Applications of Organic Chemistry into Daily Life Series

Seminar Topic: Chemical Bonds

Thur Feb 22, 2024
7:30-8:30PM at Living Skin

Goal:

Have Organic Chemistry become part of your tool-belt for examining life and become integral to your story telling

What is Organic Chemistry?

Organic chemistry is a subdiscipline within chemistry involving the scientific study of the structure, properties, and reactions of organic compounds and organic materials, i.e., matter in its various forms that contain carbon atoms.[1] Study of structure determines their structural formula. Study of properties includes physical and chemical properties, and evaluation of chemical reactivity to understand their behavior. The study of organic reactions includes the chemical synthesis of natural products, drugs, and polymers, and study of individual organic molecules in the laboratory and via theoretical (in silico) study.

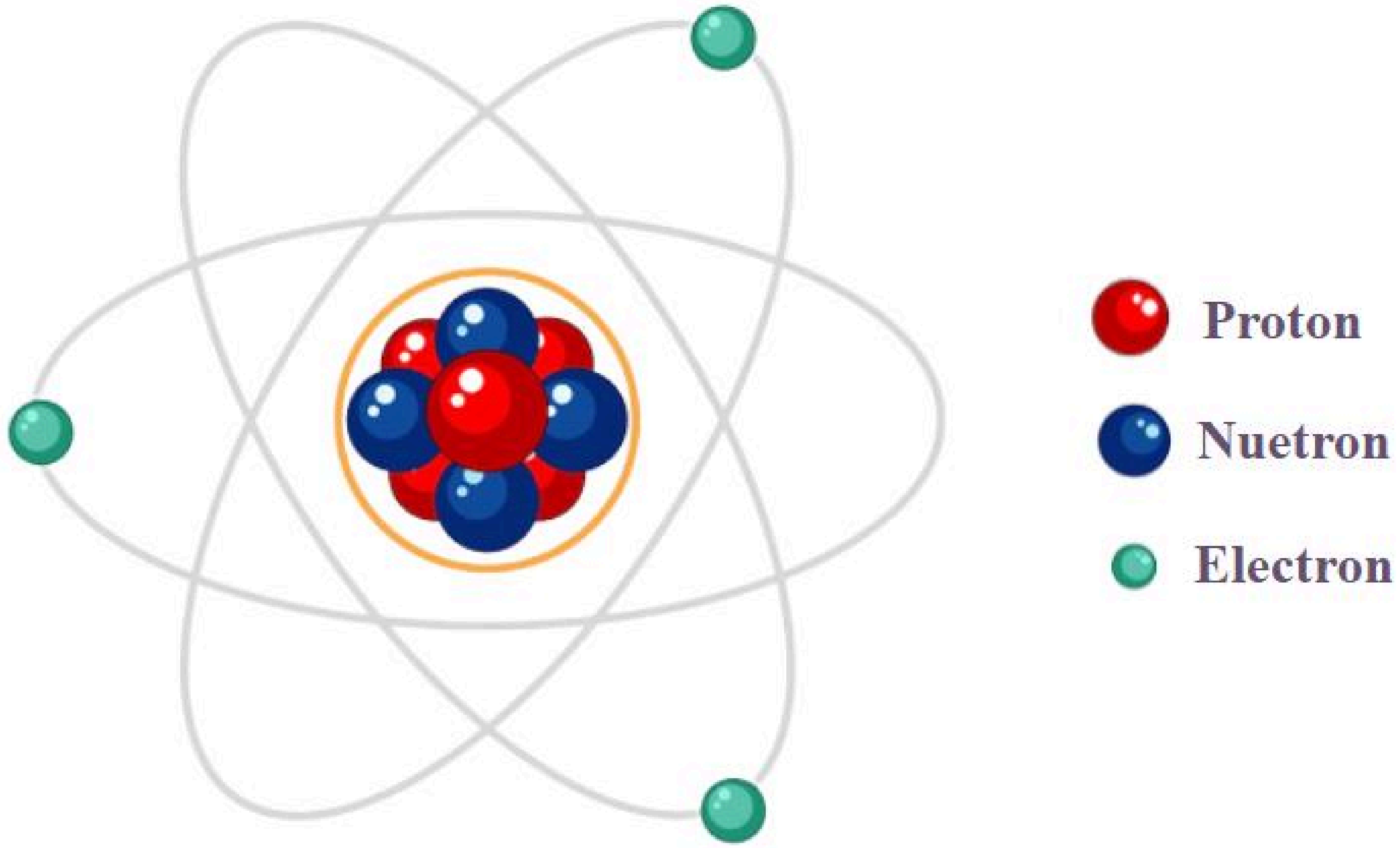
What is Chemistry?

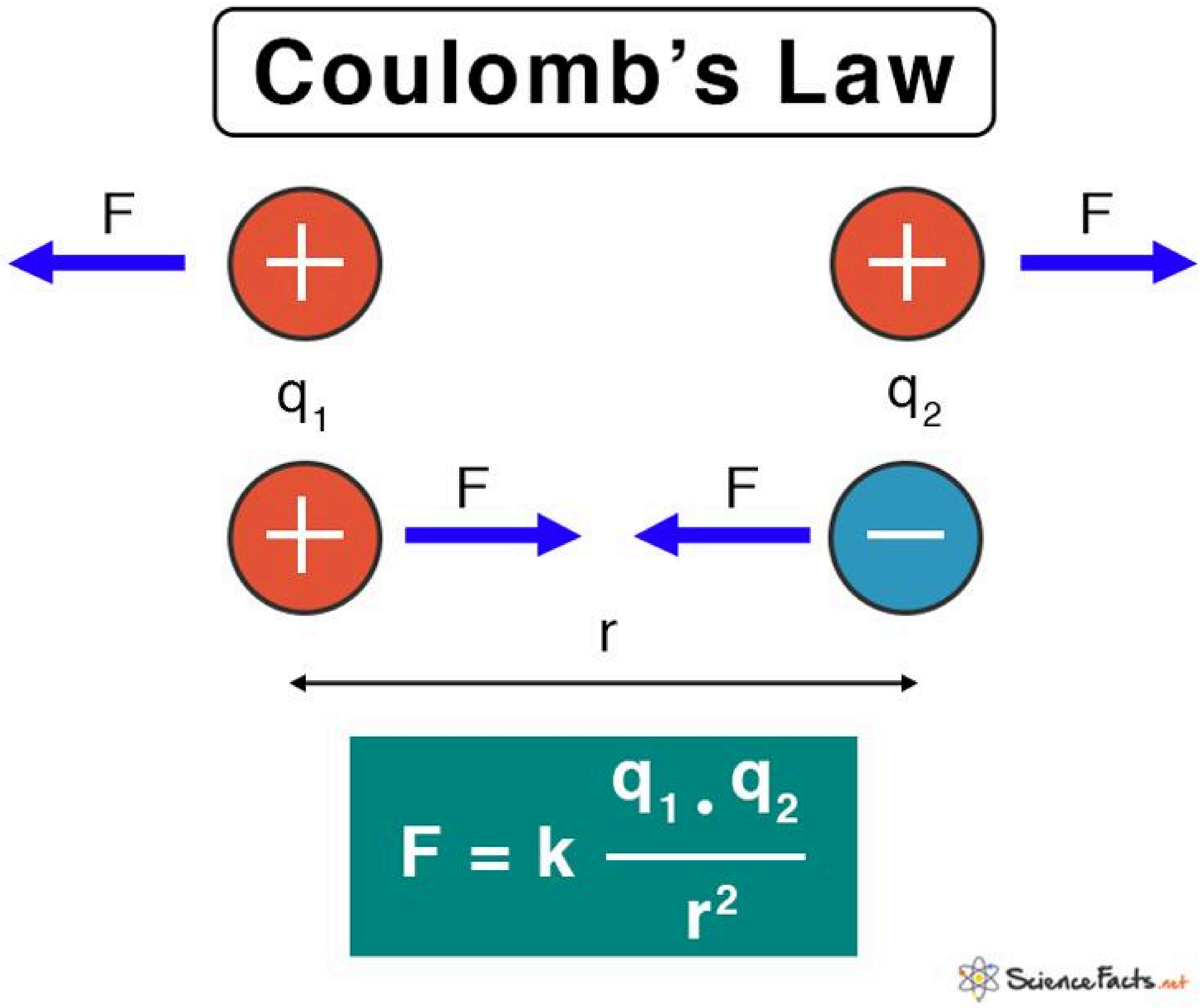
Chemistry is the scientific study of the properties and behavior of matter.[1] It is a physical science within the natural sciences that studies the chemical elements that make up matter and compounds made of atoms, molecules and ions: their composition, structure, properties, behavior and the changes they undergo during reactions with other substances.[2][3][4][5] Chemistry also addresses the nature of chemical bonds in chemical compounds.

