

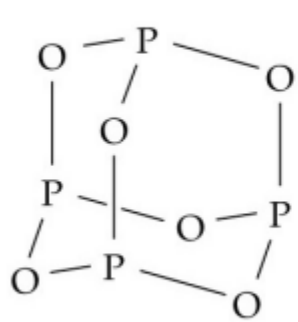
TABLE 19.5

Properties of the Group 5A Elements

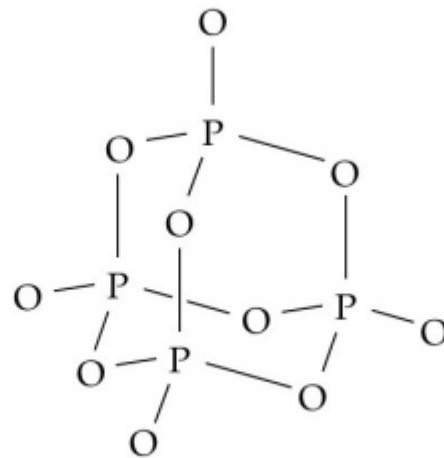
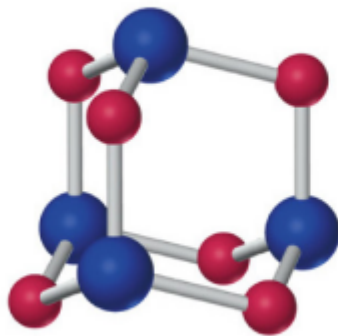
Property	Nitrogen	Phosphorus	Arsenic	Antimony	Bismuth
Valence electron configuration	$2s^2 2p^3$	$3s^2 3p^3$	$4s^2 4p^3$	$5s^2 5p^3$	$6s^2 6p^3$
Melting point (°C)	−210	44 [*]	614 [†]	631	271
Boiling point (°C)	−196	280		1587	1564
Atomic radius (pm)	75	110	120	140	150
First ionization energy (kJ/mol)	1402	1012	947	834	703
Electronegativity	3.0	2.1	2.0	1.9	1.9

^{*}White phosphorus[†]Sublimes

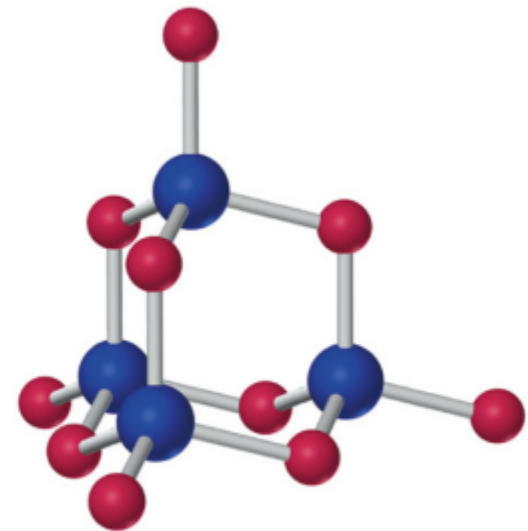
Oxide des Phosphors: Bau von P_4O_6 und P_4O_{10}



