Introduction to Concentration Space

Understanding how substances interact in a mixture is fundamental in chemistry. Concentration space is a visual tool that represents these interactions by showing the relationship between different components. This document explains concentration space diagrams, focusing on the solubility product constant (K_{sp}) and the convex hull.

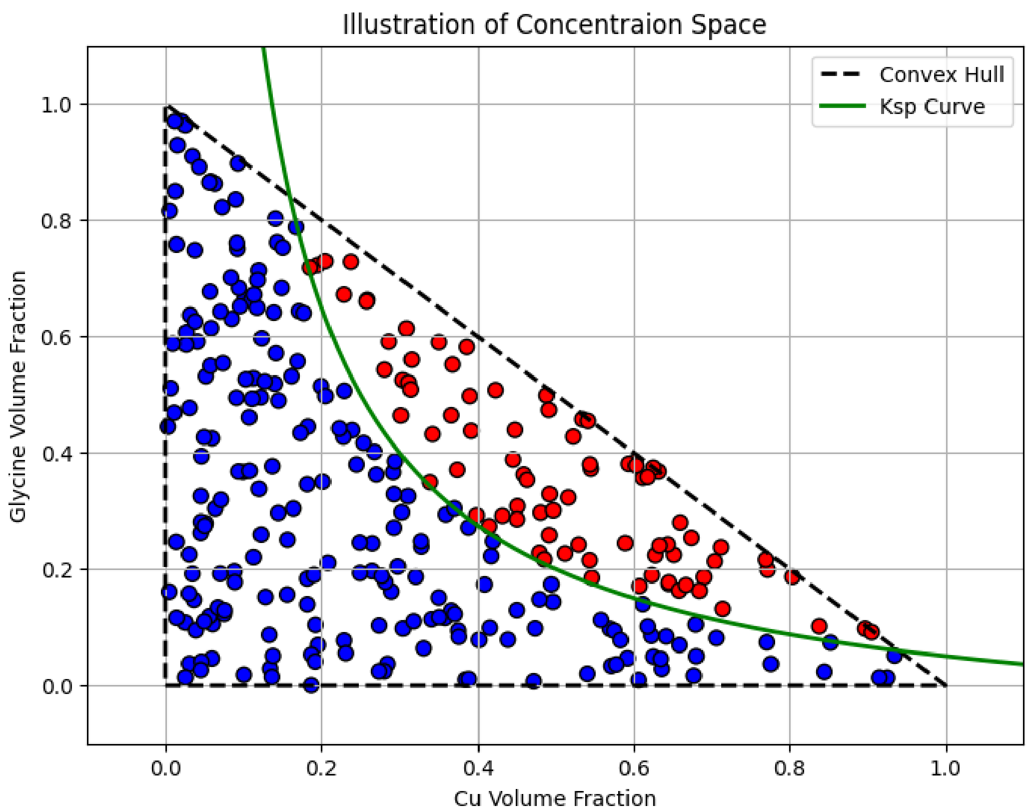

Figure 1 – Demonstration concentration space diagram representing the initial concentrations of two ionic species across multiple reaction systems. Each point corresponds to a unique set of starting conditions, allowing visualisation of how different mixtures relate to solubility and reaction outcomes.

1. Basics of Concentration Space

A concentration space diagram visually represents the proportions of components in a mixture. Here, we focus on a system containing copper (II) acetate monohydrate and glycine.

Key Elements of the Diagram

• Axes:

- X-axis: Cu volume fraction (0 to 1).
- Y-axis: Glycine volume fraction (0 to 1).

• Data Points:

- Blue dots: Mixtures below solubility limit.
- Red dots: Mixtures exceeding solubility limit, causing precipitation.

• Convex Hull (Dashed Black Lines): Outlines the feasible mixture boundary, points outside are chemically impossible.

• Solubility Curve (Green Line): Represents the solubility limit (K_{sp}).

- Below the curve: Mixture is undersaturated.
- Above the curve: Mixture is supersaturated, leading to precipitation.

2. Solubility Product Constant (K_{sp})

K_{sp} defines the maximum concentration of solutes before precipitation occurs.

What is K_{sp}?

K_{sp} is the product of ion concentrations, each raised to its stoichiometric coefficient. For example:

Copper (II) acetate monohydrate + Glycine → Copper (II) Glycinate

Role of K_{sp} in the Diagram

• The green solubility curve marks where K_{sp} is reached.

• Below the curve: Mixtures remain stable.

• Above the curve: Mixtures become supersaturated, leading to precipitation.

• As Cu fraction increases, glycine solubility decreases due to competitive solubility effects, making the solubility curve slope downward.

3. Convex Hull: Physical Constraints of the Mixture

The convex hull (dashed black boundary) encloses all feasible Cu-glycine volume fractions, defining physically possible combinations.

Convex Hull Features

• $x = 0$ → No Cu; mixture contains only glycine solutions and water.

• $y = 0$ → No glycine; mixture contains only Cu solutions and water.

• $y = -x$ → Mixture fully saturated with Cu solutions & glycine solutions, leaving no water.

4. Applications of Concentration Space Diagrams

These diagrams visually represent solubility, stability, and phase behaviour, making them valuable in chemistry.

Key Applications:

• Predicting Precipitation Reactions: Helps determine when a solution will become supersaturated, leading to solid formation.

• Optimizing Crystallization: Helps control conditions of a reaction.

• Understanding Chemical Equilibria: Visualizes the balance between dissolved and precipitated species.