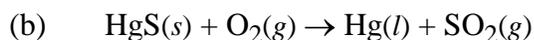


## Chapter 22

### THE GROUP 12 ELEMENTS

#### Exercises



22.4 The ions formed by these elements always have a filled set of *d* orbitals, so they do not behave like transition metals. Their ions are colorless, not colored, and both zinc and cadmium exhibit only one common oxidation state rather than a range of oxidation states, which is typical for “normal” transition metals.

22.6 Zinc and mercury, though in the same group, have several differences. The most obvious is that mercury has an “abnormally” low melting point for a member of this group. Zinc has the single oxidation state of +2, while mercury has oxidation states of +1 and +2. Most zinc salts contain the hydrated zinc ion, while most mercury salts contain covalently bonded molecules. Mercury compounds are readily reduced to mercury metal, while zinc metal is readily oxidized to the +2 ion.

22.8 The oxide ion is smaller than the sulfide ion. Thus it is probable that six oxides can fit around the cadmium ion, compared to four for the larger sulfide ion.

22.10 Calcium:

**Some similarities:**

Metal tarnishes in air

Colorless 2+ ion

Charge density  $52 \text{ C}\cdot\text{mm}^{-3}$

**Some differences:**

Metal melts  $842^\circ\text{C}$

Metal density  $1.55 \text{ g}\cdot\text{cm}^{-3}$

$\text{Ca}(\text{OH})_2$  insol. in excess  $\text{OH}^-$

Cadmium:

Metal tarnishes in air

Colorless 2+ ion

Charge density  $59 \text{ C}\cdot\text{mm}^{-3}$

Metal melts  $321^\circ\text{C}$

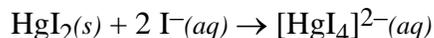
Metal density  $8.65 \text{ g}\cdot\text{cm}^{-3}$

Forms  $\text{Cd}(\text{OH})_4^-$  in excess  $\text{OH}^-$

**Beyond the Basics**

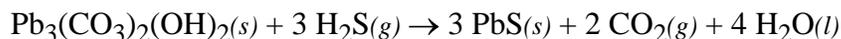
22.12 This must be a charge transfer transition:  $\text{Cd}^{2+}\text{S}^{2-} \rightarrow \text{Cd}^+\text{S}^-$

22.14  $[\text{HgI}_4]^{2-}$  since the Group 12 metals favor tetrahedral stereochemistry.



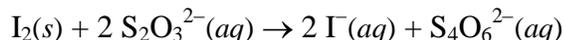
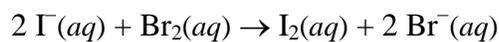
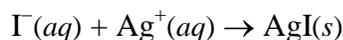
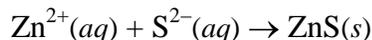
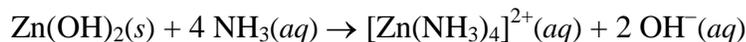
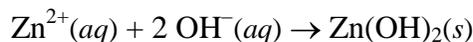
22.16 It is unwise to mix “white lead” in with “cadmium yellow” to produce pale yellow since lead compounds can react over time with traces of hydrogen sulfide in the air to form black lead(II) sulfide.

The chemical equation for this reaction would be

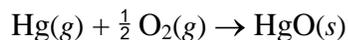


22.18 Mercury(II) is a soft acid, thus favoring soft bases such as sulfide. Zinc is a harder acid; thus it favors both hard and soft bases.

22.20 [A] Zinc iodide; [B] zinc hydroxide; [C] tetrahydroxozincate ion; [D] tetraamminezinc ion; [E] zinc sulfide; [F] silver iodide; [G] diiodine; [H] iodide; [I] tetrathionate ion.



22.22 This reaction involves a decrease in entropy, thus it must be enthalpy driven. Above 357°C, mercury is a gas, so the reaction becomes:



Because  $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ ,  $\Delta S^\circ$  will now be much more negative and the temperature term will be greater. This will be enough to “overcome” the enthalpy term and make  $\Delta G^\circ$  positive.

22.24 (a) Hg, HgS; (b) HgCl<sub>2</sub>; (c) Hg(CH<sub>3</sub>)<sub>2</sub>; (d) Hg(CH<sub>3</sub>)<sub>2</sub>; (e) Hg.