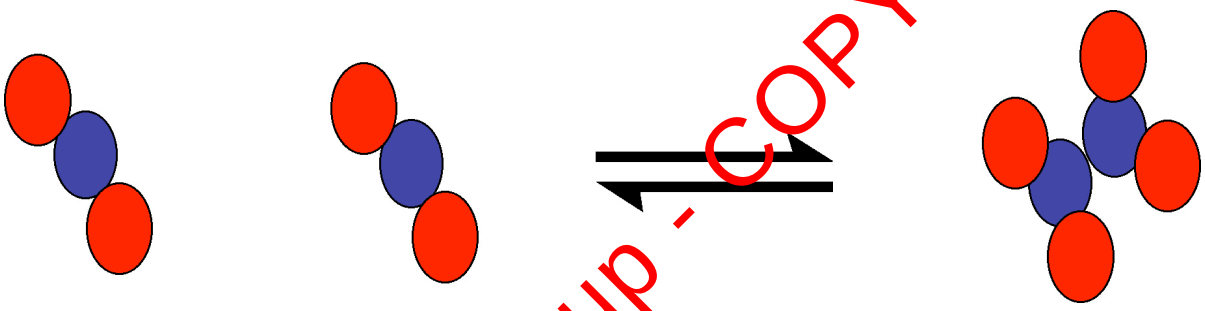
Introduction



In lesson 2, you will observe how chemical equilibrium shifts as system variables change. To complete this exploration, you will first need to make some specific observations about how the reaction changes using the tables below. Using your observations, you will derive some general rules for shifting equilibrium.

What Do You Think?

1. Write the chemical equation for this simulated reaction in the Introduction. Hint: Use the atom key from the Pre-Exploration.

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2. In your own words, explain what the equilibrium expression describes. Why is it useful to know the equilibrium expression?

Simulation Activity

This simulation will model the reaction between NO_2 and N_2O_4. Using the default settings, start the reaction.

State <u>two pieces of evidence</u> from the simulation that support your argument.

Effect of Reactant Concentration on Chemical Equilibrium

Using the default settings, run the reaction until it reaches equilibrium. Next, run 3 unique trials by altering the shaded variable <u>after</u> the reaction has come to equilibrium. For each trial, place your observations of the simulation in unshaded cells.

Trial	Reactants [NO_2]	Products [N_2O_4]	T (°C)	P (torr)	Keq	Submicroscopic Observations	Concentration Plot Observations
1 (default)							
2							
3							

Determining Shifts Based on Reactant Concentration

1. Increasing the reactant concentration shifts the equilibrium TO THE RIGHT / TO THE LEFT / NOT AT ALL (circle one). Support your claim with <u>two pieces of evidence</u> from your experiment.

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2. Decreasing the reactant concentration shifts the equilibrium TO THE RIGHT / TO THE LEFT / NOT AT ALL (circle one). Support your claims with <u>two pieces of evidence</u> from your experiment.

Effect of Product Concentration on Chemical Equilibrium

Using the default settings, run the reaction until it reaches equilibrium. Next, run 3 unique trials by altering the shaded variable only after the reaction has come to equilibrium. For each trial, place your observations of the simulation in unshaded cells.

Trial	Reactants [NO_2]	Product [N_2O_4]	T (°C)	P (torr)	Keq	Submicroscopic Observations	Concentration Plot Observations
1 (default)							
2							
3							

Determining Shifts Based on Product Concentration

1. Increasing the product concentration shifts the equilibrium TO THE RIGHT / TO THE LEFT / NOT AT ALL (circle one). Support your claims with <u>two pieces of evidence</u> from your experiment.

2. Decreasing the product concentration shifts the equilibrium TO THE RIGHT / TO THE LEFT / NOT AT ALL (circle one). Support your claims with <u>two pieces of evidence</u> from your experiment.

