Acidic and Basic Oxides

Chemicals and Equipment Needed

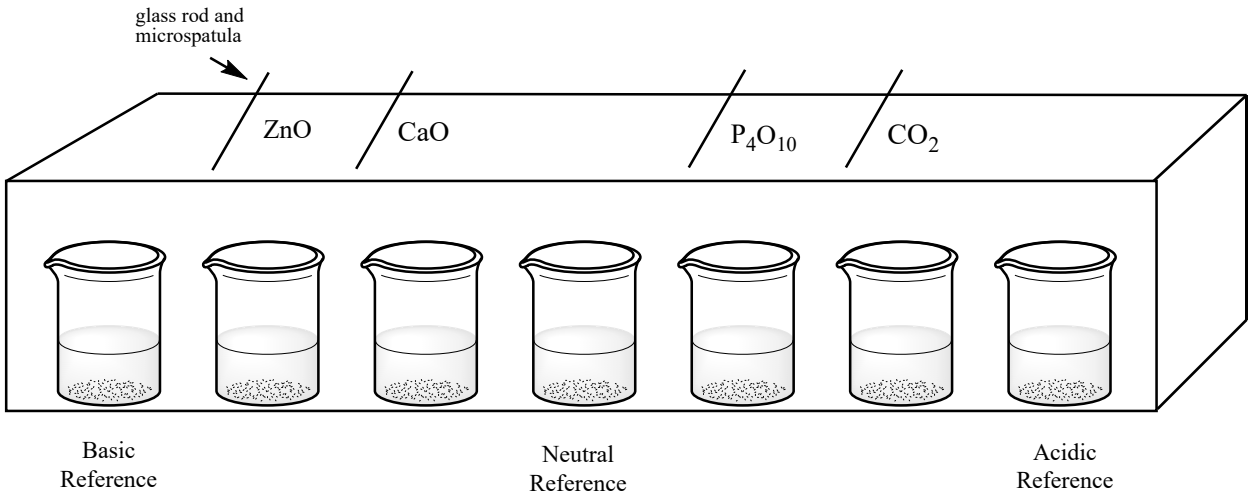
- Acidic and Basic Oxides Kit – **O1**
  - P_4O_{10}
    - More in dessicator – **J**
  - ZnO
  - CaO
  - Dropper bottle of 0.1 M NaOH
  - Dropper bottle of 0.1 M HCl
- Dry ice
  - Use small dewar
- Yamada indicator – **C or make more**
- 7-300 mL tall beakers – **Q2**
- Plastic petri dish lids – **P3**
- 3 microspatulas – **U1**
- 4 glass rods – **U1**
- Tongs with plastic covers on tips – **U2**
- Light Box – **A4**

Hazards

- Phosphorus Pentoxide (P_4O_{10}) can cause fires when it comes into contact with flammable substances that contain water
  - Even though it is kept in a desiccator, it can pick up water from the air and create a crust of hydrated compound. See end of the protocol for instructions on how to dispose of the hydrate.
- Dry ice (solid CO_2) is very cold. Do not handle with bare hands, as cold burns can occur.

Preparation

- Yamada solution: 90 mL Yamada stock solution (**N2**) dilute to 3 L with d-H_2O
  - Adjust color to pure green with 0.1 M NaOH or 0.1 M HCl.
- Fill each beaker with ~150 mL Yamada. Add drops of 0.1 M HCl to one beaker for an acid reference (orange), and 0.1 M NaOH to another beaker for a base reference (blue). Keep one beaker green for the neutral reference. Lid and label.
- On delivery, set beakers in front of the light box, with the acid ref on one end, the base ref at the other, and the neutral ref in the middle. Place the vials, glass rods, and spatulas on top of the light box, and the dry ice next to the light box. (See diagram for placement)
  - Some instructors prefer to keep the light box on the cart to save space. You can then plug it into the power strip on the underside of the overhead projector cart.



Presentation

- Use the tongs to add a small piece of dry ice to the first beaker, and use the resulting color to place it in the spectrum of beakers.
- Use a microspatula to add small amounts of the other compounds to the remaining beakers. The P_4O_{10} may sizzle when you add it; you only need a small amount.
- With Yamada indicator, red/orange/yellow are acidic, blue/purple are basic, and green is neutral.
  - P_4O_{10} and CO_2 should give orange/red colors
  - ZnO is slow to dissolve, but should give an aqua color
  - CaO should give a purple or violet color.
  - The acidity of non-metal oxides and alkalinity of metal oxides is clearly demonstrated.

Discussion

- Here are the reaction equations:

  CO_2 (s) + H_2O → H_2CO_3 (aq) (Soft drinks contain carbonic acid)

  P_4O_{10} (s) + H_2O → 4 H_3PO_4 (aq) (Soft drinks also contain phosphoric acid)

  CaO (s) + H_2O → $Ca(OH)_2$ (aq)

  ZnO + H_2O → $Zn(OH)_2$ (aq)

- With acid rain appearing in the news more and more, be sure to point out that it is caused by the reaction of water with the oxides of sulfur, which is a non-metal. Burning high sulfur coal releases these sulfur oxides into the atmosphere. Acid rain results from the following reactions:

  SO_2 (g) + H_2O → H_2SO_3 (aq)

  SO_3 (g) + H_2O → H_2SO_4 (aq)

Clean-Up

- Everything can go down the sink with plenty of water. Save the reference beakers if they'll be used again that week.

NOTES:

- P_4O_{10} is a dangerous compound, and picks up water easily. Take care when handling. When ordering replacement compound (because it becomes too wet), order as little as possible.
- If the P_4O_{10} develops a crust of hydrated compound, scrape remove the wet layer and place into a beaker. Place beaker in the hood and leave it there to pick up more water until it looks syrupy. Then you can add ~200 mL d-H_2O and pour the solution down the drain.