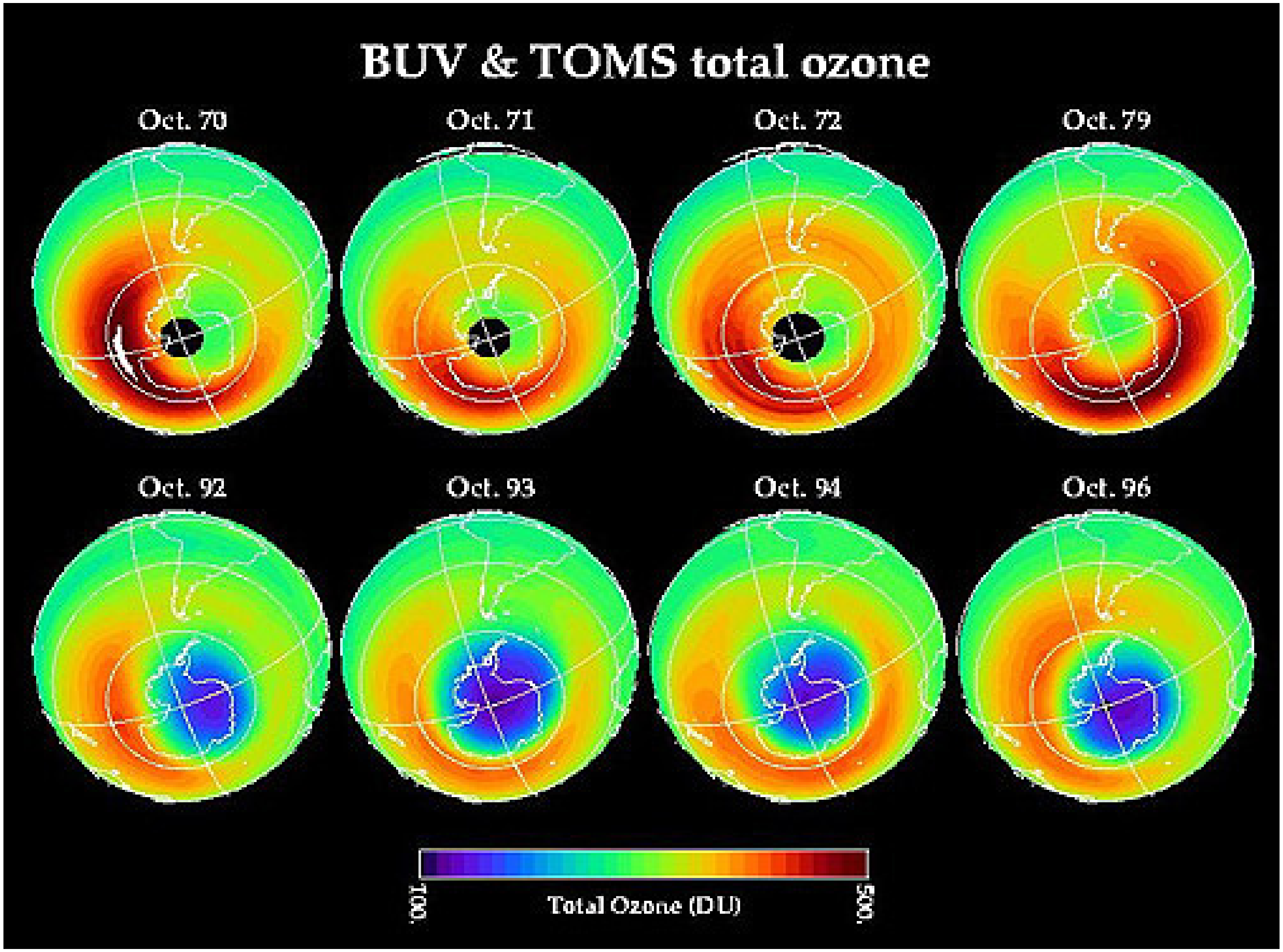
Chapter 2:
Protecting the Ozone Layer

Polar Ozone Depletion – The "Ozone Hole"



