Worksheet #1 Approaching Equilibrium

Read unit II your textbook. Answer all of the questions. Do not start the questions until you have completed the reading. Be prepared to discuss your answers next period.

1. What are the conditions necessary for equilibrium?

Must have a closed system.

Must have a constant temperature.

Ea must be low enough to allow a

reaction.

2. What is a forward reaction versus a reverse reaction?

In a forward reaction, the reactants collide to produce products and it goes from left to right.

In a reverse reaction, the products collide to produce reactants and it goes form right to left.

3. Why does the forward reaction rate decrease as equilibrium is approached?

As the reaction goes to the right, the reaction concentration decreases and

therefore, there are less reactant collisions causing the forward rate to

decrease.

4. What are the characteristics of equilibrium?

Forward rate is equal to the reverse rate.

The concentration of reactants and products are constant.(not equal)

Macroscopic properties are constant (color, mass, density, pressure, concentrations).

5. Define equilibrium.

Equilibrium occurs when:

Forward rate is equal to the reverse rate.

The concentration of reactants and products are constant.(not equal)

Macroscopic properties are constant. (color, mass, density, pressure, concentrations)

6. Define the word dynamic and explain its relevance to the concept of equilibrium.

The word dynamic means that forward and reverse continue to occur.

7. Why does the reverse reaction rate increase as equilibrium is approached?

The reverse reaction rate increases as equilibrium is approached because as the reaction goes from left to right, the concentrations of the products increases, therefore there are more product collisions causing the reverse reaction rate to increase.

As a reaction is approaching equilibrium describe how the following change. Explain what causes each change.

8. Reactant concentration. **As the reaction goes to the right, the reaction concentration decreases.**

9. Products concentration. **As the reaction goes from left to right, the concentration of the products increases.**

10. Forward reaction rate. **The reaction concentration decreases and therefore, there are less reactant collisions causing the forward rate to decreases.**

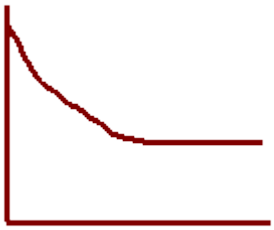
11. Reverse reaction rate. **The concentrations of the products increases, therefore there are more product collisions causing the reverse reaction rate to increase.**

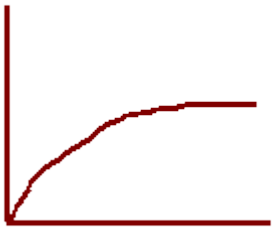
12. What is equal at equilibrium? **The forward and reverse rates are equal.**

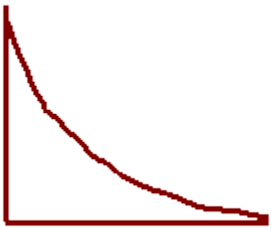
13. What is constant at equilibrium? **The reactant and product concentrations and the macroscopic properties are constant.**

