Equilibrium Concepts - An Introduction

Introduction

If equilibrium is to be achieved, opposing reactions must take place in a closed system at the same rate. The two reactions, known as forward and reverse reactions, may be represented by a general equation such as:

$$A + B \underset{\text{Reverse}}{\overset{\text{Forward}}{\rightleftharpoons}} C$$

When the forward and reverse reactions are taking place at the same rate, the system is said to be in a state of 'dynamic equilibrium'. During such a state, no changes are occurring, in the macroscopic properties of the system in spite of the fact that changes are occurring at the molecular level.

In this lab, you will construct simulations for an equilibrium reaction. In the first simulation, the reactants and products are represented by the water in two separate graduated cylinders. The volume of water exchanged will represent changes in the concentrations. In the second simulation, the reactants and products are represented by cheerios, (cereal). The number of cheerios exchanged will represent changes in the concentrations in the equilibrium reaction.

Purpose

- To illustrate the experimental conditions necessary to have a system of dynamic equilibrium.
- To illustrate the effect of applying stress to a system in equilibrium.
- To represent graphically the changes which lead to the establishment of equilibrium.

PART A: DUELLING AQUARIA (Use coloured water to enable you to read the gc)

1. Copy Table I below and record your data as you perform the experiment. Work in pairs.
2. Label a 25 mL gc "A" and fill it to the 25 mL mark with water. Label a second gc "B."
3. You and your partner are to transfer water simultaneously from one cylinder to the other, using glass tubing, (gt) of different diameters. Lower the gt into your respective cylinders, and when each gt touches the bottom of the cylinder, place your index finger over the open end of the gt. Transfer the water collected to the other cylinder and allow the gt to drain.
4. Remove each gt and record the volume of water in each cylinder in Table I.
5. Return the gt to their original cylinders and **repeat the process**, recording the volumes after each transfer in Table I.
6. After three successive transfers result in no change in volume, add 5 mL of water to cylinder "A." Record the volumes in each cylinder in Table I, then **resume** the water transfer until three successive readings are again identical.

PART B: THE GREAT CHEERIO EXCHANGE

1. Work in pairs. Give person "R" 100 cheerios and the other partner "P" none.
2. Begin a series of transactions, in which each partner gives a constant fraction of his or her cheerio to the other person. Select your fractions from 0.1 to 0.9. Both partners do NOT need the same fractions. Round off to the nearest whole cheerio.
3. Record the number of cheerios each person has left after each transaction, in Table II.
4. Continue until three successive transactions result in no change in the number of cheerios, i.e. until three successive identical readings are obtained, recording in Table II.

Calculations

1. Plot the volume of water for both "A" and "B" on the y-axis of the same piece of graph paper against the number of transfers on the x-axis. Join each set of points with a smooth curve.
2. Plot two curves, one for "R" and one for "P" on another piece of graph paper. Number of cheerios on the y-axis against the transaction number on the x-axis. Join each set of points with a smooth curve.

Data Collection

Table I

Number of transfers	Volume of water cylinder "A" (mL)	Volume of water cylinder "B" (mL)
0	25	0
1		
2		
etc.		

Table II

Transaction #	cheerios of "R"	cheerios of "P"
0	100	0
1		
2		
etc.		

Questions

1. By observing your graph, describe the changes in volume (analogous to concentration) and corresponding rates which occur in each curve for up to the point where the extra 5 mL of water was added, (i.e. describe the original situation).
2. Describe the situation which is eventually reached in each gc.
3. What does this illustrate about most physical and chemical processes?
4. Describe the change which occurs in the curve for "A" at the point where the 5 mL is added.
5. What change in the final volume of the water in cylinder "B" results from the addition of the 5 mL of water to cylinder "A"?
6. What factor controls the relative volumes of water in each cylinder at equilibrium in this experiment?
7. In a real chemical system, what factor would control the relative concentration of reactants and products present at equilibrium?
8. Is there a numerical constant seen in the water exchange?
9. Describe the original situation , and describe the situation which is eventually reached in the cheerio exchange.
10. What is the evidence that equilibrium has been established if: (a) the data for the cheerio transaction are observed, or (b) the plotted data are observed?
11. Name a 'stress' which could be imposed on the cheerio equilibria.
12. Are the systems studied in the above reaction closed? Explain.

Conclusion