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]	↑ 2A (g) + B(aq) ⇌ C (g) + 4D (g) ↓ _____	□ more _____ will be made
Pressure & Volume	□ ____ Pressure or □ ____ Volume	___ moles gas ___ moles gas 2A (g) + B(aq) ⇌ C (g) + 4D (g) _____	□ shifts to side with _____ moles of gas
Inert Gas (Noble Gases)	□ _____ at constant V	+ Ne (g) 2A (g) + B(aq) ⇌ C (g) + 4D (g) ____ _____	□ partial pressures are _____ changed □ if V or P not mentioned, assume ____ shift
	□ _____ at constant P	+ Ne (g) 2A (g) + B(aq) ⇌ 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.

a) some O_2 removed _____

b) some $C_6H_{12}O_6$ added _____

c) volume of container decreased _____

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: $N_2\,(g) + O_2\,(g) + Br_2\,(g) \rightleftharpoons 2\,NOBr\,(g)$ $\Delta H = -32.5$ kJ

The following changes will shift equilibrium to the left except:

a) Remove some N_2

b) Adding some NOBr

c) Increase partial pressure of NOBr

d) Decrease the temperature

e) Increase Pressure in container

f) Decrease the container volume

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

$$CH_4\,(g) + 4\,F_2\,(g) \rightleftharpoons CF_4\,(g) + 4\,HF\,(g) \quad \Delta H = 38.2\ kJ/mol$$

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 26ºC Kp = 2.3×10^{-12} and at 56ºC Kp = 3.7×10^{-5} for the hypothetical reaction. Determine if the reaction is endothermic or exothermic. $AB\,(s) + 2\,B\,(g) \rightleftharpoons 3\,BB\,(g) + C\,(g)$

a) endothermic

b) exothermic

c) enthalpy change equal to zero