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Reaction of Alkali Metals & Water

Preparer's Version

Introduction

The first group of the Periodic table are known as *alkali metals*. Alkali metals are familiar and commonplace to many, but primarily in their ionic forms. When they're in their solid, neutral metal state, however, they are violently reactive with water. The reaction of a pure alkali metal, like sodium or potassium, with water liberates hydrogen gas and produces metal hydroxides; metal hydroxides from Group 1 elements are considered strong bases, hence the moniker "*alkali*" metals. The reaction of a Group 1 metal (M) with water is shown below:

$$2M\ (s) + 2H_2O\ (\ell) \longrightarrow 2MOH\ (aq) + H_2\ (g)$$

$$2\ M\ (s) + 2H_2O\ (\ell) \longrightarrow 2M^+\ (aq) + 2OH^-\ (aq) + H_2\ (g)$$

The liberation of hydrogen gas is where the spectacle of these reactions comes in. Hydrogen gas is highly flammable, and the reaction of alkali metals with water is *also* very exothermic – meaning that a large quantity of heat energy is released by the reaction. This results in the potential for the hydrogen gas released to spontaneously ignite in an array of vibrant colors.

Safety Hazards

- Personal Protective Equipment
  - Nitrile gloves
  - Safety glasses/goggles
  - Chemical & flame retardant lab coat
  - Face shield recommended
- Safety Equipment
  - Fume hood
  - Blast shield
  - Fire extinguisher
  - Spill kit
- Physical Hazards
  - In contact with water, can release flammable gas that may spontaneously ignite and result in severe burns and eye damage
  - Can cause respiratory irritation
- Chemical Hazards
  - Flammable solid, may cause fire
  - In contact with water, produces metal hydroxides which may cause skin and eye corrosion and are harmful if swallowed
  - Phenolphthalein is a suspected mutagen and carcinogen, and may damage fertility or target organs through prolonged or repeated exposure

Safety Data Sheet(s)

- Sodium metal
- Potassium metal
- Sodium hydroxide (byproduct)
- Potassium hydroxide (byproduct)
- Phenolphthalein

Materials

- Sodium metal (approximately 0.5 – 0.75 g)
- Potassium metal (approximately 0.5 g)
- 2 large polycarbonate reaction vessels
- Hexanes in a small squirt bottle
- Phenolphthalein indicator solution
- Deionized water
- Phenolphthalein indicator solution
- Metal forceps
- 2 plastic weigh boats OR two watch glasses
- Paper towels

Procedure

WARNING: This demonstration must be done in a fume hood. If a portable fume hood is not available, the demonstration must be done via webcam or video from a laboratory equipped with one.

1. Fill both polycarbonate reaction vessels ⅓ to ½ of the way with deionized water.
2. Add approximately 20 – 30 drops of phenolphthalein indicator solution (preparation procedure below) to the water.
3. Set both vessels inside of the fume hood. Separate the reaction vessels by at least 18 inches.
    a. *Note: If working in a portable fume hood that is too small for two vessels separated by this distance, it may be necessary to either fully complete and clean up one reaction before performing the next, or to scale down the reactions.*
4. Using metal forceps, remove one piece of metal from its bottle. It will either be preserved in mineral oil or kerosene.
5. Using the small bottle of hexanes, squirt solvent over the metal to thoroughly rinse off any mineral oil or kerosene. Pat the metal dry with a paper towel.
6. Cut the metal and set each in a plastic weigh boat. For sodium, cut a piece weighing approximately 0.5 to 0.75 g. For potassium, cut a piece weighing approximately 0.5 g.
7. Place the blast shield between the reaction vessels and the safety glass of the fume hood.
8. Using the metal forceps, drop the piece of sodium into the water, lower the fume hood sash completely, and back away quickly.
9. The metal will begin to react violently – releasing hydrogen gas. As metal hydroxides are produced, the water will begin to turn pink, indicating the presence of a strong base. The hydrogen gas will likely ignite and/or pop/explode.
10. Repeat these steps for potassium metal.

Phenolphthalein Indicator Solution Preparation

1. If no stock phenolphthalein solution is available, dissolve 0.05 g of phenolphthalein in 50 mL of 95% ethanol.
2. Allow to stir until all phenolphthalein has dissolved.
3. Once all of the solid phenolphthalein has been dissolved in solution, dilute with 50 mL of deionized water.
4. Pour the solution into a glass bottle (amber recommended) for storage. Be sure to label this bottle with the name of the solution and the date it was made, as well as associated hazards.

Clean-Up Procedures

1. Once the metal has *completely stopped reacting*, carefully remove the reaction vessels from the hood. If the demonstration is being conducted in a portable hood, this must be done back in the lab.
2. Use pH paper to assess the basicity of the solution.
3. Neutralize the metal hydroxide in solution using the weak acid from your spill kit. This is most often citric acid. Continue using pH paper to verify that your solution has been appropriately neutralized to an approximate pH of 7.
4. Pour solution into the appropriate waste carboy and update the waste tag as appropriate.