DATE: NAME: CLASS:

CHAPTER 16	Investigation 16.A: Modelling Equilibrium	BLM 16.1.1
HANDOUT		

In this investigation, you will model what happens when forward and reverse reactions take place, and you will take measurements to gain quantitative insight into equilibrium systems. Then you will observe the effect caused by introducing a change to the equilibrium.

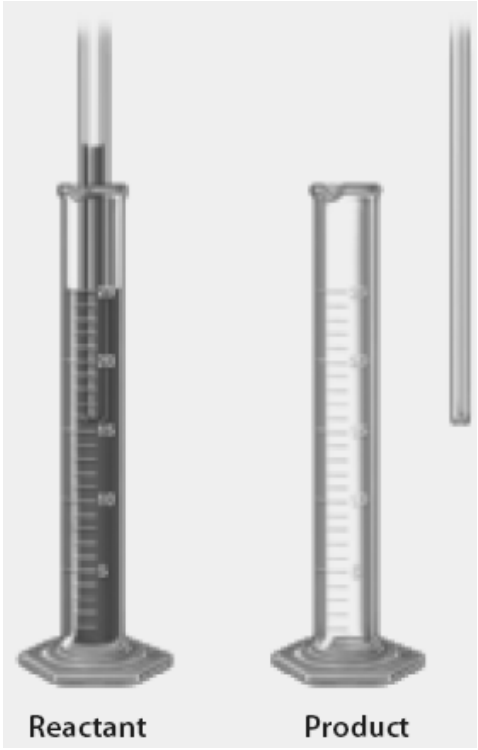
Question

How can you model a chemical equilibrium by transferring water into and out of graduated cylinders?

Materials

- water coloured with food dye
- 2 graduated cylinders (25 mL)
- 2 glass tubes of different diameters (e.g., 10 mm and 6 mm)
- 2 labels or a grease pencil

Procedure



1. Label one graduated cylinder "reactant." Label the other "product."

2. Fill the reactant graduated cylinder with coloured water up to the 25.0 mL mark. Leave the product graduated cylinder empty.

3. With your partner, transfer water simultaneously from one cylinder to the other as follows: Lower the larger diameter glass tube into the reactant graduated cylinder, keeping the top of the tube open. When the tube touches the bottom of the cylinder, cover the upper end with a finger so that the water will remain in the tube when you raise it out of the cylinder. Lift the tube that now contains water and transfer the water to the product cylinder by holding the tube over the product cylinder and releasing the water by removing your finger from the tube. *At the same time* that you are transferring liquid into the product cylinder, your partner must use the smaller diameter tube to transfer water from the product cylinder into the reactant cylinder. Of course, for the first transfer, there will be no water in the product cylinder.

4. Remove the glass tubes. In the following table, record the volume of water in each graduated cylinder to the nearest 0.1 mL.

Transfer number	Volume of water in "reactant" cylinder (mL)	Volume of water in "product" cylinder (mL)
0		
1		
2		
3		

Investigation 16.A: Modelling Equilibrium (continued)

Transfer number	Volume of water in "reactant" cylinder (mL)	Volume of water in "product" cylinder (mL)
4		
5		

5. Repeat Procedure Steps 4 and 5 until you are sure there is no change in water volume in either graduated cylinder. To be certain that no change has occurred, you will need to complete four transfers that result in approximately the same volume readings.

6. Add approximately 5 mL of water to the graduated cylinder labelled reactant. Record the volume in each cylinder, then repeat Procedure Steps 4 and 5 until your results show four transfers that result in no further change in volume.

Transfer number	Volume of water in "reactant" cylinder (mL)	Volume of water in "product" cylinder (mL)
0		
1		
2		
3		
4		
5		

HANDOUT

Investigation 16.A: Modelling Equilibrium (continued)

Analysis

1. Plot a graph of the data you collected. "Transfer number" should be recorded on the *x*-axis and "volume of liquid" on the *y*-axis. Use different symbols or colours to distinguish between the data for the reactant volume and the data for the product volume. Draw the best smooth curves you can through each set of data.

2. In this activity, the volume of liquid represents the concentration of a reactant or product. Each transfer of water represents an amount of reactant that was converted into product or product that was converted back into reactant. How can you use your graph to compare the rate of the forward reaction with the rate of the reverse reaction? What happens to these rates as the reaction proceeds? In your answers, be sure to refer to the shapes of the curves you have drawn.

3. At the point where the two curves cross, is the rate of the forward reaction equal to the rate of the reverse reaction? Explain.

4. How can you recognize when the system is at equilibrium?

Investigation 16.A: Modelling Equilibrium (continued)

5. Were the liquid volumes (that is, the concentrations of reactants and products) in the two graduated cylinders equal at the first equilibrium? Were they equal at the second equilibrium? Make a general statement about the concentrations of reactants and products at equilibrium.

6. In a chemical reaction, what corresponds to the addition of more liquid to the reactant cylinder?

7. How did the final volume of water in the product cylinder change as a result of adding more liquid to the reactant graduated cylinder?

8. Determine the ratio $\frac{\text{volume of product}}{\text{volume of reactant}}$ at the end of the first equilibrium and again at the end of the second equilibrium. Within experimental error, were these two ratios the same or different?

Investigation 16.A: Modelling Equilibrium (continued)

9. In this activity, what do you think determines the relative volumes of water in each graduated cylinder? Briefly outline an experiment you could perform to test your answer. In a real chemical reaction, what factors might affect the relative concentrations of reactants and products at equilibrium?

10. Is your experiment a model of an open or a closed system? Explain.

Conclusion

11. Describe what you learned about chemical equilibriums from completing this activity.