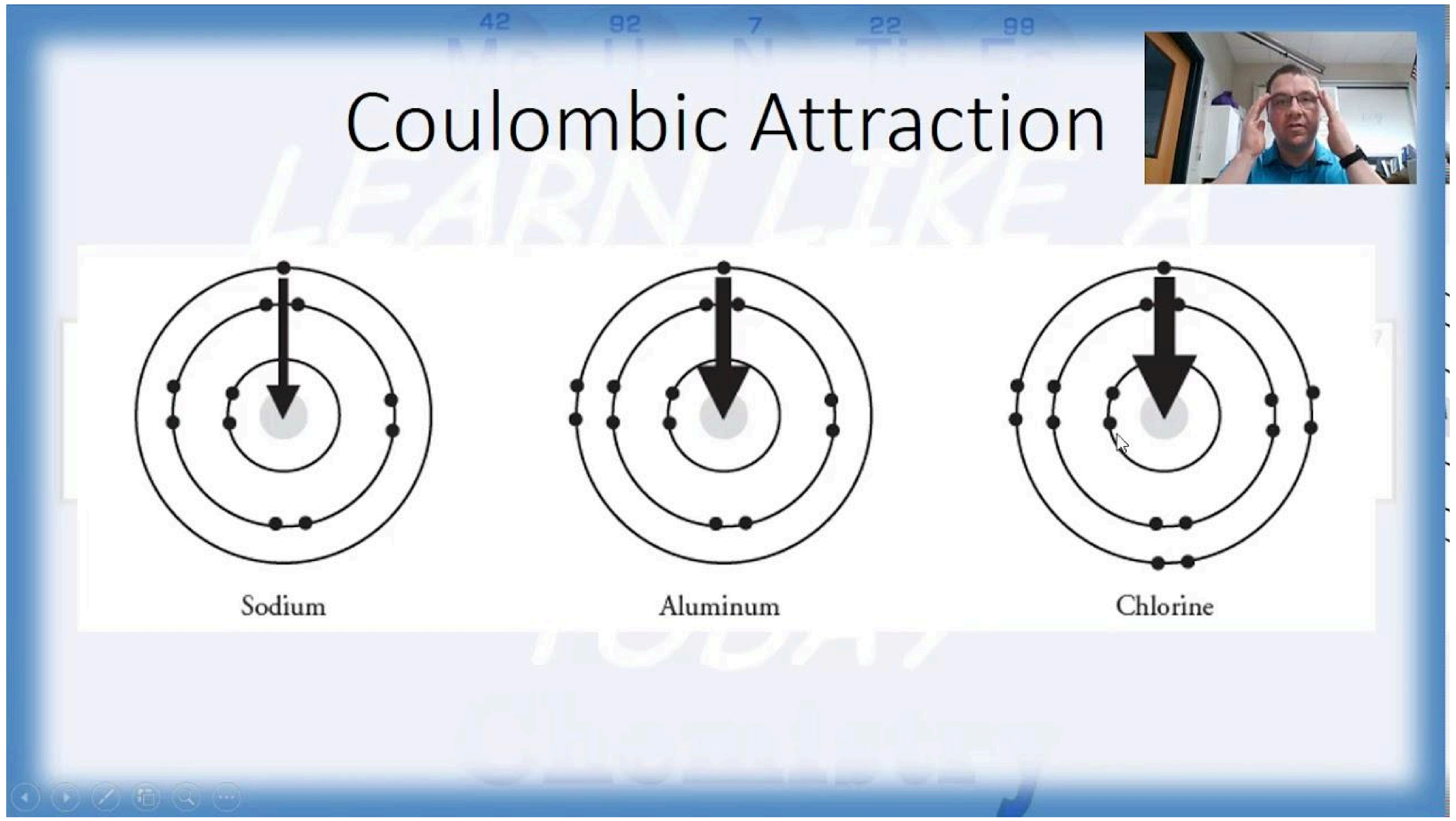
Seminar Topic #1: Chemical Bonds

The **atom** is the basic particle of the chemical elements. An atom consists of a nucleus of protons and generally neutrons, surrounded by an electromagnetically bound swarm of electrons. The chemical elements are distinguished from each other by the number of protons that are in their atoms. For example, any atom that contains 11 protons is sodium, and any atom that contains 29 protons is copper. Atoms with the same number of protons but a different number of neutrons are called isotopes of the same element.

Structure of Atom




Coulomb's Law
F
F
q1
q2
F
F
r
F = k q1 . q2 / r2
ScienceFacts.net

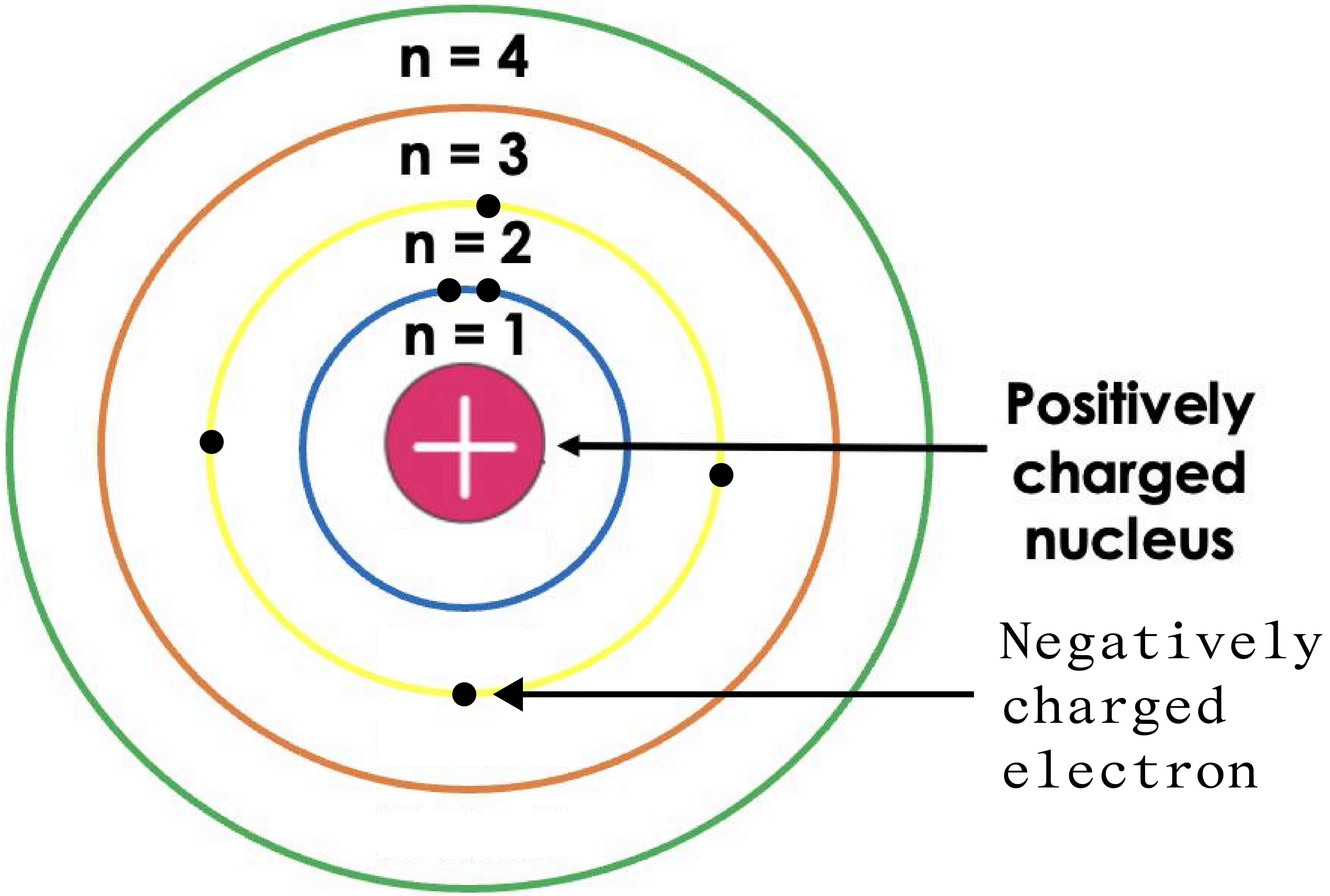

Coulombic Attraction
Sodium
Aluminum
Chlorine

The pattern of systems in the universe to achieve the lowest energy state is rooted in the second law of thermodynamics which states that in any isolated system, the total entropy (a measure of disorder or randomness) tends to increase over time, or at the very least, remain constant.

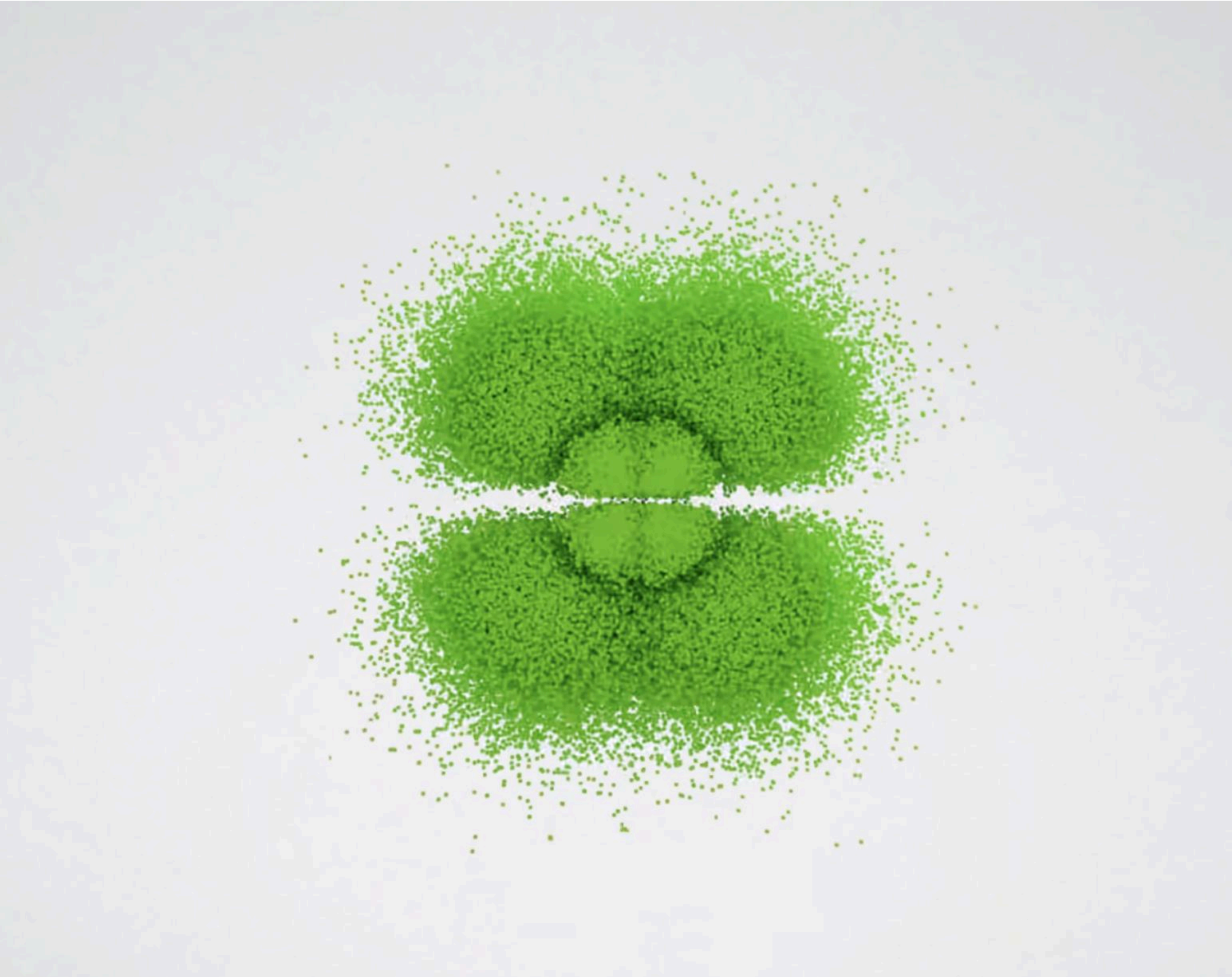
Objects in a lower energy state have greater stability, and the universe tends toward increased stability and equilibrium. When a system transitions to a lower energy state, it releases energy, and this process often leads to a more ordered and stable configuration.

