ASELL Advancing Science and Engineering through Laboratory Learning

Which metal is best for food and drink storage?

Contact: Amanda J Peters

peters.amanda.j@edumail.vic.gov.au

Mooroolbark College, Manchester Road, Mooroolbark, 3138

WHICH METAL IS BEST FOR FOOD AND DRINK STORAGE?

PRESENTED BY AMANDA PETERS – MOOROOLBARK COLLEGE

ASELL EDUCATIONAL TEMPLATE – SECTION 1 (SUMMARY OF THE EXPERIMENT)

1.1 Experiment Title

Which metal is best for food and drink storage? (Formerly: reaction of acid with metals)

1.2 Introduction and Description of the Experiment

Substances may be created by chemical change and may also undergo chemical change.

1.3 Reasons for Submission

The experiment is a standard experiment in many textbooks and has been used at the College for several years. However, the metals are mostly unreactive and therefore there is not a lot of student engagement with this practical exercise. We have tried using more concentrated acid, however, this can become a safety risk for Year 9 students.

The ASELL for Schools team have suggested modifications, to improve both the scientific and educational outcomes.

The November 2016 workshop is the first time the modified practical will be run in a class or class-like setting.

1.4 Experiment Aims and Objectives

The aim of the activity is to investigate the chemical reaction(s) of an acid with a range of metals. Students should observe that the metals exhibit a range of reactivities – some react vigorously and evolve a relatively large amount of gas, while others are unreactive.

Unlike the regular versions of this experiment, students are not told that hydrogen is generated. Students need to work out what gas is produced. Secondly, the experiment is placed in a context which requires students to investigate the reactivity of different metals.

This difference in reactivity can also be linked to energy transfer in the learning sequence.

1.5 Level of the Experiment

The level of the experiment is Year 9, which is Level 9 in the *Victorian Curriculum: Science* (Note [1]).

The main learning outcome is (Note [2]):

---

1 Victorian schools can choose to use *AusVELS* or the *Victorian Curriculum F–10* in 2016. *AusVELS* will be archived in December 2016, and replaced by the *Victorian Curriculum F–10*.

2 *Victorian Curriculum: Science,* level 9 http://victoriancurriculum.vcaa.vic.edu.au/level9?layout=1&d=S.

- Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer (VCSSU126)

Secondary learning outcomes are (potentially):

- The … properties of elements are used to organise them in the periodic table (VCSSU123)
- … chemical reactions … can occur at different rates; chemical reactions may be represented by balanced chemical equations (VCSSU125)
- Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (VCSSU115)
- The values and needs of contemporary society can influence the focus of scientific research (VCSSU116)
- Analyse patterns and trends in data, including … identifying inconsistencies in data … and drawing conclusions that are consistent with evidence (VCSIS138)
- Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (VCSIS140)

Note that the main learning outcome is slightly different from that in the former *AusVELS* because the *Victorian Curriculum: Science* directly and explicitly links chemical reactions with energy transfer.

1.6 Keyword Descriptions of the Experiment

Domain keywords: chemistry, chemical reactions

Specific Descriptors: chemical change, acid, metal.

1.7 Course Context and Students' Required Knowledge and Skills

This experiment is within the 'chemical reactions' unit at Year 9 level, particularly focusing on acids and bases.

Students will have previously learned the following knowledge and/or acquired the following skills:

- the particle model
- how to look for and describe observations of chemical reactions
- chemical change involves substances reacting to form new substances
- how to write word equations
- identifying reactants and products
- conduct scientific investigations using a fair test

1.8 Time Required to Complete

Prior to Lab: 10 minutes
In Laboratory: 25 minutes
After Laboratory: 20 minutes

1.9 Authors of Educational Analysis

Kieran F Lim (Deakin University) and Amanda J Peters (Mooroolbark College)

1.10 Experiment History

In the school setting, this experiment had little success in terms of obvious reactivity with only two of five metals tested reacting. This experiment is an important experiment as it allows students to observe and describe the reactions of metals with acid. It also has many other learning opportunities for students, including: observe and describe reactions, create an order of reactivity and link this to the periodic table, conceptualise why and how the reaction is occurring, write word and chemical equations, link these reactions to 'real-life' examples. The fundamental concepts of this experiment will be needed for future science endeavours, particularly when studying chemistry.

In the revision of this experiment, the basic textbook-based "recipe" experiment was put into an investigative context (which metal is best for food and drink storage), based on an experiment in a book on Guided Inquiry Experiments for General Chemistry by Kerner and Lamba.

Other changes to the experiment were proposed by the *ASELL for Schools* and the *ReMSTEP* teams. (Note [3])

1.11 Any Other Comments

Some Possible Inquiry Questions:

Using acids and metals to 'build' batteries (electric cells), using any of: combinations of metals; amount of metal; concentration of acid.; making a battery with a number of cells in series and compare with cells in parallel.

