

# Chapter 13 Part 2

Dr. Turner

# Relating K and Chemical Equations

- If a chemical equation is modified in some way, the equilibrium constant must be changed to reflect the modification

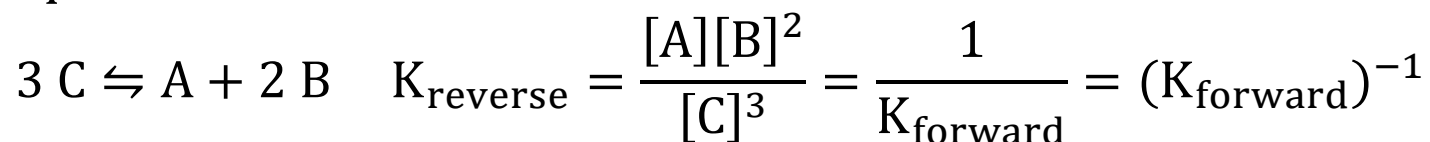
# Relating K and Chemical Equations

1. If you reverse the equation, invert the equilibrium constant

Original Equation



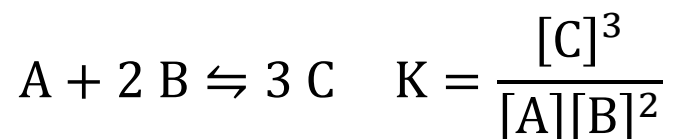
New Equation



# Relating K and Chemical Equations

2. If you multiply the coefficients in the equation by a factor, raise the equilibrium constant to the same factor

Original Equation



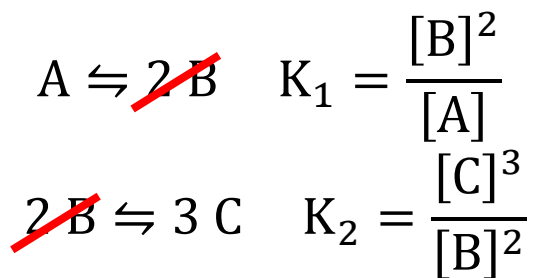
New Equation

$$n A + 2n B \rightleftharpoons 3n C \quad K' = \frac{[C]^{3n}}{[A]^n[B]^{2n}} = \left( \frac{[C]^3}{[A][B]^2} \right)^n = K^n$$

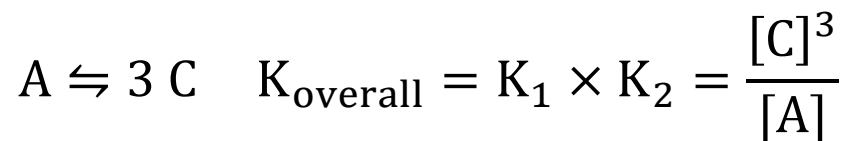
# Relating K and Chemical Equations

3. If you add two or more individual chemical equations, multiply the corresponding equilibrium constants by each other to obtain the overall equilibrium constant.

Original Equations



New Equation

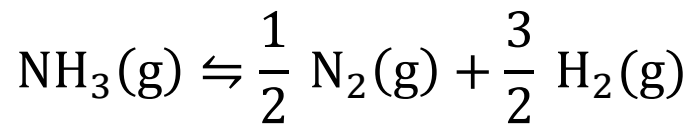


# Relating K and Chemical Equations

Consider the following chemical equation and equilibrium constant for the synthesis of ammonia at 25°C:

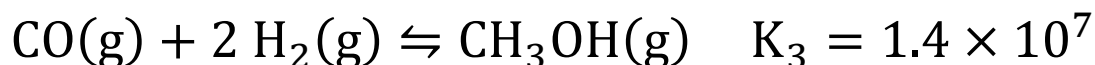
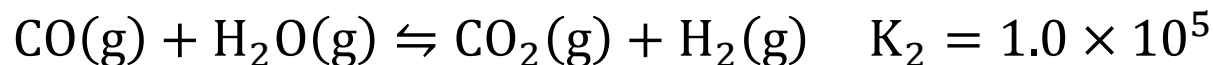
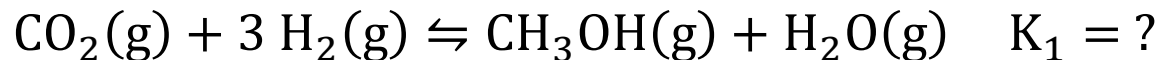


Compute the equilibrium constant for the following reaction at 25°C.



