Rate Laws of Reactions Worksheet

1. For a particular reaction at constant temperature what is the value of "?" in this table?

   A(g) + 2 B(g) ---> products

initial [A]	initial [B]	initial rate
1.00	1.00	1.00
2.00	4.00	8.00
3.00	9.00	27.00
4.00	2.00	?

2. The rate law for the reaction 2 NO + O_2 ----> 2 NO_2 is rate= $k[NO]^2[O_2]$. At 25°C, $k=7.1 \times 10^9$ L $mol^{-2}s^{-1}$.
   What is the rate of reaction when [NO] = 0.0010 mol/L and $[O_2]$=0.034 mol/L?

3. The initial rate of the reaction: $BrO_3^-(aq) + 5\ Br^-(aq) + 8\ H^+(aq)$ ----> $3\ Br_2(l) + H_2O(l)$ has been measured at the reactant concentrations shown (in mol/L):

Experiment	$[BrO_3^-]$	$[Br^-]$	$[H^+]$	Initial rate (mol/Ls)
1	0.10	0.10	0.10	8.0×10^{-4}
2	0.20	0.10	0.10	1.6×10^{-3}
3	0.10	0.20	0.10	1.6×10^{-3}
4	0.10	0.10	0.20	3.2×10^{-3}

According to these results what would be the initial rate (in mol/Ls) if all three concentrations are:

$[BrO_3^-]=[Br^-]=[H^+]=0.20$ mol/L?

4. The reaction of iodide ion with hypochlorite ion, OCl^- (which is found in liquid bleach), follows the equation: $OCl^- + I^-$ ----> $OI^- + Cl^-$ It is a rapid reaction that gives the following rate data.

Initial Concentrations $[OCl^-]$	$[I^-]$	Rate of Formation (mol/L) of Cl^- ($mol\ L^{-1}\ s^{-1}$)
1.7×10^{-3}	1.7×10^{-3}	1.75×10^4
3.4×10^{-3}	1.7×10^{-3}	3.50×10^4
1.7×10^{-3}	3.4×10^{-3}	3.50×10^4

What is the rate law for the reaction? Determine the value of the rate constant.

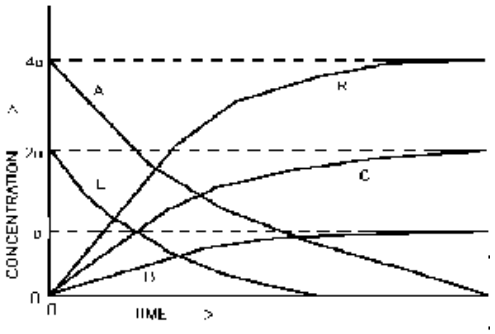
5. The decomposition of ozone, O_3, is believed to occur by the two-step mechanism

   O_3 -----> O_2 + O (slow)
   $\underline{O + O_3 \text{ -----> } 2\ O_2 \text{ (fast)}}$
   $2\ O_3$ -----> $3\ O_2$ (net reaction)

If this is the mechanism, what is the reaction's rate law?

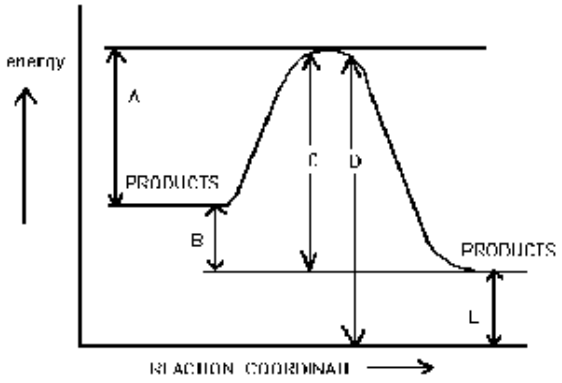
6. Write expressions for the rate of formation for these single step reactions. Indicate the units of the rate constant.
   a) $H_2 + Cl_2$ ---> $2\ HCl$
   b) $2\ O_2 + S_2$ ---> $2\ SO_2$
   c) $3\ O$ ----> O_3
   d) $2\ HI + Cl_2$ ----> $2\ HCl + I_2$
   e) $C_6H_6 + Cl_2$ ---> $C_6H_5Cl + HCl$

7. Consider the decomposition of dinitrogen pentoxide: $2\ N_2O_5\ (g)$ ----> $4\ NO_2(g) + O_2(g)$
   Given that the initial concentration of N_2O_5 is 2a mol/L, which line in the graph shows the concentration of $O_2(g)$ as a function of time?



   a) Line A, which starts at 4a and ends near zero.
   b) Line R, which starts at zero and ends near 4a.
   c) Line C, which starts at zero and ends near 2a.
   d) Line B, which starts at zero and ends near a.
   e) Line L, which starts at 2a and ends near zero.

