Lesson Title	What's the solution?
Length of Lesson	1 hour 15 min
Created By	Chris Ruhs
Subject	Chemistry
Grade Level	10-12th Grade
State Standards	Chemistry I: 13 a, c, d, e
DOK Level	DOK 2
DOK Application	Students observe and think deeply about acids and bases.
National Standards	B (Physical Science)
Graduate Research Element	Chemists must understand and be able to make solutions, understand and be able to determine pH, must understand acid/base chemistry.

Student Learning Goal:

MS 9-12th Grade:

Chemistry I: 10 (a) Compare properties of acids and bases, including how they affect indicators and the relative pH of the solution. *Students will experience and deeply understand the acid/base reactions using a standard indicator.* (c) Predict the product of an aqueous neutralization reaction. *Students will predict and balance an acid/base reaction.* (d) Calculate the pH or pOH from the hydrogen or hydroxide ion concentrations of solutions and vice versa. *Students will calculate, test, and observe an acid/base reaction, including the concentrations and pHs.* (e) Describe the role of indicators in experimental prediction of pH. *Students will observe an acid/base reaction with phenolphthalein indicator.*

National Science Education Standards of Content 9-12:

B: Physical Science: Chemical Reactions. *This lesson plan is an activity-based instruction designed to give students hands on experience with acid/base reactions in a practical way.*

Materials Needed (supplies, hand-outs, resources):

Volumetric flasks, 1.0M stock NaOH solution, 1.0M stock HCl solution, volumetric pipettes, phenolphthalein, beakers, crucibles, Bunsen burners, tongs.

Lesson Performance Task/Assessment:

Formative:

1. Review acid/base reactions
2. Review formulas related to acids/bases.
    a. $pH = -\log[H^+]$
    b. $M_1V_1 = M_2V_2$
3. Discussion of how to make a solution

Summative:

1. Place students into groups of four.
2. Walk them through the laboratory procedures.
3. Each group must:
    a. Use a volumetric flask to make 20mL of 0.5M HCl solution.
    b. Add 10mL of this solution to a beaker, adding three drops of phenolphthalein.
    c. Calculate how much 1.0M NaOH would be needed to neutralize the HCl solution.
    d. Test their calculation by adding the calculated volume of NaOH.
        i. Add the NaOH slowly, while swirling the solution in the beaker until the neutralization point is indicated by a pale pink color.
    e. Observe if the neutralization point was reached at the calculated amount; if not, note how much more or less was needed.
    f. Empty the solution down the drain and rinse out the beaker.
    g. Weigh a crucible.
    h. Pour the last 10mL of HCl solution into the clean beaker without adding phenolphthalein, adding the same amount of NaOH as was needed in step "e".
    i. Calculate how many moles of salt would be created by this acid/base reaction; convert this number of moles into a calculated mass.
    j. Pour the solution into the crucible, and carefully boil the water until only salt remains.
    k. Allow the crucible to cool, then weight it, subtracting the weight of the empty crucible to get the mass of the salt
    l. Compare your calculated mass into your observed mass.
    m. Calculate a percent error.
    n. Clean up.

Lesson Relevance to Performance Task and Students:
Real chemists are required to make accurate solutions for many applications. This skill must be mastered through practice, which also serves to reinforce the understanding of molarity and solutions. Further, experiencing an acid/base reaction, calculating a mass yield, and then testing to see if that yield was achieved will help solidify students' understanding of chemical processes.

Anticipatory Set/Capture Interest:
Simple question: can you make a 0.5 molar solution of HCl? Prove it!

Guided Practice:
Review of acid/base reactions, formulas, and solutions.

Independent Practice:

Laboratory activity.

Remediation and/or Enrichment:
Remediation:
Individual IEP.

Enrichment: Give the students an unknown HCl concentration, and ask them to determine the molarity and pH of the solution.

Check(s) for Understanding:
How do you make a dilution from a stock solution?
How do you calculate pH?
How could you determine the concentration of an unknown acid?

Closure:
Student-lead, teacher-guided review.

Possible Alternate Subject Integrations:
Environmental science: water quality and food safety.

Teacher Notes:
The combination of group work and hands on laboratory activities reinforced students' understanding of wet laboratory chemistry, acid/bases, stoichiometry, and volumetric glassware.