• Most common oxidation states: +1, +2
• M.P. -38.87º
• B.P. 356.57º
• Density 13.546 g/cm³
• Characteristics: Mercury is one of the few liquid elements. It dissolves in oxidizing acids, producing either \( \ce{Hg^{2+}} \) or \( \ce{Hg_2^{2+}} \), depending on which reagent is in excess. The metal is also soluble in aqua regia (a mixture of hydrochloric and nitric acids) to form \( \ce{HgCl_4^{(2-)}} \).

**Mercury(I) Ion: \( \text{Hg}_2^{2+} \)**

Mercury(I) compounds often undergo disproportionation, producing black metallic mercury and mercury(II) compounds.

**Chloride Ion**

Soluble chlorides, including hydrochloric acid, precipitate white mercury(I) chloride, also known as calomel:

\[
\ce{Hg_2^{2+}(aq) + 2Cl^{-}(aq) \rightleftharpoons Hg_2Cl_2(s)}
\]

Aqueous ammonia reacts with \( \ce{Hg_2Cl_2} \) to produce metallic mercury (black) and mercury(II) amidochloride (white), a disproportionation reaction:

\[
\ce{Hg_2Cl_2(s) + 2NH3(aq) \rightarrow Hg(l) + HgNH2Cl(s) + NH_4^+(aq) + Cl^-(aq)}
\]
Aqueous Ammonia

Aqueous ammonia produces a mixture of a white basic amido salt and metallic mercury:

$$\text{2Hg}^{2+}(aq) + 4\text{NH}_3(aq) + \text{NO}_3^-(aq) + \text{H}_2\text{O}(l) \rightarrow 2\text{Hg}(l) + \text{Hg}_2\text{ONH}_2\text{NO}_3(s) + 3\text{NH}_4^+(aq)$$

The precipitate is not soluble in excess aqueous ammonia.

Sodium Hydroxide

Black finely divided mercury metal and yellow mercury(II) oxide ($\text{HgO}$) are precipitated by $\text{NaOH}$:

$$\text{Hg}_2^{2+}(aq) + 2\text{OH}^-(aq) \rightarrow \text{Hg}(l) + \text{HgO}(aq) + \text{H}_2\text{O}(l)$$
Reducing Agents

Reducing agents, such as $\ce{Sn^{2+}}$ and $\ce{Fe^{2+}}$, reduce mercury(I) to the metal:

$$\ce{Hg_2^{2+}(aq) + 2Fe^{2+}(aq) -> 2Hg(l) + 2Fe^{3+}(aq)}$$

Consult an activity series or a table of reduction potentials for other possible reducing agents.

No Reaction

$\ce{SO_4^{2-}}$ (unless solutions are concentrated; solubility of mercury(I) sulfate is 0.06 g per 100 mL of water at 25oC)
**Mercury(II) Ion: Hg^{2+}\)**

**Characteristic reactions of \(\ce{Hg^{2+}}\)**

**Chloride Ion**

No reaction is visible, but Hg(II) will be present as \(\ce{[HgCl4]^{2-}}\).

**Aqueous Ammonia**

Aqueous ammonia produces white amido salts whose composition depends on the mercury(II) salt present in the solution:

\[
\ce{HgCl2(aq) + 2NH3(aq) <=> HgNH2Cl(s) + 2NH4^{+}(aq) + Cl^{-}(aq)}
\]

These salts are not soluble in excess aqueous ammonia, but do dissolve in acids:

\[
\ce{HgNH2Cl(s) + 2H^{+}(aq) + Cl^{-}(aq) <=> HgCl2(aq) + NH4^{+}(aq) + H^+(aq)}
\]
Sodium Hydroxide

A yellow precipitate of $\text{HgO}$ is produced by $\text{NaOH}$:

$$\ce{Hg^{2+}(aq) + 2OH^{-}(aq) -> HgO(s) + H2O(l)}$$

$$\ce{HgCl2(s) + 2OH^{-}(aq) -> HgO(s) + H2O(l) + 2Cl^{-}(aq)}$$

The mercury(II) oxide precipitate is insoluble in excess hydroxide but is soluble in acids:

$$\ce{HgO(s) + 2H^{+}(aq) <=> Hg^{2+}(aq) + H2O(l)}$$
Hydrogen Sulfide

Hydrogen sulfide precipitates black mercury(II) sulfide, the least soluble of all sulfide salts.

\[
\text{Hg}^{2+}(aq) + \text{H}_2\text{S}(aq) \rightleftharpoons \text{HgS}(s) + 2\text{H}^+(aq)
\]

\[
\text{[HgCl}_4]^{2-}(aq) + \text{H}_2\text{S}(aq) \rightleftharpoons \text{HgS}(s) + 2\text{H}^+(aq) + 4\text{Cl}^-(aq)
\]

Mercury(II) sulfide is insoluble in 6 M \(\text{HNO}_3\) or 12 M \(\text{HCl}\), even if heated. However, it is soluble in \(\text{aqua regia}\) (3:1 HCl:HNO3) and in hot dilute \(\text{NaOH}\) containing excess sulfide.

\[
3\text{HgS}(s) + 12\text{Cl}^-(aq) + 2\text{NO}_3^-(aq) + 8\text{H}^+(aq) \rightarrow 3[\text{HgCl}_4]^{2-}(aq) + 2\text{NO}(g) + 3\text{S}(s) + 4\text{H}_2\text{O}(l)
\]

\[
\text{HgS}(s) + \text{S}^{2-}(aq) \rightleftharpoons [\text{HgS}_2]^{2-}(aq)
\]

Tin(II) Chloride

Tin(II) chloride reduces \(\text{Hg}^{2+}\) to \(\text{Hg}^{0}\) or to metallic \(\text{Hg}\), giving a white or gray precipitate:

\[
2[\text{HgCl}_4]^{2-}(aq) + [\text{SnCl}_4]^{2-}(aq) \rightarrow \text{Hg}_2\text{Cl}_2(s) + [\text{SnCl}_6]^{2-}(aq) + 4\text{Cl}^-(aq)
\]
No Reaction

\(\text{SO}_4^{2-}\text{)}\) (may precipitate as a mixed sulfate-oxide - a basic sulfate - \(\text{HgSO}_4 \cdot 2\text{HgO}\))