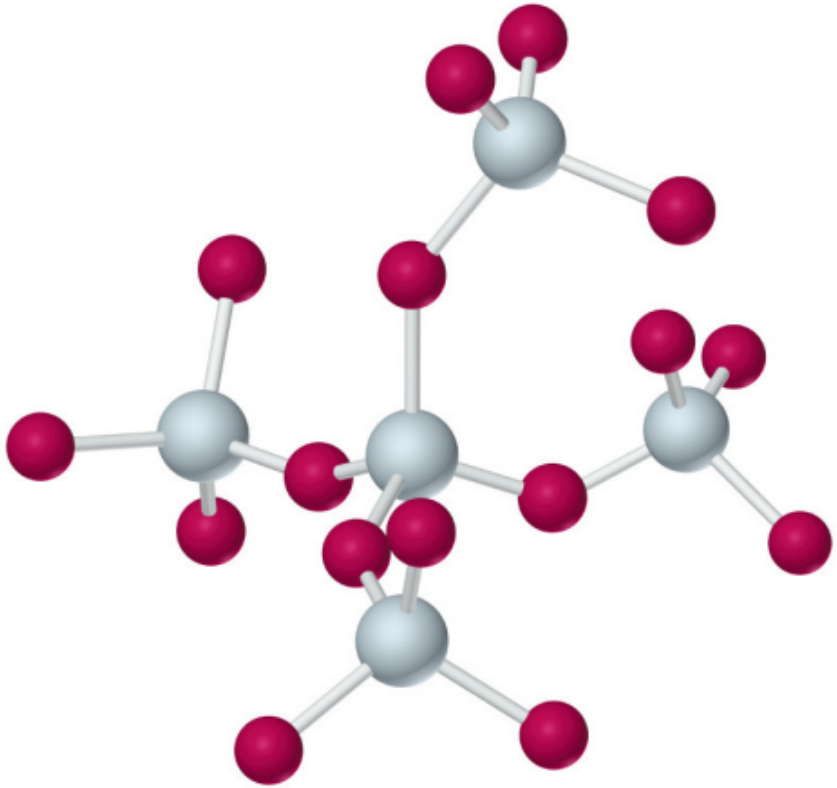
TABLE 19.4 Properties of the Group 4A Elements

Property	Carbon	Silicon	Germanium	Tin	Lead
Valence electron configuration	$2s^2\,2p^2$	$3s^2\,3p^2$	$4s^2\,4p^2$	$5s^2\,5p^2$	$6s^2\,6p^2$
Melting point (°C)	>3550*	1414	938	232†	327
Boiling point (°C)		3265	2833	2602	1749
Density (g/cm^3)	3.51*	2.33	5.32	7.26†	11.3
Abundance in Earth's crust (mass %)	0.020	28.2	0.0005	0.0002	0.0013
Common oxidation states	+2, +4	+4	+4	+2, +4	+2, +4
Atomic radius (pm)	77	117	122	140	175
First ionization energy (kJ/mol)	1086	786	762	709	716
Electronegativity	2.5	1.8	1.8	1.8	1.9
Redox potential, E° (V) for $M^{2+}(aq) + 2\,e^- \rightarrow M(s)$				−0.14	−0.13

