7.11 The triple point of iodine, I_2, occurs at 112.9°C and 11.57 kPa. The heat of fusion at the triple point is 15.27 kJ/mol, and the following vapor pressure data are available for solid iodine:

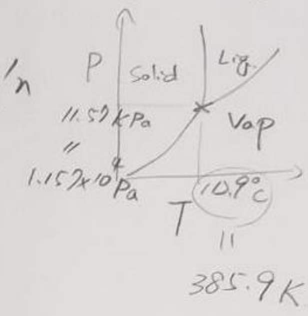
Vapor pressure (kPa)	2.67	5.33	8.00
Temperature (°C)	84.7	97.5	105.4

Estimate the normal boiling temperature of molecular iodine.

①

7.11

From Clausius-Clapeyron Eq'n



Liq → Vap

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

$\Delta \underline{H}_{fus} = 1.527 \times 10^4$ J/mol (S→L)

$\Delta \underline{H}_{sub} = \Delta \underline{H}_{fus} + \Delta \underline{H}_{vap}$
(S→V) (S→L) (L→V)

$\Rightarrow \Delta \underline{H}_{vap} = \Delta \underline{H}_{sub} - 1.527 \times 10^4$ J/mol — ①

Vapor pressure for Solid I_2

Vapor Pressure	2.67×10^3 Pa	5.33×10^3 Pa	8.00×10^3 Pa
Temp.	357.7 K	370.5 K	378.4 K

Take $P = 8.00 \times 10^3$ Pa, $T = 378.4$ K as state 1

$P = 1.157 \times 10^4$ Pa $T = 385.9$ K as state 2

$$\ln \frac{1.157 \times 10^4}{8.00 \times 10^3} = -\frac{\Delta \underline{H}_{sub}}{8.314}\left(\frac{1}{385.9} - \frac{1}{378.4}\right)$$

$$0.37 = -\frac{\Delta \underline{H}_{sub}}{8.314}\left(2.59 \times 10^{-3} - 2.64 \times 10^{-3}\right)$$

$$\Delta \underline{H}_{sub} = 0.37 \times 8.314 \times \frac{1}{0.05 \times 10^{-3}} = 6.152 \times 10^4 \text{ J/mol}$$ — ②

substitute ③ into ①

$\Delta \underline{H}_{vap} = 6.152 \times 10^4 - 1.527 \times 10^4$

$= 4.625 \times 10^4 \, J/mol \cdot K$

at normal boiling temp. $P = 1\,atm = 1.013 \times 10^5\, Pa$

Take normal boiling point as state 2

$P = 1.157 \times 10^4\ Pa \quad T = 385.9K$ as state 1

$$\ln\left(\frac{1.13 \times 10^5}{1.157 \times 10^4}\right) = \frac{-4.625 \times 10^4}{8.314}\left(\frac{1}{T_2} - \frac{1}{385.9}\right)$$

$$-\frac{2.28 \times 8.314}{4.625 \times 10^4} = \left(\frac{1}{T_2} - 2.59 \times 10^{-3}\right)$$

$$\Rightarrow -4.1 \times 10^{-4} + 2.59 \times 10^{-3} = \frac{1}{T_2}$$

$$\Rightarrow T_2 = \frac{1}{2.18 \times 10^{-3}} = 458.7K$$

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