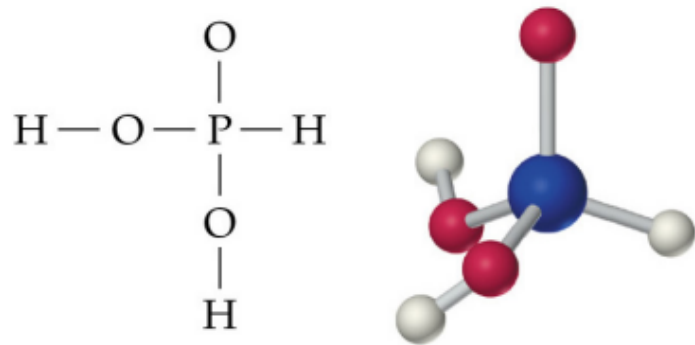
P_4O_6



P_4O_{10}



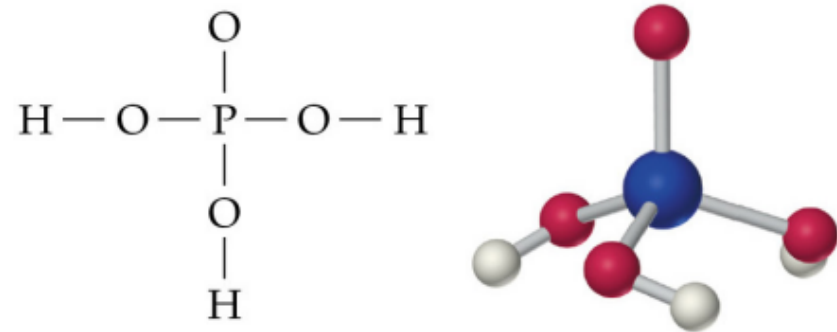
Struktur und Säurekonstanten ($\text{p}K_a = -\lg(K_a)$) von
phosphoriger Säure (rechts) und Phosphorsäure (links)



Phosphorous acid, H_3PO_3

$$K_{a1} = 1.0 \times 10^{-2}$$

$$K_{a2} = 2.6 \times 10^{-7}$$



Phosphoric acid, H_3PO_4

$$K_{a1} = 7.5 \times 10^{-3}$$

$$K_{a2} = 6.2 \times 10^{-8}$$

$$K_{a3} = 4.8 \times 10^{-13}$$

Kondensation von 2 Molekülen Phosphorsäure zu Diphosphorsäure

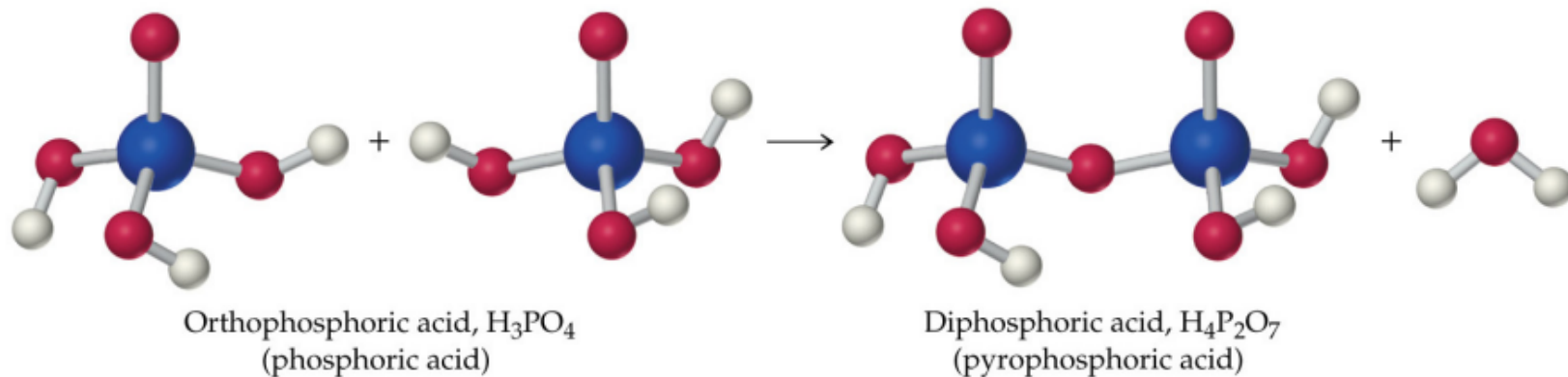
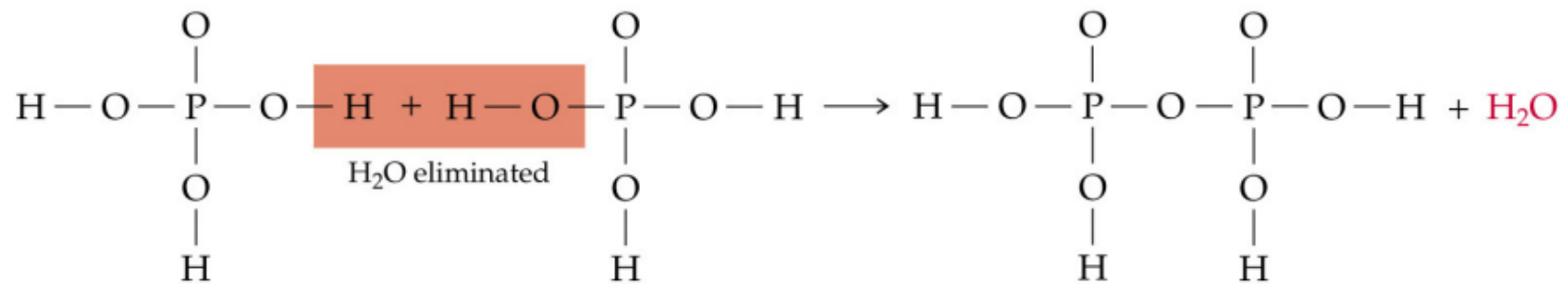


