

CONCEPT: LE CHATELIER'S PRINCIPLE

● **Le Chatelier's Principle:** if a chemical reaction at _____ is disturbed, it adjusts itself by shifting in a certain direction.

- Direction of the shift depends on minimizing or canceling the disturbance & re-establishing _____.
- The following disturbances are carried out at constant _____.

Disturbances of Chemical Equilibrium			
Factors	Type of Change	Example	Explanation
Concentrations only (g) & (aq)	□ _____ [Reactant] or □ _____ [Product]	$\uparrow 2A(g) + B(aq) \rightleftharpoons C(g) + 4D(g) \downarrow$	□ more _____ will be made
	□ _____ Pressure or □ _____ Volume	$\text{_____ moles gas } 2A(g) + B(aq) \rightleftharpoons C(g) + 4D(g) \text{ _____ moles gas}$	□ shifts to side with _____ moles of gas
Inert Gas (Noble Gases)	□ _____ at constant V	$\text{_____ } + Ne(g) \quad 2A(g) + B(aq) \rightleftharpoons C(g) + 4D(g)$	□ partial pressures are _____ changed □ if V or P not mentioned, assume _____ shift
	□ _____ at constant P	$\text{_____ } + Ne(g) \quad 2A(g) + B(aq) \rightleftharpoons C(g) + 4D(g)$	□ volume increases - shifts to side with _____ moles of gas

- *Note:* adding **Catalysts** _____ cause a shift in equilibrium position, it simply changes the reaction rates.

EXAMPLE: Consider endothermic reaction at equilibrium: $6 CO_2(g) + 6 H_2O(g) \rightleftharpoons C_6H_{12}O_6(s) + 6 O_2(g)$

Predict if reaction will shift to the right, left or no shift after each disturbance.

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| a) some O_2 removed _____ | c) volume of container decreased _____ |
| b) some $C_6H_{12}O_6$ added _____ | d) Xe gas added to reaction mixture _____ |

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Temperature Changes

- Changing the temperature of the reaction at equilibrium will _____ the equilibrium and cause a _____.
 - _____ of a reaction plays a big role in the direction of the change.
 - Recall: equilibrium constant is temperature dependent.

Temperature Changes			
Enthalpy Type	Type of Change	Example	Explanation
Exothermic (-ΔH)	□ ____ Temp	$2A(g) + B(aq) \rightleftharpoons C(g) + 4D(g) + \text{heat}$ _____	□ shifts away from heat
Endothermic (+ΔH)	□ ____ Temp	$\text{heat} + 2A(g) + B(aq) \rightleftharpoons C(g) + 4D(g)$ _____	□ shifts towards heat

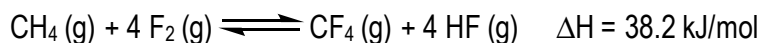
EXAMPLE: Consider the reaction: $N_2(g) + O_2(g) + Br_2(g) \rightleftharpoons 2 NOBr(g)$ $\Delta H = - 32.5 \text{ kJ}$

The following changes will shift equilibrium to the left except:

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|----------------------|--------------------------------------|-----------------------------------|
| a) Remove some N_2 | c) Increase partial pressure of NOBr | e) Increase Pressure in container |
| b) Adding some NOBr | d) Decrease the temperature | f) Decrease the container volume |

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PRACTICE: Select correct answer(s) that would yield more products in the following reaction.



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|-------------------------|-----------------------------------|------------------------------|
| a) increase pressure | c) add 0.31 moles of F_2 | e) cool down reaction vessel |
| b) increase temperature | d) add some Xenon gas | f) decrease volume |

PRACTICE: At 26°C $K_p = 2.3 \times 10^{-12}$ and at 56°C $K_p = 3.7 \times 10^{-5}$ for the hypothetical reaction. Determine if the reaction is endothermic or exothermic. $\text{AB} (\text{s}) + 2 \text{B} (\text{g}) \rightleftharpoons 3 \text{BB} (\text{g}) + \text{C} (\text{g})$

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| a) endothermic | b) exothermic | c) enthalpy change equal to zero |
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