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CH402

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : **151402**

Roll No.

B. Tech.

(SEM. IV) THEORY EXAMINATION, 2014-15

CHEMICAL ENGG. THERMODYNAMICS - I

Time : **3** Hours] [Total Marks : **100**

Note : (1) Assume suitable data if missing.
(2) Use of steam table and other thermodynamic charts is allowed.

1 Attempt all parts of the following : 2×10=20

(a) A quantity of air(γ =1.4) at 27°F is compressed suddenly to 1/4 of its original volume. Find the final temperature.

(b) Derive a formula for work done in adiabatic process.

(c) What is a quasistatic process ?

(d) What is thermodynamic system ? Explain with suitable example.

(e) Explain the Joule - Thomson coefficient.

(f) What is coefficient of Performance ?

(g) What is efficiency of an absorption refrigeration cycle ?

(h) Draw the T-S diagram of Rankine cycle.

(i) Explain intensive and extensive property with examples.

(j) Explain first law of thermodynamics for flow process with suitable figure.

2 Attempt any three parts of the following : 10×3=30

(a) Calculate the change in the melting point of ice when it is subjected to a pressure of 100 atm. density of ice=0.917 g/cm^3 and latent heat of ice=336J/kg.

(b) Calculate the increase in entropy when 1 gram of ice at -10°C is converted into steam at 100°C. Given –
Specific heat of ice=0.5, latent heat of ice=80cal/g, latent heat of steam-540cal/g.

(c) The equation of state of certain substance is given by the expression V=(RT/P-C/T^3), and the specific heat is given by the relation Cp=A+BT where A,B,C are constants; derive expressions for changes in internal energy, enthalpy and entropy for an isothermal process.

(d) One kmol of an ideal gas initially at 30 °C and 1 bar undergoes the following mechanically reversible changes. it is compressed isothermally to a point such that when it is heated at constant volume to 120 °C. Its final pressure is 12 bar. Calculate Q, W, ΔU and ΔH for the process. Take C_p = (7/2) R and C_v = (5/2) R.

(e) For liquid water the isothermal compressibility is given by k=c/(VP+Vb) where b and c are functions of temperature only. If 1 kg of water is compressed isothermally and reversibly from 1 to 500 bar at 60°C, how much work is required ? At 60°C, b=2700bar and c=0.125 cm^3/g.

3 Attempt all parts of the following : 10×5=50

(a) Air discharges from an adiabatic nozzle at 15 °C with a velocity of 580 m/s. What is the temperature at the entrance of nozzle if the entrance velocity is negligible ? Assume air to be an ideal gas for which C_p=3.5 R.

OR

Liquid water enters an adiabatic hydroturbine at 5 atm and 15 °C and exhausts at 1 atm; estimate the power output of the turbine in J/kg of water if its efficiency is 0.55. What is the outlet temperature of the water ? Assume water to be an incompressible liquid.

(b) A 0.35 m^3 vessel is used to store liquid propane at vapour pressure safety consideration dictate that at a temperature of 320 K, the liquid must occupy not 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 bar.

OR

Steam enters a nozzle at 800 kPa and 280°C with negligible velocity and discharges at a pressure of 525 kPa. Assuming isentropic expansion of the steam in the nozzle, what is the exit velocity and what is the cross sectional area at the nozzle exit for a flow rate of 0.75 kg/s.

(c) Prove that if Henery's law is obeyed by component 1 in a binary solution over certain concentration range. Lewis-Randall rule will be obeyed by component 2 over the same concentration range.

OR

For an ideal gas prove that :

$$\frac{\Delta S}{R} = \int_{T_0}^{T} \frac{C_V^{ig}}{R} \frac{dT}{T} + \ln \frac{V}{V_0}$$

(d) A 40 kg steel casting (C_p = 0.5 kJ/kg.K) at a temperature of 723.15 K is quenched in 150 kg of oil (C_p = 2.5 kJ/kg.K) at 208.15 K. If there are no heat losses, what is the change in entropy of : (i) casting (ii) oil (iii) both considered together.

OR

Steam at 2000 kPa containing 6% moisture is heated at constant pressure to 575 °C. How much heat is required per kilogram ?

(e) (i) Calculate the fugacity of liquid water at 303K and 10 bar if the saturation pressure at 303 K is 4.241 kPa and the specific volume of liquid water at 303K is 1.004×10^{-3} m^3/kg.

(ii) What is chemical potential ? Explain the effect of temperature and pressure on chemical potential.

OR

Describe the vapour compression cycle with neat sketch and also derive its COP. An incompressible liquid flows steadily through a conduit of circular cross section and increasing diameter. At location 1, the diameter is 2.5 cm and velocity is 2m/s. At location 2, diameter is 5 cm. What is velocity at location 2 What is the kinetic energy change between location 1 and 2 ?
