



**Extension Material**  
A2 Physical Chemistry

Why Equilibrium Constants change  
with temperature

Download slides and other resources at [ChemistryTuition.Net](http://ChemistryTuition.Net)

# Arrhenius Equation

Rate constant

Activation Energy

Temperature

$$\ln k = \ln A - E_a/RT$$

Pre-exponential factor

Gas Constant

At two different temperatures:

$$\ln \left( \frac{k_2}{k_1} \right) = \frac{-E_a}{R \left( \frac{1}{T_2} - \frac{1}{T_1} \right)}$$

At two different temperatures:

If  $T_2$  is greater than  $T_1$

$$\ln \left( \frac{k_2}{k_1} \right) = \frac{-E_a}{R \left( \frac{1}{T_2} - \frac{1}{T_1} \right)}$$

At two different temperatures:

If  $T_2$  is greater than  $T_1$

$$\ln \left( \frac{k_2}{k_1} \right) = \frac{-E_a}{R \left( \frac{1}{T_2} - \frac{1}{T_1} \right)}$$

This expression becomes negative

# At two different temperatures:

If  $T_2$  is greater than  $T_1$

Therefore, due to the negative sign here, the right-hand side becomes positive

$$\ln \left( \frac{k_2}{k_1} \right) = \frac{-E_a}{R \left( \frac{1}{T_2} - \frac{1}{T_1} \right)}$$

The diagram highlights the components of the equation with colored annotations:

- A red horizontal line is drawn above the fraction  $\frac{-E_a}{R \left( \frac{1}{T_2} - \frac{1}{T_1} \right)}$ .
- A red box encloses the entire right-hand side of the equation.
- A blue box encloses the expression  $\left( \frac{1}{T_2} - \frac{1}{T_1} \right)$ .
- A pink arrow points from the text "Therefore, due to the negative sign here, the right-hand side becomes positive" to the  $-E_a$  term.
- A blue arrow points from the text "This expression becomes negative" to the blue box around the temperature difference.

# At two different temperatures:

If  $T_2$  is greater than  $T_1$

Therefore, due to the negative sign here, the right-hand side becomes positive

$-E_a$

$$\ln \left( \frac{k_2}{k_1} \right) = R \left( \frac{1}{T_2} - \frac{1}{T_1} \right)$$

This expression becomes negative

Resulting in  $k_2 > k_1$ .

# At two different temperatures:

If  $T_2$  is greater than  $T_1$

Therefore, due to the negative sign here, the right-hand side becomes positive

$-E_a$

$$\ln \left( \frac{k_2}{k_1} \right) = R \left( \frac{1}{T_2} - \frac{1}{T_1} \right)$$

This expression becomes negative

Resulting in  $k_2 > k_1$ .

**Increasing the temperature increases the rate constant.**



From

$$\ln k = \ln A - \frac{E_a}{RT}$$

From

$$\ln k = \ln A - \frac{E_a}{RT}$$

The effect of temperature on k is proportional to the activation energy.

From

$$\ln k = \ln A - \frac{E_a}{RT}$$

The effect of **temperature** on **k** is proportional to the **activation energy**.

From

$$\ln k = \ln A - \frac{E_a}{RT}$$

The effect of **temperature** on **k** is proportional to the **activation energy**.

