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Cobalt Complexes

Preparer's Version

Introduction

This demonstration showcases chemical equilibrium and thermochromism using cobalt(II) chloride in aqueous and chloride-rich environments. The demonstration powerfully illustrates Le Châtelier's Principle: a system at equilibrium will respond to external changes by shifting in the direction that counteracts the disturbance. In this case, heating the solution shifts equilibrium to the right, resulting in a higher concentration of the blue complex; meanwhile, cooling shifts equilibrium to the left, resulting in a higher concentration of the pink complex. Beyond the thermochromism, adding Cl^- via the addition of HCl favors the blue complex, whereas removing Cl^- (e.g., by adding $AgNO_3$, which forms a white AgCl precipitate) would shift the system back to favor the pink complex.

Safety Hazards

- Personal Protective Equipment:
  - Safety glasses/goggles
  - Nitrile gloves
  - Chemical & flame retardant lab coat
  - Face shield (optional, but advised)
- Physical Hazards
  - Cobalt(II) chloride is very toxic to aquatic life with long lasting effects.
- Chemical Hazards
  - Cobalt(II) chloride is harmful if swallowed, may cause an allergic skin reaction and may cause allergy or asthma symptoms or breathing difficulties if inhaled, and causes serious eye damage. Cobalt(II) chloride is suspected of causing genetic defects and may damage fertility or the unborn child. Cobalt(II) chloride may cause cancer by inhalation.
  - Hydrochloric acid is corrosive, may cause eye and skin damage; irritant, may cause severe respiratory irritation.

Materials

- 200mL 0.1M Cobalt(II) chloride solution
- 200mL Hydrochloric acid, concentrated (12M)
- 500mL deionized water
- Ice
- 600mL beaker
- 2x 400mL beakers
- Insulated bucket
- Glass stir rod
- Stir/Hot plate
- Extension cord
- 3x glass test tubes (25mm dia. x 150mm length) (*Alternate Procedure only)*
- 3x Rubber stoppers (*Alternate Procedure only)*
- Parafilm (*Alternate Procedure only)*

Safety Data Sheet(s)

- Cobalt(II) chloride hexahydrate
- Hydrochloric acid, concentrated (12M

Procedure

Please note: This demonstration should be performed carefully in a large, well ventilated space or a fume hood.

1. Weigh 23.8g of Cobalt(II) chloride hexahydrate and dissolve it in deionized water and dilute to 1.0L. This makes 1.0L of 0.1M Cobalt(II) chloride solution.
2. Measure 200mL of 0.1M Cobalt(II) chloride solution and add to a 600mL beaker.
3. While stirring with either a glass stir rod or on a stir plate, add 200mL of concentrated hydrochloric acid to the 600mL beaker. This should turn the solution purple.
4. If the solution is too blue, dilute with deionized water until the desired purple color is obtained.

Alternate Procedure

1. Weigh 23.8g of Cobalt(II) chloride hexahydrate and dissolve it in deionized water and dilute to 1.0L. This makes 1.0L of 0.1M Cobalt(II) chloride solution.
2. Measure 200mL of 0.1M Cobalt(II) chloride solution and add to a 600mL beaker.
3. While stirring with either a glass stir rod or on a stir plate, add 200mL of concentrated hydrochloric acid to the 600mL beaker. This should turn the solution purple.
4. If the solution is too blue, dilute with deionized water until the desired purple color is obtained.
5. Measure 20mL of the prepared solution and pour it into a glass test tube. Seal the test tube with a rubber stopper and wrap securely in parafilm.
6. Repeat for the other two test tubes.
7. Heat a beaker of deionized water on a hot plate to create a hot water bath. Do not boil the water.
8. Place one test tube in the hot water bath.
9. Place another test tube in the insulated bucket of ice and allow it to cool.

Tips & Tricks

- When working in a less well-ventilated area or when transporting the required quantity of concentrated hydrochloric acid is not the safest option, elect to use the alternate procedure that exclusively shows the temperature-dependent reaction.

Clean-Up Procedures

1. Neutralize the solution using a weak base.
    a. When the solution is acidic, you can use sodium bicarbonate. Check the pH using a pH meter or pH paper.
2. Pour into a waste stream with other compatible substances.
3. Rinse the labware thoroughly with deionized water at least three times, emptying the runoff into the waste stream.
4. Clean thoroughly with laboratory detergent.