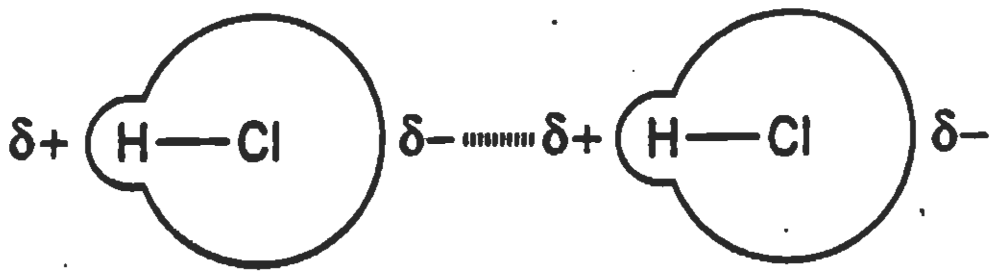
Welcome to 3.091

Lecture 12

October 6, 2004

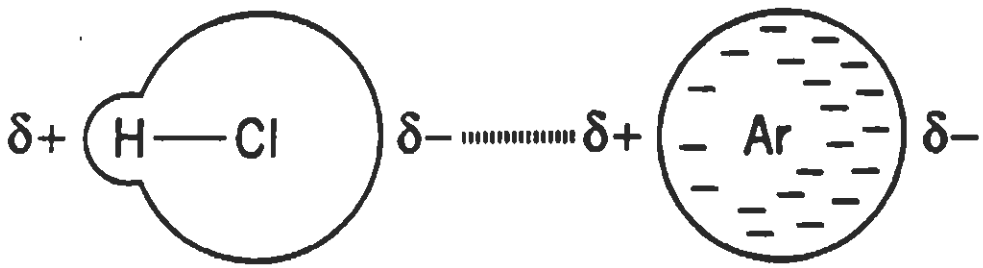
TABLE 4.3 The Relationship Between the Number of Electron Domains and the Geometry Around an Atom

Electron Domains	*Bonding Domains*	*Nonbonding Domains*	*Distribution of Electrons*	*Molecular Geometry*	*Examples*
2 (*sp*)	2	0	Linear	Linear	BeF_2, CO_2
	1	1		Linear	CO, N_2
3 (sp^2)	3	0	Trigonal planar	Trigonal planar	BF_3, CO_3^{2-}
	2	1		Bent	O_3, SO_2
	1	2		Linear	O
4 (sp^3)	4	0	Tetrahedral	Tetrahedral	CH_4, SO_4^{2-}
	3	1		Trigonal pyramidal	NH_3, H_3O^+
	2	2		Bent	H_2O, ICl_2^+
	1	3		Linear	HF, OH^-
5 (sp^3d)	5	0	Trigonal bipyramidal	Trigonal bipyramidal	PF_5
	4	1		Seesaw	SF_4, IF_4^+
	3	2		T shaped	ClF_3
	2	3		Linear	I_3^-, XeF_2
6 (sp^3d^2)	6	0	Octahedral	Octahedral	SF_6, PF_6^-
	5	1		Square pyramidal	BrF_5, $SbCl_5^{2-}$
	4	2		Square planar	XeF_4, ICl_4^-



dipole - dipole

[redacted]

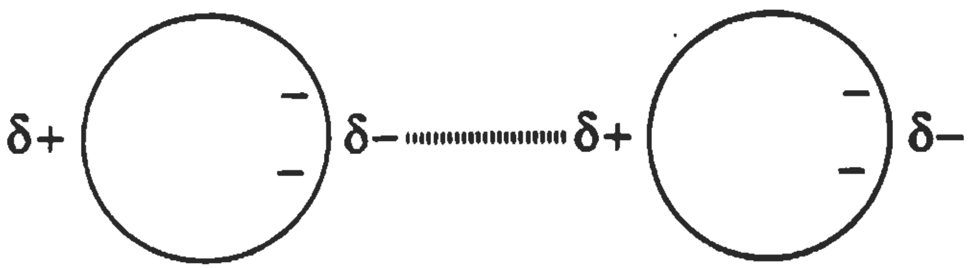


dipole–
induced dipole

(solutions)

