Code No: RR220802 **Set No. 1**

II B.Tech II Semester Supplementary Examinations, November/December 2005
CHEMICAL ENGINEERING THERMODYNAMICS-I
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Define a thermodynamic system and explain criteria of the system should satisfy for it to be in a state of thermodynamic equilibrium. How a system is characterized?
   (b) What is phase rule? Draw the single component phase diagram and explain critical point and triple point. [8+8]

2. (a) The properties of a closed system undergo change following the relation PV= 4 and P is in bar and V in metre^3. Calculate the work done when P increases from 2.5 bar to 8 bar.
   (b) Show that $\left(\frac{\partial T}{\partial V}\right)_s = -\left(\frac{\partial P}{\partial S}\right)_v$ [8+8]

3. Explain the application of steady flow energy equation to a turbine and a condenser. [16]

4. An ideal gas (1 kg-mole) from an initial state of 21^0C, $1.034 \times 10^5\ N/m^2$ is compressed adiabatically to 65.5^0C, followed by isobaric cooling to 21^0C and finally expanded isothermally to its original state. Sketch the overall process on a pv diagram. Calculate Q, W, ΔU and ΔH for each step and overall cycle. If same changes are brought about by an irreversible process which quantities will differ and how much?
   Data: C_p = 20934 joules/(kg mole) (^0C)
   C_v = 12560.4 joules/(kg mole) (^0C)
   η of irreversible process = 80%. [16]

5. Define the following:
   (a) State
   (b) Process
   (c) Property
   (d) Cycle [4x4]

6. A reversible heat engine, employing an ideal gas with constant specific heats, follows the following cycle: constant-volume heating from state 1 to state 2, adiabatic expansion from state 2 to state 3, and a constant-pressure process from state 3 to state 1. Show that for this cycle the ratio of net work produced to heat absorbed is given by
   $\frac{W}{Q} = (1-\gamma)\frac{V_3/V_1-1}{P_2/P_1-1}$ [16]

7. It is necessary to maintain a few drugs at -25^0C while the ambient temperature is 35^0C. The rate of energy loss in the form of heat from the cold space is estimated at 0.4 kW per degree Celsius difference between the cold space and the ambient. It is proposed to use a vapor compression refrigerator with Freon-12 as the refrigerant for this purpose. Determine:
(i) The COP of refrigerator
(ii) Circulation rate of refrigerant
(iii) Power needed to operate the refrigerator
(iv) COP of a Carnot refrigerator if is operated between the same temperature levels.

An expansion valve is used. The steam leaving the compressor is saturated vapour at 35^0C. The required enthalpy and entropy data is given below.

Temperature ^0C	Enthalpy of saturated	Entropy of saturated liquid	Entahalpy of saturated vapour (kJ/Kg)	Entropy of saturated vapour (kJ/kg-K)
-25	13.315	0.0552	176.352	0.7122
35	69.494	——-	201.299	0.6834

[16]

8. If the thermal efficiency of a reversible power cycle operating between two reservoirs is denoted by η_{max}, develop an expression in terms of η_{max} for the coefficient of performance of a reversible refrigeration cycle operating between the same two reservoirs. [16]

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1. (a) What is phase rule? Compute the degree of freedom if system is made up of liquid water in equilibrium with its vapour.
   (b) What is the role of thermodynamics in energy conservation? [8+8]
2. (a) A lean and thin man, who can lift a body of mass 100 kg where 'g' = 9.81 m/sec^2, claims that he can lift a body of mass 150 kg. His friend did not agree and both went into a bet. They go high in space to a H, height where the lean and thin man lift the body of mass 150 kg. If 'g' decreases at the rate 0.01 cm/sec^2 per 1000 metre of ascent, what is the value of H?
   (b) What do you understand by NTP and STP? What are their values? [10+6]
3. Explain the application of steady flow energy equation to a turbine and a condenser. [16]
4. (a) It is claimed that oxygen at 150 K and 20 bar can be treated as an ideal gas with an error of less than 15%. Is this claim valid?
   (b) Isopropanol is treated as an ideal gas at 25 ^0C and 7.5 bar pressure. Calculate the error in specific volume using virial equation of state. [8+8]
5. A pumping station transports 5000 kg/hr of natural gas at 500 kg/cm^2 and 20^0C through a pipe line of 20 cm O.D. The natural gas has the following composition:

   Methane : 85% by volume

   Ethane : 5% by volume

   Nitrogen: 10% by volume

   What is the velocity of the natural gas?

