

Exploring Possible Formation Mechanisms for NH₄SH Clouds on Jupiter

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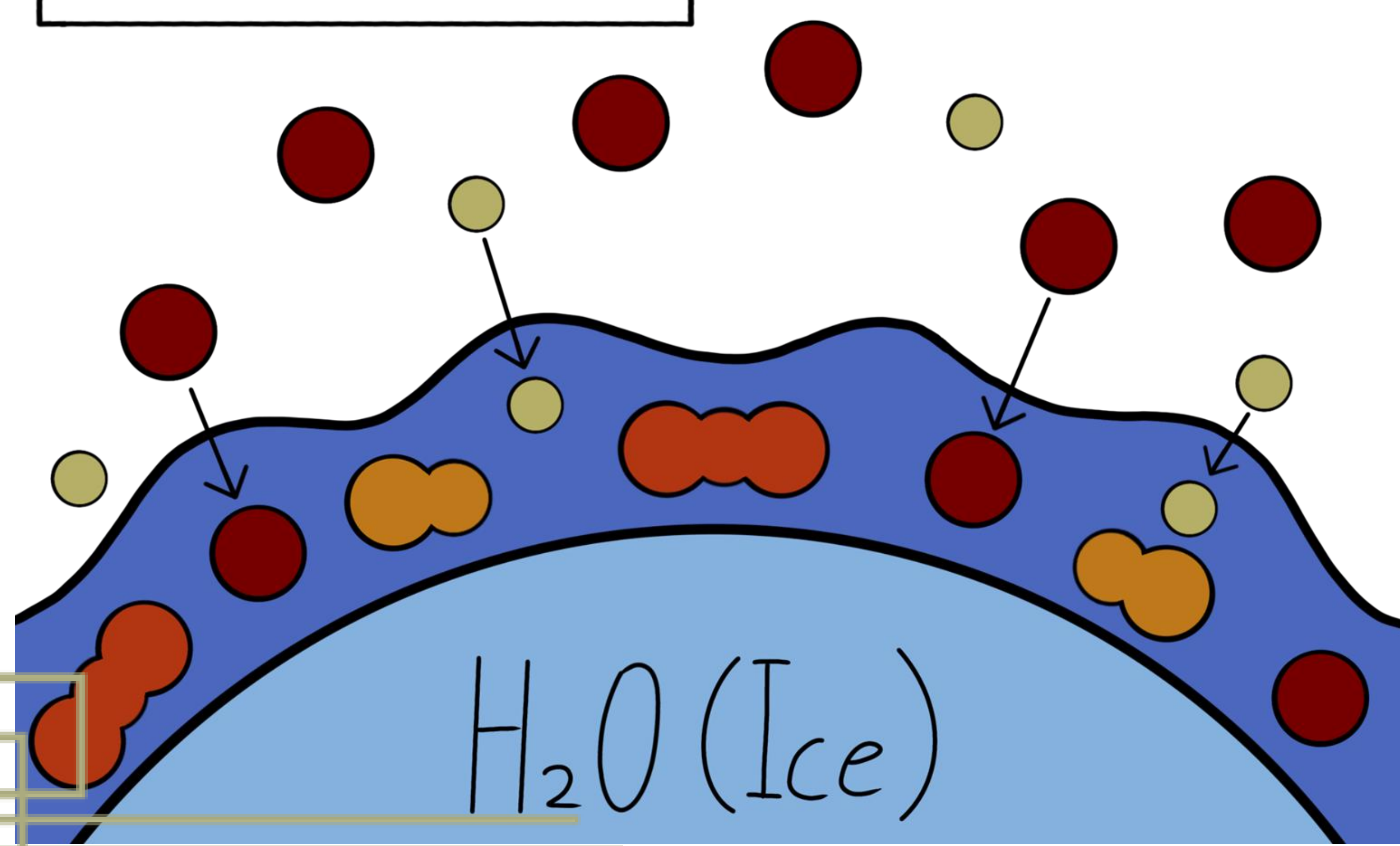
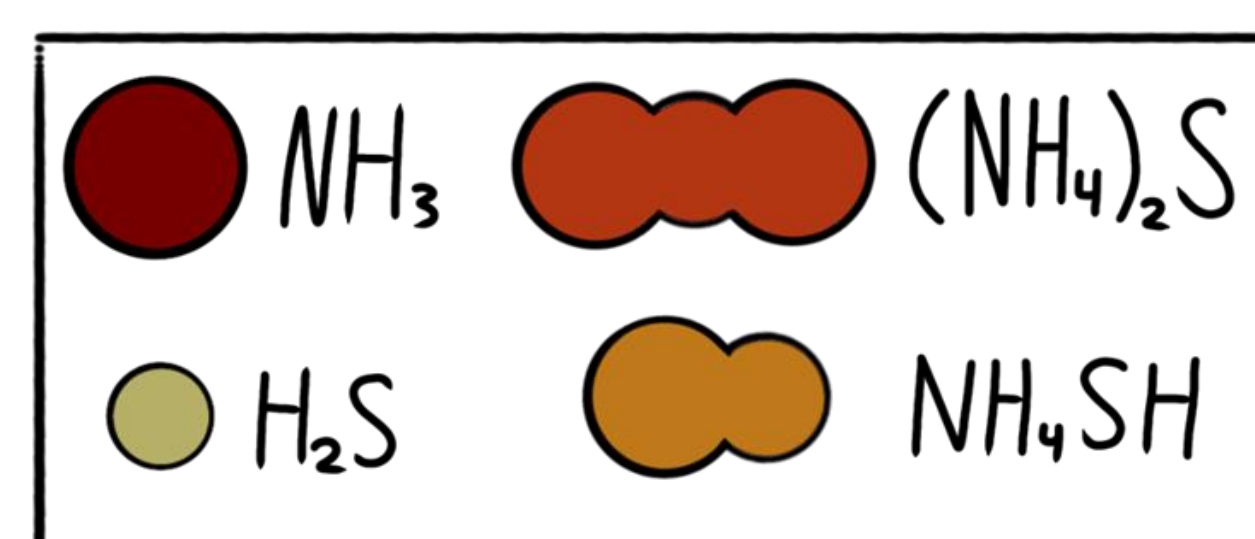
Introduction: Even after decades of research, much of Jupiter's atmosphere is poorly understood. Recently, interest in a 2-3 bar cloud deck generated by a new ammonia mapping technique has exposed the very flimsy nature of the assumption that these clouds are made primarily of ammonium hydrosulfide (NH₄SH). While there is evidence to support the existence of NH₄SH at this level, its formation reaction and the interaction between this reaction and its environment has been lacking proper study. With closer inspection, the abundance of NH₃ in the atmosphere lends itself to the possible additional formation of ammonium sulfide ((NH₄)₂S), prompting further examination of the chemistry occurring in these clouds.