*Diamond
†White Sn

Carbon dioxide



A portion of the structure of SiO_2

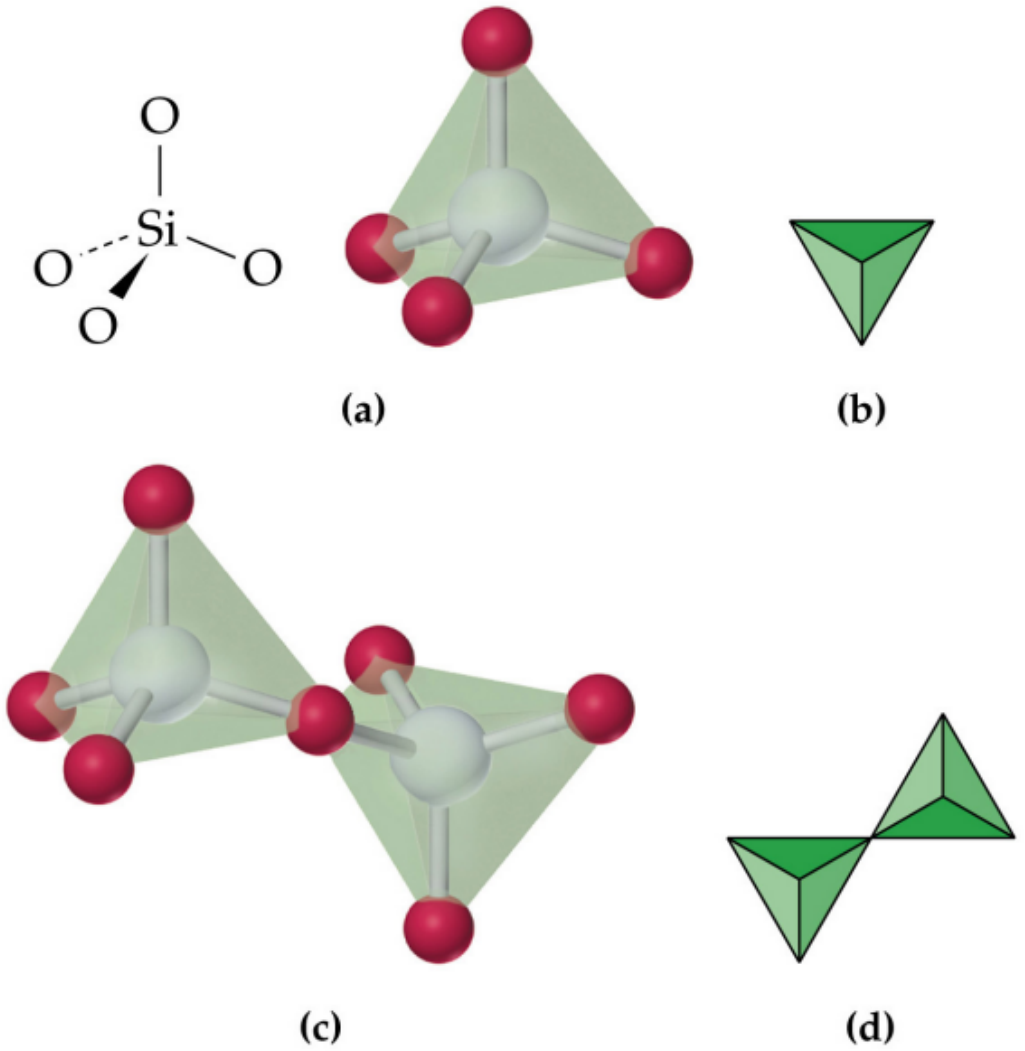
Vergleich des Baus von

Kohlendioxid

Siliciumdioxid

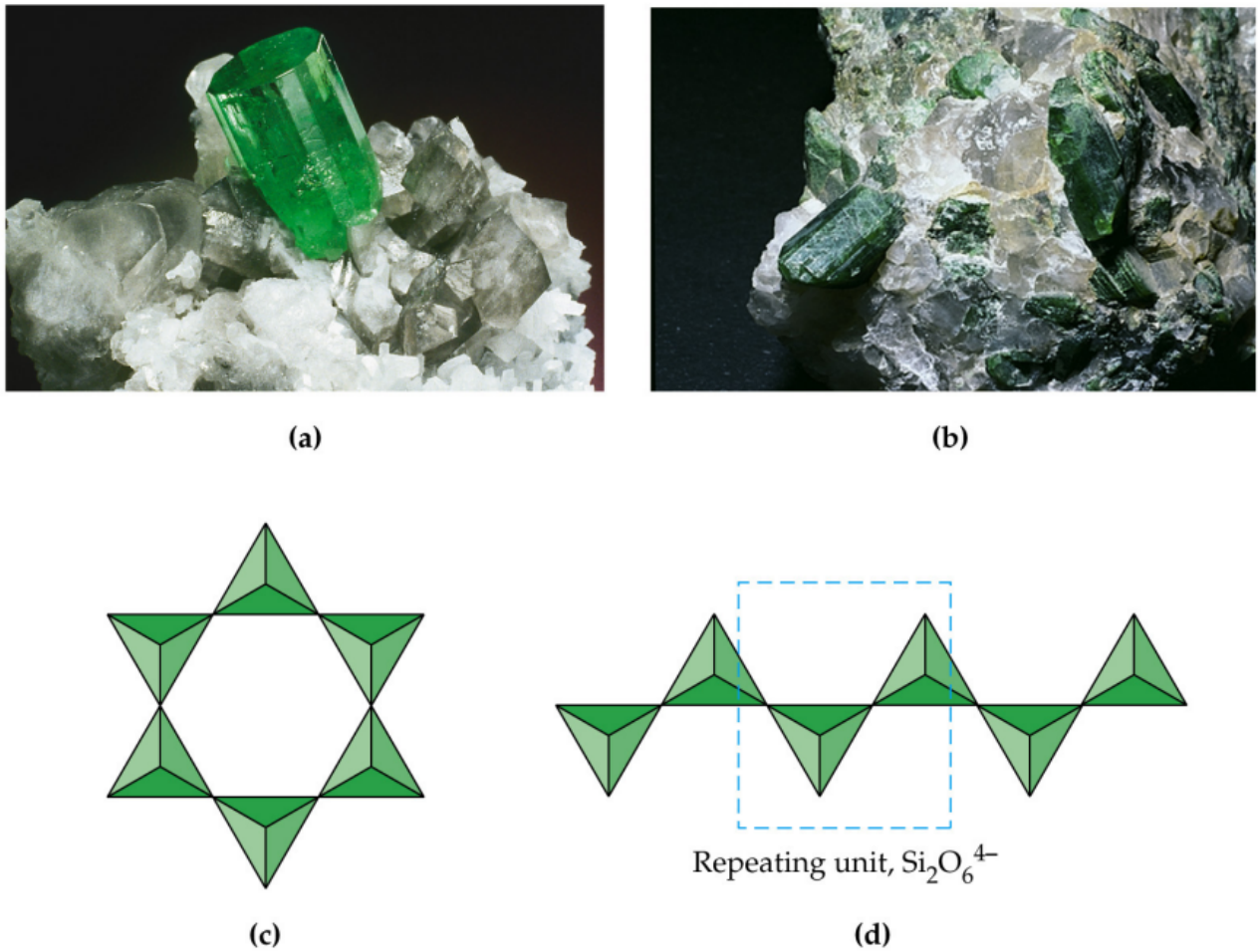
Silicate: oben: Inselsilicat (a,b), Beispiel „Zirkon“ = $ZrSiO_4$