Periodic Table of the Elements

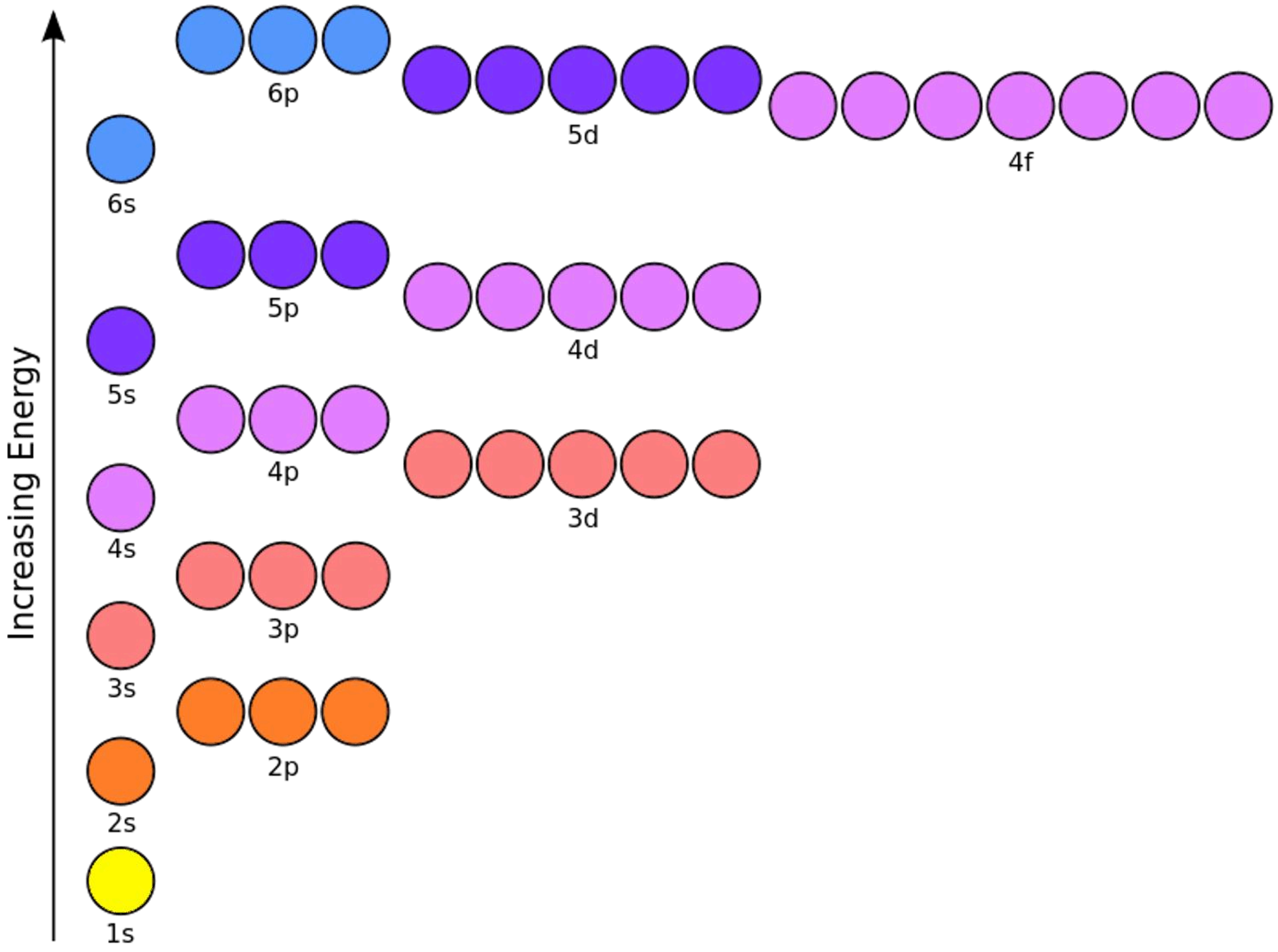
	1	2															3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
①	1 H																															2 He
②	3 Li	4 Be																									5 B	6 C	7 N	8 O	9 F	10 Ne
③	11 Na	12 Mg																									13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
④	19 K	20 Ca															21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
⑤	37 Rb	38 Sr															39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
⑥	55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
⑦	87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

