Describe chemical reactions w/ chemical equation

Reactants (starting material) $\xrightarrow{\text{Magic}}$ Products (what you end up with)

$$aA_{(x)} + bB_{(x)} \longrightarrow cC_{(x)} + dD_{(x)}$$

A, B, C, D are chemical formulas

a, b, c, d are stoichiometric coefficients - tells you how much - in moles

(x) tells you state/phase

solid, liquid, gas, aqueous

↓ ↓ ↓ ↓

s l g aq ← dissolved in water

Conservation of mass - means that all atoms in reactants have to be accounted for in products

All chemical equations must be balanced

$H_{2(g)} + O_{2(g)} \longrightarrow H_2O_{(g)}$

L	R
2H	2H
2O	1O

* Allowed to change stoichiometric coeff
* Not allowed to change chemical formula

$H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$

L	R
2H	4H
2O	2O

$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(\ell)$

L	R
4H	4H
2O	2O

** Always balance equation before use

$C_2H_6O(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$

L	R
2C	2C
6H	6H
7O	7O

$2\,C_2H_6O(\ell) + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(\ell)$

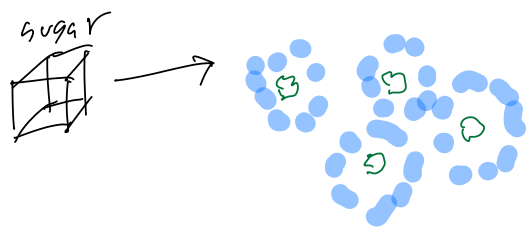
$\frac{1}{2}\,C_2H_6O(\ell) + \frac{3}{2}\,O_2(g) \rightarrow CO_2(g) + \frac{3}{2}\,H_2O(\ell)$ } equivalent to first balanced eq

Chemical reactions that occur in water - "aqueous"

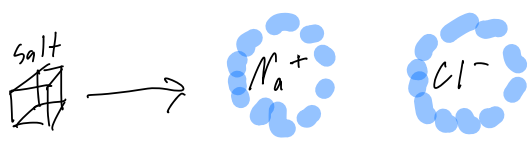
solute - is dissolved in solvent

solvent - what solute is dissolved in

molecular compound dissolved in water (sugar) - remains as original molecule



ionic compound dissolved in water (NaCl) is dissociated into its ions



each ion is "solvated" by a whole bunch of H_2O molecules

Some ionic compounds are soluble, some are insoluble

$NaNO_3$ dissolves to give Na^+ and NO_3^-

NO_3^- doesn't break up

$C_6H_{12}O_6(s) \rightarrow C_6H_{12}O_6(aq)$

$NaCl(s) \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

Solubility of ionic compounds based on their composition

Ions that give soluble compounds

Na^+	NO_3^-	F^- sometimes
K^+	Cl^-	SO_4^{2-}
NH_4^+	Br^-	
	I^-	

Ions that give insoluble compounds

CO_3^{2-} PO_4^{3-} S^{2-}

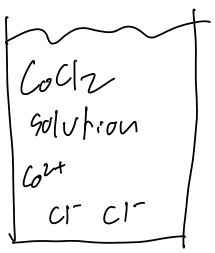
O^{2-} OH^- CrO_4^- ←

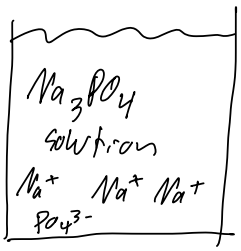
$C_2O_4^{-2}$

Na^+, K^+, NH_4^+ with these will be soluble

Precipitation reaction - combine 2 solutions (each has dissolved ionic compound)

- formation of insoluble ionic compound leads to precipitation

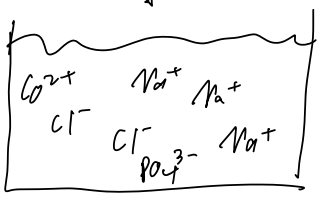




$CoCl_{2(s)} \rightarrow Co^{2+}_{(aq)} + 2Cl^-_{(aq)}$

$Na_3PO_{4(s)} \rightarrow 3Na^+_{(aq)} + PO_4^{3-}_{(aq)}$

Combine



precipitate

We could make $CoCl_2$ – soluble
Na_3PO_4 – soluble
$NaCl$ – soluble
$Co_3(PO_4)_2$

Complete ionic equation for precipitation

$3Co^{2+}_{(aq)} + \cancel{2}6Cl^-_{(aq)} + \cancel{3}6Na^+_{(aq)} + 2PO_4^{-3}_{(aq)}$

