CHAPTER 4 -- THE LABORATORY

INTRODUCTION

The laboratory is where chemistry comes to life. It is where most practicing chemists first came to like the subject. It offers one of the few opportunities students have to learn to make observations, organize information logically, draw conclusions and present results. A chemistry course without laboratory experiences for the students is at best an incomplete, inferior course. A teacher does his/her students a great disservice if no effort is made to include laboratory learning.

The reasons for not offering a laboratory are numerous and most are valid. Laboratory preparation and cleanup does involve extra work, a laboratory is expensive, accidents can happen in a laboratory, often laboratory equipment is poor. To which we respond: but laboratory instruction is so important to the learning of chemistry, it must be done.

In a manner analogous to the development of the learning objectives presented earlier, the Education Committee has compiled a list of Minimum Skills for the Chemistry Laboratory. These skills should be mastered by everyone who completes a course in high school chemistry. The list is so short and the skills so simple that a good teacher will want to make this list only the beginning of a more comprehensive list of laboratory skills.

Following the list of laboratory skills, two sample tests on laboratory learning are included. One is a "practical" test; the other is a written test. Questions on both tests are keyed to the list of Minimum Skills for the Chemistry Laboratory.

Next there are some suggestions concerning student laboratory notebooks and reports followed by detailed procedures for preparing reagent solutions.

The chapter concludes with some suggestions for estimating the cost of incorporating new experiments into the laboratory program and detailed price lists of chemicals and supplies for all the experiments described in this handbook.

Price lists for the demonstrations described in this handbook have not been prepared because only small quantities of supplies are involved and most items are readily available.
MINIMUM SKILLS FOR THE CHEMISTRY LABORATORY

1. Identify the common pieces of laboratory equipment and be able to spell the names correctly.
2. Demonstrate a knowledge of laboratory safety rules.
3. Point out the location and operation of fire extinguishers and other safety devices.
4. Demonstrate the proper use of a balance.
5. Demonstrate the proper use of a Bunsen burner.
6. Measure the mass of less than 200 g of a substance to within 0.01 g.
7. Measure the length of an object to within 0.1 cm.
8. Measure the volume of about 10 mL of a liquid to within 0.1 mL using a graduated cylinder.
9. Demonstrate the proper method for removing a small amount of solid from a bottle.
10. Demonstrate the proper method for pouring a small amount of a corrosive liquid from a bottle.
11. Measure the temperature of a liquid using a Celsius thermometer.
12. Measure the volume of a liquid delivered by a buret and/or pipet.
13. Determine the barometric pressure by using a barometer (if available).
14. Demonstrate how to separate a mixture of a solid and a liquid by filtration.
15. Make proper observations and write an understandable description of laboratory activities.
16. Organize information in a logical manner.
17. Derive conclusions based on observations using data or graphs.
## SUGGESTED QUESTIONS FOR A WRITTEN LABORATORY TEST

(Keyed to the List of Minimum Skills for the Chemistry Laboratory)

| Skill Number | 1.____________________ | 2.____________________ | 3.____________________ | 4.____________________ | 5.____________________ | 6.____________________ | 7.____________________ | 8.____________________ | 9.____________________ | 10.____________________ | 11.____________________ | 12.____________________ | 13.____________________ | 14.____________________ | 15.____________________ |
|--------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| (1)          | 1.____________________   | 2.____________________   | 3.____________________   | 4.____________________   | 5.____________________   | 6.____________________   | 7.____________________   | 8.____________________   | 9.____________________   | 10.____________________  | 11.____________________  | 12.____________________  | 13.____________________  | 14.____________________  | 15.____________________  |
What are the locations of the fire extinguishers and first aid kit?

Name one piece of safety equipment that is worn during every laboratory period.

What should be done immediately if you spill acid or other chemicals on your skin?

If you were told to obtain 10 mL of hydrochloric acid, what equipment would you use?

Describe how you would weigh:

(a) 11.5 g of salt
(b) 12 g of water

What is the measurement at:
(a) arrow A?
(b) arrow B?

What type (color) of bunsen burner flame is best for laboratory work and why?

What is the volume of the liquid in the graduated cylinder to the left?

