

## Stoichiometry Balloons

### *Preparer's Version*

#### **Introduction**

Incomplete combustion occurs when a fuel does not burn completely due to insufficient oxygen supply, leading to the production of incomplete combustion products such as carbon monoxide and soot (carbon particles). In the context of hydrogen combustion, incomplete combustion might occur if there is not enough oxygen present to fully react with the hydrogen gas, resulting in the formation of water vapor with an excess of hydrogen gas. Conversely, complete combustion occurs when a fuel burns in the presence of a sufficient amount of oxygen, resulting in the formation of only the desired combustion products—in the case of hydrogen combustion, water vapor. The concept of a limiting reactant is crucial in understanding combustion reactions. The limiting reactant is the reactant that is completely consumed in a chemical reaction, thereby determining the maximum amount of product that can be formed. In hydrogen combustion, if there is an excess of hydrogen but a limited supply of oxygen, oxygen becomes the limiting reactant, dictating the extent of the reaction and the amount of water vapor produced. When the ratio of hydrogen to oxygen is 2:1, all the hydrogen reacts with the available oxygen to form water vapor in the most efficient manner, resulting in a highly exothermic reaction and a loud, intense combustion.

#### **Safety Hazards**

- Personal Protective Equipment
  - Safety glasses/goggles
  - Nitrile gloves
  - Chemical & flame retardant lab coat
- Physical Hazards
  - Gases under pressure may explode if heated and/or form explosive mixtures with air.
  - Hydrogen is an extremely flammable gas.
  - Oxygen is an extreme oxidizer; may cause or intensify fire.
  - Extremely loud combustion; may cause hearing damage.

#### **Materials**

- 2 Qualatex balloons
- Oxygen gas, compressed
- Hydrogen gas, compressed
- BBQ lighter
- Candlestick (taper candle attached to wooden dowel)

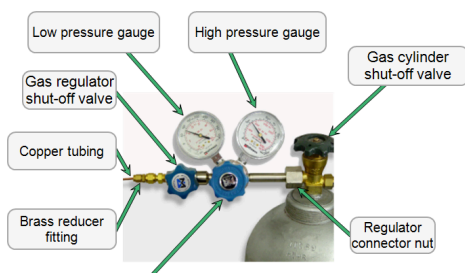
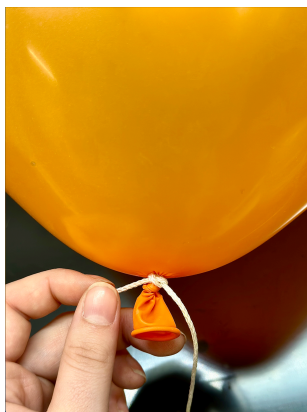
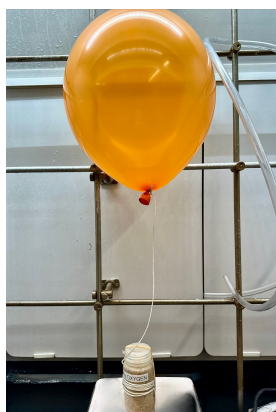
#### **Safety Data Sheet(s)**

- [Hydrogen](#)
- [Oxygen](#)
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## Procedure

1. Place the correct regulator on your compressed gas cylinder of hydrogen and oxygen.
  - a. Thread the regulator's CGA connection onto the gas cylinder. Once you cannot thread it any more by hand, tighten it with a wrench to prevent leaking.
  - b. Ensure that the regulator outlet valve is closed before opening the cylinder.
  - c. Open the cylinder by turning the valve handwheel to the left. You should hear the needles on the two gauges jump. If you have Linde's new EZ tanks, all you will need to do to open the cylinder is lift the red lever.
2. Wrap the open end of your balloon to the hydrogen regulator's brass reducer fitting (the valve where the gas will release). Tighten it as much as possible by pinching one side of the balloon.
3. Slowly open the regulator shut-off valve to fill the balloon with either halfway (1:1 balloon) or two-thirds of the way (2:1 balloon) with hydrogen.
4. While still holding the balloon in place, close the regulator shut-off valve.
5. Carefully wrap the open end of the balloon to the oxygen regulator's brass reducer fitter (the valve where the gas will release) while still pinching the balloon to prevent hydrogen from leaking. Begin the flow of oxygen and fill the balloon the rest of the way (halfway for 1:1 or one-third of the way for 2:1) with oxygen.
6. Pinch off the entire stem of the balloon to prevent the gas from leaking and pull it off of the regulator. Tie the balloon tightly.
7. Tie the string of your weight *above* the knot you tied on the balloon. If the balloon is held upright (balloon stem on the bottom), this means the string should be tied between the knot of the balloon and the body of the balloon.
8. Wrap the string around the weight to more easily transport the balloon. You can use a rubber band over the string on the weight to fasten it in place and prevent unraveling.
9. Close the cylinder by turning the cylinder valve to the right (or snapping the red lever of an EZ tank down), then slowly releasing the pressure within the regulator by opening the regulator shut-off valve and closing it when finished releasing residual gas. Carefully loosen the connector nut with a wrench until you're able to unthread the rest of the way by hand. Be sure to carefully place the safety cap back on your tank.
10. For transportation, cover all balloons with a trash bag to prevent them being exposed to potential ignition sources, including static electricity. The balloons should be set up *at least* 4 feet apart and a full straight arm + candlestick extension up. Magnesium should be performed separately.

## Set-Up Reference Photos



### **Tips & Tricks**

- The 1:1 balloon will float differently than the 2:1 balloon will; the 1:1 balloon shouldn't float, and the 2:1 balloon should *barely* float and bob up and down. In order to still keep a safe distance from the balloons when igniting them, tie the string of the balloon to a wooden dowel, tape down the string to prevent it from falling off, and have a helper hold the dowel to elevate the balloons.
- This demonstration can be extremely loud, and several parties should be notified:
  - UTPD Non-emergency line. Call (512) 471-4441 and notify UTPD of a potentially loud noise for a chemistry demonstration. Make sure they know when and where the demonstration will take place, and call them when it's finished.
  - Building management. Notify any building management staff members in advance so that they can warn nearby faculty members/classrooms of a potentially loud noise.

### **Clean-Up Procedures**

1. Make sure all gas cylinders used are correctly closed as described in the procedure above. Safety caps should always be secured on gas cylinders when they are not in use.
2. Pop the balloons, cut the string where the knot is tied, and discard the balloon in the trash.