

Introduction to Equilibrium

The purpose of this activity is to let students create a system at equilibrium in order to develop their own definition of this term.

Materials at your station:

2- straws (different diameters) 2- 25 mL graduated cylinders Water

Round 1:

- What do you think equilibrium means?

- In this activity you will be transferring water with different size straws from one graduated cylinder to another. How do you think you will know that you have reached equilibrium?

Procedure:

1. Put 25 mL of water in graduated cylinder A. Record the initial amount of water. Leave graduated cylinder B empty and record this in your data table. *(If possible, put your data in a graphing program like excel or goggle sheets. Doing so will let you see a graph being plotted at the same time you enter your data which allows for more interesting conclusions being drawn. See your teacher for more instructions)*
2. Put straw A in graduated cylinder A and straw B in graduated cylinder B until they touch the bottom of the cylinder. Place your finger over the top of the straw to capture water in the straw.
3. Transfer the water in straw A into graduated cylinder B, at the same time transfer water in straw B into graduated cylinder A. Record the new volumes in each graduated cylinder on the provided data table.
4. Repeat steps 2 and 3 until you get five readings with no change in volume. Equilibrium has been established.

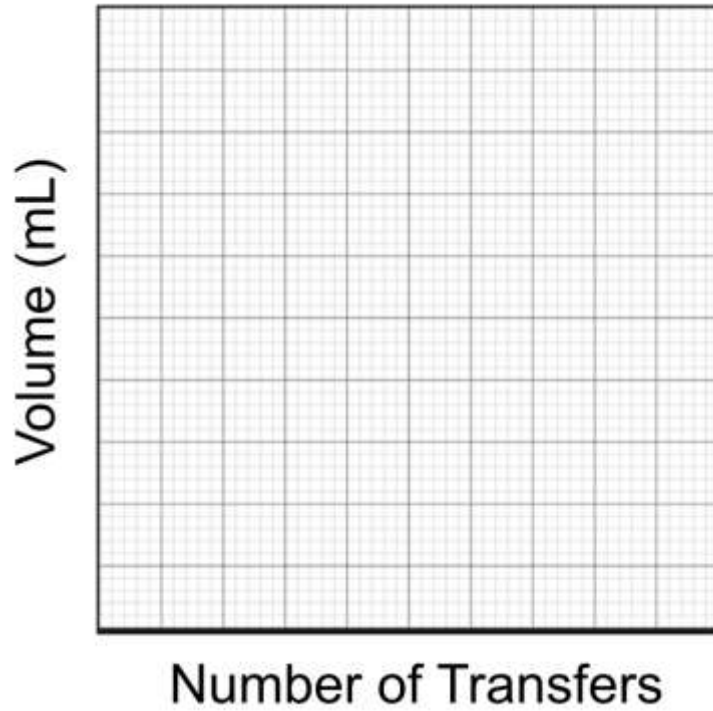
Discuss the following questions:

- What happened to the amount in graduated cylinder A? graduated cylinder B?
- Was the amount of water in graduated cylinder A equal to graduated cylinder B? If not, what was equal when you reached equilibrium?
- Write a new definition of equilibrium based on what you just learned. (Your teacher will at this point may ask you and your group to share your definition)

Data Table:

Transfers	A (mL)	B (mL)		Transfers	A (mL)	B (mL)
0				13		
1				14		
2				15		
3				16		
4				17		
5				18		
6				19		
7				20		
8				21		
9				22		
10				23		
11				24		
12				25		

Graph: Graph both the volume of A compared to number of transfers and the volume of B compared to number of transfers. Include a legend (key) to distinguish between the graph for A and the graph for B.



1. Assuming that this lab simulates the reaction: $A \rightleftharpoons B$ (reactants) \rightleftharpoons B (products)

What do the following represent?

- a. The volume of water in A _____
 - b. The volume of water in B _____
 - c. Transferring the water from A to B _____
 - d. Transferring the water from B to A _____
 - e. Number of transfers _____
2. Look at your graph.
- a. Describe what happened to the amount of A initially? _____
 - b. Describe what happened to the amount of B initially? _____
 - c. Eventually what happened to the amount of A and B? _____
 - i. What does this represent? _____
3. When your system was at equilibrium was the amount of A and B equal? _____
4. What was equal when your system was at equilibrium? _____

_____4). Which of the following best predicts how the partial pressures of the reacting species will be affected if a small amount of Ar(g) is added to the equilibrium mixture at constant volume?

- (A) P_{NO_2} will decrease and $P_{\text{N}_2\text{O}_4}$ will increase.
- (B) P_{NO_2} will increase and $P_{\text{N}_2\text{O}_4}$ will decrease.
- (C) Both P_{NO_2} and $P_{\text{N}_2\text{O}_4}$ will decrease.
- (D) No change will take place

_____5) $\text{Mg(OH)}_2(\text{s}) \rightleftharpoons \text{Mg}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$

The exothermic dissolution of $\text{Mg(OH)}_2(\text{s})$ in water is represented by the equation above. The K_{sp} of Mg(OH)_2 is 1.8×10^{-11} . Which of the following changes will increase the solubility of Mg(OH)_2 in an aqueous solution?

