¹²² ACID/BASE or NEUTRALIZATION reactions continued

- the driving force of these reactions is the formation of water molecules.

$$\begin{array}{c} \underbrace{H^{+}(u_{q})}_{\text{From the acid}} + \underbrace{OH^{-}(u_{q})}_{\text{From the base}} \rightarrow H_{2}O(\ell) \end{array} \text{ Net ionic equation} \\ \\ \underbrace{H_{2}So_{u}(u_{q})}_{\text{forcel}} + \underbrace{2N_{u}OH(u_{q})}_{\text{forcel}} \rightarrow \underbrace{H_{2}O(\ell)}_{\text{forcel}} + \underbrace{N_{u}}_{u_{2}}So_{u}(u_{q}) \\ \\ \underbrace{H_{2}So_{u}(u_{q})}_{\text{forcel}} + \underbrace{2N_{u}OH(u_{q})}_{\text{forcel}} \rightarrow \underbrace{H^{+}OH^{-}}_{\text{forcel}} + \underbrace{H_{2}O(\ell)}_{\text{forcel}} + \underbrace{N_{u}}_{u_{2}}So_{u}(u_{q}) \\ \\ \\ \underbrace{H^{+}So_{u}}_{\text{forcel}} - \underbrace{N_{u}}_{u_{1}} + \underbrace{OH^{-}}_{\text{potential}} + \underbrace{H^{+}OH^{-}}_{\text{forcel}} + \underbrace{H_{2}O(\ell)}_{u_{2}} + \underbrace{N_{u}}_{u_{2}}So_{u}(u_{q}) \\ \\ \\ - \text{How can this reaction be detected?} \\ - \text{pH detector (indicator paper, etc.)} \\ - \text{do the products have similar chemical properties to the reactants?} \\ \\ - \text{release of heat!} \end{array}$$

... formation of water is usually accompanied by a release of heat

GAS FORMATION / OTHER MOLECULES

- There are a few other molecules that can be made with exchange-type chemistry.
- Most of these molecules are unstable and can break apart to form gases.
- Formation of a weak acid:
 - The formation of ANY weak acid in an exchange-type reaction can be a driving force.
 - Some weak acids are unstable and can break apart into gas molecules.

$$H_2(O_3Lag) \longrightarrow H_2O(l) + (CO_2C_g)$$
 Gas bubbles can leave solution!

... but how would you form carbonic acid in an exchange-type reaction?

$$\begin{array}{ccc} 1_2 & SO_4(a_4) + 2N_4 & H(O_3(a_4)) \rightarrow & Na_2 & SO_4(a_4) + 2H_2(O_3(a_4)) \\ H^+ & SO_4^{2-} & Na^+ & H(O_3^-) \\ & & & & & & \\ \end{array}$$

... but when we mix sulfuric acid and sodium bicarbonate, we observe BUBBLES. We need to write an equation that agrees with our observations. We know that carbonic acid decomposes, so we go ahead and put that into our equation.

$$H_2(O_3Lag) \longrightarrow H_2O(l) + CO_2C_g)$$

$$H_2SO_4(ag) + 2N_aH(O_3Lag) \rightarrow N_{a2}SO_4(ag) + 2H_2O(l) + 2CO_2(g)$$

Other molecules of interest:

$$4250_3$$
: sulfurous acid - React an ACID with a SULFITE
 $H_250_3(n_q) \rightarrow H_20(\ell) + 50_2(g)$

 H_2S : hydrogen sulfide (gas) - React an ACID with a SULFIDE $H_2SO_4(n_q) + Na_2S(a_q) \rightarrow Na_2SO_4(a_q) + H_2S(q)$

