Name: _____ Period: ____ Date: _____

Chemistry 30 – Quantitative Chemistry – Unit Homework

Topic	Textbook Reading	Textbook Questions
Reaction Rates and Collision Theory	Section 17.1	#4-9, 34, 40
Rate Determining Factors	Section 17.2	#11-13, 42-45, 47-49
Reaction Mechanisms	Section 17.4	

Measuring Reaction Rates

1. A chemist wishes to determine the rate of reaction of zinc with hydrochloric acid. The equation for the reaction is:

$$Zn\ (s) + 2\ HCl\ (aq) \rightarrow H_2\ (g) + ZnCl_2\ (aq)$$

A piece of zinc is dropped into 1.00 L of 0.100 M HCl and the following data were obtained:

Time (s)	Mass of Zinc (g)
0	0.016
4	0.014
8	0.012
12	0.010
16	0.008
20	0.006

   a. Calculate the rate of reaction in <u>grams of zinc per second</u>.
   b. Calculate the rate of reaction in <u>moles of zinc per second</u>.
   c. What will happen to $[H^+]$ as the reaction proceeds? (Recall that [ ] means concentration!)
   d. What will happen to $[Cl^-]$ as the reaction proceeds?

2. On a set of axes, sketch the shape of the curve you would expect if you plotted [HCl] versus time, starting immediately after the two reactants were mixed. <u>Explain</u> why you chose that shape. The equation for the reaction is:

$$Mg\ (s) + 2\ HCl\ (aq) \rightarrow H_2\ (g) + MgCl_2\ (aq)$$

3. When pentane (C_5H_{12}) is burned in air (O_2), carbon dioxide and water are formed.
   a. Write the balanced formula for the reaction.
   b. If pentane is consumed at an average rate of 2.16 g/s, determine the consumption of pentane in mol/s.
   c. If pentane is consumed at an average rate of 0.030 mol/s, determine the rate of consumption of oxygen in mol/s.

4. The following table relates the time and mass of zinc during the reaction between zinc and 0.5M nitric acid:

$$Zn\ (s) + 2HNO_3\ (aq) \rightarrow H_2\ (g) + Zn(NO_3)_2\ (aq)$$

Time (s)	Mass of Zinc (g)
0	36.2
60	29.6
120	25.0
180	22.0

   a. Calculate the reaction rate in g/s from 0 to 60 seconds.
   b. Calculate the reaction rate in g/s from 120 to 180 seconds.
   c. Why would these two values be different?

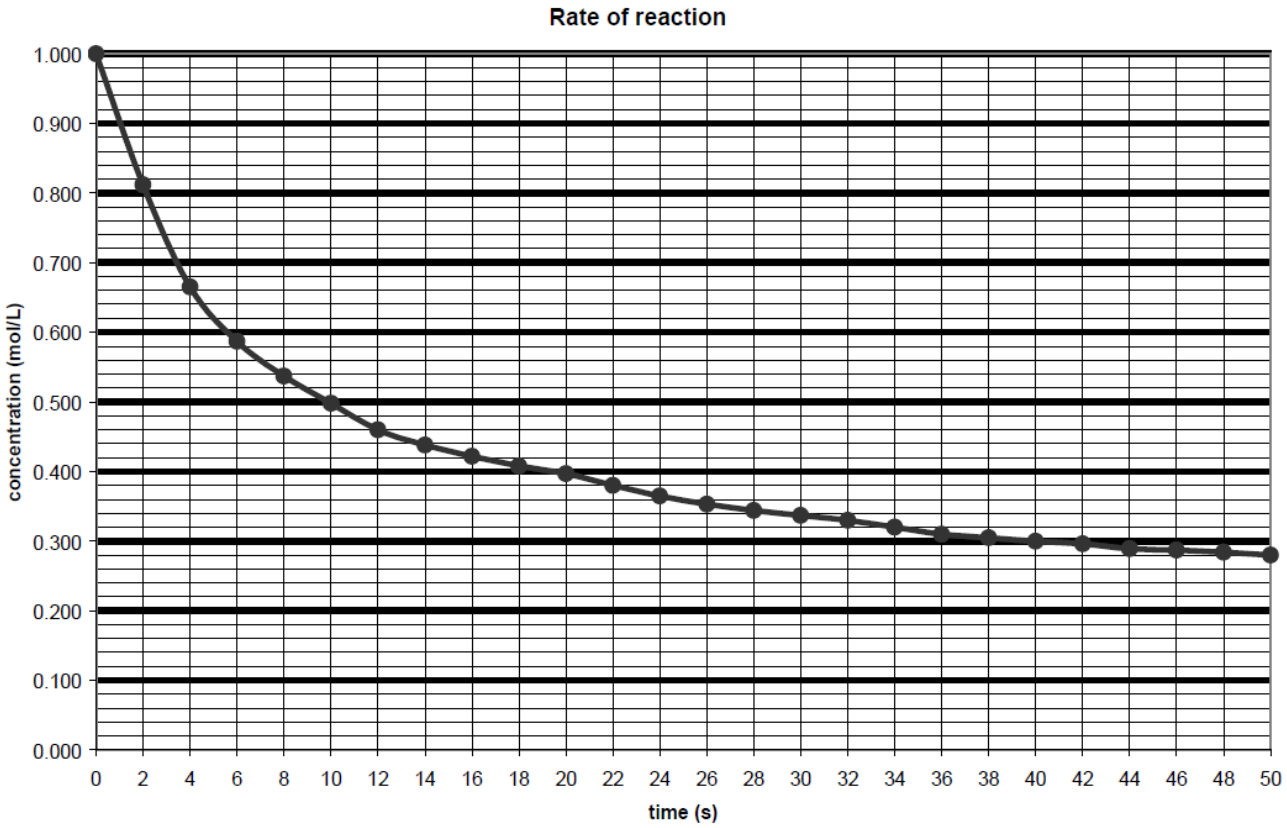
5. Consider the following reaction:

