

BITS, PILANI-DUBAI

Dubai International Academic City, Dubai, U.A.E.

III Year Chemical Engineering, I Semester 2010-'11

Comprehensive Exam

CHE C311 Chemical Engineering Thermodynamics

Maximum Marks: 80

Weightage: 40%

Duration: 3 Hrs

(Closed Book)

27.12.2010

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. (a) An ideal gas, initially at 30 °C and 100 kPa, undergo the following cyclic processes in a closed system:
- (i) In a mechanically reversible processes, the gas is first compressed adiabatically to 500 kPa, then cooled at a constant pressure of 500 kPa to 30 °C, and then finally expanded isothermally to its original state.
- (ii) The cycle traverse exactly the same changes of state, but each step is irreversible with an efficiency of 80% compared with the corresponding mechanically reversible process. *Note:* The initial step can no longer be adiabatic.
- Calculate Q, W, ΔU and ΔH for each step of the process and for the cycle. Take $C_p = (7/2) R$ and $C_v = (5/2) R$. (8 M)
- (b) Hydrocarbon fuels can be produced from methanol by reactions such as the following which yields 1-hexene:
- $$6\text{CH}_3\text{OH}_{(g)} \rightarrow \text{C}_6\text{H}_{12(g)} + 6\text{H}_2\text{O}_{(g)}$$
- Compare the standard heat of combustion at 25 °C of $6\text{CH}_3\text{OH}_{(g)}$ with the standard heat of combustion 25 °C of C_6H_{12} for reaction products $\text{CO}_{2(g)}$ and $\text{H}_2\text{O}_{(g)}$. (4 M)
- (c) A suspended spring having a mass of 2 kg on earth stretches to 30 cm. To what extent it will be stretched on moon, which has $1/6^{\text{th}}$ of gravity of earth. (4 M)
2. (a) 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 $PV/T = 83.14 \text{ bar cm}^3 \text{ mol}^{-1} \text{ K}^{-1}$, and $C_p = 29 \text{ J mol}^{-1} \text{ K}^{-1}$. (8 M)
- (b) An ideal gas with $C_p = 7/2 R$ is heated in a steady flow heat exchanger from 100 °C to 200 °C by another stream of ideal gas which enters at 300 °C. The flow rates of the two streams are same, and heat losses from the

- exchanger are negligible. Calculate the molar entropy changes of the two gas streams for both parallel and counter current flow in the exchanger. Also calculate the ΔS_{total} . (4 M)
- (c) 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)
3. (a) Wet steam at 230 °C has a density of 0.025 g cm^{-3} . Determine x, H and S. Compare the values of x, H and S at 330 °C for the same density. (8 M)
- (b) Calculate the mole fraction of water vapour in air that is saturated with water at 30 °C, 40 °C and 50 °C at 1 bar pressure. (4 M)
- (c) Discuss: Entropy and Spontaneity, Isentropic and Adiabatic, Change in Entropy and Reversible process. (4 M)
4. (a) A turbine produces 180 kW power by utilizing the steam entering at 1,700 kPa and 225 °C with a flow rate of 0.5 kg s^{-1} . Calculate the heat lost from the turbine if the exhausts steam has 10 kPa pressure and a quality of 0.95. Also calculate the power out put if the steam supplied is expanded isentropically to the final pressure. (8 M)
- (b) A steam turbine operates adiabatically at a power level of 3,500 kW. Steam enters the turbine at 2,400 kPa and 500 °C and exhausts from the turbine as saturated vapor at 20 kPa. What is the steam rate through the turbine, and what is the turbine efficiency? (4 M)
- (c) An air conditioning plant working at -20 °C is wasting 1.25×10^5 J of heat per day due to bad maintenance. The surrounding temperature is 20 °C and efficiency is of 60 % of the Carnot value. Calculate the additional cost of the electricity the owner has to afford due to the wastage, on the basis of \$ 0.08/kWhr. (4 M)
5. (a) What is the heat effect when 20 kg of LiCl(s) is added to 125 kg of an aqueous solution containing 10-wt-% LiCl in an isothermal process at 25 °C. (8M)
- (b) Show that the chemical potential of each species is same in all phases when the multiple phases are in equilibrium at the same temperature and pressure. (4M)
- (c) What is an excess property? Show that $M^E = M^R - \sum x_i M_i^R$. (4 M)
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BITS, PILANI - DUBAI, ACADEMIC CITY, DUBAI

THIRD YEAR CHEMICAL ENGG. - FIRST SEMESTER, 2010-2011

TEST- 2 (Open Book)

Course Title: Chem. Engg. Thermodynamics

Course No: CHE C311

Date: 28.11.2010

Maximum Mark: 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.

Only prescribed text book and own hand written notes are permitted.

