2002 D Required

A student is asked to determine the molar enthalpy of neutralization, ΔH_{neut}, for the reaction represented above. The student combines equal volumes of 1.0 *M* HCl and 1.0 *M* NaOH in an open polystyrene cup calorimeter. The heat released by the reaction is determined by using the equation $q = mc\Delta T$.

Assume the following.

- Both solutions are at the same temperature before they are combined.
- The densities of all the solutions are the same as that of water.
- Any heat lost to the calorimeter or to the air is negligible.
- The specific heat capacity of the combined solutions is the same as that of water.

(a) Give appropriate units for each of the terms in the equation $q = mc\Delta T$.

(b) List the measurements that must be made in order to obtain the value of q.

(c) Explain how to calculate each of the following.

(i) The number of moles of water formed during the experiment

(ii) The value of the molar enthalpy of neutralization, ΔH_{neut}, for the reaction between $HCl_{(aq)}$ and $NaOH_{(aq)}$

(d) The student repeats the experiment with the same equal volumes as before, but this time uses 2.0 *M* HCl and 2.0 *M* NaOH.

(i) Indicate whether the value of q increases, decreases, or stays the same when compared to the first experiment. Justify your prediction.

(ii) Indicate whether the value of the molar enthalpy of neutralization, ΔH_{neut}, increases, decreases, or stays the same when compared to the first experiment. Justify your prediction.

(e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH_{neut}? Justify your answer.

1996 D

A 0.500-gram sample of a weak, nonvolatile acid, HA, was dissolved in sufficient water to make 50.0 milliliters of solution. The solution was then titrated with a standard NaOH solution. Predict how the calculated molar mass of HA would be affected (too high, too low, or not affected) by the following laboratory procedures. Explain each of your answers.

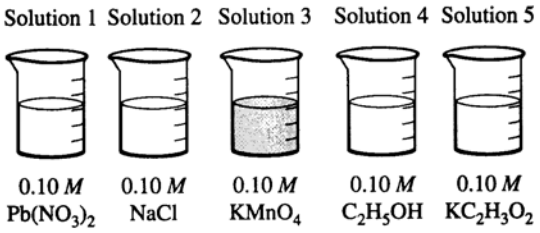
(a) After rinsing the buret with distilled water, the buret is filled with the standard NaOH solution; the weak acid HA is titrated to its equivalence point.

(b) Extra water is added to the 0.500-gram sample of HA.

(c) An indicator that changes color at pH 5 is used to signal the equivalence point.

(d) An air bubble passes unnoticed through the tip of the buret during the titration.

2001 D Required



Answer the questions below that relate to the five aqueous solutions at 25°C shown above.

(a) Which solution has the highest boiling point? Explain.

(b) Which solution has the highest pH? Explain.

(c) Identify a pair of the solutions that would produce a precipitate when mixed together. Write the formula of the precipitate.

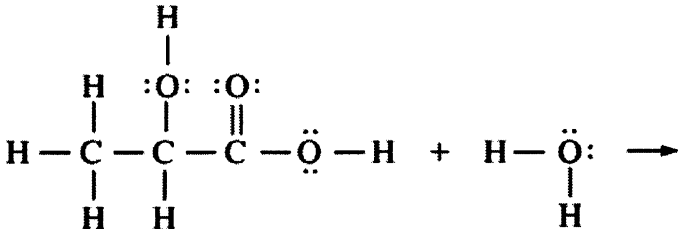
(d) Which solution could be used to oxidize the $Cl^{-}_{(aq)}$ ion? Identify the product of the oxidation.

(e) Which solution would be the <u>least</u> effective conductor of electricity? Explain.

2007 part B, form B, question #5

Answer the following questions about laboratory situations involving acids, bases, and buffer solutions.

(a) Lactic acid, $HC_3H_5O_3$, reacts with water to produce an acidic solution. Shown below are the complete Lewis structures of the reactants.



In the space provided above, complete the equation by drawing the complete Lewis structures of the reaction products.

(b) Choosing from the chemicals and equipment listed below, describe how to prepare 100.00 mL of a 1.00 M aqueous solution of NH_4C1 (molar mass 53.5 g mol^{-1}). Include specific amounts and equipment where appropriate.