$$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$$

If the rate of decomposition of $N_2(g)$ is 0.03 mol/L·s, what would you expect to be:

a. The approximate rate of decomposition of H_2?
b. The approximate rate of formation of NH_3?

6. Consider the following graph, which shows the reaction rate of a species in a system.



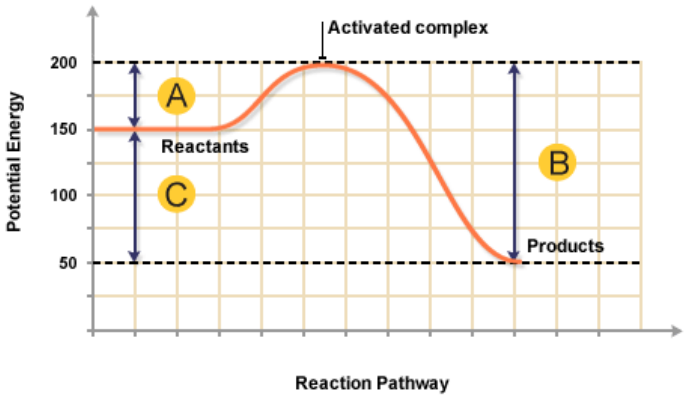
a. What is the reaction rate of the compound over the first ten seconds?
b. What is the reaction rate of the compound over the first 50 seconds?

Collision Theory and Energy Diagrams

7. Explain the three requirements for a successful reaction.

8. Answer the following questions based on the potential energy diagram shown here:

a. Does the graph represent an endothermic or exothermic reaction?
b. Determine ΔH_{rxn} for this reaction.
c. Determine the activation energy, E_a for this reaction.



Factors Affecting Reaction Rate

9. Consider the following reaction that occurs between hydrochloric acid, HCl, and zinc metal:

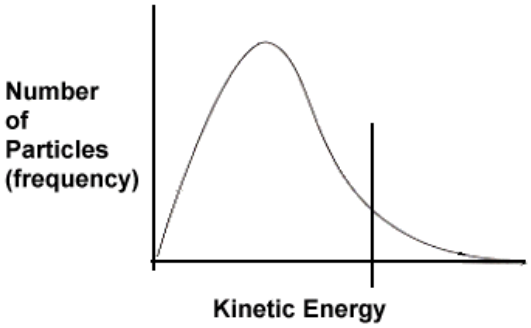
$$HCl\ (aq) + Zn\ (s) \rightarrow H_2\ (g) + ZnCl_2\ (aq)$$

   a. Will this reaction occur fastest using a 6 M solution of HCl or a 0.5 M solution of HCl? Explain.
   b. Which reaction will take longer? Why?

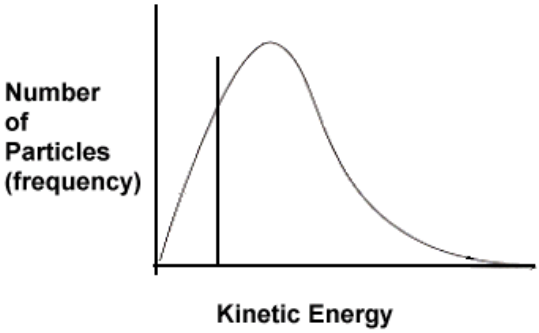
10. Again consider the reaction between hydrochloric acid and zinc. How will increasing the temperature of the acid affect the rate of the reaction? Explain.