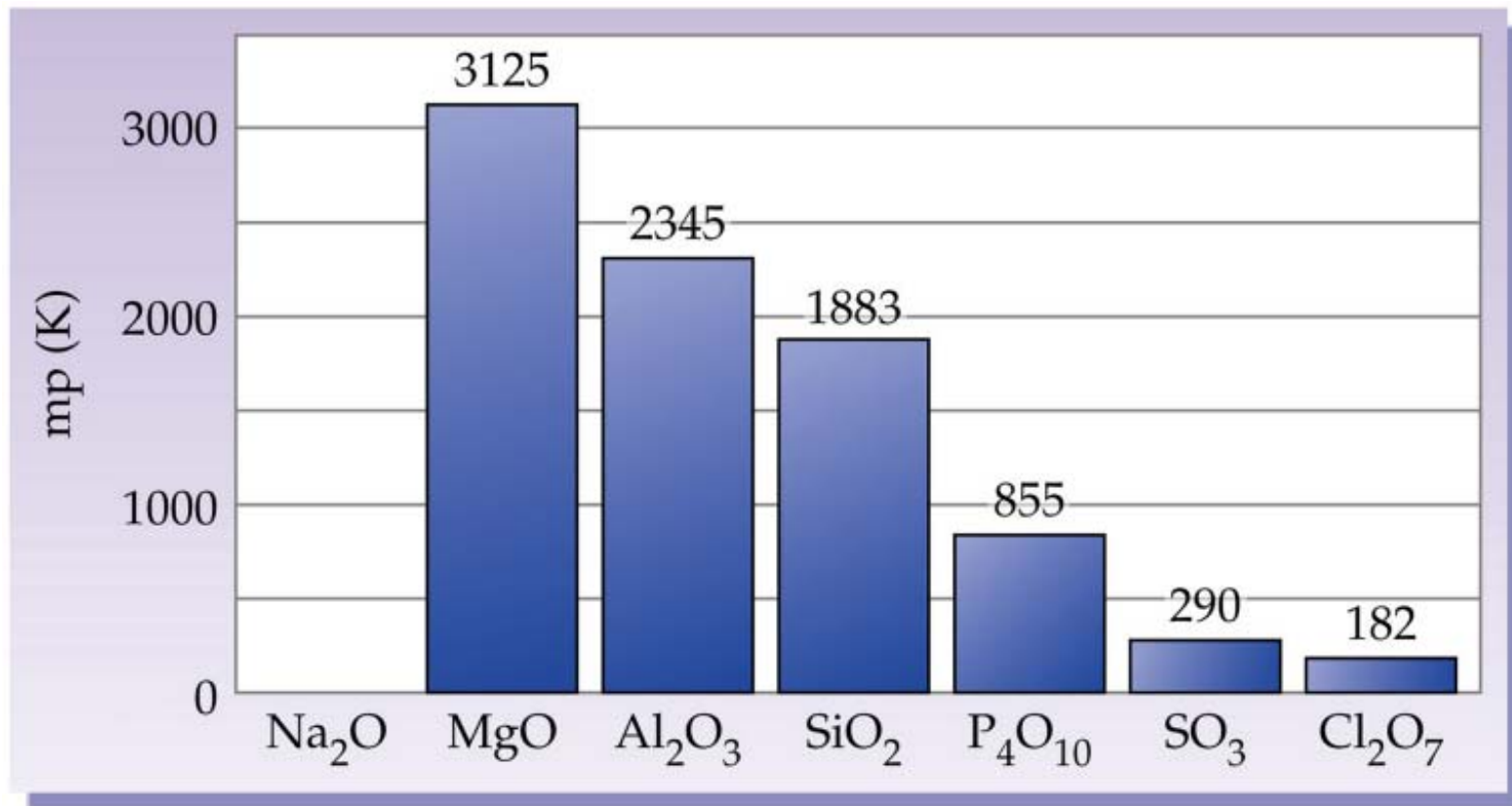
TABLE 19.7

Properties of the Group 6A Elements

Property	Oxygen	Sulfur	Selenium	Tellurium	Polonium
Valence electron configuration	$2s^2 2p^4$	$3s^2 3p^4$	$4s^2 4p^4$	$5s^2 5p^4$	$6s^2 6p^4$
Melting point (°C)	−219	113 [*]	221 [†]	450	254
Boiling point (°C)	−183	445	685	988	962
Atomic radius (pm)	66	104	116	143	167
X ^{2−} ionic radius (pm)	132	184	191	211	
First ionization energy (kJ/mol)	1314	1000	941	869	812
Electron affinity (kJ/mol)	−141	−200	−195	−190	−183
Electronegativity	3.5	2.5	2.4	2.1	2.0
Redox potential, $E^\circ(\text{V})$ for $\text{X} + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2\text{X}$	1.23	0.14	−0.40	−0.79	—

^{*}Rhombic S[†]Gray Se