[redacted]

[redacted]

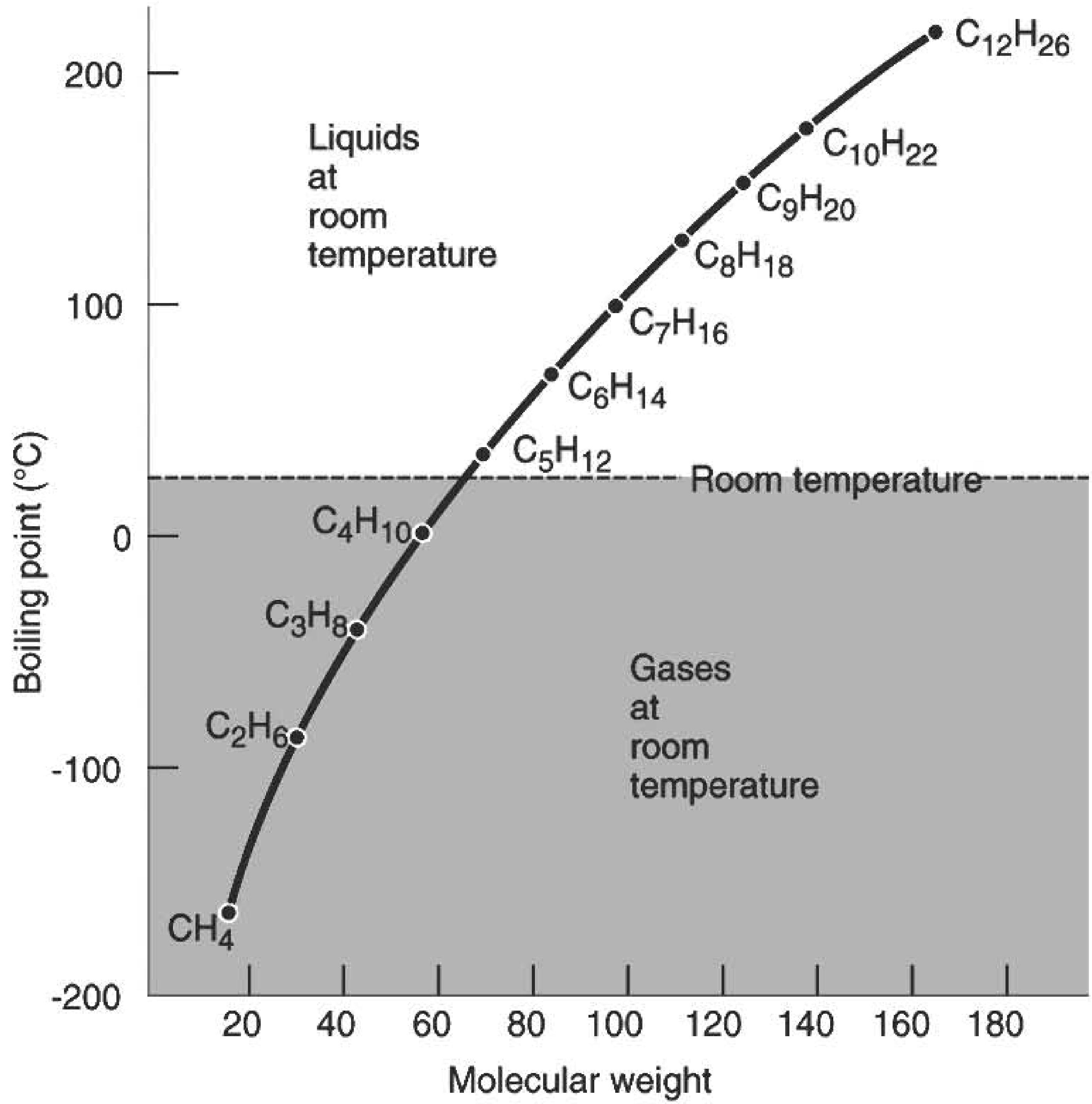


induced dipole — induced dipole

[redacted]

