



51. Making silicon and silanes from sand

Topic

The reactions of group IV elements. Comparison of hydrocarbons with silanes, with regard to thermodynamic and kinetic stability.

Timing

5 – 10 min.

Level

Pre-16 or post-16 depending on the level of discussion.

Description

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.

Apparatus

- ▼ One pyrex test-tube, approximately 150 mm x 17 mm.
- ▼ Clamp and stand.
- ▼ Bunsen burner.
- ▼ One 250 cm³ beaker.
- ▼ One 250 cm³ conical flask.
- ▼ Filter funnel and filter paper.
- ▼ Access to oven.
- ▼ Desiccator.
- ▼ Access to top pan balance.
- ▼ Safety screen.

Chemicals

The quantities given are for one demonstration.

- ▼ 1 g of dry **magnesium powder**.
- ▼ 1 g of dry silver sand.
- ▼ About 50 cm³ of approximately 2 mol dm⁻³ **hydrochloric acid**.

Method

Before the demonstration

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



The demonstration

Weigh 1 g of silver sand and 1 g of magnesium powder and mix them thoroughly. This 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. Spread the mixture along the bottom of a test-tube that is clamped almost horizontally. Place a safety screen between the tube and the audience if the spectators are close.

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. If the two powders are not dry, some magnesium will react with the steam and the resulting hydrogen will pop. This can be disconcerting if it is not expected.

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 to dissolve away unreacted magnesium and magnesium oxide. The 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 are caused by silanes that are formed from the reaction of magnesium silicide with acid. Silanes inflame spontaneously in air. Magnesium oxide will dissolve in the acid.

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. Pour off the acid, wash the solid a few times with water and filter off the silicon. It can be passed around the class to show its slightly metallic silver-grey colour. If desired show that it does not react with alkalis (or acids).

Visual tips

Make sure the safety screen is clean if one is used.

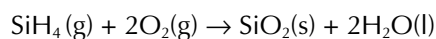
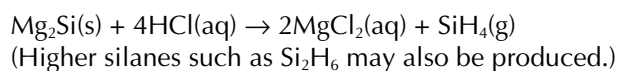
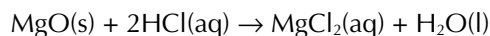
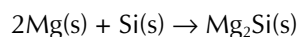
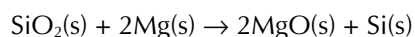
Teaching tips

There are many interesting contrasts to be drawn between silicon compounds and their carbon analogues. 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.

Theory

The reactions are:





Further details

One teacher reported that the 'pops' continued while the silicon dried on the filter paper.

Silicon is extracted from sand industrially by reduction with carbon.

Safety

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 teachers doing this demonstration to carry out an appropriate risk assessment.