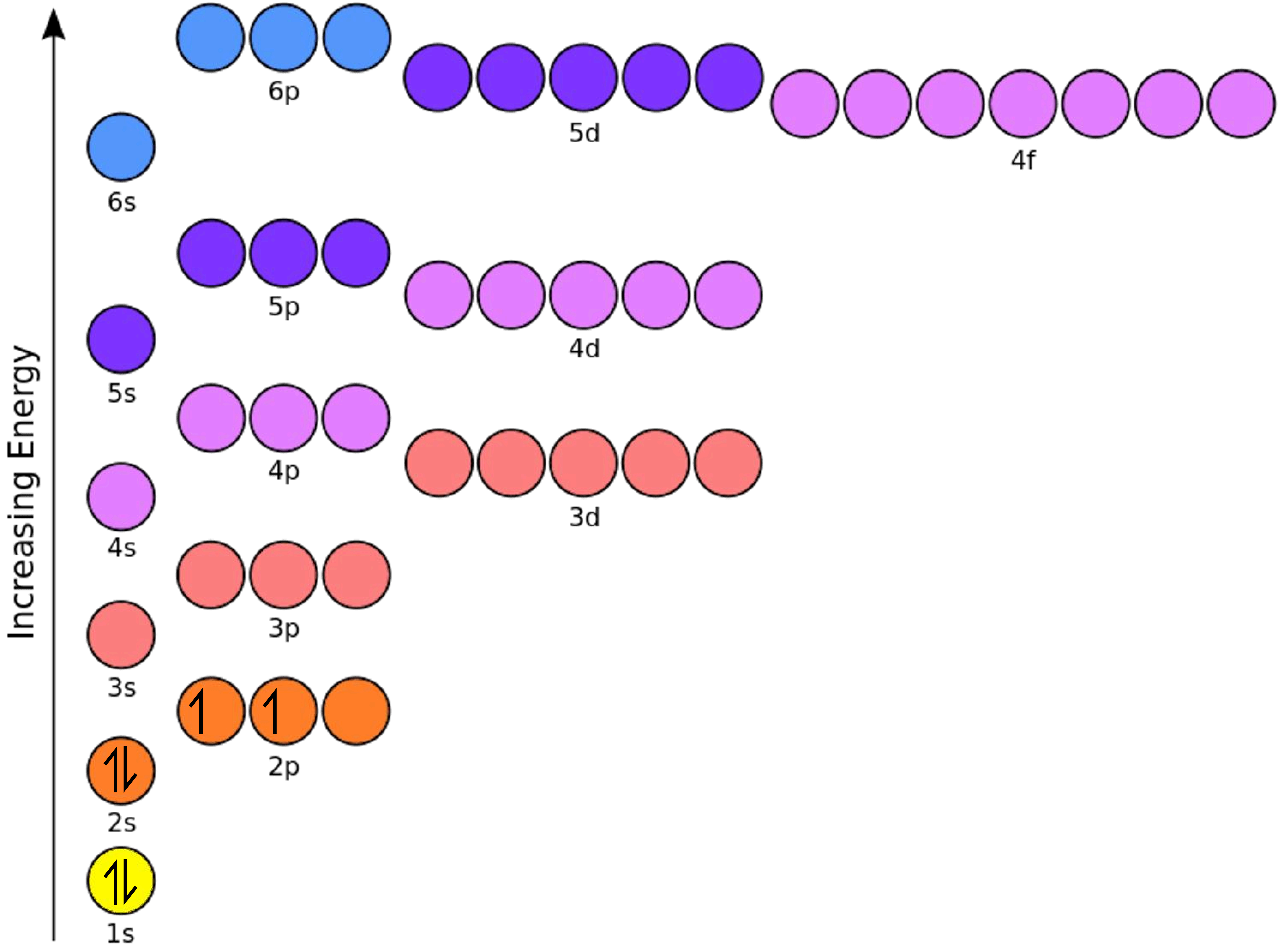


Example: Carbon

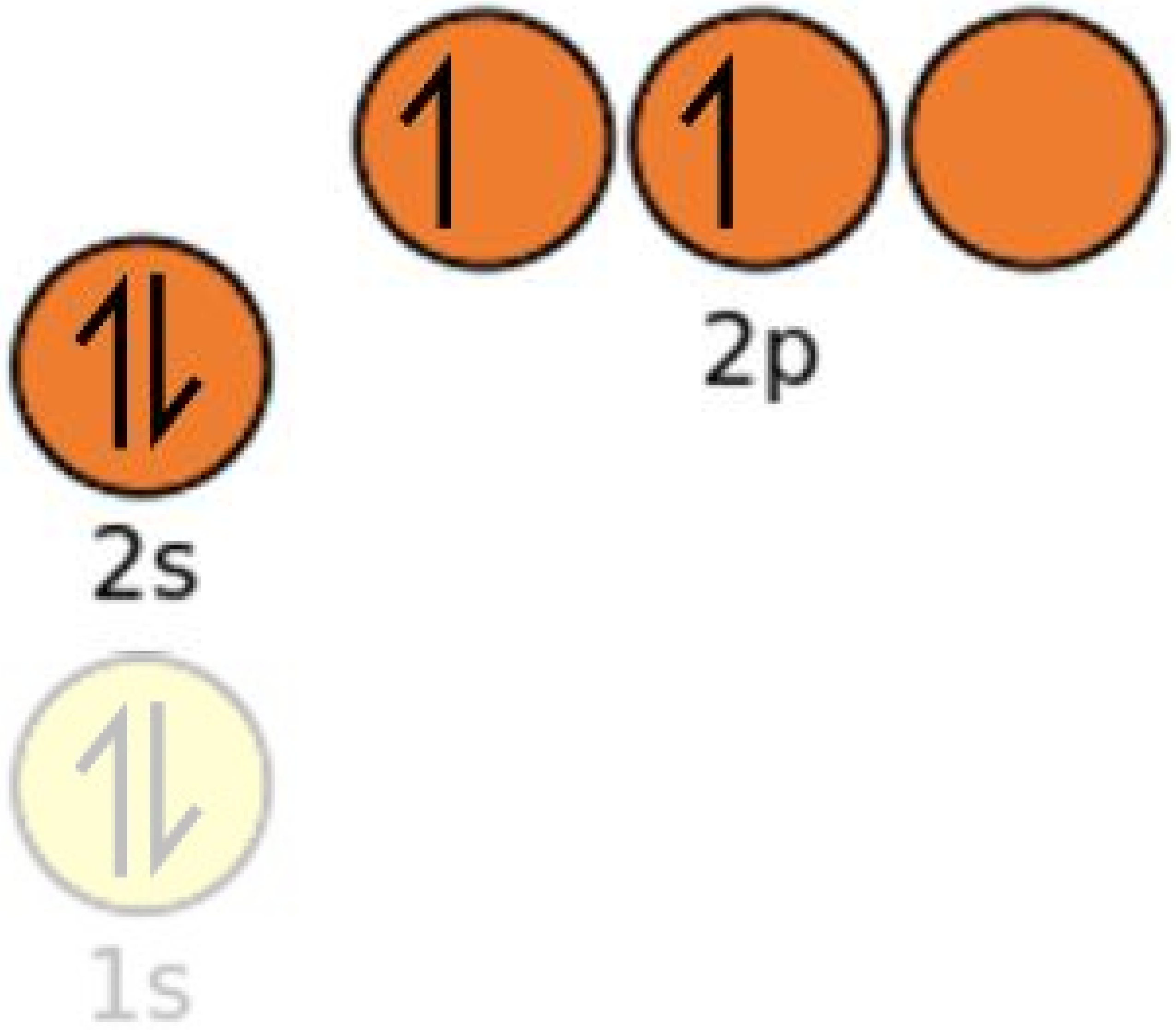


https://www.youtube.com/watch?v=W2Xb2GFK2yc&t=271s

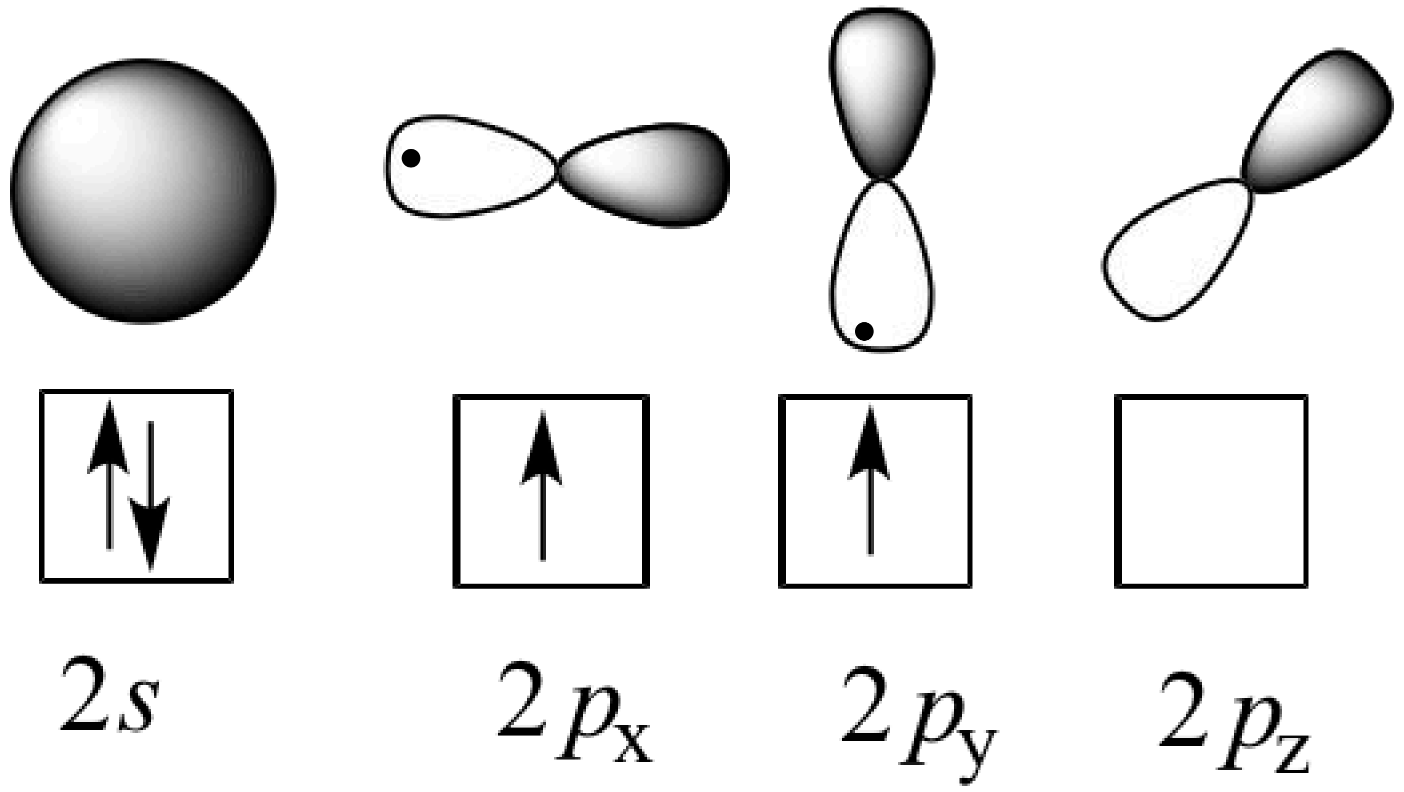

Increasing Energy
6p
5d
4f
6s
5p
4d
5s
4p
3d
4s
3p
3s
2p
2s
1s

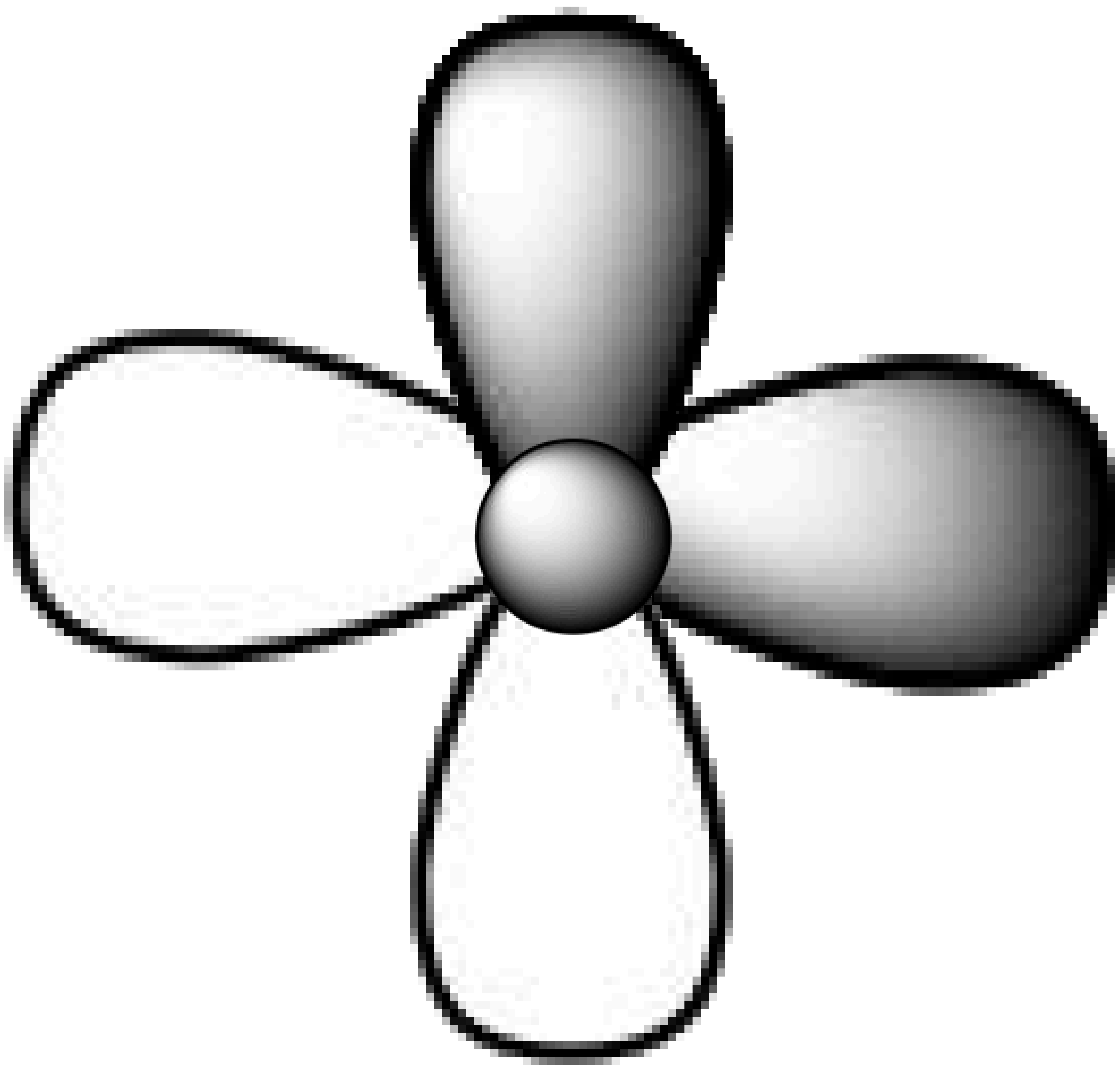


Example: Carbon

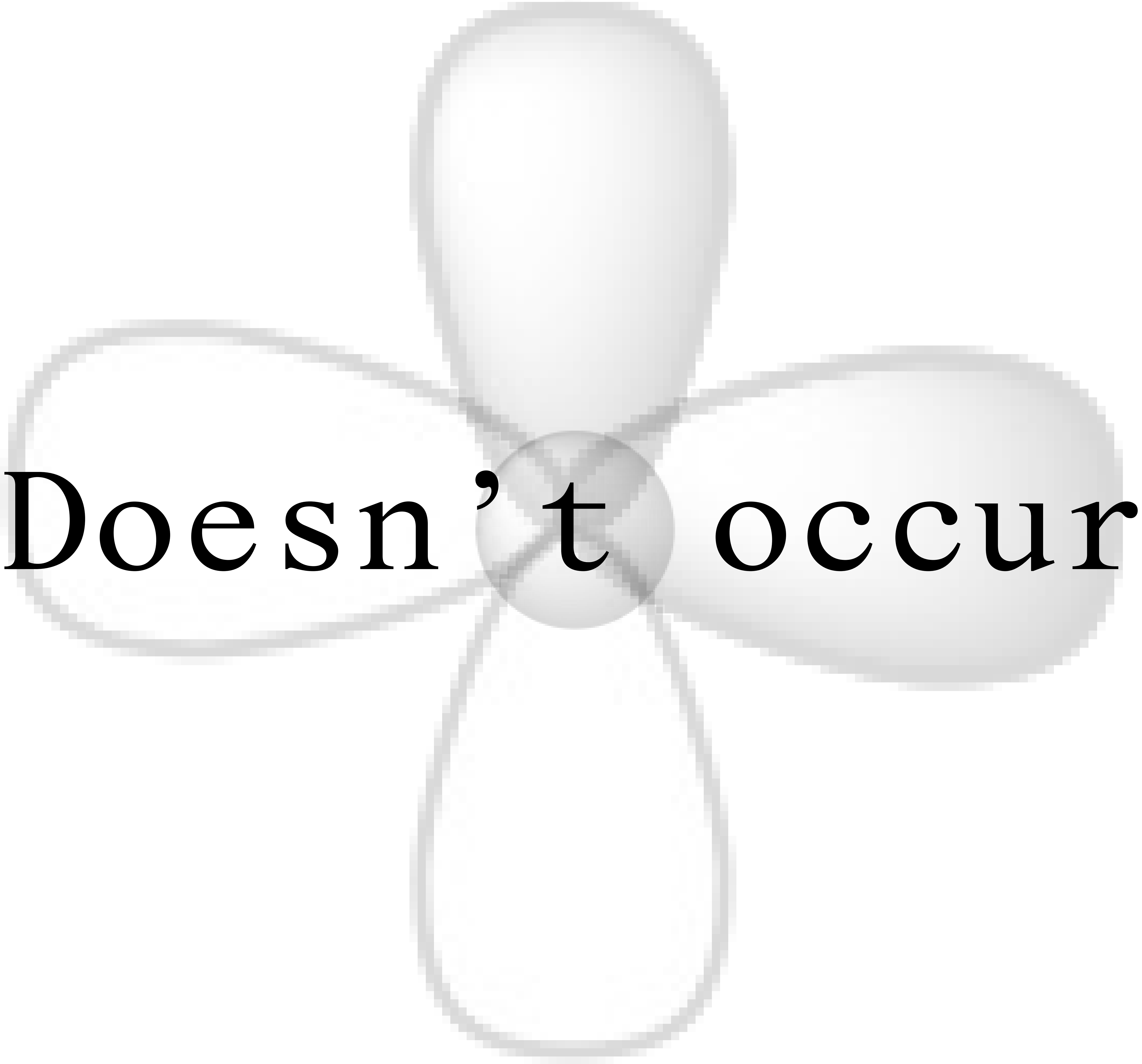


Carbon





Example: Carbon



Doesn’t occur

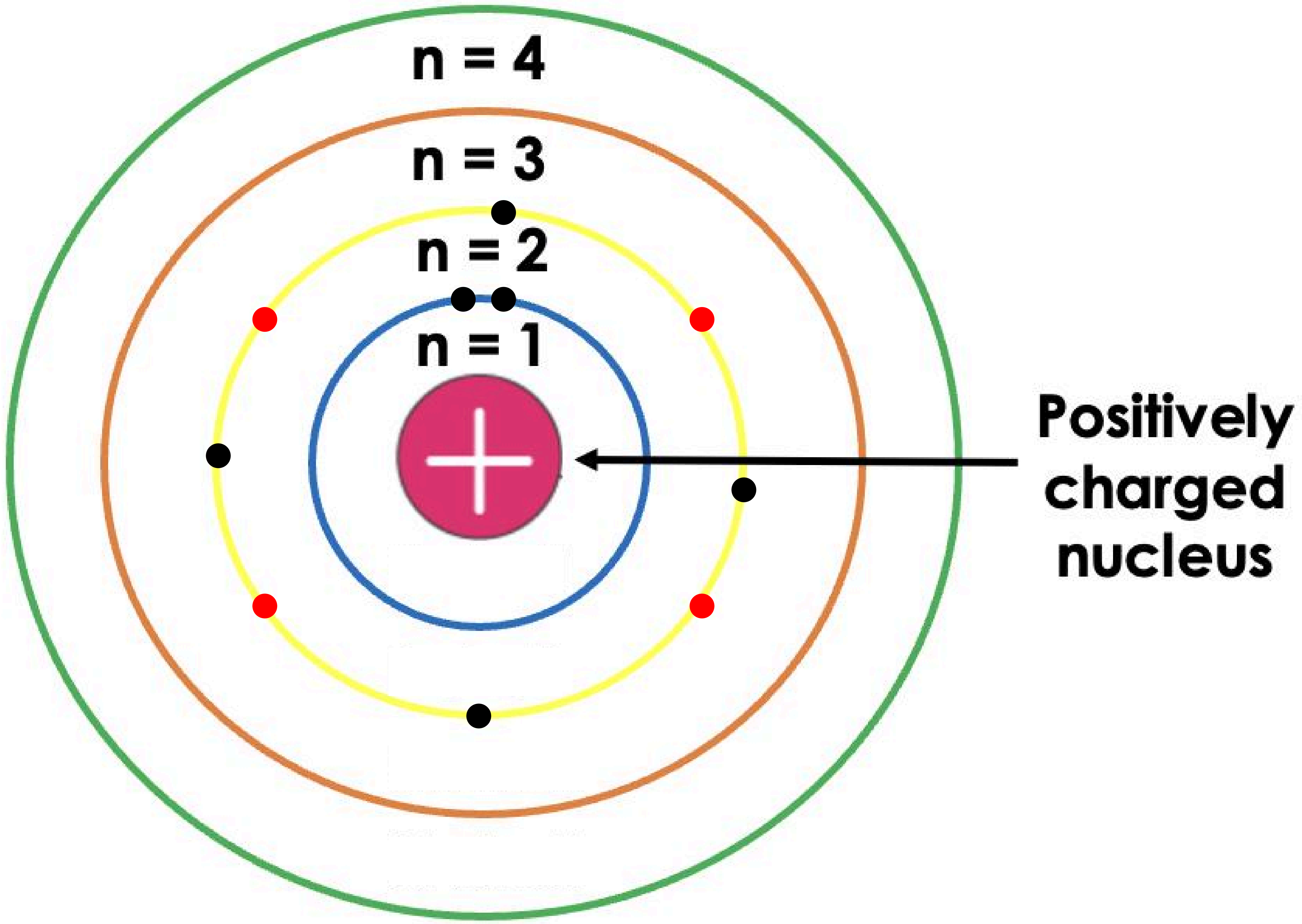
Example: Carbon

Octet Rule

The octet rule describes an atom's preference for having eight electrons in its valence shell.

Atoms with more or less than 8 valence electrons participate in chemical bonds to attain the octet.

Valence Shell: outer shell of the atom



Example: Carbon

If an atom has an incomplete outer shell, it is considered to be at a higher energy level and is more prone to reactivity. Unfilled or partially filled outer shells create a situation where the atom seeks to gain, lose, or share electrons to achieve a stable electron configuration. This tendency to interact with other atoms is the basis of chemical reactivity.

why are chemical bonds formed

Images | Quizlet | Short answer | In chemistry | Class 9 | Perspectives

About 199,000,000 results (0.48 seconds)

Why form chemical bonds? The basic answer is that atoms are trying to reach the most stable (lowest-energy) state that they can. Many atoms become stable when their valence shell is filled with electrons or when they satisfy the octet rule (by having eight valence electrons).

