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

**II B.Tech II Semester Regular Examinations, Apr/May 2006**
**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) Discuss the scope of "Thermodynamics".
   (b) What is 'thermodynamic equilibrium' and explain the zeroth law of thermodynamics. [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. State the first law of thermodynamics and apply it for isolated, closed and cylic system [16]

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. Explain briefly the p-v-T surface for the following:
   (a) A substance which expands on freezing.
   (b) A substance which contracts on freezing. [8+8]

6. (a) Give in brief account on the concept of entropy.
   (b) Discuss in detail about how to improve efficiency of a heat ingine. [8+8]

7. A conventional vapor compression refrigeration system with a throttle valve uses water as the refrigerant. If the evaporator is operated at $4^0C$, the condenser at $30^0C$, for a 1000 kJ/s heat absorption rate, determine circulation rate of the refrigerant, power requirement, COP of the system. Efficiency of the compressor is 0.75. Heat capacity of water vapor is 4.184 kJ/kg-K. The enthalpy and entropy data is given below.

| Temperature$^0C$ | Enthalpy of saturated liquid (kJ/kg) | Entropy of saturated liquid (kJ/kg-K) | Enthalpy of saturated vapour (kJ/kg) | Entropy of saturated vapour (kJ/kg-K) |
|---|---|---|---|---|
| 4 | ——- | ——- | 2508.9 | 9.0526 |
| 30 | 125.7 | ——— | 2556.4 | 8.4546 |

[16]

8. By supplying energy at an average rate of 21100 kJ/h, a heat pump maintains the temperature of dwelling at $21^0C$. If electricity 8 cents per kW.h, determine the minimum theoretical operating per each day of operation if the heat pump receives energy by heat transfer from
   (a) The outdoor air at $-5^0C$
   (b) Well water at $8^0C$. [16]

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Code No: RR220802

**Set No. 2**

**II B.Tech II Semester Regular Examinations, Apr/May 2006**
**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. Illustrate the meaning of point function and path function with suitable examples. [16]

2. Prove that the work interaction in a steady flow process is given by $-\int Pdv$ . State clearly the assumptions, if any. [16]

3. (a) What is enthalpy? Is enthalpy a path function?
   (b) One kilogram mass of water is vaporized at $25^0$C and 1 atmospheric pressure, calculate $\Delta$ U and $\Delta$ H if 10.2374 x $10^4$ joules heat is added to water.
   Data: Specific volume at 1 atm $25^0 C$.

   Liquid water = 1.044 x $10^{-3}$ m3/kg.
   Water vapour = 1.68 $m^3$/kg.
   (c) State the 'first law of thermodynamics' [4+8+4]

4. A cylinder contains 0.115 $m^3$ of gas at 1 bar and $90^0 C$. The gas is compressed to a volume 0.0288 $m^3$, the final pressure being 5.67 bar. Calculate
   (a) the mass of the gas
   (b) the value of index of compression
   (c) the increase in internal energy of the gas and
   (d) the heat transfer during the compression. [4x4]
   If, after the above compression, the gas is to be cooled at constant pressure to its original temperature of $90^0 C$, find the further work of compression required. Assume $\gamma$ = 1.4 & R = 0.3 kj / kg K

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

6. (a) A reversible engine working on the Carnot cycle has 20 kcal/s supplied from a source at a temperature of $430^0 C$, and rejects heat to a sink at a temperature of $20^0 C$. Calculate the horsepower developed and the heat rejected.

