Reaction Rates

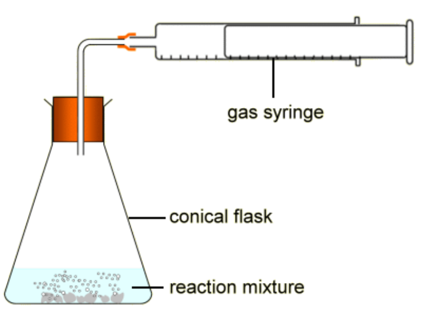
Chapter 6.1

Reaction Rates

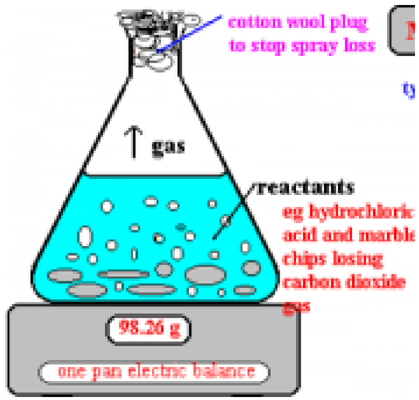
- **Chemical Kinetics** is the branch of chemistry concerned with the rates of chemical reactions
- **Reaction Rate** is the change in concentration of a reactant or a product of a chemical reaction per unit time

Measuring Reaction Rates

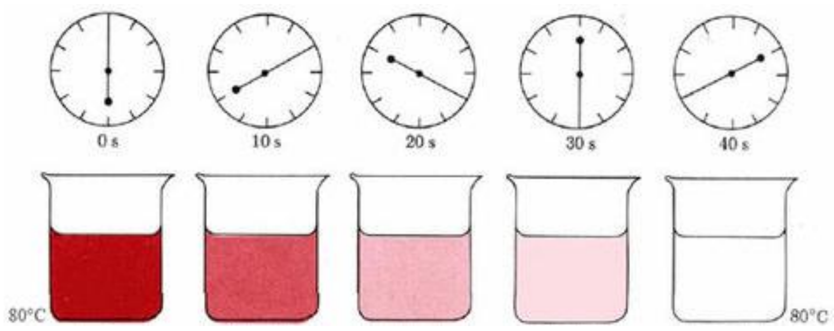
volume



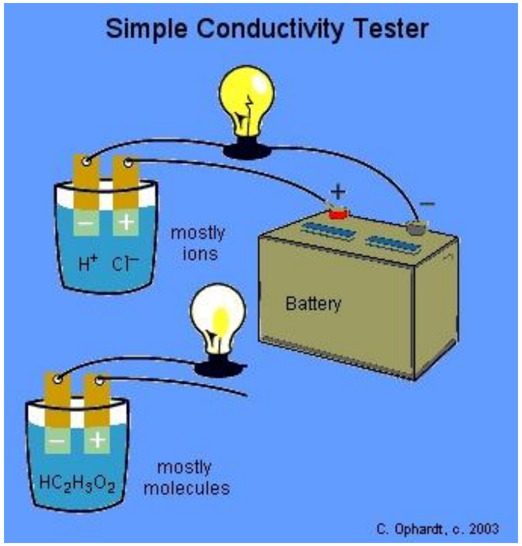
mass



colour



pH



electrical conductivity

Calculating Average Reaction Rates

- **Average Reaction Rate** is the change in reactant or product concentration over a given time interval

$$\text{rate}_A = \frac{\text{concentration of A at time } t_2 - \text{concentration of A at time } t_1}{t_2 - t_1}$$

$$\text{rate}_A = \frac{\Delta[A]}{\Delta t}$$

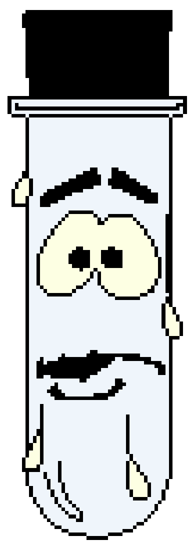
- The units for average reaction rate are mol/L•s