unten: Gruppensilicat (c,d)



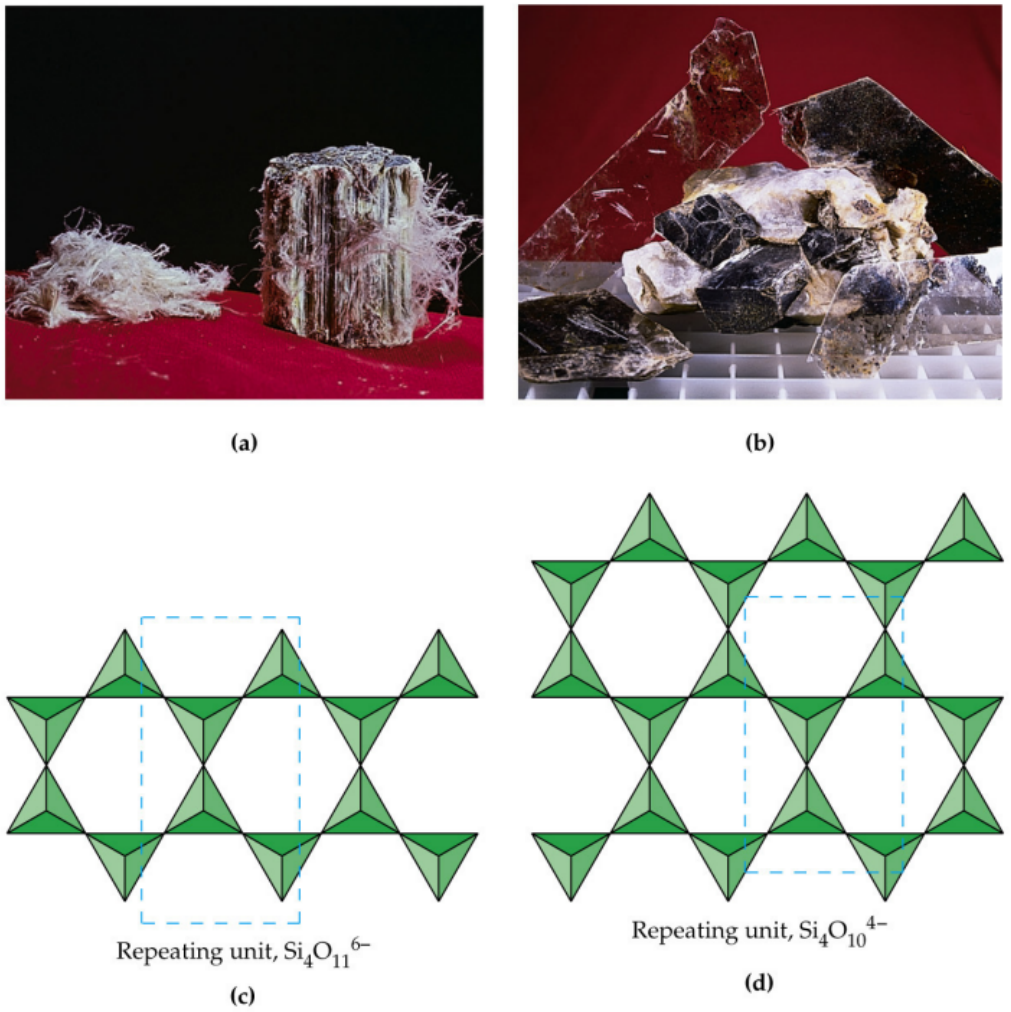
Silicate: links: Ringsilicat (a,c), Beispiel „Beryll“ = $Be_3Al_2Si_6O_{18}$

