Comparing the Acid Content of Fruit Juices and Other Samples by Drop Count Titrations

David Cash PhD Mohawk College (retired) david.cash@mohawkcollege.ca

Summary

Here is a **simple**, **quick**, and **low cost** experiment suitable for grade 7 and up. This exercise could be used when studying acids and bases, foods and nutrition, or the effect of carbon dioxide on the acidity of the oceans. It is a drop count titration analysis to compare the amount of acid present in fruit juices, soft drinks, sour lemon candies, or carbonated waters. The acid present in the samples is neutralized using 0.4 % sodium hydroxide solution from a **controlled drop-dispensing polymer squeeze-bottle,** with phenolphthalein as the indicator. A polymer dropper squeeze-bottle is safer and simpler to use than a medicine dropper. The experimental measurement is the number of drops of titrant solution used. The chemical solutions required are low cost, relatively safe for use, and non-hazardous for disposal.

Content Section	Page
1. Introduction ………………………..	…… 1
2. Sample Choice and Amount ………	…… 3
3. Dropper Bottles ……………………	…… 4
4. Chemicals and Safety ……………..	…… 6
5. Equipment, Materials and Supplies	…… 6
6. Drop Count Titrations …………….	…… 7
7. Acknowledgements ………………...	…… 7
8. References …………………………	…… 8
9. Recommendations for Teachers ….	…… 9
10. Student Instructions ……………….	….. 10
11. Photographs ……….………………	….. 13

1. Introduction

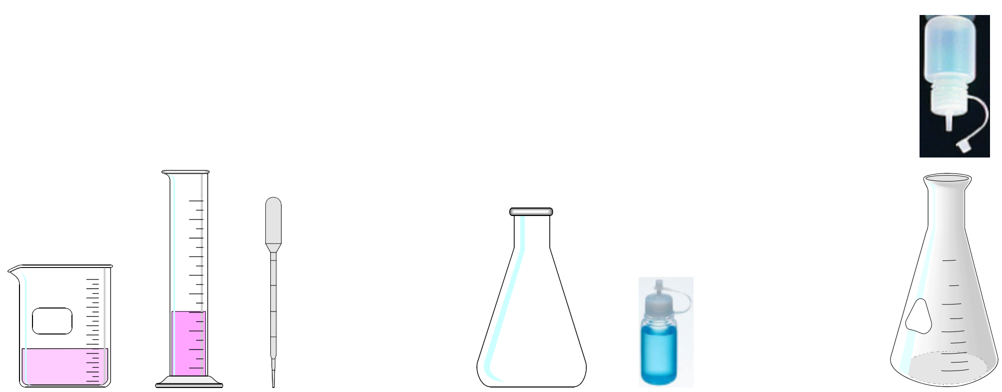
This experiment is an example of a method called a drop count titration that is commonly employed in field-testing and consumer applications (see **Section 6** below). It is adapted from a quantitative gravimetric titration experiment for chemistry students described in a previous article (1).

Overview of the Experiment

The determination of the acid content in a food is a quality control analysis that is very simple if the sample can be put into dissolved form. The method uses an acid-base neutralization titration reaction. In this experiment, the students will compare the number of drops of an alkali solution required to neutralize the acid content of equal volumes of two or more juices or drinks. The three steps required to perform the analysis are illustrated below (**Overview of an Experiment Trial**):

- Measure the sample containing acid;
- Add water and drops of indicator solution to the sample;
- Perform a drop count titration of the sample with sodium hydroxide solution.

Overview of an Experiment Trial



Left: measure a sample, usually a 5 mL sample of a liquid.

Centre: place the sample in a vessel, add drops of phenolphthalein indicator and water, and mix well.

Right: titrate with 0.4 % sodium hydroxide solution, counting drops until the indicator turns pink.

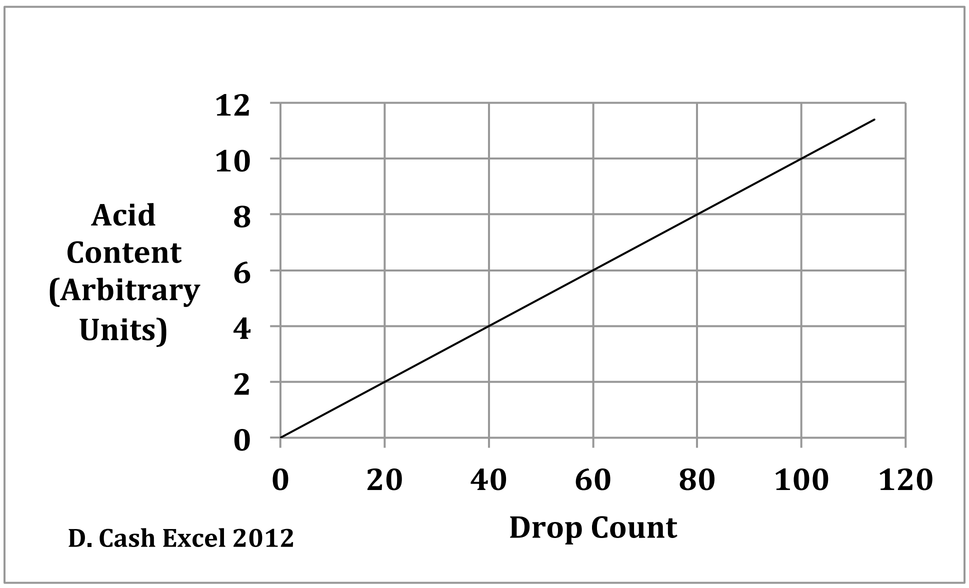
Continued on the Next Page →

Introduction (Cont.)