Oxide der Hauptgruppenelemente (jeweils höchste Oxidationszahl)
(abnehmende Schmelzpunkte durch Zunahme des kovalenten Charakters der Bindung)



Eigenschaften der Oxide der Hauptgruppenelemente

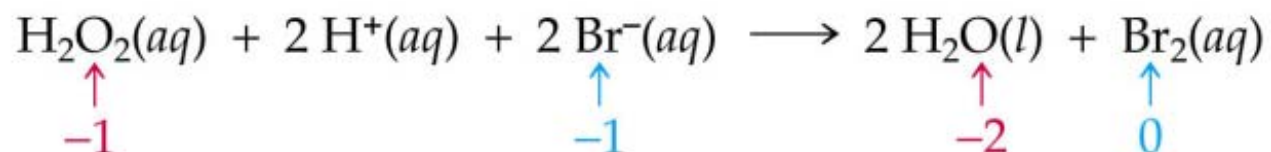
→ Increasing acidic character
→ Increasing covalent character

	1 1A															18 8A
		2 2A				13 3A	14 4A	15 5A	16 6A	17 7A						
	Li ₂ O	BeO				B ₂ O ₃	CO ₂	N ₂ O ₅								
	Na ₂ O	MgO				Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₃	Cl ₂ O ₇						
	K ₂ O	CaO				Ga ₂ O ₃	GeO ₂	As ₂ O ₅	SeO ₃	Br ₂ O ₅						
	Rb ₂ O	SrO				In ₂ O ₃	SnO ₂	Sb ₂ O ₅	TeO ₃	I ₂ O ₅						
	Cs ₂ O	BaO				Tl ₂ O ₃	PbO ₂	Bi ₂ O ₅								

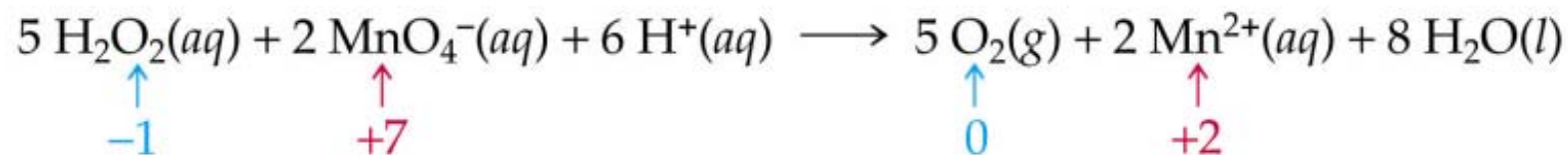
Increasing basic character
 Increasing ionic character