**As activation energy increases, the effect of changing temperature increases.**

From

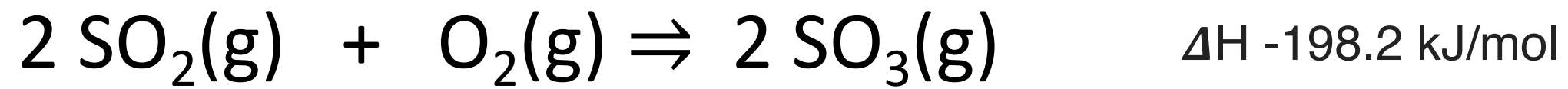
$$\ln k = \ln A - \frac{E_a}{RT}$$

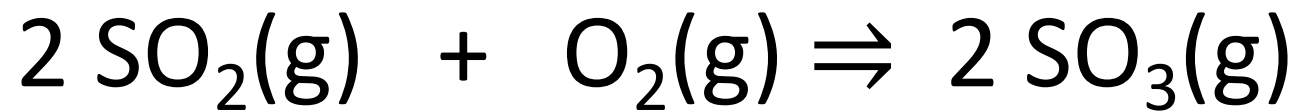
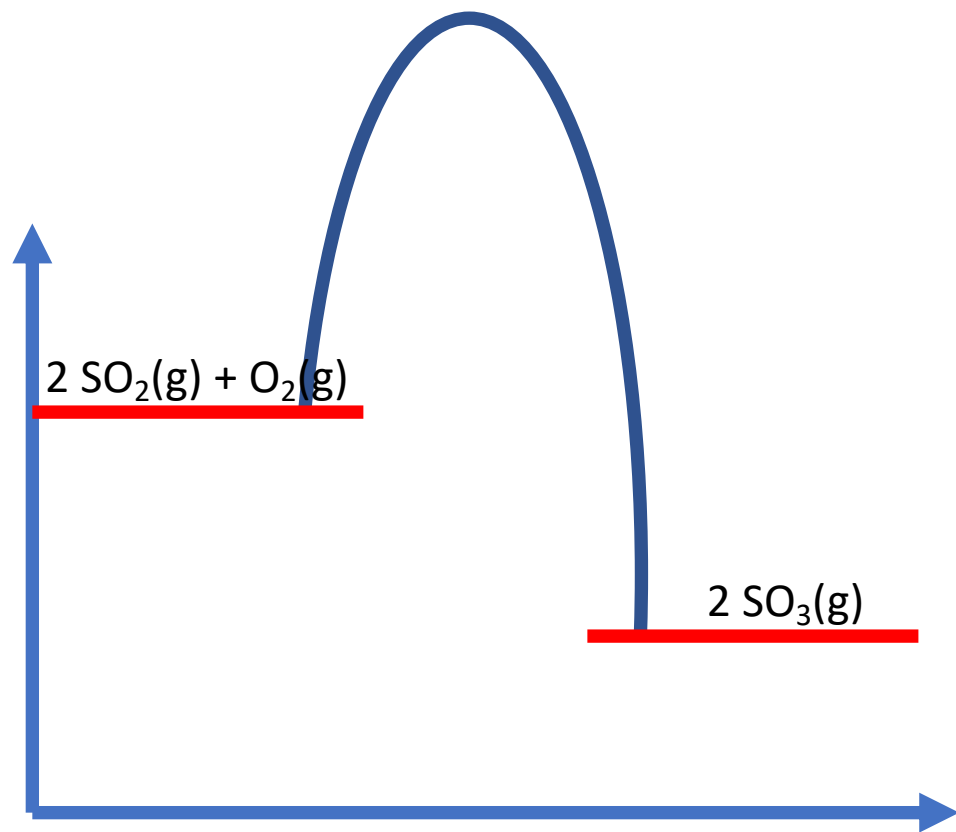
The effect of **temperature** on **k** is proportional to the **activation energy**.

