First Periodical

B.E. (Chemical) 2nd Year

1. Derive the following using Maxwell's relations:

$$\kappa_S = \kappa - \frac{VT\beta^2}{C_P}$$, where $$\kappa_S = -\left(\frac{1}{V}\right)\left(\frac{\partial V}{\partial P}\right)_S$$

2. Steam enters an adiabatic turbine at 10 MPa and 400°C and leaves at 20kPa with quality of 90%. Neglect the changes in kinetic and potential energies, determine the mass flow rate required for a power output of 5MW. (You can use online steam tables https://www.spiraxsarco.com/resources-and-design-tools/steam-tables/dry-saturated-steam-line)
3. Derive the expression for fugacity of n-butane following Vanderwaal's equation of state.
4. The coefficient of volumetric expansion of water at 373 K is 7.8×10^{-4} K^{-1}. Calculate the change in entropy when the pressure is increased from 1 bar to 100 bar. At 373 K, density of water is 958 kg/m^3.

   or

   Helium gas obeys equation of state $Pv = RT - \frac{aP}{T} + bP$ where a=386.7 Kcm^3/gmol and b=15.29 cm^3/gmol. Estimate the change in entropy and enthalpy for the gas if it changes isothermally from a state 5 bars to 15 bars at 500K

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