Le Châtelier’s Principle

- Situation
  - A system is at equilibrium
  - A change is imposed
  - The equilibrium position shifts in the direction that alleviates the stress imposed by the change.

Le Châtelier’s Principle

- Example in terms of Q and K
  - The formation of ammonia from its elements has a value of $K = 0.0596$
  - Given equilibrium concentrations of $[N_2] = 0.399 \text{ M}$; $[H_2] = 1.197 \text{ M}$ and $[NH_3] = 0.202 \text{ M}$
  - What happens when 1.000 M $N_2$ is added?

$$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$$
$$K = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{[0.202]^2}{[0.399][1.197]^3} = 0.0596$$

Le Châtelier’s Principle

- We can calculate Q by adding 1.000 M to $[N_2]$
- All other concentrations are the same.

$$Q = \frac{[0.202]^2}{[1.399][1.197]^3} = 0.0170$$
$$Q < K \text{ equilibrium shifts right (makes more } NH_3)$$

Le Châtelier’s Principle

- In the previous example the equilibrium shifted to reduce the concentration of $N_2$, which had been added to.
- You may not always know what K is or what the concentrations are.
- Need some general guidelines to predict equilibrium shifts.

Le Châtelier’s Principle

- Concentration
  - Always moves to reduce the concentration that has been added to.
  - Reactants added: more products made
  - Products added: more reactants made

Le Châtelier’s Principle

- Pressure
  - Ways to change pressure
    - Add or remove a gaseous product or reactant
    - Add an inert gas
      - Does not take part in the reaction
      - Does change the pressure of the system
    - Change the volume of the container
      - Pressure changes inversely with volume
Le Châtelier’s Principle

- **Pressure (cont’d)**
  - Adding or removing a gaseous product or reactant
  - Works the same way as changing the concentration
  - Adding an inert gas
    - No effect
    - Changes total pressure
    - Equal effects on partial pressures / concentrations of other gases

- **Temperature**
  - Changes the value of the equilibrium constant
  - Other changes described do not change $K$
  - Need to know the sign of $\Delta H$ to make a prediction
  - Exothermic – increasing temperature increases the reactants
  - Endothermic – increasing temperature increases the products

Which of the following CANNOT affect the extent of reaction?

A. changing the temperature
B. adding a catalyst
C. increasing the amounts of reactants
D. removing some product
E. changing the volume

Which of the following cases is the reaction expected to be exothermic?

A. Increasing the pressure increases the amount of product formed.
B. Increasing the amount of reactants increases the amount of product formed.
C. Increasing the temperature increases the amount of product formed.
D. Increasing the volume decreases the amount of product formed.
E. Increasing the temperature decreases the amount of product formed.