The titrating reagent used is **0.4 % (0.1 molar) sodium hydroxide (NaOH)** solution. For titration of the samples suggested here, which are clear and colourless or pale yellow, **phenolphthalein** (2) is an excellent acid-base indicator substance.

The acids in the juices and drinks suggested for the experiment are all **weak** acids. These juices and drinks all have a pH of about 3. As the sodium hydroxide is added, the acid content is neutralized, and the pH slowly rises, to about 5. When the acid has been fully neutralized, the pH rapidly shoots up to a value above 9. The phenolphthalein indicator is colourless below pH 8, becoming pink at pH 8 and red above pH 9. A permanent pink or red colour (orange for yellow samples) indicates the end of the titration.

Students may better appreciate the results of the experiment if two concepts are made explicit to them. Firstly, that the number of drops of base solution required for each titration is proportional to the amount of acid in the sample (see the plot below). Secondly, that a true solution is of uniform composition, so repeated analyses of samples of the same type should give reproducible results within experimental variability. So, for example, if 5 mL samples of apple juice require an average of 75 drops of base for neutralization, while 5 mL samples of Kool-Aid require an average of 50 drops of base for neutralization, then the students should be able to deduce that the apple juice contains more acid than the Kool-Aid.



The chemicals used in the experiment are inexpensive and relatively safe, but it will be necessary for the students to wear eye protection, safety glasses or goggles, during their work, and to have an eye rinse solution available. Tap water is fine for the experiment. All other equipment needed can be obtained at very low cost. If your school does not have safety glasses for the students, you may be able to borrow a set from a secondary school, college, or university. A mentor may be able to 'lend' you the chemicals, or store your chemicals between uses. Perhaps a mentor could provide some student volunteers to help you set up and run the experiment in your classroom.

2. Sample Choice and Amount

Foods and confections that are acidic include natural fruits and fruit juices, vinegar, sour lemon candies, synthetic soft drinks, and carbonated mineral waters. Fruit juices contain mixtures of the weakly acidic **fruit acids**: the predominant acid is **citric** acid in citrus juices; **tartaric** acid in grape juices (and wines); **malic** acid in apple juices; and **succinic** acid in cranberry juices. Synthetic soft drinks are made acidic by adding acid: **citric** acid in Kool-Aid®, lemon-limes and ginger ales; **phosphoric** acid in colas. Vinegar is acidic because it is a solution of **acetic** acid. Sour lemon and other cough drops and candies contain **citric** acid or a mixture of **citric** and **tartaric** acid. Dissolved **carbon dioxide** in carbonated soft drinks and mineral waters is also acidic.

Any clear, colourless or pale yellow juice or drink is a suitable sample for this experiment. Examples include: Kool-Aid® Invisible; Sprite®; Canada Dry® Ginger Ale; any apple juice or white grape juice. Carbonated soft drinks should be degassed (by heating) to remove the acidic carbon dioxide before titration of the non-volatile acid.

The end-point of each titration will be indicated as a lasting appearance of a pink or an orange colour due to the phenolphthalein, clearly different from an un-titrated comparison sample. For most juices or drinks, a **5 mL** sample size is the most appropriate. Vinegar is not a suitable sample unless it is diluted with water, because the amount of acid present in a given volume is roughly 20 times the amount in a juice or drink.

Some approximate drop counts for 5 mL amounts of some sample types are given in **Table 1**. The actual drop counts will vary depending on the dropper bottle used, and the strength of the base solution, but the relative counts should be as given in **Table 1**. A sample with a very low drop count should be made larger. A drop count above 80 is too large. Students will find it very tiring physically and mentally to do high drop-count titrations.

Table 1: Drop Counts for Titrations of Samples with 0.1 M NaOH Solution

Sample	Drop Count
Kool-Aid® Invisible (5 mL)	50
Welch's® White Grape Juice (5 mL)	75
Sun-Rype® Apple Juice (5 mL)	75
Sprite®* (5 mL)	35
Canada Dry® Ginger Ale* (5 mL)	30
Carbonated Mineral Water (5 mL)	40
Vicks® Lemon Cough Drop	60
Black River® 100 % Cranberry Juice	> 100
*Carbonated Drinks Degassed	

Carbonated mineral waters may also be titrated. The amount of carbonic acid (aqueous CO_2) in a 5 mL sample will vary according to the particular brand, and the history (i.e. how long the bottle has been open, etc.). Be very careful when opening a bottle of carbonated water at room temperature, the pressure can be very high. Another possibility is to compare the acid content in a regular apple juice, with the amount in a 'low-acid' juice, if you can find such a juice in your market.

Different brands and sizes of sour lemon cough drops or candies have variable acid content. A Vicks® Lemon cough drop (3) contains roughly the same amount of acid as a 5 mL sample of apple juice. Individual cough drops will dissolve in water in about 10 minutes if warmed and swirled.