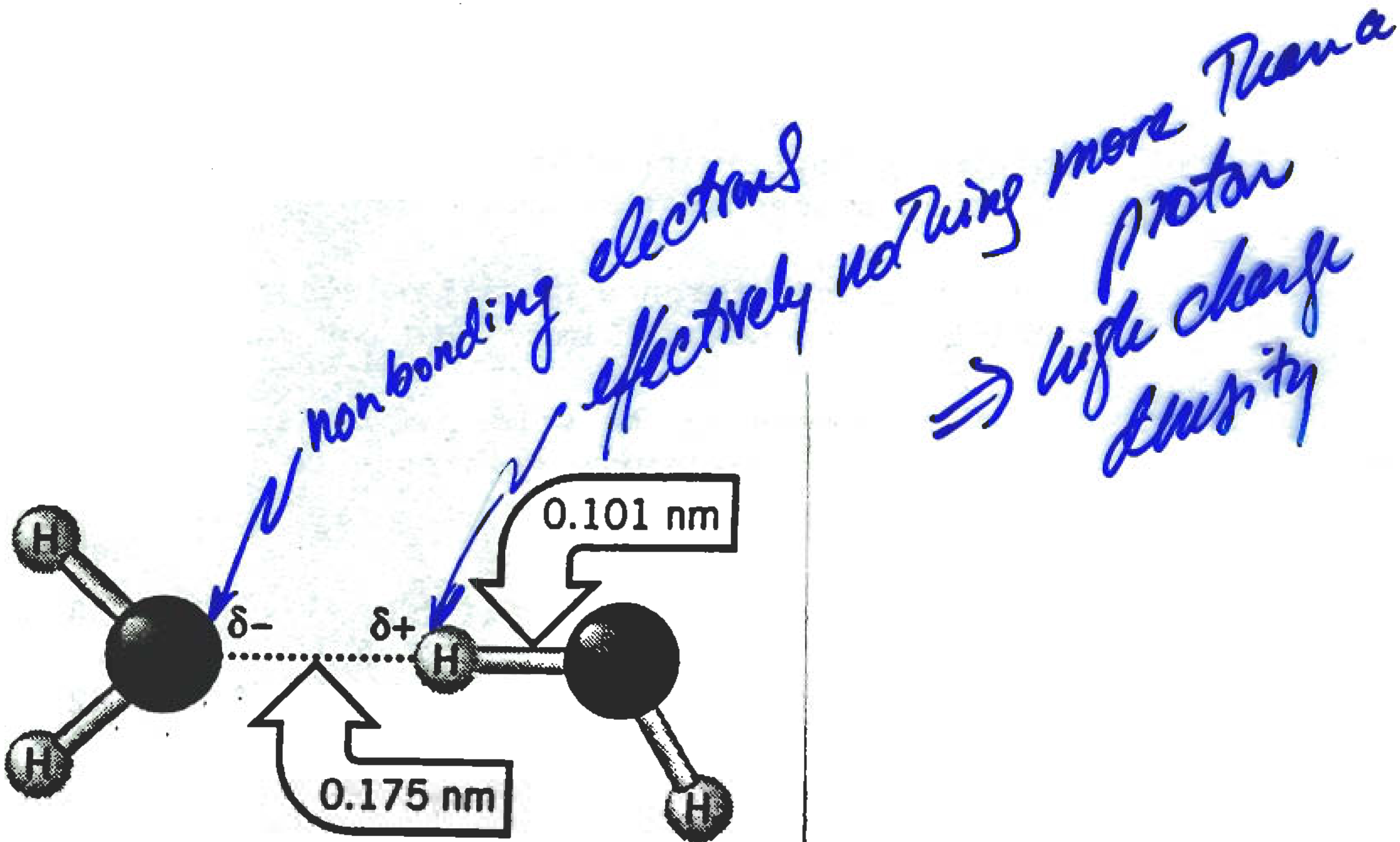
The Effect of Molecular Volume on London Dispersion Forces

