Tutorial – 2 Batch A

1. A block of copper at a pressure of 1 atm , a volume of 100 cm^3, and a temperature of 10 ^oC experiences a rise in temperature of 5 ^oC and an increase in volume of 0.005cm^3. Assuming the volume expansivity and isothermal compressibility given below calculate the final pressure.

(Note: The volume expansivity β and isothermal compressibility ƙ are not always listed in handbooks of data. However, β is three times the linear expansion coefficient α, and ƙ is the reciprocal of the bulk modulus B. For this problem, assume that the volume expansivity and isothermal compressibility remain practically constant within the temperature range of 0 to 20 ^oC at the values of $4.95 \times 10^{-5}\ K^{-1}$ and $6.17 \times 10^{-12}\ Pa^{-1}$, respectively.)

2. Constant volume gas thermometric measurement was used by Rusby et al (Metrologia, Vol 28, page 9-18, 1991) to accurately determine the steam point. They used different gases, namely, He, H2 and N2 for their measurement. They measured the pressure (for different amounts of gases in a fixed volume) of gases bringing the gas thermometer in thermal equilibrium with ice-water-steam system(Triple point) and denoted it as P_{TP}. Further, they brought the gas thermometer in equilibrium with a system at steam point (water-steam at 1 atm) and denoted the pressure as P.

The following table gives

P_{TP}(Pa)	He, P (Pa)	H2, P(Pa)	N2, P (Pa)
20	7462.8	7462.82952	7463.59704
40	14925.6	14925.83616	14928.78816
60	22388.4	22389.01992	22395.75048
120	44778	44779.81104	44807.26464

Determine the steam point accurately from this data.

Please note that – Here the thermometric property, P, is proportional to the Temperature i.e., P α T. Please note that triple point is fixed at 273.16K as the reference point. Make a plot of T at steam point vs P_{TP} and comment on the graph. What happens when you extrapolate the T when P_{TP} tends to zero.

3.
During a quasi-static expansion of a gas in an adiabatic container, the pressure at any moment is given by the equation

$$PV^{\gamma} = K,$$

where γ and K are constants. Show that the work done in expanding from a state (P_i, V_i) to a state (P_f, V_f) is

$$W = -\frac{P_iV_i - P_fV_f}{\gamma - 1}.$$

If the initial pressure and volume are 10^6 Pa and 10^{-3} m^3, respectively, and the final values are 2×10^5 Pa and 3.16×10^{-3} m^3, respectively, how much work is done on a gas having $\gamma = 1.4$?