**As activation energy increases, the effect of changing temperature increases.**

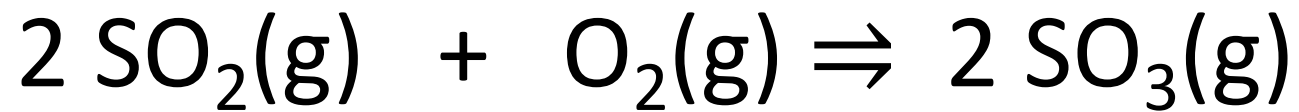
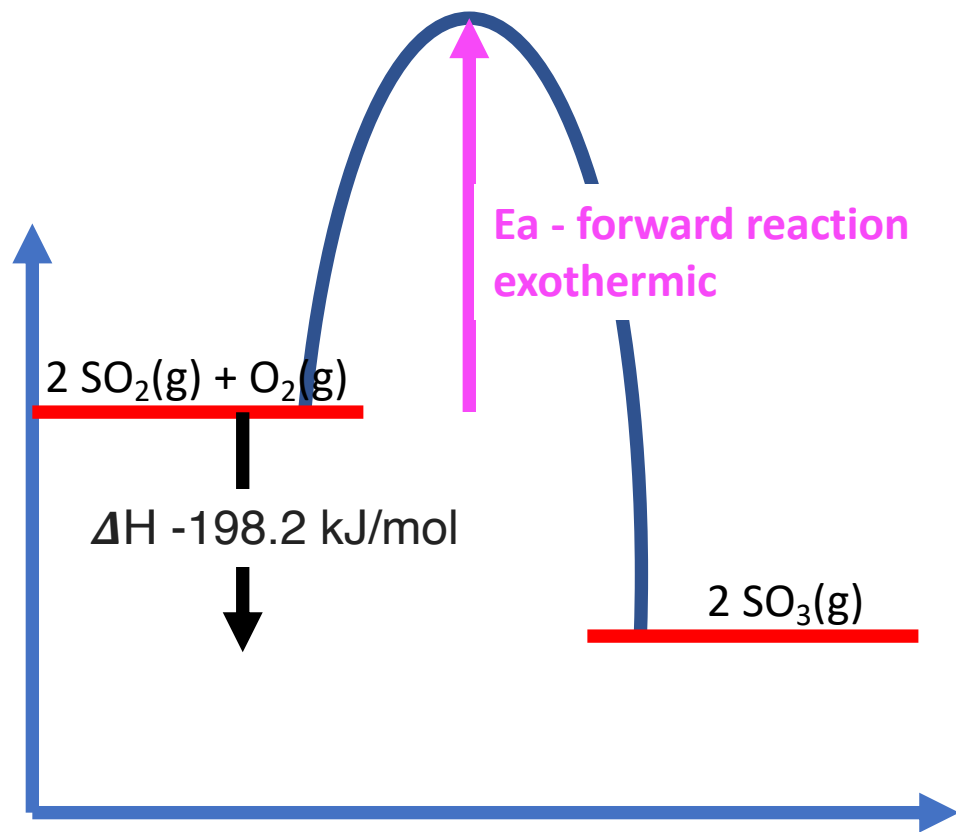
One direction of a reaction is always exothermic and the other direction is endothermic.

