B3 How does waste separation work? – Separating materials by density and magnetism

You will need a piece of paper to record your observations. The experiments are conducted in teams. Always read the instructions before you begin an experiment. Prepare all necessary materials in advance.
In these experiments, you will learn the basic principles of waste separation for recycling raw materials.

1 Separation of a mixture of solids consisting of sand and iron

1.1 Apparatus and materials

- 1 bowl, plastic
- Filter paper or newspaper
- Iron powder, can
- 1 magnet (permanent), rectangular
- 1 plastic bag 3 l (polyethylene)
- 3 plastic cups (clear), 500 ml
- Silica sand (“filter sand”)
- 1 teaspoon

Attention: After you have completed the experiment, return the materials or dispose of them properly as instructed by your teacher.

1.2 Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.
For this experiment, be aware of the following risks:

- Remove all water-sensitive materials from your workspace.
- Be careful if you use scissors.

1.3 Conducting the experiment

- First you need to create a mixture of solids using the silica sand and iron powder.
- To create the mixture, mix together about 1 teaspoon of sand and about 1/2 teaspoon of iron powder in the plastic bowl.
- Now separate the iron from the sand. To do so, insert the magnet into the plastic bag. **Attention:** The bag must be absolutely leakproof and must not have any cuts or tears. (If the iron powder comes into direct contact with the magnet, it is very difficult to remove completely!)

Fig. 1: Using the wrapped magnet to pick up the iron.

- Then “vacuum” the bottom of the bowl by moving the wrapped magnet over it.
- Then hold the plastic-wrapped magnet with the iron powder clinging to it over an empty 500-ml cup. When you remove the magnet from the plastic bag, the iron particles will fall into the cup. Reinsert the magnet into the plastic bag and run it over the sand in the bowl. Repeat this until you don’t see any more iron particles.

- Place the iron powder you collect each time into the cup.
- Pour the cleaned sand into one of the empty 500-ml cups.
- If you examine the cup containing the iron powder, you will also see some grains of sand, which were caught between the iron shavings.
- Pour the iron powder with the remaining sand back into the bowl. Once again, insert the magnet in the plastic bag, pick up the iron particles, and collect the iron powder in the cup. Add the sand left behind to the cleaned sand in the corresponding cup.
- If you carefully repeat this procedure one more time, you should end up with pure sand and pure iron powder.
- The iron powder will be collected according to your teacher's instructions for reuse in later experiments.

1.4 Observation

Write down a summary of your observations and the procedure you followed.

1.5 Analysis

Explain the properties that allow the sand and iron to be separated.

1.6 Questions

Can silica sand and iron be separated based on their densities?

2 Can we separate a mixture consisting of sand, plastic, water, and salt?

2.1 Apparatus and materials

- Digital multimeter
- Filter paper or newspaper
- 1 measuring cable assembly, banana plug to alligator clip, red and black for each
- 2 nails (steel, "iron")
- 1 pair of scissors
- Paper towels for drying cups (optional)
- 1 plastic bag, 3 l (polyethylene)
- 1 plastic cup, 100 ml
- 3 plastic cups (clear), 500 ml
- Silica sand ("filter sand")
- Table salt
- 1 teaspoon
- Water

Attention: After you have completed the experiment, return the materials or dispose of them properly as instructed by your teacher.

2.2 Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.
For this experiment, be aware of the following risks:

- Remove all water-sensitive materials from your workspace.
- Be careful if you use scissors.

2.3 Conducting the experiment

- Now we will create a mixture consisting of sand, plastic, water, and salt. First, cut a strip of plastic off the top edge of the plastic bag and cut it into small snippets about 2 mm in size. Add the snippets of plastic to the bowl containing the sand and add about 1/2 teaspoon of salt. Pour this mixture into a 500-ml cup filled about 1/3 full with water.
- Using the spoon, skim off the snippets of plastic and place them on the filter paper or newspaper to dry. Afterwards, collect them according to your teacher's instructions, since they might be reused.
- Holding the cup with the sand and water, decant (pour) the water into a 500-ml cup.

Fig. 2: Our mixture of sand, plastic, water, and salt.

- Using the decanted water, fill one of the 100-ml cups about half way.
- Fill the second 100-ml cup with distilled water or tap water.
- Using the multimeter and two nails as electrodes, measure the resistance first of the distilled or tap water, and then of the decanted water. Adjust the resistance range on the multimeter to obtain the best resolution for each cup.
  Important: Make sure that the nails are the same distance apart for all measurements.

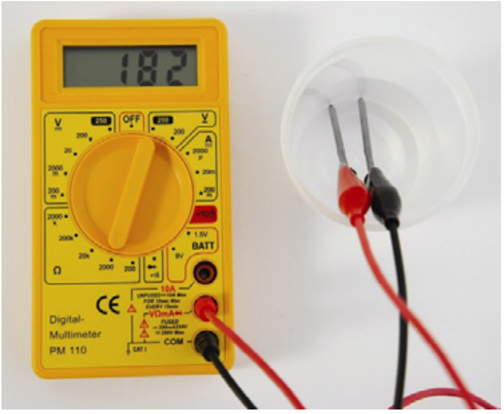


Fig. 3: Measuring the resistance of the aqueous solution.