Vicks Cherry drops and Vitamin C Orange drops also contain citric acid, although the amount may not be the same as the Lemon, and the red dye present may interfere with the titration end point. Strangely, Vicks Lemon and Orange cough drops are not sold in the U.S. The amount of acid in other sour lemon hard candies is variable, and probably much greater than the amount in a cough drop. Lemon Life Savers® and Sorbee® Sugar Free Sour Lemon candies were found to contain respectively about three and five times as much acid as the Vicks Lemon, so they are not suitable for this experiment. Another possibility is to try small 'store brand' lemon cough drops or sour lemon candies from your local stores.

This is a low precision experiment. The variation in drop count for repeated titrations will depend very much on the experience, care and skill of the students, in using the measurement vessels, the dropper bottle, and performing the titrations. It will be best to allow for a variation of up to 25 % in values. So, in choosing sample types to compare, it may be best to use pairs with widely different acid content. All samples should be checked by titration before using them with students.

3. Dropper Bottles

Photograph: Polymer Drop-Dispensing Squeeze-Bottles (Credit D. Cash 2012)		
Left: Two 60 mL Nalgene Bottles: One-Piece Integrated Tip and Cap (cost: about \$ 72 per dozen)	**Centre: Three 60 mL Wheaton Bottles: Inner Snap-Out Tip and Outer Closed Cap (cost: about \$ 30 per dozen)**	**Right: 15 mL and 10 mL Eye-Drop Bottles: Inner Snap-Out Tips Shown (cost: free eye-drop dispenser empties)**

Controlled drop-dispensing polymer squeeze-bottles are a very safe choice for this exercise. Compared to using eye-droppers or capillary tip pipets, using squeeze-bottles reduces both the likelihood of reagent spills and the chance of dripping reagent, since the bottles are capped and no reagent can be lost when a bottle is upright. There are two required properties of the bottles to be used. Firstly, the dispensing of drops must be controlled, even when the bottle is inverted. Secondly, the drop size must be consistent, not variable.

Consistent Drop Size

Comparing the drop count of base required to neutralize different samples of acid can only make sense if the drop size from the dropper bottles is consistent and reproducible. **Table 2** gives the result of weighing successive drops of distilled water from each of three types of sample bottle on a 4-place analytical balance. The balance door was open, and the last place (0.1 mg) was unsteady, so each reading was rounded to the third place (to the nearest 1 mg).

Table 2: Drop Size Determinations (Bottles Held at 90 ° to Horizontal)

(Values May be Taken as Being in g or mL)	Nalgene (60 mL)	Wheaton (60 mL)	Tears II (15 mL)
1	0.0460	0.0420	0.0420
2	0.0450	0.0410	0.0430
3	0.0440	0.0410	0.0410
4	0.0440	0.0420	0.0420
5	0.0440	0.0430	0.0410
6	0.0450	0.0390	0.0410
7	0.0410	0.0410	0.0410
8	0.0440	0.0390	0.0420
9	0.0440	0.0390	0.0420
10	0.0430	0.0420	0.0420
Mean Drop Size	0.0440	0.0409	0.0417
Range (Largest – Smallest)	0.0050	0.0040	0.0020
95 % Confidence Interval	± 0.00095	± 0.00104	± 0.00048
Drops per mL	23	24	24

Continued on the Next Page →

Dropper Bottles (Cont.)

The measured values in **Table 2** may be taken as being in g or mL units, as the density of distilled water is close to 1 g / mL. The three bottle types tested all performed well, delivering highly uniform drops, about 25 drops per mL. The materials and techniques used to manufacture these bottles are very reliable. However, a bottle with a flawed dispensing tip cannot be ruled out as a source of student error. The statistical values in the table were obtained using Microsoft Excel®.

Dispensing Angle

The bottles were held at a 90 ° angle to the horizontal in the trials. This is important, because other trials have shown that the drop size does vary with the angle. Trials at a 45 ° angle to the horizontal gave results which were as much as 20 % different from the 90 ° values; for some bottles lower, for some bottles higher. For this reason, the students should be instructed to use a dispensing angle of 90 ° to the horizontal.

To Buy or Not to Buy?

The least expensive alternative for the experiment is to re-use eye-drop bottle empties, which are of excellent quality and free. Two examples are shown on the right in the photograph above, a 15 mL and a 10 mL bottle. But they are much more difficult to refill than labware 60 mL bottles, and you will need more of them. They are less convenient for these reasons. They are rarely found in the 60 mL size. A 60 mL bottle is too heavy and too large to use for putting drops into the eye, and there is a time restriction on using up the solution in a bottle once the seal is broken, due to possible bacterial contamination. If you cannot source empties from family or friends, visit an optometrist's office and have them save you their empties.

If you are planning to do the experiment repeatedly, and have funds, you can buy larger bottles. The two bottles on the left of the photograph are 60 mL (2 oz. US) Nalgene® bottles, which are excellent, costing about $ 72 / 12 (4). An integrated tip / cap combination makes refilling easy, but storage less secure. The three bottles in the centre are Wheaton 60 mL (2 oz. US) bottles, costing about $ 30 / 12 (5). These are also excellent. Their snap-out inner tip / closed outer cap combination makes year-to-year storage more secure, at the cost of making the bottle harder to refill.