rechts: Kettensilicat (b,d)



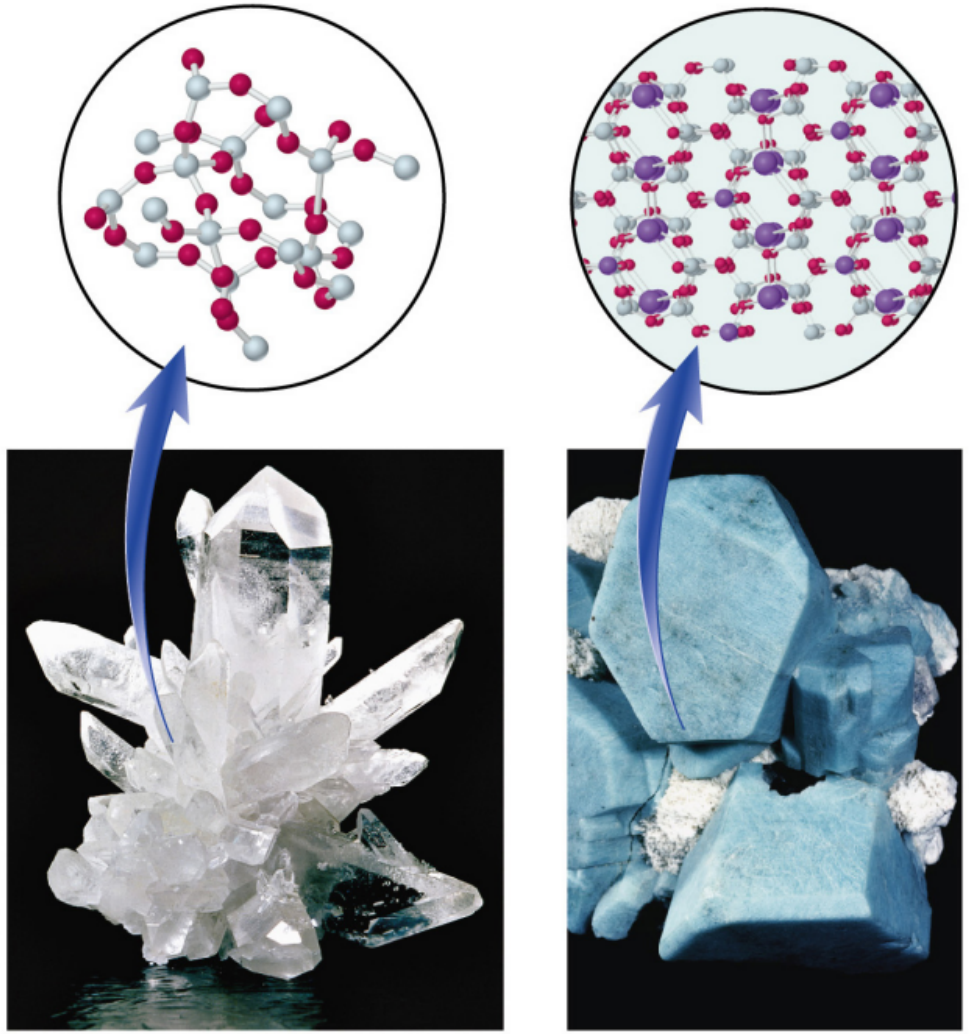
Silicate: links: Bandsilicat (a,c), Beispiel „Asbest“

rechts: Schichtsilicat (b,d), Beispiel: „Glimmer“



Silicate: links: SiO_2 (Quarz)

rechts: Gerüstsilicat - Ersatz Si durch Al (Feldspat)



(a) (b)