Absorption Spectrum of Human DNA

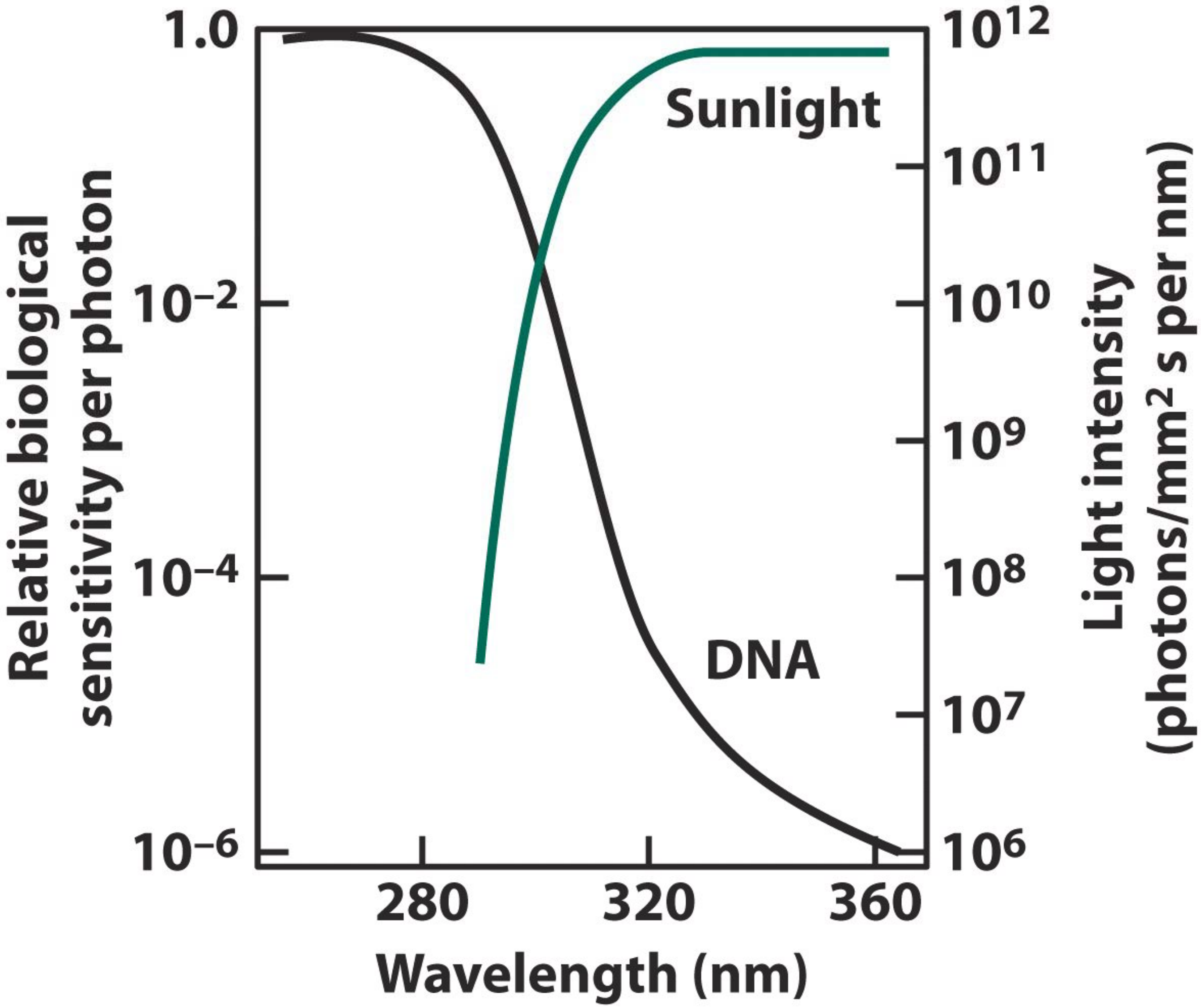


Figure 1-10
Environmental Chemistry, Third Edition

Atomic Structure and Periodicity

- Atom
  - Central Core = Nucleus
  - Nucleus contains
    - Protons (p^+) - positive
    - Neutrons (n^0) - neutrals
  - Cloud of Electrons
    - Surrounding Nucleus
    - Electrons (e^-) - negative

Table 2.1 Properties of Subatomic Particles

Particle	Relative Charge	Relative Mass	Actual Mass, kg
Proton	+1	1	1.67×10^{-27}
Neutron	0	1	1.67×10^{-27}
Electron	−1	0*	9.11×10^{-31}

* The relative mass of the electron is not actually zero, but is so small that it appears as zero when expressed to the nearest whole number.