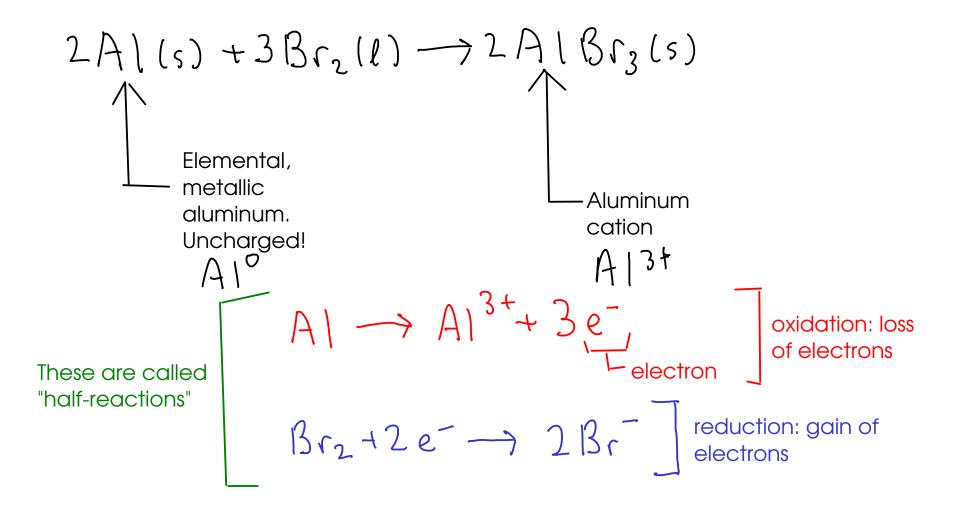
 \mathbf{Y} Transition metals DO NOT change their few more exchange examples: charge in exchange reactions! $(a(NO_3)_2(aq) + 2A_q(|s))$ $Ca(l_2l_{eq}) + 2Ag NO_3(aq) -$ Agt NO2 $C_{\alpha}^{2+} C \int_{-}^{-}$ PRECIPITATION, formation of AgCI solid drives reaction $3N_{\alpha}OH(a_{g})$ $\rightarrow 3H_2O(l) + N_{03}PO_4(aq)$ H3POy (ay) Na OH H+ PO43-*A***NEUTRALIZATION.** Formation of water drives this reaction. NaNOz (ag) -----> KNOz (ag) + NaC (ag) NO REACTION K(1(aq) +K+C1-Nat No 2 Both "products" are water-soluble ionic compounds, present in water as free ions. This is the same state they were in before being mixed. There's no driving force, and we classify this one as NO REACTION. Na, (O3(ay) -> H2(O3(ag) + Na, SO4(ag) $H_2SO_4(aq) +$ Nat 603-H+ 5042- $H_2(O_2 \rightarrow H_2O + CO_2)$ Driving force is formation of CARBONIC ACID and its decomposition into water and CARBON DIOXIDE gas bubbles. H, Soylay) + Na, (03(ay) -> H20(2)+(0, (g) + Na2Soy (ag)

¹²⁶ OXIDATION / REDUCTION CHEMISTRY

- Exchange reactions involve ions pairing up, but the ions themseves are not formed in exchange reactions. Exchanges start with pre-existing ions.

... but the ions have to be produced somehow - through a chemistry that involves the transfer of electrons.

- oxidation / reduction chemistry ("redox" chemistry) involves transfer of electrons and can make ions.



- oxidation and reduction always occur together. In other words, we can't just make free electrons using oxidation without giving them somewhere to go.

- Many of the types of reactions that we learned about in previous courses are redox reactions!

- COMBINATIONS (often but not always redox)

- DECOMPOSITIONS (often redox)

- SINGLE REPLACEMENT (always redox) (uls)+2AgNOzlag) ~ (ulvoz)2lag)+2AgIsi $C_{u} \rightarrow C_{u}^{2+} + 2e^{-}$ oxidation $2A_{g}^{+}+2e^{-} \rightarrow 2A_{g}(s)$ reduction net unic \rightarrow Cu(s) + 2 Ag⁺(ug) \rightarrow Cu²⁺(ug) + 2 Ag(i) - COMBUSTION $2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$ $2 \text{ Mg(s)} \rightarrow 2 \text{ Mg}^{2+} + 4 \text{ e}^{-}$ oxidation $02(y) + 4 \text{ e}^{-} \rightarrow 2 \text{ O}^{2-}$ reduction

COMBINATION REACTIONS

- Reactions that involve two or more simple substances COMBINING to form a SINGLE product

- Often involve large energy changes. Sometimes violent!