   Data:

	Methane	Ethane	N_2
T_c in K	191	306	126
P_c in atm	45.8	48.2	33.5

[16]

6. A reversible engine absorbs 250 Kcal of heat at 260^0C and discards heat at 40^0C, what is
   (a) the work output of the engine.
   (b) the heat rejected

(c) the entropy change of system, surrounding and total change in entropy.

(d) the efficiency of heat engine [4x4]

7. A refrigeration system requires 1.5 kW of power for a refrigerationrate of 4 kJ s^{-1}

   (a) What is the coefficient of performance ?.

   (b) How much heat is rejected in the condenser ?.

   (c) If heat rejection is at 40^0C, what is the lowest temperature the system can possibly maintain ? [6+6+4]

8. (a) Explain Cloude's process for air liquefaction with neat sketch. Show it by T-S diagram.

   (b) Obtain the relation for the COP of an absorption-refrigeration process. [8+8]

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Code No: RR220802 **Set No. 3**

II B.Tech II Semester Supplementary Examinations, November/December 2005
CHEMICAL ENGINEERING THERMODYNAMICS-I
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. Define and explain the following:
   (a) Closed System
   (b) Homogeneous and Heterogeneous System
   (c) Isolated System
   (d) Open System [4x4]

2. (a) A pressure gauge fitted to a steam boiler records a pressure of 34 bar. The vacuum gauge on the condenser indicates 0.94 bar. If the atmospheric pressure is 1 bar, calculate:
      i. Absolute pressure in the boiler in Pa
      ii. Absolute perssure in the condenser in Pa.
   (b) Show that $\left(\frac{\partial p}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T$ [8+8]

3. (a) What is the difference between the continuity equation and the Bernoulli's equation?
   (b) One kg of water at 30^0C and 100kPa is continuously heated in the open atmosphere till it is completely evaporated. Determine the heat and work interactions.
   Data: At 30^0C: Sp. Vol. Of water = 0.001004 m^3/kg.
   Sp. Vol. Of water vapor = 1.6949 m^3/kg.
   Heat content of vapor and water liquid are 2675.47 and 125.6 kJ/kg respectively [8+8]

4. A system receives 200 kj of heat at constant volume process and rejects 220 kJ of heat at constant pressure and 40 kj of work is done on the system. The system is brought to its original state by an adiabatic process calculate the adiabatic work. If the initial internal energy is 240 kj, then calculate the value of internal energy at all points [16]

5. A pumping station transports 5000 kg/hr of natural gas at 500 kg/cm^2 and 20^0C through a pipe line of 20 cm O.D. The natural gas has the following composition:

   Methane : 85% by volume

   Ethane : 5% by volume

   Nitrogen: 10% by volume

What is the velocity of the natural gas?

Data:

	Methane	Ethane	N_2
T_c in K	191	306	126
P_c in atm	45.8	48.2	33.5

[16]

6. (a) An inventor claims to have developed an engine that takes in 25,000(J)/(s) at a temperature of rejects 12,000 (J)/(s) at a temperature of 200(K), and delivers 15(kW) of mechanical power. Would you advice investing money to put this engine on the market?
   (b) State the carnot theorems.
   (c) Write shortnotes on heat engine. [7+5+4]

7. (a) Explain Carnot refrigerator and derive the relation for COP?
   (b) A Carnot refrigerator is operating between two reservoirs at temperatures -25^0C and 35^0C. Determine COP of the refrigerator. [10+6]