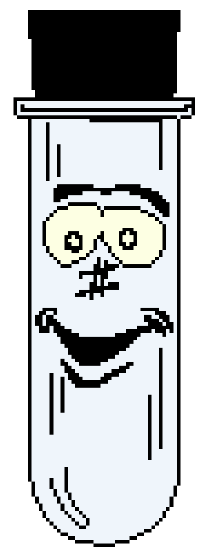
Calculating Average Reaction Rates

- The average rate of reaction can be calculated in two ways:

$$A \longrightarrow B$$

How fast a reactant disappears





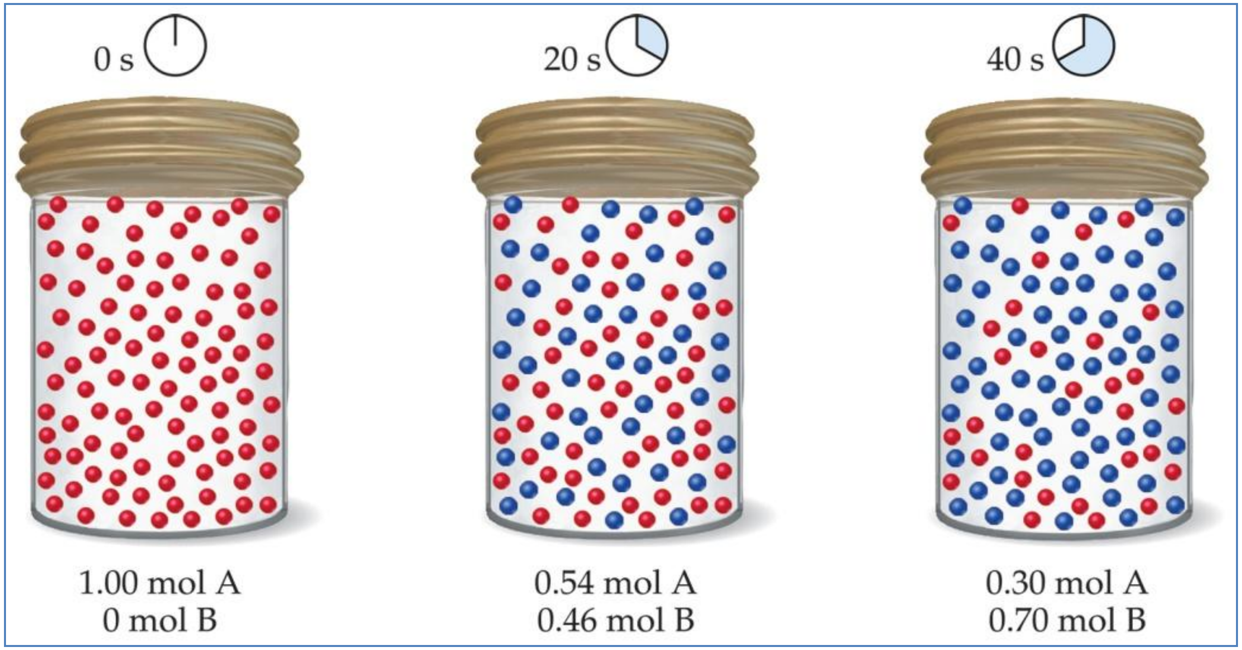
How fast a product appears

$$rate_A = -\frac{\Delta [A]}{\Delta t}$$

$$rate_B = \frac{\Delta [B]}{\Delta t}$$

Consider the following reaction:

$$A \longrightarrow B$$



Calculate the average rate at which reactant A is consumed

Calculate the average rate at which product B is produced

Calculating Average Reaction Rate

$$C_4H_9Cl_{(aq)} + H_2O_{(l)} \longrightarrow C_4H_9OH_{(aq)} + HCl_{(aq)}$$

Time, t(s)	$[C_4H_9Cl]$ (M)
0.0	0.1000
50.0	0.0905
100.0	0.0820
150.0	0.0741
200.0	0.0671
300.0	0.0549
400.0	0.0448
500.0	0.0368
800.0	0.0200
10,000	0

