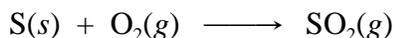


# Chemical of the Week

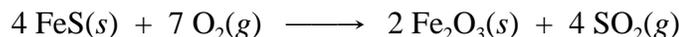
## SULFURIC ACID, $\text{H}_2\text{SO}_4$

Sulfuric acid is the product of the U.S. chemical industry produced in largest quantity in terms of mass. About 40 million tons are produced annually. There are two major processes used in the production of  $\text{H}_2\text{SO}_4$ , the lead chamber process and the contact process. The lead-chamber process is the older of the two processes, and its product is aqueous sulfuric acid containing 62% to 78%  $\text{H}_2\text{SO}_4$ . The contact process yields pure sulfuric acid. In both processes, sulfur dioxide,  $\text{SO}_2$ , is oxidized to sulfur trioxide,  $\text{SO}_3$ , and the  $\text{SO}_3$  is dissolved in water.

Sulfur dioxide is obtained by burning sulfur,



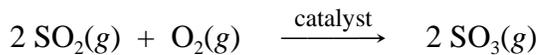
by roasting pyrite (iron sulfide) or other metal sulfides prior to smelting,



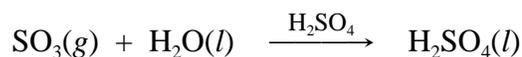
or by burning hydrogen sulfide,



The sulfur dioxide is oxidized to sulfur trioxide catalytically.



Without the catalyst, the oxidation of  $\text{SO}_2$  is quite slow. In the old lead-chamber process, the catalyst is nitrogen dioxide gas. In the contact process, the catalyst is vanadium(V) oxide,  $\text{V}_2\text{O}_5$ , mixed with an alkali metal sulfate. The mixture is supported on small silica beads, and at the high temperature inside the reactor, the mixture is a liquid. The product  $\text{SO}_3$  is dissolved in 98% sulfuric acid. The dissolved  $\text{SO}_3$  reacts with the 2% water, forming  $\text{H}_2\text{SO}_4$ .



Pure sulfuric acid is a colorless, odorless, oily liquid. It freezes at  $10.5^\circ\text{C}$ . It fumes when heated, because some of the  $\text{H}_2\text{SO}_4$  decomposes to  $\text{H}_2\text{O}$  and  $\text{SO}_3$ . The  $\text{H}_2\text{O}$  is retained in the liquid, while  $\text{SO}_3$  gas is released. Therefore, the concentration of  $\text{H}_2\text{SO}_4$  decreases, reaching a concentration of 98.33%. This solution boils at  $338^\circ\text{C}$  and is the material sold as "concentrated sulfuric acid." Concentrated sulfuric acid, which is 18M, has a strong affinity for water and is sometimes used as a drying agent. It can be used to chemically remove water from many compounds. It dehydrates sucrose (table sugar),  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ , leaving a spongy black mass of carbon and diluted sulfuric acid. Concentrated sulfuric acid reacts similarly with skin, paper, and other animal and plant matter. When it is mixed with water, a highly exothermic reaction occurs, and the energy released can be enough to heat the mixture to boiling. Therefore, concentrated sulfuric acid must be diluted by adding the acid slowly to cold water while the mixture is stirred to dissipate the heat.

Sulfuric acid has a wide range of uses and plays a part in the production of nearly all manufactured goods. About 65% of the  $\text{H}_2\text{SO}_4$  produced annually is used in the production of agricultural fertilizers.

## TOP 20 CHEMICALS

This list includes the most recent figures for the United States chemical industry. These figures are obtained from government, trade associations reports, and industry estimates. The list includes chemically homogeneous finished products. It does not include minerals which do not require processing, such as salt and sulfur, and petrochemical feedstocks, such as ethane and butane, which are considered products of oil companies.

RANK (by mass)	CHEMICAL	2006 PRODUCTION (in 10 <sup>9</sup> kg)	FORMULA	PRODUCTION (in moles)	RANK (by moles)
1	Sulfuric acid	35.9			
2	Ethylene	25.0			
3	Polyethylene	17.3			
4	Propylene	15.6			
5	Phosphoric acid	10.7			
6	Ammonia	10.4			
7	Chlorine	10.2			
8	Ethylene dichloride	9.7			
9	Polypropylene	8.3			
10	Sodium hydroxide	8.0			
11	Benzene	7.6			
12	Polyvinyl chloride	6.8			
13	Nitric acid	6.6			
14	Ammonium nitrate	6.3			
15	Urea	5.4			
16	Ethyl benzene	5.3			
17	Styrene	4.8			
18	Hydrogen chloride	4.1			
19	Cumene	3.6			
20	Ethylene oxide	3.4			

Compiled from *Chemical and Engineering News*, July 2, 2007.

**EXERCISE:** For the first ten chemicals in the table, with the exception of the polymers: polyethylene and polypropylene, write the formula of the substance in the fourth column. (Look up in the textbook the formulas you don't know. Ethylene dichloride is the trade name for 1,2-dichloroethane.) Then, calculate the number of moles of each, and record these amounts in the fifth column. Then, rank these chemicals in order of moles produced, writing this rank in the last column.