Chemistry & Agriculture

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Objectives
Introduce or review elements of chemistry to prepare for applied lessons in agricultural chemistry.

Suggested grade levels
9-12

Alaska Content Standards
Science, D1, D3

Terms to Define
ion
valence
chemical reaction
equilibrium
cations
anions
pH
alkaline
acid

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Introduction

This lesson lays the groundwork for four lesson that apply the principles of chemsitry to agriculture in real applications. It may be used for review.

Basic Chemistry Principles

A. Valence

The valence of an element can be thought of as the number of hydrogen ions it will take to replace or combine with the element in a chemical reaction. For example, two H+ ions will combine with one O-2 ion to form H2O. Thus, the valence of the oxygen element is -2.

B. Ions

A single atom (or a group of elements) with an electrical charge is called an ion. Ions which are positively charged are called cations while those with negative charges are called anions.

Cations: H+, NH_4+, Ca+2, Fe+3
Anions: OH-, NO_3-, SO_4-2, Cl-

C. Chemical Reactions

A + B   C + D

Le Chatelier's Principle:

A system has to be in chemical equilibrium. When a system at equilibrium is disturbed, the equilibrium position will shift in the direction which tends to minimize, or counteract, the effect of the disturbance.

Examples:

If the concentration of a reactant is increased, the equilibrium position shifts to use up the added reactants by producing more products.

If the pressure on an equilibrium system is increased, then the equilibrium position shifts to reduce the pressure.

If the volume of a gaseous equilibrium system is reduced (equivalent to an increase in pressure) then the equilibrium position shifts to increase the volume (equivalent to a decrease in pressure)

If the temperature of an endothermic equilibrium system is increased, the equilibrium position shifts to use up the heat by producing more products.

D. What is pH?

pH is a measure of the hydrogen ion concentration, H+

pH can be calculated using the following formula:

$pH = -\log_{10} [H+]$

Hydrogen ion concentration [H+] can be calculated using the following formula:

[H+] = 10-pH

Acid Solutions

Solutions where the H+ concentration is greater than 10-7 or the pH is less than 7 are considered acidic

Alkaline Solutions

Solutions where the H+ concentration is less than 10-7 or the pH is greater than 7 are considered alkaline or basic

Neutral Solutions

Solutions where the H+ concentration equals 10-7 or the pH equals 7 are considered neutral

E. Oxidation-reduction reactions (Redox reactions)

Oxidation is the process that results in the loss of one or more electrons.

Fe+2 – e- Fe+3

Reduction is the process that results in the gain of one or more electrons.

Fe+3 + e- Fe+2

Redox reactions

Oxidant: gains electrons (oxidant is reduced) and causes the other compound or element to be oxidized

Reductant: loses electrons (reductant is oxidized) and causes the other compound or element to be reduced

The reductant (oxidized element or compound) provides electrons to the oxidant (reduced element or compound)

Example:

Na	Na+ + e-
F + e-	F-
F + Na	F- + Na+

F is the oxidant and was reduced

Na is the reductant and was oxidized

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Table showing oxidized and reduced forms of several important elements

Element	Oxidized form found in well-aerated soils	Reduced form found in waterlogged soils
Nitrogen	NO_3^-	N_2, NH_4^+
Sulfur	SO_4^{-2}	H_2S, S^{-2}
Iron	Fe^{+3}	Fe^{+2}
Carbon	CO_2, $C_6H_{12}O_6$	CH_4, C_2H_4

F. Units of Measure

Mole = Avogadro's number of molecules = 6.023 x 1023

Molecular and formula weights:

Molecular weight = grams/mole

Formula weight = all elemental molecular weights added together

Example: What is the formula weight of ammonium nitrate NH_4NO_3 (a common fertilizer)?

Molecular weight of N = 14 g/mole x 2 = 28 g/mole
Molecular weight of H = 1 g/mole x 4 = 4 g/mole
Molecular weight of O = 16 g/mole x 3 = 48 g/mole

Formula weight of NH_4NO_3- = 80 g/mole

Concentrations:

Molarity is a measure of the concentration of a solution

Molarity refers to the number of moles of an element or compound per

Liter of solution

Molarity can be expressed as moles/liter, mol/L, mol L^{-1}, or M

Basic Chemistry Problems: Solutions

1. Cations: Cu^{+2}, NH_4+, Mn^{+2}, Ca^{+2}

   Anions: NO_3^-, $H_2PO_4^-$, SO_4^-, Cl^-

2. Write the balanced equation for the dissociation of the acid

   HCl ——> H^+(aq) + Cl^-(aq)

   Use the equation to find the $[H^+]$:

   0.2 mol L^- HCl produces 0.2 mol L^{-1} H^+ since HCl is a strong acid that fully dissociates

   Calculate pH: pH = $-\log_{10}[H^+]$

   pH = $-\log_{10}[0.2] = 0.7$

3. Write the balanced equation for the dissociation of the acid

   H_2SO_4 ——> $2H^+$(aq) + SO_4^{2-}(aq)

   Use the equation to find the $[H^+]$:

   0.2 mol L^{-1} H_2SO_4 produces 2 x 0.2 = 0.4 mol L^{-1} H^+ since H_2SO_4 is a strong acid that fully dissociates

   Calculate pH: pH = -log10$[H^+]$

   pH = $-\log_{10}[0.4] = 0.4$

4. pH= 3.0

   $[H^+] = 10^{-pH}$

   $[H^+] = 10^{-3.0}$ = 0.001mol L^{-1}

5. oxidation

   reduction

   Cu^{+2} = oxidant & Zn = reductant

6. Determine Formula Weight of ammonium nitrate= 80 g/mole

   Determine % of N in ammonium nitrate = 28 g/mole divided by 80 g/mole = 35% N

   Need 2.0 g of N, so 2.0 g N/ x g ammonium nitrate = 0.35 N / 1.0 ammonium nitrate

   0.35x = 2.0 g N x = 5.71 grams of ammonium nitrate

Name ________________________________

Basic Chemistry & Agriculture Problems

1. Which of the following elements and compounds are cations and which are anions?
   NO_3^-, $H_2PO_4^-$, Cu^{+2}, SO_4^-, NH_4^+, Mn^{+2}, Cl^-, Ca^{+2}

   Cations:
   Anions:

2. Find the pH of a 0.2mol/L (0.2M) solution of HCl.

3. Find the pH of a 0.2 mol/L (0.2M) solution of H_2SO_4.

4. Find the concentration of H^+ in a nitric acid solution with a pH of 3.0.

5. Consider the following chemical reaction: $Zn \longrightarrow Zn^{+2} + 2e^-$
   Is this an oxidation or reduction reaction?

   Consider the following chemical reaction: $Cu^{+2} + 2e- \longrightarrow Cu$
   Is this an oxidation or reduction reaction?

   Consider the following chemical reaction: $Cu^{+2} + Zn \longrightarrow Cu + Zn^{+2}$
   Which element is the oxidant and which element is the reductant?

6. How much ammonium nitrate (NH_4NO_3-) is needed to apply 2.0 g of N to a pot of soil?