$CH_3(CH_2)CH_3$	$CH_3(CH_2)_6CH_3$	$CH_3(CH_2)_{18}CH_3$
C_3H_8	C_8H_{18}	$C_{20}H_{42}$
propane	octane	eicosane
MW 44	MW 114	MW 282
mp -190°C	mp -57°C	mp +37°C
bp -42°C	bp +125°C	bp +343°C
gas at RT	liquid at RT	solid at RT

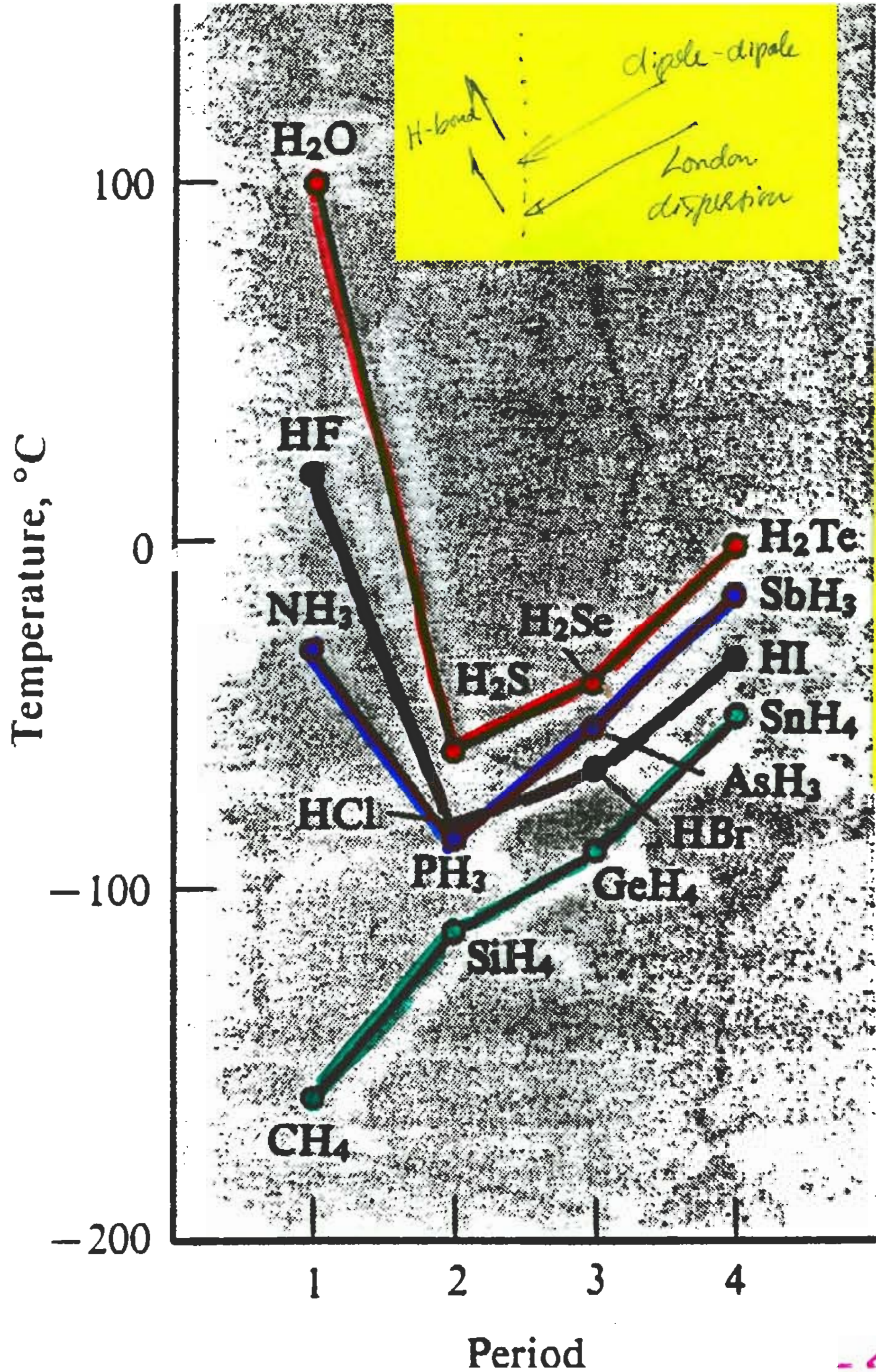


Boiling point (°C)
200
100
0
-100
-200
Liquids at room temperature
Gases at room temperature
Room temperature
$C_{12}H_{26}$
$C_{10}H_{22}$
C_9H_{20}
C_8H_{18}
C_7H_{16}
C_6H_{14}
C_5H_{12}
C_4H_{10}
C_3H_8
C_2H_6
CH_4
20 40 60 80 100 120 140 160 180
Molecular weight

	AVEE (eV)	χ
F	24	4.19
O	20	3.61
N	19	3.07
Cl	17	2.87
Br	16	2.69
C	15	2.54
H	13.6	2.30



nonbonding electrons
effectively nothing more than a proton
⇒ high charge density
0.101 nm
δ−
δ+
H
H
H
H
H
0.175 nm



H-bond
dipole-dipole
London dispersion
100
0
−100
−200
Temperature, °C
H2O
HF
NH3
H2S
H2Se
H2Te
SbH3
HI
SnH4
AsH3
HBr
HCl
PH3
GeH4
SiH4
CH4
1
2
3
4
Period

Values of Electrical Conductivity ($S\ m^{-1}$)

silver	6.1×10^{7}
copper	5.9×10^{7}