4. Chemicals and Safety

The two required chemicals are relatively inexpensive, and may be conveniently purchased in the form of dilute solutions in water:

- 0.1 molar NaOH (0.4 g / 100 mL or 4 g / L or 0.4 %) (**$7.56 / L**) (6);
- 0.5 % phenolphthalein (**$8.83 / 500 mL**) (7).

An MSDS for sodium hydroxide is intended for industrial producers and users of highly corrosive solid NaOH and concentrated aqueous solutions. It is rather frightening (8). However, dilute solutions of sodium hydroxide such as the 0.1 molar solution (0.4 %) used in this exercise are not very hazardous to use. This solution is widely used in industrial and academic laboratories, as well as in teaching laboratories at most levels. A 0.1 M solution of sodium hydroxide is not treated as being hazardous, but it must be respected (**Table 3** below). More information about the chemicals will be found in Reference 1.

The total amount of solution required for a class of 30 students, assuming they work as 15 pairs, is unlikely to exceed 2 L of the 0.4 % NaOH. This means that the total amount of sodium hydroxide being used by the entire class will be less than 8 g! The danger to skin or clothing is very minor. Skin will not be affected for many minutes. The only serious hazard is to the eyes.

Students must wear safety glasses or goggles at all times, and must wash their hands before taking the eyewear off. An eye-wash station or eye-wash kit must be at hand during the experiment. Unless you have eye-wash plumbing, a laboratory safety eye-wash solution kit is needed. These are available at a reasonable cost (9), but if you have very limited means, consider purchasing an OTC drugstore eye-wash solution kit (10).

Table 3: Hazards of Using 0.1 M Sodium Hydroxide and 0.5 % Phenolphthalein Solutions

Hazard	Remedy / Action
Eyes	WEAR SAFETY GLASSES OR GOGGLES AT ALL TIMES If an accident does occur, rinse at an eye-wash station according to the instructions.
Skin	Rinse off with tap water or wipe off with a dampened cloth. Rinse the cloth with cold water.
Clothing	Rinse the affected area with cold water.
Bench or Floor	Wipe up with a dampened cloth. Rinse the cloth with cold water.

5. Equipment, Materials and Supplies

The equipment, materials and supplies required for the experiment are summarized in **Table 4**:

Table 4: Required Equipment, Materials and Supplies

Item	Labware	Budgetware
Eye Safety	Safety Glasses or Goggles. Eye-Wash Plumbing or An Eye-Wash Kit	
Titration Vessels	125 ml Erlenmeyer Flasks	300 mL (9 oz) Clear Polymer Cups
Sample Dispensing and Measuring Equipment	Small Beakers, 10 mL and 25 mL Graduated Cylinders and Disposable Pipets (11)	Clear Polymer Cups, Measuring Spoons and Disposable Pipets if possible (11)
Controlled Drop-Dispensing Polymer Squeeze Bottles	60 mL Bottles (NaOH) 15 mL or 30 mL Bottles (Phenolphthalein)	Eye-Drop Empties from an Optometrist's Office Larger Bottles for NaOH and Smaller for Phenolphthalein
Water	Tap Water, Large and Small Bottles for Supply and Pouring Out for each Group	
Waste	Small Basins or Buckets for each Group	
Miscellaneous	Paper Towels (As a Pale Background for Titrations); Wipe-Up Cloths	

6. Drop Count Methods (Background Information)

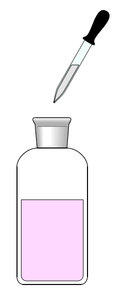
Field Test Alternatives to Laboratory Testing
Drop-count titrations and **colour comparisons** are two simple, low-cost, low-precision, field-test-type analyses commonly used in industry and by consumers as alternatives to more costly, high-precision laboratory analysis. A previous article presented a colour comparison exercise suitable for Grade 7 students (12).

Drop-Count Titrations
Drop-count titrations are employed in the determination of water quality in the general areas of drinking water, environmental surface waters, wastewater, aquaculture and agriculture, aquariums, swimming pools, and similar applications. Numerous commercial vendors market drop-count kits (13). The general method of a drop-count titration analysis is as follows:

- Measure out a sample;
- Add reagent solutions or solid from pouches;
- Add water and indicator if required;
- Count drops of the titrating reagent solution to a specified colour or colour change.

Some vendors have posted their method instructions, which illustrate the method, online as downloadable pdf files (14). The vendors supply all the reagents required either in the form of aqueous solutions or as solids in single-use pouches. Drop count titrations are performed by adding drops from a calibrated glass or polymer dropper and counting the number of drops required until a specified colour change, or end colour occurs (**Commercial Kit Titration**). The method may be simplified by measuring the water sample into a small bottle with a fill line, using the bottle as the titration vessel.

Commercial Kit Titration



Commercial drop-count kits are not suitable for classroom use. The cost of kits is too great for routine school use (15); with a few exceptions, the reagents in the kits would be disallowed for school use or storage due to their hazardous nature; and disposal of the waste generated would be highly problematic.

