Adult Education Chemistry Program

Chemistry is the study of the structure, properties, and composition of substances and the changes they undergo. Chemistry is also one of the more feared courses in high school and college. This does not change with adult education. Most adult education students who are required to take a chemistry course are apprehension as to what to expect.

A hands-on course that still has a basis in content is the way to handle this trepidation. Following is a 15-week, 3-hour syllabus of how an adult education teacher can both handle the panic of their students and still give their students a strong base into the study of this important science.

I am including my more popular and successful laboratory experiences. These labs should mirror what they do in lecture and should basically show them that what they learn can be displayed. There are literally hundreds of different laboratory experiences and demonstrations one could do. The following can all be accomplished during a 15-week, three hour class.

The most important part of any hands-on chemistry course is having the student produce a laboratory report that states what the student is doing, how he did it, the observations he or she made and the conclusions they made from their observations. This report based on the Scientific Theory should be a major part of the student's grade. Also, if possible break the class up into groups of two. This will have them demonstrate teamwork and how they can work as a group to complete a task.

Lab Report Summary

Title page: This is a cover to the lab report. It will state what the title of the lab report is. Students can use graphics in order to display their creative self. On the lower right hand corner of the lab the student will put their name, date, and class. A class could be Adult Education Chemistry. Having the student do this allows the teacher to flip through the labs.

Introduction: This forces the student to write about what he or she did. The first part of the intro will state what was done in the lab. In the text they will discuss important definitions and concepts covered in the lab. This is done in paragraph form and not as a list of terms and definitions. This has the student express him or herself in text. At the end of the introduction they will formulate a hypothesis. In quantitative labs this would be a percent error. In qualitative labs this would be how they think the lab will end.

Materials: This is a list of equipment and substances used. They will produce two separate lists. In chemistry the student will only use symbols and formulas.

Procedure: Basically the student will state what they did so someone reading the report can mirror it. This will be done in summary form. After each step where something happens they will write the word 'observe'. This will alert the reader to check into the next section to see what happened. This is not important when dealing with quantitative labs. If apparatus is involved the student will simply write 'set up apparatus as shown in diagram 1'. This diagram will be shown in the observation section of the lab.

Observation: This section will state what happened after they completed what they did in the procedures. The observations mirror the procedures. Diagrams, observation data tables, graphs, and verbal observations are found in this section. The data tables will only show what were collected and not any calculations. The use of EXCEL should be worked with beginning with the 6^{th} grade.

Conclusion: In quantitative labs this is where all calculations are displayed. Before they show any calculations they have to list what formulas are to be used. All numbers have to be labeled and all calculations must be shown. At the end of the calculations a calculation data table will be completed showing their results. In quantitative work this would be their practical data, the theoretical data, and their accuracy result as shown in their percent error. In qualitative labs this would explain what they saw in their observation after they completed their procedure. The conclusion always mirrors the observation that mirrored the procedure. At the end of the conclusion the student will write in paragraph form what they learned from the lab and what they think went wrong or right.

Each section will have separate pages.

I also believe it is important to have students have some general comprehension of EXCEL spreadsheet. You could use the following summary to teach your class how to set up a basic line graph using data you give them. A general knowledge of EXCEL could help your students in a variety of subjects.

GRAPHING WITH EXCEL SPREADSHEET

1.) Go to Start ... Programs....Microsoft Excel. This opens up your spreadsheet program.

2.) Select File....Save As...name your file and save to your H: drive.

3.) Always title your Spreadsheet.

4.) Put data into columns with the x-axis variable left of the y-axis variable. Label all data columns and make sure units are shown. If the column consists of a computation show what equation was used. Make it clear what was raw collected data and what data involved calulations.

5.) Highlight data under columns x_1 and y_1 (don't include headings). If the columns are not right next to each other highlight the x column then hit the ctrl button while highlighting the y column. Click on the Chart Wizard icon (looks like colorful bar graph on top of page).

6.) Select the type of graph you want. You can play with this but to get a standard line graph select xy(scatter), Click on second graph (smooth lines with data points) and then click next.

7.) Your first line should appear on the graph. There are tabs near the top of the chart wizard. Select the Series Tab. Click Add. Click on the excel chart icon (small with tiny red arrow inside) to the right of the "x values" box. This will take you back to your data sheet. Select the column of data under x_2 then click on the excel chart icon to the right of the Chart Wizard window to enter the data points.

