# Thermit

Thermit Reaction

## Introduction

Flames, sparks, and molten iron are produced by this spectacular reaction.

## Concepts

- Single replacement reaction
- Oxidation–reduction
- Exothermic reaction
- Activation energy

## Background

Thermit is a generic name given to very high-temperature reactions between a metal oxide and aluminum. The thermit reaction produces a metal (iron in this case), aluminum oxide, and a large amount of heat. An exterior source of very high temperature must be provided to start the reaction. Once the activation temperature is reached, the entire reaction proceeds very quickly and is over in 10 to 20 seconds.

Thermit is a product that has a wide variety of industrial applications. Thermit is most commonly used for fusion welding. Two metal parts are fusion welded by placing them in juxtaposition, inserting thermit between the parts and then igniting the thermit. A common application is to weld railroad track together.

In school science laboratories, thermit is used to demonstrate an exothermic reaction. However, this reaction must be a science teacher demonstration only!

A temperature of almost 1,200 °C is required to start the thermit reaction. A special starting material, a thermit igniting stick, is required. It is possible to use other materials to start the reaction (like glycerin and potassium permanganate); however, thermit igniting sticks are the most effective, safe, and controllable means of igniting the thermit mixture.

## Materials

Thermit black, 10–15 grams

Thermit igniting stick

Face shield

Fire extinguisher, powder, Class D or a bucket of clean, dry sand

Heat protective gloves

Heat-resistant pad, 30 cm × 30 cm

Matches, book or wooden

Safety shield, transparent

Skillet, cast iron, with at least a 9-inch diameter

## *Safety Precautions*

*The thermit reaction produces a temperature of about 2200 °C which will soften steel. This reaction must be performed in a vessel that can handle the temperature. Thermit igniting sticks are highly flammable and potentially explosive. Keep them dry and away from sparks. Wear a face shield, heat-protective gloves, and a chemical-resistant apron. If dark safety glasses or welding glasses are available, they would be a good choice. Place a transparent safety shield between the audience and the reaction vessel. Make sure all flammables and people are at least 10 feet vertically and 15 feet horizontally away from the reaction vessel. Do not use larger quantities of thermit than the amount specified in this procedure. Do this demonstration outdoors. A common variation of this thermit reaction involves placing the thermit in clay flower pots; this is not recommended. The reaction is much better contained in a cast iron pan. The consequences of using clay, porcelain, glass, or any other container instead of cast iron are unpredictable and have resulted in serious accidents. Other methods of igniting the thermit are not recommended. We recommend the thermit igniting sticks since they are more controllable. Once the thermit has ignited, do not handle the reaction mixture until all signs of the reaction have ceased. The molten metal and the pan will still be very hot—handle with care. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.*



Publication No. 811
032417

## Procedure

1. When preparing for and performing this demonstration, make sure all safety regulations are followed. Students should not be allowed to participate. This demonstration should be performed outside and be a science teacher demonstration only.
2. Put a transparent safety shield between the demonstration and the students. Sparks may be thrown 6 feet vertically and 15 feet horizontally; therefore, make sure all flammables and people are at least 10 feet vertically and 15 feet horizontally away from the reaction vessel.
3. Wear heat protective gloves, a chemical-resistant apron, and a face shield. All students should also wear protective eyewear.
4. A supply of clean, dry sand or a bottle of Class D fire extinguishing material should be immediately available.
5. Place a cast iron skillet or similar vessel on a heat-resistant pad (30 cm × 30 cm) behind the transparent safety shield. Remember: Temperatures approaching 2200 °C will be generated. Adequate protection in the form of a very heavy iron vessel is required. Do not perform this demonstration on asphalt, it will melt.
6. Pile up about 10 to 15 g of thermit black in the center of the skillet.
7. Before igniting the thermit igniting stick, again make sure no flammable material or people are within 10 feet vertically and 15 feet horizontally from the reaction vessel.
8. To ignite the thermit igniting stick, use a match or butane lighter. Once lit, the igniting stick will be like a sparkler, shooting sparks out 6–12 inches. Quickly plunge the igniting stick into the thermit mixture. Step back from the reaction. The heat and sparks from the igniting stick will ignite the thermit mixture. The igniting stick will only be active for 20–30 seconds. Never readjust the igniting stick after it's in contact with the thermit. Wait until the igniting stick is extinguished, remove it and start again with a fresh igniting stick.
9. As soon as the thermit is activated, sparks, flames, smoke and molten iron will be observed. The reaction is violent and proceeds quickly.
10. The molten iron produced by the reaction may weld itself to the cast iron skillet. If the iron is not welded to the skillet, then it may be picked up using metal tongs. Do not handle the skillet unless heat protective gloves are worn. Allow the vessel to cool to ambient temperature. Don't handle it unless absolutely necessary.
11. Not all the thermit may react. As the reaction progresses, it may lose temperature and some thermit may not react. This material can be reused.

## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. After cooling, the aluminum oxide and iron produced may be disposed of in the trash according to Flinn Suggested Disposal Method #26a.

## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

***Unifying Concepts and Processes: Grades K–12***
Evidence, models, and explanation

***Content Standards: Grades 9–12***
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

## Tips

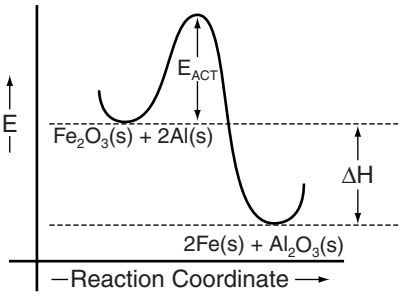
- The thermit black must be dry in order to work properly. The slightest bit of moisture may be enough to prevent it from igniting. If a supply of this material is required in the future, store it in a Flinn Chem-Saf® can with a dessicant like Drierite (Flinn Catalog No. D0011).
- As is always good practice, try this demonstration first with the aid of another science teacher before doing it in front of a class. Do this demonstration outdoors.
- The thermit igniting sticks are not easy to light—this is a safety feature. To light, keep a flame on the very tip for 10–20 seconds or until it ignites.
- Place the ignition stick under the thermit mixture. This will ensure the greatest degree of complete reaction.
- The reaction may generate enough heat to crack or burn a hole in the cast iron pan. Use an old cast iron pan.

## Discussion

Thermit black is a mixture of ferric oxide ($Fe_2O_3$) and very fine aluminum powder (Al). When the thermit black is ignited, aluminum oxide ($Al_2O_3$), elemental iron (Fe), and a large amount of heat are produced. The reaction is a highly exothermic, single replacement reaction (exothermic = heat producing). Aluminum is oxidized and iron is reduced. The melting point of iron is 1530 °C and the reaction temperature reaches approximately 2200 °C. ($\Delta H° = -849$ kJ/mole)

$$Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(s) + \text{heat}$$

The thermit igniting stick is needed to provide the high ignition temperature for thermit black. This represents the large activation energy ($E_{ACT}$) needed to start the reaction. Once this activation energy is reached, the reaction proceeds very rapidly to the products generating heat ($\Delta H$).




## Acknowledgment

Shakhashiri, B. Z. *Chemical Demonstrations: A Handbook for Teachers in Chemistry;* University of Wisconsin: Madison, 1983; Vol. 1, p 85.

## Materials for *Thermit* are available from Flinn Scientific, Inc.

| Catalog No. | Description |
|---|---|
| T0007 | Thermit Black, 500 g |
| T0086 | Thermit Igniting Sticks, pkg. of 10 |
| SE261 | Safety Shield, 36″ × 24″ |
| AP3240 | Gloves, Zetex™, 119 length |
| SE2265 | Full Face Shield |
| SE3004 | Fire Extinguisher, Powder, Class D |

Consult the Flinn Scientific website for current prices.