Name BETH "KEY" Period ____________

Chemical Kinetics Review WS

1. (a) What is meant by the term reaction rate? CHANGE IN CONCENTRATION/UNIT TIME
(b) Name three factors that can affect the rate of a chemical reaction? TEMP/CONCENTRATION/SURFACE AREA
(c) What information is necessary to relate the rate of disappearance of reactants to the rate of appearance of products?
THE MOLE RATIO FROM THE BALANCED EQUATION.

2. Consider the hypothetical aqueous reaction A(aq) → B(aq). A flask is charged with 0.065 mol of A in a total volume of 100.0 mL. The following data are collected:

Time (min)	0	10	20	30	40
Moles of A	0.065	0.051	0.042	0.036	0.031

(a) Calculate the number of moles of B at each time in the table. Assume there are no molecules of B at time zero.
(b) Calculate the average rate of disappearance of A for each 10-minute interval, in units of mol/s.
(c) Between t = 10 min and t = 30 min, what is the average rate of disappearance of B in units of M/s? Assume that the volume of the solution is constant.

a)

TIME (MIN)	0	10	20	30	40
MOLES OF B	0	0.014	0.023	0.029	0.034

b)

TIME (min)	0 - 10	10 - 20	20 - 30	30 - 40
Rate =	$-\frac{(0.051\,mol - 0.065\,mol)}{600\,s} = 2.3\times10^{-5}\,mol/s$	$-\frac{(0.042-0.051)}{600\,s} = 1.5\times10^{-5}\,mol/s$	$-\frac{(0.036-0.042)}{600\,s} = 1.0\times10^{-5}\,mol/s$	$-\frac{(0.031-0.036)}{600\,s} = 8.3\times10^{-6}\,mol/s$

c) $\frac{\left[\left(\frac{0.029\,mol}{0.1000\,L}\right) - \left(\frac{0.014\,mol}{0.1000\,L}\right)\right]}{\left(20\,min \times \frac{60\,s}{min}\right)}$ $\boxed{= 1.3\times10^{-4}\,M/s}$

3. The isomerization of methyl isonitrile, CH_3NC, to acetonitrile, CH_3CN, was studied in the gas phase at 215°C, and the following data were obtained:

Time (s)	$[CH_3NC]$ (M)
0	0.0165
2000	0.0110
5000	0.00591
8000	0.00314
12000	0.00137
15000	0.00074

Calculate the average rate of reaction between, in M/s, for the time interval between each measurement.

Rate $= -\frac{(0.0110\,M - 0.0165\,M)}{(2000\,s - 0\,s)} = 2.75\times10^{-6}\,M/s$

$-\frac{(0.00591\,M - 0.0110\,M)}{(5000\,s - 2000\,s)} = 1.70\times10^{-6}\,\frac{M}{s}$

$-\frac{(0.00314\,M - 0.00591\,M)}{(8000\,s - 5000\,s)} = 9.23\times10^{-7}\,\frac{M}{s}$

$-\frac{(0.00137\,M - 0.00314\,M)}{(12000\,s - 8000\,s)} = 4.43\times10^{-7}\,\frac{M}{s}$

$-\frac{(0.00074\,M - 0.00137\,M)}{(15000\,s - 12000\,s)} = 2.1\times10^{-7}\,\frac{M}{s}$

5. For each of the following gas-phase reactions, indicate how the rate of disappearance of each reactant is related to the rate of appearance of each product:
(a) $H_2O_2(g) \rightarrow H_2(g) + O_2(g)$
(b) $2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$
(c) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

a) RATE OF APPEARANCE H_2 & O_2 = RATE OF DISAPPEARANCE H_2O

b) RATE OF APPEARANCE N_2 = RATE OF DISAPPEARANCE OF N_2O.
RATE OF APPEARANCE O_2 = ½ RATE OF DISAPPEARANCE N_2O.

c) RATE OF APPEARANCE NH_3 IS TWICE RATE DISAPPEARANCE N_2
H_2 DISAPPEARS AT 1.5 TIMES RATE NH_3 APPEARS.

