Some Typical Reactions of Arrhenius Acids and Bases Aided By Lewis Structures

I. Acid + Base → Salt + Water

E.G., Mixing Aqueous Solutions of Hydrobromic Acid and Barium Hydroxide

Overall: $2HBr(aq) + Ba(OH)_2(aq) \rightarrow BaBr_2(aq) + 2H_2O(l)$

Ionic: $2H^+(aq) + 2Br^-(aq) + Ba^{2+}(aq) + 2OH^-(aq) \rightarrow Ba^{2+}(aq) + 2Br^-(aq) + 2H_2O(l)$

Net: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

HBr Is A Strong Acid, $Ba(OH)_2$ Is A Strong Base So They Are Essentially Completely Dissociated In Water:

$$HBr \rightarrow H^+ + :\ddot{\underset{\ddot{}}{Br}}:^-$$

$$Ba(OH)_2 \rightarrow Ba^{2+} + 2\ H\text{-}\ddot{\underset{\ddot{}}{O}}:^-$$

Remembering The Structure For Water

We Can Understand Its Formation By The

ADDITION OF THE ACIDIC PROTON (H^+) TO THE BASIC HYDROXIDE (OH^-) TO FORM THE STABLE MOLECULAR COMPOUND (COVALENT BONDS) H_2O.

(HYDROGEN CARBONATE)

II. ACID + CARBONATE $\longrightarrow$ SALT + WATER + CO_2

E.G., ADDITION OF AQUEOUS NITRIC ACID TO SOLID SODIUM HYDROGEN CARBONATE

OVERALL: $NaHCO_3(s) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l) + CO_2(g)$

IONIC: $NaHCO_3(s) + H^+(aq) + NO_3^-(aq) \rightarrow Na^+(aq) + NO_3^-(aq) + H_2O(l) + CO_2(g)$

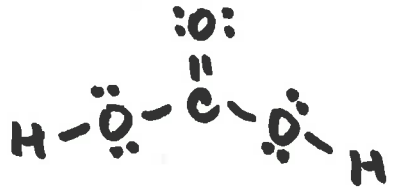
NET: $NaHCO_3(s) + H^+(aq) \rightarrow Na^+(aq) + H_2O(l) + CO_2(g)$

LEWIS STRUCTURE OF HCO_3^-

AND OF CO_2

IN THE PRESENCE OF H^+ YOU MIGHT EXPECT THE

PROTON TO ADD TO HCO_3^- TO FORM CARBONIC ACID H_2CO_3 - AND YOU WOULD BE PERFECTLY CORRECT



H_2CO_3 IS NOT VERY STABLE AND IT DECOMPOSES INTO H_2O AND CO_2. CO_2 IS NOT VERY SOLUBLE IN WATER AND IS LIBERATED FROM SOLUTION AS THE GAS.

III. ACID + METAL OXIDE → SALT + WATER

E.G., ADDITION OF SOLID MANGANESE (II) OXIDE TO CONCENTRATED AQUEOUS HYDROCHLORIC ACID

OVERALL: $MnO(s) + 2HCl(aq) \rightarrow MnCl_2(aq) + H_2O(l)$

IONIC: $MnO(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow Mn^{2+}(aq) + 2Cl^-(aq) + H_2O(l)$

NET: $MnO(s) + 2H^+(aq) \rightarrow Mn^{2+}(aq) + H_2O(l)$

THIS REACTION CAN BE BEST SEEN BY RECOGNIZING MnO AS IONIC SO THAT OXYGEN IS PRESENT AS THE OXIDE ANION, O^{2-}, AND

FORMING WATER.

III. BASE + AMMONIUM SALT → SALT + WATER + NH_3

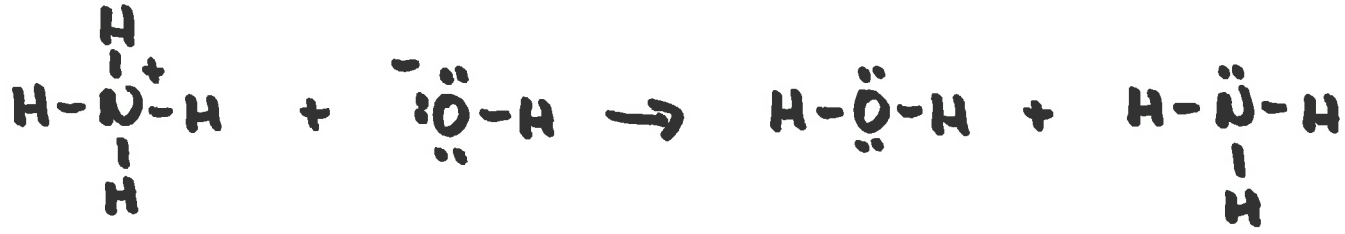
E.G., MIXING AQUEOUS SOLUTIONS OF POTASSIUM HYDROXIDE AND AMMONIUM SULFATE

OVERALL: $(NH_4)_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l) + 2NH_3(g)$

IONIC: $2NH_4^+(aq) + SO_4^{2-}(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow 2K^+(aq) + SO_4^{2-}(aq) + 2H_2O(l) + 2NH_3(g)$

NET: $NH_4^+(aq) + OH^-(aq) \rightarrow H_2O(l) + NH_3(g)$

AS BEFORE, LEWIS STRUCTURES ELUCIDATE THE REACTION WHERE THE STRONG BASE OH^- PLUCKS A PROTON OFF NH_4^+ TO MAKE WATER, LEAVING AMMONIA BEHIND:



GENERALLY IF A REACTION CAN MAKE WATER IT DOES.

V. Base + Nonmetal Oxide → Salt + Water

E.G., Bubbling Dichlorine Pentaoxide Gas Into An Aqueous Solution Of Sodium Hydroxide

Overall: $Cl_2O_5(g) + 2NaOH(aq) \rightarrow 2NaClO_3(aq) + H_2O(l)$

Ionic: $Cl_2O_5(g) + 2Na^+(aq) + 2OH^-(aq) \rightarrow 2Na^+(aq) + 2ClO_3^-(aq) + H_2O(l)$

Net: $Cl_2O_5(g) + 2OH^-(aq) \rightarrow 2ClO_3^-(aq) + H_2O(l)$

This Reaction Can Be Recognized As A "Typical" Acid / Base Neutralization When The Nonmetal Oxide Is Remembered To Be An Acid Anhydride. Upon Formal Addition Of Water The Corresponding Acid Can Be Identified And Hence The Anion Of The Salt

$$Cl_2O_5 + "H_2O" \sim H_2Cl_2O_6 = 2HClO_3$$

$\therefore$ Salt Anion Is Chlorate, ClO_3^-

III. WHERE METAL IN METAL OXIDE IS FROM GROUP I OR GROUP II

E.G., CaO

IN V RECOGNIZING Cl_2O_5 AS THE ACID ANHYDRIDE OF CHLORIC ACID HELPED US TO SEE THAT Cl_2O_5 WOULD ACT AS AN ACID AND THAT THE SALT FORMED WOULD BE A CHLORATE. HERE THE REACTION OF INTEREST IS:

OVERALL: $CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$

IONIC: $CaO(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq) + H_2O(l)$

NET: $CaO(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l)$

WE COULD STILL MAKE THE ARGUMENT THAT O^{2-} AND TWO PROTONS MAKE WATER BUT LET US SEE THAT CaO BEHAVES AS A BASE BY RECOGNIZING IT AS THE BASE ANHYDRIDE OF $Ca(OH)_2$:

$$CaO + \text{“}H_2O\text{”} \sim CaH_2O_2 = Ca(OH)_2$$