11. Based on the following kinetic energy curves:
   a. Which reaction will have a faster rate - A or B? Explain.
   b. Which reaction, A or B, would benefit most in terms of increased rate if the temperature of the system were increased?

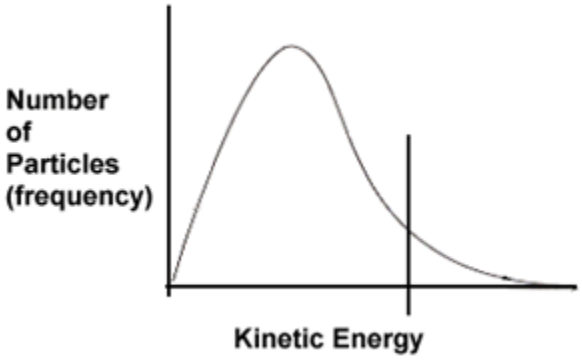
A



B



12. On the image, sketch how the Maxwell-Boltzmann curve will change for:
   a. A temperature increase
   b. A temperature decrease
   c. The addition of a catalyst



13. An inhibitor slows down a chemical reaction in the same way that a catalyst speeds up a reaction.
   a. What other ways can a reaction be slowed down?
   b. Why would you want a reaction to occur more slowly? Give an example of a situation where this would be preferable.

14. In a room filled with hydrogen and oxygen gas, there are about 10^{32} collisions per second.
   a. Give a reason why this reaction at room temperature is so slow as to be unnoticed.
   b. Suggest two ways that the reaction rate could be increased.

Reaction Mechanisms

15. Given the following reaction mechanism, determine the equation for the overall reaction.

Step 1: $A_2\ (g) \rightarrow 2\ A(g)$

Step 2: $2\ A(g) + 2\ B\ (g) \rightarrow 2\ AB(g)$

Step 3: $2\ AB(g) + C_2(g) \rightarrow 2\ ABC(g)$

Step 4: $2\ ABC(g) \rightarrow 2\ AC(g) + 2\ B(g)$

List the reaction intermediates for this reaction.

16. Hydrogen peroxide reacts with hydrogen ions and iodide ions according to the following reaction mechanism:

Step 1.	$H^+ + H_2O_2 \rightarrow H_3O_2^+$	fast
Step 2.	$H_3O_2^+ + I^- \rightarrow H_2O + HOI$	slow

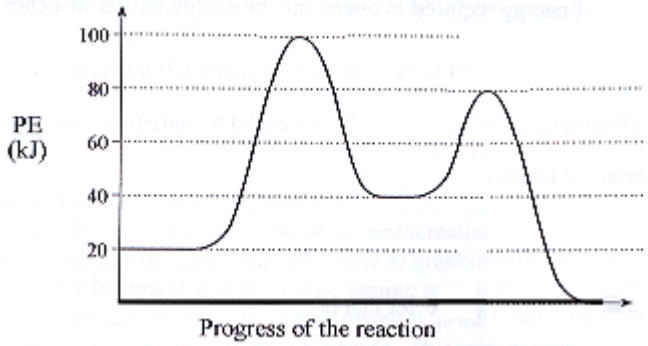
a. Write the overall reaction described by this mechanism
b. If you wanted to increase the rate of the overall reaction, would it be better to increase the concentration of H^+ or I^-? Explain why.

17. Phosgene, $COCl_2$, one of the poison gases used during World War I, is formed from chlorine and carbon monoxide. The mechanism is thought to proceed by:

Step 1: $Cl + CO \rightarrow COCl$

Step 2: $COCl + Cl_2 \rightarrow COCl_2 + Cl$

a. Write the overall reaction equation.
b. Identify any reaction intermediates.
c. Identify any catalysts.



18. Consider the energy diagram for a two-step reaction:
a. What is ΔH for the overall reaction?
b. What is\ ΔH for the first step and second step of the reaction mechanism?
c. What is E_a for the first step?
d. What is E_a for the second step?
e. Which is the rate-determining step - step 1 or step 2? How do you know?
f. Is the overall reaction endothermic or exothermic?

19. Given the reaction:

$$HCOOH \rightarrow CO + H_2O$$

a. This reaction, without a catalyst, is very slow at room temperature. Suggest why.
b. This reaction is thought to take place by means of the following mechanism:

Step 1: $HCOOH + H^+ \rightarrow HCOOH_2^+$ (fast)

Step 2: $HCOOH_2^+ \rightarrow H_2O + HCO^+$ (slow)

Step 3: $HCO^+ \rightarrow CO + H^+$ (fast)

Identify the reaction intermediates.
c. Which intermediate is a catalyst?
d. Another catalyst can be added that will increase the rate of step 3. Would it be worth it to add this catalyst? Why or why not?
e. Which step has the greatest activation energy?