The endothermic direction has the larger activation energy.



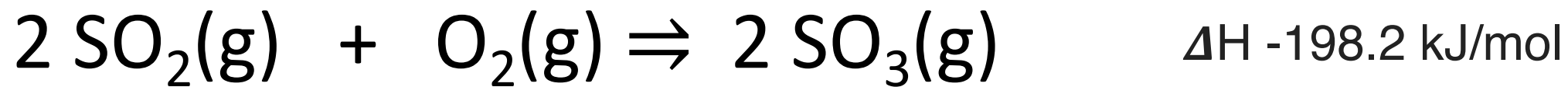
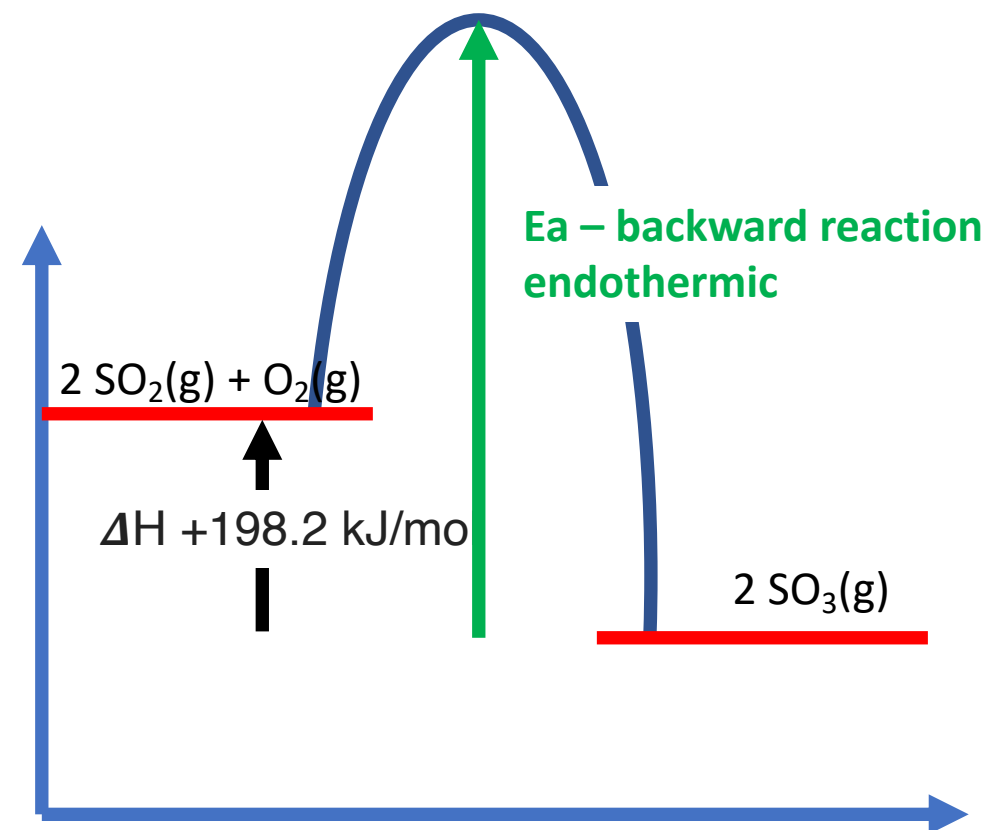
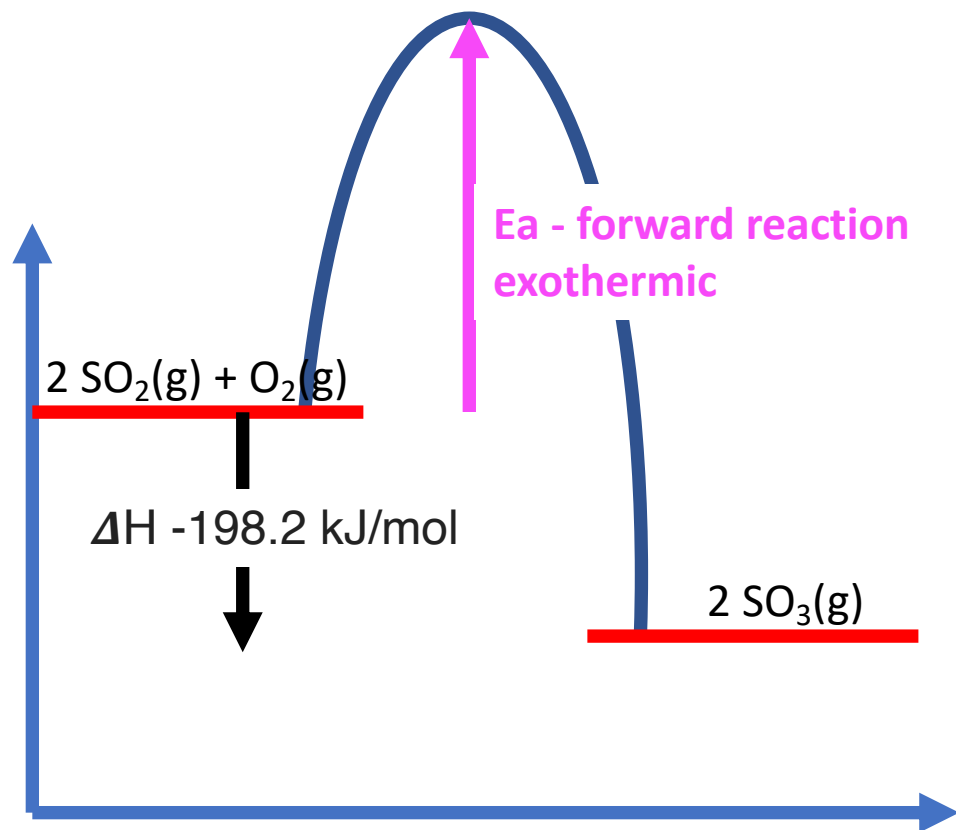


