Code No: R09220804 **R09** **Set No. 2**

II B.Tech II Semester Examinations,April/May 2012
CHEMICAL ENGINEERING THERMODYNAMICS-I
Chemical Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain the establishment of a thermodynamic temperature scale. [15]
2. Describe about turbines or expanders and derive the relevant equations to define turbine efficiency. [15]
3. Sketch the phase diagram for a substance that expands on freezing and indicate the regions of subcooled liquid and superheated vapor. [15]
4. Prove that: $dU = C_V dT + (\beta/\kappa T - P)dV$ [15]
5. What is liquefaction? Explain the different approaches in liquefaction Process. [15]
6. Compute the degrees of freedom if:
   (a) System is made up of liquid water in equilibrium with its vapor.
   (b) System consists of liquid water and liquid toluene (immiscible) in equilibrium with its vapors.
   (c) System consisting of solid carbon, CO,CO_2, O_2 in chemical equilibrium.
   (d) System is made by of partial decomposition of $MgCO_3$.
   (e) System is made by of partial decomposition of NH_4Cl. [15]
7. An automobile having a mass of 1250 kg is travelling at 40 m/s. What is its kinetic energy in kJ? How much work must be done to bring it to a stop? [15]
8. An inventor has devised a complicated non-flow process in which 1 mol of air is the working fluid. The net effects of the process are claimed to be:
   (a) A change in state of the air from 523.15 K (250^0C) and 3 bar to 353.15 K and 1 bar.
   (b) The production of 1800 J of work.
   (c) The transfer of an undisclosed amount of heat to a heat reservoir at 303.15 K.

   Determine whether the claimed performance of the process is consistent with the second law. Assume that air is an ideal gas for which Cp = (7/2)R. [15]

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Code No: R09220804 **R09** **Set No. 4**

II B.Tech II Semester Examinations,April/May 2012
CHEMICAL ENGINEERING THERMODYNAMICS-I
Chemical Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What is meant by a heat engine and what are its characteristics?
   (b) A reversible heat engine has an efficiency of 0.6 when it absorbs 400kJ of energy as heat from a reservoir at 537^0C. Calculate the sink temperature and energy rejected as heat to the sink. [6+9]

2. For a mechanically reversible closed-system, derive the equation for 'Q' and 'W' in each of the following processes
   (a) Isothermal
   (b) Isobaric
   (c) Isochoric
   (d) Adiabatic process [15]

3. Liquid water enters an adiabatic hydro turbine at 5 atm and 288.15 K, and exhausts at 1 atm. Estimate the power output of the turbine in J/ kg of water if its efficiency is $\eta = 0.55$. What is the outlet temperature of the water? Assume water to be an incompressible liquid. [15]

4. Describe about vapour-compression refrigeration cycle with neat diagram. [15]

5. Ten kmol per hour of air is throttled from upstream conditions of 298.15 K and 10 bar to a downstream pressure of 1.2 bar. Assume air to be an ideal gas with Cp = (7/2)R.
   (a) What is the downstream temperature?
   (b) What is the entropy change of the air in J/ mol K? [6+9]

6. Derive and discuss about the generalized correlations for the liquids. [15]

7. The P V T behavior of a certain gas is described by the equation of state:
   P(V-b) = RT
   where b is a constant. If in addition C_V is constant, show that:
   (a) U is a function of T only.
   (b) γ = constant.
   (c) For a mechanically reversible process, $P(V - b)^\gamma$ = constant. [15]

8. (a) Explain the concept of pressure using dead weight gauge.

(b) Pressures up to 3000 atm are measured with a dead-weight gauge. The piston diameter is 0.17 (in). What is the approximate mass in (lb,) of the weights required? [6+9]

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Code No: R09220804 **R09** **Set No. 1**

II B.Tech II Semester Examinations,April/May 2012
CHEMICAL ENGINEERING THERMODYNAMICS-I
Chemical Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Define coefficient of volume expansion β and isothermal compressibility κ.
   (b) A definite mass of mercury is heated from 1 bar and 20^0C to 40^0C under constant volume conditions. What is the final pressure if $\beta = 0.182 \times 10^{-3} K^{-1}$, $\kappa = 4.02 \times 10^{-6} (bar)^{-1}$ [6+9]

2. Air expands adiabatically through a nozzle from a negligible initial velocity to a final velocity of 325 m/s. What is the temperature drop of the air, if air is assumed to be an ideal gas for which Cp = (7/2)R? [15]

3. A central power plant, rated at 800,000kW, generates steam at 585 K and discards heat to a river at 295 K. If the thermal efficiency of the plant is 70% of the maximum possible value, how much heat is discarded to the river at rated power? [15]

