Lecture 4: Condensation

1. Condensation of corundum

We acknowledge and respect the lək̓ʷəŋən peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.

Practice Problem: Condensation of Corundum from the Solar Nebula

Q1: Calculate the temperature that Corundum (Al_2O_3) begins condensing from the solar nebula using the following values (assume no other reactions):

$$2\mathrm{Al} + 3\mathrm{O} \leftrightarrow \mathrm{Al}_2\mathrm{O}_3$$

- Solar abundance (molar abundance) of Al: 8.51 x 10^4
- Solar abundance (molar abundance) of O: 2.36 x 10^7
- Solar abundance (molar abundance) of H: 2.6 x 10^{10}
- Pressure in the nebula: 10^{-3} atm
- Gas constant (R): 8.314 J/mol K
- $\Delta G°$ (standard free energy of reaction) for condensation of Al_2O_3: -1.23 x 10^6 J/mol

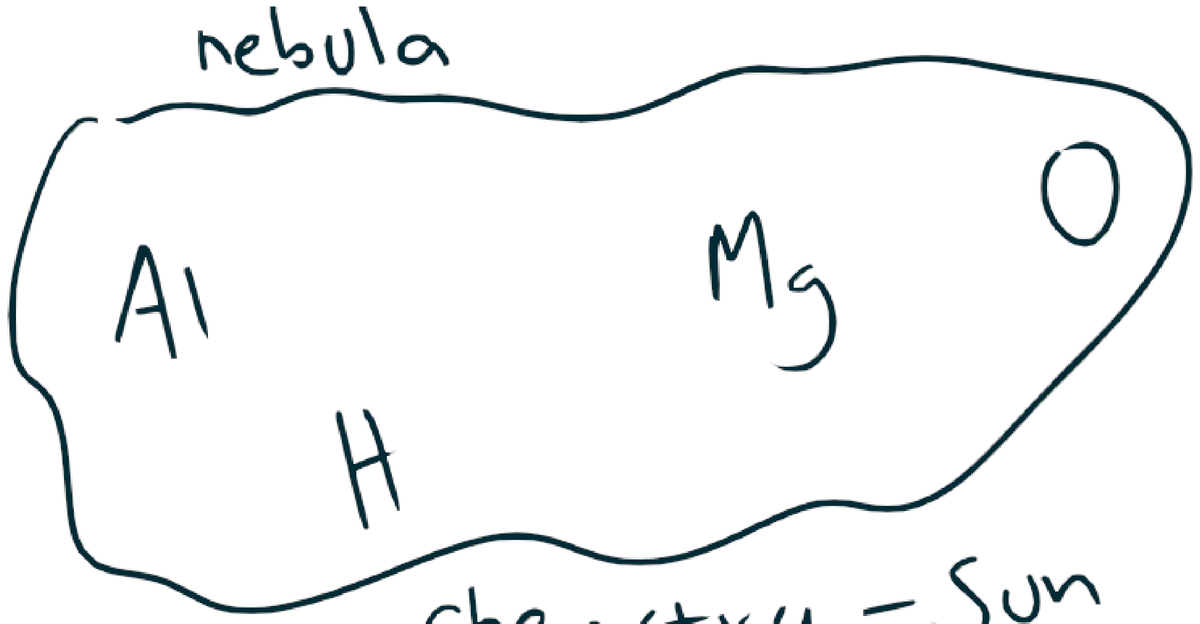
Q2: At what temperature will this reaction finish condensing all of the Aluminum in the nebula?

Condensation of corundum (ruby/sapphire)

$$2\,Al(g) + 3\,O(g) \longleftrightarrow Al_2O_3\,(c)$$

$$Q = \frac{\{Al_2O_3\}}{\{Al\}^2\{O\}^3} = \frac{1}{P_{Al}^2 \cdot P_O^3}$$

at high T, low P safe to assume ideal gas $\quad \{x\} = P_x$



chemistry = Sun

$P_T = 10^{-3}$ atm

assumption: $P_T = P_{H_2}$

$$\frac{P_x}{P_{H_2}} = \frac{N_x}{N_{H_2}} \qquad N_{H_2} = \frac{1}{2} N_H$$

$$P_{Al} = \frac{N_{Al}}{\frac{1}{2}N_H} \cdot P_{H_2} = \frac{2\,N_{Al}}{N_H} \cdot P_T$$