Describe how you would remove a small amount of a solid chemical from a reagent bottle?

A student did an experiment to determine the percent of water in a potato. She weighed an evaporating dish and found the mass to be 60.75 g. She placed some pieces of potato in the dish and found the mass of dish and potato to be 110.90 g. After heating the dish and potato until all the water was removed the mass of dish and potato was 70.78 g. Set up a data table for this data and calculate and record the mass of and percent of water in the potato.

Draw a graph to represent the following data.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 g</td>
<td>5 cm³</td>
</tr>
<tr>
<td>3 g</td>
<td>15 cm³</td>
</tr>
<tr>
<td>5 g</td>
<td>25 cm³</td>
</tr>
<tr>
<td>7 g</td>
<td>35 cm³</td>
</tr>
</tbody>
</table>
ANSWERS TO SUGGESTED QUESTIONS FOR A WRITTEN LABORATORY TEST

1. Bunsen burner
2. Test tube holder
3. Ring clamp
4. Ring stand/ring
5. Watch glass
6. Wire gauze
7. Evaporating dish
8. Beaker
9. Graduated cylinder
10. Spatula
11. Test tube clamp/utility clamp/buret clamp
12. Balance
13. Funnel
14. Erlenmeyer flask
15. Test tube
16. Description of locations
17. Safety glasses/safety goggles
18. Flush with an ample supply of water. Contact the teacher.
19. Graduated cylinder
20. (a) Make sure the pointer on the balance is set at zero. Place a piece of weighing (glazed) paper on the balance pan and determine its mass. Record the mass of the paper. Set the balance to read the mass of the paper plus 11.5 g. Using a spatula, obtain a quantity of salt from a bottle and carefully pour the salt onto the weighing paper until the pointer of the balance comes to zero.

(b) Repeat procedure above except use a beaker instead of weighing paper.
21. (a) 22.65  
    (b) 23.02

22. Blue, because it burns hotter and cleaner.

23. 87.5 mL.

24. First read the label on the bottle to make sure you are getting the chemical requested. Using a spatula remove the desired amount of salt and put it on a glazed paper. Do not put any surplus salt back in the reagent bottle; instead discard it.

25. Mass of dish + fresh potato  
    Mass of dish  
    Mass of fresh potato  
    Mass of dish + dry potato  
    Mass of dry potato  
    Mass of water  
    % of water in potato

\[
\begin{align*}
\text{Mass of dish + fresh potato} &= 110.90 \text{ g} \\
\text{Mass of dish} &= 60.75 \text{ g} \\
\text{Mass of fresh potato} &= 110.90 \text{ g} - 60.75 \text{ g} = 50.15 \text{ g} \\
\text{Mass of dish + dry potato} &= 70.78 \text{ g} \\
\text{Mass of dry potato} &= 70.78 \text{ g} - 60.75 \text{ g} = 10.03 \text{ g} \\
\text{Mass of water} &= 50.15 \text{ g} - 10.03 \text{ g} = 40.12 \text{ g} \\
\% \text{ of water in potato} &= \frac{40.12 - 50.15 \text{ g}}{50.15 \text{ g}} \times 100 = 80.00\%
\end{align*}
\]

26. [Graphs showing the relationship between M and V.]
SUGGESTED QUESTIONS FOR A PRACTICAL LABORATORY TEST

(Keyed to the List of Minimum Skills for the Chemistry Laboratory)

Skill Number

(1)  1. Items of equipment have been placed on laboratory tables with a number beside each piece of equipment. Identify each item of equipment by writing its name by the appropriate number.

   (1) ___________________    (8) ______________________
   (2) ___________________    (9) ______________________
   (3) ___________________    (10) ______________________
   (4) ___________________    (11) ______________________
   (5) ___________________    (12) ______________________
   (6) ___________________    (13) ______________________
   (7) ___________________    (14) ______________________

(3)  2. Describe the position of the fire extinguisher and first aid kit in this room.

(4,6) 3. Weigh 7.60 g of sodium chloride using the balance.

(5)  4. Light and adjust a Bunsen burner to produce a flame appropriate for laboratory use.

(7)  5. Obtain a meter stick and determine the length (height) of your chemistry textbook in centimeters.