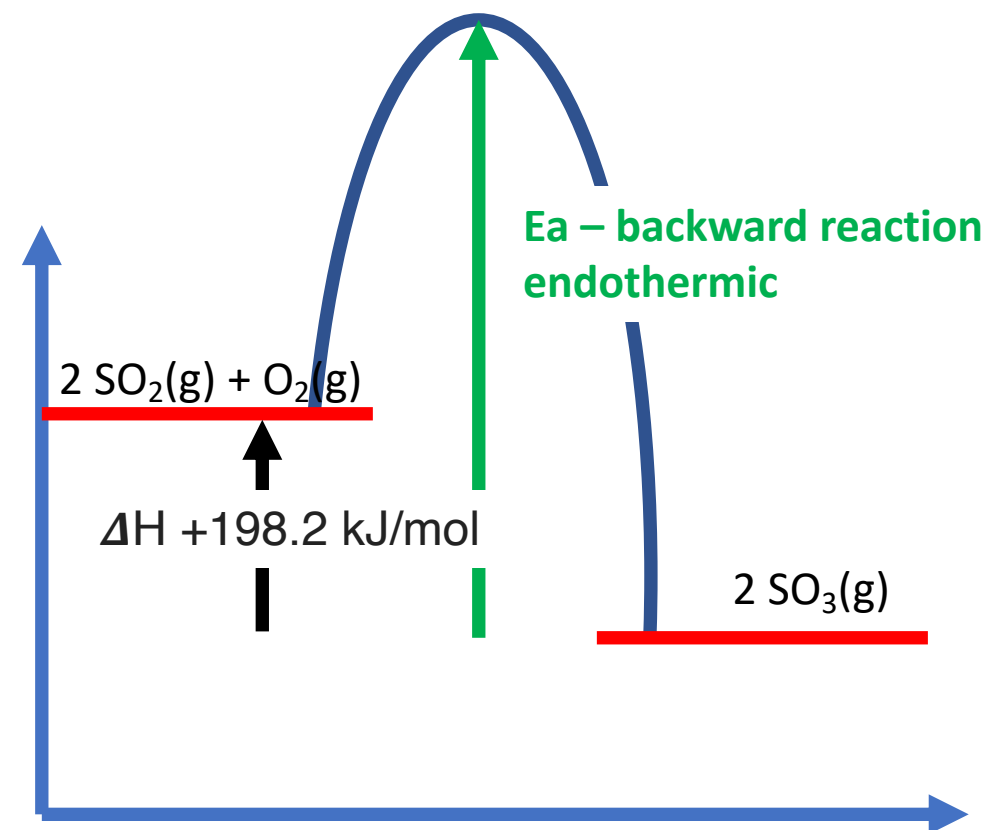
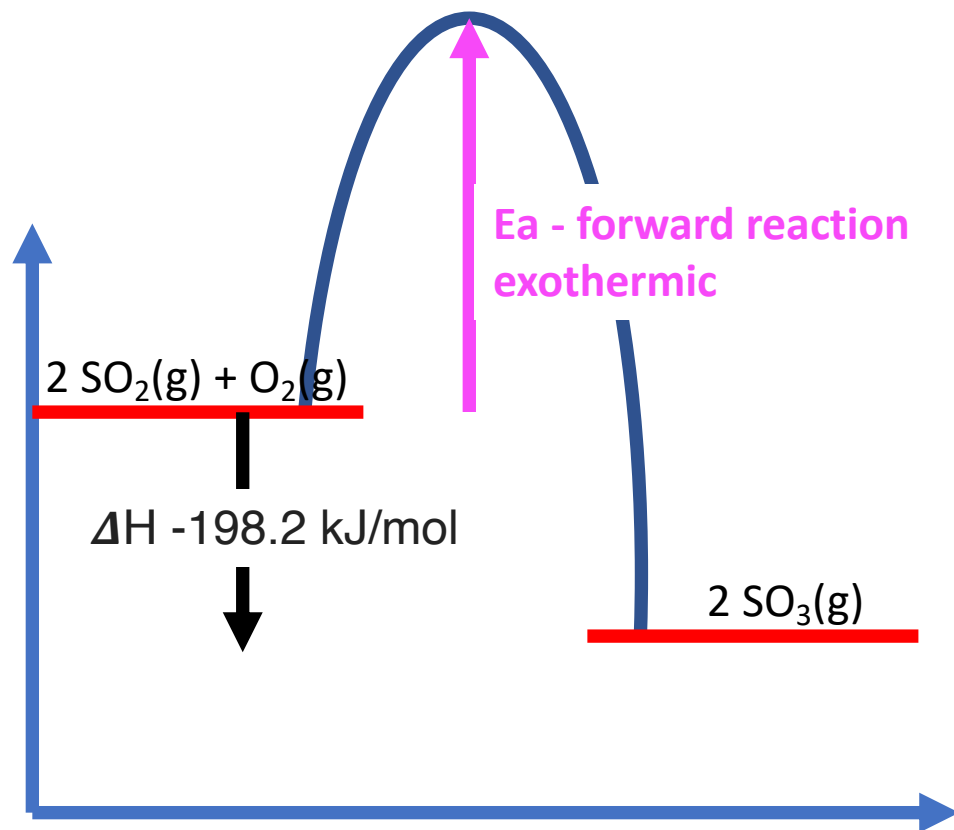
$\Delta H -198.2 \text{ kJ/mol}$