6. (a) Consider the combustion of $H_2(g)$: $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$. If hydrogen is burning at the rate of 4.6 mol/s, what is the rate of consumption of oxygen? What is the rate of formation of water vapor?
(b) The reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ is carried out in a closed vessel. If the partial pressure of NO is decreasing at the rate of 30 torr/min, what is the rate of change of the total pressure of the vessel?

a) $4.6\,\frac{mol}{s} \times \frac{1\,mol/s\ O_2}{2\,mol/s\ H_2} = 2.3\,\frac{mol}{s}\,O_2$

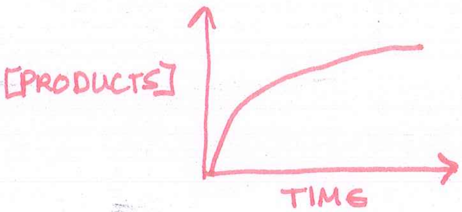
$4.6\,\frac{mol}{s}\,H_2 \times \frac{2\,mol/s\ H_2O}{2\,mol/s\ H_2} = 4.6\,\frac{mol}{s}\,H_2O$

b) Pressure NO ↓ at 30 torr/min
\+ Pressure Cl_2 ↓ at 15 torr/min
TOTAL PRESSURE ↓ = 45 $\frac{torr}{min}$

PRESSURE NOCl ↑ 30 torr/min

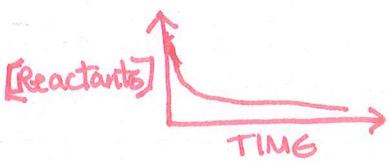
↓45 $\frac{torr}{min}$ + ↑ 30 $\frac{torr}{min}$ = ↓15 $\frac{torr}{min}$

7. Draw a graph that shows the concentration of products with time as a reaction goes to completion. Explain the shape of the graph.



At t=0, there is no product. As time passes, [PRODUCT] increases. Rate is high at first because concentration of reactants is high. Rate slows as reactants are used up.

8. Draw a graph that shows the concentration of reactants with time as a reaction goes to completion. Explain the shape of the graph.



At t=0, only reactants are present so concentration is high. As the reaction proceeds, the conc of reactants decreases as they are consumed. The rate of rxn is fast to start with and slows due to fewer reactant collisons because of lower reactant concentration.

9. Give two reasons why a collision would not result in a reaction.

1) The collisions energy is below activation energy.
2) Particles do not collide with required orientation.

10. The reaction between nitrogen and oxygen in the atmosphere under normal conditions is extremely slow. Which statement best explains this?

Same basic idea.

A. The concentration of oxygen is much lower than that of nitrogen – NOT AN EXPLANATION
B. The molar mass of nitrogen is less than that of oxygen – Doesn't matter
C. The frequency of collisions between nitrogen and oxygen molecules is lower than that between nitrogen molecules themselves ← Doesn't explain why it is slow, why collisions are ineffective.
D. Very few nitrogen and oxygen molecules have sufficient energy to react

This does the best job of explaining why few collisions are effective.

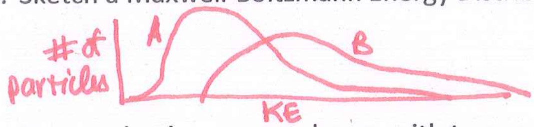
11. List 4 factors that affect reaction rates and explain why using the principles of collision theory.

Concentration: higher conc. means higher rxn rate because there are more chances for molecules to collide in a given period of time.
Surface area: ↑ # of collisions in a given period of time.
Temperature: Particles move faster so more collision/unit time. More molecules collide meeting activation energy requirement.
Catalyst: Lower ACTIVATION energy so that greater % of collisions are successful. Catalysts may also aid in proper orientation for a collision.

12. Define *activation energy*

Minimum amount of energy required for a collision to be effective.

13. Sketch a Maxwell-Boltzmann Energy Distribution Curve for two different temperatures.

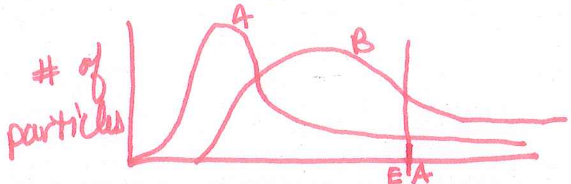


A = Lower Temp
B = Higher Temp.