(8)  6. Use a graduated cylinder to measure 15.6 mL of tap water.

(9)  7. Use a spatula to remove approximately 3 g of sodium chloride from the reagent bottle.

(10)  8. Pour 15.0 mL of hydrochloric acid into a 50.0 mL graduated cylinder (or 5.0 mL into a 10.0 mL graduated cylinder).

Note to the Teacher: There can be no accompanying answer sheet for this test which requires observation of student skills.
REPORTING LABORATORY RESULTS

There are many ways to structure the presentation of laboratory results. Individual reports may be required for each experiment, fill-in-the-blank report sheets could be provided, or each student could keep a laboratory notebook. No matter which choice is made, the students should be informed of the required format before the first experiment.

A laboratory notebook should be hardbound (not spiral or looseleaf) with ruled paper. When graphs are required, commercial graph paper should be used. The graphs may be taped or stapled into the notebook. All entries in the notebook should be neat, orderly, and legible. However, experimental data should not be recopied. If a change is necessary, a line should be drawn neatly through the data to be changed, and the new data entered.

Shown below is a suggested format for the student to use in recording information about an experiment in the laboratory notebook. Alternatively, this format could be used for individual reports submitted by the student to the teacher. Note that the report of each experiment is divided into three sections.

Pre-laboratory:
1. The date of the experiment
2. The title of the experiment
3. A statement of the objective of the experiment
4. The pre-laboratory assignments
5. An outline of the experimental procedure

Laboratory:
1. A detailed record of all observations
2. A record of all measurements made in the experiment
3. Names and quantities of materials used

Post-Laboratory:
1. Answers to all questions asked about the experiment
2. Each calculation shown in detail
3. A statement that summarizes the success or failure of the experiment. This can include error calculations.
4. Information and answers relating to "further study" assignments
REAGENT SOLUTION PREPARATION

Reagent solutions must be prepared properly if laboratory work is to be successful. Procedures for preparing reagent solutions are relatively simple but require practice for proficiency. As a review, presented below are detailed instructions for the preparation of two common laboratory solutions: 0.10 M CuSO\(_4\) · 5H\(_2\)O and 1.0 M HCl. The techniques described are general and can be used to prepare various other solutions.

I. For the preparation of 1.0 L of 0.10 M CuSO\(_4\) · 5H\(_2\)O, the following procedure is suggested:

1. Obtain the needed chemicals, glassware, and equipment:
   (a) CuSO\(_4\) · 5H\(_2\)O (solid)
   (b) Distilled water
   (c) Balance, 0.01 g sensitivity
   (d) Beaker, 250 ml
   (e) Volumetric flask, 1.0 L, with stopper
   (f) Funnel
   (g) Stirring rod
   (h) Spatula
   (i) Plastic wash bottle

2. Clean glassware with detergent and tap water, rinse well with tap water, and rinse finally with 2 or 3 portions (20 - 15 mL each) of distilled water.

3. Calculate the mass of CuSO\(_4\) · 5H\(_2\)O needed to prepare 1.0 L of 0.10 M CuSO\(_4\) · 5H\(_2\)O (molar mass or gram formula weight = 249.68)

\[
g \text{ CuSO}_4 \cdot 5\text{H}_2\text{O} = 1.0 \text{ L} \times \frac{0.10 \text{ mol CuSO}_4 \cdot 5\text{H}_2\text{O}}{\text{L}} \times \frac{249.68 \text{ g CuSO}_4 \cdot 5\text{H}_2\text{O}}{\text{mol CuSO}_4 \cdot 5\text{H}_2\text{O}}
\]

\[
= 24.97 \text{ g CuSO}_4 \cdot 5\text{H}_2\text{O}
\]

4. Weigh out 24.97 g of CuSO\(_4\) · 5H\(_2\)O into a 250 ml beaker.

5. Add 100 - 150 mL distilled water to the beaker and stir with a stirring rod to dissolve the CuSO\(_4\) · 5H\(_2\)O.

6. Pour the CuSO\(_4\) · 5H\(_2\)O solution through a funnel into a 1.0 L volumetric flask.

   Care should be taken to transfer all the CuSO\(_4\) · 5H\(_2\)O solution from the beaker to the flask by rinsing the beaker with several portions of distilled water or by washing the side of the beaker carefully with distilled water from a plastic
wash bottle, adding the wash water to the volumetric flask also. Finally, rinse the funnel several times before removing it.