- Form:
$$A + B + \dots \longrightarrow C$$

Example:

 $2A|(s) + 3Br_2(l) \longrightarrow 2A|Br_3(s)$



- Reactions where a SINGLE REACTANT breaks apart into several products

- Form:
$$A \longrightarrow B + C + ...$$

Example:

 $2H_2O_2(\ell) \longrightarrow 2H_2O(\ell) + O_2(g)$

* This reaction is NOT a combustion reaction, even though O_2 is involved!

* Combustion reactions CONSUME ${\rm O_2}$, while this reaction PRODUCES ${\rm O_2}$

COMBUSTION REACTIONS

- Reactions of substances with MOLECULAR OXYGEN (${\rm O_2}$) to form OXIDES.

hydrocarbons makes carbon dioxide and

environments, carbon

monoxide is made

water, if enough oxygen is present.

In low-oxygen

instead!

)xides!

- Combustion forms an OXIDE of EACH ELEMENT in the burned substance!

- Form:
$$AB + O_{2} \rightarrow AO + BO$$

Oxide: a compound containing OXYGEN and one other element!

Examples:

$$\begin{array}{c} \star \\ C_{3}H_{8}(g) + 5O_{2}(g) \longrightarrow 4H_{2}U(g) + 3CO_{2}(g) \end{array}$$

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

This reaction can also be called a combination! Two reactants form a single product.

SINGLE REPLACEMENT REACTIONS

- Reactions where one element REPLACES another element in a compound.
- Can be predicted via an ACTIVITY SERIES (p151, 9th edition)

- Form:
$$A + BC \longrightarrow AC + B$$

"A" and "B" are elements, often metals.

- Easy to spot, since there is an element "by itself" on each side of the equation.

Examples:

$$(u(s) + 2A_g ND_3(aq)) \rightarrow (u(ND_3)_2(aq) + 2A_g(s))$$

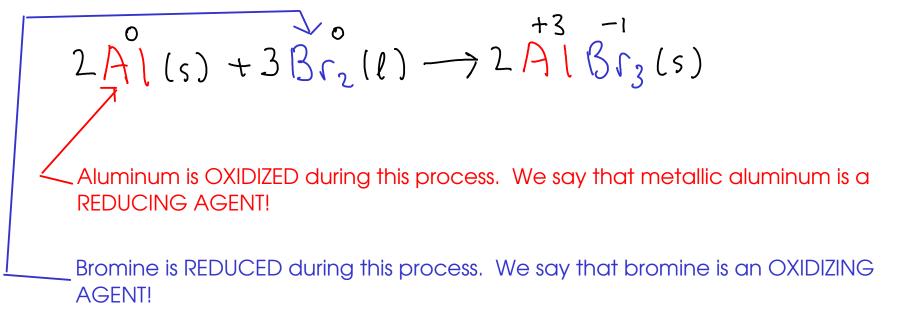
 $(u(s) + 4A_g ND_3(aq)) \rightarrow (u(ND_3)_2(aq) + 2A_g(s))$
 $(u(s) + 4A_g ND_3(aq)) \rightarrow (u(ND_3)_2(aq) + 4A_g(s))$
 $(u(s) + 4A_g ND_3(aq)) \rightarrow (u(ND_3)_2(aq) + 4A_g(s))$

REDOX LANGUAGE

"oxidizer"

- "Oxidation" is loss of electrons, but an OXIDIZING AGENT is something that causes ANOTHER substance to lose electrons. An oxidizing agent is itself reduced during a redox reaction.

- "Reduction" is gain of electrons, but a REDUCING AGENT is something that causes ANOTHER substace to gain electrons. Reducing agents are themselves oxidized during a redox reaction.



* Strong oxidizers (oxidizing agents) can cause spontaneous fires if placed into contact with combustibles (safety issue!).

* Reactive metals tend to be REDUCING AGENTS, while oxygen-rich ions like NITRATES tend to be OXIDIZING AGENTS. HALOGENS (Group VIIA) also tend to be OXIDIZING AGENTS

END OF CHAPTER 4 MATERIAL