Acid-Base Reactions (Gas Producing)

"Gas-forming Reactions"
Some acid or base reaction produce a specific gas. This section will look at four acid-base reactions that generate a gas as a product.

<u>Type #1 - metal carbonate (or bicarbonate) + acid reaction</u>
This reaction could be considered an acid-base neutralization reaction. Compounds with carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions act as a base because they will accept hydrogen ions from acid molecules. This lowers the amount of hydrogen ions in the aqueous solution produced by the reaction and neutralizes the acid. The products formed include water and a salt but the difference between this type of reaction and neutralization reactions is that carbon dioxide gas is also produced.

metal carbonate (bicarbonate) + acid → salt + CO_2 + H_2O

An example of this reaction would when a solution of sodium carbonate and solution of hydrochloric acid are added together:

$Na_2CO_3 + 2\ HCl \rightarrow 2\ NaCl + CO_2 + H_2O$ [molecular]

On the AP exam, your weekly quizzes, and unit exams you need to provide the net-ionic equation. So we need to show all strong electrolytes and/or aqueous solutions as ions. The sodium carbonate, hydrochloric acid, and sodium chloride (would dissociate in water) all need to be written as ions and then any spectator ions will need to be removed. The sodium and chlorine ions are found on both sides of the arrow.

$2\ Na^+ + CO_3^{2-} + 2\ H^+ + Cl^- \rightarrow 2Na^+ + Cl^- + CO_2 + H_2O$ [ionic]

$CO_3^{2-} + 2\ H^+ \rightarrow CO_2 + H_2O$ [net-ionic]

<u>Type #2 - metal sulfide + acid reaction</u>
This reaction looks like a metathesis reaction, where positive parts of the compounds exchange negative parts. The products formed by this category of reaction include hydrogen sulfide gas and a salt.

metal sulfide + acid → salt + H_2S

An example of this reaction would when a solid copper sulfide and solution of hydrofluoric acid are added together:

$CuS + 2\ HF \rightarrow CuF_2 + H_2S$ [molecular]

Again, on the AP exam, your weekly quizzes, and unit exams you need to provide the net-ionic equation. In this reaction, CuS is a solid so it should be written as ions. Hydrofluoric acid is a weak acid so we should use the molecular formula for this species also. Copper fluoride according to the solubility rules is soluble so it should be written as ions. Lastly, hydrogen sulfide is a gas and should use the molecular formula.

$CuS + 2\ HF \rightarrow Cu^{2+} + 2\ F^- + H_2S$ [net-ionic]

Because there are no spectator ions the equation as written is the correct net-ionic equation.

Type #3 - metal sulfite + acid reaction

This reaction also looks like a type #1 gas-forming reaction, except we replace the carbonate (CO_3) with a sulfite (SO_3). The products formed by this category of reaction include a salt, water and sulfur dioxide gas (instead of carbon dioxide).

metal sulfite + acid → salt + SO_2 + H_2O

An example of this reaction would when a solution of potassium sulfite and solution of nitric acid are added together:

$K_2SO_3 + 2\ HNO_3 \rightarrow KNO_3 + SO_2 + H_2O$ [molecular]

Again, on the AP exam, your weekly quizzes, and unit exams you need to provide the net-ionic equation. In this reaction, the potassium sulfite, nitric acid, and potassium nitrate (would dissociate in water) all need to be written as ions and then any spectator ions will need to be removed. The sodium and chlorine ions are found on both sides of the arrow.

$2\ K^+ + SO_3^{2-} + 2\ H^+ + NO_3^- \rightarrow 2\ K^+ + NO_3^- + SO_2 + H_2O$ [ionic]

$SO_3^{2-} + 2\ H^+ \rightarrow SO_2 + H_2O$ [net-ionic]

Type #4 - ammonium salt + strong base reaction

This reaction is different than other looks like a metathesis reaction, where positive parts of the compounds exchange negative parts. The products formed by this category of reaction include hydrogen sulfide gas and a salt.

ammonium salt + strong base → metal salt + NH_3 + H_2O

An example of this reaction would when a solution of ammonium chloride and solution of potassium hydroxide are added together:

$NH_4Cl + KOH \rightarrow KCl + NH_3 + H_2O$ [molecular]

Again, on the AP exam, your weekly quizzes, and unit exams you need to provide the net-ionic equation. In this reaction, the ammonium chloride, ptoassium hydroxide, and potassium chloride0 (would dissociate in water) all need to be written as ions and then any spectator ions will need to be removed. The potassium and chlorine ions are found on both sides of the arrow. Lastly, the ammonia (a gas) and water (a liquid) should be written as molecular formulas.

$NH_4^+ + Cl^- + K^+ + OH^- \rightarrow K^+ + Cl^- + NH_3 + H_2O$ [ionic]

$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ [net-ionic]

Sample Problems

1. (i) Solid zinc sulfide is added to a solution of hydrobromic acid

2. (i) Solid calcium sulfite is added to a solution hydrochloric acid

3. (i) Dilute sulfuric acid is added to lithium bicarbonate solution

4. (i) Crystals of ammonium bromide are added to a solution of potassium hydroxide