

Chemical equilibrium

If we add an excess of soluble chloride to a *pink* aqueous solution of cobalt(II) salt, its colour will change to *blue*. This chemical change can be described by the equation



The reaction is endothermic ($\Delta_r H^\ominus > 0$) therefore, the composition of a reaction mixture may be influenced by temperature.

Work

Observe the colour changes of equilibrium mixture of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{CoCl}_4]^{2-}$ depending on temperature and addition of reactant and/or product.

Chemicals

- cobalt(II) chloride hexahydrate, $\text{CoCl}_2 \cdot 6 \text{H}_2\text{O}$
- sodium chloride, NaCl

Procedure

- 1 Dissolve 2,0 g of $\text{CoCl}_2 \cdot 6 \text{H}_2\text{O}$ in 50 cm³ of distilled water. The resulting pink solution contains hexaaquacobalt(II) cations $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$.
- 2 Heat the pink solution almost to its boiling point. Its colour will not change, because there is no excess of chloride ions. However, on the hot wall of a beaker we may observe formation of pale blue crystals of anhydrous CoCl_2 .
- 3 To the almost boiling pink solution add slowly 8 g of powdered NaCl . After dissolving changes its colour to blue – in excess of chloride anions tetrachloridocobaltite anions $[\text{CoCl}_4]^{2-}$ will form. (eqn. 1). We shift the equilibrium to the products by adding the reactant (Cl^{-}).
- 4 Cool the blue solution containing the $[\text{CoCl}_4]^{2-}$ anions in an ice bath (ice + water + NaCl). In a short time the colour changes back to pink. We shift the equilibrium to the reactants by decreasing temperature ($\Delta T < 0$).
- 5 Heat the pink solution again to its boiling point. The solution changes (of course) its colour to blue. We shift the equilibrium to the products by increasing temperature ($\Delta T > 0$).
- 6 To the hot blue solution add 100 cm³ of boiling distilled water. Colour changes to pink. Because there is no change in temperature (boiling solution + boiling water), we may explain the colour change only by shifting the equilibrium to the reactants by adding the product (H_2O).
- 7 The final pink solution will not change its colour to blue, because the great excess of water keeps the equilibrium on site of reactants.

Safety instructions

Cobalt(II) chloride hexahydrate – CoCl₂ · 6 H₂O

- R22** Harmful if swallowed.
- R49** May cause cancer by inhalation.
- R42/43** May cause sensitization by inhalation and skin contact.
- R50/53** Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
- S22** Do not breathe dust
- S45** In case of accident or if you feel unwell seek medical advice immediately (show the label where possible)
- S53** Avoid exposure – Obtain special instructions before use
- S60** This material and its container must be disposed of as hazardous waste
- S61** Avoid release to the environment. Refer to special instructions/safety data sheet

Sodium chloride – NaCl

- R36/37/38** Irritating to eyes, respiratory system and skin.
- S26** In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
- S36** Wear suitable protective clothing