Lecture 4 CH131 Summer 1

Tuesday, May 28, 2019

The will be lab on Wednesday, May 29

- Lewis diagrams
- Shapes and polarity of molecules

Begin ch9 (9.1—9.6): The gaseous state

- Pressure and temperature of gases
- Ideal gas law

Next lecture: Continue 9.1—9.6: Partial pressures; Kinetic theory of gases; real gases

BOSTON UNIVERSITY

Lewis diagram of acetic acid, CH_3COOH

0. skeleton
1. e's we have = 4 + 8 + 12 = 24
2. e's needed: 8 + 32 = 40
3. e's shared single
   = needed – have = 40 – 24 = 16
4. e's shared multiple
   = shared single – shared = 16 – 14 = 2
5. e's unshared lone
   = have — shared = 24 – 16 = 8
6. formal charge determines best place for shared double pair

BOSTON UNIVERSITY

Shape of acetic acid, CH_3COOH

Steric number → Geometry → Shape

BOSTON UNIVERSITY

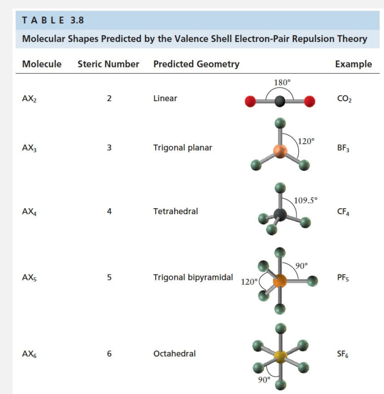


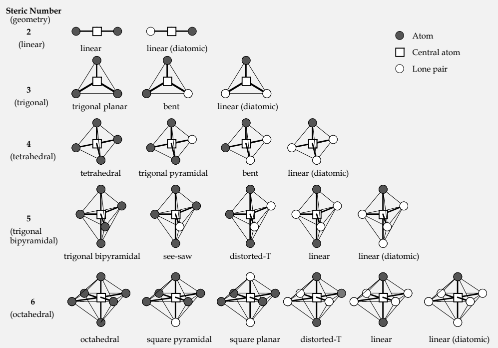
TABLE 3.8

Molecular Shapes Predicted by the Valence Shell Electron-Pair Repulsion Theory

Molecule	Steric Number	Predicted Geometry	Example
AX_2	2	Linear (180°)	CO_2
AX_3	3	Trigonal planar (120°)	BF_3
AX_4	4	Tetrahedral (109.5°)	CF_4
AX_5	5	Trigonal bipyramidal (90°, 120°)	PF_5
AX_6	6	Octahedral (90°)	SF_6

Table 3-8, p. 119

BOSTON UNIVERSITY



Steric Numbers, Geometries and the Shapes of Molecules

6

Formal charge determines "best" structure

41. Determine the formal charges on all the atoms in the following Lewis diagrams.

H—N̈=Ö and H—Ö=N̈

Which one would best represent bonding in the molecule HNO?

7

Expanded octet example

Problem 3.61, ICl_4^-

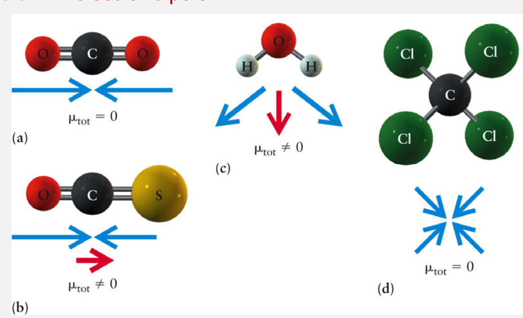
61. For each of the following molecules or molecular ions, give the steric number, sketch and name the approximate molecular geometry, and describe the directions of any *distortions* from the approximate geometry due to lone pairs. In each case, the central atom is listed first and the other atoms are all bonded directly to it.

(a) ICl_4^- (b) OF_2
(c) BrO_3^- (d) CS_2

8

Polarity

Bond dipole → molecular dipole



9

How solid, liquid, and gas phase differ

In solid phase, particles occupy fixed positions, 'close' to one another. Make a sketch.

In liquid phase, particles move about, but at comparable distances from one another as in the solid phase. Make a sketch.