Possible Compositions

As NH₄SH and (NH₄)₂S reactions form clouds, the products are most likely mixed with other components. Over time, we seek to consider each of these possibilities:

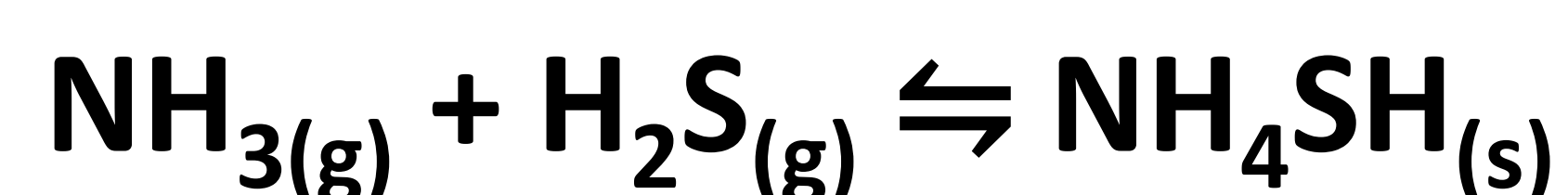
- Pure NH₄SH
- NH₄SH & NH_{3(s)}
- NH₄SH & H₂O_(s)
- NH₄SH & (NH₄)₂S
- NH₄SH & (NH₄)₂S & H₂O_(s)
- NH₃ & H₂O_(l)
- Pure H₂O_(s)

Here, we will focus on the possibility of (NH₄)₂S forming in solution, as shown:



