Neutralization of Pond Water

Introduction:

The neutralization of pond water lab demonstrates the neutralization (pH adjustment) of process pond water the Phosphate Industry goes through to protect the environment. This represents the Quicklime or CaO that the Phosphate Industry uses.

In the Phosphate Industry, phosphate rock is reacted with sulfuric acid to form phosphoric acid and phosphogypsum. Large amounts of water are recycled during the process of making these products. This process pond water is very acidic and is stored on top of the phosphogypsum stack and is continuously recycled. The Phosphate Industry must be prepared for extreme conditions when the stack might be unable to contain all the water. Sometimes it will be necessary to adjust the pH of process pond water. If necessary, the phosphate company will add CaO, or Quicklime, to the process pond water. When the CaO is added to water it reacts to form Calcium Hydroxide, $Ca(OH)_2$. Heat is generated during the reaction. This is known as an exothermic reaction. This is done to minimize the impacts acidic water might have on the environment if it were not treated. An example of an extreme condition is a hurricane or large rain event. When a plant shuts down the process water that remains must also be treated in this manner and released.

Universal Indicators can be used rather than a *pH* meter to determine an acid or base by knowing the corresponding color relationship to *pH*. The color relations to pH: pH 2 – red, pH 3 – red orange, pH 4 – orange, pH 5 – yellow orange, pH 6 – yellow, pH 7 – green, pH 8 – blue green, pH 9 - blue gray and pH 10 – violet.

The *pH* scale ranges from 0 to 14 with 7 being neutral. Neutral means an equal amount of hydrogen and hydroxide ions. Hydrogen ions increase exponentially in powers of 10 from pH 14 to 0. Hydroxide ions increases exponentially in powers of 10 from pH 0 to 14.

Estimated Time:

30 min

Grade Level:

9-12

Standards:

SC.912.P.8.11
SC.912.P.10.7
SC.912.P.12.12
SC.912.P.12.13

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Objectives:

- Work cooperatively in groups
- Follow written lab and safety procedures
- Titrate a solution to neutralize pond water
- Understand the role of hydrogen in solutions
- Observe results and graph data

Vocabulary:

pH (potential of hydrogen)
Hydrogen
Hydroxide
Titration
Equivalence point
Neutralize

Materials: (for 8 groups of 4)

100 ml Beakers
2 liter Volumetric Flask
Stirring Rods or Stirrers with Teflon Magnets
Droppers with graduated mls or a small Burette (10 or 25 ml) & Stand
10 ml graduated cylinders
Universal Indicator or pH Meter
Solid Sodium Hydroxide
Liquid 70% Phosphoric Acid
Notebook
Graph Paper
Color Chart for pH
Goggles
Gloves
Apron

Procedure:

1. Practice lab safety at all times. This laboratory experiment requires gloves, goggles, and an apron.
2. Add 10 mls of phosphoric acid solution to a 100 ml beaker using a graduated cylinder. Add 50 mls of distilled water to beaker.
3. Add 2 drops of universal indicator to the solution of phosphoric acid. (Color should be red)
4. Using a dropper add a small amount of sodium hydroxide into the beaker. (Start with 0.5 ml with each addition.) Use a stirring rod to keep the solution mixed well. Increments of

drops will be necessary to see all the colors. Drops may vary with dropper size, but usually 20 drops is equal to 1 milliliter.

