4. (Partial answer)

| Fast reactions | Slow reactions |
|---|---|
| cooking in the stove or microwave (use temperature to increase the kinetic energy of reacting molecules) | decay of food, perfumes, and pharmaceutical products (controlled by lowering temperature) |
| contact lens cleaning solutions and meat tenderizers (use catalysts: hydrogen peroxide and papain) | corrosion of garden implements (controlled by painting, which reduces the contact of oxygen with the metal and keeps salt away) |
| fireworks | |
| burning of fuels in home heating, lighters, and automobiles | |

5. (Answers will vary.) Fast reactions could include burning of any hydrocarbon fuel (barbecues, automobiles, home-heating systems, cigarette lighters), rapid cooking of food (frying, broiling), explosive reactions (fireworks, highway building, mining), and use of some household cleansers (bleach, tarnish remover). Slow reactions could include paint drying, decay of food, corrosion (rusting, oxidation of other metals), photochemical degradation of plastics, and slow bleaching of dyes by the Sun.
6. (a) Some reactant molecules have complex structures and strong chemical bonds that make reaction more difficult. In such situations, the chemical nature of the reactants gives them large activation energies. Other reactions involve simple ions or molecules with weak or unstable chemical bonds in which most collisions result in reaction. In these situations, the chemical nature of the reactants gives them small activation energies. Some exothermic reactions produce large amounts of heat which then accelerate further reaction by giving a larger fraction of molecules sufficient energy to exceed the activation energy barrier. A few reactions are autocatalytic: Their products include catalyst molecules which accelerate the reaction by lowering the activation energy barrier.
   (b) (Answers will vary, but the student should have a more sophisticated view of the explanation of chemical reaction rate in terms of activation energy barriers and collision mechanisms.)

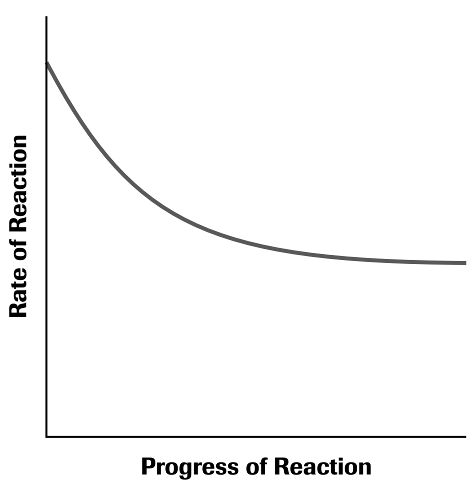
# CHAPTER 6 LAB ACTIVITIES

## LAB EXERCISE 6.1.1 DETERMINING A RATE OF REACTION

**(Page 401)**

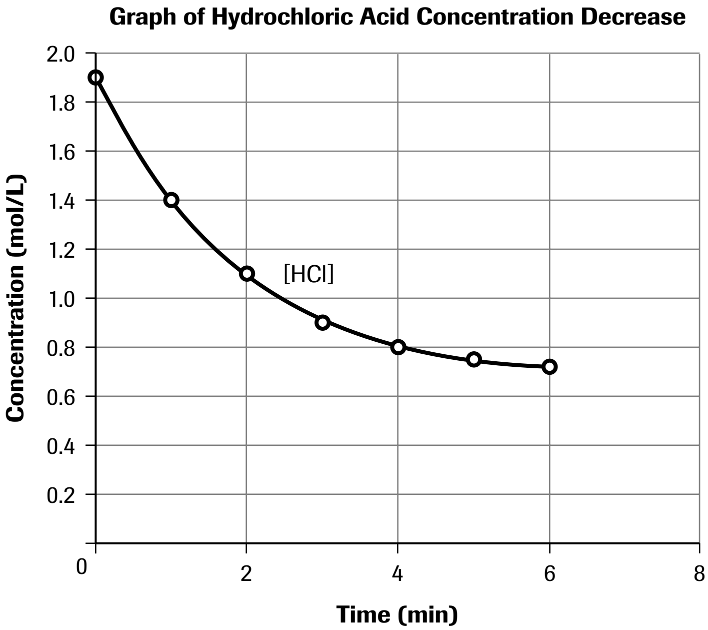
### Prediction

(a) (Sample answer)



### Analysis

(b)