Silicat - Typen

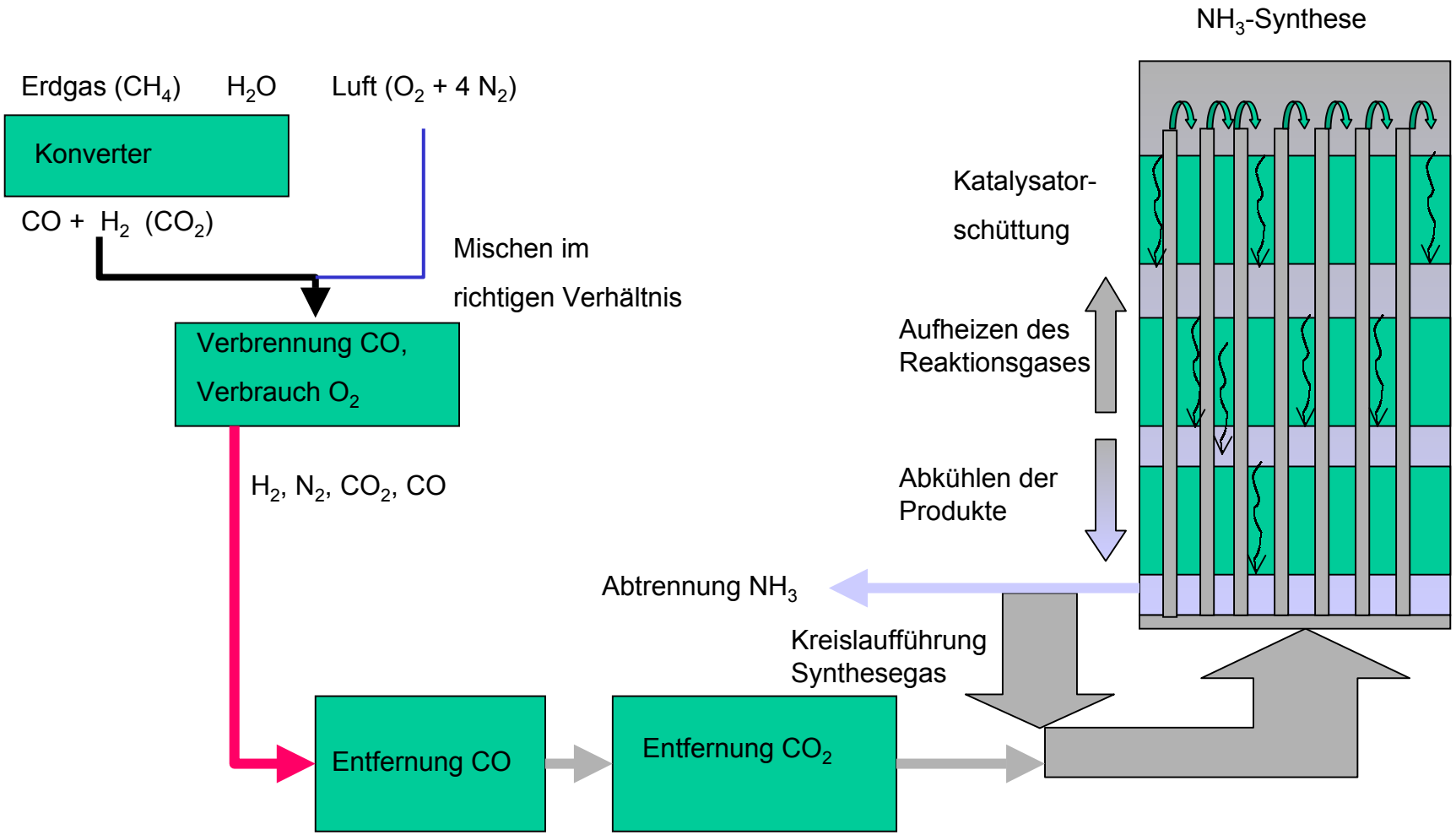
Typ	Formel (Anion)	Beispiele für Mineralien
Inselsilicate	$(SiO_4)^{4-}$	Olivin: $(Mg, Fe)_2[SiO_4]$, Granat: $Mg_3Al_2[SiO_4]_3$; Zirkon: $Zr[SiO_4]$
Gruppensilicate	$(Si_2O_7)^{6-}$	Thortveitit: $Sc_2[Si_2O_7]$
Ringsilicate	$(Si_3O_9)^{6-}$	α-Wollastonit: $Ca_3[Si_3O_9]$
	$(Si_6O_{18})^{12-}$	Beryll: $Be_3Al_2[Si_6O_{18}]$
Kettensilicate	$(SiO_3)_n^{2-}$	Pyroxene, z.B. Enstatit: $Mg[SiO_3]$
Bandsilicate	$(Si_4O_{11})_n^{6-}$	Amphibol-Asbeste, z.B. Tremolit: $Mg_5Ca_2(OH)_2(Si_4O_{11})_2$
Schichtsilicate	$(Si_2O_5)_n^{2-}$	Kaolinit: $Al_2(OH)_4[Si_2O_5]$; Talk: $Mg_3(OH)_2[Si_2O_5]_2$
	$(AlSi_3O_{10})_n^{5-}$	Glimmer, z.B. Muskovit: $KAl_2(OH)_2[AlSi_3O_{10}]$
Gerüstsilicate	$(AlSi_3O_8)_n^{-}$	Feldspäte, z.B. Orthoklas: $K[AlSi_3O_8]$
	$(AlSiO_4)_n^{-}$	Feldspäte, z.B. Anorthit: $Ca[AlSiO_4]_2$
	$(AlSi_2O_6)_n^{-}$	Zeolithe, z.B. Chabasit: $Na_{2-2x}Ca_x[AlSi_2O_5]_2 \cdot 6H_2O$