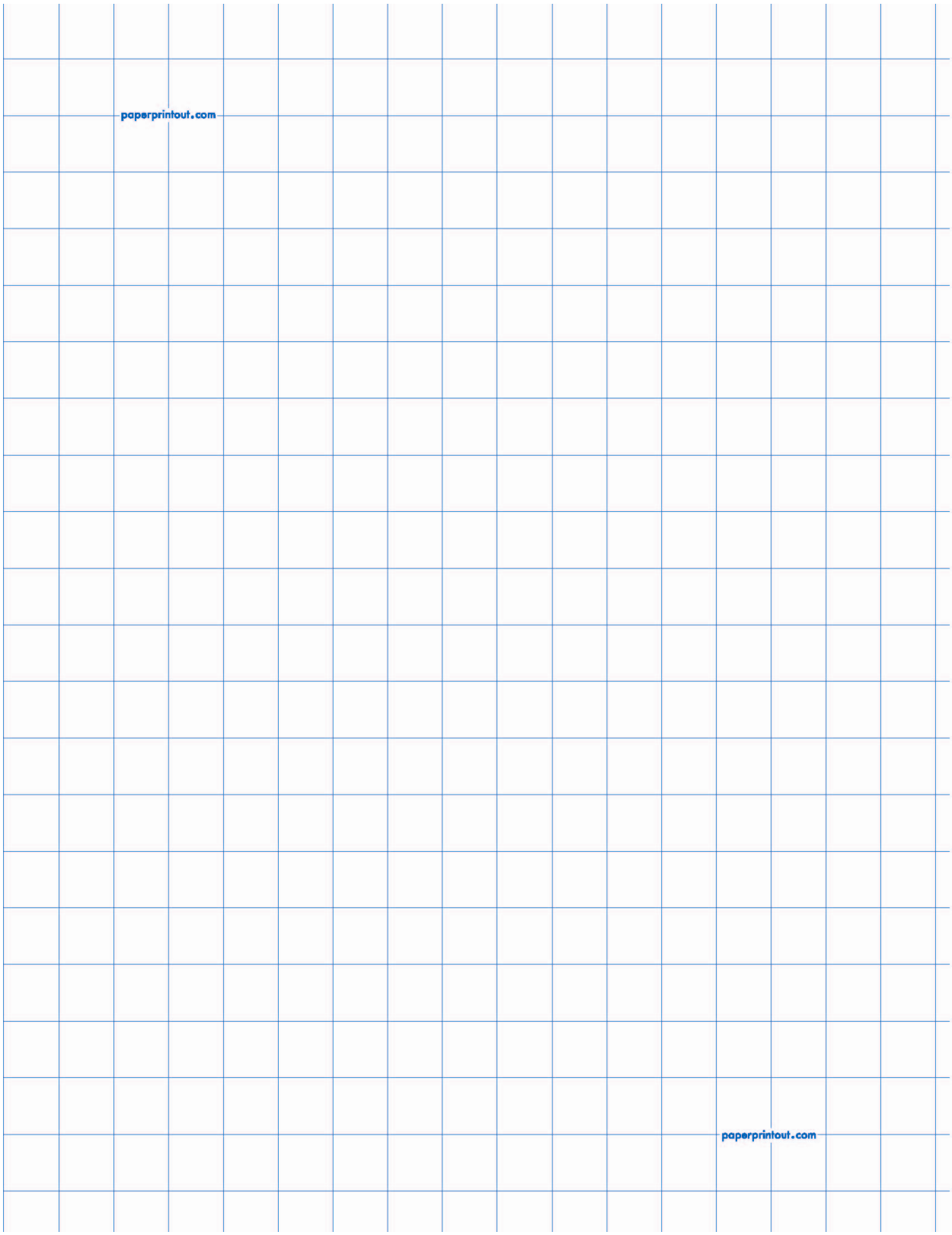
5. Record the number of *milliliters* (mls) of sodium hydroxide required for each color change. There will be nine (9) different color changes. (Drops may vary with dropper size, but usually 20 drops is equal to 1 milliliter.)
6. Record and Graph your data. Use Figure 1. Be sure to note observations during experimentation.

Data/Observations:

Color Change	Volume of Phosphoric Acid	Volume of Distilled Water	Volume of Universal Indicator	Volume of Sodium Hydroxide added	Total Volume of Sodium Hydroxide	Color	pH
Initial	10 mL	50 mL	2 drops or 0.1 mL	0	0	Red	1.5
1	10 mL	50 mL	0.1 mL				
2	10 mL	50 mL	0.1 mL				
3	10 mL	50 mL	0.1 mL				
4	10 mL	50 mL	0.1 mL				
5	10 mL	50 mL	0.1 mL				
6	10 mL	50 mL	0.1 mL				
7	10 mL	50 mL	0.1 mL				
8	10 mL	50 mL	0.1 mL				
9	10 mL	50 mL	0.1 mL				

