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[5559]-218

S.E. (Chemical) (Second Semester) EXAMINATION, 2019

CHEMICAL ENGINEERING THERMODYNAMICS—I

(2015 PATTERN)

Time : 2 Hours

Maximum Marks : 50

- N.B. :—** (i) Answer Q. No. 1 or Q. No. 2, Q. No. 3 or Q. No. 4, Q. No. 5 or Q. No. 6, Q. No. 7 or Q. No. 8.
(ii) Neat diagrams must be drawn wherever necessary.
(iii) Assume suitable data, if necessary.
(iv) Use of logarithmic tables slide rule, Mollier charts, electronic pocket calculator and steam tables is permitted

Q 1 a 1 kg of water in water fall is flowing down from a height of 100 m and at the 06
bottom of the fall it joins a river. Neglecting energy exchange between the
water and the surroundings and assuming the river downstream velocity is
negligible, calculate:

- The potential energy of water at the top of the fall.
- The kinetic energy just before the water strikes the bottom
- The change in temperature of water when it enters the river.

Q 1 b A spherical balloon of 0.5 m diameter contains a gas at 1 bar and 300K. The 06
gas is heated and the balloon is allowed to expand. The pressure inside the
balloon varies linearly with the diameter. What would be the work done by the
gas when pressure inside reaches 5 bar?

OR

Q 2 a Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K until 07
its temperature reaches 600 K. Determine the change in internal energy,
change in enthalpy and work done if the process is carried out under:

- Constant volume conditions
- Constant pressure conditions

Assume that air behaves ideally. $MW = 29$, $C_p = 29.099 \text{ J/mol.K}$ and $C_v = 20.785 \text{ J/mol.K}$.

P.T.O.

- Q 2 b Calculate the compressibility factor and molar volume of methanol vapor at 450K and 15 bar by using: a) Truncated form of virial equation, b) Redlich-Kwong equation 05

Experimental values of virial coefficients are:

$$B = -2.19 \times 10^{-4} \text{ m}^3/\text{mol}$$

$$C = -1.73 \times 10^{-8} \text{ m}^6/\text{mol}^2$$

The critical temperature and pressure of methanol are 512.6K and 81 bar.

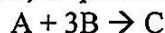
Constants of Redlich-Kwong equation: $a = 21.7181 \text{ Nm}^4\text{K}^{1/2}/\text{mol}^2$, $b = 4.5617 \text{ m}^3/\text{mol}$.

- Q 3 a An inventor claims have developed a heat pump, having COP of 6 which maintains a cold space at 250 K while operating in a surrounding temperature of 310 K. would you agree with his claim. 07

- Q 3 b Explain the concept of entropy and prove that entropy is a state function 05

OR

- Q 4 a The heat of reaction at 300 K and 1 atmosphere pressure for the following reaction is (-200) kJ per mol of A converted. 08



Data on the molar heat capacity at constant pressure (kJ/mol K) for the various components are:

$$C_p \text{ for A} = -1.7 \times 10^{-3} + 3.4 \times 10^{-4} T, \text{ where } T \text{ is in K,}$$

$$C_p \text{ for B} = 0.03$$

$$C_p \text{ for C} = 0.1$$

Calculate the heat of reaction at 500 K and at a pressure of 100 kPa.

- Q 4b Explain: 04

- Hess's law of constant heat summation
- Heat of Formation

- Q 5 a Show that 08

$$\text{i) } dE = C_v dT + \left(\frac{\beta}{K} T - P \right) dV$$

$$\text{ii) } dS = \frac{C_v}{T} dT + \frac{\beta}{K} dV$$

- Q 5 b Explain thermodynamic diagrams. 05
- OR
- Q 6 a Derive Maxwell's Equation 08
- Q 6 b Derive the Clausius-Clapeyron equation for vapor-liquid two phase system 05
- Q 7 a A vapour compression cycle using ammonia as refrigerant is employed in an ice manufacturing plant. Cooling water at 288 K enters the condenser at a rate of 0.25 kg/sec and leaves at 300 K. Ammonia at 294 K condenses at a rate of 0.50 kg/minute. Enthalpy of liquid ammonia at 294 K is 281.5 kJ/kg. The compressor efficiency is 90%. Saturated ammonia vapour at 258 K and the enthalpy of 1426 kJ/kg enters the compressor. What is the power requirement of the compressor and refrigeration capacity in tons ? 08
- Q 7 b Explain Linde process for gas liquefaction. 05
- OR
- Q 8 a A heat pump is used to maintain the temperature inside a building at 295 K by pumping heat from the outside air at 275 K. The unit has an overall efficiency of 25%. The pump is driven electrically and the electric power is generated by the combustion of certain fuel gas. The heat of combustion of the fuel is 890.0 kJ/mol. It is estimated that only 33% of the heat of combustion of the fuel is converted into electricity. Determine the amount of fuel burned for delivering 1000 MJ of heat to the building. 08
- Q 8b Describe the various properties of refrigerant required to be considered for its selection 05