$NH_4Cl_{(s)}$	50 mL buret	100 mL graduated cylinder	100mL pipet
Distilled water	100 mL beaker	100 mL volumetric flask	Balance

(c) Two buffer solutions, each containing acetic acid and sodium acetate, are prepared. A student adds 0.10 mol of HCl to 1.0 L of each of these buffer solutions and to 1.0 L of distilled water. The table below shows the pH measurements made before and after the 0.10 mol of HCl is added.

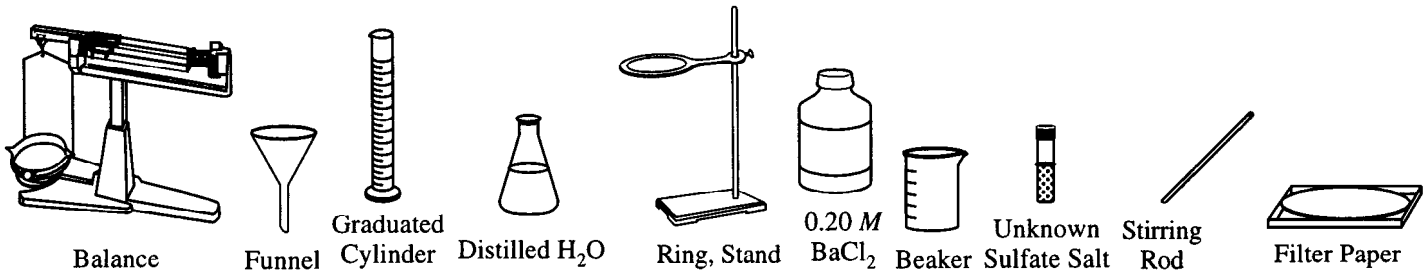
	pH Before HCl Added	pH After HCl Added
Distilled water	7.0	1.0
Buffer 1	4.7	2.7
Buffer 2	4.7	4.3

(i) Write the balanced net-ionic equation for the reaction that takes place when the HCl is added to buffer 1 or buffer 2.

(ii) Explain why the pH of buffer 1 is different from the pH of buffer 2 after 0.10 mol of HCl is added.

(iii) Explain why the pH of buffer 1 is the same as the pH of buffer 2 before 0.10 mol of HCl is added.

1997 D



An experiment is to be performed to determine the mass percent of sulfate in an unknown soluble sulfate salt. The equipment shown above is available for the experiment. A drying oven is also available.

(a) Briefly list the steps needed to carry out this experiment.

(b) What experimental data need to be collected to calculate the mass percent of sulfate in the unknown?

(c) List the calculations necessary to determine the mass percent of sulfate in the unknown.

(d) Would 0.20-molar $MgCl_2$ be an acceptable substitute for the $BaCl_2$ solution provided for this experiment? Explain.

1990 D

An experiment is performed to determine the empirical formula of a copper iodide formed by direct combination of elements. A clean strip of copper metal is weighed accurately. It is suspended in a test tube containing iodine vapor generated by heating solid iodine. A white compound forms on the strip of copper, coating it uniformly. The strip with the adhering compound is weighed. Finally, the compound is washed completely from the surface of the metal and the clean strip is dried and reweighed.

DATA TABLE	
Mass of clean copper strip	1.2789 grams
Mass of copper strip and compound	1.2874 grams
Mass of copper strip after washing	1.2748 grams

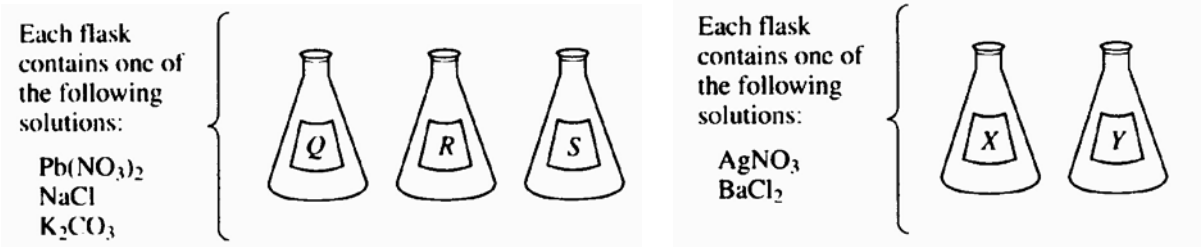
(a) State how you would use the data above to determine each of the following. (Calculations not required.)
   (1) The number of moles of iodine that reacted
   (2) The number of moles of copper that reacted

(b) Explain how you would determine the empirical formula for the copper iodide.