8.) Click on the excel chart icon (small with tiny red arrow inside) to the right of the "y values" box. This will take you back to your data sheet. Select the column of data under y_2 then click on the excel chart icon to the right of the Chart Wizard window to enter the data points. This adds your second line.

9.) Repeat steps 7 & 8 for data for x_3 and y_3. This will produce your third line (series 1, series 2, and series 3). Click Next.

10.) Fill in Chart Title...Use a descriptive title that would be self explanatory to most readers and label x-axis and y-axis...again include what your variable is and the units it was measured in. Then Click Next.

11.) Click circle next to "As new sheet" then click Finish.

Now you have a labeled graph with your lines.

- **You can click on data points to find coordinates.**
- **To change your Title after you finish your graph go to Chart...Chart options.**
- **If you want to change data lines, go to Chart...Source Data...Series Tab then add or remove data.**
- **If you want to save graph as a chart on your data page, go to Chart... Location then save as a chart.**
- **To have some fun click on your chart in different areas and add color by going to Format then Selected Areas and chose colors and fun fill patterns. Have Fun!**

Laboratory Exercise One:

This should be an introduction to the world of chemistry. A discussion of the syllabus and what is expected should take up the first half-hour of the class. A discussion of atoms, elements, compounds, molecules, equations, reactions, definitions of terms, and the concept of qualitative work and quantitative work should be completed. This is important to see what your students understand and how heterogeneous the class is.

The comparison between physical and chemical properties:
This is a good exercise getting your students used to the equipment and substances they will be using throughout the entire year.

Definitions:
Physical property: a quality of a substance that can be observed or measured without changing the substance's chemical composition.
Chemical property: the ability of a substance to undergo chemical reactions and to form new substances.
Qualitative measurement: a measurement which gives descriptive nonnumeric results.
Qualitative measurement: a measurement which gives definite, usually numeric results.

Materials:

Substances:
Powdered S
Powdered Fe
$NaHCO_3$
Mg ribbon
NaCl
$C_{12}H_{22}O_{11}$
Sand
6M HCl
Distilled H_2O

Equipment:

7-test tubes
Test tube rack
Piece of white paper
100 ml beaker

Syringe
Magnifying glass
Magnet
Small crucible
Ring Stand
Ring
Pipe triangle
Evaporating Dish
Watch glass
Funnel
2- 250 ml beaker
Filter paper
Spatula
Bunsen burner
Igniter
Squeeze tongs
Wire gauze
Test tube holder
Match
Tweezers
Apron
Goggles

Hypothesis:

Before each lab have the student guess their results from what they know. For example in this qualitative lab have the students guess if they will be able to tell the difference between physical and chemical properties.

Procedure:

Have the students draw a grid on a piece of white paper. In other words, have them section off the paper drawing 9 squares. They only will need 7. On the lower part of each square have them write the formula for the chemical that will be placed on the square.

Fe	S	sand
NaCl	$C_{12}H_{22})_{11}$	$NaHCO_3$
Mg		

Have them carefully place about 3 grams of substance on the box of their labeled paper. This would be the tip of most small spatulas. As for the Mg, have them tear off a piece approximately ½ inch.

Have your students set up a test tube rack with seven test tubes. Label the test tubes 1-7 and set up a key stating which test tube goes with which substance.

Have you students now set up an observation data table as such.

Substance	Physical State	Color	Odor	Solubility	Effect of Magnet
Fe					
S					
NaCl					
Sand					
$NaHCO_3$					
Mg					

$C_{12}H_{22}O_{11}$

Have students look at the materials through a magnifying glass to determine if they are amorphous or crystalline.
Have students write down the color of the material
Have students state whether each material has an odor. You do this by whiffing.
Have students place a small amount of material in the labeled test tube to see if it is soluble.
Have students place a small amount of material on a second piece of paper. Then have them place a magnet under the paper to see if it is affected by the magnet.

Other than the physical state, color, or odors, if any of these are true have the students place a (+) in the corresponding box
Other than the physical state, color, or odor, If any of these are not true have the students place a (–) in the corresponding box.

As part of their conclusions have them state why these parameters are considered physical and not chemical.

For the second part of the lab set up the following sections.

Set up a simple filtration device using the ring stand, funnel, filter paper, and 250-ml beaker.

Diagram A:

http://icn2.umeche.maine.edu/newnav/newnavigator/images/P7280072.JPG

Have students mix some sand, salt, and water (about 100 ml) in a 250-ml beaker. Mix with stirring rod and then pour through funnel. Have them collect the supernant in the second 250-beaker. Have the students then pour the supernant into an evaporating dish as shown in this diagram:

Diagram B:

http://icn2.umeche.maine.edu/newnav/newnavigator/images/P7220121.JPG

Boil off the liquid until you see the salt in the dish.

