# Foundations of Physics 2B/3C 2019-2020

## Thermodynamics – Weekly Problem, Th. 5

### Publication: 15th Nov Completion: 25th Nov

The following Maxwell Relation may be useful when solving this problem. It is derived by considering the Gibbs function, $G = U + pV - TS$,

$$\left(\frac{\partial S}{\partial p}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_p$$

a) Consider the entropy as a function of temperature and pressure, $S = S(p, T)$.

i) First, derive the second $TdS$ equation given below,

$$TdS = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_p dp.$$

[3 *marks*]

ii) Hence show that in an isothermal process, at $T_0$, the heat change can be related to the isobaric expansivity $\beta_p = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p$, via the following relationship

$$\delta Q = -T_0 \beta_p V dp.$$

If ten moles of water, at 1.0 °C, that occupy a volume of $1.8 \times 10^{-4}\ \mathrm{m}^3$ and have a volume expansivity coefficient $\beta_P = -50 \times 10^{-6}\ \mathrm{K}^{-1}$, what is the heat transferred to the water, if the pressure is increased from 1.0 to 10 atm isothermally?

[3 *marks*]

b) Derive the general relation given below, and evaluate the expression for one mole of monoatomic ideal gas, for which $\gamma = 5/3$,

$$C_p = T\left(\frac{\partial V}{\partial T}\right)_p \left(\frac{\partial p}{\partial T}\right)_S.$$

[Hint: recall that the equation of state for an adiabatic process for an ideal gas is $pV^\gamma$.

[4 *marks*]