$$\Delta H -198.2 \text{ kJ/mol}$$

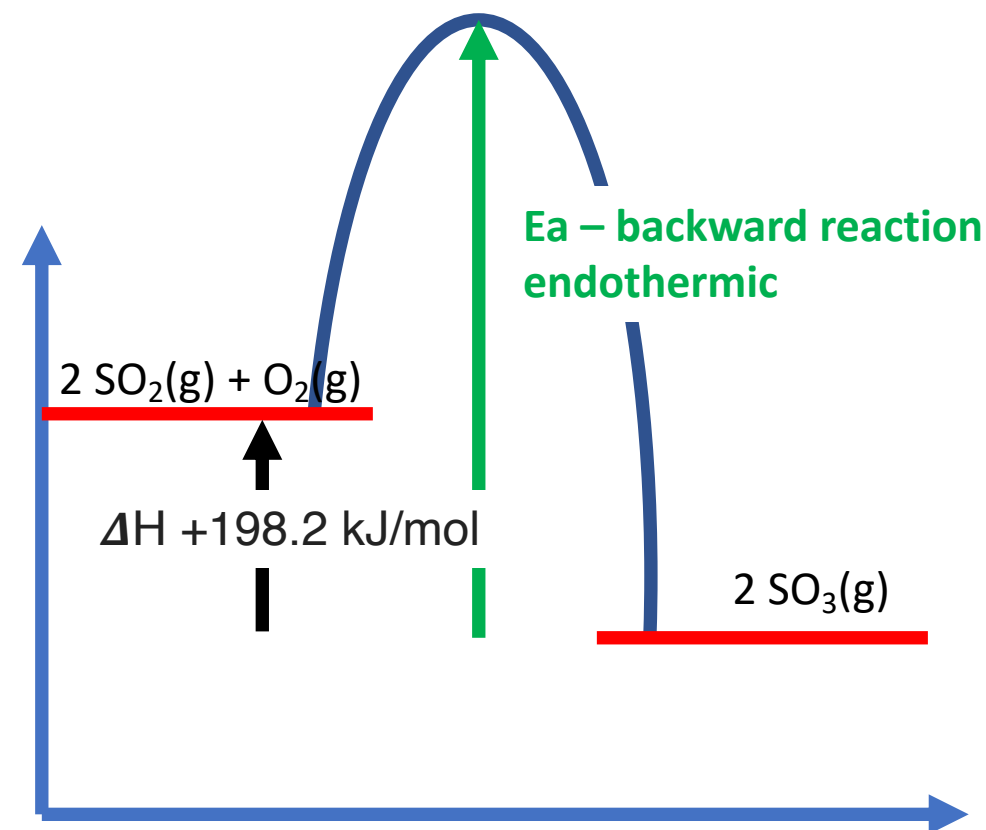
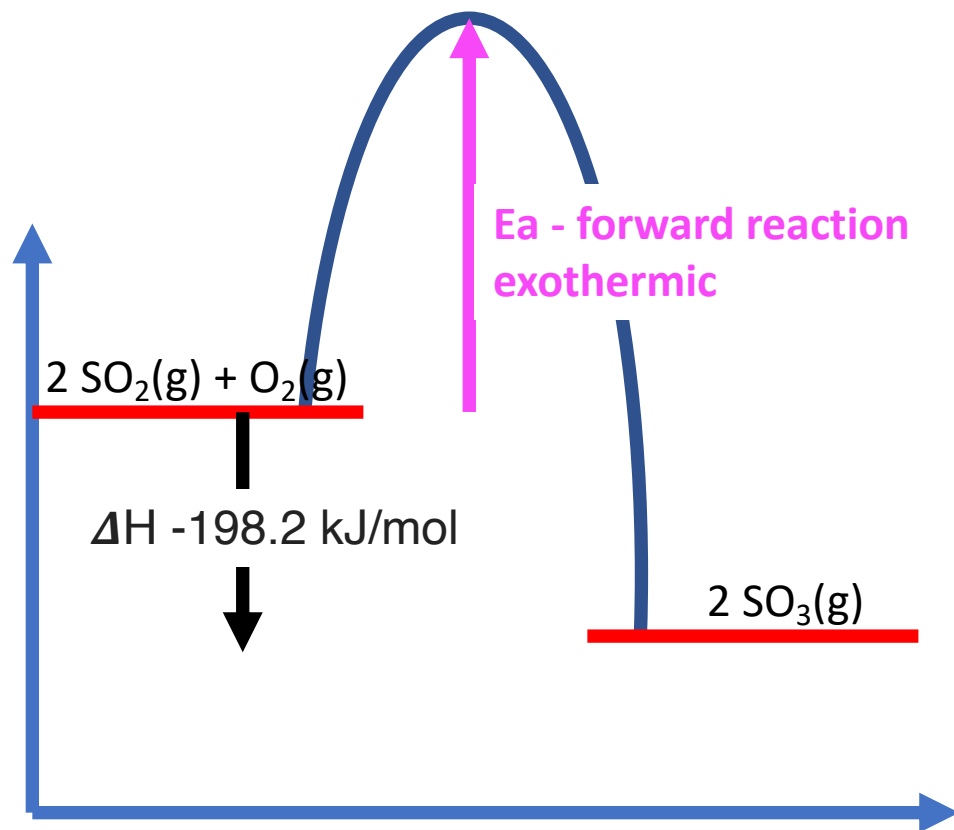






