Brønsted-Lowry Reactions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Example 1. Predict the reaction of aqueous sodium hydrogen sulfite and aqueous ammonia.

**Rules**

1. List and label all species in the reaction mixture as acid (A), base (B), both, or neither.

Strong acids are written as H3O+(aq) and the appropriate conjugate base. Weak acids are written in molecular form. Metal hydroxides and other salts, if high solubility, are written in dissociated form otherwise write the solid. (Entities that are acid and base are **amphiprotic.)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Spectator** |  | **A** |  | **A** |
| Na+(aq) |  | HSO3–(aq) | NH3(aq) | H2O(l) |
|  |  | **B** | **B** | **B** |

2. Find the strongest acid, SA (highest acid on the LHS of an acid base table).

|  |  |  |  |
| --- | --- | --- | --- |
| **Spectator** | **SA** |  | **A** |
| Na+(aq) | HSO3–(aq) | NH3(aq) | H2O(l) |
|  | **B** | **B** | **B** |

3. Find the strongest base, SB (lowest base on the RHS of an acid base table).

|  |  |  |  |
| --- | --- | --- | --- |
| **Spectator** | **SA** |  | **A** |
| Na+(aq) | HSO3–(aq) | NH3(aq) | H2O(l) |
|  | **B** | **SB** | **B** |

4. Exchange a proton from the SA to the SB to give the conjugate base and conjugate acid.

|  |  |  |
| --- | --- | --- |
| HSO3–(aq) + NH3(aq) | \_\_\_\_\_\_\_ | SO32–(aq) + NH4+ (aq) |

5. Determine the appropriate reaction arrow for the neutralization.

Guidelines for determining the “arrow” (WA = weak acid: WB = weak base).

a. H3O+(aq) + Base **below** **NO2–(aq)** 100%, quantitative.

b. OH–(aq) + Acid (**HCN(aq) and up**) 100%, quantitative.

c. WA + WB (WA above WB) > 50%, equilibrium favours the products.

d. WA + WB (WA below WB) < 50%, equilibrium favours the reactants.

|  |  |  |  |
| --- | --- | --- | --- |
| HSO3–(aq) + NH3(aq) |  | SO32–(aq) + NH4+ (aq) | > 50%, Favours products. |

(The extent of reaction, > 50%, can be anything from 51 - 100 % - precision is not an issue with Bransted-Lowry theory – we are more interested in tendancy.)

6. For the reactions of polyprotic acids/bases repeat steps 1 through 5 for **updated species lists** - make sure you include the products of quantitative reactions. **Stop** predicting further reaction **at** an equilibrium or **before** water reacts. The net acid base reaction in this case is the sum of all the quantitative reactions, i.e. Overall Net = Σ(100% Rxns).

1. Predict the Brønsted-Lowry neutralization in all the following reactions:

(a) Does sodium cyanide form basic solutions? Explain.

(b) Aqueous solutions of sodium bicarbonate and ammonium chloride are mixed.

(c) Potassium hydrogen sulphate and sodium acetate are mixed in aqueous solution.

(d) Hypochlorous acid and aqueous sodium bicarbonate are mixed. Is the acid completely neutralized? Explain.

(e) Hydrochloric acid and aqueous sodium hydroxide are mixed during a titration analysis.

(f) The calcium carbonate dissolved in an Albertan lake neutralizes acid pollution (assume the polluting acid is sulphuric acid).

(g) If acid precipitation (see f) reacts with the limestone (calcium carbonate) in public statues and building stone predict a likely percent reaction. Explain!

(h) Household ammonia and sodium bicarbonate are mixed in aqueous solution.

(i) Vinegar and Liquid Drano® (mostly NaOH(aq)) are mixed.

( j ) In the classic Volcano demonstration baking soda/sodium bicarbonate, NaHCO3(s), reacts with vinegar and to produce a gas. Is baking soda capable of completely neutralizing the vinegar?

2. Predict the Brønsted-Lowry neutralization in all the following reactions:

(a) Sulfuric acid is titrated with aqueous potassium hydroxide.

(b) Hydrochloric acid is continuously added to aqueous solutions of sodium carbonate.

(c) Aqueous potassium oxalate is titrated with nitric acid.

(d) Aqueous potassium hydroxide is continuously added to phosphoric acid.

(e) Hydrochloric acid is titrated into aqueous sodium phosphate.

(f) The noxious smell of hydrogen sulfide from a drain is deodourized with excess Drano – aqueous potassium hydroxide.

(g) Hydroiodic acid is continuously added to aqueous solutions of sodium citrate.

(h) Citric acid samples can be analyzed by titrating them with aqueous sodium hydroxide.

(i) Aqueous potassium ascorbate is titrated with nitric acid.

( j ) hydrochloric acid is continuously added to aqueous sodium carbonate.