Reaktionen von Wasserstoffperoxid

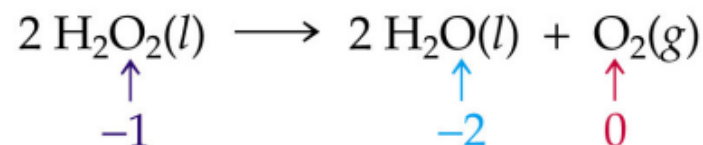
Oxidationsmittel



Reduktionsmittel



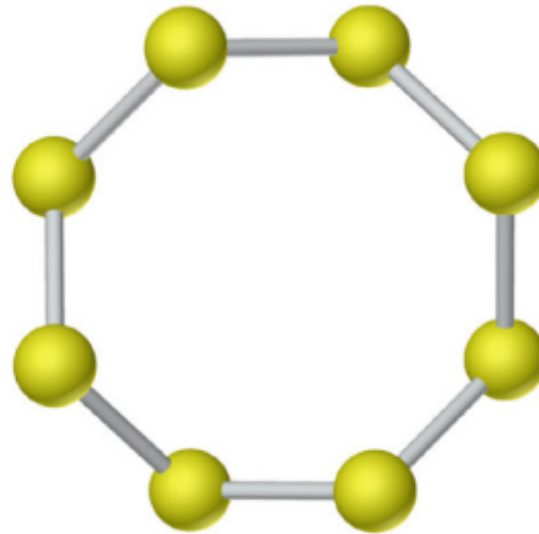
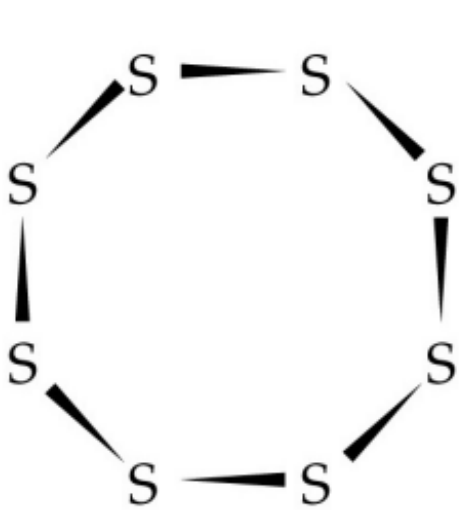
Disproportionierung des Sauerstoffs



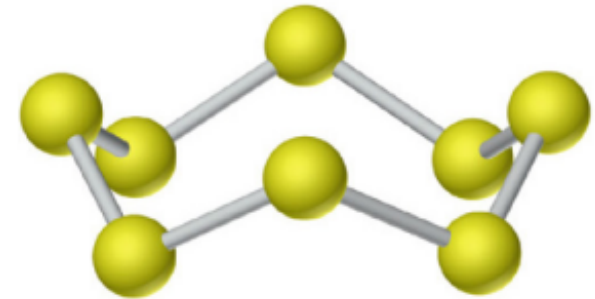
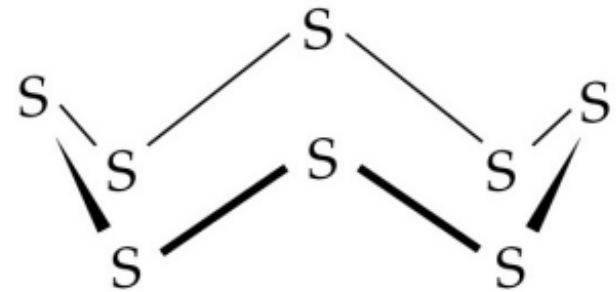
Struktur des kristallinen Schwefels (S_8 -Moleküle)