7. Add distilled water to the volumetric flask to bring the liquid level up to near the mark on the neck of the flask.

8. Mix the contents of the flask by swirling and then allow the liquid to reach room temperature.

9. Use a plastic wash bottle to bring the level of solution exactly to the mark. Cap the flask with the stopper provided.

10. Mix the contents of the flask by inverting the flask and swirling. Repeat the inverting and swirling process at least 10 times.

11. Transfer the solution to a clean glass or plastic bottle for storage.

12. Label the bottle "0.10 M CuSO₄ · 5H₂O". Put the date of preparation on the label. Initial the label.

II. A procedure for the preparation of 250 mL of 1.0 M HCl:

1. Obtain the needed chemicals, glassware, and equipment.
   (a) Concentrated hydrochloric acid, 12 M
   (b) Distilled water
   (c) Beaker, 100 mL
   (d) Graduated cylinder, 10 mL
   (e) Volumetric flask, 250 mL
   (f) Funnel on ring stand
   (g) Plastic wash bottle

2. Clean all glassware with detergent and tap water, rinse well with tap water, and rinse finally with 2 or 3 portions (10-15 mL each) of distilled water.
3. Calculate the volume of concentrated (12M) HCl needed to prepare 250 mL of 1.0 M HCl. Use this formula:

\[ V_1 \times M_1 = V_2 \times M_2 \]

\[ V_1 = \text{volume of 12 M HCl needed} \]
\[ M_1 = 12 \text{ M} \]
\[ V_2 = 250 \text{ mL} \]
\[ M_2 = 1.0 \text{ M} \]

\[ V_1 = \frac{V_2 \times M_2}{M_1} = \frac{250 \text{ mL} \times 1.0 \text{ M}}{12 \text{ M}} = 20.8 \text{ mL} \]

4. Using a funnel, carefully pour slightly more than 21 mL of concentrated HCl into the 250 mL beaker.

5. Transfer the concentrated HCl from the beaker to a 25 mL graduated cylinder to give a volume of exactly 20.8 mL. Discard the excess concentrated HCl by rinsing down the drain with a large quantity of water.

6. Add approximately 100 mL of distilled water to a 250 mL volumetric flask.

7. Pour the 20.8 mL of concentrated HCl through a funnel into the 250 mL volumetric flask. Care should be taken to transfer all the HCl from the graduated cylinder to the flask by rinsing the cylinder with 2 or 3 small portions of distilled water, and also rinsing the funnel before removing it.

8. Add distilled water to the flask to bring the liquid level up to near the mark on the neck of the flask.

9. Mix the contents of the flask by swirling and then allow the contents to reach room temperature.

10. Use a plastic wash bottle to bring the level of solution exactly to the mark. Cap the flask with the stopper provided.

11. Mix the contents of the flask by inverting the flask and swirling. Repeat the inverting and swirling process at least 10 times.

12. Transfer the solution to a clean glass or plastic bottle for storage.

13. Label the bottle "1.0 M HCl". Put the date of preparation on the label. Initial the label.
ESTIMATING THE COST OF LABORATORY INSTRUCTION

Before incorporating a new experiment or demonstration into the chemistry course, a teacher will want to know the approximate cost of the chemicals, supplies, and equipment involved.

Usually it will be possible to reduce the cost of supplies by using common sense and making some obvious substitutions. For example, if the procedure for an experiment you are thinking of using reads "Pour 250 mL of water into a 400 mL beaker," it would be foolish to buy 400 mL beakers if your laboratory is already stocked with 500 mL beakers and if the slightly larger beaker would serve the purpose of the experiment just as well. Sometimes a satisfactory substitution may not be as obvious. For example, an experiment might require the use of an accurate timer, which costs about $70. However, among any group of high school students today, it is almost certain that several will be wearing digital wristwatches with a stopwatch function. These watches are probably more accurate than the timer and their use costs nothing!

