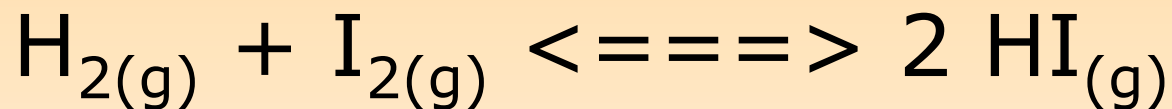


# EQUILIBRIUM LAW - $K_{eq}$

A simple mathematical relationship defines each reaction at chemical equilibrium.

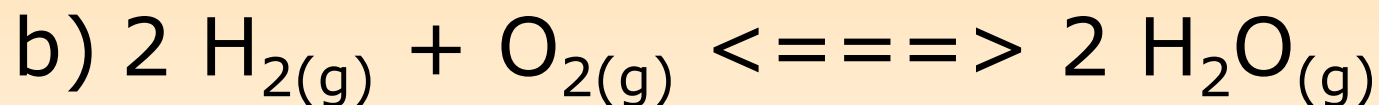
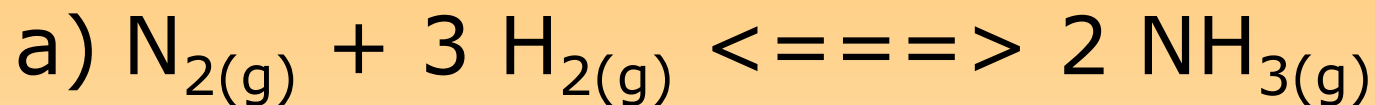


# EQUILIBRIUM LAW - $K_{eq}$

- can always be developed from the balanced chemical equation
- $K_{eq}$  will always have a specific value at specific environmental conditions
  - if the conditions change, the  $K_{eq}$  will also change
- units for  $K_{eq}$  will never be used

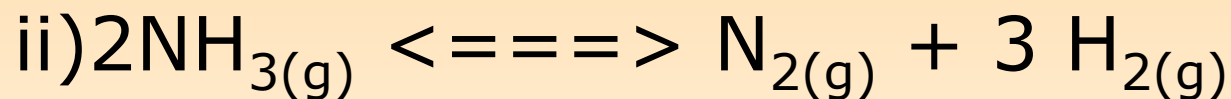
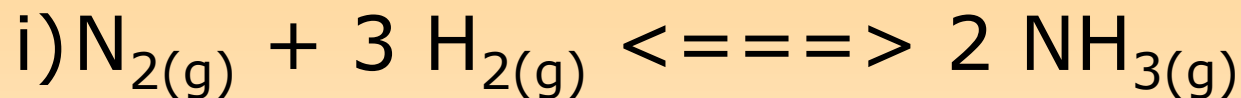
# EQUILIBRIUM LAW - $K_{eq}$

## Example #1



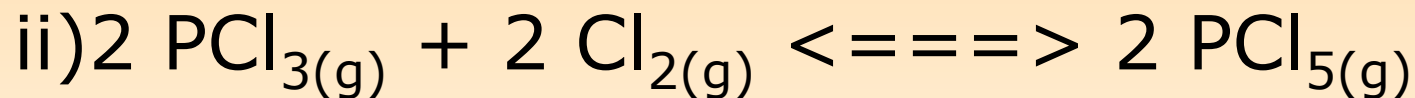
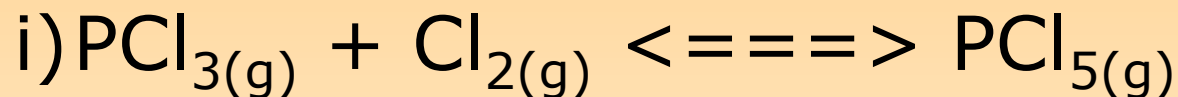
# EQUILIBRIUM LAW - $K_{eq}$

How are the equilibrium laws of the following equations related?



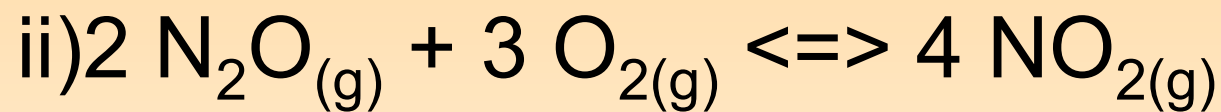
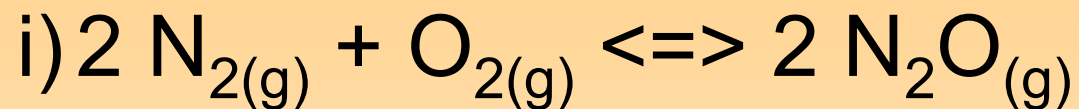
# EQUILIBRIUM LAW - $K_{eq}$

How are the equilibrium laws of the following equations related?



# EQUILIBRIUM LAW - $K_{eq}$

What is the equilibrium law of the sum of the following reactions?