Have the students describe what happened in their observation data table. As part of their conclusions have them state why this process was a physical and not chemical one.

In a clean test tube have the student pour approximately 10 ml of HCl into the tube. Have the second student of the group light a match at the precise point the second student drops the Mg ribbon into the tube. Check out the temperature of the test tube.

Diagram C:

http://www.zianet.com/savya/physical_science/Chapter_2/Freezing%20Point%20A146_assets/span-urb-a02-cia-124a.gif

There will be two reactions here. Have the students describe what happened in their observation data table.

Using a tweezers have one student hold a small piece of Mg. Light it with the Bunsen burner, catch the residue over a watch glass.

Diagram D:

http://www.angelo.edu/faculty/kboudrea/demos/burning_magnesium/BurningMg05.jpg

Have the students describe what happened in their observation data table.

Pour a small amount of HCl on top of the residue left by the Mg. Describe what happened.

Place a small amount of $NaHCO_3$ in a test tube. While the test tube is in the test tube rack pour about 10 ml of HCl into the tube. As you pour the acid into the tube have a second student light a match and like they did with the Mg and HCl place the lit over the lip of the test tube. Check out the temperature of the test tube.

Have the student fill a crucible 1/3 full of sugar. Place the crucible on the rings stand and heat it with the Bunsen burner until it burns. Allow it to burn completely and observe the results.

Diagram E:

http://www.uen.org/utahlink/tours/admin/tour/14346/14346TriangeCrucible170x.jpg

As the students are working with the chemical property portion of this lab have them fill out the following observation data table:

Reaction	Observation
NaCl + sand + water	
Mg + HCl	
Mg residue + HCl	
Mg + fire	
$NaHCO_3$ + HCl	
$C_{12}H_{22}O_{11}$ + fire	

As part of the student's conclusions they should be able to state why these were chemical changes. They should list all the conditions that made it a chemical change. If these students are comfortable with this and they seem a bit advanced this is a great time for the instructor to introduce chemical formulas and equations.

For example for the reactions on the observation data table the instructor could write equations describing what happened in the reaction.

NaCl + sand + water → physical change
$Mg + 2HCl \rightarrow MgCl_2 + H_2$
$H_2 + O_2 \rightarrow 2H_2O$
$2Mg + O_2$ (needed for combustion) → $2MgO$
$MgCl_2$ (residue) + HCl → no reaction
$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$
$C_{12}H_{22}O_{11} + O_2 \rightarrow C + H_2O + CO_2$
This would also be a good means to have the students get used to balancing equations.

Laboratory Exercise 2:

Introducing quantitative chemistry:

This quantitative lab is a good means of having your students become familiar with the concepts of quantitative, accuracy, precision, significant digits and working in metrics. Similar to the last lab the student will produce a lab report as outlined.

Materials:

Metric scale: a digital can be used by a triple beam balance would be best to describe the concept of significant digits.
25 ml graduated cylinder
Spatula

Substances:
Any metal of which you know what the theoretical density is:
For example:
Cu
Zn
Mg
Si
Fe
Sn
Ni
(These should all be in shot form)
H_2O
A liquid with a known density
Example:
CH_3OH
C_2H_5OH
C_3H_7OH

As for the hypothesis have the student guess what his percent error would be (accuracy) and what the precision of the class will be (precision). Sometimes a competition as to who gets the best average % error can be incorporated.

Procedure:

Always have students first calibrate their scales to where they will lie on their lab table.
Weigh a clean and empty 25-ml graduated cylinder
Add exactly 10 ml of water to the graduate
Weigh the graduate plus the water
Add enough metal so the level of the water rises at least 5 ml.

Weigh the graduate + water + metal.
Repeat using other metals.

Weigh an empty 25-ml graduated cylinder
Add exactly 10ml of liquid to be tested
Weigh the graduate plus the liquid
Repeat using other liquids.

Have students set up observation data table to display their results

	Cu	Mg	Fe
Volume of H_2O			
Mass of graduate + H_2O			
Volume of H_2O + metal			
Mass of graduate + H_2O + metal			

The instructor should now work with his students to show how to calibrate the practical densities of the metals from the data. Their practical result should then be compared to the theoretical result in order to produce a % error:

% error = theoretical – practical divided by theoretical x 100

The instructor should then take a standard deviation of the whole class in order to discuss what the students did right or what they did wrong in the lab.