2.4 Observation

Write down a summary of your observations and the procedure you followed.

2.5 Analysis

a) Explain the properties that allow the polyethylene plastic and sand to be separated.
b) Explain why the resistance and conductivity of the distilled or tap water and the decanted water vary so significantly.

2.6 Questions

a) What other properties of materials do you think could be used for product separation?
b) Why it is so difficult to separate non-ferrous metals such as aluminum, copper, brass, tin, and zinc from ferrous metals on one hand and from glass, paper, and plastics on the other?
c) What suggestions can you come up with for how you could separate solid materials (e.g., salts) that are dissolved in water from the water?

3 Principle of the separation of aluminum from other non-ferrous metals

This experiment will demonstrate that two or more different physical properties are often used for separation methods. In this experiment, you will use magnetic repulsion in a non-ferrous metal that occurs based on induced eddy currents.

3.1 Apparatus and materials

- Aluminum foil, roll
- 1 bowl, plastic
- 1 neodymium magnet, very strong
- 1 pair of scissors
- 1 ruler or set square
- Water

Attention: After you have completed the experiment, return the materials or dispose of them properly as instructed by your teacher.

3.2 Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.
For this experiment, be aware of the following risks:

- Remove all water-sensitive materials from your workspace.
- Be careful if you use scissors.
- Never use the neodymium magnet in the proximity of magnetic data media, such as debit cards!

3.3 Conducting the experiment

- Cut a 20 cm x 20 cm square from the aluminum foil and fold it into an octagon following the instructions given in the appendix.
- Test whether the aluminum octagon is attracted to the magnet.
- Fill the plastic bowl with water.
- Place the aluminum octagon on the surface of the water. At a distance of about 1 cm above the aluminum octagon, slowly move the magnet in clockwise circles. Make sure to always maintain the same distance.
- Change the speed and the direction in which you move the magnet (in circles, counter-clockwise).

Fig. 4: Move the magnet in circles above the aluminum octagon.

3.4 Observation

Write down a summary of your observations.

3.5 Analysis

a) What happens to the folded aluminum octagon when you place it on the surface of the water? Why doesn't the folded foil sink?
b) What happens to the aluminum octagon when you move the magnet in circles above it?
c) Does anything change when you alter the speed or the direction of the circles?
d) Attempt to explain the influence of the magnet on the aluminum octagon.
(Tip: What happens when a magnetic field moves through an electric conductor?
What kind of magnetic effect happens if current flows in an electric conductor?)
e) What does the experiment have to do with the phenomenon of eddy currents?

3.6 Questions

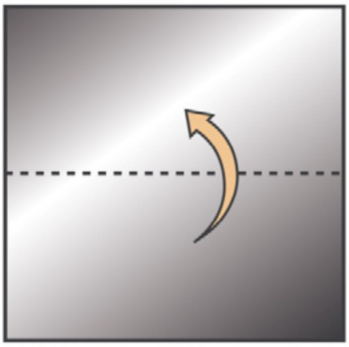
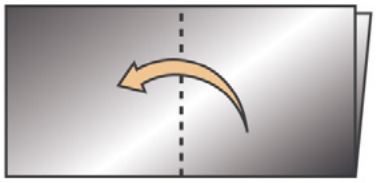
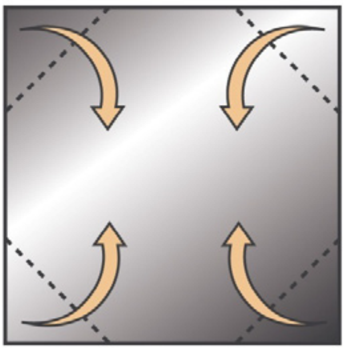
a) Check the garbage at home or at school. How much do the proportions of components in the garbage differ? Write down the proportions.

If you have Internet access:

b) How is the principle of eddy current separation used in waste separation and in metal recycling? Search online for your answer.
c) In what other areas is the generation of eddy currents used in industry and technology?
d) Recovering raw materials from garbage is particularly useful if they can be separated in an energy-efficient manner and if the materials in question require a high level of energy for production. What examples for this concept can you find online?
e) A very interesting recycling process is the recycling of raw materials from Tetra Pak packaging materials. What are the material components of Tetra Pak packaging?
How would you design a separating method?
f) What options do industrial plants, such as car factories, have for avoiding unnecessary waste?

Appendix: How to fold an octagon from aluminum foil

These folding instructions are for subexperiment 2, “Principle of the separation of aluminum from other non-ferrous metals”.

1. Take a square piece of aluminum foil (about 20 cm x 20 cm) and loosely fold it in half, creating a rectangle. Leave a little air between the two layers.	
2. Fold the rectangle in half again, creating a square.	
3. Repeat steps 1 and 2 so that you have a square with sixteen layers (see photo).	
4. Now fold each of the four corners toward the center of the square and smooth down the folded corners.	
5. The finished octagon should look as shown (see photo).