aluminum	3.7×10^{7}
stainless steel	1.4×10^{6}
graphite	7.3×10^{4}
lead dioxide	1.1×10^{4}
silicon	4.4×10^{-4}
germanium	1.1×10^{-5}
gallium arsenide	10^{-6}
diamond	10^{-11}
PMMA	$<10^{-12}$
aluminum oxide	10^{-14}
polystyrene	$<10^{-14}$
PTFE	$<10^{-16}$

$$S \equiv \text{Siemens}$$

$$S = ohm^{-1} = \Omega^{-1} = mho$$

Charles William **Siemens**
(born Karl Wilhelm Siemens)

- open-hearth furnace 1861
- trans-Atlantic telegraph cable 1875
- electric traction

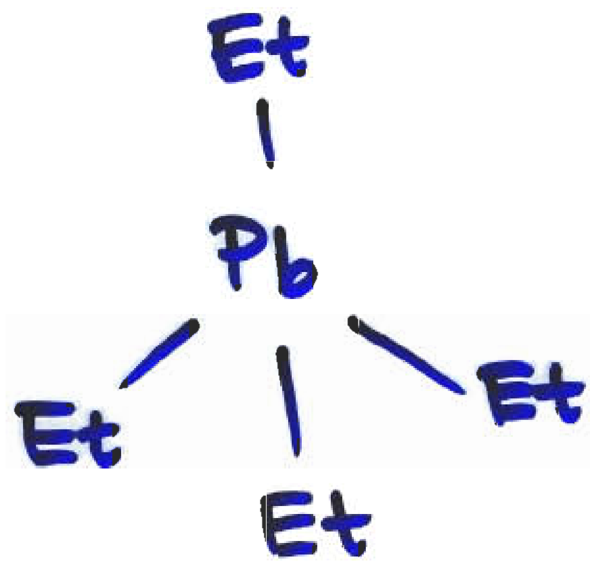
Georg Simon **Ohm**

- Ohm's Law 1827

Thomas "*sp*^{3}" Midgley

- 1916 Dayton Engineering Company (DELCO)
- 1921 discovers tetraethyl lead (TEL), an anti-knock agent for gasoline

Pb: $[Xe]4f^{14}5d^{10}6s^2p^2 \Rightarrow 6sp^3$



Et ≡ C_2H_5

- 1970s catalytic converters (Pt, Pd, Rh)
- TEL burns to form H_2O, CO_2, PbO
- PbO reduced to Pb which alloys with catalyst ➡ poisoning ➡ lead-free fuel
- 10¢/gal differential between regular and unleaded fuel
- self-serve gas pumps

➡ air quality?