Combustion of H_2

Recommended for Chapter(s): 15

Demo #037

Materials NOT in box

1. Safety goggles
2. H_2 (To get H_2 in a balloon take a balloon to Richard in the glass shop (PSBN 2520E) or let Darby (feldwinn@chem.ucsb.edu) know a few days in advance and she will have a H_2 balloon waiting for you in the demonstration room.
3. Lighting stick

Procedure

1. (Prep) Get the H_2 balloon and tie it to the ribbon.
2. Unwind the ribbon until the balloon is located ~3 feet above your head.
3. Light the lighting stick and touch the candle to the balloon.

Safety

1. Wear safety goggles.
2. Make sure the balloon is far enough away from you and the students before you light the balloon.

Clean Up

1. Return the materials to the cart in the demonstration library room.

Stockroom Notes

2. Return items to demonstration tub.
3. Return tub to the demonstration library.
    a. Return the goggles to the goggle box.

Discussion

This demonstration can be used to show the difference between kinetics and thermodynamics.

The reaction that occurs is the combustion of H_2 as seen in the reaction below.

$O_2(g) + 2H_2(g) \rightarrow 2H_2O(g)$

Thermodynamics

Students should be able to predict that

ΔH = -# (combustion reaction)

ΔS= -# (3 moles of gas turns into 2 moles of gas, therefore, positional probability decreases)

In order to determine the sign of ΔG more information needs to be given.

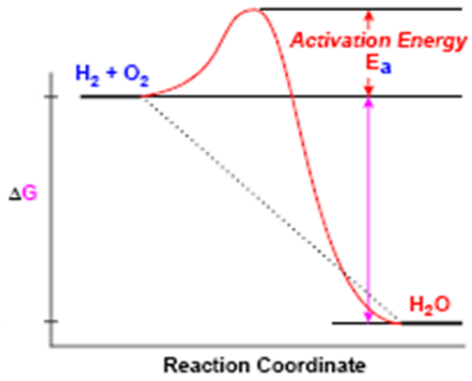
$$\Delta H^{\circ}_{rxn} = -484 \frac{kJ}{mol}$$

$$\Delta S^{\circ}_{rxn} = -89 \frac{J}{molK}$$

$$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$$

$$\Delta G^{\circ} = \left(-484 \frac{kJ}{mol}\right) - \left(298K\right)\left(-0.089 \frac{kJ}{molK}\right) = -457 \frac{kJ}{mol}$$

According to thermodynamics a negative ΔG indicates that a reaction is spontaneous. However, the balloon does not burst in to flames unless the candle is touched to the balloon. The reaction coordinates for the combustion of H_2 are seen below. From the plot it can be seen that although thermodynamically the reaction is spontaneous, the reactants needs to overcome a significant amount of activation energy (breaking the H-H and O-O bonds) in order for the reaction to proceed. In order to overcome the activation energy the flame provided the additional energy needed.



Thermodynamics does not address the activation energy of a reaction; it only tells if a reaction will happen. The study of kinetics (how fast reactions occur) deals with activation energies.

A ½ O_2 ½ H_2 balloon can also be made. If you light this balloon it will cause a louder explosion due to the H_2 and O_2 being in closer proximity to each other.

Materials for demo 037

1. Balloons
2. Ribbon
3. Birthday Candles
4. Matches
5. Scissors