Possible Extension for lower year levels:
Use this as a demonstration for making observations and placing different reactions in order of reactivity.

Possible Extension for higher year levels:

1. Compare the results to the periodic table. Is there a pattern with the results and where the metals are placed on the periodic table? Suggest a reason why.
2. Choose different metals to compare reactivity. Hypothesise the expected results and test.

1.12 References

Kerner, N., & Lamba, R. (2008). *Guided Inquiry Experiments for General Chemistry: Practical Problems and Applications*. New York: John Wiley and Sons.

Lofts, G. Evergreen, M. (2015). Science Quest 9 for Victoria. Australian Curriculum Edition. Milton (Qld): Jacaranda. p. 283

[3] *ReMSTEP*: Reconceptualising Mathematics and Science Teacher Education Programs through collaborative partnerships between scientists and educators <http://remstep.org.au/> accessed on 19 November 2015.

SECTION 2 – EDUCATIONAL ANALYSIS

Note: Starred outcomes are those that are the principal focus of the exercise. Non-starred outcomes may either be less important, or be outcomes, which could be the focus of the experiment if it were modified. Please restrict yourself to no more than 10 outcomes, with no more than 5 starred, and include at least one outcome in each section.

Learning Outcomes		**Process**	**Indicators**
What will students learn?	**(*)**	**How will students learn it?**	*How will teachers **and** students know that the students have achieved the learning outcomes?*
2.1 Theoretical and Conceptual Knowledge			
Some metals will react with acid to produce dissolved substance(s) and hydrogen gas	*	Some metals will dissolve (seem to disappear) while generating a gas, which ignites with a "pop".	Students are able to describe and explain their observations using pictures (representations) and/or words (word equations).
Metals have a range of reactivities with acid	*	Different metals are mixed with acid to observe their reactivities	Some metals react with acid, some very vigorously and some less vigorously; other metals have no observable reaction
The reactivities of different metals are related to energy of reaction	*	As an extension exercise, students will build a battery using a piece of fruit and two metals as the electrodes.	The best choice of the metals as the electrodes will be the metals that are most and least reactive when reacted with acid
2.2 Scientific and Practical Skills			
Students can create and complete and perform a planned procedure	*	Creating and/or following steps in the procedure	Successfully completing the experiment
Communication – with each other in the group.	*	Students will communicate with each other to coordinate teamwork and to discuss ideas.	Students are able to coordinate their various tasks in a cooperative manner. Students participate in discussions with each other and with the teacher to arrive at conclusions that was consistent with other scientific concepts.
Observation – detailed and accurate. Working in cooperative groups	*	Students will perform tests and record their observations	Observations will be recorded and shared with the class.

Learning Outcomes		Process	Indicators
What will students learn?	**(*)**	**How will students learn it?**	*How will teachers **and** students know that the students have achieved the learning outcomes?*

2.3 Thinking Skills and Generic Attributes

Students can rank the reactivities of different substances	*	Students observe the vigorous-ness (rate or speed) of different metals reacting with acid	Students produce a ranking that is consistent with their own observations and those of other students, and with "textbook" information such as the position of particular metals in the periodic table

LABORATORY EXERCISE

Which metal is best for food and drink storage?

Introduction

A local company plans to use some of their excess metal to produce cans for food and soft drink storage. They are aware that some metals are highly reactive on contact with the acids in food while others are not. They have asked for your help in sorting the group of metals based on their reactivity. The company asks you to recommend one or more metals for can production.

Materials

- Safety glasses
- Apron or laboratory coat
- Bench mat
- Test tubes and test-tube rack
- Pieces of metal – sodium, calcium, magnesium, aluminium (source 1), aluminium (source 2), zinc, copper
- Dropping bottle containing 2 mol L^{-1} hydrochloric acid solution
- Rubber stoppers
- Matches

Method

Different foods and drinks contain a variety of acids, including acetic acid (vinegar), citric acid (a component of orange and lemon juice), ascorbic acid (vitamin C), phosphoric acid (found

in soft drinks), benzoic acid (a preservative) and other acids. In this experiment, hydrochloric acid (the main component of digestive acid in the stomach) will be used as a typical acid in order to have a standardised test.

Some metals might react with hydrochloric acid to produce a gas. Hydrochloric acid in water is made from hydrogen, oxygen and chlorine, so they are the possibilities for any observed gas. A lighted match can used to distinguish between these gases.

- If hydrogen gas is present, the lighted match will ignite the hydrogen gas, making a popping sound.
- If oxygen gas is present, the lighted match will flare up.
- If chlorine gas is present, the lighted match will be extinguished.

1. **Clean a piece of metal (for example, zinc or magnesium) with sandpaper.**
2. **Place a small piece of the metal in a test tube.**
3. **Add hydrochloric acid to the test tube to a depth of 1 cm.**

CAUTION!

Do not push the stopper into the test tube firmly. Just hold it in the top of the test tube for few seconds.

