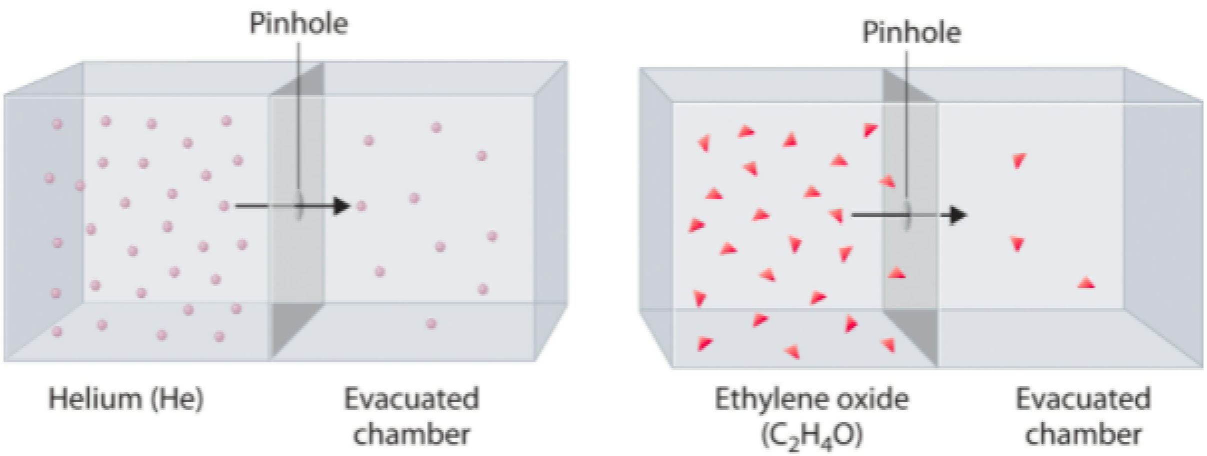
Graham's Law of Effusion and Diffusion

Diffusion is the gradual mixing of gases due to the motion of their component particles even in the absence of mechanical agitation such as stirring. The result is a gas mixture with uniform composition. Diffusion is also a property of the particles in liquids and liquid solutions and, to a lesser extent, of solids and solid solutions. The related process, effusion, is the escape of gaseous molecules through a small (usually microscopic) hole, such as a hole in a balloon, into an evacuated space.

$$\frac{\text{rate of effusion A}}{\text{rate of effusion B}} = \sqrt{\frac{M_B}{M_A}}$$



The Relative Rates of Effusion of Two Gases with Different Masses. The lighter He atoms (M = 4.00 g/mol) effuse through the small hole more rapidly than the heavier ethylene oxide (C_2H_4O) molecules (*M* = 44.0 g/mol), as predicted by Graham's law.

Heavy molecules effuse through a porous material more slowly than light molecules, as illustrated schematically ethylene oxide (C_2H_4O) and helium (He). Helium (*M* = 4.00 g/mol) effuses much more rapidly than ethylene oxide (*M* = 44.0 g/mol). Because helium is less dense than air, helium-filled balloons "float" at the end of a tethering string. Unfortunately, rubber balloons filled with helium soon lose their buoyancy along with much of their volume. In contrast, rubber balloons filled with air tend to retain their shape and volume for a much longer time. Because helium has a molar mass of 4.00 g/mol, whereas air has an average molar mass of about 29 g/mol, pure helium effuses through the microscopic pores in the rubber balloon $\sqrt{\frac{29}{4.00}} = 2.7$ times faster than air. For this reason, high-quality helium-filled balloons are usually made of Mylar, a dense, strong, opaque material with a high molecular mass that forms films that have many fewer pores than rubber. Hence, mylar balloons can retain their helium for days.

NON IDEAL SITUATIONS

Under what conditions do gases not act as an idea gas?

Mass %

Mass% by composition(% m/m)

$$\% \, m/m = \frac{mass \, of \, solute}{mss \, of \, entire \, sample} \text{ x } 100$$

ppm

$$ppm = \frac{mass \, of \, solute}{mass \, of \, sample} \text{ x } 10^6$$

What is the mass percentage of Fe in a piece of metal with 87.9 g of Fe in a 113 g sample? (77.8%)

What is the mass percentage of H_2O_2 in a solution with 6.67 g of H_2O_2 and 55.5 g of water? (10.7%)

If there is 0.551 mg of As in 348 g of solution, what is the As concentration in ppm? (1.58 ppm)

The concentration of Cl^- ion in a sample of H_2O is 15.0 ppm. What mass of Cl^- ion is present in 240.0 mL of H_2O, which has a density of 1.00 g/mL? (3.6 mg)

ACIDS AND BASES

Two types of Acids and Bases Definition
Arrhenius Definition

What is a weak acid and a strong acid?

