Limiting Reagent (Baking Soda with Vinegar)

Purpose

To demonstrate the concept of limiting reactants

Materials

Vinegar

Baking Soda

500 mL Erlenmeyer flasks

Balloons

Procedure

1. Pour 150 mL of vinegar into each of the Erlenmeyer flasks.
2. Loosen the balloons that are going to be used by stretching them out (this will make it easier for the balloons to expand during the reaction).
3. Place the following amounts of baking soda into the balloons and then attach the balloons to the appropriate flask without letting the baking soda spill into the vinegar.

Experiment number	Baking soda mass (g)	Baking soda moles	Vinegar volume (mL)	Vinegar moles	Limiting reactant
1	3.3	.039	150	.1248	Baking soda
2	5.7	.0678	150	.1248	Baking soda
3	10.5	.1248	150	.1248	Equal
4	21.0	.2502	150	.1248	Vinegar
5	31.8	.3786	150	.1248	Vinegar

4. Dump the baking soda into flask 1.
5. Ask the students what is going to happen when you dump the baking soda into flask 2.
6. Dump the baking soda into flask 2. You may need to support the balloon until the reaction completes.

7. Repeat this process for the other three flasks.
8. For flasks 3-5, the reaction will result in an overflow of liquid into the balloon. After the most vigorous portion of the reaction, gently hold up the balloon and allow the contents to drain back into the reaction flask.

Alternate

This demo can be performed using Mg and HCl in place of vinegar/baking soda, however the HCl can bubble over into the balloon, forming holes in the latex and causing the acid to spill out.

Discussion

This demonstration can be used to illustrate the concept of limiting reagents.

When vinegar (a dilute solution of acetic acid: CH_3COOH) and baking soda ($NaHCO_3$) react, carbon dioxide, a gas, is produced:

$$\underset{\text{(baking soda)}}{NaHCO_{3\,(aq)}} + \underset{\text{(vinegar)}}{CH_3COOH_{(aq)}} \rightarrow CO_{2\,(g)} + H_2O_{(l)} + CH_3COONa_{(aq)}$$

In the first two flasks the limiting reagent is the baking soda, so as you add more baking soda the balloon gets bigger. The third flask contains a 1:1 molar ratio of vinegar and baking soda. In the fourth and fifth flasks the limiting reagent is now the vinegar, so the balloons remain the size as the balloon on the third flask.

Disposal

All solutions can be poured down the drain with excess water and balloons can be thrown away.

Reference

Dr. Feldwinn Demo Library, UCSB:

http://www.chem.ucsb.edu/~feldwinn/DemoLibrary/DemoPDFs/Demo010.pdf