(c) (i) $r = \frac{\Delta c}{\Delta t}$

$= \frac{1.10 \text{ mol/L} - 1.90 \text{ mol/L}}{2 \text{ min}}$

$r = 0.4 \text{ mol/(L•min)}$

(ii) $r = \frac{\Delta c}{\Delta t}$

$= \frac{0.75 \text{ mol/L} - 0.9 \text{ mol/L}}{2 \text{ min}}$

$r = 0.075 \text{ mol/(L•min)}$

(d) When we use slopes of tangents for instantaneous rate, approximate values are

(i) $r_{t = 1} = 0.41 \text{ mol/(L•min)}$

(ii) $r_{t = 4} = 0.075 \text{ mol/(L•min)}$

(e) The reaction rate decreases with time.

### Evaluation

(f) In controlled experiments, only one variable changes. In this heterogeneous system, changes are occurring in the calcium carbonate surface area as the reaction proceeds. Therefore, this is not truly a controlled situation.

(g) (Answers will vary, and will depend on the student's original prediction.)

### Synthesis

(h) $r_{t = 1}$ for HCl $= \frac{-\Delta[\text{HCl}]}{\Delta t}$

$r_{t = 1} = 0.41 \text{ mol/(L•min)}$

$\frac{-\Delta[\text{CaCO}_3]}{\Delta t} = 0.21 \text{ mol/(L•min)}$ (half as much)

$\frac{+\Delta[\text{CO}_2]}{\Delta t} = 0.21 \text{ mol/(L•min)}$ (half as much)

(i) The solution becomes a better conductor as three product ions are produced from two reactant ions; pressure or volume of hydrogen gas also increases over time.

## INVESTIGATION 6.2.1 CHEMICAL KINETICS AND FACTORS AFFECTING RATE

**(Page 402)**

### Question

(a) How do chemical nature of reactants, concentration, temperature, surface area, and catalysis affect rate of reaction?

### Prediction

(b) (Answers will vary, given that catalysts and changes in surface area do not apply to all of the systems that the student may choose. A sample answer is provided.) In reacting a metal like zinc with sulfuric acid, surface area, concentration of acid, temperature, chemical nature of reactants, and catalysts may all be variables. Catalysis will not be a consideration for the bicarbonate system, and surface area will be irrelevant for the decomposition of hydrogen peroxide because the system is homogeneous.

### Experimental Design

(c) (Answers will vary.) For the peroxide system, the control could be a fixed volume of 3% hydrogen peroxide at 20ºC to which a lump of pyrolusite rock or a fixed amount of manganese dioxide is added. Other trials would keep all variables constant except one of the following:
(i) vary temperature by using separate samples at 10, 15, and 25ºC,
(ii) vary catalysis by using gravel pellets or a small rock instead of the catalyst,
(iii) vary concentration by using separate samples of 2% and 5% hydrogen peroxide, or
(iv) vary chemical nature of reactant by using the same volume of water instead of hydrogen peroxide.

### Materials

(d) (Sample answer)
lab apron
eye protection
6% hydrogen peroxide
pyrolusite rock or granular manganese dioxide
Erlenmeyer flask
stopper-delivery tube assembly
pneumatic trough
graduated cylinder
retort clamp
retort stand

### Procedure

(e) (Sample answer) Place 30 mL of hydrogen peroxide in a flask, and close with a rubber stopper and delivery tube leading to an inverted graduated cylinder, filled with water and inverted in a pneumatic trough. Add a lump of pyrolusite rock to the solution, quickly stopper the flask, and measure the time required for 20 mL of gas to be produced. Repeat the procedure, changing single variables as described in the experimental design.

### Evidence

(f) (Sample answer) The control will typically take 2 min. Halving the concentration of hydrogen peroxide will double the reaction time to about 4 min. Colder peroxide will take more time. Using water in place of peroxide will produce no gas at all.

### Analysis

(g) (Sample answer) The rate may be expressed in mL of gas produced per min, or converted to mol/min. (Some students may plot rate as a function of concentration of peroxide.)
(h) Generally, temperature and concentration changes provide the best and most predictable results. Catalytic effects can be dramatic if a catalyst is known.

### Evaluation

(i) More trials with any particular set of conditions will improve results. Experiments involving gas collection are subject to errors caused by leakage of gas.
(j) (Answers will vary, and will depend on the prediction that the student originally made.)