Artist Credit: Jocelyn Ripley

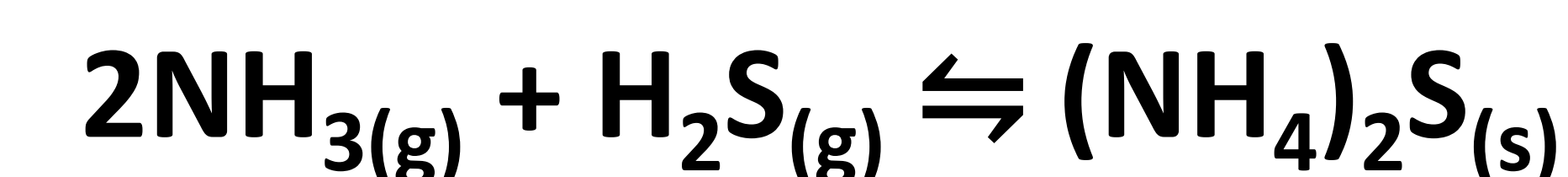
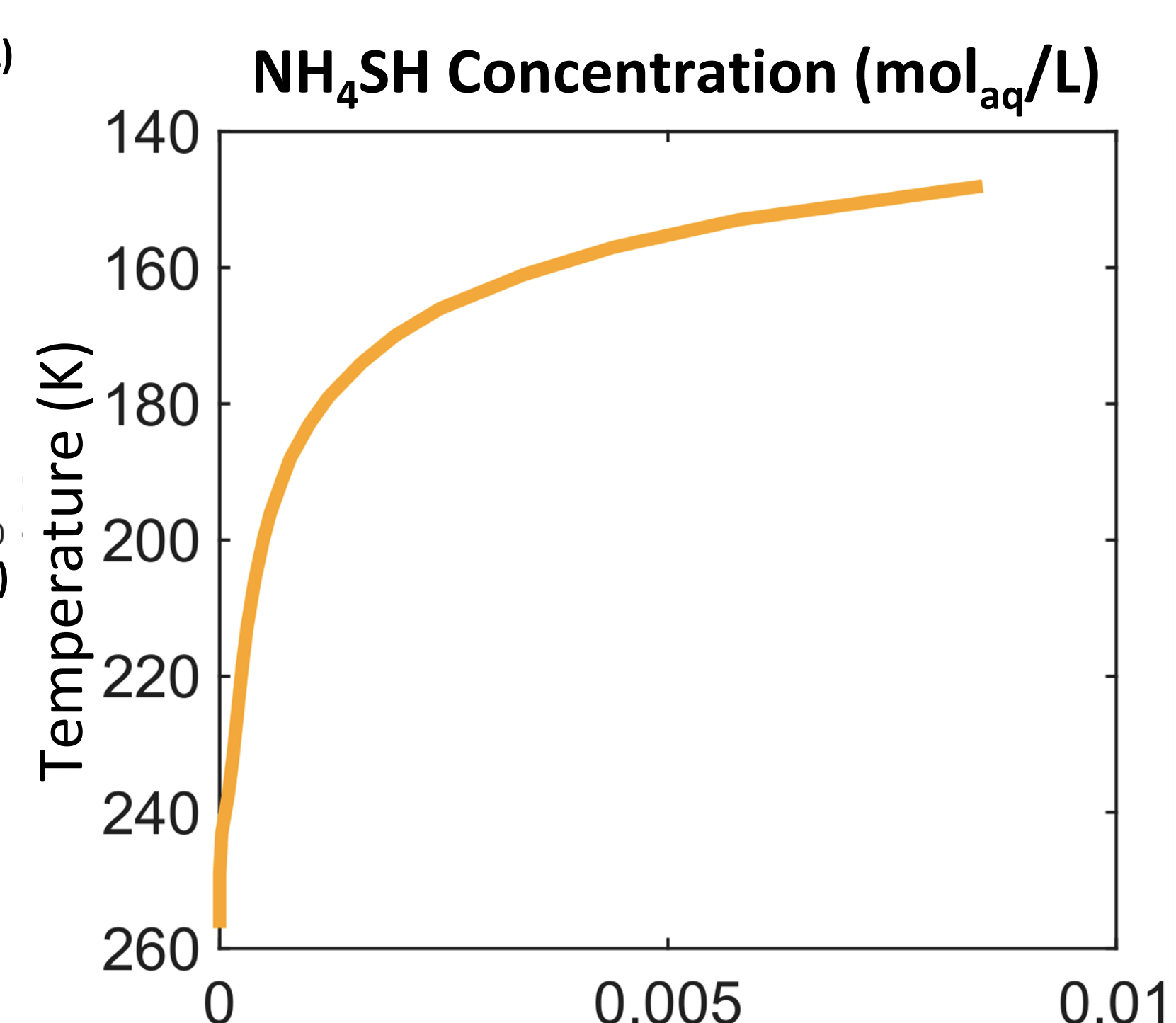
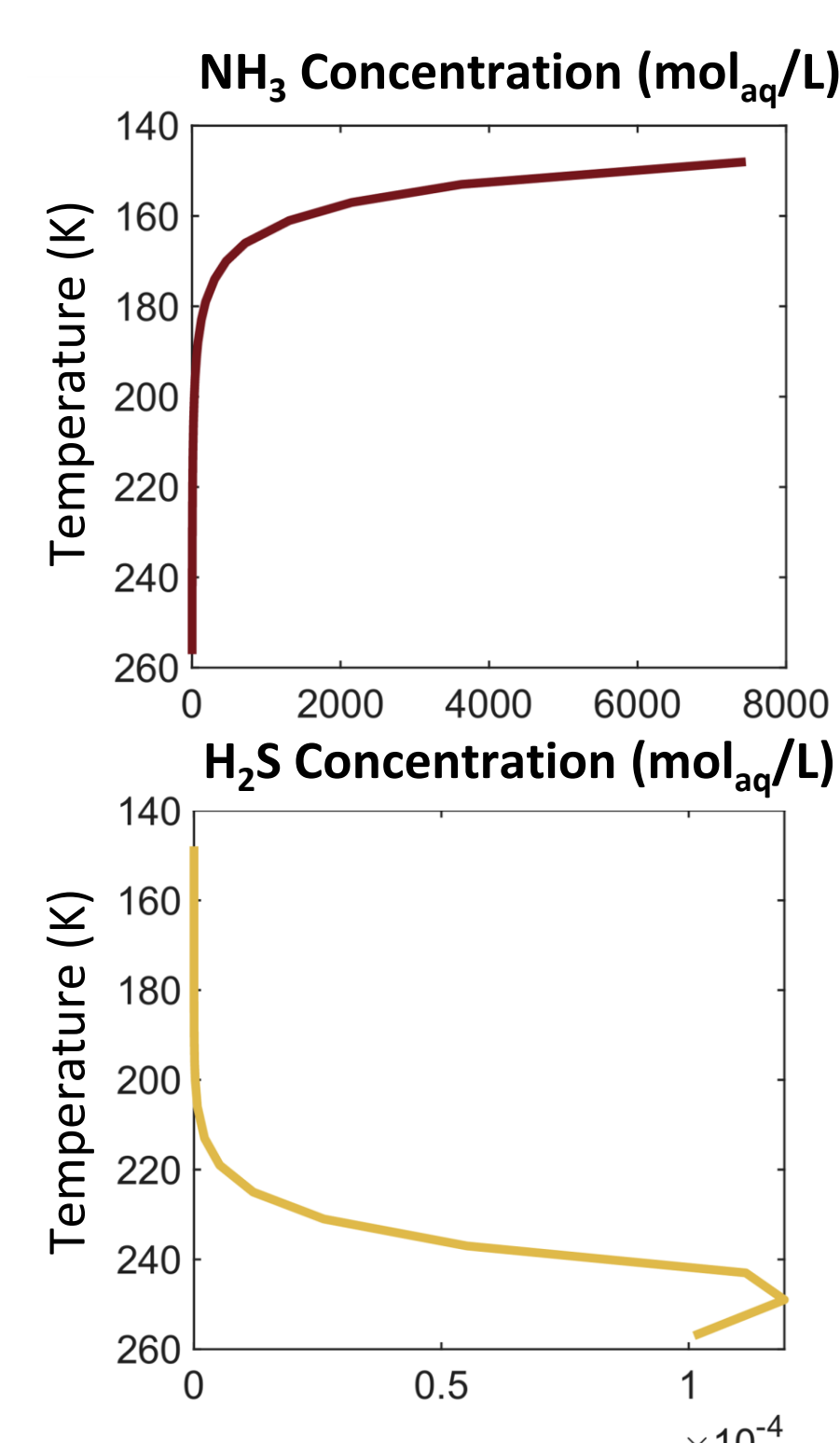
NH₄SH vs (NH₄)₂S:



