Ionic equations

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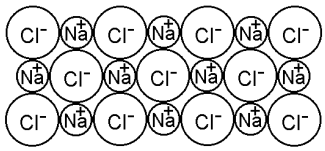
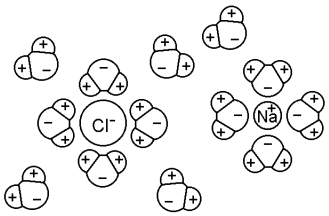
Ionic salts: no true molecule

- **Crystal lattice of NaCl:**



- **Dissolution of NaCl in water: electrolytic dissociation producing hydrated independent ions Na^+, Cl^-**



Reaction I

Stoichiometric equation:

$AgNO_3 + KCl \longrightarrow AgCl + KNO_3$

Ionic equation:

$Ag^+ + NO_3^- + K^+ + Cl^- \longrightarrow AgCl + K^+ + NO_3^-$

Net ionic equation:

$Ag^+ + \cancel{NO_3^-} + \cancel{K^+} + Cl^- \longrightarrow AgCl + \cancel{K^+} + \cancel{NO_3^-}$

$\mathbf{Ag^+ + Cl^- \longrightarrow AgCl}$ white ppt

Also possible:

$AgNO_3(aq) + KCl(aq) \longrightarrow AgCl(s) + KNO_3(aq)$

$\mathbf{Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)}$

(aq)	... aqueous
(s)	... solid
(l)	... liquid
(g)	... gaseous

Reaction II

$$CuSO_4 + 2NaOH \longrightarrow Cu(OH)_2 + Na_2SO_4$$

ionic:

$$Cu^{2+} + SO_4^{2-} + 2Na^+ + 2\,OH^- \longrightarrow Cu(OH)_2 + SO_4^{2-} + 2\,Na^+$$

net ionic:

$$Cu^{2+} + \cancel{SO_4^{2-}} + \cancel{2Na^+} + 2\,OH^- \longrightarrow Cu(OH)_2 + \cancel{SO_4^{2-}} + \cancel{2\,Na^+}$$

$$\boxed{\mathbf{Cu^{2+} + 2\,OH^- \longrightarrow Cu(OH)_2}}$$

pale blue ppt

Reaction III

$$2\,NaOH + (NH_4)_2SO_4 \longrightarrow 2\,NH_3 + Na_2SO_4 + 2H_2O$$

ionic:

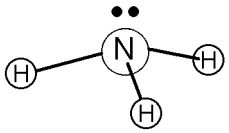
$$2Na^+ + 2OH^- + 2NH_4^+ + SO_4^{2-} \longrightarrow 2NH_3 + 2Na^+ + SO_4^{2-} + 2H_2O$$

net ionic:

$$\cancel{2Na^+} + \cancel{2OH^-} + \cancel{2NH_4^+} + \cancel{SO_4^{2-}} \longrightarrow \cancel{2NH_3} + \cancel{2Na^+} + \cancel{SO_4^{2-}} + \cancel{2H_2O}$$

$$\boxed{\mathbf{OH^- + NH_4^+ \longrightarrow NH_3 + H_2O}}$$

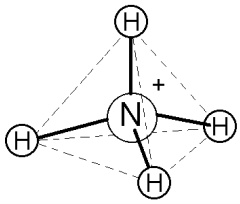
Ammonia gas: NH_3, $NH_3(g)$



Aqueous ammonia: $NH_3(aq)$, $NH_3.H_2O$, NH_4OH

$$NH_3.H_2O \longleftrightarrow NH_4OH$$

$$NH_4OH \longleftrightarrow NH_4^+ + OH^-$$



Reaction IV

$$Cu(OH)_2 + 2(NH_4)_2SO_4 + 2NaOH \longrightarrow [Cu(NH_3)_4]SO_4 + Na_2SO_4 + 4H_2O$$

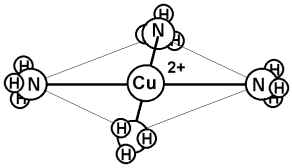
Ionic:

$$Cu(OH)_2 + 4NH_4^+ + 2SO_4^{2-} + 2Na^+ + 2OH^- \longrightarrow [Cu(NH_3)_4]^{2+} + 2SO_4^{2-} + 2Na^+ + 4H_2O$$

Net ionic:

$$Cu(OH)_2 + 4NH_4^+ + 2OH^- \longrightarrow [Cu(NH_3)_4]^{2+} + 4H_2O$$

Dark blue complex



Writing Ionic equations: Summary

1. write correct and balanced stoichiometric equation first
2. rewrite to ionic: write separately any species that exist separately and indicate its charge if present, but write together what exists joined (usually a precipitate of insoluble salt, or a soluble coordination complex)
3. Cancel out all species not involved in the reaction
4. Check that the equation is still balanced

What combinations of cations and anions are insoluble?

- All nitrates (NO_3^-) and acetates ($CH3COO^-$) are soluble
- All salts of Na, K, Li, and NH_4^+ are soluble
- All chlorides, bromides and iodides are soluble except salts of Pb^{2+}, Ag^+, and Hg_2^{2+}
- Most sulfate salts are soluble except $BaSO_4$, $PbSO_4$, $HgSO_4$, and $CaSO_4$.
- Most hydroxides are insoluble. Soluble are only NaOH and KOH. $Ba(OH)_2$, and $Ca(OH)_2$ are marginally soluble.
- Most sulfides (S^{2-}), carbonates (CO_3^{2-}) and phosphates (PO_4^{3-}) are insoluble.