compressed adiabatically to 150 ^{o}C and then cooled to 70 ^{o}C at constant pressure. Then it is expanded isothermally to its initial state. Assuming the process mechanically reversible, calculate ΔH, ΔU, W and Q for each process and for the entire cycle. [Given that $C_p = (7/2\ R)$ & $C_v = (5/2\ R)$]. Plot the process in a PV diagram. **(10 M)**
2. Calculate the internal energy and enthalpy changes that occur when the conditions of a gas changes in steady-flow process from 293.15 K and 1000 kPa to 333.15 K and 100 kPa. (Devise a reversible non-flow process of any desired number of steps). Assuming one mole of the gas is under study with Cv = (5/2)R & Cp = (7/2)R and PV/T = constant. **(8 M)**
3. Draw a neat sketch and explain the principle and objective of a flow calorimeter. **(4 M)**
4. A suspended spring having a mass of 2 kg on earth stretches to 30 cm. To what extend it will be stretched on moon, which has 1/6 th of gravity of earth. **(3 M)**

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BITS PILANI – DUBAI CAMPUS

FIRST SEMESTER : 2013 – 2014

QUIZ-1 (Closed Book)

Course Code: CHE F213		Date	: 23-10-2013
Course Title	: Chemical Engineering Thermodynamics	Max Marks	: 10
Duration	: 20 minutes	Weightage	: 10 %

Name: ..... **ID No:** ..... **Sec / Prog:** .....

Instructions: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1. Calculate ΔH, ΔU, W and Q when one mole of an ideal gas expands from 8 bar and 600 K to 1 bar through an adiabatic process.[Given that $C_p = (7/2\ R)$ & $C_v = (5/2\ R$]. (4M)

2. Estimate the specific volume of liquid ammonia at 20 °C whose Vc, Zc and Tc values are 72.5 cm^3/mol, 2.42 x 10^{-1} and 405.7 K respectively. (2M)

3. Write the expressions for the volume expansivity and isothermal compressibility for liquids (2M)

4. Draw a representative PT diagram of a pure substance with all labeling (2M)