4. Discuss about the entropy from microscopic view point. [15]

5. A 0.35-m^3 vessel is used to store liquid propane at its vapor pressure. Safety considerations dictate that at a temperature of 320 K the liquid must occupy no more than 80% of the total volume of the vessel. For these conditions, determine the mass of vapor and the mass of liquid in the vessel. At 320 K the vapor pressure of propane is 16.0 bar. [15]

6. (a) Discuss about Carnot refrigerator.
   (b) Discuss the uses of liquefied gasses with examples. [6+9]

7. In the following take C_v = 20.8 and C_p = 29.1 J / mol ^{0}C for nitrogen gas:
   (a) Three moles of nitrogen at 303.15 K, contained in a rigid vessel, is heated to 523.15 K. How much heat is required if the vessel has a negligible heat capacity? If the vessel weighs 100 kg and has a heat capacity of 0.5 kJ /kg ^{0}C, how much heat is required?
   (b) Four moles of nitrogen at 473.15 K is contained in a piston /cylinder arrangement. How much heat must be extracted from this system, which is kept at constant pressure, to cool it to 313.15 K if the heat capacity of the piston and cylinder is neglected? [15]

8. The reading on a mercury manometer at 298.15 K (open to the atmosphere at one end) is 56.38 cm. The local acceleration of gravity is 9.8 m/ sec^2. Atmospheric pressure is 101.78 kPa. What is the absolute pressure in kPa being measured? The density of mercury at 298.15 K is 13.5 g /cm^3. [15]

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Code No: R09220804 **R09** **Set No. 3**

II B.Tech II Semester Examinations,April/May 2012
CHEMICAL ENGINEERING THERMODYNAMICS-I
Chemical Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What is enthalpy? Is enthalpy a path function?
   (b) State the zeroth and first law of thermodynamics.
   (c) What is meant by a reversible process? Explain it with the help of an example. [5+5+5]

2. (a) What pressure difference does a 10 m column of atmospheric air show? Density of air = 1.2 kg/m^3.
   (b) A manometer shows a pressure difference of 1 m of liquid mercury. Find ΔP in kPa. [8+7]

3. Write shorts on the following:
   (a) Compressors
   (b) Pumps. [7+8]

4. If an ideal gas undergoes a reversible adiabatic process and changes from P_1,T_1 to P_2,T_2, show that the change in entropy is equal to zero. [15]

5. The following heat engines produce power of 95 000 kW. Determine in each case the rates at which heat is absorbed from the hot reservoir and discarded to the cold reservoir.
   (a) A Carnot engine operates between heat reservoirs at 750 K and 300 K.
   (b) A practical engine operates between the same heat reservoirs but with a thermal efficiency $\eta = 0.35$. [15]

6. Estimate the entropy change of vaporization of benzene at 323.15 K. The vapor pressure of benzene is given by the equation:
   $\frac{\ln P^{sat}}{kPa} = 13.8858 - \frac{2788.51}{T-52.94}$
   Use Clapeyron equation with an estimated value of ΔH^{lv}. [15]

7. A heat pump is used to heat a house in the winter and to cool it in the summer. During the winter, the outside air serves as a low -temperature heat source; during the summer, it acts as a high -temperature heat sink. The heat-transfer rate through the walls and roof of the house is 0.75 kW for each kelvin of temperature difference between the inside and outside of the house, summer and winter. The heat -pump motor is rated at 1.5 kW. Determine the minimum outside temperature for which the house can be maintained at 293.15 K during the winter and the maximum outside temperature for which the house can be maintained at 298.15 K during the summer. [15]

8. A 0.4 kg mass of nitrogen at 27^0C is held in a vertical cylinder by a frictionless Piston. The weight of the piston makes the pressure of the nitrogen 0.35 bar higher than that of the surrounding atmosphere, which is at 1bar and 27^0C. Thus the nitrogen is initially at a pressure of 1.35 bar, and is in mechanical and thermal equilibrium with its surroundings. Consider the following sequence of processes:

   (a) The apparatus is immersed in an ice/water bath and is allowed to come to Equilibrium.

   (b) A variable force is slowly applied to the piston so that the nitrogen is compressed reversibly at the constant temperature of 0^0C until the gas volume reaches one-half the value at the end of step (a). At this point the piston is held in place by latches.

   (c) The apparatus is removed from the ice/water bath and comes to the thermal Equilibrium with the surrounding atmosphere at 27^0C.

   (d) The latches are removed and the apparatus is allowed to return to complete equilibrium with its surroundings.

   Sketch the entire cycle on PV diagram, and calculate Q, W, for the nitrogen for each step of the cycle. Nitrogen may be considered as an ideal gas for which $C_V = (5/2)R$ and $C_P = (7/2)R$. [15]

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