7. Acknowledgements

Thanks are due to the Department of Chemical, Environmental, and Biotechnology of Mohawk College for the use of laboratory space, equipment, and chemicals for the author's experimental work, and to Chief Technologist Bill Rolfe and Technologist Randy Travis for their assistance. A small trial of the procedure was carried out with grade 7 students visiting Mohawk College for 'Destination College' day in May, 2012. The author also thanks David Lipinski of The National Ballet of Canada School and his grade 7 students for trying out the procedure in June, 2012, and Marty Oslinger, who formerly taught at that school, for making the arrangements.

8. References

1. Article by David Cash, from page http://www.uclmail.net/users/dn.cash/articles.html (retrieved 2012 10 02); http://www.uclmail.net/users/dn.cash/GravTitr3.pdf.

2. Wikipedia: Phenolphthalein (retrieved 2012 10 02): http://en.wikipedia.org/wiki/Phenolphthalein.

3. Vicks Cough Drops (retrieved 2012 10 02): http://www.vicks.ca/products/vapo-family/vapodrops-cough-drops/.

4. Nalgene: Drop-Dispensing Polyethylene Bottles (retrieved 2012 10 02): http://www.nalgenunc.com/products/productDetail.asp?product_id=121&subcategory_id=144&category_id=144&brand_name=Labware&category_name=Dropper+Bottles&subcategory_name=;
Cole-Parmer: Nalgene 60 mL $68.76 / 12 (retrieved 2012 10 02): http://www.coleparmer.ca/catalog/product_view.asp?sku=0608630;
Sigma-Aldrich: Nalgene 60 mL $80.10 / 12 (retrieved 2012 10 02): http://www.sigmaaldrich.com/catalog/product/aldrich/z252034?lang=en&region=CA.

5. Wheaton: (retrieved 2012 10 02): http://wheaton.com/media/press-releases/2012PressReleases/lit/WBRO_009%20Plastic%20Bottles%20Brochure.pdf;
Boreal-Northwest: Wheaton 60 mL $29.40 / 12 (retrieved 2012 10 02): http://boreal.com/controlled-dropping-bottles-polyethylene/p/IG0025932/;

6. Boreal-Northwest: Sodium Hydroxide (0.1 M) $7.56 / 1 L (retrieved 2012 10 02): http://boreal.com/sodium-hydroxide/p/IG0015546/.

7. Boreal-Northwest: Phenolphthalein (0.5 %) $8.83 / 500 mL (retrieved 2012 10 02): http://boreal.com/phenolphthalein/p/IG0015439/.

8. Boreal-Northwest: MSDS for 0.5 M NaOH Solution (retrieved 2012 10 02): http://boreal.com/images/art/Sodium_Hydroxide_Solution_0.5M_670.00.pdf.

9. Seton: Eye Wash Bottle $28 each (retrieved 2012 10 02): http://www.seton.ca/eye-wash-station-bottles-sc136.html.

10. Optrex: Eye Wash (about $9 each) (retrieved 2012 10 02): http://www.optrex.co.uk/optrex_range/optrex_multi_action_eye_wash.php.

11. Boreal-Northwest: Disposable Polyethylene Pipets (retrieved 2012 10 02): http://boreal.com/dropper-pipets-disposable-mdash-polyethylene/p/IG0026084/.

12. Cash, D., Food Dye Analysis by Visual Colour Comparison, Crucible Online (Science Teachers' Association of Ontario), June, 2010, copy available by email request.

13. Hach Instruments, Most Popular Test Kits (retrieved 2012 10 02): http://www.hach.com/populartestkits.

14. Hanna Instruments, Ascorbic Acid Drop Count Test Kit Instructions (retrieved 2012 10 02): http://www.hannacan.com/PDF/manHI3850.pdf;
Hach Instruments, General Water Test Kit Instructions (retrieved 2012 10 02):: http://www.hach.com/general-boiler-water-test-kit-model-al-94-mg-l-drop-count-titration/product-downloads?id=7640217347&callback=qs

15. Fondriest Environmental, Hach Total Chlorine Drop Count Titration Kit (retrieved 2012 10 02): http://www.fondriest.com/hach-225401.htm.

9. Recommendations for Teachers

Students should be placed into pairs or groups of three or four for the experiment. Counting drops can be tricky, and having several partners to watch, count and record is an advantage. The students can take turns with each required task. Depending on the age and experience level of the students, at least one full demonstration by the instructor, and perhaps one full group guided titration as well is necessary. The number of titrations each group can do will vary. Trials with grade 7 students suggest that at least 2 or 3 titrations can be done in 15 minutes of independent work, so long as there is assistance available. Older students can do much more with less guidance.

The ideal is to have samples, equipment, water supply, and waste disposal at the bench or table where each group is working. This will cut down on delays and student movements that can cause accidents. Tap water can be placed in large bottles or jugs, and stepped down to smaller bottles (e.g. 500 mL bottles) for end-use pouring. Waste can be put into small buckets or basins for later collection and disposal. All of the waste can go into a washroom sink.

Demonstrate to the students how to clean-up spills, and also how an eye-rinse will be performed in the very unlikely event that anyone will get chemical solution into their eye.