BOSTON UNIVERSITY

[TP] In gas phase, particles move about, but 'far' from one another, compared to distances in the solid and liquid phases. How many times farther do you think are gas particles from one another than are liquid or solid particles from one another?

0% 1. 10
0% 2. 100
0% 3. 1,000
0% 4. 10,000
0% 5. 100,000
0% 6. 1,000,000
0% 7. 10,000,000
0% 8. > 10,000,000

BOSTON UNIVERSITY

Response Counter 10

How solid, liquid, and gas phase differ

In solid phase, particles occupy fixed positions, 'close' to one another. Make a sketch.

In liquid phase, particles move about, but at comparable distances from one another as in the solid phase. Make a sketch.

In gas phase, particles move about, but 'far' from one another, compared to distances in the solid and liquid phases. Make a sketch.

BOSTON UNIVERSITY

Key features of gas behavior

1. Gas particles are ~10 times farther apart then liquid or solid particles (really!).
2. Gas behavior depends on number of particles (moles n), but not on what the particles are (really!).
3. Gas is characterized by volume, V, of the enclosing container.
4. Gas is characterized by temperature, T, a measure of the average speed of the gas particles.
5. Gas is characterized by pressure, P.

BOSTON UNIVERSITY

Atmospheric pressure

Column of air 150 km high

Column of water 33.8 feet high

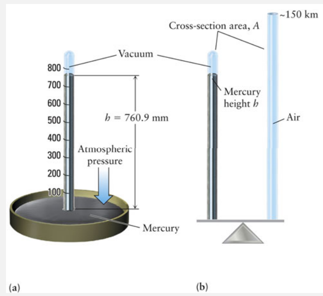
Column of liquid mercury 760 mm high

1 mm Hg = 1 torr

1 atm = 760 torr

= 1.01325 bar

= 14.6960 lb/in^2



Pressure = Force/Area

force/area = mass × acceleration/area = …
energy/distance^3

SI unit of pressure is the Pascal (Pa) …
force/area = energy/distance^3 = …
J/m^3 = Pa

1 bar = 100,000 Pa = 100 kPa

1 atm = force exerted by 760 mm = column of Hg = …
101325 Pa = 101.325 kPa = 1.01325 bar

1 atm is about 1% greater than 1 bar

Key features of gas behavior

Let's see how n, V, T, and P relate to one another.

In terms of the particles of a gas …

At a given P and n, explain how an increase in T must affect V.

Charles's law: $V \propto T$

In terms of the particles of a gas …

At a given T and n, explain how an increase in V must affect P.

Boyle's law: $P \propto 1/V$

BOSTON UNIVERSITY

In terms of the particles of a gas …

At a given P and T, explain how an increase in n must affect V.

Avogadro's hypothesis: $V \propto n$

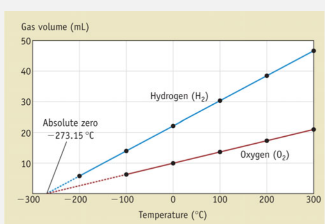
BOSTON UNIVERSITY

In terms of the particles of a gas …

From Charles's law, $V \propto T$, what must the volume of a gas be at $T = 0$ °C?

From Charles's law, $V \propto T$, what must the volume of a gas be at $T = 0$?

For gas behavior T is measured in K = °C + 273.15



BOSTON UNIVERSITY

Ideal gas equation

- Boyle's law: $P \propto 1/V$
- Charles's law: $V \propto T$
- Avogadro's hypothesis: $V \propto n$

These three relations combined into one relation…

Ideal gas equation: $PV \propto nT$

The constant of proportionality is R,

$PV = nRT$
$R = 8.314$ J /(K mol)

BOSTON UNIVERSITY

[TP] Express J/(K mol) in terms of m^3.

0% 1. ∝ m^3/(K mol)
0% 2. ∝ Pa m^3/(K mol)
0% 3. ∝ L m^3/(K mol)
0% 4. Something else

Response Counter
10

Pressure = Force/Area

Pa = J/m^3

1 atm = 101325 Pa

m^3 = 1000 L

Convert R = 8.314 J / (K mol) to L atm / (K mol).

Answer: R = 0.08206 L atm / (K mol).