To help the teacher who is considering using some of the experiments described in this handbook, a list of the approximate cost of chemicals and supplies for each experiment is presented on the following pages. The prices are 1985 retail prices for individual items. Buying in quantity will reduce the costs significantly. "State contract" prices, if applicable to purchases by your school, will further reduce costs.

It is suggested that chemicals and supplies be bought for only a few new experiments each year (but on a regular year-to-year basis) rather than a huge one-time purchase of items for a large number of new experiments. This approach will allow you to make a more careful evaluation of the experiments in the hands of your students. Moreover, in the future, additional new experiments can be incorporated to make use of many of the items of chemicals and supplies already on hand for the few initial new experiments you adopted.
PRICE LISTS OF CHEMICALS AND SUPPLIES
FOR THE EXPERIMENTS DESCRIBED IN THIS HANDBOOK

EXPERIMENT 1. THE BURNING OF A CANDLE

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity</th>
<th>Cost</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>lampblack</td>
<td>500 g</td>
<td>$14.00</td>
<td>many</td>
</tr>
<tr>
<td>sugar, cube</td>
<td>1 lb.</td>
<td>.60</td>
<td>100</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

- beaker, 400 mL 1.81
- beaker, 1000 mL 4.34
- burner, Bunsen 7.20
- candle .27
- cardboard free
- cotton ball .01
- flask, Erlenmeyer, 500 mL 3.00
- forceps .65
- wire gauze 1.00
- watch glass .95
- match .15
- paper, plain, white free from school office
- watch or timer 70.00*

* a wristwatch with stopwatch function may be used

EXPERIMENT 2. MASS AND VOLUME RELATIONSHIP

A. CHEMICALS

- aluminum metal, 13 mm dia x 5.1 cm long $1.25 each
- brass metal, 13 mm dia x 5.1 cm long 1.25 each
- unknown metal 1.25 each

B. SUPPLIES (PER STATION)

- graduated cylinder, 100 Ml 6.80
- balance, 200 g, 0.01 g sensitivity 112.00*
- thread .20

*One balance per 4 stations
EXPERIMENT 3. SCIENTIFIC NOTATION AND INDIRECT MEASUREMENTS

A. CHEMICALS
   NONE

B. SUPPLIES (PER STATION)
   - balance, 200 g, 0.01 g sensitivity: 112.00*
   - 50 or 100 mL beaker: 1.60 or 1.80
   - evaporating dish, small: 3.94
   - medicine dropper: .15
   - ream of paper (borrow from school office): .80
   - ruler, metric: .80

* One balance per 4 stations

EXPERIMENT 4. SYMBOLS AND FORMULAS

A. CHEMICALS
   NONE

B. SUPPLIES (PER STATION)
   - cardboard or heavy paper: $ .75
   - graph paper: 1.00
   - scissors: 3.00

EXPERIMENT 5. CHEMICAL EQUATIONS

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity</th>
<th>Cost</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>barium chloride</td>
<td>100 g</td>
<td>5.30</td>
<td>many (&gt;200)</td>
</tr>
<tr>
<td>hydrochloric acid</td>
<td>2.37 L</td>
<td>12.95</td>
<td>many (&gt;200)</td>
</tr>
<tr>
<td>magnesium sulfate</td>
<td>500 g</td>
<td>19.75</td>
<td>many (&gt;500)</td>
</tr>
<tr>
<td>sugar</td>
<td>5 pounds</td>
<td>1.60</td>
<td>many (&gt;1500)</td>
</tr>
<tr>
<td>magnesium ribbon</td>
<td>12</td>
<td>9.95</td>
<td>(for teacher's demonstration)</td>
</tr>
<tr>
<td>1984 or later penny</td>
<td>1 ea</td>
<td>.01</td>
<td>.5</td>
</tr>
</tbody>
</table>
B. SUPPLIES (PER STATION)

- burner, Bunsen $7.20
- graduated cylinder, 10 mL 4.90
- graduated cylinder, 100 mL 6.80
- file, triangular 3.50
- wire gauze .95
- watch glass .95 (for teacher's demonstration)
- test tube holder 2.50
- litmus paper, red .50 (for teacher's demonstration)
- ring with clamp 4.00
- ring stand 13.00
- test tube, 25 mm x 200 mm .73
- test tube, 16 x 150 mm .29
- test tube holder 2.50
- tongs 6.80 (for teacher's demonstration)

