Grade 12 Chemistry
Rates of Reaction Unit Review

Name..... **Date**.....

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Which statement about the instantaneous rate of a reaction is not correct?
a. The higher the rate, the greater is the slope of a line on a concentration-time graph.
b. The instantaneous rate is the slope of the tangent to a line on a concentration-time graph.
c. The instantaneous rate is the slope of the secant to a line on a concentration-time graph.
d. The instantaneous rate decreases over time.
e. All of these statements are correct.

____ 2. In the following reaction, what is equal to the rate of production of NO gas?
$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$
a. the rate of production of NH_3 gas
b. one third the rate of production of water
c. four fifths the rate of disappearance of O_2 gas
d. one quarter the rate of disappearance of NH_3 gas
e. six times the production of water vapour

____ 3. The initial rate of production of Br_2 gas in the following reaction is 0.0750 mol/(L·s). What is the rate of loss of HBr gas?
$4HBr_{(g)} + O_{2(g)} \rightarrow 2Br_{2(g)} + 2H_2O_{(g)}$
a. 0.0188 mol/(L·s)
b. 0.0375 mol/(L·s)
c. 0.0750 mol/(L·s)
d. 0.150 mol/(L·s)
e. 0.300 mol/(L·s)

____ 4. In the following reaction, butane is consumed at the rate of 0.0333 mol/(L·s). Determine the rate at which CO_2 is produced.
$C_4H_{10(g)} + \frac{13}{2}O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(g)}$
a. 0.008 25 mol/(L·s)
b. 0.0165 mol/(L·s)
c. 0.0333 mol/(L·s)
d. 0.0667 mol/(L·s)
e. 0.133 mol/(L·s)

____ 5. Which factor will not affect the rate of the following reaction?
$Na_{(s)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + Ag_{(s)}$
a. the addition of a catalyst
b. an increase in pressure
c. an increase in the concentration of $AgNO_{3(aq)}$
d. an increase in temperature
e. all of these factors will have a strong effect on the rate of the reaction

____ 6. Which step of a reaction is the rate-determining step?
   a. the fastest step
   b. the first step
   c. the last step of the reaction mechanism
   d. the step with the greatest number of molecules
   e. the slowest step

____ 7. Which statement about the factors that affect reaction rates is false?
   a. Decreasing the concentrations of the reacting particles decreases the chance of collision.
   b. A collision with poor orientation requires a higher activation energy than a collision with optimum orientation.
   c. Increasing the pressure in a gaseous reaction increases the chance of collision.
   d. A reaction occurs every time particles of the reactants collide.
   e. Increasing the temperature increases the reaction rate.

____ 8. Given the following reaction mechanism, what is the equation for the overall reaction?
   $2A \rightarrow B + 2C$ (slow)
   $B + C \rightarrow D + E$ (fast)
   $C + D \rightarrow E + F$ (fast)
   a. $2A \rightarrow 2E + F$
   b. $2A + B + 2C \rightarrow D + 2E + F$
   c. $2A + 2C \rightarrow 2E + F$
   d. $2A + B + 2C + D \rightarrow B + 2C + D + 2E + F$
   e. $2A + C \rightarrow 2E + F$

____ 9. Consider the following reaction mechanism. Changing the concentration of which substance(s) would have the most effect on the rate of the overall reaction?
   $2A \rightarrow B + 2C$ (slow)
   $B + C \rightarrow D + E$ (fast)
   $C + D \rightarrow E + F$ (fast)
   a. A
   b. A and C
   c. B
   d. D
   e. D and E

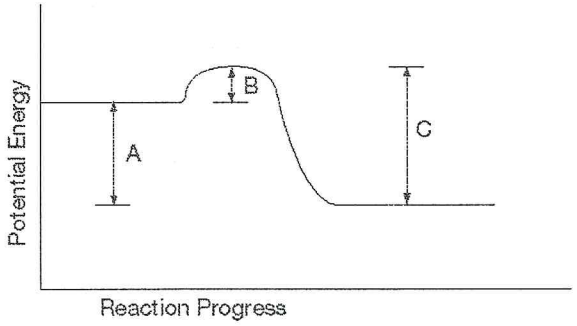
____ 10. Why does the rate of reaction increase with increasing temperature?
   a. The activation energy decreases as the temperature increases.
   b. Changing the temperature usually alters the reaction mechanism, similar to the effect of a catalyst.
   c. The change in temperature reduces the overall potential energy change between reactants and products.
   d. A greater proportion of all the molecules possess kinetic energy that is equal to or greater than the activation energy.
   e. Hotter molecules stick together better.

