Unit 9 Practice Problems (with answers at end)

> He has no right to make himself so small--he is not that big.--Thomas Mann

Rate Laws

1. Consider the reaction below:

$$2\ H_2(g) + 2\ NO(g) \rightarrow 2\ H_2O(g) + N_2(g)$$

Initial rate data for this system are given below. Determine the rate law and the value of k, the rate constant (show units).

Initial concentration $[H_2]$	$[NO]$	Initial rate (mm Hg/min)
1	6	20
2	6	40
3	6	60
18	1	10
18	2	40
18	3	90

2. Consider the hypothetical reaction:

$$2\ P + 3\ Q + R \rightarrow QR + 2\ PQ$$

Experimental initial rate data for this reaction are given below. From this information, determine the rate law and the value of k (with units).

Initial concentration [P]	[Q]	[R]	Initial rate (M/min)
1	1	1	3.0
1	2	2	6.0
1	2	3	6.0
1	3	4	9.0
2	3	5	36
3	3	6	81

Collision Theory

3. What are two reasons (according to collision theory) that the rates of most reactions increase with increasing temperature?

4. For each of the following reactions, predict whether the rate is likely to be fast or slow, once initiated based on the physical state of the reactants:

a. $H_2(g) + Cl_2(g) \rightarrow 2\ HCl(g)$
b. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
c. $Fe(s) + S(\ell) \rightarrow FeS(s)$

5. What does a balanced chemical equation reveal about the mechanism of a reaction?

6. When a complex chemical reaction takes place in a series of steps, which step determines the rate of the overall reaction?

> A man gazing on the stars is proverbially at the mercy of the puddles on the road.
> --Alexander Smith

Activation energy

7. The rate constant for the decomposition of CH_3CHO is 0.0105 $dm^3/mol{\cdot}s$ at 700 K. If the activation energy for this reaction is 188 kJ, find the rate constant at 800 K.

8. For the reaction $2\ NO_2 \rightarrow 2\ NO + O_2$, the rate constant at 600 K is 0.75 $dm^3/mol{\cdot}s$, at 700 K the value for the constant is 20$dm^3/mol{\cdot}s$, and at 800 K it is 232 $dm^3/mol{\cdot}s$. Solve for E_a graphically.

Answers:

1. rate = $k[H_2][NO]^2$ k = 0.56 mm Hg/$M^3{\cdot}$min
2. rate = $k[P]^2[Q]^1[R]^0$ or simply $k[P]^2[Q]$ k = 3.0/$M^2{\cdot}$min
3. more collisions will occur in a unit of time because particles are moving faster; more of these collisions will involve the energy needed for reaction
4. (a) very fast (b) fast (c) slow
5. generally nothing; the steps in the mechanism must add up to give the balanced equation, but otherwise for all but the simplest reactions the balanced equation is not indicative of how the reaction actually occurs

6. the slowest step, sometimes called the 'rate determining step'
7. 0.597 $dm^3/mol{\cdot}s$
8. a plot of ln k vs. 1/T is a straight line with slope equal to -1.4 x 10^4; therefore E_a = 1.2 x 10^5 J/mol