- (A) Decreasing the pH
- (B) Increasing the pH
- (C) Adding NH_3 to the solution
- (D) Adding $\text{Mg(NO}_3)_2$

_____6) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$

$\text{NH}_3(\text{g})$ was synthesized at 200°C in the presence of a powdered Os(s) catalyst, leading to the equilibrium system represented above. Which of the following changes would result in more $\text{NH}_3(\text{g})$ in the mixture after equilibrium is reestablished?

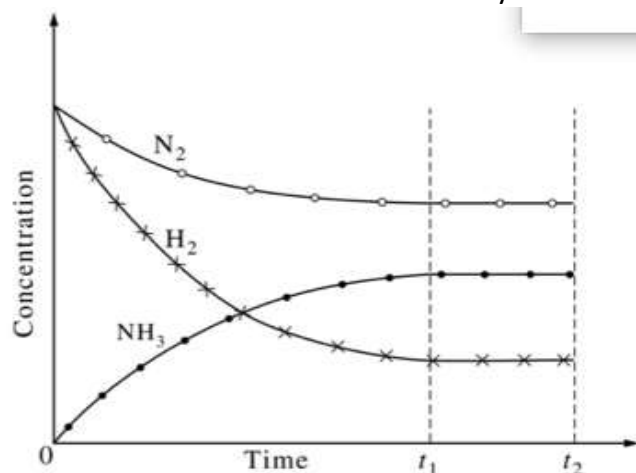
- (A) Replacing the powdered Os (s) with a solid cube of Os (s) of the same total mass.
- (B) Increasing the temperature of the system to 250°C .
- (C) Removing some H_2
- (D) Adding some N_2

Use the following information for questions 7 and 8:

H₂ gas and N₂ gas were placed in a rigid vessel and allowed to reach equilibrium in the presence of a catalyst according to the following equation.



The diagram below shows how the concentration in the system change over time.



____ 7) Which of the following was true for the system between t₁ and t₂?

- (A) The concentration of N₂ decreased.
- (B) The temperature for the system decreased.
- (C) The number of effective collisions between H₂ gas and N₂ gas was zero
- (D) The rate of the forward and reverse reactions were equal.
- (E) The rate of formation of NH₃ molecules was equal to the rate of disappearance of H₂ molecules.

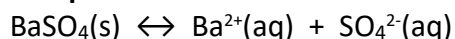
____ 8) More NH₃ gas is added to the system at time t₂ while the temperature is held constant. Which of the following will most likely occur?

- (A) The value of the equilibrium constant will increase.
- (B) The value of the equilibrium constant will decrease
- (C) The total pressure in the container will decrease
- (D) The amount of N₂ will increase.
- (E) The amount of H₂ will decrease.

____ 9). In which reaction will the point of equilibrium shift to the left when the pressure on the system is increased?

- (A) $2\text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{MgO}(\text{s})$
- (B) $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
- (C) $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g})$
- (D) $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{H}_2\text{O}(\text{g})$

Use the following information for questions 10-11



The questions below apply to an equilibrium system based on the reversible reaction given above.

_____10) What will happen to $[\text{Ba}^{2+}]$ if additional solid BaSO_4 is added to the flask?

- (A) It will increase
- (B) It will decrease
- (C) It will not change
- (D) Cannot tell with the information provided

_____11) Which direction will this reaction shift if water is added to the system above at equilibrium:

- (A) The reaction shifts left because $Q > K$
- (B) The reaction shifts right because $Q < K$
- (C) The reaction does not shift because $Q = K$
- (D) The reaction does not shift because water is a pure liquid

_____12) $\text{CH}_3\text{CH}=\text{CH}_2(g) \leftrightarrow \text{C}_3\text{H}_6(g)$

Le Chatelier's Principle predicts which action causes the endothermic reaction above to form more $\text{CH}_3\text{CH}=\text{CH}_2$ than initially present at equilibrium?

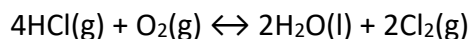
- (A) Increasing the system temperature
- (B) Decreasing the system temperature
- (C) Increasing the system pressure
- (D) Decreasing the system pressure

_____13) For the endothermic reaction: $\text{CaCO}_3(s) \leftrightarrow \text{CaO}(s) + \text{CO}_2(g)$

Only _____ would favor shifting the equilibrium position to form more CO_2 gas

- (A) increasing the pressure
- (B) decreasing the system temperature
- (C) decreasing the pressure
- (D) decreasing the volume

_____14) Which direction will this reaction shift if water is added to the system below at equilibrium:



- (A) The reaction shifts left because $Q > K$
- (B) The reaction shifts right because $Q < K$
- (C) The reaction does not shift because $Q = K$
- (D) The reaction does not shift because water is a pure liquid