14. Sketch each graph to show how concentrations change as equilibrium is approached

[reactant] [product] Overall Rate

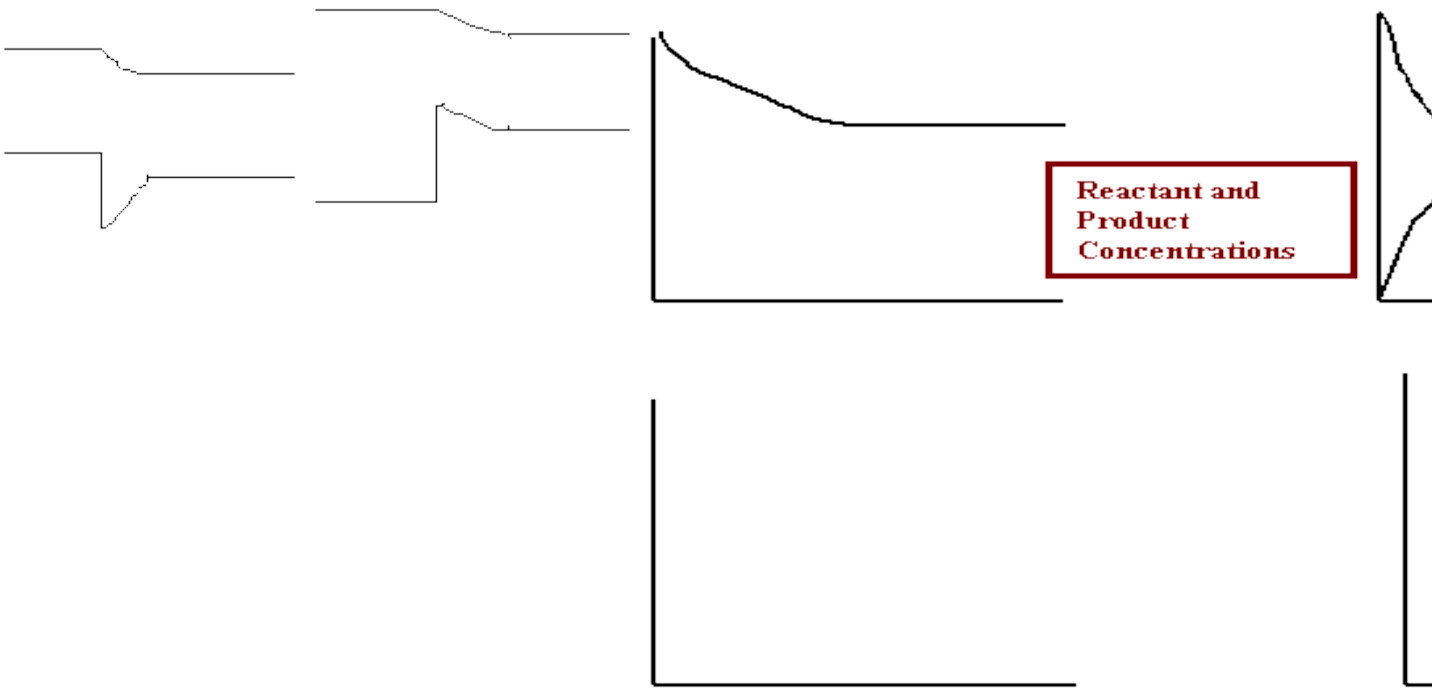






15. Label each graph with the correct description.

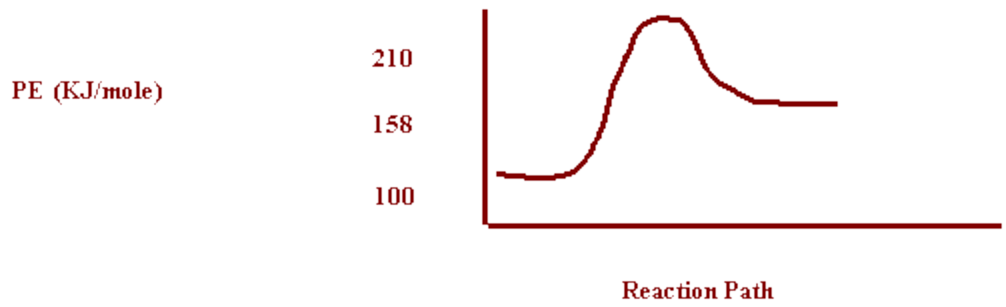
- The forward and reverse rates as equilibrium is approached
- The overall rate as equilibrium is approached
- The reactant and product concentrations as equilibrium is approached (two graphs)



16. Draw a PE Diagram for the reaction if PE of the reactants is 100 KJ/mole N_2O_4 and Ea = 110 KJ/mole N_2O_4.

$N_2O_{4\,(g)}$ <-----> $2\ NO_{2\,(g)}$ $\Delta H = +58KJ$

(colorless) (brown)



If a catalyst was added to the reaction, what would happen to the PE Diagram, the forward rate, and the reverse rate?

PE Diagram **The activation energy would decrease**
Forward rate **Increase**
Reverse rate **Increase**

One mole of very cold, colorless $N_2O_{4\,(g)}$ is placed into a 1.0L glass container of room temperature. The reaction:

