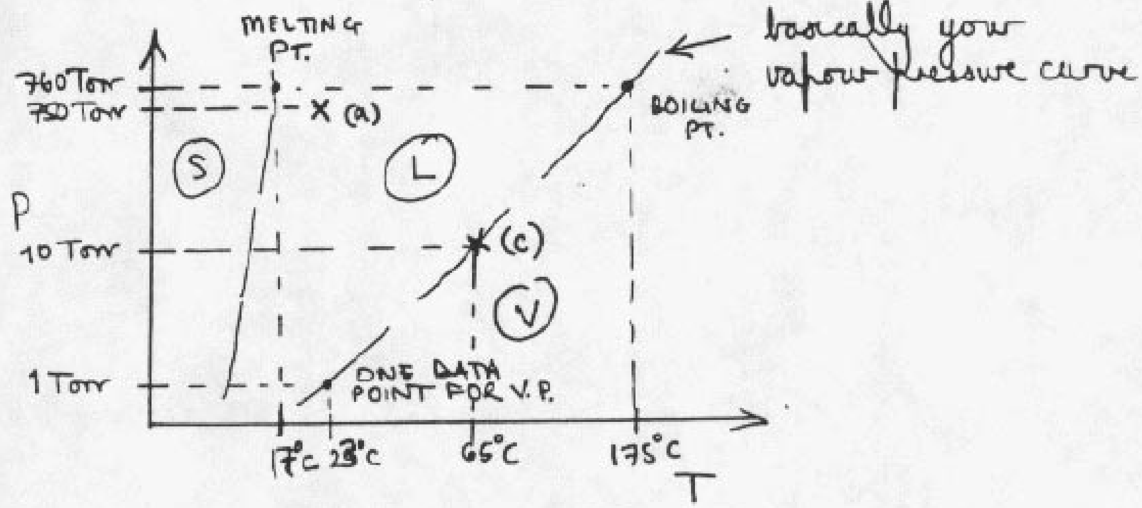
10.213 Problem #3 Solution

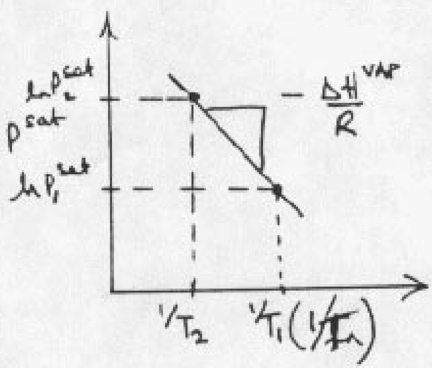
a) The easiest way to tackle this type of problem is to sketch the P–T diagram. You are given quite a lot of information:



a) So, from the above, at 1 bar & 25°C, we are in the liquid region. It is LIQ. at ambient conditions.

b) So, we want to be in the vapour region at 23°C. ∴ We need to operate at ≤ 1 Torr.

c)



— We want to know what temperature we need to heat the crucible to in order to have a vapour pressure of 10 Torr.

— The Clausius–Clapeyron equation gives us an estimate of the relationship between P^{sat} and T: i.e. the vapour pressure curve:

$$+\, d(1/T) = -\frac{R}{\Delta H^{vap}}\, d(\ln P^{sat})$$

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- integrating: $1/T \Big|_{T_1}^{T_2} = -\left(\frac{R}{\Delta H^{vap}}\right) \ln P^{sat} \Big|_{P_1^{sat}}^{P_2^{sat}}$

$$\frac{1}{T_2} - \frac{1}{T_1} = -\left(\frac{R}{\Delta H_{vap}}\right) \ln \frac{P_2^{sat}}{P_1^{sat}} \quad \text{—— (1)}$$

- this will give us T_2 for a certain P_2^{sat}, provided we know T, P^{sat} at some other conditions.

- we could use the boiling pt for T_1, P_1^{sat} (−175°C, 1 atm) but the other data we were given are closer to our condition of interest. It is likely to give more accurate results.

- so,

$$T_1 = 23°C, \quad P_1^{sat} = 1 \text{ Torr}$$
$$T_2 = \,?\,, \quad P_2^{sat} = 10 \text{ Torr}$$

- Use (1) to find T_2:

$$\frac{1}{T_2} = \frac{1}{T_1} - \left(\frac{R}{\Delta H^{vap}}\right) \ln\left(\frac{P_2^{sat}}{P_1^{sat}}\right)$$

$$T_2 = \left[\frac{1}{(296K)} - \left(\frac{1.987 \frac{cal}{mol \cdot K}}{10{,}900 \frac{cal}{mol}}\right) \ln(10)\right]^{-1}$$

$$= 338 \text{ K}$$

$$\underline{T_2 = 65°C}$$

d) see part (a)

(e) Looking at the melting pt. (65°C), we expect that OBr_3 will be solid at room temperature and 1 atm.