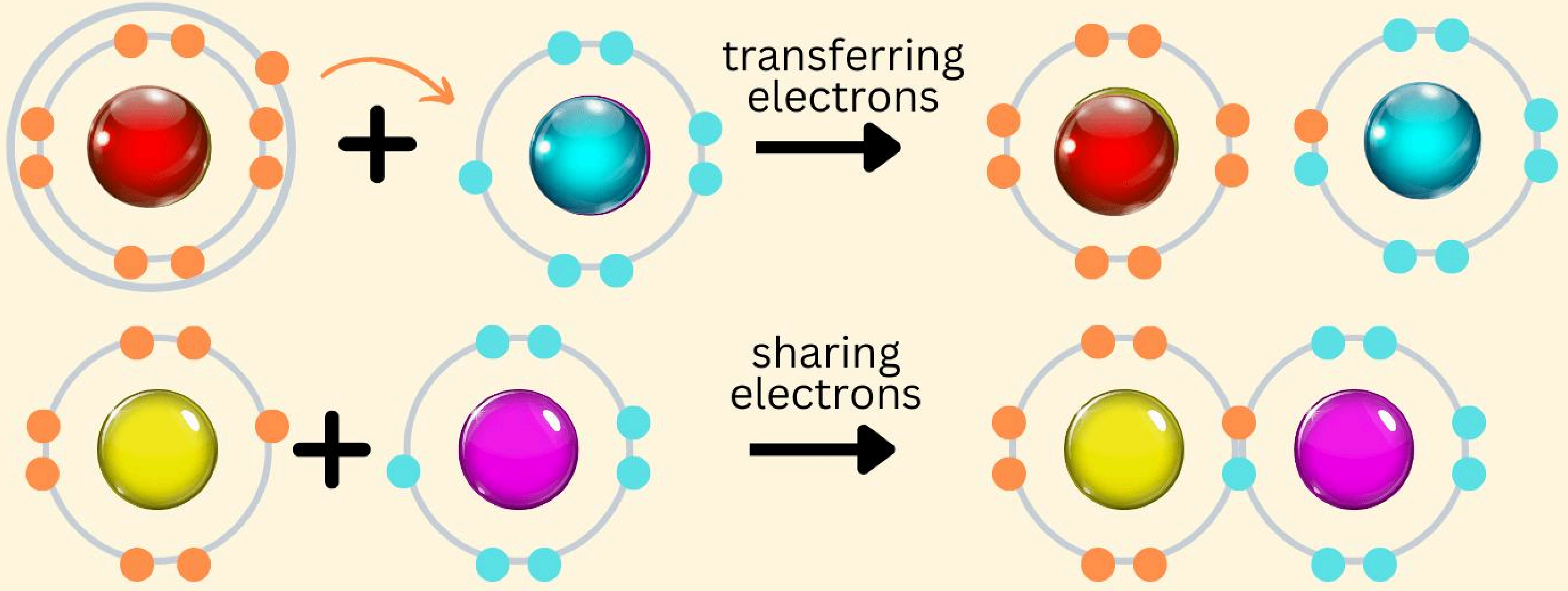
Khan Academy
https://www.khanacademy.org › chemistry-of-life › che...

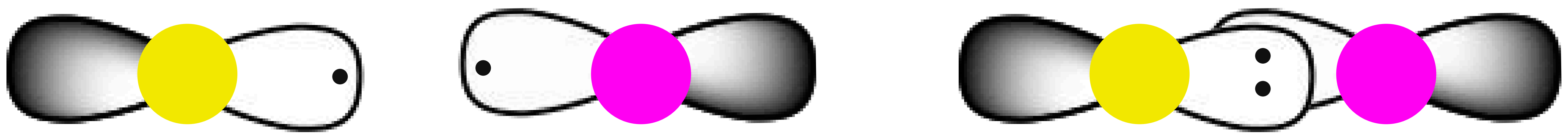
Chemical bonds | Chemistry of life | Biology (article)

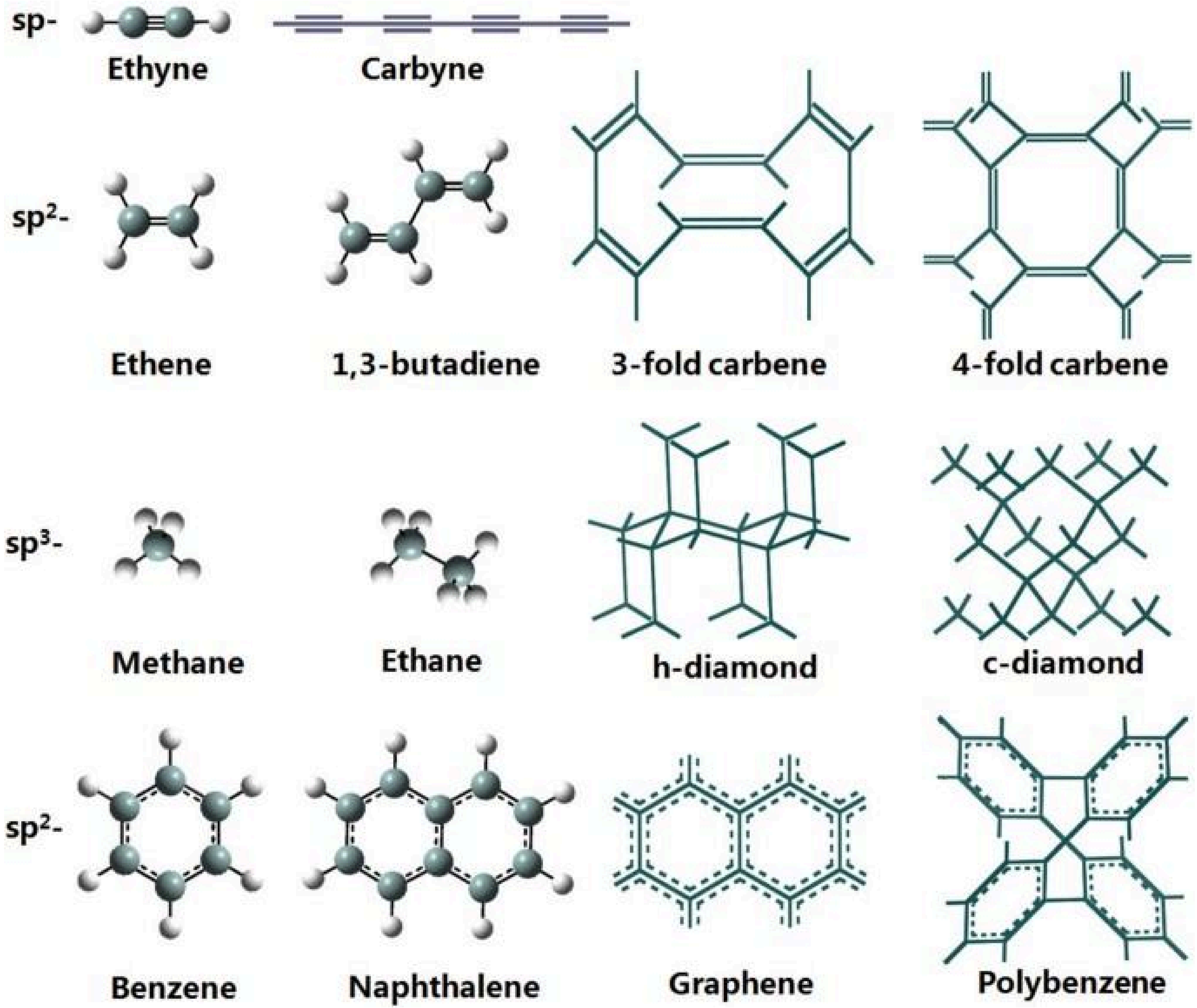
Octet Rule

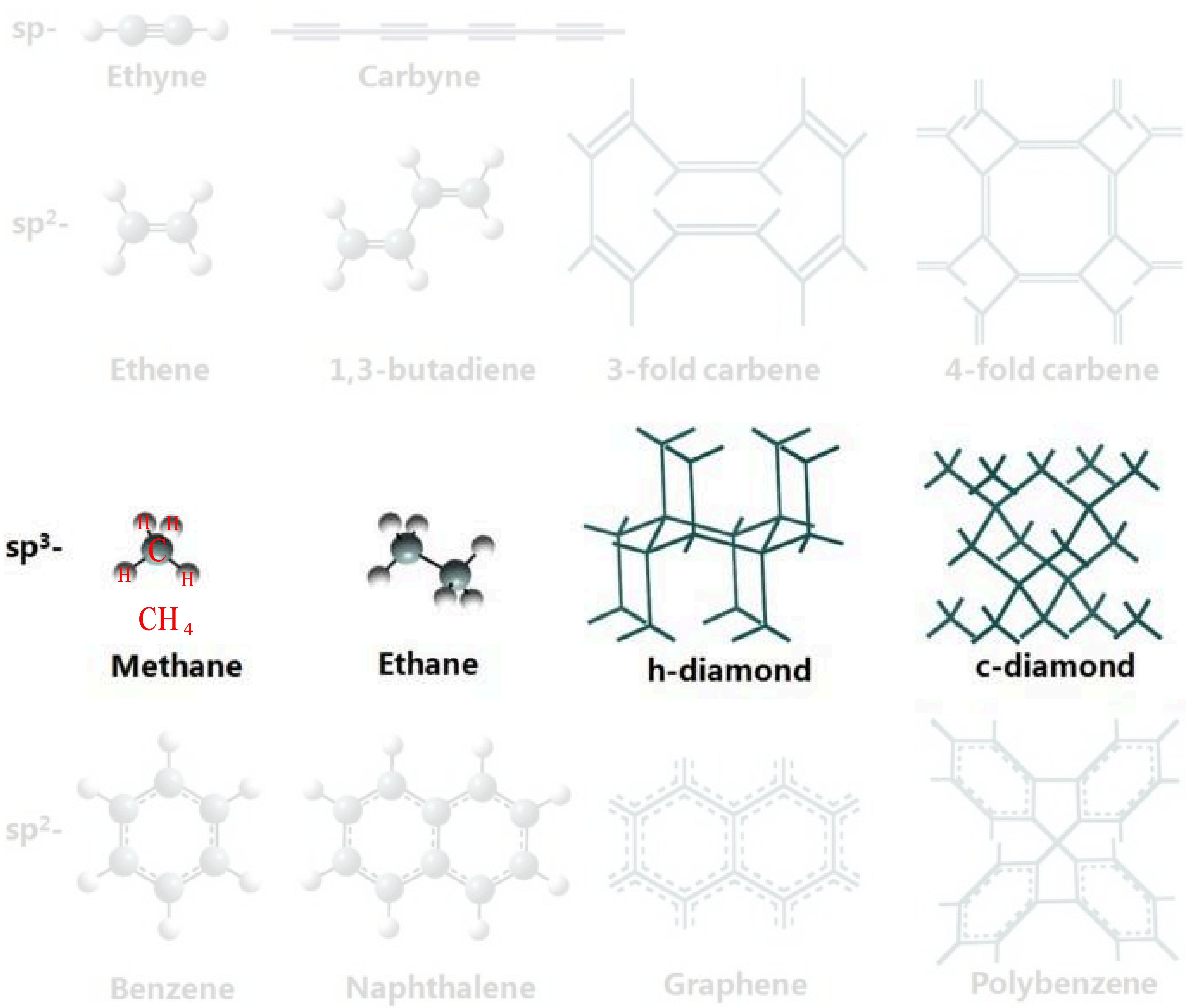
The octet rule describes an atom's preference for having eight electrons in its valence shell.