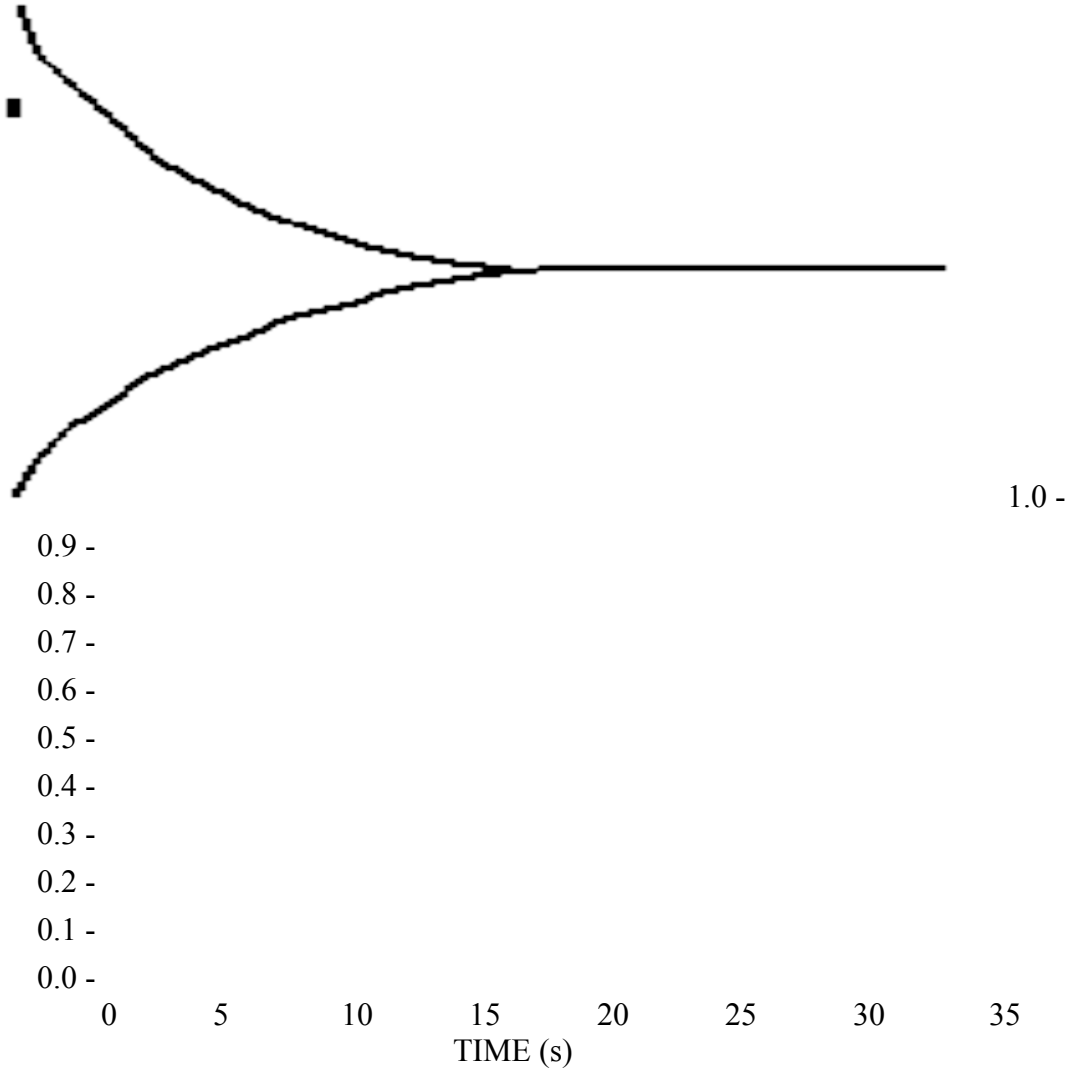
$N_2O_{4\,(g)} \rightleftharpoons 2\ N0_{2\,(g)}$ $\Delta H = +58KJ$

(colorless) (brown)

proceeds to equilibrium. The concentration of each gas is measured as a function of time.

Time (s)	0	5	10	15	20	25
$[N_2O_4]$ (M)	**1.0**	**0.83**	**0.81**	**0.80**	**0.80**	**0.80**
$[N0_2]$ (M)	**0.0**	**0.34**	**0.38**	**0.40**	**0.40**	**0.40**

17. Plot concentration of N_2O_4 and $N0_2$ against time on the same graph below.



18. After what time interval has equilibrium been established? **15 seconds**

19. Describe the change in the appearance of the container over 25 seconds (describe the colour change and when it becomes constant).

The container will gradually increase the intensity of brown and then remain constant after 15 seconds.

20. Calculate the rate of N_2O_4 consumption in (M/s) over the first 5s period and then the second 5s period.

0-5 sec. **rate = 1.0 – 0.83**

M = 0.034 M / s

5.0 sec

5-10 sec. **rate = 0.83 – 0.81**

M = 0.004 M / s

5.0 sec

Why is the rate greater over the first five minutes compared to the second five minutes (think in terms of reactant and product concentrations?

The reactant concentration has decreased and the product concentration increased. The forward rate has decreased and the reverse rate increased and because of this the overall net rate has decreased.

21. Calculate the rate of $N0_2$ production in (M/s) over the first 5s period and then the second 5s period.

0-5 sec. **rate = 0.34 – 0.00**

M = 0.068 M / s

5.0 sec

5-10 sec. **rate = 0.38 – 0.34**

M = 0.008 M / s

5.0 sec

How does the rate of formation of $N0_2$ compare to the rate of consumption of N_2O_4? Remember, if you measure the reactants or products, it is still the overall rate.

It is twice as great because of the stoichiometric relationship. $\frac{2 \text{moles } NO_2}{1 \text{mole } N_2O_4}$

22. What are the equilibrium concentrations of N_2O_4 and $N0_2$?

$[N_2O_4]$= 0.80 M **Are they equal? No!**
$[N0_2]$ = 0.40 M

23. Is the reaction over, when equilibrium has been achieved? If not, explain.

No it is not. Although the concentrations are constant, the forward and reverse reactions continue forever.

24. What are the necessary conditions to establish equilibrium?

Must have a closed system.

Must have a constant temperature.

Ea must be low enough to allow a reaction.

25. What are the characteristics of an equilibrium?

Forward rate is equal to the reverse rate.

The concentration of reactants and products are constant.(not equal)

Macroscopic properties are constant. (color, mass, density, pressure, concentrations)