____ 11. Why does an increase in concentration increase the rate of reaction?
a. Collisions become more effective.
b. The number of collisions increases.
c. The activation energy decreases.
d. The average kinetic energy increases.
e. When there are more molecules in the container, they all speed up.

____ 12. Which quantity does not increase when the temperature of a reaction system is raised?
a. activation energy
b. number of collisions
c. number of effective collisions
d. average kinetic energy of the particles
e. all of the above increase

____ 13. To determine the rate of the following reaction, what physical property could be measured?
$H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$
a. change in concentration
b. change in pH
c. change in mass
d. change in colour
e. change in pressure

Potential Energy Diagram



____ 14. Use the Potential Energy Diagram. What is shown by the letter A?
a. the activation energy of the forward reaction
b. the activation energy of the reverse reaction
c. the transition state
d. the heat of reaction

____ 15. Use the Potential Energy Diagram. What is shown by the letter B?
a. the activation energy of the forward reaction
b. the activation energy of the reverse reaction
c. the transition state
d. the heat of reaction

____ 16. Use the Potential Energy Diagram. What is shown by the letter C?
a. the activation energy of the forward reaction
b. the activation energy of the reverse reaction
c. the transition state
d. the heat of reaction

____ 17. For an exothermic reaction, what does the activation energy of the reverse reaction equal?
a. the activation energy of the forward reaction
b. the heat of reaction minus the activation energy of the forward reaction
c. the activation energy of the forward reaction minus the heat of reaction
d. the heat of reaction plus the activation energy of the forward reaction
e. the heat of reaction minus the activation energy of the reverse reaction

Short Answer

For the following questions, write the most appropriate answer in the space provided.

1. What is an elementary reaction?

2. Define the mechanism of a reaction.

3. What is a bimolecular elementary reaction?

4. How does a catalyst affect the enthalpy change of a reaction?

5. Suppose that you use one lump of sugar in your tea. You would like the lump of sugar to dissolve quickly. How can you increase the rate at which it dissolves?

Problem

Graphics

For the following questions, use the graphics provided to review terms or skills. Add any missing labels, draw any missing parts, or use the graphics to help you answer a question.

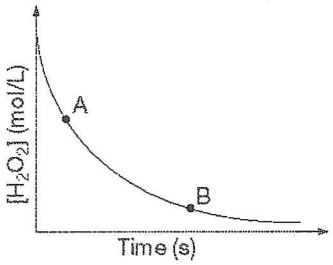
1. a) Sketch a graph to show the change in concentration of $CO_{(g)}$, with respect to time, during the following reaction.
$CO_{(g)} + Cl_{2(g)} \rightarrow COCl_{2(g)}$
b) Sketch a graph to show the change in concentration of $COCl_{2(g)}$, with respect to time, during the same reaction.
c) On the first graph, show and explain how you would determine the average rate of reaction.
d) On the first graph, show and explain how you would determine the instantaneous rate of reaction.

2. The forward activation energy of a reaction is 25 kJ/mol, and the heat of reaction is -286.4 kJ/mol.
a) Sketch a potential energy diagram for the reaction. Label the axes, the forward activation energy, the heat of reaction, the transition state, and the reactants and products.
b) Indicate the numerical values of the forward activation energy and the enthalpy change on your diagram.
c) Show and label the effect of a catalyst.

3. Sketch a potential energy diagram for an exothermic reaction and for an endothermic reaction. Label the axes, reactants, products, heat of reaction, activation energy, and transition state on each diagram.

b) Determine the instantaneous rate of reaction at 20 min and at 180 min.

4. The following graph represents the concentration of $H_2O_{2(aq)}$ over time for the decomposition of hydrogen peroxide into water.
$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$



a) What would you do to determine the rate of reaction at A?
b) Compare the rate of reaction at A with the rate of reaction at B. Explain the difference in terms of the collision theory.
c) Sketch the general shape of the curve, showing the concentration of H_2O versus time on the same graph.