Atoms with more or less than 8 valence electrons participate in chemical bonds to attain the octet.

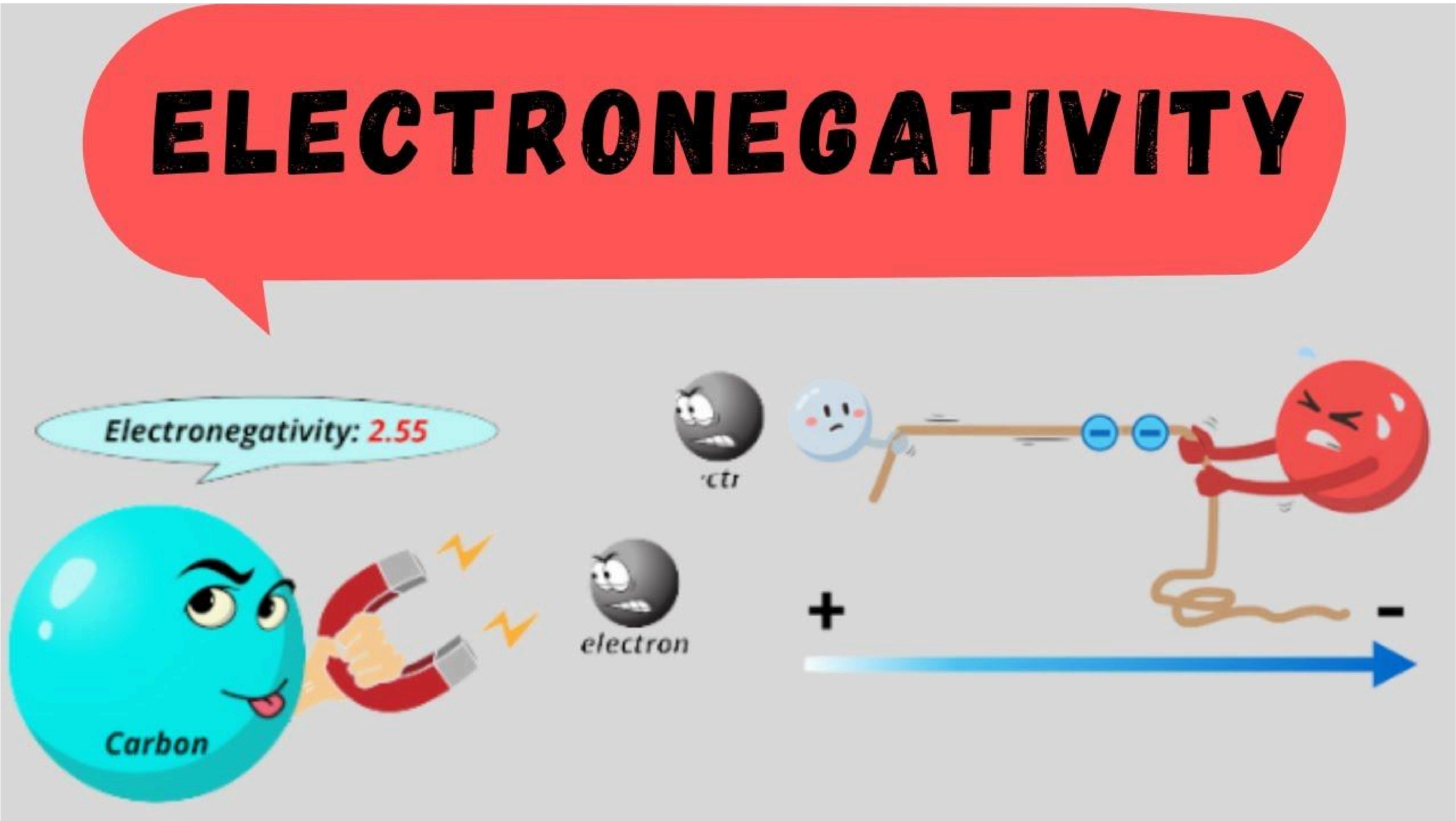




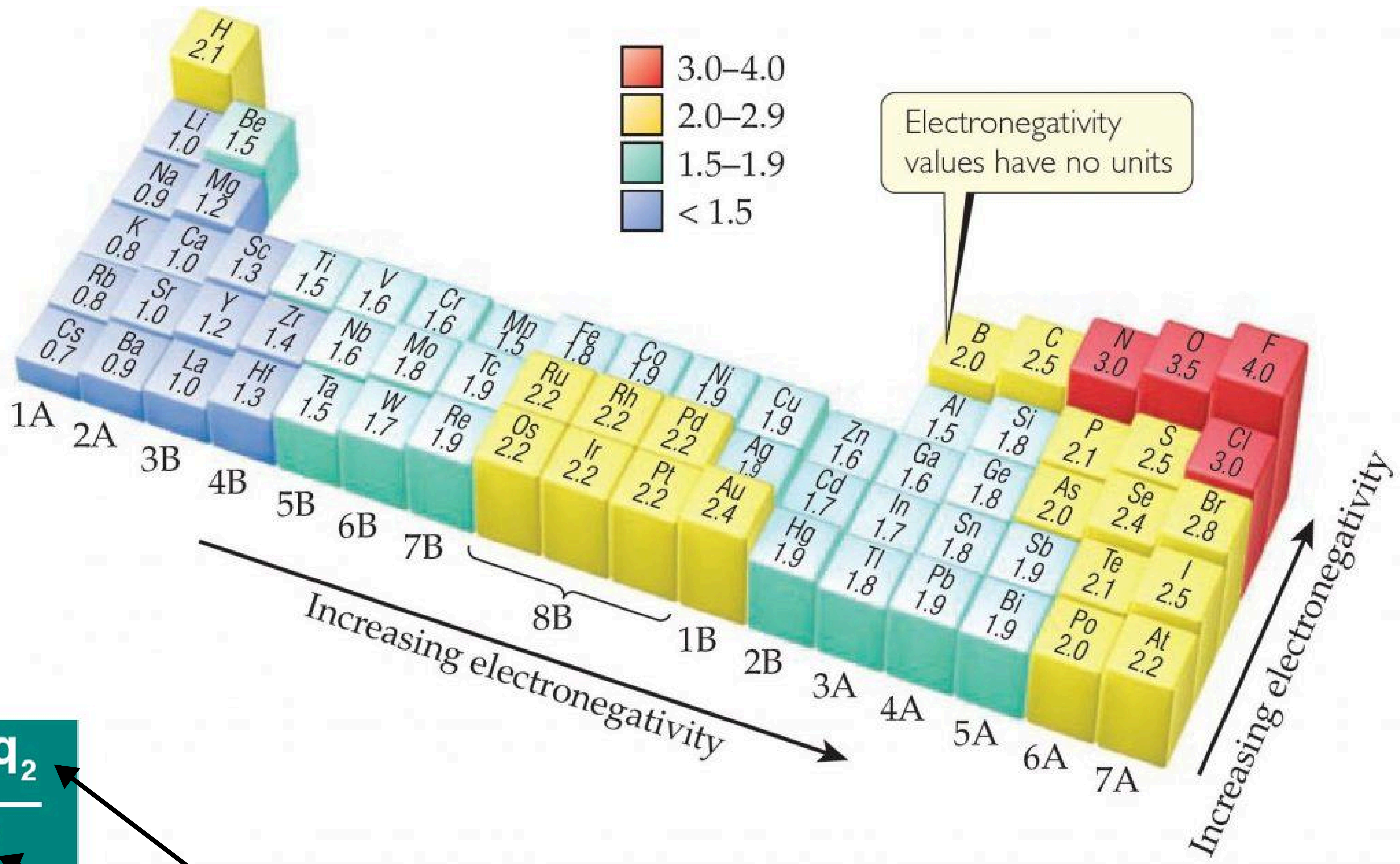

sp-
Ethyne
Carbyne
sp²-
Ethene
1,3-butadiene
3-fold carbene
4-fold carbene
sp³-
Methane
Ethane
h-diamond
c-diamond
sp²-
Benzene
Naphthalene
Graphene
Polybenzene



sp-
Ethyne
Carbyne
sp2-
Ethene
1,3-butadiene
3-fold carbene
4-fold carbene
sp3-
H
H
C
H
H
CH 4
Methane
Ethane
h-diamond
c-diamond
sp2-
Benzene
Naphthalene
Graphene
Polybenzene



