Name: **Date:**

act **Equilibrium: Simulation**

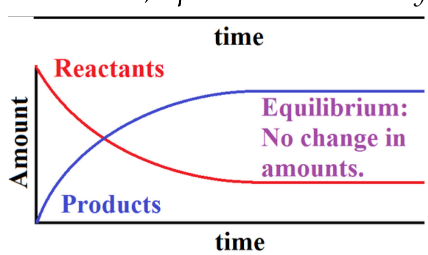
Most Important Idea:

Purpose
The purpose of this activity is to simulate a chemical reaction at equilibrium. After completing this activity, you will be able to describe the process of equilibrium, and determine a simple equilibrium constant.

Background
Up to now, we have written most chemical equations with an arrow (→) signifying that the reaction proceeds in one direction until all of the reactants (or at least the limiting reactant) is used up. However, life is a little more complicated than that. In reality, reactions actually are reversible. Most reactions proceed so much in one direction (→) that we can ignore the reverse reaction (←). In this activity, we consider a dynamic reaction - i.e., one that is in equilibrium, where both directions of the reaction are important (⇄). In other words, ***chemical equilibrium*** *is reached when the rate of the forward reaction equals the rate of the reverse reaction and the concentrations of the reactants and products no longer change with time.*

Analogy: Cans on the grocery store. If you take several still photographs at different times, the number of cans seems to stay the same. But it you take time-elapsed photography, it's obvious that cans are being added and cans are being removed.

At equilibrium, there is no net change in the concentration of reactants or products. There is still movement between reactants and products. So, equilibrium is actually a dynamic equilibrium[1]



The principle concept for equilibrium is the ***law of mass action****: concentrations of reactants and products are related. In essence, this is the law of conservation of mass.*

Activity
This activity simulates a reversible reaction, where k_f is the rate constant in the forward direction and k_r is the rate constant for the reverse direction. In this reaction simulation $k_f = 0.2$; $k_r = 0.01$.

$$A \underset{k_r}{\overset{k_f}{\rightleftharpoons}} B$$

Procedure
1. Decide which student is 'R' (reactant) and which student is 'P' (product). Student 'R' takes 100 beans; Student 'P' has no beans.

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[1] Editorial comment: The term 'dynamic equilibrium' is nearly redundant: a system must be dynamic to achieve equilibrium. The human body maintains equilibrium by homeostasis.

Reference: Wilson, Audrey H. *Equilibrium: A Teaching/Learning Activity*. J. Chem. Ed. 75(9): pp. 1176-1177. (1998)

2. Both students will exchange beans but at different rates:
   a. Student 'R' will hand over 0.2 (20%) of his/her beans.
   b. Student 'P' will hand over only 0.1 (10%) of his/her beans. Round to the closest even number whenever less than a whole bean is to be exchanged (e.g., 1.5 becomes 2; 2.5 becomes 2.)

3. Continue exchanging beans until the number of beans stays the same for three steps. Notice, by using two types of beans, you should have observed that beans are continually exchanged (reactant versus product) BUT the number of beans each student has remains the same.

4. Repeat this process of exchanging beans except the exchange rate is 0.33 [R] and 0.15 [P].

Problems:

1. Graph the data.

2. The **Equilibrium Constant (K)** gives the ratio between the reactant concentration and product concentration at equilibrium. In general, for the reaction:

$$aA + bB \rightleftarrows cC + dD$$

$$K = \frac{[C]^c\ [D]^d}{[A]^a\ [B]^b}$$

   Where a, b, c, and d are the coefficients in the balanced chemical equations and [A], [B], [C], and [D] and the concentrations of the reactants and products at equilibrium.

3. Bean equilibrium.
   a. What are the concentrations of [R] and [P] at equilibrium in the first simulation? In the second? Are they the same or different? Explain.

Data Table 1: Concentrations of Reactants & Products Over Time using 0.20 A and 0.10 B

	[Reactant] Rate: 0.20			[Product] Rate: 0.10		
STEP	lost	gained	total	lost	gained	total
0						
1						
2						
3						
4						
5						
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11						
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