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04/12/2015  
 Chemical Engineering Thermodynamics - I  
 SE/IV/CBGS/CHEM/CET-I

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Q.P.Code No. 5416

(3 Hours)

[Total Marks: 80]

- N.B. (1) Question No. 1 is compulsory.  
 (2) Attempt any three questions out of remaining five questions.  
 (3) Figures to the right indicate full marks.  
 (4) Assume suitable data, if necessary.

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- Q.1 a) State i) Kelvin-Plank statement 05  
 ii) Clausius statement of second law of thermodynamics. 05  
 b) Distinguish between extensive and intensive properties. 05  
 c) State and explain in brief Zeroth law of thermodynamics. 05  
 d) Explain the procedure to prepare Temperature-Entropy diagramme. 05  
 Q.2 a) Derive an expression for entropy change of mixing of non-identical ideal gases. 10  
 b) A Carnot engine operating between  $800^{\circ}\text{C}$  and  $25^{\circ}\text{C}$  is used to run a Carnot refrigerator operating between  $-20^{\circ}\text{C}$  and  $25^{\circ}\text{C}$ . If the engine absorbs  $10\text{ kJ/s}$  from the reservoir at  $800^{\circ}\text{C}$ , determine the capacity of the refrigerator. Also determine the rate of energy rejection as heat to the reservoir at  $25^{\circ}\text{C}$  by both the devices. 10  
 Q.3 a) An ideal gas undergoes the following reversible processes: 10  
 i) From an initial state of  $343\text{ K}$  and  $1\text{ bar}$  it is compressed adiabatically to  $423\text{ K}$ .  
 ii) It is then cooled to  $343\text{ K}$  at constant pressure.  
 iii) Finally, it is expanded to its original state isothermally.  
 Calculate  $\Delta U$ ,  $\Delta H$ ,  $Q$  and  $W$  for each step as well as for entire cycle. Assume  $C_v = (3/2)R$   
 b) Derive an expression for Joule Thomson inversion temperature using van der Waals equation of state. 10

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Q.4 a) Using virial equation of state calculate the molar volume and compressibility factor of isopropanol vapour at 473 k and 10 bar. The virial coefficients are:

$B = -3.88 \times 10^{-4} \text{ m}^3/\text{mol}$     $C = -2.6 \times 10^{-8} (\text{m}^3/\text{mol})^2$    10

b) A block of 10 kg ice at 0°C is dumped in an insulated tank containing 100 kg water at 30°C. Calculate the change in entropy of the mixture and entropy generated. The heat capacity of water is 4.24 kJ/kg K and the latent heat of melting of ice is 333.44 kJ/kg. 10

Q.5a) Calculate the enthalpy and entropy departures for ethylene gas at 8.25 MPa and 25 °C, assuming that ethylene gas obeys the van der Waals equation of state. 10

b) Derive the relation to estimate the enthalpy and entropy departures for gas obeying the Berthelot equation of state given by

$(P + \frac{a}{rv^2})(v - b) = RT$    10

Q.6 a) Write a short note on:

i) Availability and lost work   05

ii) Maxwell's relations   05

b) A gas obeying the following equation of state:  $P(V-b) = RT$ . Where the constant b was found to be 0.2 m<sup>3</sup>/mol. Over the temperature range 300K to 400K. The heat capacity may be constant at 40 kJ/kmolK Calculate  $\Delta H$  and  $\Delta S$  for the following change of state

State 1 : P = 10 bar , T = 300K   10

State 2 : P = 20 bar , T = 400K