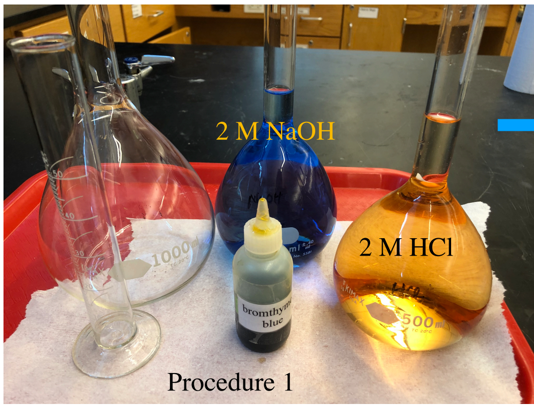
Acid Base Reaction aka Neutralization and other Net Ionic Equation Practice

TEACHER

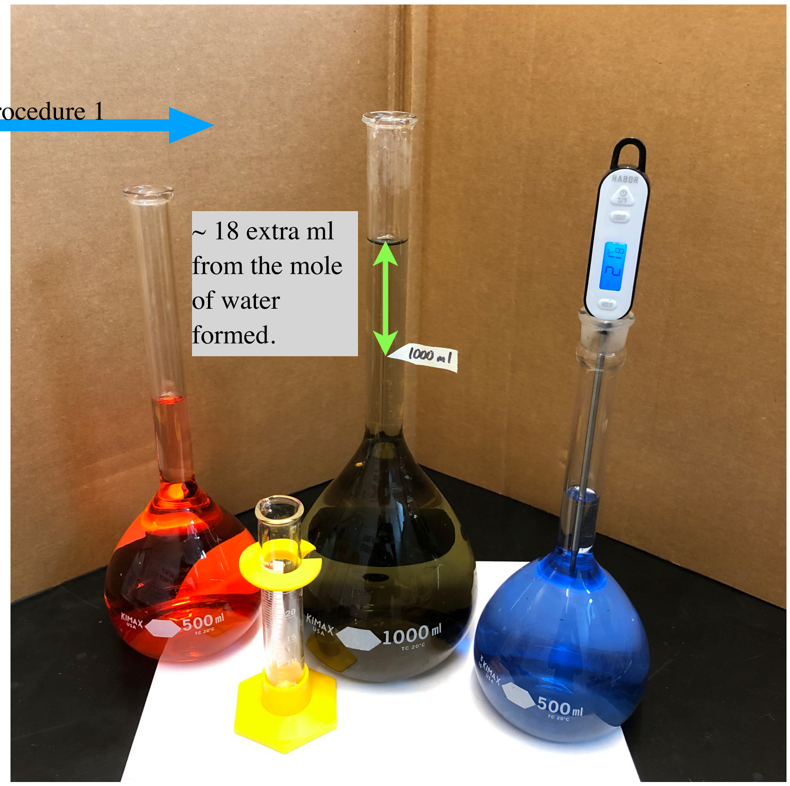
This lab is essentially a repeat of a lab done in my first year chemistry class, but I believe the 35 or 40 minutes bears repeating, and is a good way to kick off net-ionic equation work, that my students were exposed to in first year chemistry.

There is a follow up practice in unit B to bring up net ionic equations again.

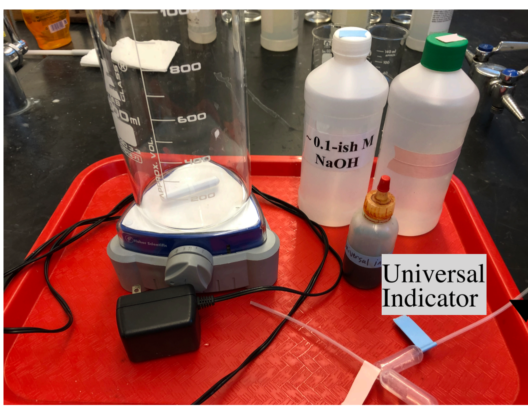
Procedure 1: This demonstration uses 500 ml of 2 M HCl with bromothymol blue (showing yellow) in the volumetric flask on the right, and 500 ml of 2 M NaOH with bromothymol blue. Make up solutions the day before so they will be at room temperature. Have a student feel the flask, and take the temp. Pour some HCl into the 1 L flask, then pour in NaOH, and repeat back and forth a couple of times, to see color change, then slowly finish off, and notice the solution will end up above the 1 L mark. You can pour the excess into a grad cylinder, and it will usually be between 18-20 ml extra. Should be 18 ml, since you are making 1 mole of water, but often you'll get 19 ml or so. The solution will have warmed, so you should have a student feel the flask, and take the temperature, and impress upon the students that neutralization is exothermic. It is difficult to get the BTB to end up just a green, I usually end up red or blue, hitting pH of 7 with the SA and SB is tricky.



