NAME: **HONORS CHEMISTRY**

SECTION: KINETICS PROBLEM SET

A. Monitoring Reactions

1. Describe an experiment you could carry out to compare the reaction rate of magnesium metal and 1M HBr with the reaction rate of magnesium metal and 0.25M HBr.

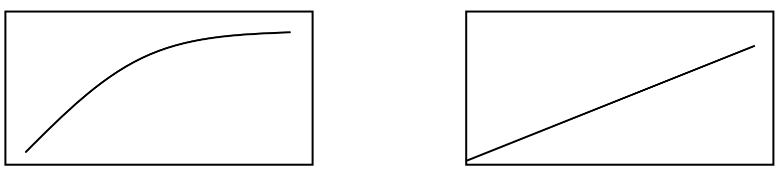
2. A solution of copper (II) sulfate is blue. When you put zinc into this solution, the following reaction takes place: $CuSO_4(aq) + Zn(s) \rightarrow ZnSO_4(aq) + Cu(s)$
   What property of this reaction could you follow if you were interested in comparing the rates of its reaction under different conditions?

3. Relative to automobile travel, which of these three variables does a reaction rate most closely resemble: the speed of the automobile, the distance it travels, or the time of travel?

4. A friend tells you that you can recognize a fast reaction because it produces more product than a slow reaction. What other factors must be included to make this a correct statement?

5. Suppose substances A and B react to form C, as shown below.
   $$A + B \rightarrow C$$
   The rate of this reaction can be followed by measuring the mass of substance C, which forms over time. The two graphs below show two of the many possible results that could be found for this reaction. Determine whether the reaction rate is increasing, decreasing, or remaining constant over time for graph I and graph II.

Graph I Graph II



Time Time

6. Explain how you can tell from a plot of product concentration versus time—without actually calculating reaction rates—whether the reaction rate is increasing, decreasing, or remaining constant.

B. Factors Affecting Reaction Rates

7. Hydrogen and iodine react at 400°C, according to the equation, $H_2(g) + I_2(g) \rightarrow 2HI\ (g)$. How would the rate of reaction be affected by the following:
   a) increasing the temperature
   b) increasing the concentration of hydrogen
   c) increasing the concentration of both the hydrogen and the iodine
   d) adding a catalyst

8. Which will react faster: zinc and 3M hydrochloric acid, or zinc and 1 M hydrochloric acid?

9. Use collision theory to explain why increasing the concentration of hydrochloric acid would cause an increase in the rate of its reaction with zinc.

10. Which will burn faster: a solid log, a split log, or wood shavings?

11. When you pour a solution of lead (II) nitrate, $Pb(NO_3)_2$, into a solution of potassium iodide, KI, you notice the formation of a yellow solid as soon as the solutions meet. Would you expect this reaction to take place at the same rate if you mixed solid lead nitrate with solid potassium iodide? Explain.

12. Why is 6M hydrochloric acid more hazardous to skin and eyes than 0.2 M hydrochloric acid?

13. You have a cube of zinc measuring 1000 cm on each edge.
    a) Calculate the surface area of the cube.
    b) If the cube is cut into smaller cubes that are 10 cm on each edge, find the surface area of each cube, the number of these cubes, and the total surface area of all the cube.
    c) The cubes are then cut into cubes that are 1 cm on each edge. Find the surface area of one of these cubes, the number of these cubes, and the total surface area of all the 1 cm cubes.
    d) In which of the three forms described will the zinc react fastest with 1M HCl? Explain using collision theory.

14. Using collision theory described in this chapter, explain the following:
    a) Sugar dissolves faster in a cup of hot coffee than in cold lemonade.
    b) A sugar cube dissolves more slowly than granulated sugar.
    c) Stirring a teaspoon of sugar helps it dissolve faster than not stirring it.

15. White phosphorus reacts rapidly with oxygen when exposed to air. What can you say about the magnitude of the activation energy for this reaction?

16. The metallic luster of fine copper wool doesn't readily change unless it is put into a crucible and heated at a high temperature. This causes the copper to darken as it reacts with oxygen. How, do you think, does the activation energy of this reaction compare with that of the phosphorus reaction described in question 15?