Bronsted-Lowry Definition

Conjugate acid-base pairs - two species that differ by a proton. The species with more protons is the acid

In the following reactions, indicate the acid, base, conjugate acid, and conjugate base

$$H_2CO_3\ (aq) + H_2O\ (l) \Leftrightarrow H_3O^+\ (aq) + HCO_3^{-1}\ (aq)$$

$$HCO_3^{-1}\ (aq) + H_2O\ (l) \Leftrightarrow H_3O^{+1}\ (aq) + CO_3^{-2}\ (aq)$$

$$NH_3\ (aq) + H_2O\ (l) \Leftrightarrow NH_4^+\ (aq) + OH^{-1}\ (aq)$$

Water is the universal solvent - most of the acid-base chemistry that you'll encounter takes place in aqueous solution.

$$2H_2O\ (l) \Leftrightarrow H_3O^{+1}\ (aq) + OH^{-1}\ (aq)$$

This is known as the autoionization of water. One water molecule can either be a base or an acid (amphoteric).

$$K_w = [H_3O^{+1}][OH^{-1}] = 1.0x10^{-14} \text{ at 25 C}$$

The K_w is the equilibrium constant of water.

When $[H_3O^{+1}] = [OH^{-1}]$ the solution is neutral
When $[H_3O^{+1}] > [OH^{-1}]$ the solution is acidic
When $[H_3O^{+1}] < [OH^{-1}]$ the solution is basic

1. The concentration of hydronium ions in stomach acid is 0.10 M. What is the concentration of hydroxide ions? ($1.0x10^{-13}$M)

2. $[OH^{-1}] = 5.0 \times 10^{-4}$ M $[H_3O^{+1}] = ?$

The pH Scale

$$\mathbf{pH = -log\ [H^{+1}]}$$
$$\mathbf{[H^{+1}] = 10^{-pH}}$$
$$\mathbf{pOH = -log\ [OH^{-1}]}$$
$$\mathbf{[OH^{-1}] = 10^{-pOH}}$$
$$\mathbf{pH + pOH = 14}$$

Find the pH for #1 and #2

Acid Ionization Constants (K_a)
Strong acids really high - we don't usually use this for strong acids
Weak acids really low

$$HA\ (aq) + H_2O\ (l) \Leftrightarrow H_3O^{+1}\ (aq) + A^{-1}\ (aq)$$

The Ka can be written as

ICE Box method

What is the pH of a 0.50 M HF solution where the K_a is 7.1×10^{-4}. (1.72)

Determine the pH of a weak acid with a concentration of 0.10 M and K_a of 2.5×10^{-5}. (2.8)

Determine the Ka of a weak acid if a 0.12 M solution as a pH of 3.82. (1.9×10^{-7})

Base Ionization Constant (K_b)

$$B (aq) + H_2O (l) \Leftrightarrow HB^{+} (aq) + OH^{-1} (aq)$$

Kb =

What is the pH of a 0.040 M ammonia (NH_3) solution? $K_b = 1.8 \times 10^{-5}$ (10.9)

BUFFER SOLUTIONS

A solution that contains a weak acid and its conjugate base (or a weak base and its conjugate acid) is a BUFFER solution. To make it a buffer solution, the amounts of weak acid and conjugate base much be comparable. Buffer solutions, by virtue of their composition, resists changes in pH upon addition of small amounts of either an acid or a base. The ability to resist pH changes is very important to chemical and biological systems.

Consider a solution that is 1.0 M CH_3COOH and 1.0 M $NaCH_3COO$. What is the pH if Ka = $1.8x10^{-5}$?

Consider if you add 0.10 mole of HCl to the buffer (no volume change). What is the new pH?

Henderson-Hasselbalch equation

$$\mathbf{pH = pK_a +} \; log\frac{[conjugate\ base]}{[weak\ acid]}$$

If you have 1.00 L of a buffer that is 1.00 M acetic acid and 1.00 M sodium acetate, calculate the pH after the addition of 0.100 moles of NaOH. Assume no volume change (4.83)