A calculation data table could also be produced by the student to be used in their lab report.

	Practical	Theoretical	% error
Cu			
Fe			

Laboratory Exercise 3:

Another good quantitative lab like the density lab but a bit more complicated would be a specific heat lab.

Specific Heat is the amount of energy that is required to raise the temperature of one gram of a substance by one degree Celsius. This is a good means of quantitatively figuring what a substance is.

Materials needed:
50 ml beaker
250 ml beaker
400 ml beaker
100 ml graduated cylinder
1 large test tube
glass stirring rod
buret clamp
ring stand
ring
wire gauge
Bunsen burner
Balance
Styrofoam cup
Thermometer

Samples of Cu, Pb, Al, or any other pure metal you may have.
Distilled water

Procedure:

Have students set up a hot water bath as follows:

Diagram F:

http://web.centre.edu/che/che131_lab/Exp2heatmix.jpg

The basic difference is you would set up a buret clamp with the test tube that will be heated.

Place a Styrofoam cup in a 250 ml beaker for support

Weigh an empty 50 ml beaker
Fill the large test ¼ with the metal to be tested
Place the metal in the 50 ml beaker
Weigh the beaker and the metal.

Place the metal back into the test tube
Drop the test tube into a 400 ml beaker now with boiling water.
Wait 10 minutes
During this time fill the Styrofoam cut with 100 ml of distilled water.
Take an initial temperature of the water in the Syrofoam cup
After the metal has been heating for 10 minutes quickly transfer it into the Syrofoam cum
Take the temperature of the water to the highest degree.
Clean up and repeat using other metals.

Observation data table:

Mass of emty 50 ml beaker	**g**
Mass of beaker and metal	**g**
Mass of metal	**g**
Initial temp of water	**^{o}C**
Initial temp of metal (100^{o} C)	**^{o}C**
Max temp of metal and water	**^{o}C**
Mass of water (1 g = 1 ml = 1 cm^{3} cm)	**g**

For the conclusions have students use the following equation to calculate the specific heat of the metal chosen.

Specific heat $_{(water)}$ x mass $_{(water)}$ x Delta T $_{(water)}$ =

Specific heat $_{(metal)}$ x mass $_{(metal)}$ x Delta T $_{(metal)}$

Have the students compare their results with the known specific heats.

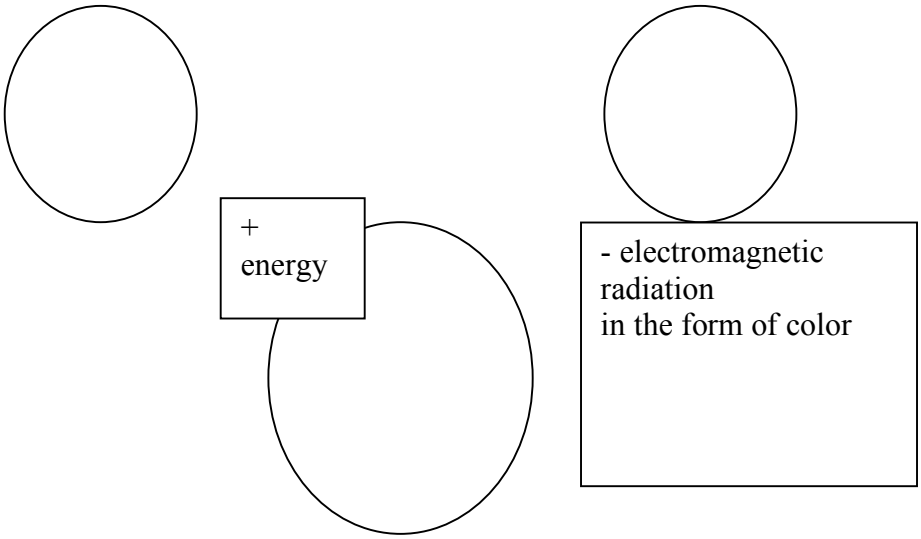
Use the accuracy formula to do this.

Laboratory Exercise 4:

When studying the atom if is important that you relate this abstract issue with some concrete examples. For example a good way to introduce atomic theory is to ask your students how we know what a far off star is made of. This has a tendency to build interest and curiosity.

The title of the lab is: The Flame Test

When studying about the shape of an atom one has to work with ground state vs excited state atoms.