(c) Explain how each of the following would affect the empirical formula that could be calculated.
   (1) Some unreacted iodine condensed on the strip.
   (2) A small amount of the white compound flaked off before weighing.

2004 D Required

In a laboratory class, a student is given three flasks that are labeled *Q*, *R*, and *S*. Each flask contains one of the following solutions: 1.0 *M* $Pb(NO_3)_2$, 1.0 *M* NaCl, or 1.0 *M* K_2CO_3. The student is also given two flasks that are labeled *X* and *Y*. One of these flasks contains 1.0 *M* $AgNO_3$, and the other contains 1.0 *M* $BaCl_2$. This information is summarized in the diagram below.



(a) When the student combined a sample of the solution *Q* with a sample of *X*, a precipitate formed. A precipitate also formed when samples of solutions *Q* and *Y* are combined.
   (i) Identify solution *Q*.
   (ii) Write the chemical formulas for each of the two precipitates.

(b) When solution *Q* is mixed with solution *R*, a precipitate forms. However, no precipitate forms when solution *Q* is mixed with solution *S*.
   (i) Identify solution *R* and solution *S*.
   (ii) Write the chemical formula of the precipitate that forms when solution *Q* is mixed with solution *R*.

(c) The identity of solution *X* and solution *Y* are to be determined using the following solutions: 1.0 *M* $Pb(NO_3)_2$, 1.0 *M* NaCl, and 1.0 *M* K_2CO_3.
   (i) Describe a procedure to identify solution *X* and solution *Y*.
   (ii) Describe the observations that would allow you to distinguish between solution *X* and solution *Y*.
   (iii) Explain how the observations would enable you to distinguish between solution *X* and solution *Y*.

2008 Form B

5. The identity of an unknown solid is to be determined. The compound is one of the seven salts in the following table:

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	$CaCO_3$	$CuSO_4 \cdot 5H_2O$
NaCl	$BaSO_4$	$Ni(NO_3)_2 \cdot 6H_2O$	

Use the results of the following observations or laboratory tests to explain how each compound in the table may be eliminated or confirmed. The tests are done in sequence from (a) through (e).

(a) The unknown compound is white. In the table below, cross out the two compounds that can be eliminated using this observation. Be sure to cross out these same two compounds in the tables in parts (b), (c), and (d).

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	$CaCO_3$	$CuSO_4 \cdot 5H_2O$
NaCl	$BaSO_4$	$Ni(NO_3)_2 \cdot 6H_2O$	

(b) When the unknown compound is added to water, it dissolves readily. In the table below, cross out the two compounds that can be eliminated using this test. Be sure to cross out these same two compounds in the tables in parts (c) and (d).

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	$CaCO_3$	$CuSO_4 \cdot 5H_2O$
NaCl	$BaSO_4$	$Ni(NO_3)_2 \cdot 6H_2O$	

(c) When $AgNO_3(aq)$ is added to an aqueous solution of the unknown compound, a white precipitate forms. In the table below, cross out each compound that can be eliminated using this test. Be sure to cross out the same compound(s) in the table in part (d).

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	$CaCO_3$	$CuSO_4 \cdot 5H_2O$
NaCl	$BaSO_4$	$Ni(NO_3)_2 \cdot 6H_2O$	

(d) When the unknown compound is carefully heated, it loses mass. In the table below, cross out each compound that can be eliminated using this test.

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	$CaCO_3$	$CuSO_4 \cdot 5H_2O$
NaCl	$BaSO_4$	$Ni(NO_3)_2 \cdot 6H_2O$	

(e) Describe a test that can be used to confirm the identity of the unknown compound identified in part (d). Limit your confirmation test to a reaction between an aqueous solution of the unknown compound and an aqueous solution of one of the other soluble salts listed in the tables. Describe the expected results of the test; include the formula(s) of any product(s).