Exercise walk-through

Stability constants, Kstab ▪ 28.5

eXercise

You must be able to

- define the stability constant of a complex
- write a K_{stab} expression (leaving out water)
- use K_{stab} values to compare stability and predict ligand exchange

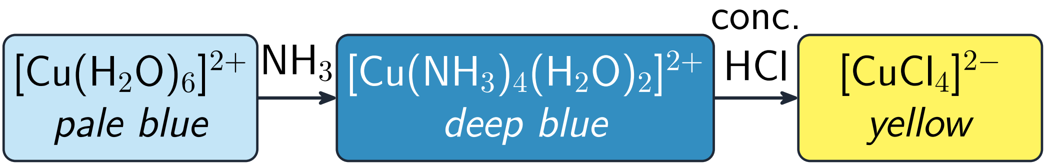
Method — Stability constants

The **stability constant** K_{stab} is the equilibrium constant for forming a complex ion from the metal ion and its ligands in solution. **Water is left out** of the expression. For $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightleftharpoons [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$:

$$K_{\text{stab}} = \frac{[[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}]}{[[\text{Cu}(\text{H}_2\text{O})_6]^{2+}][\text{NH}_3]^4}$$

*A **large** K_{stab} = a very stable complex; ligand exchange moves towards the larger K_{stab}*

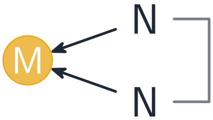
Method — Stability constants



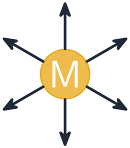
Ligand exchange shifts towards the complex with the larger Kstab

Method — Stability constants

monodentate: 1 bond
(H_2O, NH_3, Cl^-)



bidentate: 2 bonds
("en")



polydentate: many
(EDTA uses 6)

Ligand denticity affects stability constants

Practice 2.1 ▪ 1 mark

Define the **stability constant** of a complex.

Solution 2.1

Method: Stability constants

Worked steps

the equilibrium constant for the formation of a complex ion from the metal ion and its ligands in solution **B1**.

Practice 2.2 ▪ 1 mark

State what a large value of K_{stab} tells you about a complex.

Solution 2.2

Method: Stability constants

Worked steps

the complex is very stable **B1**.

Exam-style 3.1 ▪ 1 mark

Which species is **omitted** from a K_{stab} expression in aqueous solution?

A the metal ion

B the incoming ligand

C water

D the complex ion

Solution 3.1

Method: Stability constants

A the metal ion

B the incoming ligand

C water ✓

D the complex ion

Worked steps

C. Water is omitted from the K_{stab} expression.

Exam-style 3.2 ▪ 1 mark

In a ligand exchange, the equilibrium moves towards the complex with the:

A smaller K_{stab}

B larger K_{stab}

C smaller charge

D more water ligands

Solution 3.2

Method: Stability constants

A smaller K_{stab}

B larger K_{stab} ✓

C smaller charge

D more water ligands

Worked steps

B. The equilibrium moves towards the complex with the larger K_{stab}.

Exam-style 3.3 ▪ 2 marks

For $[Cu(H_2O)_6]^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$:
(a) Write the expression for K_{stab}.
(b) The ammonia complex has a much larger K_{stab} than the water complex. Explain what this means for the ligand-exchange reaction.

Solution 3.3

Method: Stability constants

Worked steps

(a) $K_{\text{stab}} = \dfrac{[[Cu(NH_3)_4(H_2O)_2]^{2+}]}{[[Cu(H_2O)_6]^{2+}][NH_3]^4}$ **M1** **A1** *numerator, denominator without water.*

(b) the ammonia complex is more stable, so the equilibrium lies far to the right and the exchange goes almost to completion **M1** **A1**.

Exam-style 3.4 ▪ 2 marks

Explain why adding excess ammonia to $[Cu(H_2O)_6]^{2+}$ forms the ammonia complex.

Solution 3.4

Method: Stability constants

Worked steps

the ammonia complex has a much larger K_{stab} (is more stable) **M1**; so excess ammonia drives the equilibrium to replace the water ligands and form the ammonia complex **A1**.