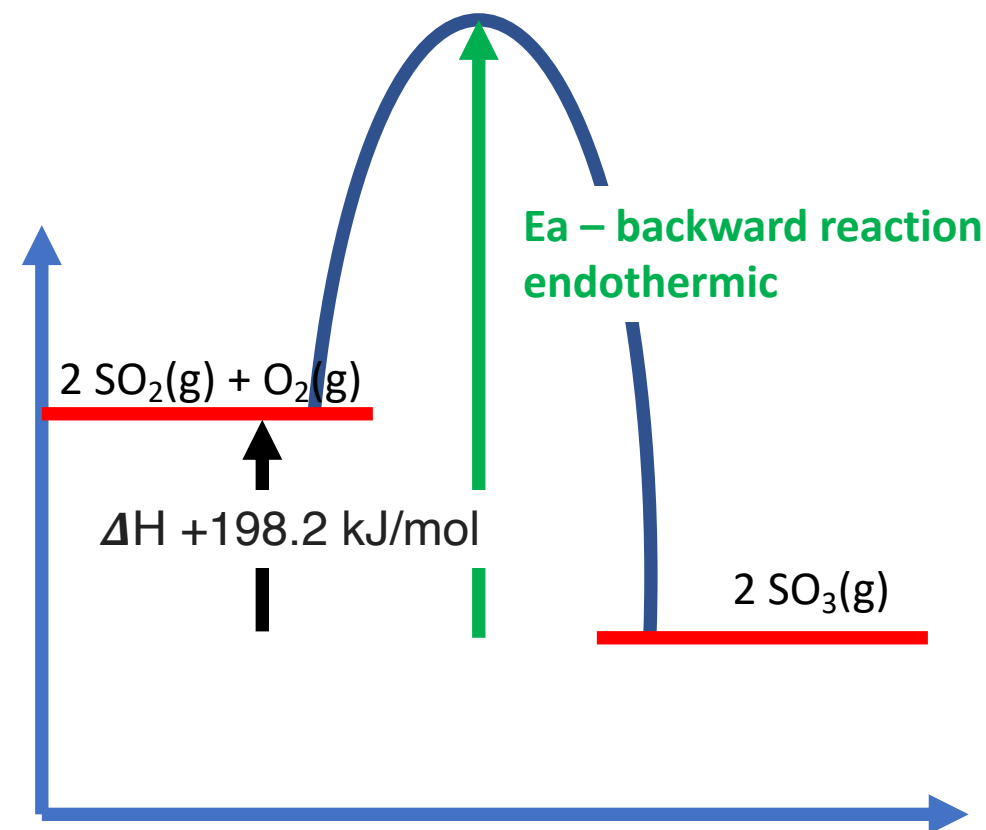
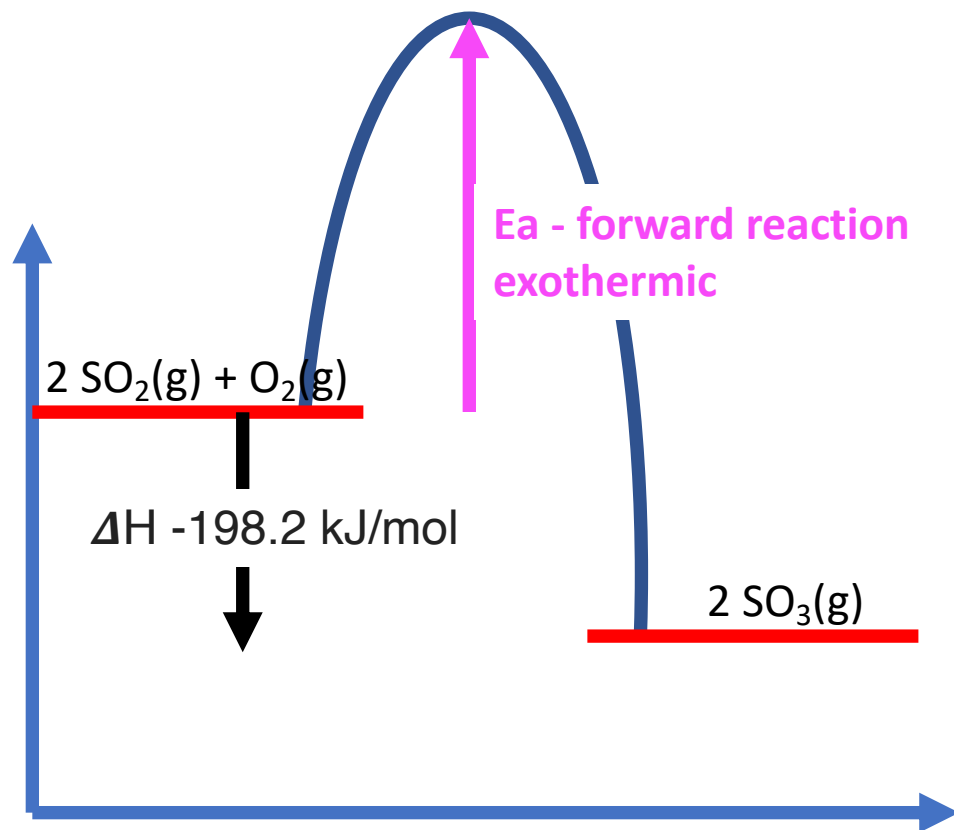
When temperature increases, both rates (forward and reverse) increase but the rate of the endothermic reaction increases more.

Equilibrium shifts in the endothermic direction.