Observations:

Figure 1



Analysis and Conclusion:

1. What is pH?
2. Draw a pH scale indicating the amounts of hydrogen and hydroxide ions present at different pH levels.
3. At a pH of 9 will the hydrogen ions outnumber the hydroxide ions?
4. What are equivalence points?
5. When using universal indicator the color green indicates what pH?
6. What must be worn during the experiment of neutralization of pond water?
7. Pond water is _____ in the Phosphate Industry.
8. A cm^3 is equal to approximately ____ milliliter.
9. What does exothermic mean?

Teachers Notes:

Teacher Preparation:
Supplies can be order from Flinn's Chemical & Biological Catalog. Call 800-452-1261 or email: flinn@flinnsci.com to receive a catalog. Website: www.flinnsci.com. Flinn's catalog is designed for school teachers and has excellent notes on safety when using chemicals. Phosphoric Acid # PO201 – 100ml, Sodium Hydroxide # S0074 – 100 grams, Universal Indicator # U0001 – 100 mls

Universal Indicator
Phosphoric Acid – Weigh approximately 30 grams of 70% H_3PO_4 into a 2 liter volumetric flask. Bring to volume with distilled water and mix thoroughly.
Sodium Hydroxide – Weigh approximately 30.0 grams into a 2 liter volumetric flask. Caution: When NaOH is added to water the solution becomes hot. (Exothermic – Heat Generation). Bring to volume with distilled water and mix thoroughly.
If one of the components is known such as the pond water, then the other (NaOH) can be calculated.

Groups can be four students. One student will pick up supplies. The second student will record all data collected and draw the titration curve. The other two students will perform the experiment.

$H_3PO_4 + NaOH \rightarrow NaH_2PO_4$ (1^{st} eq. Pt.)

$H_2PO_4^{-1} + NaOH \rightarrow Na_2HPO_4$ (2^{nd} eq. Pt.)

$HPO_4^{-2} + NaOH \rightarrow Na_3PO_4$ (3^{rd} eq. Pt.)

Neutralization of Pond Water

$CaO + H_2O \rightarrow Ca(OH)_2 + \Delta$ (HEAT Symbol)

Quicklime or Calcium Oxide reacts with water to produce Hydrated Lime or Calcium Hydroxide and heat. This is an exothermic reaction.

$3Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6H_2O$

Hydrated Lime reacts with Pond Water (H_3PO_4) to produces Calcium Mono orthophosphate (1st Stage), Calcium Di orthophosphate (2nd stage) Tri Calcium Phosphate (3rd Stage) reaction and water.

Assessment:
Titration curves should be inspected for *equivalent points*. The first *equivalent point* should be between pH 4-5, the second should be between pH 9 – 10. Using universal indicator will allow two equivalence points. The third *equivalent point* is approximately a pH of 12 and can be achieved using a pH meter.
See Figure 2 for correct graph and Table 1 for correct

Extension:
This titration to the amount needed by calculating the amount of sodium hydroxide (NaOH) or quicklime (CaO) required for neutralizing pond water.

