Unit 8 Quiz (5/2/19)

Name: Henderson / Key

Kinetics and Equilibrium Quiz

(40 pts Possible)

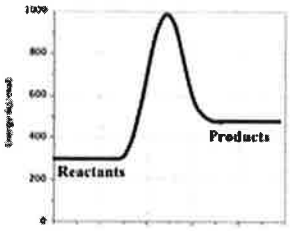
1. According to the **Collision Model**, there are two requirements that must be met in order for a collision between reactant molecules to lead to the formation of products. Describe these two requirements.

Colliding particles must have...

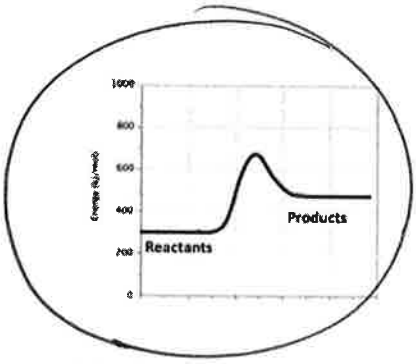
1. Sufficient energy (exceeding the activation energy)
2. Proper orientation

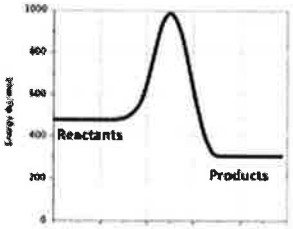
4

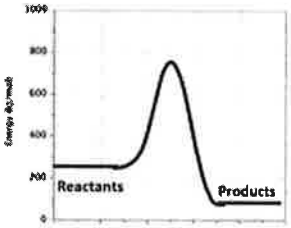
2. The graph at the right shows the energy profile for an uncatalyzed reaction – with energy levels of reactants, products, and activation complex. If a catalyst is used for this reaction, then the new energy profile would be … (circle the answer).



Catalysts lower the activation energy







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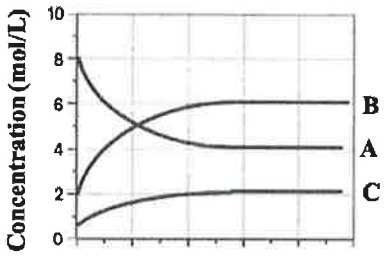
3. Which statement explains why increasing the temperature of a reaction vessel will increase reaction rates?
   a. Activation energies are reduced to lower values at higher temperatures.
   b. Temperatures can catalyze reactions altering the mechanism by which a reaction occurs.
   c. Colliding particles experience higher activation energies when present at higher temperatures.
   d. Average kinetic energy values are greater at higher temperatures,, increasing the percentage of collisions that exceed the activation energy

2

4. The graph shows the variation of concentration of reactants and products with time for the reaction at 25 °C.



$$3\ \mathbf{A}(aq) \leftrightarrows 3\ \mathbf{B}(aq) + 1\ \mathbf{C}(aq)$$

What is the value of the equilibrium constant? **PSYW**

$$K = \frac{[C]^1[B]^3}{[A]^3} = \frac{(2)^1(6)^3}{(4)^3} = 6.75$$

4

12

5. The following data were obtained for the reaction of nitrogen monoxide gas, $NO_{(g)}$, with oxygen gas to form nitrogen dioxide gas, $NO_{2(g)}$, at a specific temperature.

Experiment	[NO] mol/dm^{-3}	[O_2] mol/dm^{-3}	Initial rate mol/dm^3/s
1	0.25	0.40	2.0×10^{-3}
2	0.25	0.80	4.0×10^{-3}
3	0.50	0.40	8.0×10^{-2}

x2 (0.25 → 0.50); x2 (0.40 → 0.80); x4 (2.0 → 8.0); x2

= Double O_2 → Double Rate

= Double NO → Quadruple Rate

Determine the overall rate equation for this reaction and calculate the rate constant. Put your answers in the boxes.