# EQUILIBRIUM LAW - $K_{eq}$

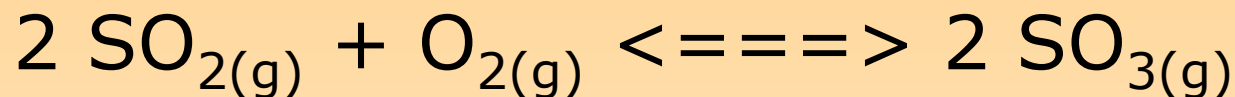
When chemical equilibria are added together, the equilibrium constants are multiplied together.

$$K_{eq \text{ final rxn}} = K_{eq \text{ rxn 1}} \times K_{eq \text{ rxn 2}}$$

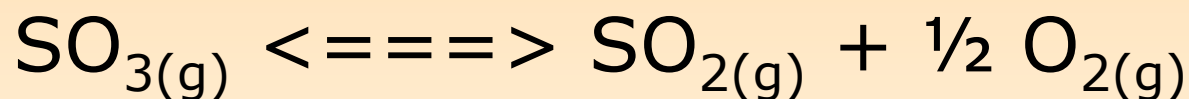
# EQUILIBRIUM LAW - $K_{eq}$

## Example #2

At 25°C,  $K_{eq} = 7.0 \times 10^{25}$  for:



What is the value of  $K_{eq}$  for:



$$\begin{aligned} K_{eq} &= 7.0 \times 10^{25} \text{ inversed, to the power of } 0.5 \\ &= 1.195 \times 10^{-13} \\ &= 1.2 \times 10^{-13} \end{aligned}$$



# EQUILIBRIUM LAW - $K_{eq}$

## MAGNITUDE OF $K_{eq}$

The value of  $K_{eq}$  (large or small) can provide a hint to the ratio of reactants to products at equilibrium.

# EQUILIBRIUM LAW - $K_{eq}$

## MAGNITUDE OF $K_{eq}$

1.  $K_{eq}$  is very large ( $K_{eq} > 1$ )

-  $\frac{[\text{products}]}{[\text{reactants}]}$

2.  $K_{eq} \approx 1$

-  $\frac{[\text{products}]}{[\text{reactants}]}$

3.  $K_{eq}$  is very small ( $K_{eq} < 1$ )

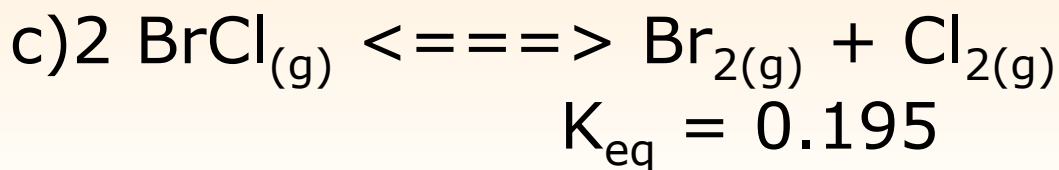
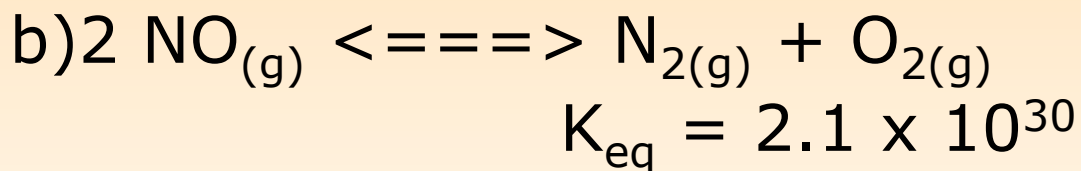
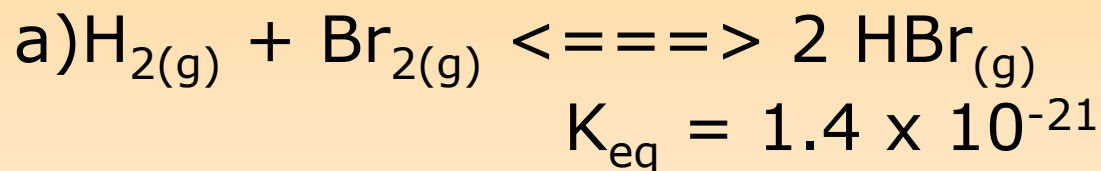
-  $\frac{[\text{products}]}{[\text{reactants}]}$

# EQUILIBRIUM LAW - $K_{eq}$

## MAGNITUDE OF $K_{eq}$

### Example #3

Which of the following reactions will tend to proceed farthest toward completion?