α -Schwefel: rhombische Kristalle

β -Schwefel: monokline Kristalle



Top view

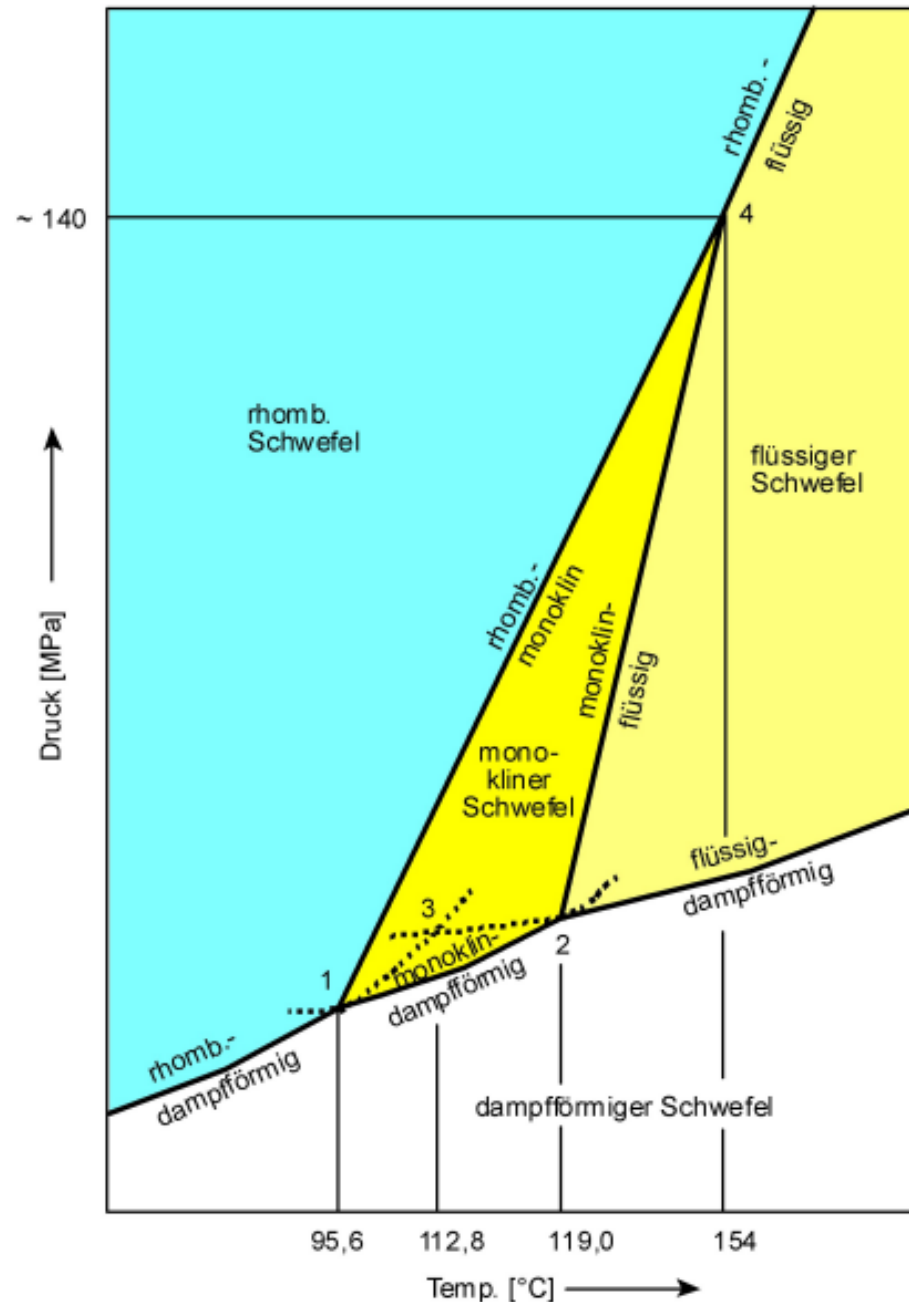


Side view

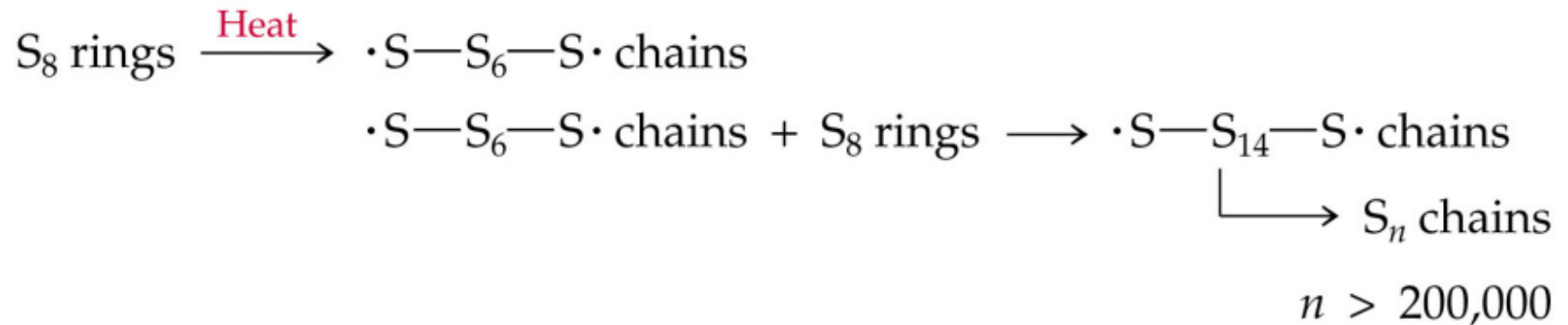
Stark vereinfachtes
Zustandsdiagramm des Schwefels.