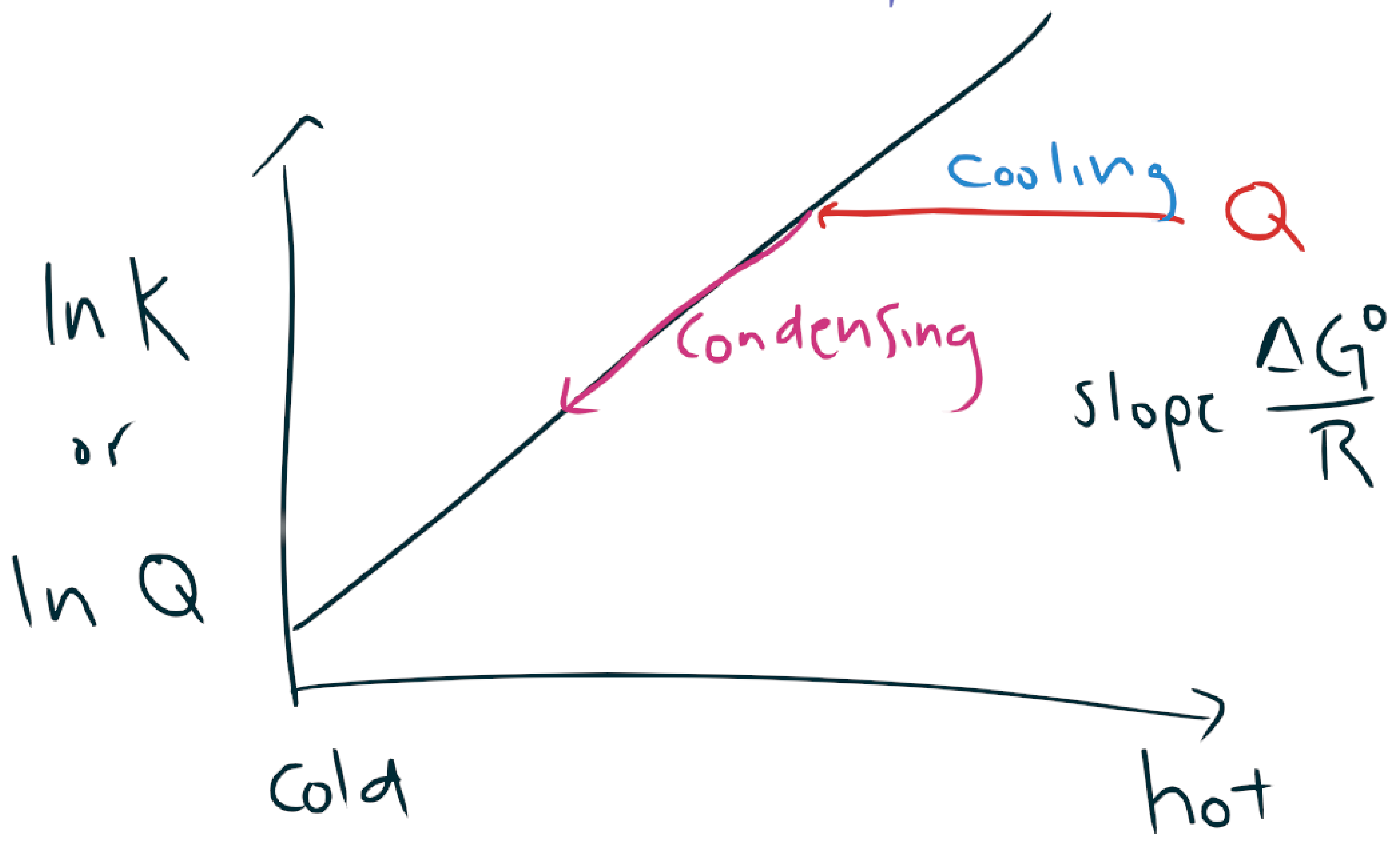
$$\Delta G^\circ = -RT \ln K$$

$$-\frac{\Delta G^\circ}{RT} = \ln K \rightarrow \text{let:}$$

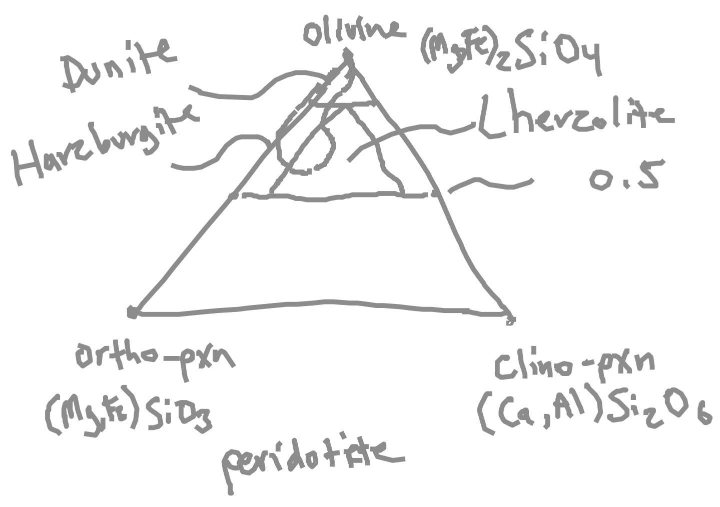
this sign corresponds to reaction direction

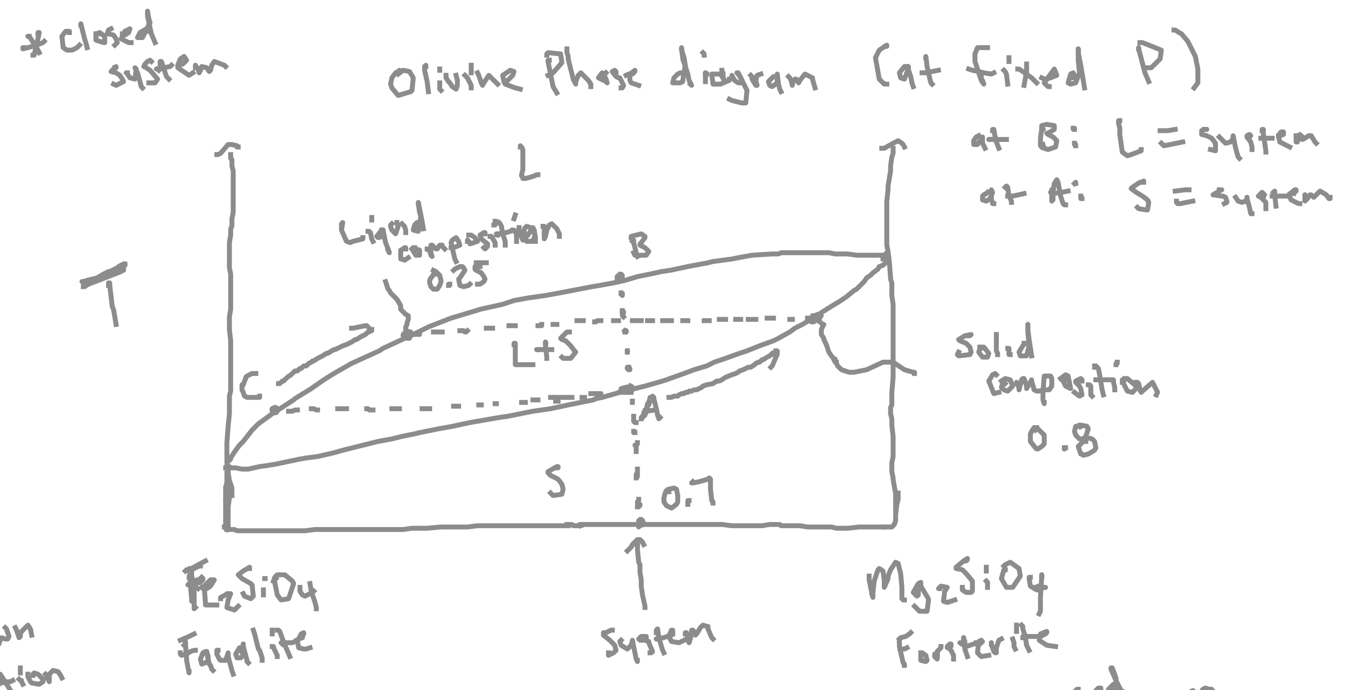
$$x = \frac{-1}{T} \qquad y = -\ln K$$

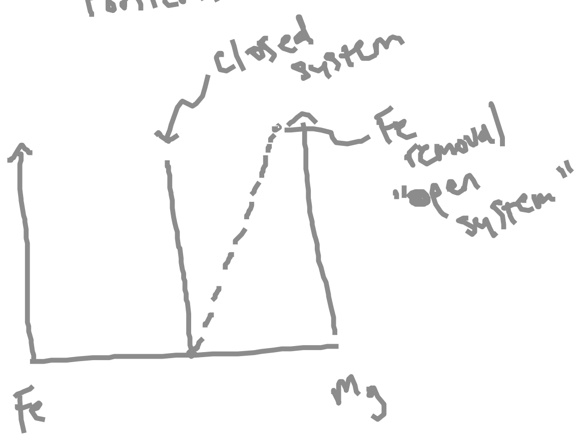
$$x \, \frac{-\Delta G^\circ}{R} = y$$



Olivine Solid Solution Phase Diagram.







Lever Rule:
(mass balance)

unknown fraction

$\underline{a} \cdot L + \underline{b}\, S = \text{system}$

$a + b = 1$ mass balance

$b = 1 - a$

$a L + (1-a) S = \text{system}$

$a\, 0.25 + (1-a)\, 0.8 = 0.7$