EXPERIMENT 6. EXPERIMENTAL STOICHIOMETRY

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity</th>
<th>Cost</th>
<th>Maximum Number of Stations</th>
<th>Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethyl alcohol</td>
<td>500 mL</td>
<td>3.20</td>
<td>many (&gt;800)</td>
<td>many (&gt;800)</td>
</tr>
<tr>
<td>hydrochloric acid</td>
<td>2.37 L</td>
<td>12.95</td>
<td>many (&gt;100)</td>
<td>100</td>
</tr>
<tr>
<td>phenolphthalein</td>
<td>25 g</td>
<td>8.35</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>sodium hydroxide</td>
<td>500 g</td>
<td>10.35</td>
<td>many (&gt;100)</td>
<td></td>
</tr>
<tr>
<td>sulfuric acid</td>
<td>4 kg</td>
<td>25.50</td>
<td>many (&gt;100)</td>
<td></td>
</tr>
<tr>
<td>distilled water</td>
<td>1 gal</td>
<td>.65</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

- beaker, 50 mL 1.60
- graduated cylinder, 5 or 10 mL 4.90
- medicine dropper .15
- six 20x150 mm test tubes 2.64 (.44 each)
EXPERIMENT 7. INVESTIGATION OF HARD AND SOFT WATER

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity Purchased</th>
<th>Cost</th>
<th>Maximum Number of Stations</th>
<th>Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>calcium chloride</td>
<td>100 g</td>
<td>$ 5.95</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>calcium sulfate</td>
<td>100 g</td>
<td>9.90</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>distilled water</td>
<td>1 gal</td>
<td>.65</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>liquid detergent</td>
<td>80 oz.</td>
<td>.89</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>magnesium chloride</td>
<td>100 g</td>
<td>7.60</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>sodium carbonate</td>
<td>100 g</td>
<td>13.85</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>solid soap</td>
<td>1 bar</td>
<td>.60</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

- 1 balance, 200 g cap., 0.01 g sens.  112.00*
- 3 test tubes. 13 x 100 mm  .69
- 1 test tube rack  5.15

*One balance per 4 stations

EXPERIMENT 8. IONS AND THEIR REACTIONS

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity Purchased</th>
<th>Cost</th>
<th>Maximum Number of Stations</th>
<th>Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>barium chloride</td>
<td>100 g</td>
<td>$5.30</td>
<td>190</td>
<td>190</td>
</tr>
<tr>
<td>copper(II) sulfate pentahydrate</td>
<td>100 g</td>
<td>5.90</td>
<td>163**</td>
<td>163**</td>
</tr>
<tr>
<td>hydrochloric acid</td>
<td>2.37 L</td>
<td>12.95</td>
<td>11,376</td>
<td>11,376</td>
</tr>
<tr>
<td>iron(III) chloride</td>
<td>100 g</td>
<td>5.60</td>
<td>246</td>
<td>246</td>
</tr>
<tr>
<td>lead(II) nitrate</td>
<td>100 g</td>
<td>4.75</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>silver nitrate</td>
<td>113 g</td>
<td>76.00</td>
<td>265</td>
<td>265</td>
</tr>
<tr>
<td>sodium carbonate</td>
<td>500 g</td>
<td>13.85</td>
<td>446 x 5 = 2,230</td>
<td>446 x 5 = 2,230</td>
</tr>
<tr>
<td>sodium hydroxide</td>
<td>500 g</td>
<td>10.35</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>sodium phosphate</td>
<td>500 g</td>
<td>4.90</td>
<td>1,220</td>
<td>1,220</td>
</tr>
<tr>
<td>distilled water</td>
<td>1 gal</td>
<td>.65</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>
B. SUPPLIES (PER STATION)

One spot plate 6.63  
Nine small bottles with screw caps 16.58  
Nine medicine droppers 1.35  

*This is calculated value. Any waste will decrease number of stations served.