Atomic Structure and Periodicity

- A neutral atom has the same number of protons and electrons
- This number is the Atomic Number, Z
  - Defined as the number of protons in an element
  - Each element has its own distinct atomic number

24 — Atomic number
Cr
52.00 — Atomic mass

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (269)	109 **Mt** (268)	110 **Ds** (271)	111	112	113	114	115	(116)	(117)	(118)

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Metals

Metalloids

Nonmetals

The 1–18 group designation has been recommended by the International Union of Pure and Applied Chemistry (IUPAC) but is not yet in wide use. In this text we use the standard U.S. notation for group numbers (1A–8A and 1B–8B). No names have been assigned for elements 111–115. Elements 116–118 have not yet been synthesized.

Atomic Structure and Periodicity

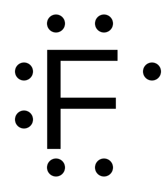
- Periodic Table
  - Puts elements in order of increasing atomic number
  - 'Groups' elements with similar chemical and physical properties
  - Main Group Elements (1A – 8A)
    - Group Label defines the number of **VALENCE ELECTRONS**

Table 2.2 Total and Outer Electrons for Atoms of the First 18 Elements

Group 1A	2A	3A	4A	5A	6A	7A	Noble Gases 8A
1 H 1							2 He 2
3 Li 1	4 Be 2	5 B 3	6 C 4	7 N 5	8 O 6	9 F 7	10 Ne 8
11 Na 1	12 Mg 2	13 Al 3	14 Si 4	15 P 5	16 S 6	17 Cl 7	18 Ar 8

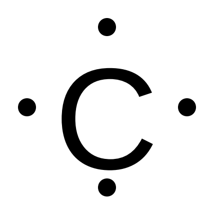
Atomic Structure and Periodicity

F in group 7A so has 7 valence electrons, as do Cl, Br, I



Atomic Structure and Periodicity

C in group 4A so has 4 valence electrons, as do Si, Ge, Sn



Atomic Structure and Periodicity

- What about the neutrons?
  - Neutrons help to stabilize the nucleus
  - Practically ALL elements have neutrons
  - Only exception is atomic hydrogen
    - Has one proton and one electron
  - 1H in every 6700 *will* have a neutron
    - This is Deuterium
    - It has one proton, one electron and one neutron, and thus **a different mass**

Atomic Structure and Periodicity

- Isotope
  - Two or more forms of the same element (same number of protons) whose atoms differ in number of neutrons, and hence in mass.
- Mass Number
  - The sum of the number of protons and the number of neutrons in the nucleus of an atom
  - Identifies different isotopes
- Atomic Mass
  - The weighted average of all naturally occurring isotopes of an element

Atomic Structure and Periodicity

Table 2.3 Isotopes of Hydrogen

Isotope	Isotopic Symbol	Number of Protons	Number of Neutrons	Sum of Protons and Neutrons
hydrogen, H-1	$^{1}_{1}H$	1	0	1
deuterium, H-2	$^{2}_{1}H$	1	1	2
tritium, H-3	$^{3}_{1}H$	1	2	3

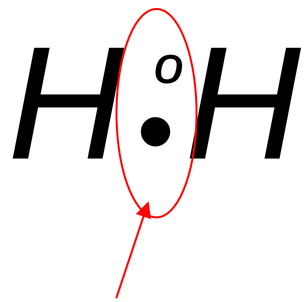
Molecules and Models

- Lewis Structure
  - A representation showing valence electrons
  - Dot structure
- Covalent bond
  - Electrons are *shared* by two elements
  - Single bond – when only one pair of shared electrons involved in a covalent bond