Procedure 1



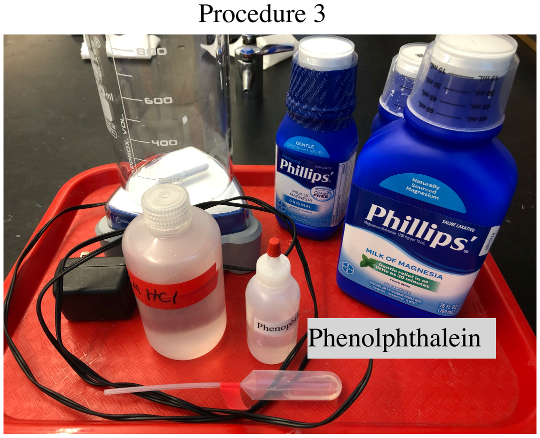
Procedure 2



In Procedure 2, to keep the volumes to a minimum, you can just use the droppers shown, and work with a large test tube instead of the large beaker shown.

Procedure 2: The NaOH is ~ 0.1 ish, so use an acetic acid that is ~0.1 ish. The concentration is not particularly important, but helpful if they are similar. The picture is misleading, I just put the acetic acid in a large test tube maybe a disposable plastic pipet, and add some water so they can have a bit more to view, then when you add a pipet or so of NaOH, you will neutralize, then another pipet of acetic again, and back and forth a couple of times. Very qualitative just to see color changes and then write the net ionic equation.

Procedure 3

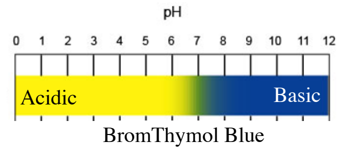


Store brand milk of magnesia works just fine.

Procedure 3: just put a splash of Mg(OH)2 (the milk of Magnesia) in the large beaker (maybe 30-50 ml) Then add double amount of water so the kids can see it better. Then us a Jumbo pipet to add 6 or 12 M HCl in small squirts and drops. Run first with no indicator, then with phenol

LAD A3 (pg 2 of 3) Acid Base Reaction aka Neutralization and other Net Ionic Equation Practice

ANSWERS



1. Consider the reaction between hydrochloric acid solution and sodium hydroxide solution with BTB indicator to show acidic and basic.
   a. Write the balanced overall equation.

   $$HCl + NaOH \rightarrow H_2O + NaCl$$

   b. Write the net ionic equation.

   $$H^+ + OH^- \rightarrow H_2O$$

   c. Calculate the number of moles of H^+ in 500 ml of 2.0 M HCl (*How warm or cold is the acid sol'n.*)

   $2M \times .5L = 1 mol\ H^+$

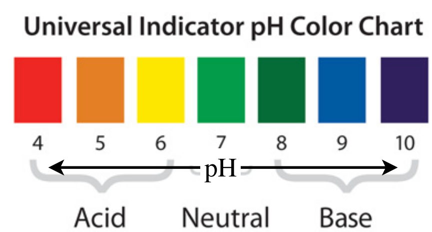
   d. Calculate the number of moles of OH^- in 500 ml of 2.0 M NaOH (*How warm or cold is the base sol'n.*)

   $2M \times 0.5L = 1 mol\ OH^-$

   e. Calculate the number of moles of water formed during the reaction. (*Feel the temperature of the neutralized sol'n.*)

   Per 1 H^+ to 1 OH^- ratio to 1 mole H_2O will be produced

   $1 mol\ H_2O \times \frac{18g}{1mol} = 18g\ H_2O$, density water 1g/ml ⇒ 18 ml H_2O produced

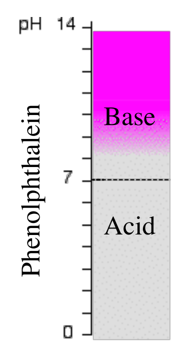


2. Consider the reaction between acetic acid, $HC_2H_3O_2$ and sodium hydroxide with universal indicator to show acidic and basic.
   a. Write the balanced overall equation.

   $$HC_2H_3O_2 + NaOH \rightarrow H_2O + NaC_2H_3O_2$$

   b. Write the net ionic equation.

   $$HC_2H_3O_2 + OH^- \rightarrow H_2O + C_2H_3O_2^-$$



3. Consider the reaction between a *suspension* of magnesium hydroxide and hydrochloric acid. Test the temp before and after. Use phenolphthalein indicator to show acidic and basic
   a. Write the balanced overall equation.

   $$Mg(OH)_2 + 2\ HCl \rightarrow MgCl_2 + 2\ H_2O$$

   b. Write the net ionic equation. *Eliminate the spectator ions.*

   $$Mg(OH)_2 + 2\ H^+ \rightarrow Mg^{2+} + 2\ H_2O$$

   c. Each teaspoon of Milk of Magnesia contains 400 mg of magnesium hydroxide (58.32 g/mol). Calculate the volume of 1.2 M hydrochloric acid required to neutralize this amount of milk of magnesia in the typical dose of 3 teaspoons. Each teaspoon is 5.0 ml.