TABLE 19.5 Properties of the Group 5A Elements

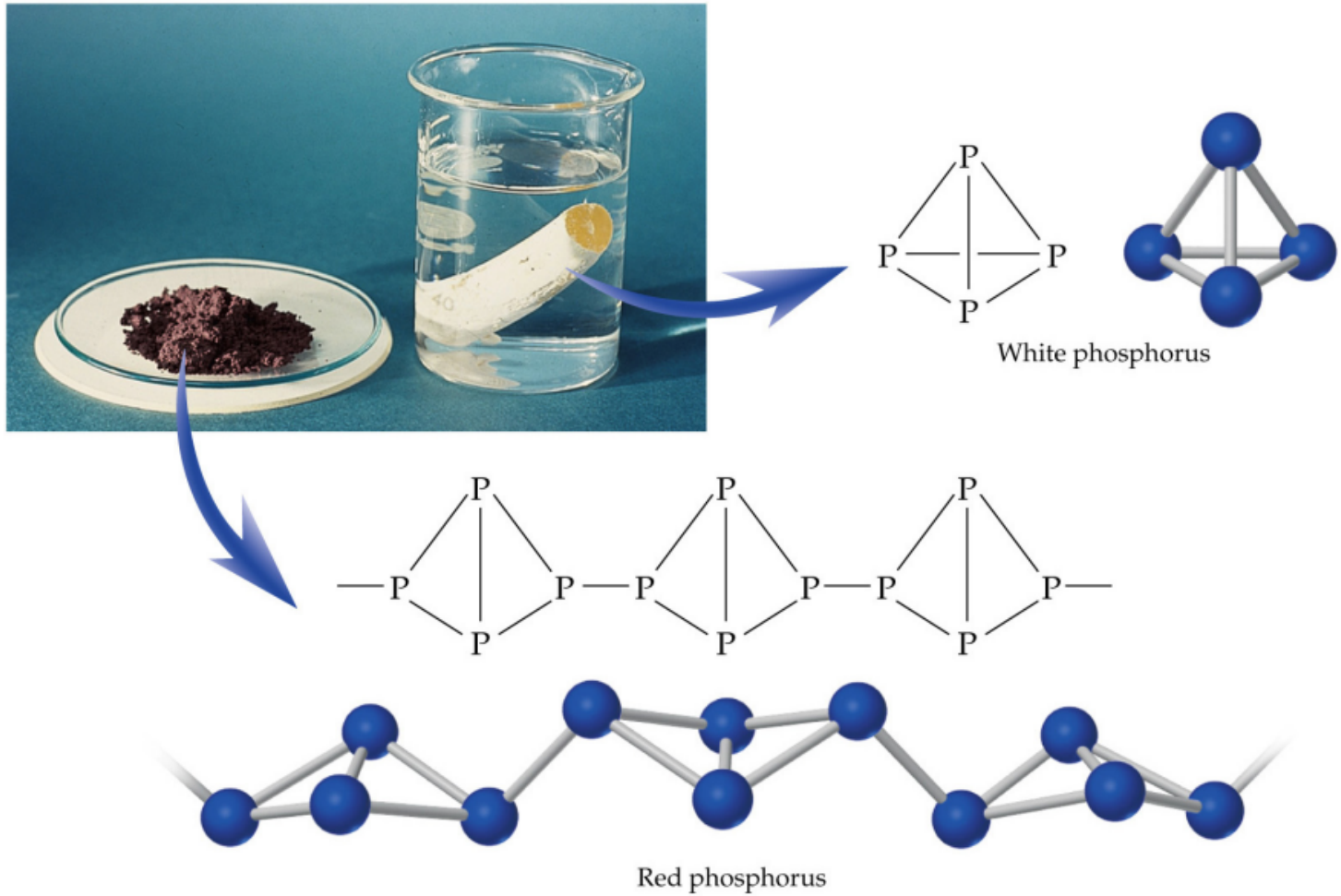
Property	Nitrogen	Phosphorus	Arsenic	Antimony	Bismuth
Valence electron configuration	$2s^2\,2p^3$	$3s^2\,3p^3$	$4s^2\,4p^3$	$5s^2\,5p^3$	$6s^2\,6p^3$
Melting point (°C)	−210	44*	614†	631	271
Boiling point (°C)	−196	280		1587	1564
Atomic radius (pm)	75	110	120	140	150
First ionization energy (kJ/mol)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