4. **Gently hold a rubber stopper over the end of the test tube for a few seconds and then placing a lighted match at the mouth of the test tube.**

N.B.

Your observations should make use of as many senses as possible. Was there a change in appearance? Was there a change in temperature? Was there a sound?

CAUTION!

Do not test for changes in smell or taste.

5. **Record your observations table provided (see below). If possible, take a photo of each result.**
6. **Repeat steps 1-5 for the other metals.**
7. **If possible, determine a ranking of the metals from least reactive to most reactive.**

Results

Metal	Result of combining acid and metal	Result of lighted match test	Order of reactivity (1 being least reactive, 7 being most reactive)

The order of reactivity from least reactive to most reactive is:

Discussion

List three safety rules you should follow in this experiment.

1.

2.

3.

What is the aim of this experiment? What scientific question are you trying to answer?

How did you determine the order of reactivity of metals?

What do you think is happening in the test tube to make the chemical reaction? Draw a picture, with labels, explaining your answer.

When zinc metal reacts with hydrochloric acid, zinc chloride and a gas are formed. (Hint: what did you determine to be the gas?) Write a word equation to describe this reaction.

If any of your reactions produced a 'pop' with the lighted match test, hydrogen gas reacted with oxygen in the air to form water. You may have noticed the water form at the top of the test tube after you performed the match test. Write a word equation for this chemical reaction.

Did you notice any difference in reactivity for the two types of aluminium? If so, please suggest a reason for any difference.

Based only on the reactivity of metals with acid, which metal or metals would be best for food and drink storage?

TEACHER NOTES

Which metal is best for food and drink storage?

Background

This practical activity is a variation on the standard "acid plus metal" experiment found in most textbooks.

WORD EQUATOIN 1

Acid + metal $\rightarrow$ hydrogen gas + dissolved metal chloride.

Indeed, students carry out exactly the same experimental procedures as in the standard experiment.

A local company plans to use some of their excess metal to produce cans for food and soft drink storage. They are aware that some metals are highly reactive on contact with the acids in food while others are not. They have asked for your help in sorting the group of metals based on their reactivity. The company asks you to recommend one or more metals for can production.

Learning outcomes

At the end of this practical activity, students should

- Be able to make accurate observations of a reaction
- Know that hydrogen gas is produced by an acid plus metal reaction
- Know that various metals have different reactivities when mixed with hydrochloric acid.

Links to the Victorian Curriculum F–10

The main learning outcome is:

- Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer (VCSSU126)

Secondary learning outcomes are (potentially):

- The … properties of elements are used to organise them in the periodic table (VCSSU123)
- … chemical reactions … can occur at different rates; chemical reactions may be represented by balanced chemical equations (VCSSU125)
- Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (VCSSU115)
- The values and needs of contemporary society can influence the focus of scientific research (VCSSU116)
- Formulate questions or hypotheses that can be investigated scientifically, including identification of independent, dependent and controlled variables (VCSIS134)
- Analyse patterns and trends in data, including … identifying inconsistencies in data … and drawing conclusions that are consistent with evidence (VCSIS138)
- Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (VCSIS140)

Extensions

This experiment is intended for year 9.

This experiment can be extended by including a further inquiry question:

> Using acids and metals to ‘build’ batteries (electric cells), using any of: combinations of metals; amount of metal; concentration of acid.; making a battery with a number of cells in series and compare with cells in parallel.

Possible extension for lower year levels:

Use this as a demonstration for making observations and placing different reactions in order of reactivity.

Possible extension(s) for higher year levels:

1. Compare the results to the periodic table. Is there a pattern with the results and where the metals are placed on the periodic table? Suggest a reason why.
2. Choose different metals to compare reactivity. Hypothesise the expected results and test.

RISK ASSESSMENT FORM

Experiment /Process

Reactions of Acids with Metals. p 266. Quest 9.

MOOROOLBARK COLLEGE

Year Level 8/9.

Name of Assessor (Print Name) JUDY LACKMAN. **Date** 5/9/14.

HAZARDOUS SUBSTANCE	STATE (S/L/G)	Corrosive	Poison	Irritant	Carcinogen	Mutagen	Teratogen	Route of Entry				MSDS Date
								Skin	Eyes	Ingestion	Respiratory	
Hydrochloric acid 2M	L	✓		✓				✓	✓	✓	✓	Oct '12
Magnesium ribbon. - Non Haz.	S.			✓				✓	✓			Jun '11.
Hazardous Products												

CONTROLS

SAFETY GLASSES ✓	Apron/Lab Coat ✓	Gloves	Exhaust Fan	Wash hands at conclusion ✓
Work in Fumehood	Other			

Disposal of Waste Safe for sewerage system Collect for disposal ✓

OTHER HAZARDS eg: Spillage Splashes **Flammability** **Burns** **stains**

Wash with copious amounts of water.

Are existing controls suitable and maintained? YES NO

If not, What is required? LONG TERM SHORT TERM