A Pluriliteracies Approach to Teaching for Learning

Iron production and rust removal
Materials for intermediate learners

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www.ecml.at/pluriliteracies
Create your own rust remover!

In groups of four, carry out the experiment described below. You have 20 minutes for the practical work and 30 minutes for the analysis (wait at least one day).

*Make sure to assign the following tasks within your group (presenter, writer/recorder, time watcher, emissary, language guard)*

**material** 6 test tubes, test tube rack, funnel, spatula, Bunsen burner, lighter, test tube clamp

**chemicals** 6 rusty iron nails, tab water, Coca Cola, Sinalco, Sprite, soda water, citric acid solution (20%),

**procedure** Place the six rusty nails in one test tube each. Dissolve the citric acid crystals in distilled water to produce a 20% solution. Fill the tubes with one of the possible “rust-removers” each so that two thirds of the nail is covered with liquid.

**hypothesis** What do you expect to happen and why?  

If... then ... because ...

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Observation

1. Write down your observations in the chart below.

   *Have a close look at colour, aggregate states, consistency, precipitate, weight and any possible noises.*

<table>
<thead>
<tr>
<th></th>
<th><strong>before the reaction</strong></th>
<th><strong>after the reaction</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>liquid</td>
<td>nail</td>
</tr>
<tr>
<td>tab water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coca Cola</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinalco</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>citric acid solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>soda water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explanation

2. Form all chemical equations similar to the example below. *Help cards provided.*

\[
\begin{align*}
\text{water (l)} + \text{iron (s)} & \rightarrow \text{iron oxide (s)} + \text{hydrogen (g)} \\
\text{H}_2\text{O (l)} + \text{Fe (s)} & \rightarrow \text{Fe}_2\text{O}_3 (s) + \text{H}_2 (g)
\end{align*}
\]

Tab water + iron oxide \[\rightarrow \text{_________________________} + \text{_________________________}\]

\[_________________ ( ) + __________________ ( ) \rightarrow __________________ ( ) + __________________ ( )\]

Coca Cola + iron oxide \[\rightarrow \text{_________________________} + \text{_________________________}\]

\[_________________ ( ) + __________________ ( ) \rightarrow __________________ ( ) + __________________ ( )\]
Sinalco + iron oxide → ________________ + ________________

_____________ ( ) + _______________ ( ) → ______________ ( ) + ______________ ( )

Sprite + iron oxide → ________________ + ________________

_____________ ( ) + _______________ ( ) → ______________ ( ) + ______________ ( )

citric acid solution (20%) + iron oxide → ________________ + ________________

_____________ ( ) + _______________ ( ) → ______________ ( ) + ______________ ( )

soda water + iron oxide → ________________ + ________________

_____________ ( ) + _______________ ( ) → ______________ ( ) + ______________ ( )

Discussion

3. Restate the purpose, problem and hypothesis of your experiment in a coherent paragraph. Use the word bank below.

<table>
<thead>
<tr>
<th>The</th>
<th>main chief primary principal</th>
<th>aim objective purpose</th>
<th>of the study investigation experiment</th>
<th>was to determine examine</th>
<th>the value, mass, amount, effect, change, difference, increase, structure, reaction, mechanism, behavior structure, presence, existence, of</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was</td>
<td>our aim</td>
<td>to (re-)examine, find (out about), obtain, elucidate</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>It was</td>
<td>the purpose of this</td>
<td>study, investigation, experiment</td>
<td>to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>we</td>
<td>aimed to identify, sought to justify</td>
<td>have concentrated on, carried out a study of, decided to (re-)examine X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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4. Sum up your findings.

*Start each sentence at the beginning of a new line and use every third line only.*

<table>
<thead>
<tr>
<th>It was</th>
<th>found shown</th>
<th>X</th>
<th>increased</th>
<th>decreased</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>The</td>
<td>experiment investigation study</td>
<td>showed revealed</td>
<td></td>
<td></td>
<td>that…</td>
</tr>
</tbody>
</table>

Example: *It was found that the dry nail was still coloured red after the experiment.*

The experiment showed__________________________________________________________

It was found that________________________________________________________________

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5. Now explain your findings in academic language! Therefore restate the above listed observations with nominalizations and give reasons for your observations. What a nominalization is and how it is formed can be found in the grammar box below.