Suggested Equipment for each Student Group

- **Safety glasses or goggles**;
- Tap water supply bottles, large and small, to make final pouring easier;
- One or more small beakers or pouring cups;
- A small and a large measuring vessel (10 mL and 25 mL graduated cylinders or 5 mL and 15 mL kitchen measuring spoons);
- Some small (1 or 2 mL) disposable polymer pipets (11);
- One or more titration vessels (125 mL Erlenmeyer flask or small polymer cup);
- Waste collection vessel (small basin or bucket);
- Labelled controlled dropper bottle(s) containing 0.4 % sodium hydroxide (one 60 mL bottle or a matched set of smaller bottles containing a total of 60 mL);
- Labelled controlled dropper bottle containing phenolphthalein indicator solution (one 10 mL or 15 mL bottle);
- Paper towels, wipe-up cloth.

Suggested Sample Pairings for Student Analysis

Pair samples, one each from the following three general groups:

- High drop count samples: Apple juice / white grape juice;
- Medium drop count samples: Kool-Aid Invisible;
- Low drop count samples: Degassed Sprite / 7-Up / Ginger Ale.

The ideal situation is to have a matching set of 60 mL bottles for the sodium hydroxide solution, and a set of smaller bottles for the phenolphthalein indicator solution. A 60 mL bottle holds enough NaOH reagent for a laboratory session without needing a refill, yet is not so heavy as to be tiring. However, smaller bottles for the NaOH solution are adequate, if you can either have more than one per group, or are able to refill them as needed. Be warned, refilling bottles during the experiment will be difficult.

Using a matching set of bottles for the sodium hydroxide solution for all of your student groups allows you to compare the drop count results from the different groups with some confidence. Having a smaller bottle for the phenolphthalein solution will help the students identify the correct solution.

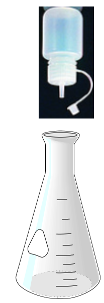
When the titrations are completed, results for each sample type can be put up in a display for the entire class, and comparisons made between sample types. Conclusions can then be drawn about acid content of the various samples. The results can be recorded for later use. You may want to have the students do some taste tests of the various samples, either before or after the experimental work. Of course, this must not be done with the chemicals present.

The data analysis, questions, and other post-laboratory exercises will vary according to your curriculum, and the age and grade level of the students.

10. Student Instructions

What Are You Going to Do?
Many fruit juices and soft drinks are acidic, having a sharp but pleasant taste. In this experiment, you will compare the amount of acid in some juices and drinks. In each experiment, you are going to measure out a 5 mL volume of a juice or a drink, and determine how many drops of a base (sodium hydroxide solution) is required to neutralize the acid. The drops of base will be added from a controlled dropper squeeze bottle (**Drop Count Titration**).

Drop Count Titration



Chemists call this procedure a titration. The end of the titration will be signalled using **phenolphthalein** as an acid-base indicator. Phenolphthalein is colourless in acid and pink or red in base. As the titration proceeds, a colourless sample will eventually become pink or red, at which point the titration is ended. In a yellow juice or drink, the yellow colour will become slightly orange-red, at which point the titration is ended.

Safety
Safety is very important when doing chemistry (**Table 3**). You must keep your eye protection on at all times. Do not touch or rub your eyes until you have washed your hands off under a tap.

Table 3: Hazards of Using 0.1 M Sodium Hydroxide and 0.5 % Phenolphthalein Solutions

Hazard	Remedy / Action
Eyes	WEAR SAFETY GLASSES OR GOGGLES AT ALL TIMES If an accident does occur, rinse at an eye-wash station according to the instructions.
Skin	Rinse off with tap water or wipe off with a dampened cloth. Rinse the cloth with cold water.
Clothing	Rinse the affected area with cold water.
Bench or Floor	Wipe up with a dampened cloth. Rinse the cloth with cold water.

Continued on the Next Page →

Student Instructions (Cont.)

Work with a partner or in a group as instructed. Rotate tasks.

Using a Controlled Dropper Squeeze Bottle

1. You will have one or more dropper bottles that are labelled Sodium Hydroxide, and also a waste basin or bucket. Practice using the dropper bottle over the waste container. If a spill occurs onto the table or the floor, wipe it up with a cloth or paper towel made moist with tap water.

   Hold the bottle upside down, vertically over the waste container. Squeeze out a few drops. Relax your fingers, and let some air come into the bottle. Squeeze out one drop. Repeat until you can control the drops. Drops must come out only when you want them to.

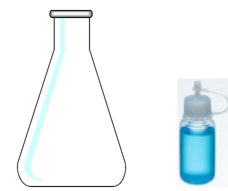
Checking the Water Supply for Acid Content

2. Measure out about 25 mL of the supplied tap water as demonstrated by the teacher into a 125 mL Erlenmeyer flask or a small polymer cup. Carefully add 5 drops of the phenolphthalein indicator solution from its labelled dropper bottle (**Adding Phenolphthalein Indicator**).

   If a spill occurs, wipe it up with a cloth or paper towel made moist with tap water.

   Swirl gently to mix the indicator with the water. Is the indicator colourless or pink? Colourless indicates that the water is acidic or neutral.

Adding Phenolphthalein Indicator



3. Carefully add one drop of the sodium hydroxide solution from its dropper bottle. Swirl gently to mix the base with the water. Is the indicator colourless or pink? Colourless indicates that the water is still acidic or neutral. Pink indicates that any acid present has been neutralized, and the solution is now basic. This is good, since it means that the tap water will not affect the experiment.