14. Does activation energy change with temperature?

NO

15. How does the number of molecules with the required activation EA energy change at higher temperatures? Use energy distribution to explain.



B = Higher temp.
Area under curve to right of EA is larger meaning more particles at or above EA.

16. Give two reasons why a temperature increase, increases reaction rate and identify the more important reason.

1) ↑ in # of overall collisions.

This one is most important. It does more to ↑ rxn rate. → 2) ↑ in # of collisions at or above activation energy because more molecules have increased KE at a higher temp.

17. Explain, using the Maxwell-Boltzmann Energy distribution, why adding a catalyst increases reaction rate.

A catalyst lowers activation energy. More of the collisions taking place will be at activation energy and will successfully react.

18. Determine the rate law for the following reaction

$A + 2B \rightarrow AB_2$

A (molarity)	B (molarity)	Rate (M/s)
2	2	5
→ 2	4	10
4	4	40

$\text{Rate} = K[A]^2[B]$

19. Using the data from the previous problem, calculate the rate constant

$$K = \frac{10\ M/s}{(2M)^2(4M)} = 0.6\ M^{-2}s^{-1}$$

20. What would the rate be if the [A] = 2.5 mol dm^{-3} and [B] = 3.0 mol dm^{-3}?

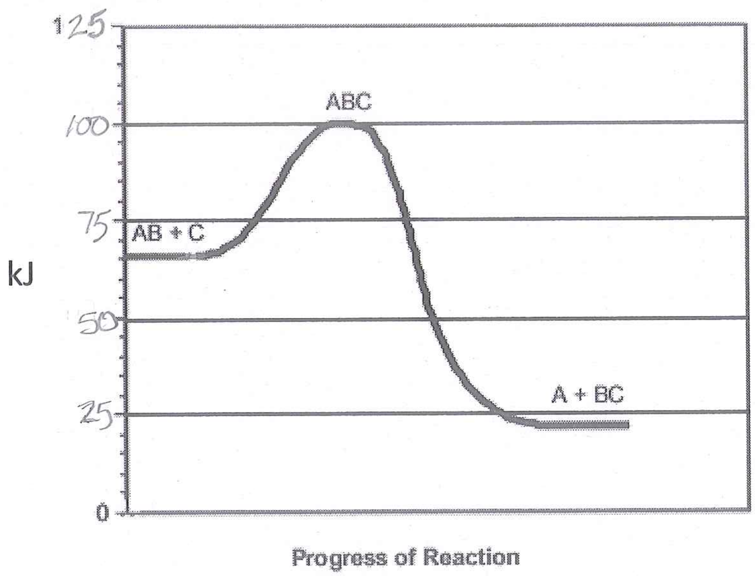
$$\text{Rate} = 0.6M^{-2}s^{-1}(2.5M)^2(3.0M) = 11\ \frac{M}{s} \Rightarrow 1\times10^{1}\ \frac{M}{s}$$

21. What is the order of reaction for the following rate laws?

	With respect to A	With respect to B	Overall
a. Rate = k [A]	1	0	1
b. Rate = k $[A]^2$	2	0	2
c. Rate = k[A][B]	1	1	2
d. Rate = $k[A]^3$	3	0	3
e. Rate = $k[A]^2[B]$	2	1	3
f. Rate = $k[A][B]^2$	1	2	3
g. Rate = k	0	0	0

22. Use the potential energy diagram (enthalpy diagram) to answer the following questions.

a.



a. Determine the activation enery for the forward reaction. 35 kJ

b. Determine the activation energy for the reverse reaction. 80 kJ

c. What is ΔH_{RXN} for the forward rxn? − 45kJ

d. What is ΔH_{RXN} for the reverse rxn? + 45 kJ

e. The forward reaction is exo thermic.

f. The reverse reaction is end thermic.

g. Which species forms the activated complex? ABC

h. Which bond is stronger, A-B or B-C? BC Explain: It has less enthalpy (potential energy). More energy required to react.

i. Which particles would have the greatest kinetic energy? A + BC

Potential energy given up converted to kinetic energy.