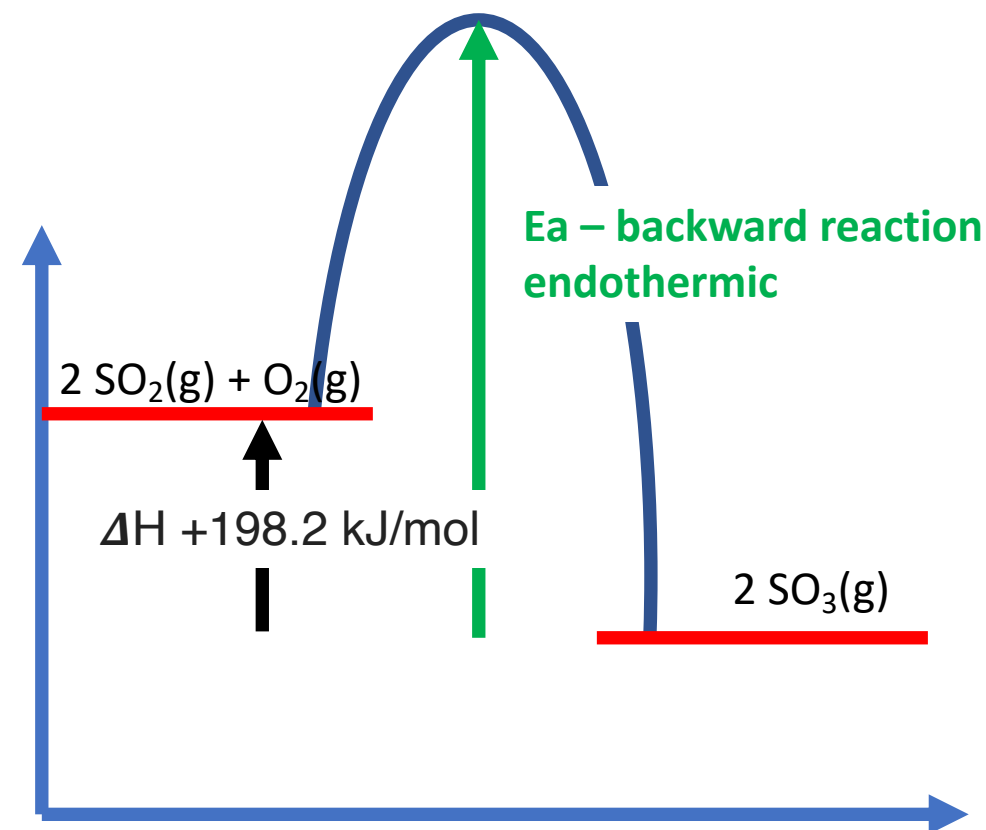
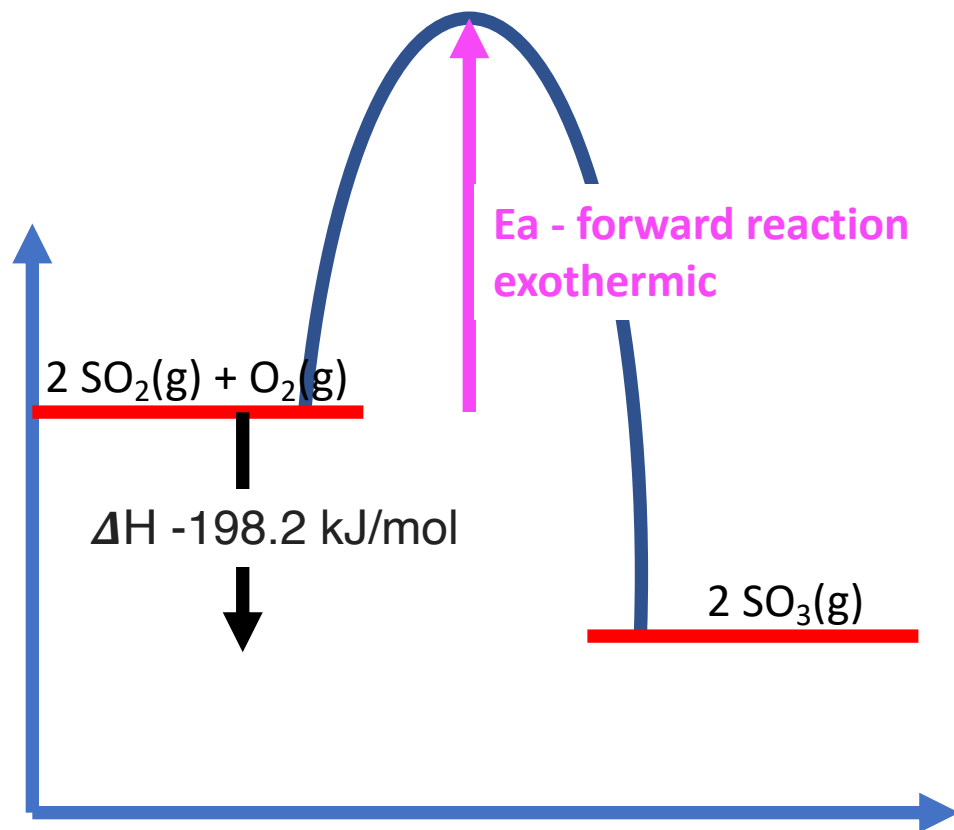
When temperature **increases**, both rates (forward and reverse) increase but the rate of the endothermic reaction increases more.

**Equilibrium shifts in the endothermic direction.**



When temperature **decreases**, both rates (forward and reverse) decrease but the rate of the endothermic reaction decreases more!

**Equilibrium shifts in the exothermic direction.**



Raising the temperature increases  $K_c/K_p$  for an endothermic reaction and lowers  $K_c/K_p$  for an exothermic reaction



# Online Teaching and Learning Resources for Chemistry Students

[ChemistryTuition.Net](https://www.chemistrytuition.net)