Department of Chemical Engineering

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Test I

CH2007 Chemical Engineering Thermodynamics I

Duration: 1 hour Date: 11/02/2015 ***Maximum Marks: [20]***

Answer all questions

1) a) State the general mass and energy balance equation for open flow system and define the terms. [2]
   b) From this get simplified equations for steady state processes. [1]

2) A vertical cylinder with a freely floating piston contains 0.1 kg air at 1.2 bar and a small electric resistor. The resistor is wired to an external 12V battery. When a current of 1.5A is passed through the resistor for 90 sec, the piston sweeps a volume of $0.01 m^3$. Assume (i) piston and cylinder are insulated and (ii) air behaves as an ideal gas with $C_v = 700 J\ kg^{-1}\ K^{-1}$. Find the rise in temperature of air. [3]

3) The Redlich-Kwong (RK) equation of state given below is widely used to represent the *P-v-T* behaviour of several gases: [3]

$$P = \frac{RT}{v-b} - \frac{a}{v(v-b)T^{1/2}}$$

   Where v is the specific volume and all units are in SI. Determine the units of the constants a and b of the RK equation of state.

4) It is desired to establish a particular temperature scale according to the relation [3]

$$t = ae^r + b$$

   Where a and b are constants, r is the reading of the thermometric property as read by the thermometer and t is in °C. The values of r at ice point and steam point are 5.6 and 8.19. Determine:
   a) The temperature of the body which gives $r = 7.25$
   b) The value of r at 55°C.

5) The conditions of a gas change in a steady-flow process from 293.15 K (20°C) and 1000 kPa to 333.15 K (60°C) and 100 kPa. Devise a reversible non-flow process (cooling at constant volume followed by heating at constant pressure) for accomplishing this change of state, and calculate ΔU and ΔH for the process on the basis of 1 mol of gas. Assume for the gas that PV/T is a constant, $C_v = (5/2)R$, and $C_p = (7/2)R$. [4]

6) An adiabatic steady state turbine is being designed to serve as an energy source for a small electrical generator. The inlet to the turbine is steam at 600°C and 10 bar with a mass flow rate of 2.5 kg/s trough an inlet pipe that is 10 cm in diameter. The conditions at the turbine exit are T = 400°C and P = 1 bar. Since the steam expands through the turbine, the outlet pipe is 25 cm in diameter. Estimate the rate at which work can be obtained from this turbine. [4]

   Data :

   Steam at 600°C and 10 bar: $H_1 = 3697.9$ kJ/kg $v_1 = 0.4011 m^3/kg$

   Steam at 400°C and 1 bar : $H_2 = 3278.2$ kJ/kg $v_2 = 3.013 m^3/kg$