- Calculate the average rate of disappearance of chlorobutane

a) between 0s and 50.0s

b) between 50.0s and 100.0s

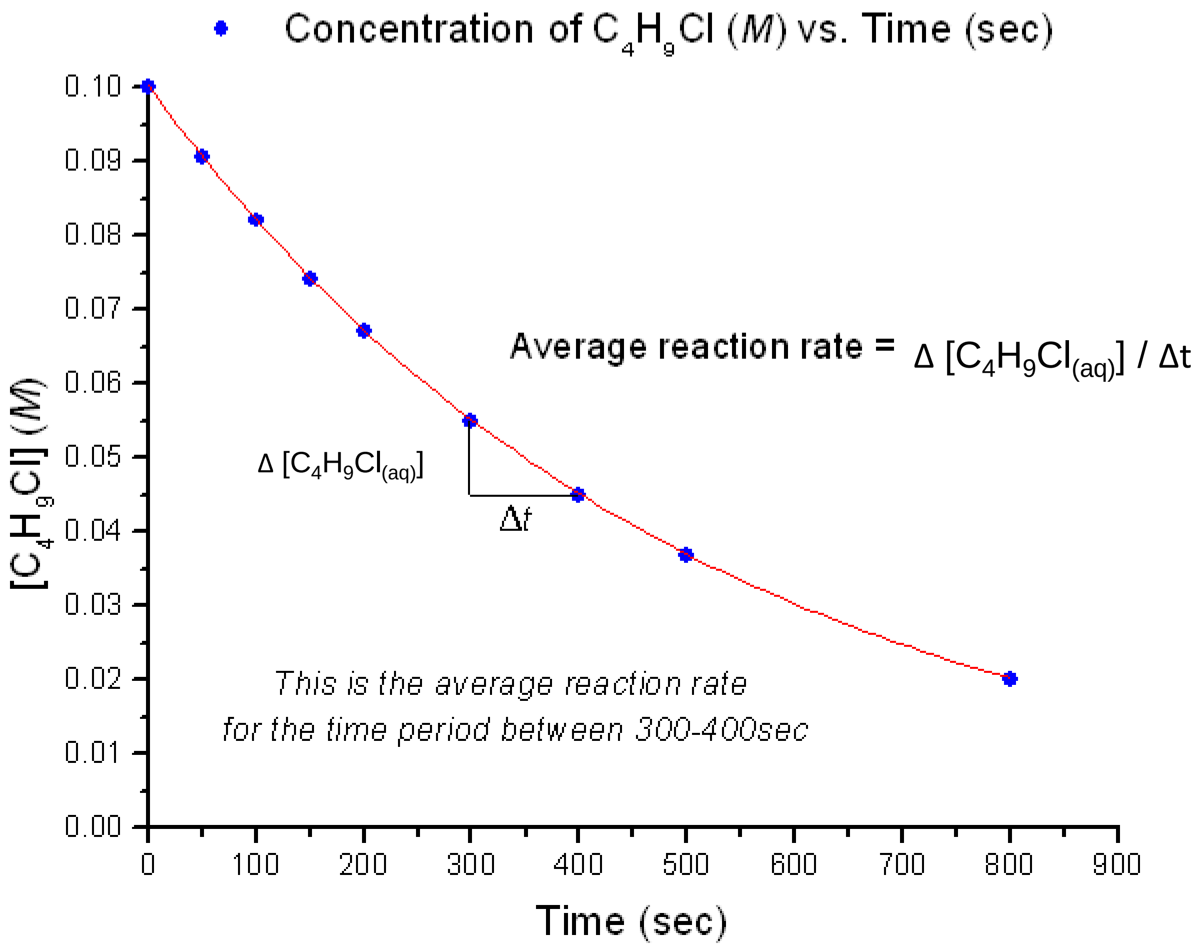
Graphing Average Reaction Rate

- What patterns do you notice in the data table below?

$$C_4H_9Cl_{(aq)} + H_2O_{(l)} \longrightarrow C_4H_9OH_{(aq)} + HCl_{(aq)}$$

Time, t(s)	$[C_4H_9Cl]$ (M)	Average Rate (M/s)
0.0	0.1000	
		1.9×10^{-4}
50.0	0.0905	
		1.7×10^{-4}
100.0	0.0820	
		1.6×10^{-4}
150.0	0.0741	
		1.4×10^{-4}
200.0	0.0671	
		1.22×10^{-4}
300.0	0.0549	
		1.01×10^{-4}
400.0	0.0448	
		0.80×10^{-4}
500.0	0.0368	
		0.560×10^{-4}
800.0	0.0200	
10,000	0	