# EQUILIBRIUM LAW - $K_{eq}$

## EQUILIBRIUM - SOLIDS AND LIQUIDS

What is the concentration of a solid or liquid? (i.e.  $H_2O$ )

Does the concentration of these pure compounds change?

ex. 1 mol  $NaHCO_3$  occupies  $38.9 \text{ cm}^3$

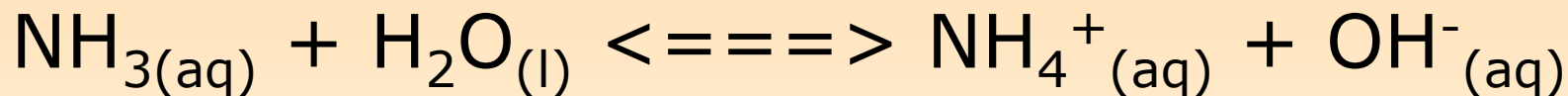
2 mol  $NaHCO_3$  occupies  $77.8 \text{ cm}^3$

Molar concentration remains the same. Solids and liquids are unaffected by concentration

# EQUILIBRIUM LAW - $K_{eq}$

## EQUILIBRIUM - SOLIDS AND LIQUIDS

In the equilibrium law, solids and liquids do not need to be included as it becomes part of the equilibrium constant.



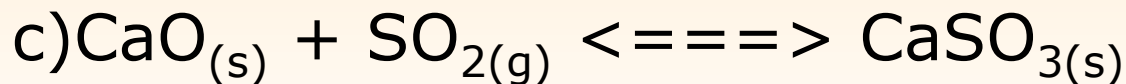
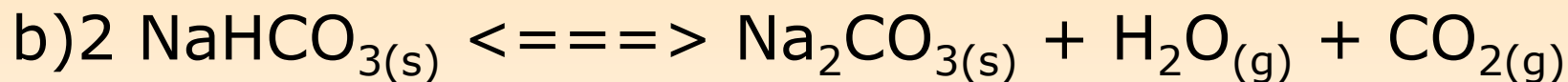
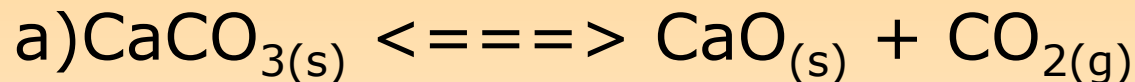
$$K_{eq} = \frac{[\text{NH}_4^+_{(aq)}][\text{OH}^-_{(aq)}]}{[\text{NH}_{3(aq)}]}$$

# EQUILIBRIUM LAW - $K_{eq}$

## EQUILIBRIUM - SOLIDS AND LIQUIDS

### Example #4

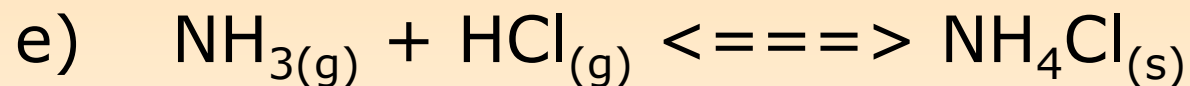
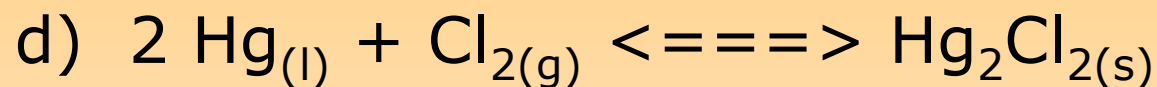
Write the equilibrium law for the following reactions:



# EQUILIBRIUM LAW - $K_{eq}$

## EQUILIBRIUM - SOLIDS AND LIQUIDS

### Example #4



# EQUILIBRIUM LAW - $K_{eq}$

## EQUILIBRIUM - TEMPERATURE

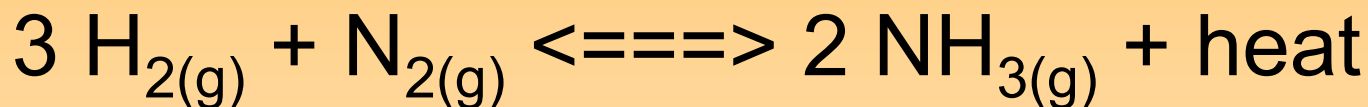
Will temperature change the value of  $K_{eq}$ ? Why or why not?

Reactions are endothermic or exothermic and therefore will be affected by the addition or removal of heat.



# EQUILIBRIUM LAW - $K_{eq}$

## EQUILIBRIUM - TEMPERATURE



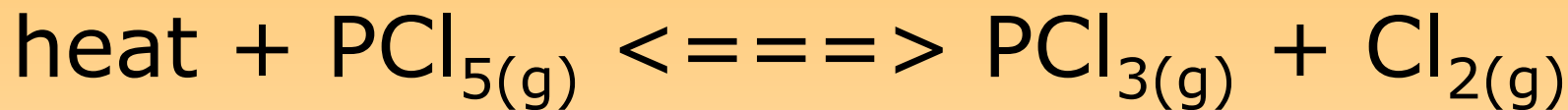
a) What is the equilibrium law?

b) Which way does equilibrium shift when temperature increases? How will  $K_{eq}$  change?

c) When temperature decreases?

# EQUILIBRIUM LAW - $K_{eq}$

## EQUILIBRIUM - TEMPERATURE



a) What is the equilibrium law?

b) Which way does equilibrium shift when temperature increases? How will  $K_{eq}$  change?

c) When temperature decreases?