A temperature change occurs when temperature is increased or decreased by the flow of heat. This shifts chemical equilibria toward the products or reactants, which can be determined by studying the reaction and deciding whether it is endothermic or exothermic.

### Introduction

Le Châtelier's principle states that a change in temperature, pressure, or concentration of reactants in an equilibrated system will stimulate a response that partially offsets the change to establish a new equilibrium. In the case of changing temperature, adding or removing of heat shifts the equilibrium. Typically chemical reactions are written to not explicitly address the flow of heat in the reaction. For example, the below chemical equation describing the oxidation of carbon to make carbon monoxide contains all the information regarding matter and bonding:

\[2C \; (s) + O_{2} \; (g) \rightarrow 2CO \; (g) \tag{1}\]

However, reactions invariably involve changes in enthalpy, with energy (typically in the form of heat, but can involve light) either being absorbed or released during the reaction. The more complete reaction would be written as

\[2C \; (s) + O_{2} \; (g) \rightarrow 2CO_{(g)} + heat \tag{2}\]

### Heat of Reaction

The Heat of Reaction is the change in the enthalpy of a chemical reaction. In endothermic reactions, \((\Delta H>0)\) heat is absorbed with the reactants. For example, more energy is needed to overcome the forces of attraction between molecules and to separate them from one another (the activation energy) than the energy gained when new bonds are formed.

\[heat + 6CO_{(g)} + 6H_{2O_{(l)}} \rightarrow C_{6}H_{12}O_{6(aq)} + 6O_{2(g)}\]

In exothermic reactions, \((\Delta H<0)\) heat is released with the products. When separated molecules join together, enough energy is released to overcompensate for the energy required to break reactant bonds. In this chemical reaction

\[CaO_{(s)} + H_{2O_{(l)}} \rightarrow Ca(OH)_{2(s)} + heat\]

the forward reaction is exothermic because energy is released when \(\langle CaO_{(s)}\rangle\) and \(\langle H_{2O_{(l)}}\rangle\) combine to form \(\langle Ca(OH)_{2(s)}\rangle\). The energy to break the bonds in \(\langle CaO_{(s)}\rangle\) and \(\langle H_{2O_{(l)}}\rangle\) on the left side of the equation is lower than the amount of energy released from forming the \(\langle Ca(OH)_{2(s)}\rangle\) on the right side of the equation, and the net difference is observed as heat on the right side of the equation.

Example \(\langle PageIndex{1}\rangle\)

In the oxidation reaction

\[CaO_{(s)} + H_{2O_{(l)}} \rightarrow Ca(OH)_{2(s)} + heat\]

- Raising the temperature favors the reverse reaction (endothermic)
• **Lowering** the temperature favors the **forward** reaction (exothermic)

Example \(\PageIndex{2}\)

In the reaction

\[2C_{(s)} + O_{2 \; (g)} \rightleftharpoons 2CO_{(g)} + \text{heat}\]

Le Châtelier’s principle explains that the reaction will proceed in such a way as to counteract the temperature change. The exothermic reaction will favor the reverse reaction, opposite the side heat is (the opposite is true in endothermic reactions; the reaction will proceed in the forward reaction)

Although it is not technically correct to do so, if heat is treated as product in the above reaction, then it becomes clear that if the temperature is increased the equilibrium will shift to the left (using Le Châtelier's principle). If temperature is decreased, the reaction will proceed forward to produce more heat (which is lacking). The effect of temperature on equilibrium will also change the value of the equilibrium constant.

---

**Problems**

1. If heat is added to a phase change equation at equilibrium from solid to liquid, which way will the reaction proceed?
2. Which side is heat on in this reaction (photosynthesis): \(6CO_{2\; (g)} + 6H_2O_{\text{aq}} \rightleftharpoons C_6H_{12}O_6(aq) + 6O_2(g)\)?
3. In a combustion reaction is heat absorbed or released?
4. In this reaction: \(H_2O_{(l)} \rightleftharpoons H_2O_{(g)}\), how could conditions be manipulated to create more \(H_2O_{(l)}\)?
5. Explain how to determine if a reaction is exothermic or endothermic.

---

**Solutions**

1. The reaction will proceed towards the liquid phase.
2. Heat is on the reactant side of the equation.
3. Heat is released in a combustion reaction.
4. Lowering temperature will shift equilibrium left, creating more liquid water.
5. A reaction that is exothermic releases heat, while an endothermic reaction absorbs heat.

---

**Internal Links**

• [Exothermic vs. Endothermic and K](#)
References


Contributors

• Karissa Pulido (UCD), Carlynn Chappell (UCD), Aileen McDuff (UCD)