Graphing Average Reaction Rate



Graphing Average Reaction Rate

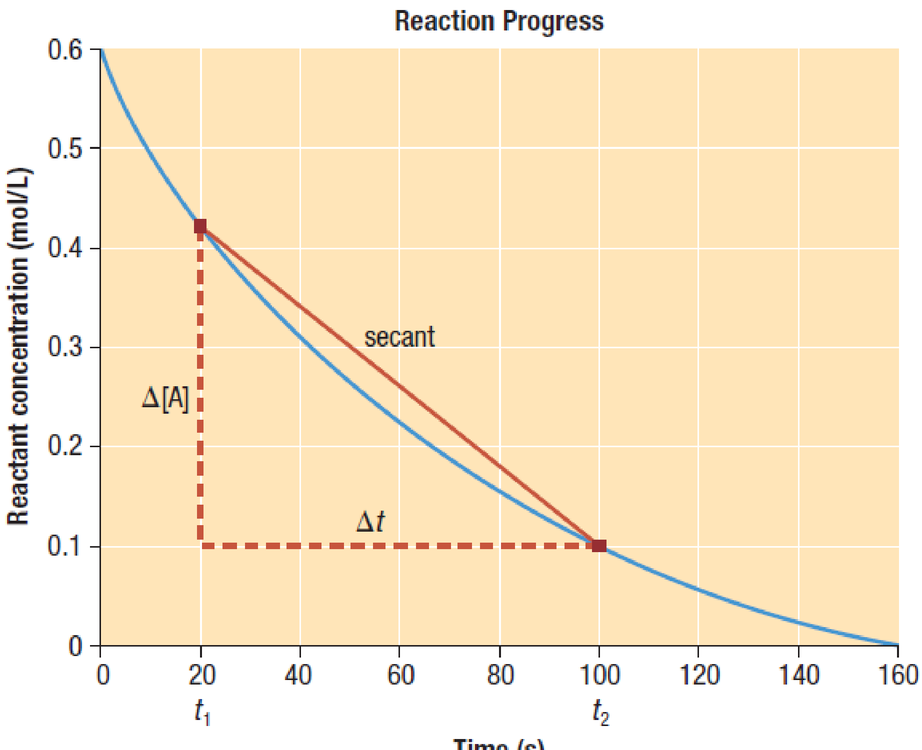


Figure 4 Concentration of a reactant, A, plotted as a function of time. The average rate of disappearance of the reactant from point t_1 to point t_2 is the slope of the secant line.

The average reaction rate can be calculated from the **slope of the secant** on a concentration-time graph

$$\text{rate}_A = -\frac{\Delta[A]}{\Delta t} \quad \text{or} \quad -\frac{\Delta y\,(\text{concentration})}{\Delta x\,(\text{time})}$$

Graphing Average Reaction Rate

- What chemical reaction does this graph show?