5. The experimental data in the table below were collected for the following reaction of nitrogen monoxide and hydrogen.

i) What is the rate law for this reaction?
ii) Solve for rate law constant k with proper units

$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$

Trial	Initial concentration (mol/L)		Initial rate of disappearance of NO (mol/L·s)
	[NO]	$[H_2]$	
1	0.10	0.10	1.23×10^{-3}
2	0.10	0.20	2.46×10^{-3}
3	0.20	0.10	4.92×10^{-3}

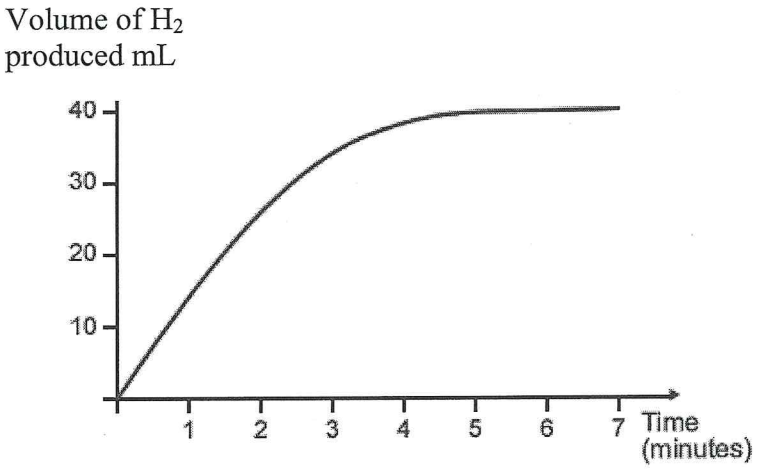
6. Grain that is stored in a grain elevator is unreactive. If a spark is placed near fine dust in the silos, however, an explosive reaction will occur. Explain this observation, based on what you learned in this chapter.

7. Often small twigs are used to start a campfire instead of large logs. Explain why, using what you learned in this unit.

8. A refrigerator keeps food fresh and stops it from spoiling. If food is left long enough in a refrigerator, however, it goes bad. Explain.

Rates of Reaction Review

1. Here is a rate graph for a reaction involving 0.5 mol/L hydrochloric acid and magnesium.



a. Write a balanced equation for the single displacement reaction of HCl with Mg.

b. Is the above rate graph representing the formation of product or the consumption of a reactant?

c. Describe what the graph shows you about the rate of reaction. (Why is the curve flat at the end?)

d. How you think the curve would look if you repeated the experiment:
   (i) at a lower temperature
   (ii) at a higher temperature *and* with a catalyst present.

e. Calculate the average rate of production of hydrogen gas from 1 – 7 minutes from the graph. Be careful of units.

f. What would be the average rate of consumption of HCl be based on your answer from e) and your balanced equation?

2. State the collision theory. Know the theoretical effects that temperature, concentration, surface area, pressure and catalysts have on the rate of a reaction.

3. Determine the rate law and calculate the rate constant for the following data.

trial	initial [A]	initial [B]	rate
#1	1.00×10^{-3}	0.25×10^{-3}	0.26×10^{-9}
#2	1.00×10^{-3}	0.50×10^{-3}	0.52×10^{-9}
#3	1.00×10^{-3}	1.00×10^{-3}	1.04×10^{-9}
#4	2.00×10^{-3}	1.00×10^{-3}	4.16×10^{-9}
#5	3.00×10^{-3}	1.00×10^{-3}	9.36×10^{-9}
#6	4.00×10^{-3}	1.00×10^{-3}	16.64×10^{-9}

4. Definitions to know: activation energy, activated complex, rate determining step, reaction mechanisms, elementary steps, instantaneous rate, average rate.

5. Given the following mechanism, answer the questions below:

Step 1: $O_3 + NO \rightarrow NO_2 + O_2$ (slow)

Step 2: $NO_2 + O \rightarrow NO + O_2$ (fast)

a) Give the equation for the ***overall reaction***.

_____

b) What could the ***catalyst*** be in this mechanism? _____

c) What is an ***intermediate*** in this mechanism?

_____

d) Given that the **uncatalyzed** overall reaction is a ***slow exothermic*** reaction, draw a *potential energy graph* which shows the possible shape of the curve for the ***above*** reaction mechanism. On the same graph, show a possible curve for the ***catalyzed*** reaction. Label all reactants, products, enthalpy, Ea1, Ea2, Ea', activated complexes and intermediates.