4. If the solution is not pink after adding one drop of base, add additional drops of base, one at a time, with swirling, until it turns pink. Count the total number of drops of base required. If more than one drop is required, this value will have to be used to correct all other values in the experiment.

Titrations

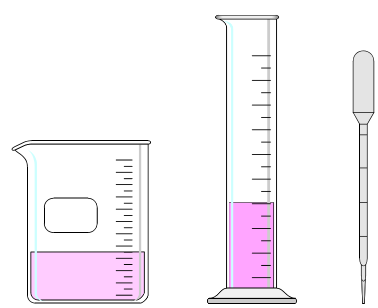
5. Place some of your first juice or drink samples into a small beaker or measuring cup. Measure out 5 mL of the sample as demonstrated by the teacher, using a polymer pipet (if available) to assist you in measuring the correct amount (**Measuring Out a Sample Volume**). Place the sample into your titration vessel.

6. Add approximately 20 mL of distilled water to the vessel. Add 4 or 5 drops of the phenolphthalein indicator solution to the vessel (**Adding Phenolphthalein Indicator**). Mix the contents by swirling gently (no spilling).

   <u>**In Each Titration:**</u>

   - 5 mL of Sample;
   - About 20 mL of Tap Water
   - 4 or 5 Drops of Phenolphthalein

Measuring Out a Sample Volume



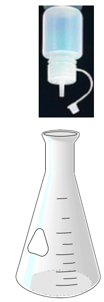
Continued on the Next Page →

Student Instructions (Cont.)

7. If you have a second vessel available, repeat with a second 5 mL of the sample. Set aside one vessel as a colour comparison standard.

8. Record the name of the first sample type in the data table provided (**Table 5**). Hold the dropper bottle containing the 0.4 % sodium hydroxide solution vertically, upside down above the vessel. Add drops of base to the flask, swirling gently to mix (**Drop Count Titration**). Count the total of drops added. Pause after each 5 drops, to see if any colour change is occurring.

Drop Count Titration



9. Continue until you begin to see a short-lived change to a pink or an orange-red colour. Now add fewer drops each time between pauses. When the colour changes permanently, stop adding base. If the colour returns to colourless or pale yellow, add additional drops of base to a permanent change to pink or orange-red. Permanent means for at least one minute.