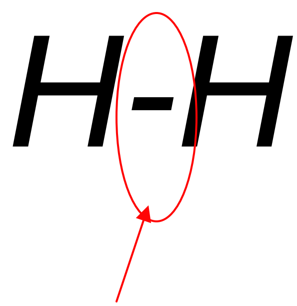
Molecules and Models

$H\bullet \qquad {}^{o}H$

Molecules and Models



Shared Electrons



Single Covalent Bond

Hydrogen needs only two electrons for it's shell to be full

Molecules and Models

$$S = N - A$$

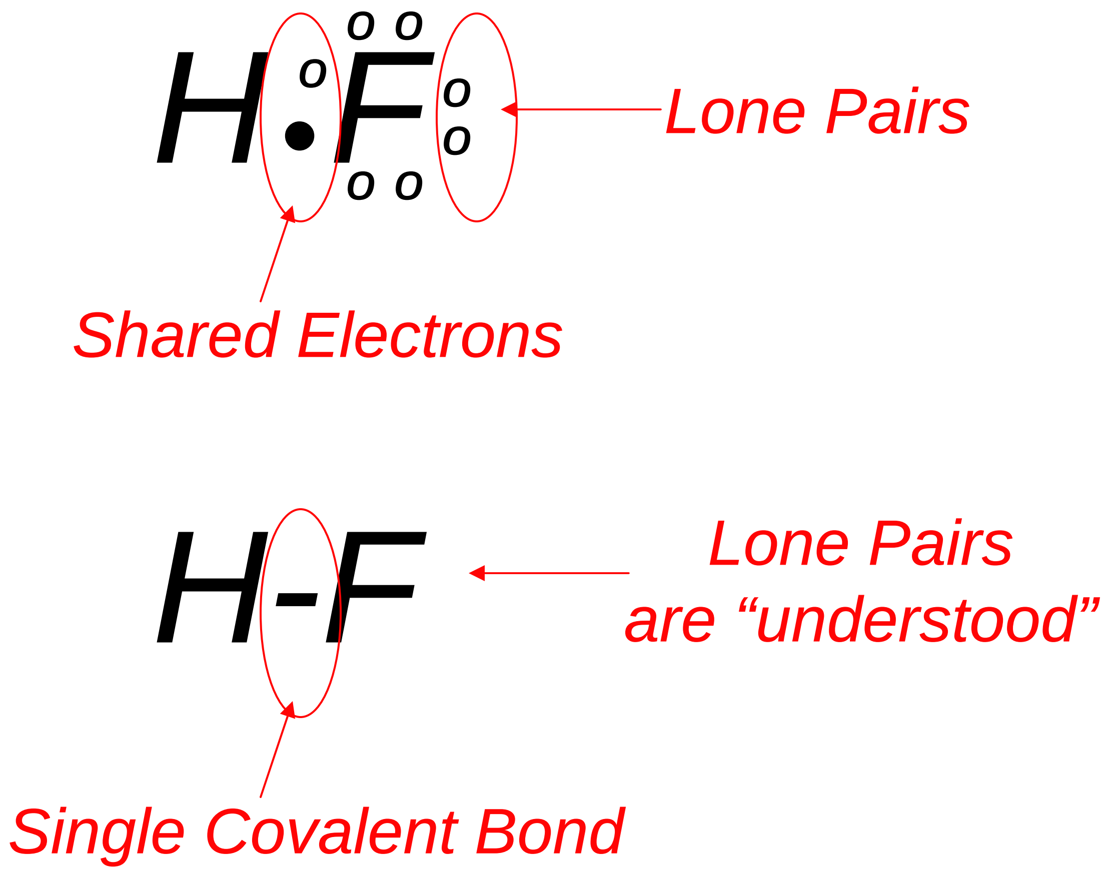
- **S =** # of shared electrons
  - Remember it takes 2 e- to make a bond
- **N** = # of electrons to needed to fill the valence shell
  - Usually 8 (the octet rule) except for hydrogen it's 2
- **A** = # of electrons available in the valence shell
  - The group number

Molecules and Models

$S = N - A$

- Example: hydrogen fluoride, HF
  - Needed (N): hydrogen needs $2e^-$ and fluorine needs $8e^-$.
    - N = 2 + 8 = 10
  - Available (A): hydrogen has $1e^-$ and fluorine has $7e^-$.
    - A = 1 + 7 = 8
  - Shared (S) = N – A = 10 – 8 = 2
  - So $2e^-$ shared between H and F, a single covalent bond

Molecules and Models



Molecules and Models

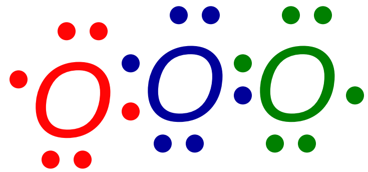
- Double Bond
  - A covalent bond consisting of two pairs of shared electrons
  - Shorter, stronger and harder to break than single bonds
  - O_2
- Triple Bond
  - A covalent bond consisting of three pairs of shared electrons
  - Shorter, stronger and harder to break than double bonds
  - N_2

Molecules and Models

$S = N - A$

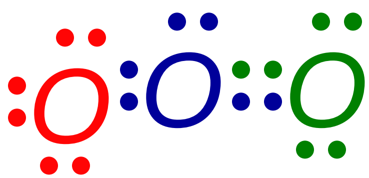
- Example: ozone, O_3, an allotrope of oxygen
  - Needed: N = 3 x 8 = 24
  - Available: A = 3 x 6 = 18
  - Shared: S = N – A = 24 – 18 = 6
  - So 6 e^- shared between the three oxygen atoms
  - HOW?