Effect of Pressure on Chemical Equilibrium

Using the default settings, run the reaction until it reaches equilibrium. Next, run 3 unique trials by altering the shaded variable only after the reaction has come to equilibrium. For each trial, place your observations of the simulation in unshaded cells.

Trial	Reactants [NO_2]	Products [N_2O_4]	P (torr)	T (°C)	Keq	Submicroscopic Observations	Concentration Plot Observations
1 (default)							
2							
3							

Determining Shifts Based on Pressure

1. Increasing the pressure shifts the equilibrium TO THE RIGHT / TO THE LEFT / NOT AT ALL (circle one). Support your claims with <u>two pieces of evidence</u> from your experiment

2. Decreasing the pressure shifts the equilibrium TO THE RIGHT / TO THE LEFT / NOT AT ALL (circle one). Support your claims with <u>two pieces of evidence</u> from your experiment.

Effect of Temperature on Chemical Equilibrium

Using the default settings, run the reaction until it reaches equilibrium. Next, run 3 unique trials by altering the shaded variable only after the reaction has come to equilibrium. For each trial, place your observations of the simulation in unshaded cells.

Trial	Reactants [NO_2]	Products [N_2O_4]	P (torr)	T (^oC)	Keq	Submicroscopic Observations	Concentration Plot Observations
1 (default)							
2							
3							

Determining Shifts Based on Temperature

1. Increasing the temperature INCREASES / DECREASES / DOES NOT CHANGE (circle one) the equilibrium position of the reaction.

2. Decreasing the temperature INCREASES / DECREASES / DOES NOT CHANGE (circle one) the equilibrium position of the reaction.

Effect of a Catalyst on Chemical Equilibrium

Begin by setting the following variables and allowing the reaction to reach equilibrium. Next, run three unique trials in which you add a catalyst to the reaction at the time in the **shaded cells**. Record your observations of the simulation in the unshaded cells.

Trial	Reactants [NO_2]	Products [N_2O_4]	P (torr)	T (^oC)	Keq	Submicroscopic Observations	Concentration Plot Observations
1 (default)							
2 t=10s							
3 t=250s							

What Do You Think About Catalysts?

In your own words, describe how the addition of a catalyst affects chemical equilibrium. Why does it have this effect? Support your claims with two pieces of evidence from your experiment.

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Effect of an Inert Gas on Chemical Equilibrium

Begin by setting the following variables and allowing the reaction to reach equilibrium. Next run three unique trials in which you add an inert gas to the reaction at the time in the **shaded cells**. Record your observations of the simulation in the unshaded cells.

Trial	Reactants $[NO_2]$	Product $[N_2O_4]$	P (torr)	T (^oC)	Keq	Submicroscopic Observations	Concentration Plot Observations
1 (default)							
2 t=10s							
3 t=250s							

What Do You Think About Inert Gases?

In your own words, describe how the addition of an inert gas affects the chemical equilibrium of a gaseous reaction. Support your claims with two pieces of evidence from your experiment.

Final Predictions

As you conclude the lesson, predict the effect of each of the following variables on chemical equilibrium.

$2NO_2 \leftrightarrow N_2O_4$ + heat

- Increasing the reactant concentration shifts the equilibrium
  TO THE RIGHT / TO THE LEFT / NOT AT ALL.
- Increasing the product concentration shifts the equilibrium
  TO THE RIGHT / TO THE LEFT / NOT AT ALL.
- Increasing the pressure shifts the equilibrium
  TO THE RIGHT / TO THE LEFT / NOT AT ALL.
- Increasing the temperature shifts the equilibrium
  TO THE RIGHT / TO THE LEFT / NOT AT ALL.
- Adding a catalyst to a reaction shifts the equilibrium
  TO THE RIGHT / TO THE LEFT / NOT AT ALL.
- Adding an inert gas to a reaction shifts the equilibrium
  TO THE RIGHT / TO THE LEFT / NOT AT ALL.