Chem/Rev/IV 2.30-5.30 3/12/14

Chemical Engineering Thermodynamics

QP Code : 12488

30

(3 Hours) **[Total Marks : 80**

N.B : (1) Question No.1 is **compulsory.**
(2) Attempt any **three** out of remaining **five** questions.
(3) **Assume** suitable **data** if required and mention it clearly.
(4) **Figures** to the **right** indicate **full** marks.
(5) Write separate question-answer on separate page.

1. (a) Differentiate between energy, entropy and exergy. **5**

(b) The Van der Waals equation of state is given by $\left[p+\frac{a}{V^2}\right][v-b]=RT$ **5**
where v is in m^3/mol. Determine SI units of a and b.

(c) An insulated piston-cylinder assembly contains 1kg superheated ammonia at 1MPa and 100°C. If the ammonia is allowed to expand, till it reaches the state of 0.1MPa and 50°C, determine the work done by ammonia. **5**

(d) Write statements of second law of thermodynamics. **5**

2. An ideal gas undergoes the following sequence of mechanically reversible processes in a closed system. **20**
(a) From an initial state of 70°C and 1bar, it is compressed adiabatically to 150°C.
(b) It is then coaled frem 150 to 70°C at constant pressure.
(c) Finally, it is expanded isothermally to its original state
Calculate W, Q, ΔU and ΔH for each of the three process and for the entire cycle. Take Cv=(3/2)R and Cp=(5/2)R.
It these processes are carried out irreversibly but so as to accomplish exactly the same changes of state (i.e. the same changes in P, T, V and H), then different values of Q and W result. Calculate Q and W if each step is carried out with 80% efficiency.

3. (a) For an ideal gas with constant heat capacities undergoing a reversible adiabatic process, **10**

$$\frac{T_2}{T_1}=\left(\frac{P_2}{P_1}\right)^{\frac{(\gamma-1)}{\gamma}}$$

Show that same equation results by using $\frac{\Delta S}{R}=\int_{T^0}^{T}\frac{C_p^{ig}}{R}\frac{dT}{T}-\ln\frac{P}{P^0}$.

(b) In a steady-state flow process, 1mol/s of air at 600K and 1atm is continuously mixed with 2mol/s of air at 450K and 1atm. The product stream is at 400K and 1atm. Determine the rate of heat transfer and the rate of entropy generation for the process. Assume that air is an ideal gas with Cp=(7/2)R, that the surroundings are at 300K, and that kinetic and potential energy changes are negligible. **10**

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4. (a) Derive maxwells relations from fundamental property relations. 10
(b) Express the vender waals equation of state in terms of Z factor. 10

5. (a) Five kg of ice at 260 K is dropped into a thermally insulated container which holds 20kg of water at 300k. What is the total entropy change? 10
Data :- Cp of ice = 2.064 KJ/kg k
Cp of water = 4.187 KJ/kg k
Enthalpy of fusion of ice = 333.5 KJ/kg.
(b) Using the virial equation, calculate the molar volume and compressibility factor of isopropanol vapor at 405 K and 8 bar. The virval coefficients are 10
$B = -3.88 \times 10^{-1}$ m^3/k mol
$C = -2.6 \times 10^{-2}$ m^6 / k mol^2

6. (a) Calculate the enthalpy and entropy departures for n - octane vapor at 427.85 K and 0.215 MPa using peng-Robinson equation of State. 12
Data :- $S = 0.9457$, $\alpha = 1.2677$, $a = 5.2024$, $b = 1.4750 \times 10^{-4}$,
$B = 8.9151 \times 10^{-3}$, $z = 0.9151$. $T_c = 569.4$ K.
(b) Derive an expression to determine the fugacity coefficient for a vander waals gas. 8
