

## Oxidation-Reduction Demonstrations

The oxidation of glycerol by potassium permanganate:  
(care of: [http://sci\\_wiz.tripod.com/Spontaneous\\_Combustion.htm](http://sci_wiz.tripod.com/Spontaneous_Combustion.htm))

**Purpose -** Cool and quick oxidation reaction. Also shows an extreme exothermic reaction.

**Nature -** Demonstration

**Materials -** Potassium permanganate  $\text{KMnO}_4$ , Glycerol  $\text{C}_3\text{H}_5(\text{OH})_3$ , Heat proof tile, Mortar and Pestle, Spatula



**Method -**

1. Grind up approximately 20 gm of Potassium permanganate using the mortar and pestle.
2. Pile this on the heat proof mat and use the stirring rod to make a small volcano shape.
3. Fill the crater of the volcano with glycerol and stand back.
4. It takes a few moments for the reaction to occur, but when it does you'll be impressed.

**Safety -** A great deal of heat is produced so be aware of the potential for burns. The fumes given off are best avoided, so doing this outside or in the fume cupboard is a good idea.

**Explanation -** There is an exothermic reaction that takes place between the potassium permanganate and the glycerol as summarized below -



### The Blue-Bottle Demonstration

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Nearly every demonstration of "chemical magic" involves the classic Blue Bottle. This demonstration has been reported in numerous places including Alyea and Dulton (1) and Summerlin and Ealy (2) and involves the alkaline glucose reduction of methylene blue. Even though this is a very simple demonstration it fascinates audiences, especially those of middle-school age and younger.

We have found other indicators that may be added to the classic Blue Bottle to produce a rainbow of colors. Some of these indicators are listed in Table 1.1

Indicator(s)	Oxidized	Reduced
o-Cresolsulfonphthalein <sup>a</sup>	blue purple	violet
Phenolphthalein <sup>b</sup>	blue purple	red to pink
Methyl red	blue green	yellow
Methylene blue	blue	colorless
Titan yellow <sup>c</sup>	blue drab	green green
Azo violet	blue purple	light violet
Phenol red	blue purple	red

**a** Also known as o-cresolphthalein or cresol red.

**b** Phenolphthalein also undergoes a reduction under these conditions, but at a much slower rate. The phenolphthalein/methylene blue starts out intensely red; with each cycle it becomes lighter until it is pale pink in the reduced form.

**c** Also known as Clayton yellow.

### 19.1 The Blue Bottle Demonstration

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**Chemical Concept Demonstrated: Reversible oxidation-reduction reactions**

**Demonstration:**

KOH is dissolved in water. Dextrose (glucose) is dissolved in this solution and methylene blue is added.

**Observations:**

When the indicator is initially added to the solution, the solution turns blue. The color gradually fades and becomes colorless. The color reappears when the flask is vigorously shaken. The color then begins to fade again.

**Explanations (including important chemical equations):**

The color change results from the reversible oxidation-reduction reaction of the methylene blue indicator. In alkaline solutions, glucose is oxidized to D-gluconic acid or alpha-D-gluconolactone



In the course of this reaction, methylene blue is reduced from the blue (oxidized) form to the colorless (reduced) form.

Shaking the flask dissolves O<sub>2</sub> in the solution, which oxidizes the indicator back to the blue (oxidized) form.

## Materials

Seven 250-mL Florence (or Erlenmeyer) flasks with tight-fitting stoppers

Indicators 2

800 mL of 0.7 M potassium hydroxide solution

30 g of dextrose (glucose)

5% sodium hydroxide solution

Procedure

Prepare 800 mL of 0.7 M potassium hydroxide solution. To this add one or more crystals of methylene blue to just obtain a royal blue colored solution.<sup>3</sup> Do not add too much!

**Caution:** Potassium hydroxide solutions are very corrosive and can lead to severe burns if spilled upon the skin.

To one flask add about 200 mL of the potassium hydroxide-methylene blue solution. To each of the remaining 6 flasks add about 100 mL of water and 3-5 drops of 5% sodium hydroxide solution. Then to each of the 6 flasks add the chosen indicator until the solution is the color desired for the reduced solution<sup>3</sup> (again, do not add too much).

Add 5 g of glucose to each of the 7 flasks, and 120 mL of the methylene blue/potassium hydroxide solution to the 6 flasks with the additional indicator. Stopper the flasks and allow to stand. The color of the oxidized solution will slowly change to that of the reduced solution (the color of the indicator in base).

The color of the oxidized solution can be regenerated by giving the flask a few vigorous shakes. (The stopper will need to be removed periodically to allow a fresh supply of oxygen into the flask.)

We have found this to be an effective addition to our presentations of "chemical magic" that the department gives annually to 5th and 6th grade students in the area.

## Notes

1. See page 361 for color pictures of the oxidized and reduced forms of the first six methylene blue-indicators listed in Table 1.
2. All of the indicators used here can be obtained from Aldrich Chemical Company, Inc.
3. For the methylene blue solution, the intense royal blue color requires 10 mg of the indicator; for the other solutions about 1 mg is required. It is important that none of the solutions be so intense as to mask the other.