4 Rate Equation: $Rate = k[NO]^2[O_2]^1$

2 Rate Constant = k = 0.080

Row 1: $2.0\times10^{-3} = k(.25)^2(.4)$

$k = \frac{2\times10^{-3}}{(.25)^2(.4)} = 0.080$

6. Consider the following reaction mechanism:

$Cl_2 \rightarrow 2Cl\cdot$ (Step 1)

$Cl\cdot + CO \rightarrow COCl$ (Step 2)

$COCl + Cl_2 \rightarrow COCl_2 + Cl\cdot$ (Step 3)

$2Cl\cdot \rightarrow Cl_2$ (Step 4)

a. What are the reactants of this reaction? $CO + Cl_2$

4 b. What are the products of this reaction? $COCl_2$

c. Which specie(s) is/are reaction intermediate(s)? $Cl\cdot$, $COCl$

d. Which species is a catalyst for this reaction? None

7. Write the equilibrium constant equation for: $Fe_3O_{4(s)} + 4\,H_{2(g)} \leftrightarrow 3\,Fe_{(s)} + 4\,H_2O_{(g)}$

4 $K = \frac{[H_2O]^4}{[H_2]^4}$

8. Consider the reversible reaction system: $N_{2\,(g)} + 3\,H_{2\,(g)} \leftrightarrow 2\,NH_{3\,(g)}$ $Q = \frac{[NH_3]^2}{[N_2][H_2]^3}$

Circle the answers to complete the following paragraph:

4 Suppose that the system is at equilibrium. Then nitrogen (N_2) is added to the system. This will cause the reaction quotient to be _____ (greater than, less than) the equilibrium constant (**K**). This will cause the equilibrium position to shift towards the _____ (right, left, not all).

18

9. Consider the following decompositionreaction at some temperature.

$$2\,HI_{(g)} \leftrightarrow H_{2\,(g)} + I_{2\,(g)}$$

The equilibrium constant (K_c) for this reaction at the given temperature is 4.0. A 1.50-L reaction vessel is prepared with 6.00 mol of H_2, 6.00 mol of I_2, and 30.0 mol of HI. Complete the ICE table and calculate the equilibrium concentrations of the reactants and products. **PSYW**

	HI	↔	H_2	I_2
Initial []	$\frac{30\text{ mol}}{1.5\text{ L}} = 20.0\text{ M}$		$\frac{6\text{ mol}}{1.5\text{ L}} = 4.0\text{ M}$	$\frac{6\text{ mol}}{1.5\text{ L}} = 4.0\text{ M}$
Change in []	$-2x$		$+x$	$+x$
Equilibrium []	$20-2x$		$4+x$	$4+x$

Initially $Q = \frac{[H_2][I_2]}{[HI]^2} = \frac{(4)\cdot(4)}{(20)} = \frac{16}{20} = 0.75$

Since $Q < K$, Rxn proceeds to right

At Equilibrium: $K = 4.0$ (given) $= \frac{(4+x)(4+x)}{(20-2x)^2} = \frac{(4+x)^2}{(20-2x)^2}$

Take $\sqrt{}$ of each side

$\sqrt{4.0} \rightarrow 2.0 = \frac{4+x}{20-2x}$

$40 - 4x = 4 + x$

$36 = 5x$

$x = \frac{36}{5} = 7.2$

Check: $K = \frac{(11.2)(11.2)}{(5.6)^2} = 4.0$ ☺

$\therefore [HI] = 5.6\text{ M}$ $\quad [H_2] = [I_2] = 11.2\text{ M}$

$20-2(7.2)$ $\quad (4+7.2)$

10

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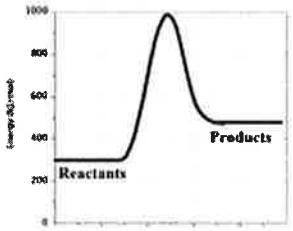
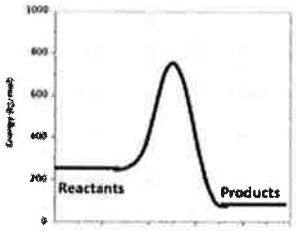
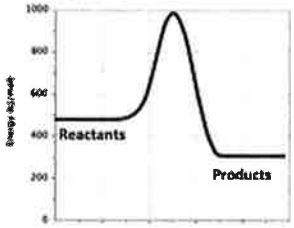
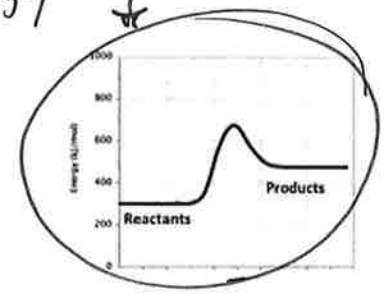