Molecules and Models



?

Three Bonds



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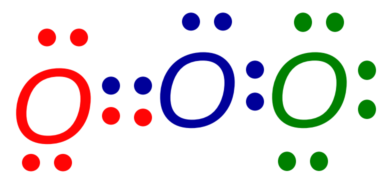
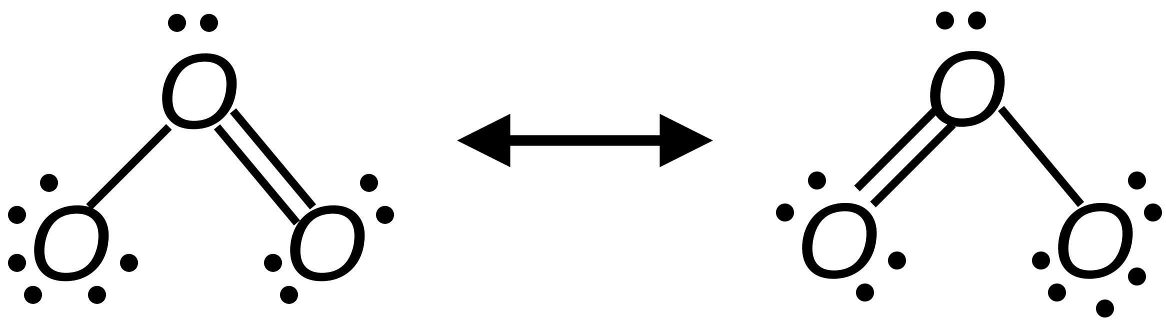
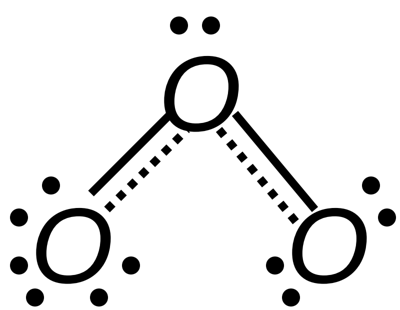


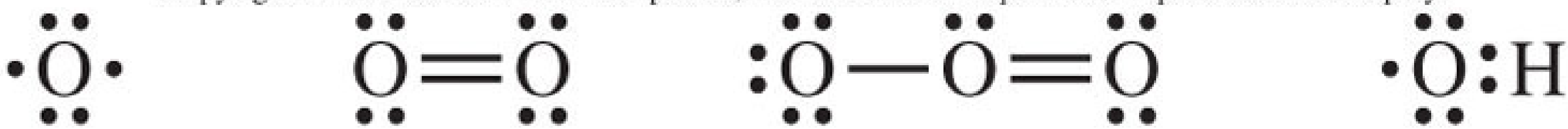


Molecules and Models

- Resonance Forms
  – Structures that are hypothetical extremes of electron arrangements that do not exist exactly as represented by any one Lewis structure.
- Ozone's structure is 'in-between' the two resonance structures.



Molecules and Models



oxygen atom | oxygen molecule | ozone molecule | hydroxyl free radical

“Free Radicals”

What happens when no amount of sharing electrons will result in a full valence?

NO, nitrogen monoxide

S = N – A

N = 3 for N, 2 for O = 5

A = 5 for N, 6 for O = 11

S = 11 – 5 = 6, a triple covalent bond

But that leaves only 5 electrons NOT shared – and you **can’t** arrange 5 electrons evenly between 2 atoms!