$\downarrow$

$Co_3(PO_4)_{2(s)} + 6Cl^-_{(aq)} + 6Na^+_{(aq)}$

* Co^{2+} : Cl^- ratio is fixed
* Na^+ : PO_4^{3-} ratio is fixed

Cl^-, Na^+ are "spectator ions"

Net ionic equation – without spectator ions

$3Co^{2+}_{(aq)} + 2PO_4^{3-}_{(aq)} \rightarrow Co_3(PO_4)_{2(s)}$

Acids/Bases and their reactions

Acids give away H^+ ion

Base takes H^+ ion

Acids/Bases react with water

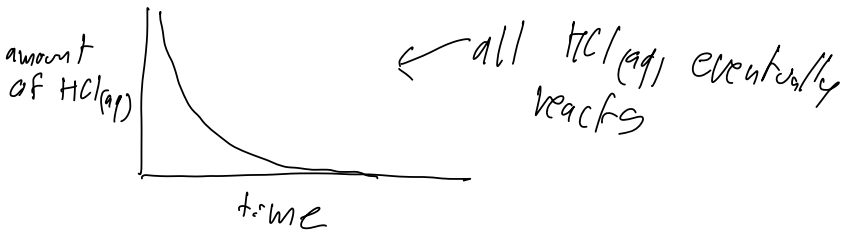
HCl = hydrochloric acid

HCl(g) is pure form

$HCl_{(aq)} \not\rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

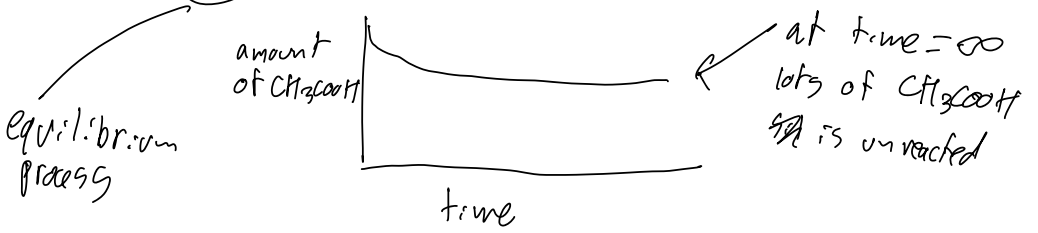
$HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

HCl is strong acid



Acetic acid is a weak acid

$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$



equilib process - some starting material and some product at end of reaction

Bases

$NH_3(aq) + H_2O(l) \rightarrow NH_4^+_{(aq)} + OH^-_{(aq)}$

Strong bases are often ionic compounds like NaOH

$NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

Water can act as acid or base

$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CO_3^{2-}{}_{(aq)}$

$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + OH^-$

Any reaction w/ acid will involve base

Oxidation/reduction reactions - involve transfer of electrons

↓ losing e^- ↓ gaining e^-

must have both Ox and Red to conserve e^-s

$Cu_{(s)} + Ag^+_{(aq)} \rightarrow Ag_{(s)} + Cu^{2+}_{(aq)}$

Ag^+ gained e^- and was reduced to $Ag_{(s)}$

Cu lost 2 e^- and was oxidized to Cu^{2+}

* Must balance for atoms and charge

$Cu_{(s)} + 2Ag^+_{(aq)} \rightarrow Ag_{(s)} + Cu^{2+}_{(aq)}$

$Cu_{(s)} + 2Ag^+_{(aq)} \rightarrow 2Ag_{(s)} + Cu^{2+}_{(aq)}$

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$ - involve Ox/Red but we can't tell

Keeping track of oxidation numbers will allow us to determine if Ox/Red is occurring

ON Rules

ON of pure elements = 0

ON of monoatomic ions = charge

ON of I, Br, Cl, F in compounds = -1 almost always

ON of O in compounds = -2 almost always

ON of H in compounds = +1 almost always

Sum of all ON of all atoms = 0 for compound

= charge for polyatomic ion

$$\underset{\substack{\downarrow \\ -4}}{CH_{\downarrow 4}} + \underset{\downarrow}{2O_2} \rightarrow \underset{\substack{\downarrow \\ +4}}{CO_2} + \underset{\substack{\downarrow \\ 2x+1}}{2H_2O_{\downarrow}}$$

$4x+1$ 0 $2x-2$ -2

C went from $-4 \rightarrow +4$ (ox)

H went from $+1 \rightarrow +1$

O went from $0 \rightarrow -2$ (red)

* If atoms undergo change in ON, then Ox/Red reaction is occurring