Catalysts Lower Activation Energy







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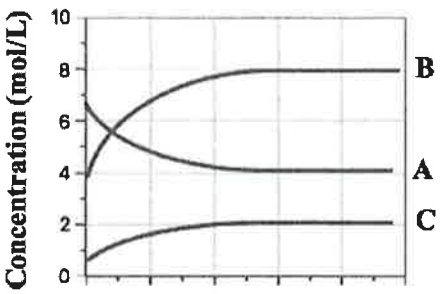

$$2\ A_{(aq)} \leftrightarrow 3\ B_{(aq)} + C_{(aq)}$$

What is the value of the equilibrium constant? **PSYW**

$$K = \frac{[B]^3[C]}{[A]^2} = \frac{(8)^3(2)}{(4)^2}$$

$K = 64.0$

4

12

5. The following data were obtained for the reaction of nitrogen monoxide gas, $NO_{(g)}$, with oxygen gas to form nitrogen dioxide gas, $NO_{2(g)}$, at a specific temperature.

Experiment	[NO] mol/dm^{-3}	[O_2] mol/dm^{-3}	Initial rate mol/dm^3/s
1	0.25	0.40	2.0 x 10^{-3}
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3	0.25	0.80	8.0 x 10^{-3}

= Double NO, double Rate

= Double O_2, Quadruple Rate

Determine the overall rate equation for this reaction and calculate the rate constant. Put your answers in the boxes.

4 Rate Equation: $Rate = k[NO]^1 \cdot [O_2]^2$

2 Rate Constant = k = 0.050

Rxn 1: $2.0\times10^{-3} = k(.25)(.4)^2$

$k = \frac{2\times10^{-3}}{(.25)(.4)^2} = 0.05$

6. Consider the following reaction mechanism:

$COCl + Cl_2 \rightarrow COCl_2 + Cl\cdot$ (Step 1)

$Cl_2 \rightarrow 2\,Cl\cdot$ (Step 2)

$Cl\cdot + CO \rightarrow COCl$ (Step 3)

$2\,Cl\cdot \rightarrow Cl_2$ (Step 4)

a. What are the reactants of this reaction? $CO + Cl_2$

4 b. What are the products of this reaction? $COCl_2$

c. Which specie(s) is/are reaction intermediate(s)? $Cl\cdot$

d. Which species is a catalyst for this reaction? $COCl$

7. Write the equilibrium constant equation for: $3\,Fe_{(s)} + 4\,H_2O_{(g)} \leftrightarrow Fe_3O_{4(s)} + 4\,H_{2(g)}$

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Circle the answers to complete the following paragraph:

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18

9. Consider the following decompositionreaction at some temperature.

$$2\,HI_{(g)} \leftrightarrow H_{2\,(g)} + I_{2\,(g)}$$

The equilibrium constant (K_c) for this reaction at the given temperature is 9.0. A 2.50-L reaction vessel is prepared with 20.0 mol of H_2, 20.0 mol of I_2, and 50.0 mol of HI. Complete the ICE table and calculate the equilibrium concentrations of the reactants and products. **PSYW**

	HI	↔	H_2	I_2
Initial []	$\frac{50\text{ mol}}{2.5\text{L}} = 20.0M$		$\frac{20\text{ mol}}{2.5\text{L}} = 8.0M$	$\frac{20\text{ mol}}{2.5\text{L}} = 8.0M$
Change in []	$-2x$		$+x$	$+x$
Equilibrium []	$20.0-2x$		$8.0+x$	$8.0+x$

Initially, $Q = \frac{[H_2]\cdot[I_2]}{[HI]^2} = \frac{8\cdot 8}{20^2} = \frac{64}{400} = 0.16$

Since $Q < K$, Rxn proceeds to the right

At Equilibrium: $K = 9.0 = \frac{(8+x)(8+x)}{(20-2x)^2} = \frac{(8+x)^2}{(20-2x)^2}$

Given

Take $\sqrt{\ }$ of each side

$\sqrt{9}$

$3.0 = \frac{8+x}{20-2x}$

$60-6x = 8+x$

$52 = 7x$

$x = 7.428$

Check:

$K = \frac{(15.428)(15.428)}{5.1428}$

$K = 9.0$ ☺

HI $[H_2] = \frac{5.1428\ M}{4}$ $20-2(7.428)$

$[I_2] = \frac{15.428\ M}{4}$

H_2 $[HI] = \frac{15.428\ M}{5}$ $8.0+7.428$

10