8. The value for the energy of activation of the foward reaction is represented by which letter in the diagram below?



   a) A
   b) B
   c) C
   d) D
   e) E

9. Consider the following reactions:

   I $Ag^+(aq) + I^-(aq)$ ------> $AgI(s)$

   II $4\ Fe(s) + 3\ O_2(g)$ ------> $2\ Fe_2O_3(s)$

   Which one of the following statements best described the relative rates of the two reactions?

   a. II is faster than I
   b. I and II are both slow
   c. I and II are both fast
   d. I is faster than II

10. Persons who have been submerged in very cold water and who are believed to have drowned sometimes can be revived. On the other hand, persons who have been submerged in warmer water for the same length of time have died. Explain this in terms of factors that affect the rates of chemical reactions.

11. Which of these reactions are likely to proceed rapidly once they have begun? Explain.

    a) $H_2(g) + Cl_2(g)$ ---> $2\ HCl(g)$
    b) $C_6H_{12}O_5(aq) + 6\ O_2(g)$ ---> $6\ CO_2(g) + 6\ H_2O(l)$
    c) $Cu^{2+}(aq) + S^{2-}(aq)$ ---> $CuS(s)$
    d) A lump of iron in melted sulphur
    e) Powdered iron in melted sulphur

12. In terms of elementary processes what determines the order of a reaction of a particular chemical?

13. Can the order be determined from the equation for the overall reaction?

14. If the sum of the coefficients of the reactants in the equation equals the total order of a reaction, can it be assumed that the equation represents an elementary process?

15. The following data were collected for the reaction SO_2Cl_2 --> $SO_2 + Cl_2$ at a certain temperature.

$[SO_2Cl_2]$(mol/L)	Time(s)
0.100	0
0.082	100
0.067	200
0.055	300
0.045	400
0.037	500
0.030	600
0.025	700
0.020	800

Make a graph of concentration versus time and determine the rate of the reaction at t=200 seconds and t=600 seconds.

Using the graph that you have prepared, determine the time required for the SO_2Cl_2 concentration to drop from 0.100 mol/L to 0.050 mol/L. How long does it take for the concentration to drop from 0.050 mol/L to 0.025 mol/L? What is the order of this reaction? (hint: How is the half-life related to concentration?)

16. The rate of the chemical reaction between substances A and B is found to follow the equation rate= $k[A]^2[B]$, where k is a constant. If the concentration of A is halved, what should be done to the concentration of B to make the reaction go to 75% of its former rate?
    a. The concentration of B should be kept constant
    b. The concentration of B should be doubled
    c. The concentration of B should be tripled
    d. The concentration of B should be halved
    e. The concentration of B should be multiplied by 4/3.

17. An exothermic reaction has the following mechanism in the gas phase:

$2NO \rightarrow N_2O_2$	FAST
$N_2O_2 + H_2 \rightarrow N_2O + H_2O$	SLOW
$N_2O + H_2 \rightarrow N_2 + H_2O$	FAST

    a) What is the overall equation for this reaction?
    b) Sketch a potential energy diagram for this mechanism, identifying the reaction intermediates. Explain your diagram.
    c) Write the rate law expression for the overall reaction.

18. Two gaseous reactants, sulfur dioxide and oxygen, react to form sulfur trioxide according to the following reaction.

$$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$$

Assume that a 1.0 litre flask has been filled with equal numbers of moles of the two reactant gases. The reaction represents a one step reaction. (press. same as conc.)

    a) Write the rate expression for the forward reaction.
    b) By what factor would the rate change if the partial pressure of the sulfur dioxide gas were tripled?
    c) How would a change in the temperature of the reactants affect the rate of the reaction? (Explain in terms of collision theory.)

19. The following data were obtained for the reaction of 2-bromo-2-methylpropane with hydroxide ion at 55'C.

$$(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$$

Initial Concentrations (mol/L)		Initial rate (mol/Ls)
$[(CH_3)_3CBr]$	$[OH^-]$	
0.10	0.10	$1.0*10^{-3}$
0.20	0.10	$2.0*10^{-3}$
0.30	0.10	$3.0*10^{-3}$
0.10	0.20	$1.0*10^{-3}$
0.10	0.30	$1.0*10^{-3}$

    a) Write the rate law for this reaction.
    b) What is the value of the rate constant at this temperature? (include correct units)