8. A house has a winter heating requirement of 30 kJs^{-1} and a summer cooling requirement of 60 kJ s^{-1}. Consider a heat pump installation to maintain the house temperature at 20^0C in winter and 25^0C in summer. This requires circulation of the refrigerant through interior exchanger coils at 30^0C in winter and 5^0C in summer. Underground coils provide the heat source in winter and heat sink in summer. For a year-round ground temperature of 15^0C, the heat transfer characteristics of the coils necessitate refrigerant temperatures of 10^0C in winter and 25^0C in summer. What are the minimum power requirements for winter heating and summer cooling? [16]

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1. (a) Name some properties which are relevant in thermodynamics. Why the shape, colour and odour are irrelevant is thermodynamics?
   (b) Define open, closed and isolated systems with suitable examples. Show energy of an isolated system is conserved. [8+8]

2. The piston of a piston cylinder device containing a gas has a mass of 75 Kg. Diameter of piston is 250 mm. The local atmospheric pressure is 0.97 bar gravitational acceleration is 9.8 m/second square.
   (a) Determine the pressure inside the cylinder.
   (b) If some heat is transferred and its volume doubles, do you expect the pressure inside the cylinder to change. [8+8]

3. (a) What are the forms of energy that are considered to be energy in transit across the boundary of the system? What are those that are contained in the body or system?
   (b) The internal energy U^t of an amount of a gas is given by $U^t = 0.01\ PV^t$, where P is in kPa and V^t is in m^3. The gas undergoes a mechanically reversible process from an initial state at 10,000 kPa and 250 K. During the process V^t is held constant and equal to 0.3 m^3 and P increases by 50%. Determine values for Q and $\Delta\ H^t$ in kJ. [8+8]

4. A cylinder closed at both ends contains a free piston, on one side of which is nitrogen and other side air. The initial pressure and volume of each being 1.03 bar and 0.5 m^3 respectively. Both the piston and cylinder are perfectly insulated. In the cylinder on the air side of the piston there is an electric heater which is used to heat the air. Heat is added to the air in this manner until the volume occupied by the nitrogen is 0.3 m^3. The initial temperature of each gas is 50^0C. Determine
   (a) the final temperature of air and
   (b) the heat supplied to air.
   Assume Cp for air as 1.005 and R for air as 0.287 kj / kg K and $\gamma = 1.4$ for nitrogen. Also draw the PV diagram. [16]

5. (a) Define reduced temperature, pressure and density.
   (b) Air obeying ideal gas law undergoes a change of state from P_1=1 atm, V_1=10 m^3, to P_2 = 10 atm and 0.1 m^3 by the following reversible processes:

i. Compression at constant temperature.
ii. Adiabatic compression followed by isobaric cooling.
iii. Isochoric heating followed by isobaric cooling.

[6+10]

6. (a) An inventor claims to have developed an engine that takes in 25,000(J)/(s) at a temperature of rejects 12,000 (J)/(s) at a temperature of 200(K), and delivers 15(kW) of mechanical power. Would you advice investing money to put this engine on the market?
   (b) State the carnot theorems.
   (c) Write shortnotes on heat engine. [7+5+4]

7. (a) Sketch an ideal vapor compression cycle on a T-S diagram.
   (b) 50 kW of refrigeration is to be supplied by a refrigerating machine operating on a reversed Carnot cycle. The evaporator temperature is -10^0C and the condenser temperature is 35^0C. Determine the power required and the coefficient of performance. [8+8]

8. A house has a winter heating requirement of 30 kJs^{-1} and a summer cooling requirement of 60 kJ s^{-1}. Consider a heat pump installation to maintain the house temperature at 20^0C in winter and 25^0C in summer. This requires circulation of the refrigerant through interior exchanger coils at 30^0C in winter and 5^0C in summer. Underground coils provide the heat source in winter and heat sink in summer. For a year-round ground temperature of 15^0C, the heat transfer characteristics of the coils necessitate refrigerant temperatures of 10^0C in winter and 25^0C in summer. What are the minimum power requirements for winter heating and summer cooling? [16]

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