(b) Show that Carnot cylce of heat engine is most efficient. Discuss in detail. [8+8]

7. By steadily circulating a refrigerant at low temperature through passages in the walls of the freezer compartment, a refrigerator maintains the freezer compartment at $-5^0C$ when the air surrounding the refrigerator is at $22^0C$. The rate of heat transfer from the freezer compartment to the refrigerant is 8000 kJ/ h and the power input required to operate the refrigerator is 3200 kJ/h. Determine the coefficient of performance of the refrigerator and compare with the COP of a reversible refrigeration cycle operating between reservoirs at the same two temperatures. [16]

8. Suppose a Carnot refrigerator operating between $-25^0C$ and $40^0C$ consumes 0.5 kW power. Determine the rate of energy removal $(Q_L)$ from the cold body. If carnot heat pump operating between the same reservoirs is requires which rejects energy $(Q_H)$ to the high temperature body at the same rate as the Carnot refregerator is extracting from the cold body $(Q_L)$. Calculate the power consumption. [16]

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

**II B.Tech II Semester Regular Examinations, Apr/May 2006**
**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) What is a quasi-static process?
   (b) In the macroscopic study of thermodynamics, the structure of matter is not taken into account. Are the results predicted from this approach applicable to all types of matter? Give an example.
   (c) State and explain the criterion of reversibility. [4+6+6]

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 physical significance of the various terms of the steady flow energy equation & also explain how all the terms in that expression has the same units. [16]

4. 2 $m^3$ of hydrogen at a pressure of 1 bar and $20^0C$ is compressed isentropically to 4 bar. The same gas is expanded isothermally to the original volume. Finally, the gas pressure is restored to the original volume by a constant volume heat rejection process. Determine
   (a) pressure, volume and temperature at each end of operation
   (b) the heat added during the isothermal process
   (c) the heat rejected during constant volume process and
   (d) change in internal energy during each process.
   Assume R = 4.206 kj / kg K & $C_p$ = 14.25 kj / kg K. [4x4]

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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) State the second law of thermodynamics and explain how it is applied for development of heat engine.
   (b) Derive an expression for the efficiency of heat engine. [8+8]

7. (a) Write the mathematical statement of second law.
   (b) The COP of a Carnot refrigerator can be increased either by increasing the temperature of the low temperature reservoir while keeping the other reservoir at a constant temperature or by decreasing the temperature of high temperature reservoir while maintaining the other reservoir at constant temperature. Which of the two alternatives is more effective?
   (c) Show that COP of a carnot refrigerator depends only on temperature. [4+8+4]

8. (a) The COP of an irreversible heat pump cycle is always less than the COP of a reversible heat pump cycle when both exchange energy by heat transfer with the same reservoirs. Explain your answer.
   (b) Define approach temperature. Show its effect on COP. [8+8]

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**Set No. 4**

**II B.Tech II Semester Regular Examinations, Apr/May 2006**
**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 temperature. Name the different temperature scales in common use. Establish relation between Celsius and Fahrenheit scales.
   (b) Define and explain the following:
      i. Intensive property
      ii. Point function
      iii. Closed system
      iv. Spontaneous process.

[4x4]

2. (a) Define internal energy. Name those energy which constitute Internal energy.
   (b) State the thermodynamic definition of work.
   (c) Show that $\left(\frac{\partial v}{\partial T}\right)_T = -\left(\frac{\partial s}{\partial p}\right)_T$ [4+4+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. Define the following:

(a) State

(b) Process

(c) Property

(d) Cycle [4x4]

6. (a) Derive an expression for the efficiency of reversible heat engine.

   (b) In thermodynamics cycle the heat and work as follows.

| Process | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Q | 30 | -10 | -20 | 5 |
| W | 3 | 10 | -8 | 0 |

Calculate the thermal efficiency. [8+8]

7. A solar heater is used to heat 10 kg of a liquid from $95^0C$ to $150^0C$. What is the availability if surrounding is at $25^0C$. The specific heat and boiling point of the are 0.9 kcal/kg$^0K$ and $200^0C$ respectively. What is the percentage of absorbed energy that is available? [16]

8. A Carnot engine is coupled to a Carnot refrigerator so that all the work produced by the engine is used by the refrigerator in extraction of heat from a heat reservoir at $0^0C$ at the rate of 35 kJ$s^{-1}$. The source of energy for the Carnot engine is a heat reservoir at $250^0C$. If both the devices discard heat to the surroundings at $25^0C$, how much heat does the engine absorb from its heat source reservoir? [16]

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