What this means is when you add energy to the atom it becomes excited but then immediately goes back to its ground state. Because of the law of conservation of matter and energy the energy is transformed into electromagnetic radiation in the form of color. Each atom has its own size and thus will emit a different electromagnetic radiation. This is how we can tell what far off celestial objects are made of.

Materials:

Inoculation loop
2 small beakers
cobalt glass
Bunsen burner

Diagram G:

http://content.answers.com/main/content/wp/en-commons/thumb/1/1d/300px-Bunsen_burner_flame_types_.jpg

Substances:

Ba in the form of $Ba(NO_3)_2$

Li in the form of $Li(NO_3)$

K in the form of $K(NO_3)$

Sr in the form of $Sr(NO_3)_2$

Na in the form of $Na(NO_3)$

Ca in the form of $Ca(NO_3)_2$

Mg in the form of $Mg(NO_3)_2$

Cu in the form of $Cu(NO_3)_2$

HCl

H_2O

Procedure:

Have the students first place the inoculation loop in the Bunsen burner flame in order to get rid of any impurities. Then have the student place the loop into the HCl and then back into the flame. Then have the student place the loop into the substance and then into the flame. A color should appear. Have the student observe this color with and without viewing it through the cobalt glass. Have them repeat using the other substances and complete a data table.

Substance	Color without Cobalt glass	Color with cobalt glass
Ba^{+2}		
Li^{+1}		
K^{+1}		
Sr^{+2}		
Na^{+1}		
Ca^{+2}		
Mg^{+2} Cu^{+2}		

A good means of completing this exercise would be to give your student three unknowns at which they have to tell you what they are using the flame test.

Laboratory Exercise 5:

The concept of the mole is a very difficult one for most students to comprehend. When one explains that the definition of the mole is the amount of substance that contains the Avogadro number of particles most adult education students shut down. But, when one can show how the concept of the mole can be used to write correct empirical formulas the concept becomes understandable.

In adult education the best way to do this is with the empirical formula of a hydrate.

Equipment:
Balance
Crucible and cover
Tongs
Ring stand
Ring
Pipe triangle
Spatula
Bunsen Burner

Substances:
$MgCl_2 \cdot x\ H_2O$
$Na_2S_2O_3 \cdot x\ H_2O$

If time permits you can use more hydrates.

Procedure:

Set up apparatus as shown in diagram

Diagram H:

C:\Documents and Settings\FabianoJ\Local Settings\Temp\image010.gif

Weigh the empty crucible and cover
Add approximately 3 grams of substance
Place the crucible and cover on the pipe triangle and heat for approximately 3 minutes or until the chemical looks powdery. Do not over heat to the point to combust the material. The student can check the material as it is being heated by lifting the cover with the tongs.

Place crucible on the lab table allowing it to cool for 3 minutes.
Weigh the crucible, cover and anhydrous chemical.

Repeat using other chemicals.

Observation Data Table:

Mass of empty crucible and cover	**g**
Mass of crucible, cover, and hydrated chemical before it is heated.	**g**
Mass of crucible, cover, and anhydrous chemical after it is heated.	**g**

The calculation for this quantitative lab would follow the data collected.

First you would have to show the mass of the anhydrous chemical. This would be the chemical after it is heated. You would do this by subtracting the mass of the crucible, cover, and anhydrous chemical from the empty crucible and cover.

Then you would calculate the number of moles of the anhydrous chemical by dividing it by the formula weight.

The student would then calculate the water being driven off by subtracting the crucible, cover and anhydrous chemical from the crucible, cover and hydrated chemical.

Then have the student calculate the amount of water released in moles. They would do this by dividing the amount of water released by the formula weight of water.

In order to find the ratio of water in the hydrated chemical you would divide the number of moles of water driven off by the number of moles of anhydrous chemical. This will give you a ratio. Round off to a whole number and compare it to the theoretical.

The student could then calculate his or her accuracy by comparing their raw result to the theoretical value.

Laboratory Exercise 6:

This lab will allow the students to not only see a reaction but also control the speed of the reaction. Basically this is a simplified clock reaction without the use of H_2O_2. This is also a good experiment to perform to keep the motivation of your students high. In other words, this is actually fun.

After completing this exercise the student should be able to determine the effect of concentration, temperature, and catalyst on the rate of a chemical reaction.

Materials:

2 – 25 ml graduated cylinders
Hot water bath (as shown in Diagram F)
Thermometer
600 ml beaker
100 ml beaker
stop watch
2 large test tubes

Substances:

Solution A: