

## Chemical Reactions - Extent and Speed

Consider the reactions when we dissolved baking soda  $\text{NaHCO}_3$ , washing soda  $\text{Na}_2\text{CO}_3$ , and chalk  $\text{CaCO}_3$  in water and when we added vinegar, (6-7% acetic acid in water) to them.

Solubility of  $\text{NaHCO}_3$  in water: dissolved, but not quickly up to a maximum of 9 g/100 mL

Solubility of  $\text{Na}_2\text{CO}_3$  in water: dissolved quickly up to a maximum of 21.5g/100 mL

Solubility of  $\text{CaCO}_3$  in water: did not dissolve noticeably, but did up to a maximum of 0.0013g/100 mL

Reaction of  $\text{NaHCO}_3$  with vinegar: yes, violently, foamed up with released  $\text{CO}_2$  gas

Reaction of  $\text{Na}_2\text{CO}_3$  with vinegar: yes, bubbles of  $\text{CO}_2$  gas formed

Reaction of  $\text{CaCO}_3$  with vinegar: yes, but extremely slowly, helps if  $\text{CaCO}_3$  is ground to a fine powder

Mixture of  $\text{H}_2$  and  $\text{O}_2$  gases at room temperature and no spark: essentially no reaction

Mixture of  $\text{H}_2$  and  $\text{O}_2$  gases with spark: explosive reaction

Diamond at room temperature: changes to carbon so slowly it appears stable

Chemical reactions can go either way depending on the temperature (energy), entropy (concentration) differences:

Explosions provide their own extra energy to raise the temperature and speed up their reaction.

Combustion proceeds at a speed dependent on oxygen availability and temperature.

Reactions with aqueous reactants and products go both ways, reaching an equilibrium point.

Aqueous reactions that release gas bubbles (that can leave the solution) or form an insoluble solid (that can no longer react) go to completion, the point where at least one of the reactants are completely consumed.

Lower temperatures slow reactions. Freezing slows food spoilage.

Sea shells dissolve when  $\text{Ca}^{++}$  and/or  $\text{CO}_3^{--}$  are removed from the surrounding water. (When additional  $\text{CO}_2$  from the atmosphere is dissolved in water, the subsequent reactions reduce the  $\text{CO}_3^{--}$  concentration.)

A lower reaction energy barrier speeds reactions. Enzymes greatly speed up biological reactions.

Electricity can direct oxidation-reduction reactions like electrolysis of water or electroplating.

Oxidation-reduction reactions can produce electricity.