** # Stations = \frac{1 \text{ station}}{2.5 \text{ ml soln.}} \times \frac{10^3 \text{ ml}}{1 \text{ mole}} \times \frac{\text{mole}}{2.44.6g} \times 100 g - 163

EXPERIMENT 9. ENERGY OF A CHEMICAL CHANGE

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity Purchased</th>
<th>Cost</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium hydroxide</td>
<td>2.5 Kg</td>
<td>$23.10</td>
<td>400</td>
</tr>
<tr>
<td>sulfuric acid</td>
<td>4 Kg</td>
<td>25.50</td>
<td>many (&gt;1400)</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

balance, 200 g cap 0.01 g sensitivity 112.00*  
styrofoam cup .05  
gradiated cylinder, 100 mL 6.80  
flask, Erlenmeyer, 250 mL 2.74  
thermometer, -20 to 100°C, 1°div. 6.90  

*One balance per 4 stations

EXPERIMENT 10. THE MOLECULAR MASS OF A GAS

A. CHEMICALS

NONE

B. SUPPLIES PER STATION

balance 112.00*  
butane lighter .60  
gradiated cylinder, 100 mL 6.80  
flask, Erlenmeyer, 250 mL 2.74  
marking pencil .65  
glass plate or watch glass .95  
thermometer 20°C - 100°C, 1°div. 6.90  
trough, metal 7.50  

*One balance per 4 stations
EXPERIMENT 11. ISOTOPIC MASS VS. ATOMIC MASS

A. CHEMICALS

NONE

B. SUPPLIES (PER STATION)

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>navy beans</td>
<td></td>
<td>$0.90/lb</td>
</tr>
<tr>
<td>pinto beans</td>
<td></td>
<td>0.90/lb</td>
</tr>
<tr>
<td>blackeyed peas</td>
<td></td>
<td>0.90/lb</td>
</tr>
<tr>
<td>400 mL beakers</td>
<td></td>
<td>5.43/4 beakers</td>
</tr>
<tr>
<td>1 200 g cap. balance</td>
<td></td>
<td>112.00*</td>
</tr>
</tbody>
</table>

* One balance per 4 stations

EXPERIMENT 12. ELECTRICAL CONDUCTIVITY AND CHEMICAL BONDING

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity</th>
<th>Cost</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>calcium chloride</td>
<td>100 g</td>
<td>5.95</td>
<td>100</td>
</tr>
<tr>
<td>ethyl alcohol</td>
<td>500 mL</td>
<td>5.95</td>
<td>5</td>
</tr>
<tr>
<td>lead acetate</td>
<td>100 g</td>
<td>8.20</td>
<td>100</td>
</tr>
<tr>
<td>potassium bromide</td>
<td>100 g</td>
<td>5.95</td>
<td>200</td>
</tr>
<tr>
<td>sodium chloride</td>
<td>1 lb</td>
<td>0.27  (from grocery)</td>
<td>453</td>
</tr>
<tr>
<td>sugar</td>
<td>1 lb</td>
<td>1.29  (from grocery)</td>
<td>453</td>
</tr>
<tr>
<td>distilled water</td>
<td>1 gal.</td>
<td>0.65  (from grocery)</td>
<td>37</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-volt battery</td>
<td>.90</td>
</tr>
<tr>
<td>conductivity cell components</td>
<td></td>
</tr>
<tr>
<td>2 paper clips</td>
<td>free from school office</td>
</tr>
<tr>
<td>cork</td>
<td>.04</td>
</tr>
<tr>
<td>4 dram vial</td>
<td>.20</td>
</tr>
</tbody>
</table>
EXPERIMENT 13. PREPARATION OF A STANDARD SOLUTION

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper sulfate</td>
<td>100 g</td>
<td>33</td>
</tr>
<tr>
<td>distilled water</td>
<td>1 gal</td>
<td>75</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

- balance 200 g cap, 0.01 g sensitivity: 112.00*
- two beakers, 100 mL: 3.32 (1.66 each)
- wash bottle: 1.20
- graduated cylinder, 25 mL: 5.40
- medicine dropper: .15
- sheet of white paper: free from school office
- stirring rod: .23
- 2 test tubes, 13 x 100 mm: .46 (.23 each)