*White phosphorus
†Sublimes

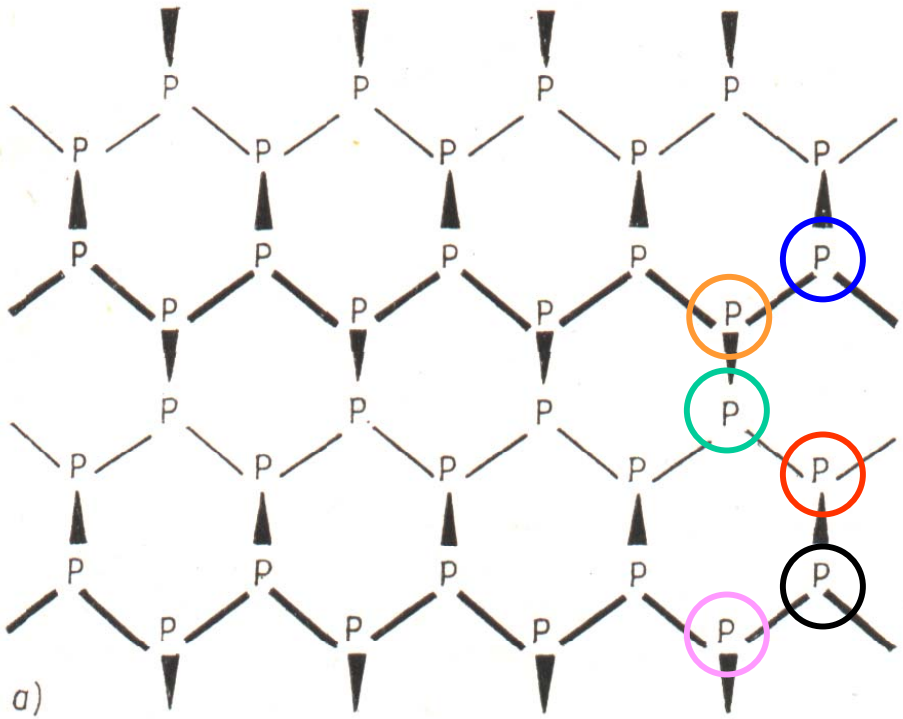
Ammoniak-Synthese nach Haber-Bosch aus Erdgas, Luft, Wasser



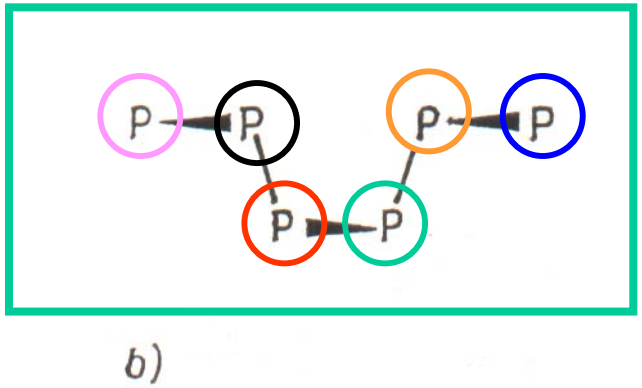
Allotrope des Phosphors: weißer und roter Phosphor