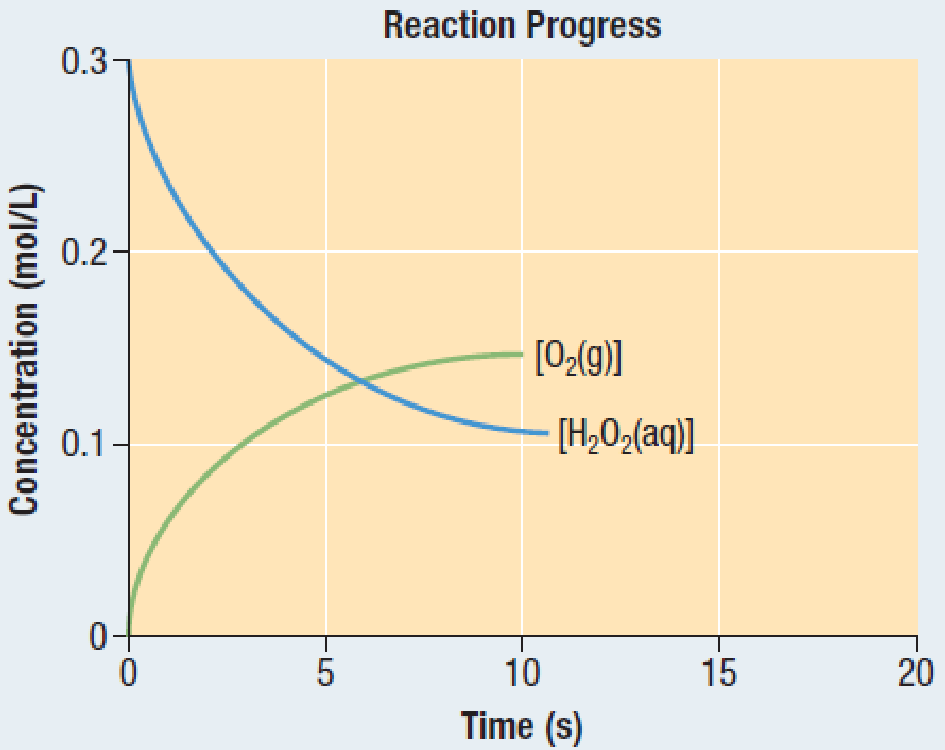
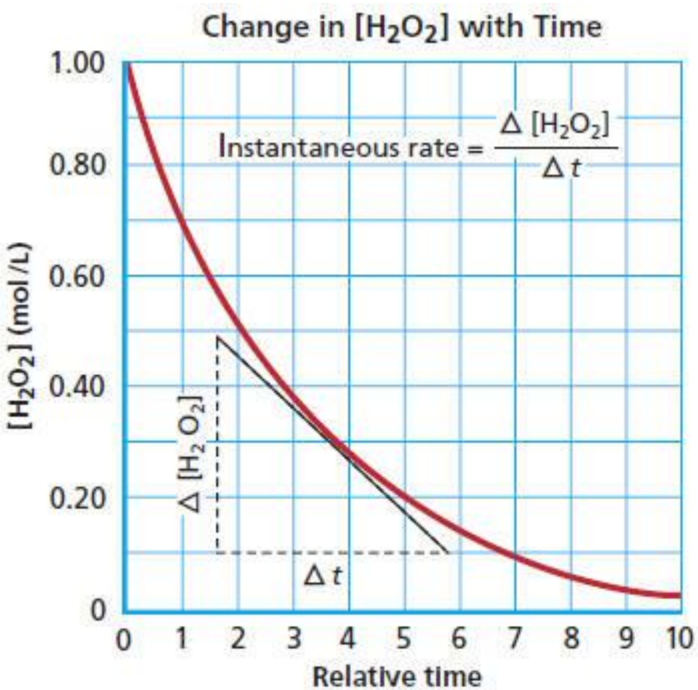


Figure 6 Change in the concentration of aqueous hydrogen peroxide and oxygen gas over time

Instantaneous Rate of Reaction

- **Instantaneous reaction rate** is the rate of a chemical reaction at a single point in time
- It can be calculated from the **slope of the tangent** on a concentration-time graph



Stoichiometric Rate Relationships

- Consider the following reaction:

$$2H_2O_{2(l)} \longrightarrow O_{2(g)} + 2H_2O_{(l)}$$

- We can use the stoichiometry of the reaction to conclude that the rate of appearance of oxygen is equal to half of the rate of disappearance of hydrogen peroxide

Stoichiometric Rate Relationships

We can use the stoichiometry of a chemical reaction to make predictions about reaction rate

In general:

$$aA + bB \longrightarrow cC + dD$$

$$rate = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = \frac{1}{c}\frac{\Delta[C]}{\Delta t} = \frac{1}{d}\frac{\Delta[D]}{\Delta t}$$

Practice

- Dinitrogen pentoxide gas decomposes to produce nitrogen dioxide gas and oxygen gas. If the rate of appearance of $NO_{2(g)}$ is 2.0×10^{-2} mol/L•s at 90s.

a) Determine the rate of appearance of $O_{2(g)}$ at the same point in time

b) Determine the rate of disappearance of $N_2O_{5(g)}$ at the same point in time

HOMEWORK

Required Reading:

p. 346-361

(remember to supplement your notes!)

Questions:

p. 350 #1

p. 352 #1

p. 356 #1-2

p. 360 #1-3

p. 361 #1-5