Q. P. Code: 09852

Time: 3 Hours **Total Marks: 80**

N.B.:
(i) Question No.1. is compulsory.
(ii) Attempt any three questions out of remaining five questions.
(iii) Assume suitable data and justify the same.
(iv) Figures to the right indicate full marks.

1. (a) Define adiabatic process. Give 2 examples of irreversible adiabatic processes. 05
(b) Derive an expression to estimate entropy change of an ideal gas. 05
(c) How do you explain physical significance of Virial coefficients? 05
(d) Show that C_p and C_v of an ideal gas depend on temperature alone. 05

2. One kmol of an ideal gas at 100 kPa and 300 K undergoes the following reversible changes: 20
(i) Compressed adiabatically to 500 kPa.
(ii) Heated at constant pressure to 800 K.
(iii) Expanded adiabatically to 210 kPa.
(iv) Cooled at constant volume to 300 K.
(v) Expanded isothermally to 100 kPa.
Find ΔU, ΔH, Q and W for the individual stage and for the entire cycle.
Data: C_p = 29.099 J/(mol.K) & C_v = 20.785 J/(mol.K)

3. (a) The coefficients of pressure explicit form & volume explicit form of Virial equation of state are related. Derive the relations between them (upto B and B', C and C'). 10

(b) Estimate the molar volume and compressibility factor of methane at 373 K and 10 bar using Redlich Kwong Soave equation of state. 10
Redlich Kwong Soave equation of state is given by:

$$P = \frac{RT}{(V-b)} - \frac{a\alpha}{V(V+b)}$$

Where:

$$a = 0.42748\frac{R^2T_c^2}{P_c} \quad \text{and} \quad b = 0.08664\frac{RT_c}{P_c}$$

$\alpha = [\,1 + S\,(\,1 - \sqrt{T_r}\,)\,]^2$
$S = 0.48508 + 1.55171\,w - 0.15613\,w^2$
Data: T_c = 190.6 K, P_c = 46 bar and w = 0.193

4. (a) A mass of water at temperature T_1 is adiabatically mixed with equal mass of water at temperature T_2, show that the entropy change of the universe is, $= 2mC_p ln \frac{T_1+T_2}{2\sqrt{T_1 T_2}}$ — 10

And also show that, Maximum work done$= mC_p\left(\sqrt{T_1 - T_2}\right)^2$

(b) An inventor claims to have designed a heat engine which absorbs 260 kJ of energy as heat from a reservoir at 52°C and delivers 72 kJ work. He also states that the engine rejects 100 kJ and 88 kJ of energy to the reservoirs at 27°C and 2°C, respectively. Judge whether the claim is acceptable or not. — 10

5. (a) How is Joule Thomson coefficient evaluated from P-V-T information? Prove that an ideal gas would not undergo any temperature change on throttling — 10

(b) Calculate the residual enthalpy and residual entropy for n-butane at 800 kPa and 600 K using the Berthlot equation of state. The Berthlot equation of state is given by: — 10

$[P + a / (T.V^2)]\ [V - b] = RT$

Data:

$T_c = 425.2$ K, $P_c = 3797$ kPa

6. Write short notes on any four of the following: — 20
   (a) Transient flow process
   (b) Carnot principle
   (c) Reduced equation of state
   (d) Fugacity and fugacity coefficient
   (e) H-T diagram

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