   $\frac{1 mol}{58.32g} \times \frac{1000 mmol}{1 mol} \times \frac{1g}{1000mg} = \frac{1 mmol}{58.32 mg}$

   $3 tsp \times \frac{400 mg\ Mg(OH)_2}{1 tsp} = 1200 mg\ Mg(OH)_2 \times \frac{1 mmol}{58.32 mg} = 20.6 mmol$

Embrace the millimol and milligram!

$1.2M$ is $\frac{1.2 mol}{1L} \times \frac{1L}{1000 ml} \times \frac{1000 mmol}{1 mol} = \frac{1.2 mmol}{ml}$

$20.6 mmol\ Mg(OH)_2 \times \frac{2 HCl}{1 Mg(OH)_2} = \frac{41.2 mmol\ HCl}{x\ vol} = 1.2M$ → 34 ml HCl needed

 Net Ionic Equations (Neutralization and other **Net Ionic Equation)**

d. Post Lab Practice

1. Is the acid in the reaction below weak or strong? Convert the equation shown below into a balanced net ionic equation.

$$HBrO_{3(aq)} + NaOH_{(aq)} \rightarrow NaBrO_{3(aq)} + H_2O_{(L)}$$

$HBrO_3$ is a weak acid, and most of the molecules will not be ionized when dissolved in water. When the fully ionized hydroxide interacts with the acid, the neutralization reaction is aggressive enough to tear off all the H's from the acid. The sodium ions are a spectator ion and should be eliminated.

$$HBrO_3 + OH^- \rightarrow H_2O + BrO_3^-$$

2. Is the acid in the reaction below weak or strong? Convert the equation shown below into a balanced net ionic equation.

$$HClO_{4(aq)} + KOH_{(aq)} \rightarrow KClO_{4(aq)} + H_2O_{(L)}$$

$HClO_4$ is a strong acid and will be fully ionized before the reaction begins. The sodium hydroxide is also fully ionized,

$$H^+ + OH^- \rightarrow H_2O$$

3. Write the balanced net ionic equation for the reaction between aqueous solutions of nitrous acid, HNO_2, and barium hydroxide, $Ba(OH)_2$. No precipitate forms.

HNO_2 is a weak acid, and most of the molecules will not be ionized when dissolved in water, When the fully ionized hydroxide interacts with the weak acid, the neutralization reaction is aggressive enough to tear off all the H^+'s from the acid. The sodium ions are a spectator ion and should be eliminated.

$$HNO_2 + OH^- \rightarrow H_2O + NO_2^-$$

4. Convert the equation shown below into a balanced net ionic equation.
(Hint: net ionic, always means ions, but does not always mean there will be something to cross off.)

$$MgCO_{3(s)} + 2\ HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + H_2O_{(L)} + CO_{2(g)}$$

The nitrate ions are spectator ions, and must be eliminated from the equation. Pay close attention to the (s) after the $MgCO_3$, which means you must leave this compound intact, and no parts of it can be crossed off in the net-ionic equation.

$$MgCO_3 + 2\ H^+ \rightarrow Mg^{2+} + H_2O + CO_2$$

5. Write the balanced net ionic equation to represent the reaction between aqueous solutions of strontium nitrate and sodium hydroxide in which a white precipitate forms.

The nitrate and sodium ions are spectator ions, and must be eliminated from the equation.

$$Sr^{2+} + 2\ OH^- \rightarrow Sr(OH)_2$$

6. Convert the equation shown below into a balanced net ionic equation.

$$Pb(NO_3)_{2(aq)} + 2\ KI_{(aq)} \rightarrow PbI_{2(s)} + KNO_{3(aq)}$$

The nitrate and potassium ions are spectator ions, and must be eliminated from the equation.

$$Pb^{2+} + 2\ I^- \rightarrow PbI_2$$

7. Many metals react with acid to produce hydrogen gas in an aqueous solution. Balance the equation below, and then convert to a net ionic equation.

$$Al_{(s)} + HBr_{(aq)} \rightarrow AlBr_{3(aq)} + H_{2(g)}$$

Since HBr is a strong acid, the molecule is completely ionized, and bromide ions are spectator ions, and must be eliminated from the equation. This is a redox reaction as you can see the aluminum is oxidized. The hydrogen is reduced to elemental, diatomic H_2.

$$6\ H^+ + 2\ Al \rightarrow 2\ Al^{3+} + 3\ H_2$$

8. An aqueous solution of nickel(II) bromide will react with aluminum foil to produce an aqueous solution of aluminum bromide and nickel metal. Write the net-ionic equation for this reaction.

$HBrO_3$ is a weak acid, and most of the molecules will not be ionized when dissolved in water. When the fully ionized hydroxide interacts with the acid, the neutralization reaction is aggressive enough to tear off all the H's from the acid. The sodium ions are a spectator ion and should be eliminated.

$$HBrO_3 + OH^- \rightarrow H_2O + BrO_3^-$$