In ihm entsprechen die einzelnen Felder den Existenzbereichen der 4 wichtigsten Zustandsformen.

Längs der Begrenzungs-
linien stehen je 2, und an den
Punkten 1, 2, 3 und 4 (an den
Tripelpunkten) je 3 Phasen
des Schwefels miteinander
im Gleichgewicht.

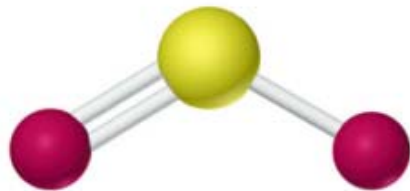


Verhalten des Schwefels beim Erhitzen (in flüssiger Phase)

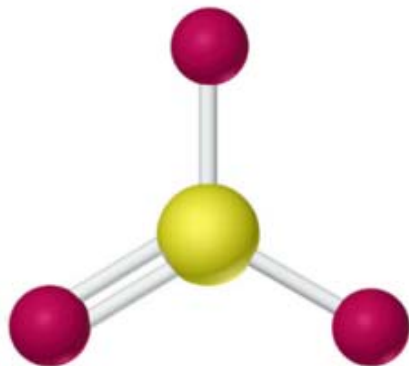
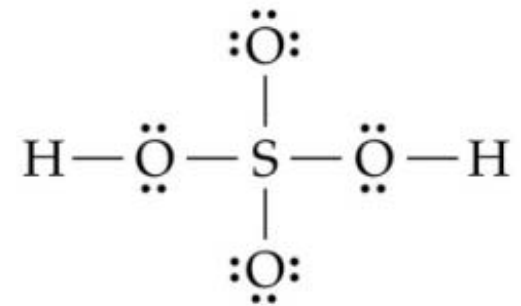


ab 150 °C: Zunahme der S_n-Ketten (Viskositätsmaximum bei 187 °C,
Verfärbung nach rotbraun, dann wieder fallende Viskosität)

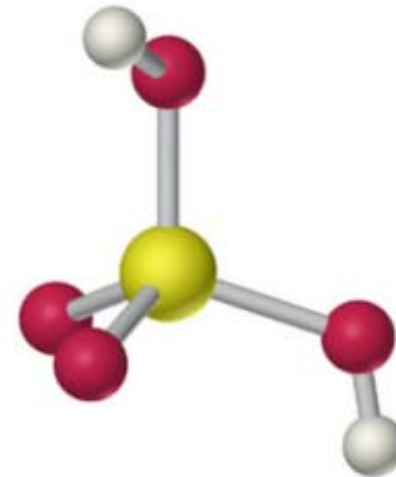
Struktur der Schwefeloxide und der Schwefelsäure



Sulfur dioxide



Sulfur trioxide



Sulfuric acid

Die 10 wichtigsten Industriechemikalien

beachte: Schwefelsäure ist die wichtigste!

TABLE 19.1

The Top 10 Chemicals (2001 U.S. Production)

Chemical	Millions of Tons	Principal Uses
Sulfuric acid (H_2SO_4)	40.1	Fertilizers, chemicals, oil refining
Nitrogen (N_2)	35.5	Inert atmospheres, low temperatures
Oxygen (O_2)	26.0	Steelmaking, welding, medical uses
Ethylene ($\text{CH}_2=\text{CH}_2$)	24.8	Plastics, antifreeze
Lime (CaO)	20.6	Steelmaking, chemicals, water treatment
Propylene ($\text{CH}_3\text{CH}=\text{CH}_2$)	14.5	Plastics, fibers, solvents
Ammonia (NH_3)	13.0	Fertilizers, nitric acid
Chlorine (Cl_2)	12.0	Chemicals, plastics, water treatment
Phosphoric acid (H_3PO_4)	11.6	Fertilizers, detergents
Sodium hydroxide (NaOH)	10.7	Chemicals, textiles, soaps

Verwendung von Schwefelsäure