17. If you add 1.0 g of manganese dioxide to 1.0 L of 3 % hydrogen peroxide, the solution will fizz. When the fizzing stops, how much manganese dioxide would you expect to recover? Explain your answer.

18. The reaction represented by this equation takes place very slowly (if at all) at room temperature:

    $$CH_3CH_2OH(\ell) \rightarrow CH_2CH_2(g) + H_2O$$

    However, in the presence of an acid (H^+), the reaction takes place much faster. It is believed to follow this mechanism:

    $$CH_3CH_2OH + H^+ \rightarrow CH_3CH_2OH_2^+$$
    $$CH_3CH_2OH_2^+ \rightarrow CH_3CH_2^+ + H_2O$$
    $$CH_3CH_2^+ \rightarrow CH_2CH_2 + H^+$$

    Give two reasons why the acid can be considered a catalyst for the reaction.

Reaction Pathways

19. Sketch a potential-energy curve for an endothermic reaction. Label the parts representing the activated complex, activation energy, and change in enthalpy.

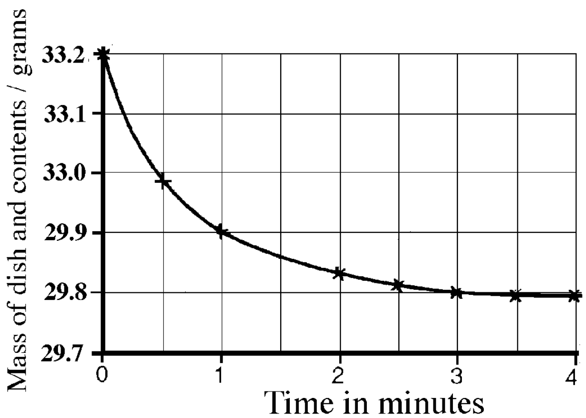
20. Repeat question 19, this time for an exothermic reaction.

21. How does a catalyst affect the activation energy for a reaction? Sketch two potential energy curves for a reaction, one showing the uncatalyzed reaction, and the other showing the catalyzed reaction. Label each curve.

22. At 20^{o}C, a 3% solution of hydrogen peroxide produces 15 mL of oxygen gas in 120 seconds. What is the rate of this reaction? (0.13 mL/sec)

23. In 60 seconds, 90% of 50 mL of a 3% solution of hydrogen peroxide decomposes at 20^{o}C in the presence of a catalyst. If the rate of this reaction doubles for each 10 degree increase in temperature, how long might it take for the same amount of this solution to decompose at 40^{o}C? (15 seconds)

24. A large quantity of dilute nitric acid was added to a 5.0 g sample of marble powder in an evaporating dish, which was placed on the pan of a balance. A chemical reaction occurred, forming calcium nitrate, carbon dioxide, and water. The mass of the dish and its contents was recorded every half minute. The results are shown in the graph below. Using the data in the graph, calculate the average rate of the disappearance of gaseous products between one and three minutes.



25. Look at the graph from problem 9 over the last minute. Without doing another calculation, determine how the rate of the reaction at this point compares with the rate you calculated in problem 9.

26. At 20^{o}C, a small strip of magnesium reacts with 3.0M hydrochloric acid to produce 0.00050 mole of H_2 gas in 20 seconds.
    a) What is the rate of this reaction in mol/min? (0.0015 mol/min)
    b) Suppose 6.0 M hydrochloric acid is substituted for the 3.0M acid. Predict whether the new rate will be faster or slower than before.
    c) How much magnesium reacts to form 0.00050 mole of hydrogen gas?
    d) How many moles of hydrochloric acid (HCl) react to form 0.00050 mole of hydrogen gas?
    e) What would be the rate of disappearance of the magnesium metal? Of the hydrochloric acid in mol/min? (Mg: 0.0015 mol/min; HCl: 0.0030 mol/min)

27. List the steps involved in washing dishes by hand. If each step is carried out by a different person, what step could be considered the rate-limiting step? Explain your answer.

28. For the same dishwashing analogy, describe the effects on the reaction rate if another person is added to do the following:
    a) clear the table
    b) wash the dishes
    c) dry dishes