# Teacher Guide

## Green Laboratory

This teaching unit is designed as Step-by-Step Instruction. Students will find out more about green chemistry and chemical reactions through experimental work and by using textbooks and other available sources.

### STUDENTS’ AGE

The experiment is suitable for students in the upper secondary school (age 16 to 18).

### TIME REQUIRED

About 60 minutes.

### CURRICULAR RELEVANCE

The National Finnish curriculum for chemistry in upper secondary schools emphasise as general goals the following aspects related to this experimental work:

* a student can evaluate various solutions offered by chemistry and related technologies and evaluate their relevance to the individual, the environment and society
* a student can conduct experimental work and use working methods typical for chemistry
* a student understands and can apply the key concepts of chemistry

For example, the experimental work can be included into course KE4 Chemical reaction as it focuses on the key concept of the course and enables students to study chemical reactions experimentally, which is an aim at course KE4.

### RISK ASSESMENT

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| **List significant hazards** | **Describe what could happen** | **Precautionary measures** | **Measures to be taken if something goes wrong** |
| Copper(II) chloride | Slika, ki vsebuje besede znak  Opis je samodejno ustvarjenDead plant and dead fish Harmed material and harmed hand  H290 May be corrosive to metals.  H302 Harmful if swallowed.  H315 Causes skin irritation.  H319 Causes serious eye irritation.  H410 Very toxic to aquatic life with long lasting effects. | P273 Avoid release to the environment.  P280 Wear protective gloves/protective clothing/eye protection.  P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.  P302+P352 IF ON SKIN: Wash with plenty of water  P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.  P312 Call a POISON CENTER if you feel unwell. | Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid.  Skin: Get medical aid. Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.  Ingestion: Do not induce vomiting. Get medical aid immediately. Call a poison control center.  Inhalation: Remove from exposure and move to fresh air immediately. If breathing is difficult, give oxygen. Get medical aid. |
| 0.5 M Hydrochloric acid solution | Harmed material and harmed hand  H290 May be corrosive to metals.  Not classified as a harmful mixture |  |  |
| 0.1 M Copper(II) sulfate solution | Dead plant and dead fish  H410 Very toxic to aquatic life with long lasting effects | P273 Avoid release to the environment. | First-aid measures after skin contact: Gently wash with plenty of soap and water. If skin irritation occurs: Get medical  advice/attention.  First-aid measures after eye contact: Remove contact lenses, if present and easy to do. Continue rinsing. Rinse cautiously  with water for several minutes. If eye irritation persists: Get medical advice/attention.  First-aid measures after ingestion: Rinse mouth out with water. If you feel unwell, seek medical advice. |
| Potassium carbonate | Slika, ki vsebuje besede znak  Opis je samodejno ustvarjen  H315 Causes skin irritation.  H319 Causes serious eye irritation.  H335 May cause respiratory irritation. | P280 Wear protective gloves/protective clothing/eye protection.  P302+P352 IF ON SKIN: Wash with plenty of water  P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. | General notes: Take off contaminated clothing.  Following inhalation: Provide fresh air. In all cases of doubt, or when symptoms persist, seek medical advice.  Following skin contact: Rinse skin with water/shower. In case of skin irritation, consult a physician.  Following eye contact: Irrigate copiously with clean, fresh water for at least 10 minutes, holding the eyelids apart. In case of  eye irritation, consult an ophthalmologist.  Following ingestion: Rinse mouth. Call a doctor if you feel unwell. |
| 0.1 M Calsium chloride solution | Not classified as a harmful mixture |  |  |
| 0.1 M Sodium carbonate solution | Not classified as a harmful mixture |  |  |
| Calsium oxide | Harmed material and harmed handSlika, ki vsebuje besede znak  Opis je samodejno ustvarjen  H315 Causes skin irritation.  H318 Causes serious eye damage.  H335 May cause respiratory irritation. | P261 Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray.  P264 Wash skin thoroughly after handling.  P271 Use only outdoors or in a well-ventilated area.  P280 Wear protective gloves/ eye protection/ face protection.  P302 + P352 IF ON SKIN: Wash with plenty of water.  P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes.  Remove contact lenses, if present and easy to do. Continue  rinsing. | After inhalation: fresh air.  In case of skin contact: Take off immediately all contaminated clothing. Rinse skin with  water/ shower.  After eye contact: rinse out with plenty of water. Immediately call in ophthalmologist.  Remove contact lenses.  After swallowing: immediately make victim drink water (two glasses at most). Consult a  physician. |
| Magnesium ribbon | H228 Flammable solid.  H251 Self-heating; may catch fire.  H261 In contact with water releases flammable gas. | P210 Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.  P223 Do not allow contact with water.  P231 + P232 Handle and store contents under inert gas. Protect frommoisture.  P235 Keep cool.  P240 Ground and bond container and receiving equipment.  P403 + P235 Store in a well-ventilated place. Keep cool. | After inhalation: fresh air.  In case of skin contact: Take off immediately all contaminated clothing. Rinse skin with  water/ shower.  After eye contact: rinse out with plenty of water. Remove contact lenses.  After swallowing: make victim drink water (two glasses at most). Consult doctor if feeling  unwell. |
| Copper wire | Not classified as a harmful |  |  |

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| **Disposal and any other comments** | Reaction products should be disposed in accordance with instructions written in SDS and local/regional/national/international regulations.  Students should wear personal protective equipment (gloves, goggles, and lab coat). |
| **In case of emergency** | Call 112 or a doctor. |

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| **Date of assessment** |  | **Written by** |  | **Class/lesson** |  |

### Reaction equations

Pair A:

CuCl2(aq) + Mg(s) → MgCl2(aq) + Cu(s)

Mg(s) + 2 HCl(aq) → MgCl2(aq) + H2(g)

Pair B:

CaCl2(aq) + Na2CO3(aq) → CaCO3(s) + 2 NaCl(aq)

CuSO4(aq) + K2CO3(aq) → CuCO3(s) + K2SO4(aq)

Pair C:

CaO(s) + H2O(l) → Ca(OH)2(aq) → Ca2+(aq) + 2 OH-(aq)

2 Cu(s) + O2(g) → 2 CuO(s)

### Example answers to the questions

1. What does green chemistry mean?  
   *Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances*.
2. How can one measure the “greenness” of a chemical reaction?  
   *By assessing how well the reaction follows the Green Chemistry Principles. This can be done for example by using the Green Star (see Appendix 1–4) as an assessment tool.*
3. Which of the reactions were greener in pairs A, B and C?  
   *For pair A: Option 2 with HCl is greener: It does not create solid waste and copper(II) chloride of the first option is an environmentally hazardous substance.*  
   *For pair B: Option 1 (with calcium chlorite and sodium carbonite) is greener as the substances used and generated in the reaction are safer than in option 2. Copper sulfate is hazardous to the environment. In addition, the atom economy in option 1 is better.*   
   *For pair C: Option 2 (copper and oxygen gas) is greener thanks to safer chemical choices. Calcium oxide and calcium hydroxide are harmful substances that can irritate the eyes, skin, and respiration.*

### REFERENCES

ChemistryLab Gadolin. Kemianluokka Gadolinin työohjeiden materiaalipankki [material bank for experimental works]. [Kemianluokka Gadolinin työohjeiden materiaalipankki | Tiedekasvatus | Helsingin yliopisto (helsinki.fi)](https://www.helsinki.fi/fi/tiedekasvatus/opettajille-ja-opetuksen-tueksi/opintokaynnit-ja-lainattavat-tarvikkeet/kemianluokka-gadolin/kemianluokka-gadolinin-tyoohjeiden-materiaalipankki)

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