10. Record the total drop count of the titration in the table (**Table 5**).

11. Repeat the procedure with a second 5 mL sample of the first juice or drink.

12. Repeat the experiment with your second type of juice or drink.

13. If time allows, repeat the experiment with a third type of juice or drink.

14. If time allows, share your results with other groups.

Group Members: ______________________________

____

____

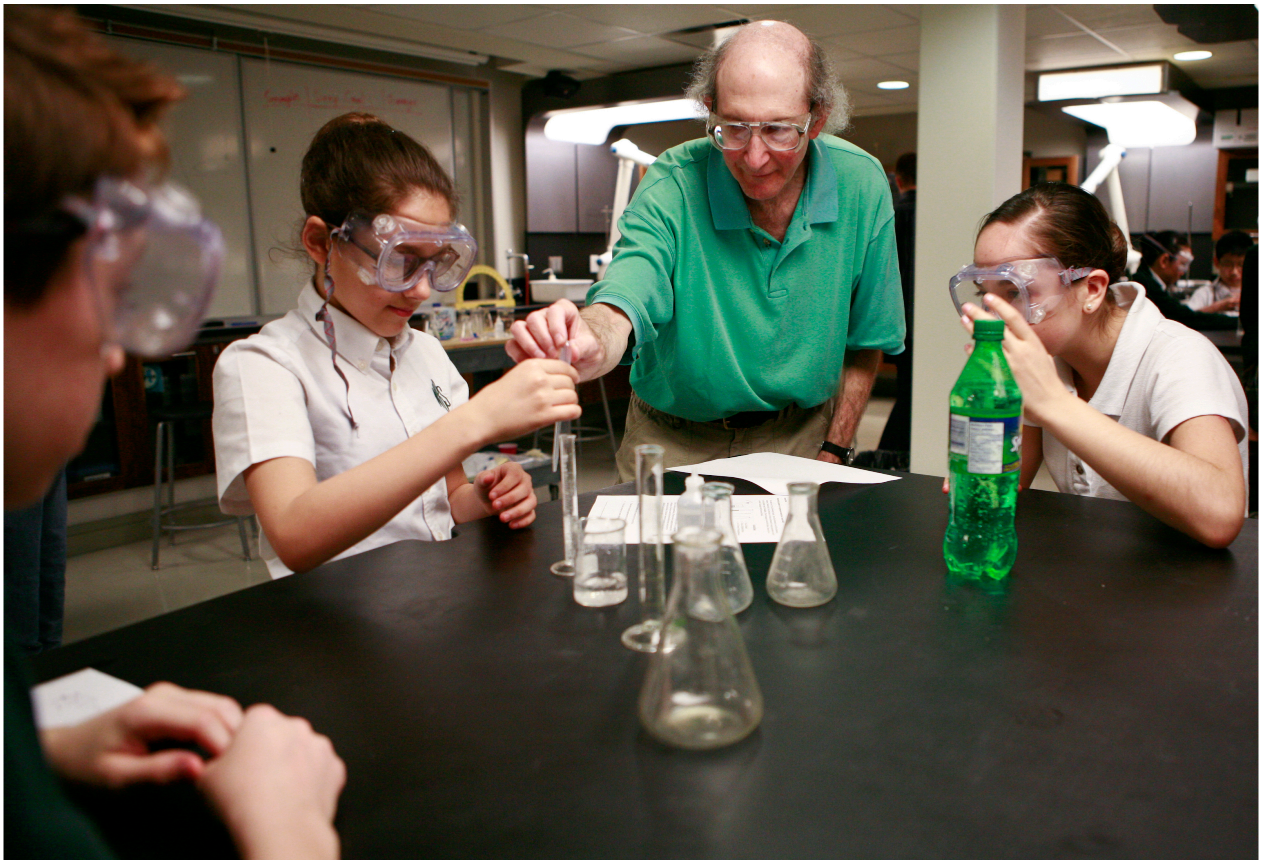
____

Table 5: Titration Data

	Sample Type 1	**Sample Type 2**	**Sample Type 3**
Sample Name			
First Titration Drop Count			
Second Titration Drop Count			

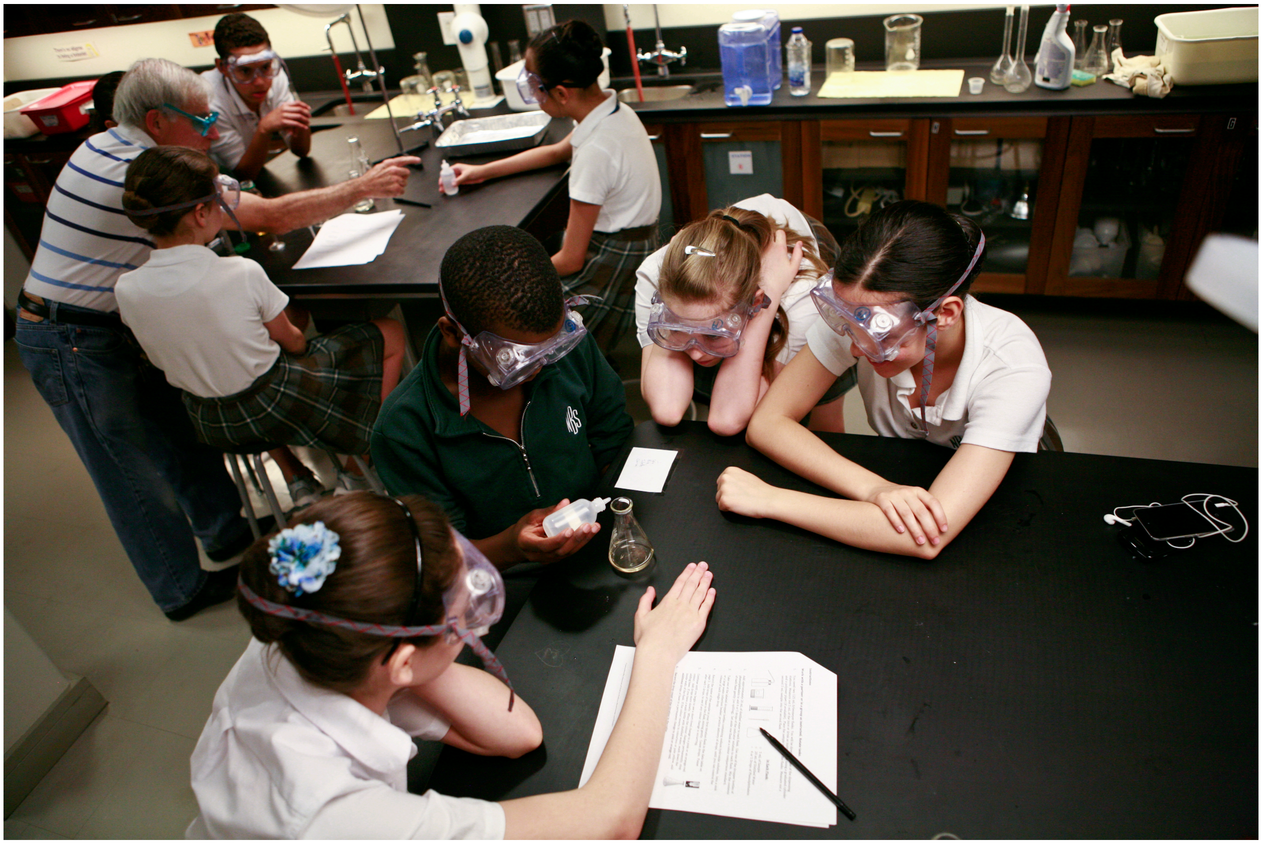
Lisa Fleischmann/National Ballet of Canada School /2012

The author demonstrating to Grade 7 students, National Ballet of Canada School



Lisa Fleischmann/National Ballet of Canada School /2012

The author demonstrating to Grade 7 students, National Ballet of Canada School



Lisa Fleischmann/National Ballet of Canada School /2012

Grade 7 students, National Ballet of Canada School, with Marty Oslinger, former teacher at the School