$$K_{H,T} = K_{H0} \times \exp((\Delta H_{\text{sol}}/R)(1/T - 1/T_0))$$

$$K_{\text{HON}} = 5.8\text{E-}6 \text{ mol/L/Pa}; \Delta H_{\text{solN}} = -30.5 \text{ kJ/mol}$$

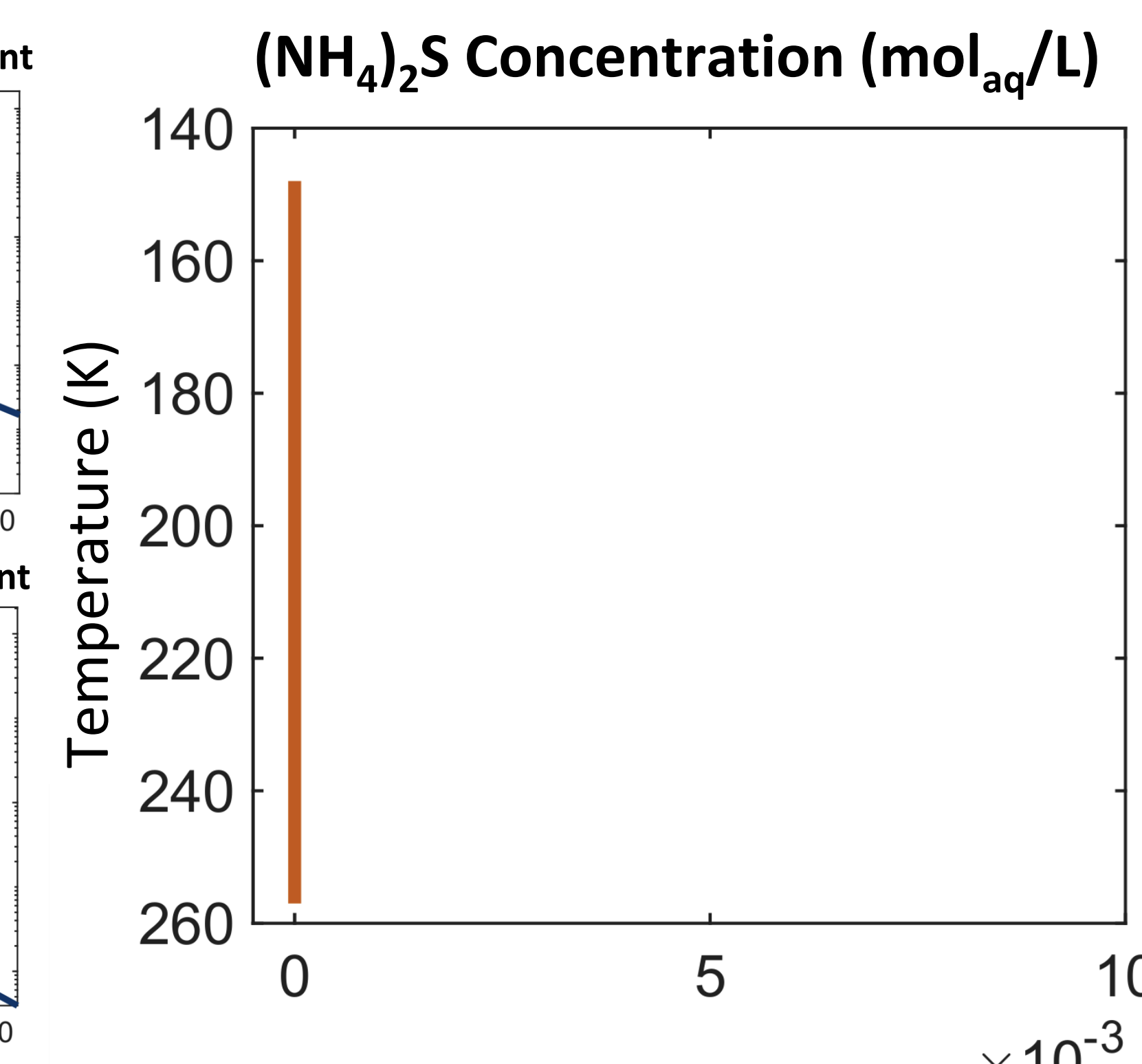
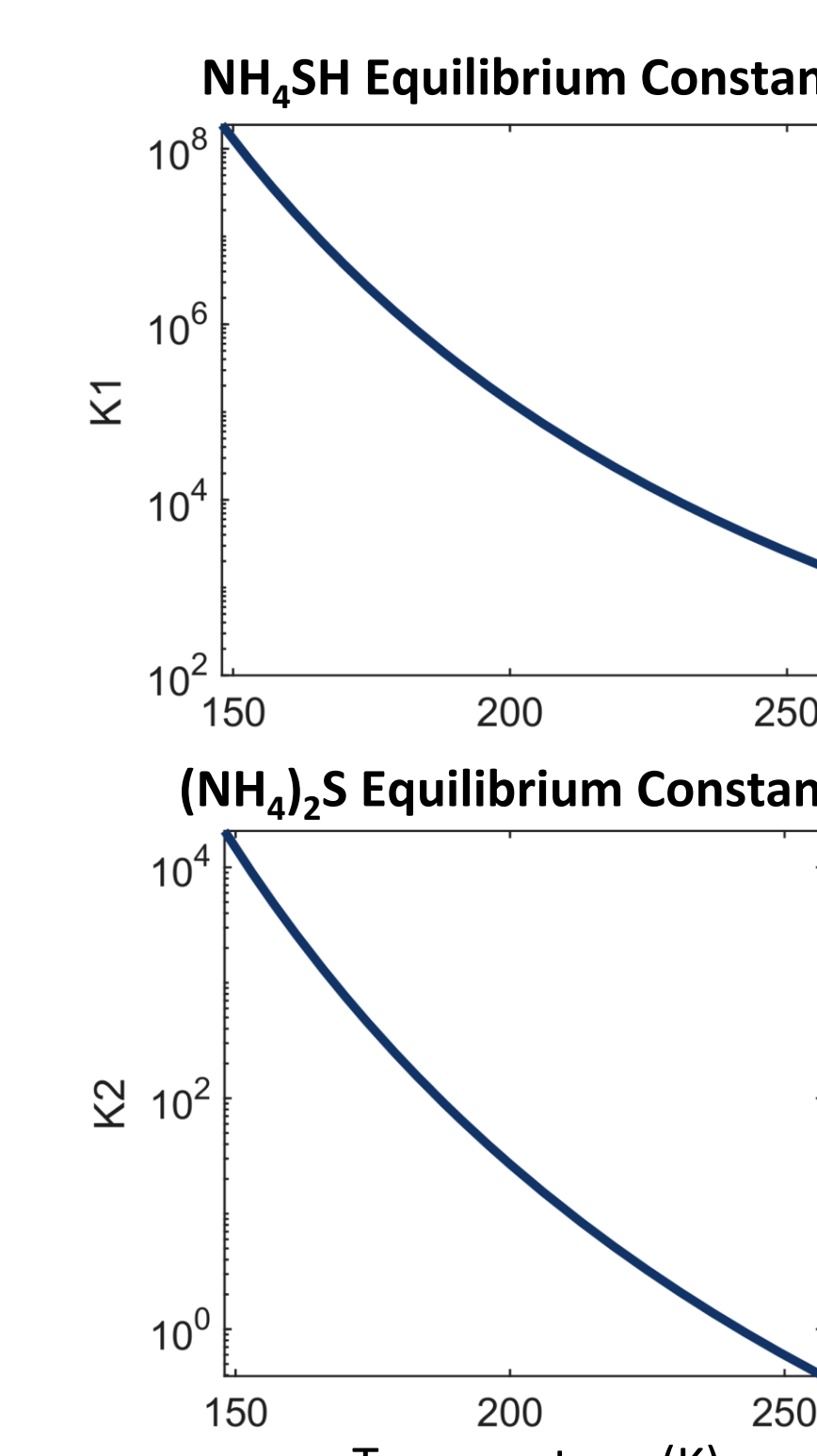
$$K_{\text{HOS}} = 1.0\text{E-}6 \text{ mol/L/Pa}; \Delta H_{\text{solS}} = -18 \text{ kJ/mol}$$



$$K_{\text{eq}} = \exp(\Delta G/(R \times T))$$

$$\Delta G = \Delta G_0 - (\Delta S \times (T - 298)) + \Delta C \times (T \times (\ln(T/298)) - (T - 298))$$

$$\Delta G_0_{\text{NH}_4\text{SH}} = -67.25 \text{ kJ/mol}; \Delta G_0_{(\text{NH}_4)_2\text{S}} = -72.9 \text{ kJ/mol}$$



Preliminary calculations for concentrations of relevant compounds in aqueous solution. Does not account for the condensation temperature of NH₃, outward diffusion of NH₄SH, or possible conversion of NH₄SH into (NH₄)₂S over time. Does not show total atmospheric concentrations. These considerations will be explored in future calculations.

Future Work: The results shown here depict only one possible mechanism for cloud formation on Jupiter. Without much experimental data to compare and confirm these predictions with, it is necessary that other mechanisms are studied to the same or greater degree and compared to find the greatest accuracy to the observed clouds in the Jovian atmosphere. Currently, there are also plans for a lab experiment to attempt to observe the reactions of NH₃ and H₂S firsthand under the relevant conditions.

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