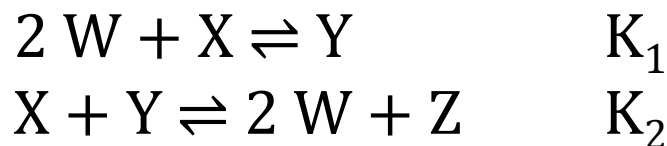
# Relating K and Chemical Equations

Predict the equilibrium constant for the first reaction given the equilibrium constants for the second and third reactions:



# Relating K and Chemical Equations

How should the two equilibrium constants  $K_1$  and  $K_2$  be mathematically combined to give the overall equilibrium constant for the reaction  $2 X \rightleftharpoons Z$ ?



- A.  $(K_1) + (K_2)$
- B.  $(K_1) - (K_2)$
- C.  $(K_1)(K_2)$
- D.  $(K_1)/(K_2)$



# Le Chatelier's Principle

- When a system at equilibrium is disturbed, it returns to equilibrium by counteracting the disturbance.

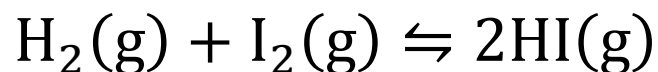
# Changing the concentration

The equation for a system at equilibrium is:



# Changing the concentration

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Which direction will the equilibrium shift in order to reestablish equilibrium if

- the concentration of  $\text{H}_2$  is increased?

# Changing the concentration

The equation for a system at equilibrium is:



Which direction will the equilibrium shift in order to reestablish equilibrium if

- the concentration of  $\text{I}_2$  is decreased?

# Changing the concentration

The equation for a system at equilibrium is:

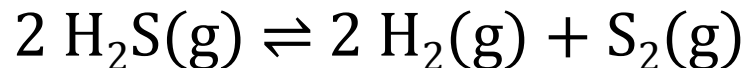


Which direction will the equilibrium shift in order to reestablish equilibrium if

- the concentration of HI is decreased?

# Changing the concentration

Determine the direction in which this reaction shifts after the following changes are made to the system.



- A. increasing the concentration of  $\text{H}_2\text{S}$
- B. increasing the concentration of  $\text{H}_2$
- C. removing  $\text{S}_2$  from the system

# Changing the concentration

- Changing the concentrations of solids and pure liquids do not apply to Le Chatelier's principle as they do not affect the equilibrium constant.

# Changing the temperature

The equation for a system at equilibrium is:



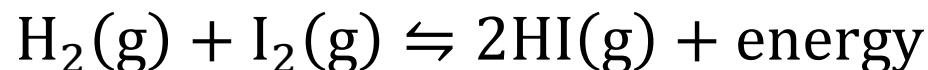
Is this reaction endothermic or exothermic?

Does this mean that energy is released or absorbed?



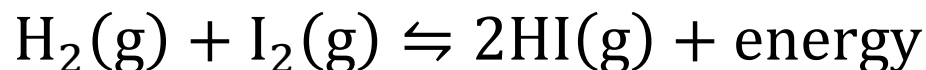
# Changing the temperature

This means that we can write the equation with energy as a product



# Changing the temperature

This means that we can write the equation with energy as a product



Changing the temperature will now just be like changing the concentration

- Raising the temperature is increasing the concentration of energy
- Lowering the temperature is decreasing the concentration of energy

# Changing the temperature

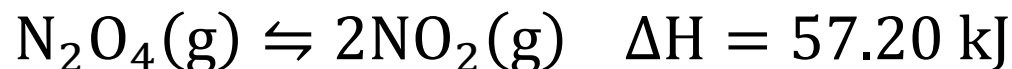
The equation for a system at equilibrium is:



What direction will the equilibrium shift if the temperature is increased?