“Free Radicals”

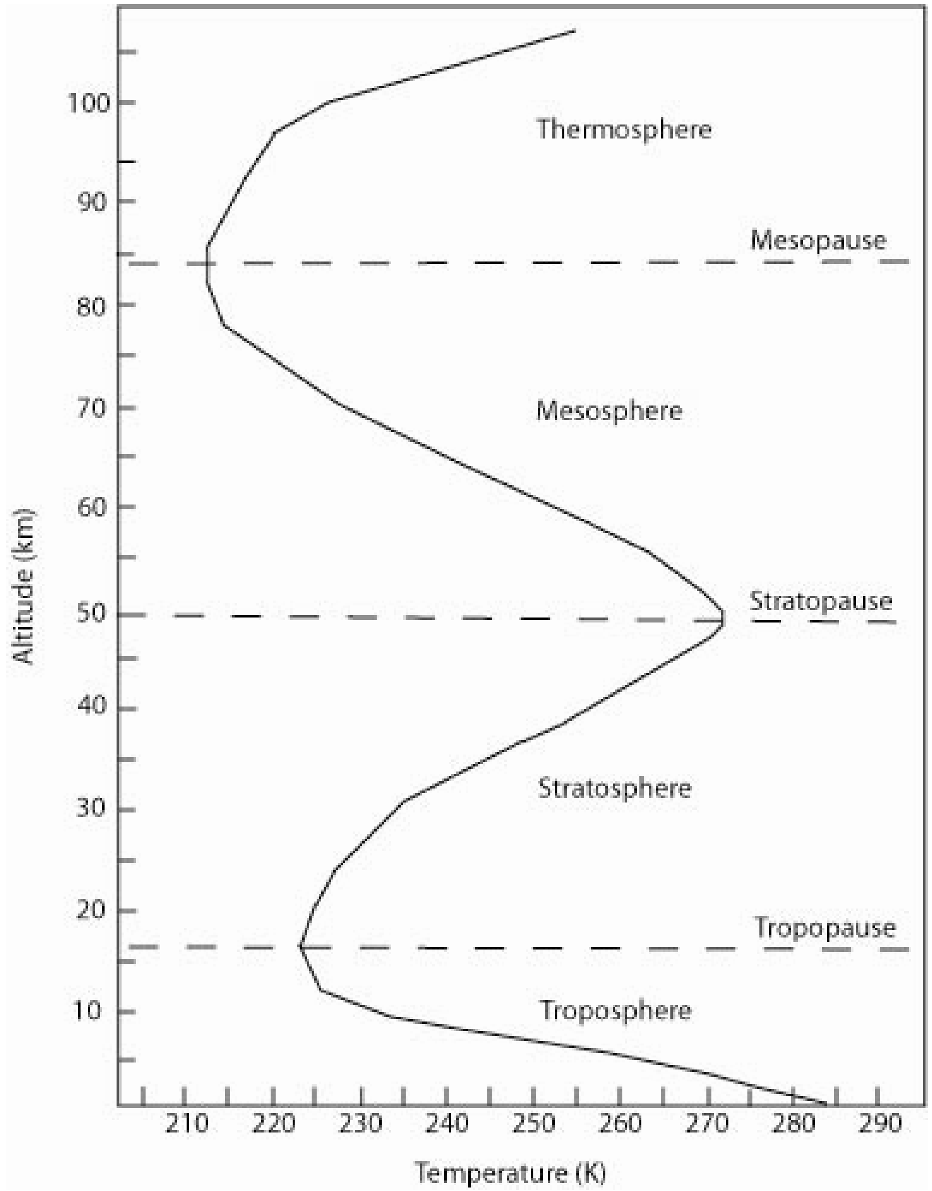
Species with an odd number of electrons – or “unpaired” electrons – are referred to as Free Radicals, or Radicals

Radicals are extremely reactive, because that single unpaired electron will do just about anything to make a pair