1. Steam with a quality of 0.90 at 2700 kPa is subjected to a reversible, adiabatic expansion in a non-flow process to 400 kPa. It is then heated at constant volume until it becomes saturated vapor. Determine Q and W for the process. (10 M)
 2. Steam at 2100 kPa and 533.15 K (260 °C) expands at constant enthalpy, (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 for an ideal gas? (5 M)
 3. One kg of water in a vessel is in equilibrium as liquid and vapor at 1000 kPa. If the liquid water occupies 30 % of the total volume of the vessel, determine the H and S for the 1 kg of water, (5 M)
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BITS PILANI, INTERNATIONAL ACADEMIC CITY, DUBAI

THIRD YEAR CHEMICAL ENGG. - FIRST SEMESTER, 2010-2011

TEST- 1 (Closed Book)

Course Title : Chem. Engg. Thermodynamics

Course No: CHE C311

Date:17.10.2010

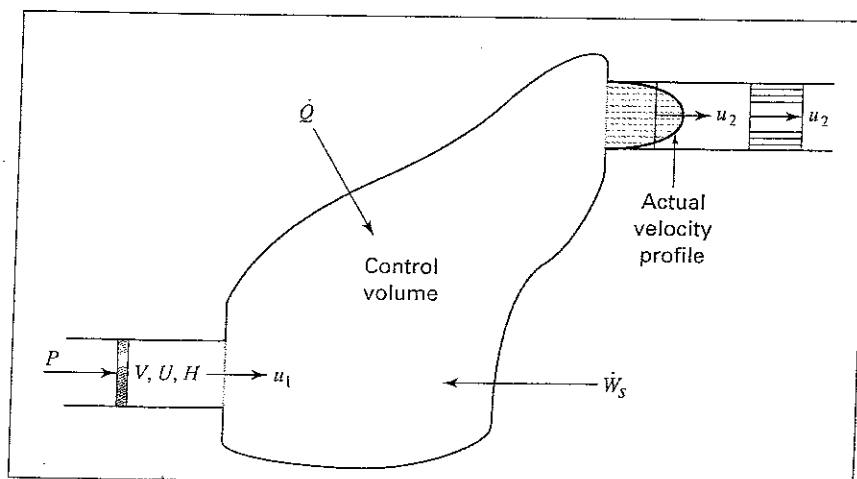
MAXIMUM MARKS: 25

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. Pressures up to 3000 bar are measured with a dead weight gauge. The piston diameter is 4 mm. What is the approximate mass in Kg of the weights required?
(3M)
2. Heat in amount of 7.5 kJ is added to a closed system while its internal energy decreases by 12 kJ. How much energy is transferred as work? For a process causing the same change of state but for which the work is zero, how much heat is transferred?
(3M)
3. Derive the expression for the general energy balance for a flowing stream as shown in the figure.
(4M)



4. Five kg of liquid carbon tetra chloride undergo a mechanically reversible, isobaric change of state at 1 bar during which the temperature changes from 0 °C to 20 °C. Determine ΔV^t , W , Q , ΔH^t and ΔU^t . The properties of liquid carbon tetra chloride at 1 bar and 0 °C may be assumed independent of temperature: $\beta = 1.2 \cdot 10^{-3} \text{ K}^{-1}$, $C_p = 0.84 \text{ kJ kg}^{-1} \text{ K}^{-1}$, and $\rho = 1,590 \text{ kg m}^{-3}$. (8M)
5. One mole of an ideal gas is expanded from 8 bar pressure to 1 bar pressure at 600 K by each of the following paths. (a) Constant temperature (b) Adiabatically. Assuming mechanical reversibility, calculate W , Q , ΔU and ΔH for each process. $[C_p = (7/2 R) \text{ \& } C_v = (5/2 R)]$ (7M)
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BITS, PILANI – DUBAI
FIRST SEMESTER 2010 – 2011
THIRD YEAR : CHEMICAL ENGG.

Course Code: CHE C311 **QUIZ-2 (Closed Book)** Date : 06-12-2010
Course Title : Chemical Engineering Thermodynamics Max Marks : 7
Duration : 20 minutes Weightage : 7%

Name:	ID No:	Sec / Prog:
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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. Give the uses of the following gases in their liquid state.
i. Oxygen. ii. Nitrogen. iii. Propane. iv. Natural Gas. (2M)

2. What is the role of water in absorption refrigeration system? (1M)

3. What is the major difference between the Linde and Claude processes of liquefaction? (1 M)

4. A two stage cascade refrigeration system operates between 200 K and 310 K. The intermediate temperatures are 250 K and 260 K. Coefficients of performance of each stage are 62% of the corresponding Carnot refrigerator. Determine the efficiency for the real cascade, and compare it with that for a Carnot refrigerator operating between T_H and T_C . (3M)

(Use the next page for answering)

BITS, PILANI – DUBAI
FIRST SEMESTER 2009 – 2010
THIRD YEAR : CHEMICAL ENGG.

Course Code: CHE C311 **QUIZ-1 (Closed Book)** Date : 10-11-2010
Course Title : Chemical Engineering Thermodynamics Max Marks : 8
Duration : 20 minutes Weightage : 8%

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. Write the expression for the absolute entropy of a gas at temperature T , based on calorimetric data (2M)

2. Write the two statements of the Carnot's theorem. (2M)

3. The S_G and ΔS for a particular process are 48.9 W/K and 17.6 J/mol/K respectively. If the surrounding temperature is 20°C, what will be W_{lost} ? (2M)

4. A Carnot engine with efficiency 0.37 operates between 700 and 300 K and produces a power of 13,500 kW. Find the quantity of heat absorbed and discarded. (2 M)