Example:

**observation:** The dry nail was still coloured red after the experiment.

**nominalisation:** The red colour of the dry nail remained unchanged . . .

**reason:** . . . because/since/as it did not get in contact with any rust remover enabling the dissolution/reduction of red iron oxide.

NOMINALIZATIONS are used to make a text sound more academic. They are created by turning verbs and adjectives into nouns, which then function as subject or object of the sentence. This can be achieved by adding suffixes to a verb as in

- **-tion:** to suggest → the suggestion
- **-ing:** to play → the playing
- **-ment:** to achieve → achievement

or to an adjective as in

- **-ness:** lonely → loneliness
- **-ance:** relevant → relevance

6. Define the process of rust removal.

Include cause and effect constructions (if... then... because...), compare examples of good and inefficient chemicals, name the classes these substances belong to, describe which characteristics a rust remover must have.
Write a coherent conclusion. *Remember the following aspects:*

- connection between your results and existing theories/ previous findings
- practical and theoretical implications of your obtained findings
- generalizations and future research questions

<table>
<thead>
<tr>
<th>From the results</th>
<th>The results suggest imply that the hypothesis should be revised abandoned restricted to the cases of X extended to the cases of Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>The results</td>
<td>(do not) seem to confirm the explanation</td>
</tr>
<tr>
<td>Our data</td>
<td>seem to support the hypothesis/ data as proposed in XYZ (...). contradicit the hypothesis developed by XYZ (...).</td>
</tr>
<tr>
<td>Thus, Hence, Therefore,</td>
<td>X provides a reasonable satisfactory convincing explanation for Y.</td>
</tr>
<tr>
<td>The findings make it possible to</td>
<td>conclude explain suggest that… a new treatment a new model</td>
</tr>
<tr>
<td>Thus,</td>
<td>X is clearly not Y X shows that Y is (not) Z.</td>
</tr>
<tr>
<td>These assumptions conclusions are also confirmed supported by the data reported in/ by ...</td>
<td></td>
</tr>
</tbody>
</table>

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Homework

Can vinegar be used as rust remover? *Compare it to any of the substance classes/ chemicals used during the experiment? Which features does a rust remover need to have?*
help card 1

relevant ingredients:

<table>
<thead>
<tr>
<th>tab water</th>
<th>Coca Cola</th>
<th>Sinalco</th>
<th>Sprite</th>
<th>citric acid</th>
<th>soda water</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O</td>
<td>H₃PO₄</td>
<td>CitH₃</td>
<td>CitH₃</td>
<td>CitH₃ (a lot)</td>
<td>H₂CO₃</td>
</tr>
</tbody>
</table>

help card 2

What does rust consist of? How is it formed?
The chemical reaction of rust removal must include the opposite processes!

help card 3

Even though citric acid is a weak acid and not fully dissociated, it quite often builds complexes with base metals.
help card 4

These are some of the resulting products:

\[
\text{Fe(OH)}_3(s) \text{ (also rust)} \quad 2 \text{ FePO}_4_{(\text{solid})} \quad \text{CO}_2(g)
\]
Who is the strongest?

To find out who the strongest reducing agent is, you will have to test the elements against each other. Work in groups of four to six students using the jigsaw method. Decide in class which combinations of chemicals you want to try out and divide the experiments evenly. Follow the procedure below and fill out the lab report sheet provided. You have 15 minutes time to complete your experiments and 30 minutes to analyse your findings.

**material** Bunsen burner, spade, test tubes, test tube rack, utility clamp, ring stand

**chemicals** red iron oxide, black copper oxide, zinc oxide, magnesium oxide, iron powder, copper powder, zinc powder, magnesium powder

**procedure** - fill one spade point tip of metal oxide in a test tube and add one spade point tip of metal to it
- shake the test tube to mix up the chemicals
- attach the test tube to the ring stand with a utility clamp
- heat up the mixture with a Bunsen burner

_____________________________________________________________________________________________________

**Homework**

Look up the term **thermit** and **blast furnace technology**. Explain the chemical reaction behind the process and decide whether the reaction is faster/more aggressive with iron or with copper. *Enjoy watching the videos afterwards :)*

Thermit reaction with iron: https://www.youtube.com/watch?v=P1ls0jc5j2A
Thermit reaction with copper: https://www.youtube.com/watch?v=Z9R-gcKv7dI

Write a 500 word article for the science fair introducing the technology, chemical reaction and relevance for the industry and public.
Title
1. Assign a suitable title to your experiment.
   The reaction of ... and ...
   The effect of ... on ...

