

Problem Set 3

Problems

Include Problem 14 of Problem Set 2.

1. At 25°C a sealed, rigid container is completely filled with liquid Water. If the temperature is raised by 10°C, what pressure will develop in the container? For Water:

$$\begin{aligned}\alpha &= 2.07 \times 10^{-4} \text{ K}^{-1} \\ \kappa &= 4.50 \times 10^{-5} \text{ atm}^{-1}\end{aligned}$$

[Ans. $\Delta P = 46 \text{ atm}$]

2. The coefficient of Linear Expansion a is defined as:

$$a = \left(\frac{1}{l}\right) \left(\frac{\partial l}{\partial T}\right)_p$$

If a is very small and has the same value in any direction for a solid, show that the Volume Expansion Coefficient is approximately equal to:

$$\alpha \sim 3a$$

Identify the point in your derivation where the approximation is made.

3. Show that the Volume Expansion Coefficient can be written as:

$$\alpha = -\left(\frac{1}{\rho}\right) \left(\frac{\partial \rho}{\partial T}\right)_p$$

where ρ is the density.

4. Show that:

$$\frac{d\rho}{\rho} = -\alpha dT + \kappa dP$$

where ρ is the density.

5. In forming second mixed partial derivatives of a function, the order of differentiation does not matter. So,

$$\left(\frac{\partial^2 V}{\partial T \partial P}\right) = \left(\frac{\partial^2 V}{\partial P \partial T}\right)$$

Use this fact to show that:

$$\left(\frac{\partial \alpha}{\partial P}\right)_T = \left(\frac{\partial \kappa}{\partial T}\right)_P$$

6. From the general definition of α , we find:

$$V = V_0 \exp\left(\int_0^t \alpha dt\right)$$

If α has the following form:

$$\alpha = \alpha_0 + \alpha' t + \left(\frac{1}{2}\right) \alpha'' t^2$$

where α_0 , α' and α'' are constants, find the relationship between these constants and the constants a , b , and c in the empirical equation:

$$V = V_0 (1 + at + bt^2 + ct^3)$$