Name: _____ Period : _____

Reaction Rates and Equilibrium Exam Review

1. For the reaction $NO_2 + O_2 \rightarrow 2N_2O_4$, the data shown was collected.

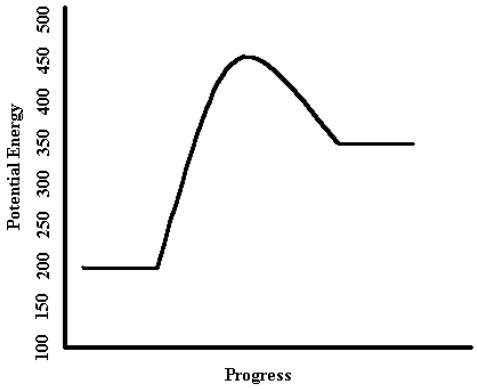
Trial #	Initial $[NO_2]$	Initial $[O_2]$	Initial Rate of formation of N_2O_4
1	0.025 M	0.011 M	3.1×10^{-4} mol/L·s
2	0.025 M	0.022 M	6.2×10^{-4} mol/L·s
3	0.050 M	0.011 M	6.2×10^{-4} mol/L·s

   a. Write the rate law expression for the reaction.

   b. Calculate the value of the rate constant.

   c. Use the rate law expression and calculated value of k to compute the initial rate of formation of N_2O_4, if the initial concentrations of NO_2 and O_2 were each 0.030M.

2. An energy diagram is shown to the right. Answer the following:



   a. What is the definition of "activated complex"?

   b. What is the definition of "activation energy"?

   c. What is the potential energy of the products? _____
   d. What is the potential energy of the reactants? _____
   e. What is the activation energy of the forward reaction? _____
   f. What is the activation energy of the reverse reaction? _____
   g. What is ΔH for the forward reaction? _____
   h. Draw a line to represent the reaction with a catalyst. What does the catalyst do to the rate of the reaction?

3. The rate law for the reaction $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ is a first-order in NO and O_3, and second order overall. Write the complete rate law for this reaction.

   _____

4. Consider the decomposition of N_2O_5 in carbon tetrachloride (CCl_4) at 45ºC.
   $2\ N_2O_5\ (aq) \leftrightarrow 4\ NO_2\ (g) + O_2\ (g)$
   The reaction is first-order in N_2O_5, with the specific rate constant 6.08×10^{-4}/s. Calculate the reaction rate at these conditions.
   a. $[N_2O_5] = 0.200$ mol/L
   b. $[N_2O_5] = 0.319$ mol/L

5. For the reaction $A + B \leftrightarrow C$, the activation energy of the forward reaction is 5 kJ and the total energy change is -20 kJ. What is the activation energy of the reverse reaction? *(hint: draw a picture)*

6. For the following reaction: $Zn\ (s) + 2\ H^+\ (aq) \rightarrow Zn^{2+}\ (aq) + H_2\ (g)$ **The reaction is exothermic.**
   Indicate the direction of the equilibrium shift.
   a. add H^+ _____
   b. remove Zn^{2+} _____
   c. decrease temp _____
   d. decrease pressure _____
   e. add Zn (s) _____
   f. add catalyst _____

7. A mixture at equilibrium at 827ºC contains 0.552 mol CO_2, 0.552 mol H_2, 0.448 mol CO, 0.448 mol H_2O. What is the value of K_{eq}? $CO_2\ (g) + H_2\ (g) \leftrightarrow CO\ (g) + H_2O\ (g)$

   Would more products or reactants be present at equilibrium? _____

8. List 3 ways that reaction rates can generally be increased:
   a) _____ b) _____ c) _____

9. A catalyst _____ reaction rates by _____ the activation energy.
   Biological catalysts are called _____.

10. It has been determined that the rate law for the following reaction is third-order overall and first-order with respect to $HgCl_2$. Write the rate law for this reaction:
    $2\ HgCl_2 + Na_2C_2O_4 \leftrightarrow 2\ NaCl + 2\ CO_2 + Hg_2Cl_2$

11. Write the equilibrium constant expression for the following reaction: $2\ N_2O_3\ (g) \leftrightarrow 4\ NO_2\ (g) + O_2\ (g)$
    Calculate K_{eq} for the reaction if the equilibrium concentrations are:
    $[N_2O_5] = 0.50$ M, $[NO_2] = 0.80$ M, and $[O_2] = 0.20$ M.

12. For the following reaction, calculate which direction the reaction will shift when these stresses are applied:
    $2\ NO_2\ (g) \leftrightarrow N_2O_4\ (g) + 57.2\ kJ$
    a. The temperature is increased _____
    b. The pressure is lowered _____
    c. NO_2 is added _____
    d. N_2O_4 is added _____

13. Is entropy (disorder) increasing or decreasing in these reactions or processes?
    a. $2\ XeO_3\ (s) \rightarrow 2\ Xe\ (g) + 3\ O_2\ (g)$
    b. $NaCl\ (s) \rightarrow Na^+\ (aq) + Cl^-\ (aq)$
    c. Loose stamps → Stamps in an album
    d. Messy room → clean room
    e. Ice → water

14. Which combination of factors will always give a spontaneous reaction?
    a. $+\Delta H, -\Delta S$
    b. $-\Delta H, +\Delta S$
    c. $-\Delta H, -\Delta S$
    d. $+\Delta H, -\Delta S$

15. Which combination(s) in question #14 will never give a spontaneous reaction? _____