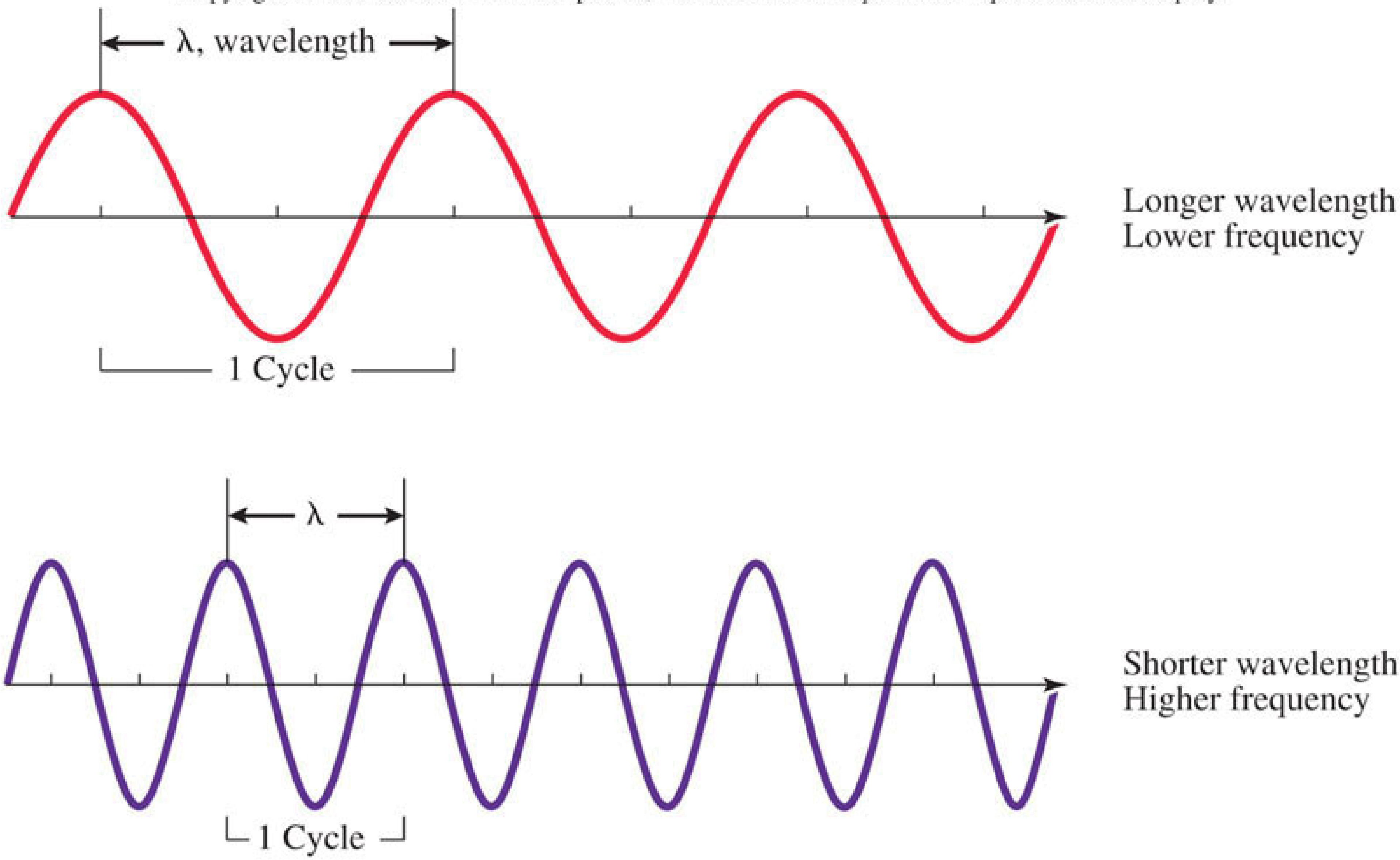
Often (but not always), we indicate that a species is a radical by representing the unpaired electron with a single dot: •

NO•, NO_2•, Cl•, Br•, OH• , ...