Schwarzer Phosphor

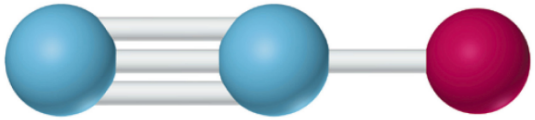


Schicht von oben gesehen



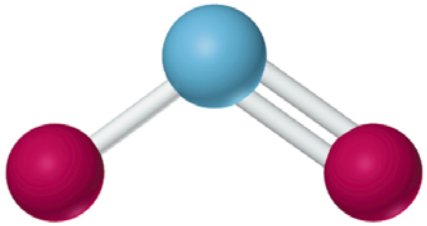
Schicht von der Seite gesehen

Oxide und Oxosäuren des Stickstoffs

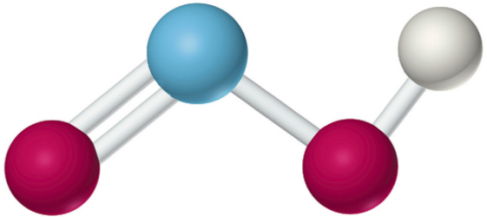


Distickstoffmonoxid
= Lachgas

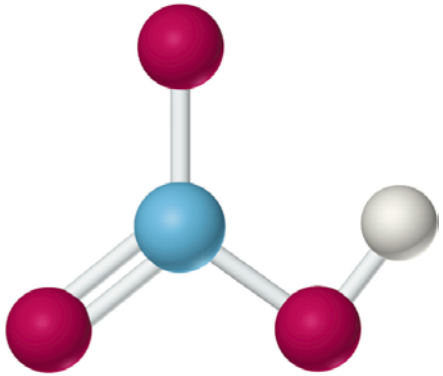
Stickstoffmonoxid



Stickstoffdioxid

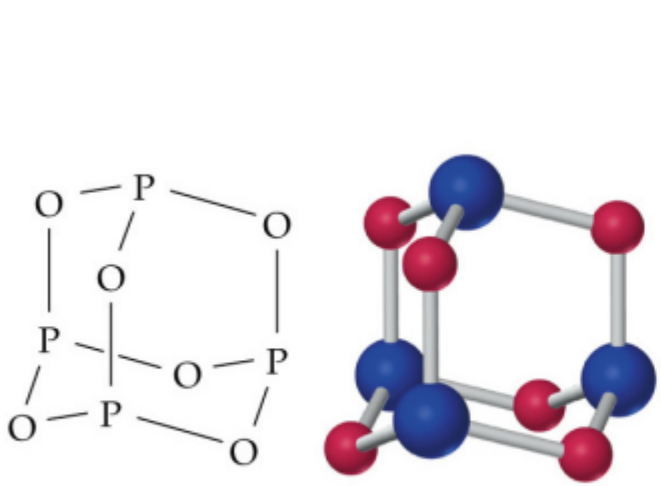


salpetrige Säure

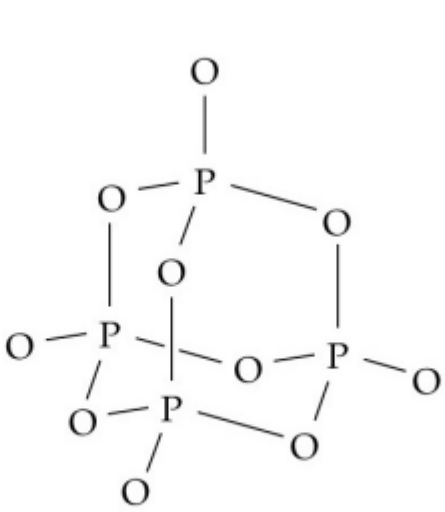


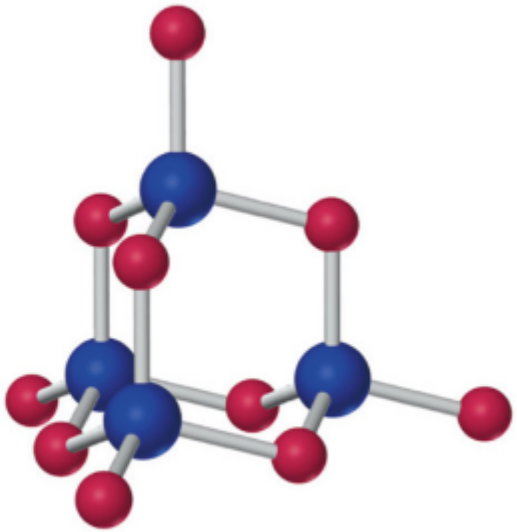
Salpetersäure

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



P_4O_6





P_4O_{10}