# Changing the temperature

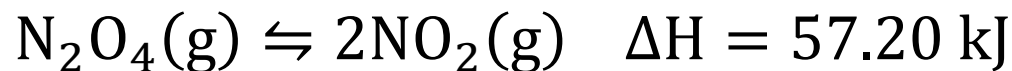
The equation for a system at equilibrium is:



What direction will the equilibrium shift if the temperature is increased?

# Changing the temperature

The equation for a system at equilibrium is:



What direction will the equilibrium shift if the temperature is decreased?

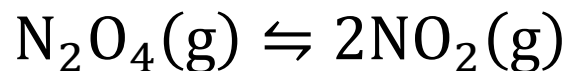
# Changing the pressure



Changing the pressure only has a measureable effect on gaseous systems

# Changing the pressure (of a gaseous system)

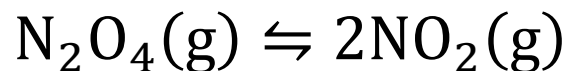
The equation for a system at equilibrium is:



How many moles are on the products side?

# Changing the pressure (of a gaseous system)

The equation for a system at equilibrium is:

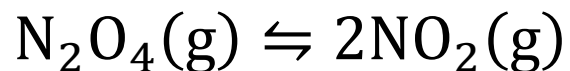


Would increasing the pressure of the system put more strain on a reaction making something with more moles or less moles?



# Changing the pressure (of a gaseous system)

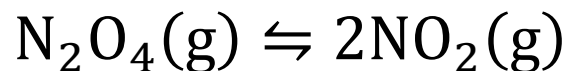
The equation for a system at equilibrium is:



Which direction will the equilibrium shift upon increasing the pressure?

# Changing the pressure (of a gaseous system)

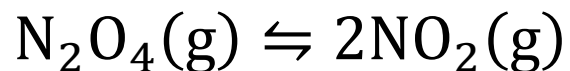
The equation for a system at equilibrium is:



Which direction will the equilibrium shift upon decreasing the pressure?

# Changing the volume (of a gaseous system)

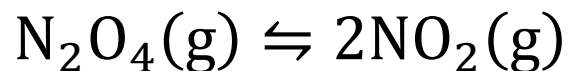
The equation for a system at equilibrium is:



Which direction will the equilibrium shift upon increasing the volume of the container?

# Changing the volume (of a gaseous system)

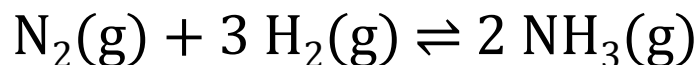
The equation for a system at equilibrium is:



Which direction will the equilibrium shift upon decreasing the volume of the container?

# Changing volume and pressure

Determine the direction in which the equilibrium position of this reaction, occurring in a sealed container with variable volume, shifts after the changes below.



- A. The volume of the container is decreased.
- B. The volume of the container is increased.
- C. The pressure of the container is increased.

# Adding Catalysts

## Does change

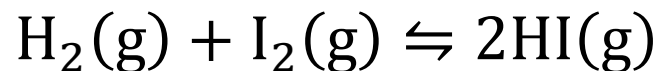
- The rate of the forward and reverse reaction (The system will reach equilibrium more quickly)

## Doesn't change

- The value of the equilibrium constant
- Equilibrium concentrations

# Adding a catalyst

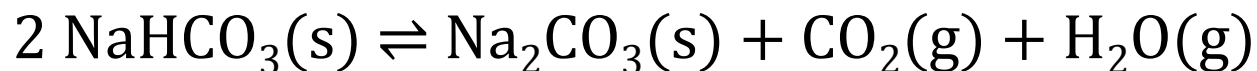
The equation for a system at equilibrium is:



Which direction will the equilibrium shift upon adding a catalyst?

# Le Chatelier's Principle

Which change will cause more  $\text{CO}_2$  to form in a closed container?  $\Delta H = 136 \text{ kJ}$



- A. adding  $\text{H}_2\text{O}(\text{g})$
- B. removing  $\text{NaHCO}_3(\text{s})$
- C. removing  $\text{Na}_2\text{CO}_3(\text{s})$
- D. increasing the pressure
- E. heating the container



# Le Chatelier's Principle

Which change will shift this exothermic reaction to the right?



- A. adding argon and holding the container volume constant
- B. adding a catalyst
- C. removing products
- D. removing reactants
- E. heating the container