

Making silicon and silanes from sand – teacher notes

Introduction

Magnesium and sand are heated together, and silicon is produced by an exothermic reaction. The product is placed in acid to remove magnesium oxide and unreacted magnesium. Small amounts of silanes are produced by the reaction of magnesium silicide (a side product) with the acid. These react spontaneously with air to give spectacular but harmless small explosions.

This experiment should take around 5-10 minutes.

Equipment

Apparatus

- Eye protection
- Safety screen
- Pyrex test tube, approximately 150 mm x 17 mm
- Clamp and stand
- Bunsen burner
- Beaker, 250 cm³
- Conical flask, 250 cm³
- Filter funnel and filter paper
- Access to oven
- Desiccator
- Access to top pan balance

Chemicals

- Dry magnesium powder, 1 g
- Dry silver sand, 1 g
- Hydrochloric acid, 2 mol dm⁻³, 50 cm³

Health, safety and technical notes

- Read our standard health and safety guidance here <https://rsc.li/3U9dYzG>
- Always wear eye protection.
- Use a safety screen between the apparatus and the audience.
- Magnesium powder burns vigorously in air. The dust from magnesium powder may be hazardous.
- Ensure that the mixed powders are absolutely dry before the reaction.
- It is the responsibility of the teacher to check the employer's risk assessment.
- Magnesium powder is highly flammable (see CLEAPSS Hazcard [HC059b](#)).
- Hydrochloric acid is an irritant at the concentration used (see CLEAPSS Hazcard [HC047a](#)).

Procedure

Before the demonstration

1. Dry the magnesium powder and the sand for a few hours in an oven at about 100°C.
2. Store them in the desiccator until ready to use them.
3. Ensure that the test-tube is dry.

The demonstration

1. Weigh 1 g of silver sand and 1 g of magnesium powder and mix them thoroughly.
2. Spread the mixture along the bottom of a test tube that is clamped almost horizontally.
3. Place a safety screen between the tube and the audience if the spectators are close.
4. Heat one end of the mixture with a roaring Bunsen flame, holding the burner by hand. After a few seconds, the mixture will start to glow. This glow can be 'chased' along the tube with the flame until all the mixture has reacted. The tube will blacken and partly melt.
5. If the two powders are not dry, some magnesium will react with the steam and the resulting hydrogen will pop.
6. When the reaction is complete, allow the mixture to cool (about five minutes) and with the aid of a spatula pour the products into about 50 cm³ of 2 mol dm⁻³ hydrochloric acid.
7. After a few minutes the pops will cease and grey silicon powder, possibly with a little unreacted sand, will be left on the bottom of the beaker.
8. Pour off the acid, wash the solid a few times with water and filter off the silicon.
9. Pass around the class to show its slightly metallic silver-grey colour. If desired, show that it does not react with alkalis (or acids).

Notes

- Silicon dioxide is a solid with a giant structure, while carbon dioxide is molecular.
- Silanes react spontaneously with air at room temperature, while alkanes are stable.
- These differences can be explained by considering the relevant bond energies and availability of d-orbitals in silicon but not in carbon.
- Bond energies in kJ mol⁻¹: Si=O 638; Si-O 466; C-O 336; C=O 805; Si-H 318; C-H 413.
- The reactions are:
 - $\text{SiO}_2(\text{s}) + 2\text{Mg}(\text{s}) \rightarrow 2\text{MgO}(\text{s}) + \text{Si}(\text{s})$
 - $2\text{Mg}(\text{s}) + \text{Si}(\text{s}) \rightarrow \text{Mg}_2\text{Si}(\text{s})$
 - $\text{MgO}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$
 - $\text{Mg}_2\text{Si}(\text{s}) + 4\text{HCl}(\text{aq}) \rightarrow 2\text{MgCl}_2(\text{aq}) + \text{SiH}_4(\text{g})$
 - Higher silanes such as Si₂H₆ may also be produced
 - $\text{SiH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{SiO}_2(\text{s}) + 2\text{H}_2\text{O}(\text{l})$

Further details

- This original mixture has a small excess of magnesium over the stoichiometric masses (1 g of sand to 0.8 g of magnesium) because some magnesium will inevitably react with air.
- The resulting solid will contain silicon, magnesium oxide (the main products), magnesium silicide formed from the reaction of excess magnesium with silicon, unreacted magnesium and possibly a little unreacted sand.
- The mixture will fizz as excess magnesium reacts with the acid.
- There will also be pops accompanied by small yellow flames.
- These flames are caused by silanes that are formed from the reaction of magnesium silicide with acid.
- Silanes inflame spontaneously in air.
- Magnesium oxide will react with the acid to form a solution of magnesium chloride.