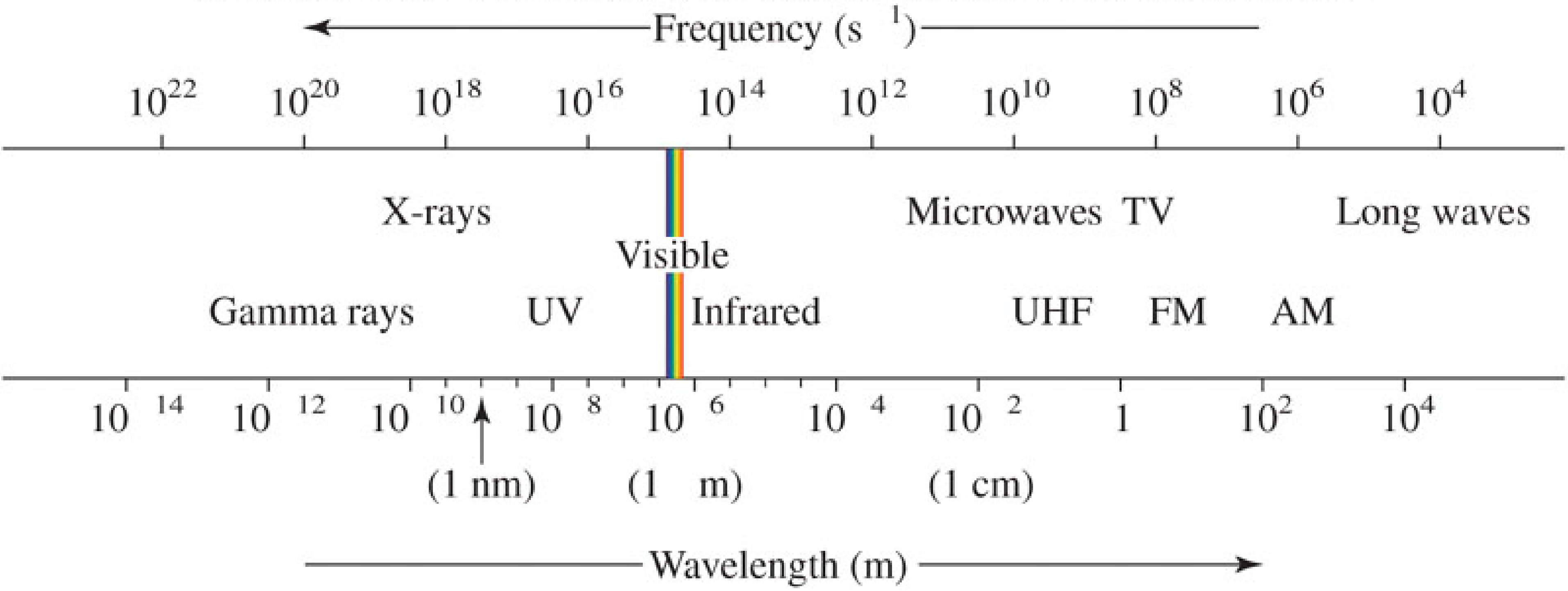
Vertical Structure of the Atmosphere - Temperature



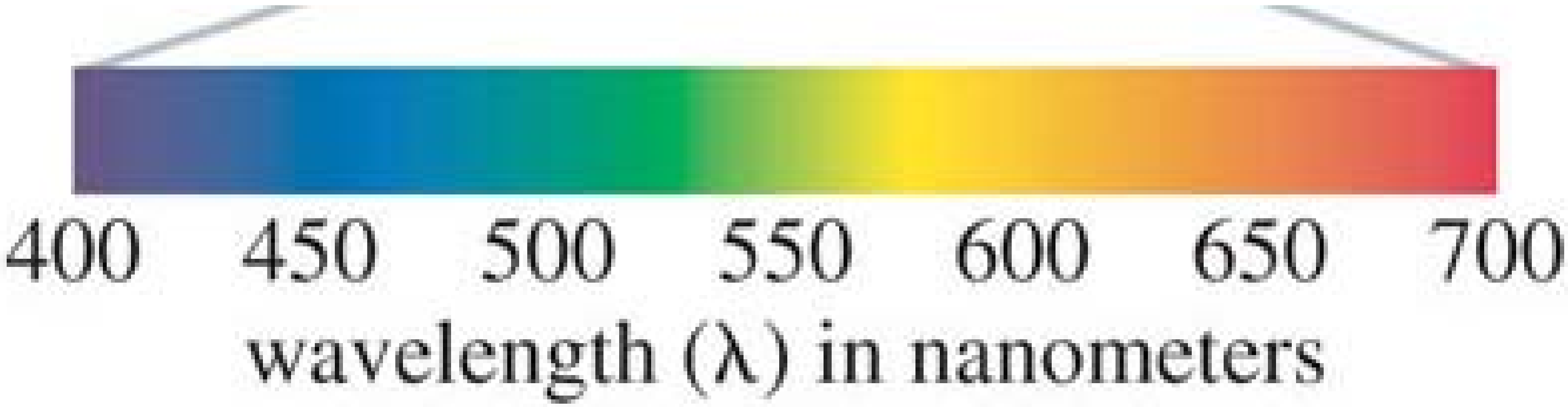
Waves of Light



Waves of Light



Waves of Light



Visible Light