*One balance per 4 stations

---

EXPERIMENT 14. APPLYING "STRESS" TO A SYSTEM IN EQUILIBRIUM

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrochloric acid</td>
<td>2.37 L</td>
<td>many (&gt;500)</td>
</tr>
<tr>
<td>ice</td>
<td>5 lbs</td>
<td>25 - 30</td>
</tr>
<tr>
<td>potassium nitrate</td>
<td>125 g</td>
<td>60</td>
</tr>
<tr>
<td>sodium chloride</td>
<td>2000 g</td>
<td>17.95* 100</td>
</tr>
<tr>
<td>distilled water</td>
<td>1 gal</td>
<td>many (&gt;500)</td>
</tr>
</tbody>
</table>

*school cafeteria may supply this free of charge

B. SUPPLIES (PER STATION)

- beaker, 250 mL: 1.52
- graduated cylinder, 10 mL: 4.90
- medicine dropper: .15
- stirring rod: .23
- 2 test tubes, 13 x 100 mm: .46 (.23 each)
- thermometer, -20 to 100°C, 1°C: 5.90
EXPERIMENT 15. OXIDATION-REDUCTION REACTIONS OF METALS AND METAL IONS

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity Purchased</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper metal (wire)</td>
<td>4 oz</td>
<td>many</td>
</tr>
<tr>
<td>copper(II) nitrate (cupric nitrate)</td>
<td>25 g</td>
<td>about 10</td>
</tr>
<tr>
<td>iron metal</td>
<td>100 g</td>
<td>about 40</td>
</tr>
<tr>
<td>iron(II) sulfate (ferrous sulfate)</td>
<td>500 g</td>
<td>about 40</td>
</tr>
<tr>
<td>lead metal</td>
<td>500 g</td>
<td>about 40</td>
</tr>
<tr>
<td>lead(II) nitrate</td>
<td>100 g</td>
<td>about 40</td>
</tr>
<tr>
<td>magnesium metal (ribbon)</td>
<td>many</td>
<td></td>
</tr>
<tr>
<td>magnesium nitrate</td>
<td>100 g</td>
<td>about 40</td>
</tr>
<tr>
<td>zinc metal</td>
<td>500 g</td>
<td>many</td>
</tr>
<tr>
<td>zinc nitrate</td>
<td>100 g</td>
<td>about 40</td>
</tr>
<tr>
<td>distilled water</td>
<td>1 gal</td>
<td>37</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

- paper for labels: free from school office
- 9 test tubes (15mm x 125mm): 2.79 (0.31 each)
- test tube rack: 5.65

EXPERIMENT 16. ELECTROLYSIS OF POTASSIUM IODIDE IN WATER

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity Purchased</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>potassium iodide (or sodium iodide)</td>
<td>100 g (25 g)</td>
<td>300 (75)</td>
</tr>
<tr>
<td>copper wire, #13-18</td>
<td>10 meters</td>
<td>50</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

- 2 battery, lantern 1.5 V D.C.: 8.40
- (9 volt battery): (.90)
- buret stand with clamp: 13.00 + 6.50
- litmus paper, blue: .30
- litmus paper, red: .30
- U-tube: 3.25
EXPERIMENT 17. ELECTROPLATING COPPER

A. CHEMICALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Quantity Purchased</th>
<th>Cost</th>
<th>Maximum Number of Stations Served By Minimum Quantity Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper(II) sulfate</td>
<td>100 g</td>
<td>5.90</td>
<td>20</td>
</tr>
<tr>
<td>copper wire</td>
<td>230 ft</td>
<td>10.95</td>
<td>28</td>
</tr>
<tr>
<td>ethanol</td>
<td>4 L</td>
<td>9.85</td>
<td>many (&gt;700)</td>
</tr>
<tr>
<td>sulfuric acid</td>
<td>4 Kg</td>
<td>25.50</td>
<td>many (&gt;2700)</td>
</tr>
</tbody>
</table>

B. SUPPLIES (PER STATION)

- batteries, 1.5 V D.C. Lantern: 8.40
- beaker, 250 mL: 1.52
- paper clip: free from school office
- sand paper, fine: .50
- balance, analytical (optional)