Introduction
2. Formulate a coherent introduction including: aim, theoretical background, and a connection to previous research
   The aim of the experiment was to test According to XYZ (2014), ...
   It is known from the lecture that ...
   Further research on ... is still needed

Problem
3. Write down the problem of your experiment.
   What happens if ... and ... react together?

Hypothesis
4. Develop a hypothesis including the independent and dependent variables.
   If ... then ... because ...
Material

5. List all tools and chemicals used in your experiment.

Chemicals: ______________________________________________

Tools: ______________________________________________

6. Draw your experimental set up.

Procedure

7. Write down the procedure. *Keep the rules in mind!*

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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Results

8. Write down your observations using the word box below.

Describe your substances before, during and after the reaction including (color, aggregate state, smell, texture, weight, noises, ...).

<table>
<thead>
<tr>
<th></th>
<th>found shown</th>
<th>that...</th>
<th>X</th>
<th>increased</th>
<th>decreased</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>The</td>
<td>experiment investigation study</td>
<td>showed revealed</td>
<td></td>
<td></td>
<td>that...</td>
<td></td>
</tr>
</tbody>
</table>

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

9. Go back into your original group and complete the table with the findings of the other group members.

<table>
<thead>
<tr>
<th>metal oxide</th>
<th>iron</th>
<th>magnesium</th>
<th>zinc</th>
<th>copper</th>
<th>aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>iron oxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>magnesium oxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>zinc oxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>copper oxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aluminium oxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Discussion

10. Order the metals on page 23 according to their ability as reduction agent.

11. Name two more noble and base metals. *Make use of the PSE!*

_______________________________________________________________________

_______________________________________________________________________

12. Explain the results and say whether or not they were expected.

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

13. Write down the equations for either one metal with all oxides or one oxide with all metals.

\[
\text{base metal} \quad \rightarrow \quad \text{noble metal}
\]

\[
\text{base metal} \quad \rightarrow \quad \text{noble metal}
\]

\[
\text{base metal} \quad \rightarrow \quad \text{noble metal}
\]

\[
\text{base metal} \quad \rightarrow \quad \text{noble metal}
\]

\[
\text{base metal} \quad \rightarrow \quad \text{noble metal}
\]

\[
\text{base metal} \quad \rightarrow \quad \text{noble metal}
\]
14. Re-define the terms oxidation, reduction, redox-reaction, reducing agent, oxidizing agent. Use the given formulations and chemical termini.

<table>
<thead>
<tr>
<th>A . . .</th>
<th>is a . . .</th>
<th>that who which</th>
<th>is made up of . . .</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>has the following characteristics . . .</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>is used for . . .</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>is opposed to . . .</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>can be used for . . .</td>
</tr>
</tbody>
</table>

The term . . . comes from two terms, namely . . . which means . . . and . . . which means . . .

You might have to add words if necessary.


oxidation:  ____________________________________________________________

 reduction: ___________________________________________________________

redox-reaction: _______________________________________________________

reducing agent: _______________________________________________________

oxidizing agent: _______________________________________________________

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help card 1

order the elements in the yellow squares according to their ability as reducing agent
help card 2

help card 3

**Standard electrode potential:**

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>+1.69 V</td>
</tr>
<tr>
<td>Magnesium</td>
<td>-2.362 V</td>
</tr>
<tr>
<td>Lead</td>
<td>-0.13 V</td>
</tr>
<tr>
<td>Silver</td>
<td>+0.80 V</td>
</tr>
<tr>
<td>Copper</td>
<td>+0.35 V</td>
</tr>
<tr>
<td>Platinum</td>
<td>+1.20 V</td>
</tr>
<tr>
<td>Iron</td>
<td>-0.41 V</td>
</tr>
<tr>
<td>Alumina</td>
<td>-1.66 V</td>
</tr>
<tr>
<td>Zinc</td>
<td>-0.76 V</td>
</tr>
</tbody>
</table>

The standard reduction potential describes the likelihood for a chemical substance to be reduced. The more positive the potential is, the more likely it will be reduced. **KEEP IN MIND:** ability to get reduced is contrary to the strength as reducing agent!
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