Figure 2

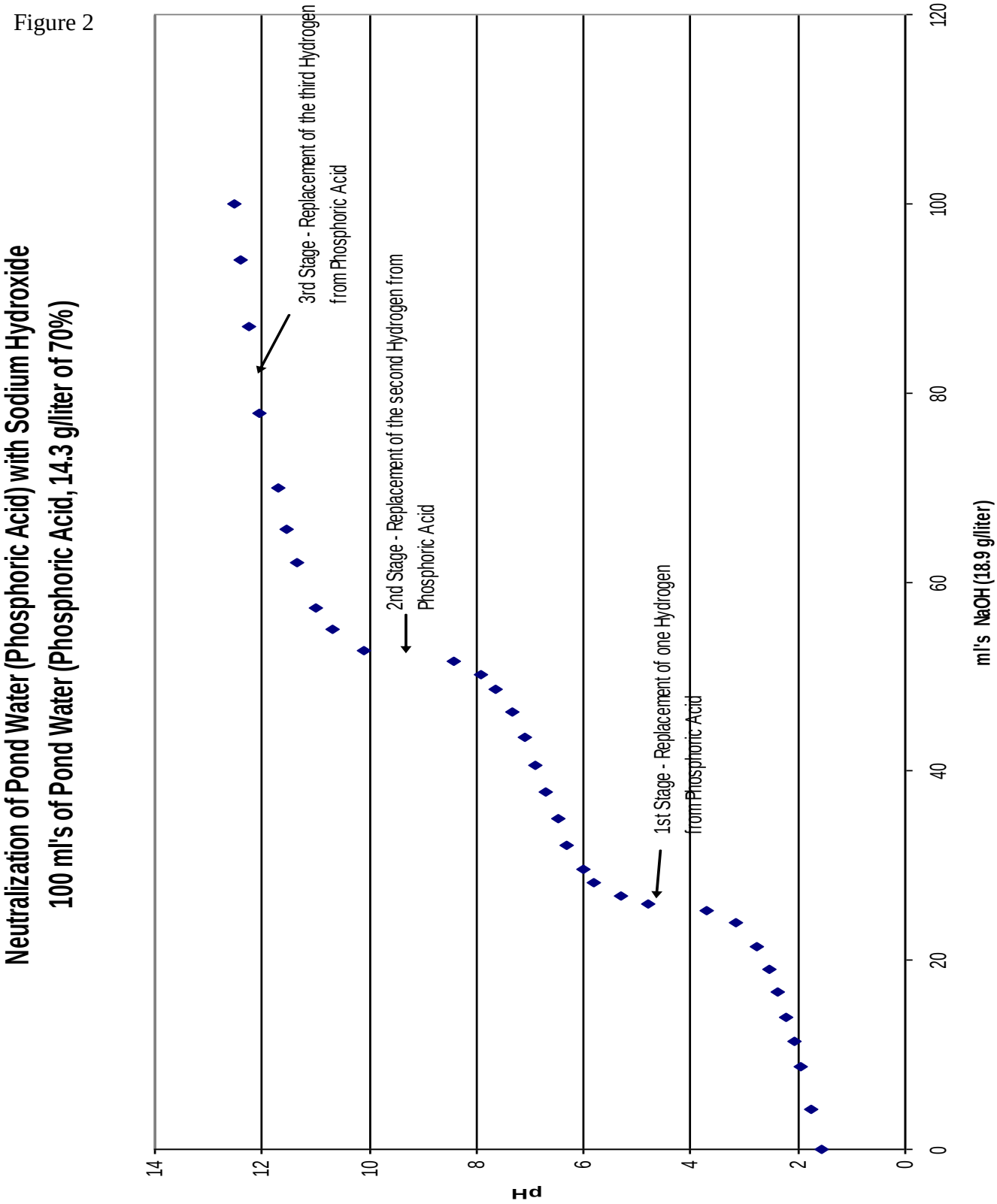

Neutralization of Pond Water (Phosphoric Acid) with Sodium Hydroxide
100 ml's of Pond Water (Phosphoric Acid, 14.3 g/liter of 70%)
3rd Stage - Replacement of the third Hydrogen from Phosphoric Acid
2nd Stage - Replacement of the second Hydrogen from Phosphoric Acid
1st Stage - Replacement of one Hydrogen from Phosphoric Acid
pH
ml's NaOH (18.9 g/liter)
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120

Table 1

Neutralization of Phosphoric Acid with Sodium Hydroxide

mls	pH
0	1.56
4.3	1.76
8.8	1.95
11.4	2.06
14	2.22
16.6	2.37
19	2.54
21.4	2.78
24	3.15
25.2	3.69
26	4.81
26.8	5.31
28.2	5.8
29.6	6.01
32.2	6.3
35	6.49
37.8	6.7
40.6	6.91
43.6	7.11
46.3	7.35
48.6	7.63
50.2	7.93
51.6	8.44
52.8	10.09
55	10.7
57.2	10.99
62	11.36
65.6	11.53
70	11.71
77.8	12.04
87	12.25
94	12.39
100	12.5