Required Training

UC Lab Safety Fundamentals

Required PPE

Flame-resistant lab coat, safety glasses/goggles, hearing protection, nitrile gloves

Performers Required: 1 (2 recommended)

Equipment

Latex balloons

Chemicals

Propane (C₃H₈), with regulator and tubing installed

String

Hydrogen (H₂), with regulator and tubing installed

Weighted objects to anchor balloons

Oxygen (O₂), with regulator and tubing installed

Tissue fixed to a 1-meter stick/pole

Ethanol (EtOH), 95%

Procedure:

1.) Fill the balloons from the gas cylinders with the appropriate gases. This includes pure propane, pure hydrogen, and pure hydrogen and oxygen for a 2:1 mixture. Tie the gas balloons off and attach the strings to both the balloons and the weighted anchors. The H₂ and O₂ for the mixture should not be tied, but should be reversibly-sealed to prevent leaking. These should never be combined before transport. Label the top of each balloon with a sharpie marker.

2.) Position the balloons and their anchors at least 10 feet from the audience.

3.) **Ensure you are wearing hearing protection and that the audience has been warned to cover their ears before proceeding.** Make sure you are standing upwind of the balloon. Light the ethanol-soaked tissue on the end of the pole, and place it next to the balloon so that the flame touches the balloon, **not** the tissue. It will pop (air), ignite (H₂ and C₃H₈), or explode (H₂/O₂) after a few seconds. The H₂/O₂ will release a shockwave.

Clean-up: Make sure to clean up all of the pieces of latex and string.

**Hazards:** The H₂, C₃H₈, and H₂/O₂ balloons produce heat, fire, and a loud noise when ignited. Hazards include thermal burns from the fire and hearing damage from the explosion. When transporting H₂, C₃H₈, and H₂/O₂ balloons, take care to keep them away from ignition sources and each other, if moving multiple balloons. They should never be grouped into a bag for transportation, as the build-up of static electricity could cause them to ignite. **Never** bring a H₂/O₂ balloon into a confined space such as an elevator, as an accidental explosion could cause deafness and great personal injury.
H₂/O₂ balloons cannot be transported in vehicles for legal reasons, and may only be used for outdoor demonstrations. However, transporting H₂ and O₂ balloons together is fine, so do not combine them until transportation to the site is complete.

**Principle:** The air balloon doesn’t explode because the components have not reached the upper flammable limit. The flammable gases in the balloons combust into water vapor (and CO₂ with C₃H₈ fuel) when ignited. The C₃H₈ balloon releases the most energy, but it has the lowest power because the combustion proceeds slowly. The H₂ balloon releases approximately 1/3rd of the energy, but it burns much faster and therefore produces much more power. The H₂/O₂ balloon releases the same energy as the H₂ balloon, but with significantly more power (creating a shock wave); the H₂ does not need to diffuse into the air to mix with oxygen, the combustion occurs with much greater speed.

**Notes:** When making mixed H₂/O₂ balloons, first fill the balloon one third with oxygen, and then fill it the rest of the way with hydrogen, stopping shortly after it becomes positively buoyant. This is still a very oxygen-rich mixture, but it limits the concussive force of the explosion. The mixed balloons should not exceed 6-8” in diameter, and must never be ignited indoors. Never make a mixed CH₄/O₂ balloon – the power output is too large (~3 times that of a H₂/O₂ balloon), making it unsafe for performance even when outdoors. Methane does not work well as a balloon due to its variable results. We no longer use helium due to finite resources and its need in medical devices and scientific experiments.