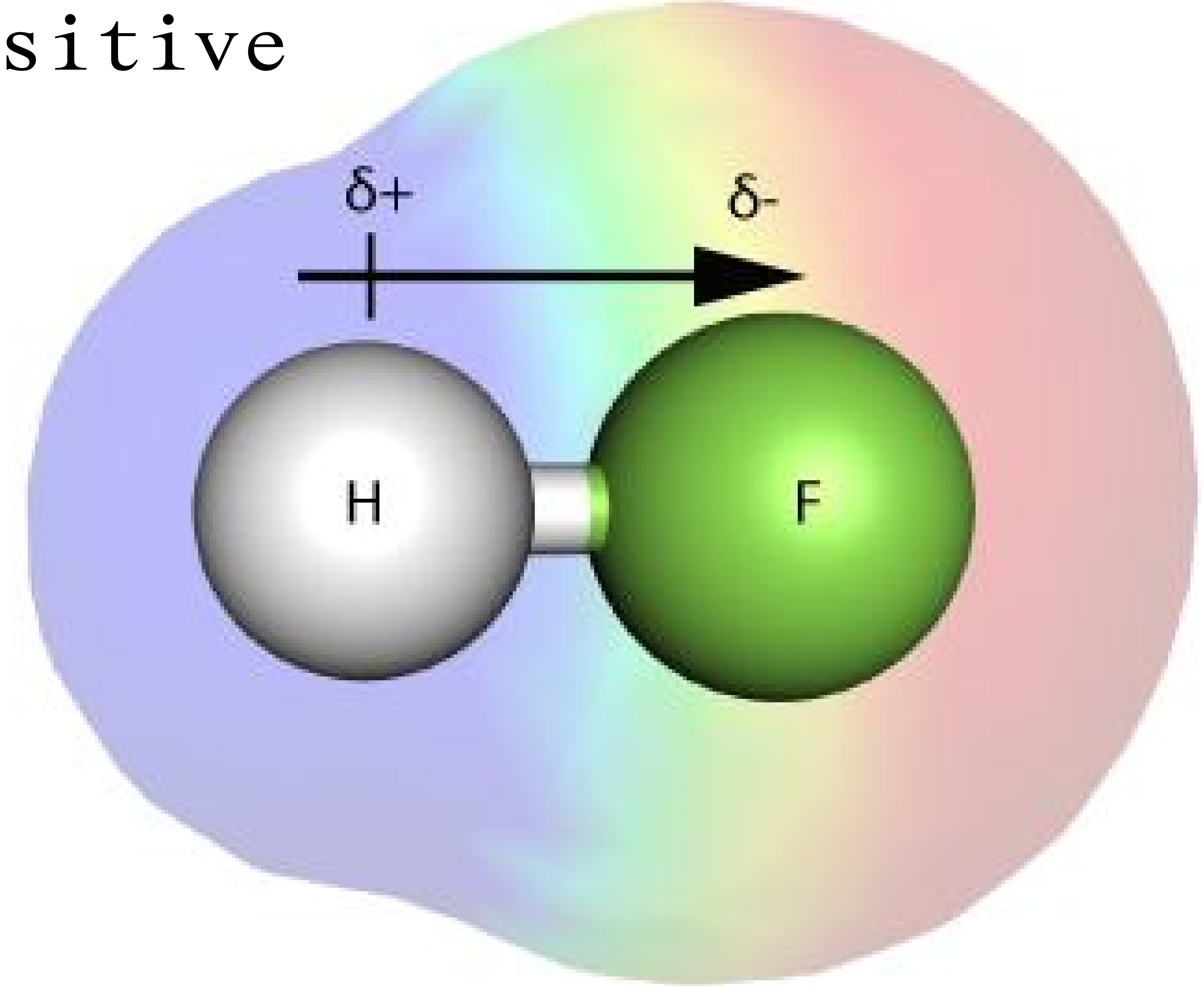
Electronegativity is the attraction an atom has for a shared pair of electrons



$$F = k\,\frac{q_1 \cdot q_2}{r^2}$$

1. # of protons (positive charge)
2. # of electron shells

Delta
positive



Delta
negative

More electron
density

Types of Bonds

Government bonds

Support government spending; risk based on credit rating

Corporate bonds

Raise capital for companies; risk linked to finances

Municipal bonds

Fund local government operations and projects

Agency bonds

Issued by government agencies, often considered safe

Junk bonds

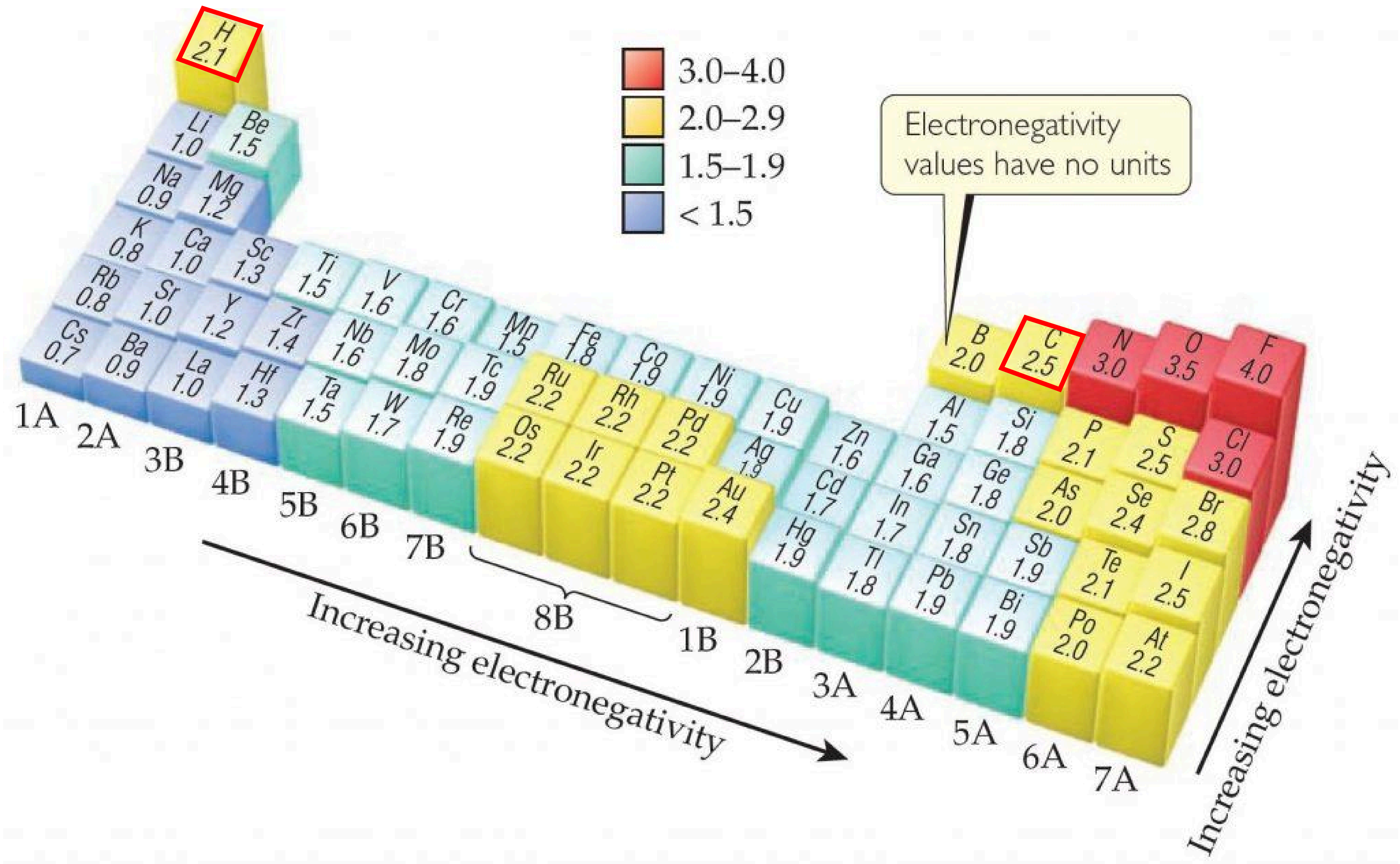
High-risk, high-yield bonds from low-rated companies

Zero-Coupon bonds

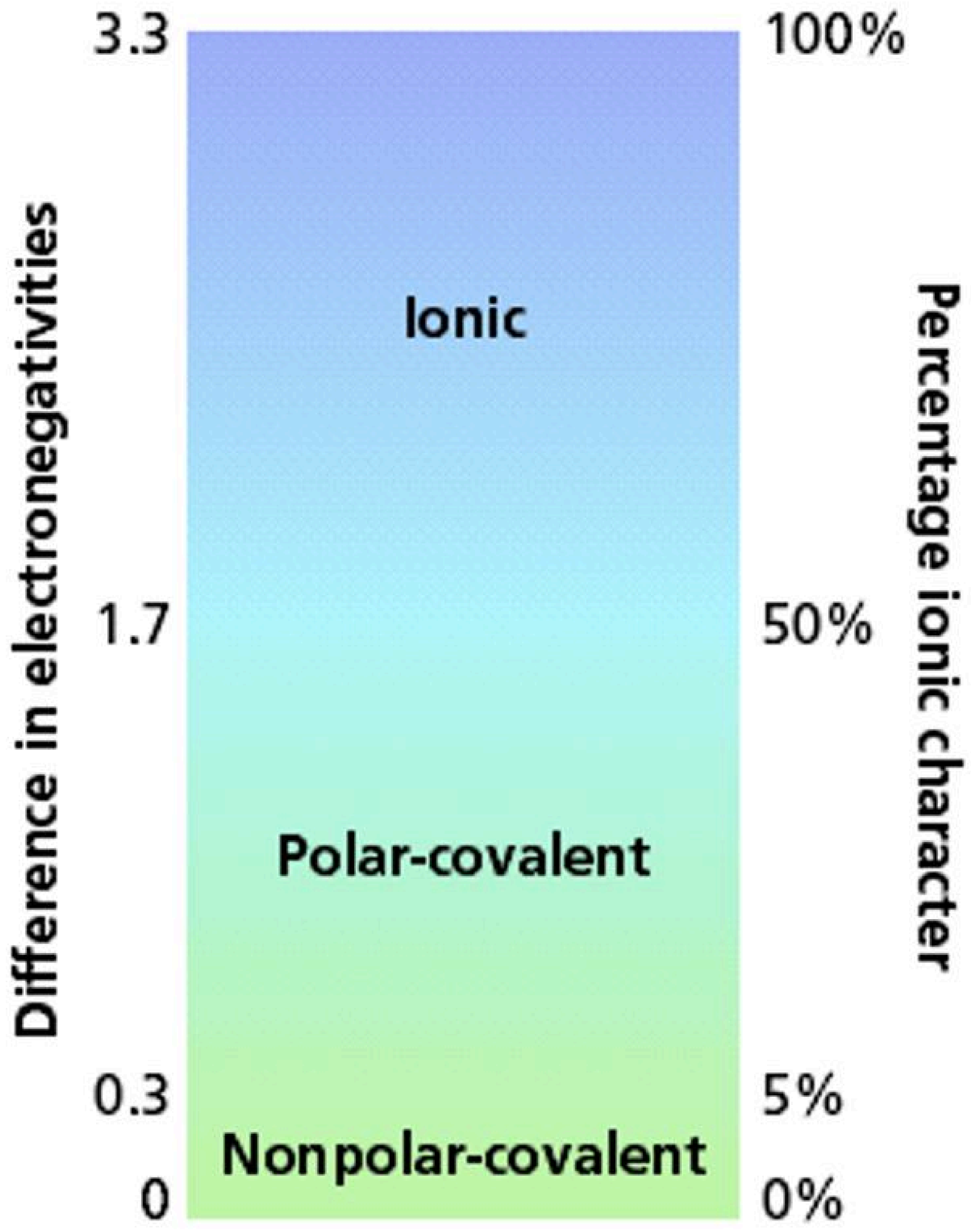
No interest, sold at a discount, return at maturity

Techopedia

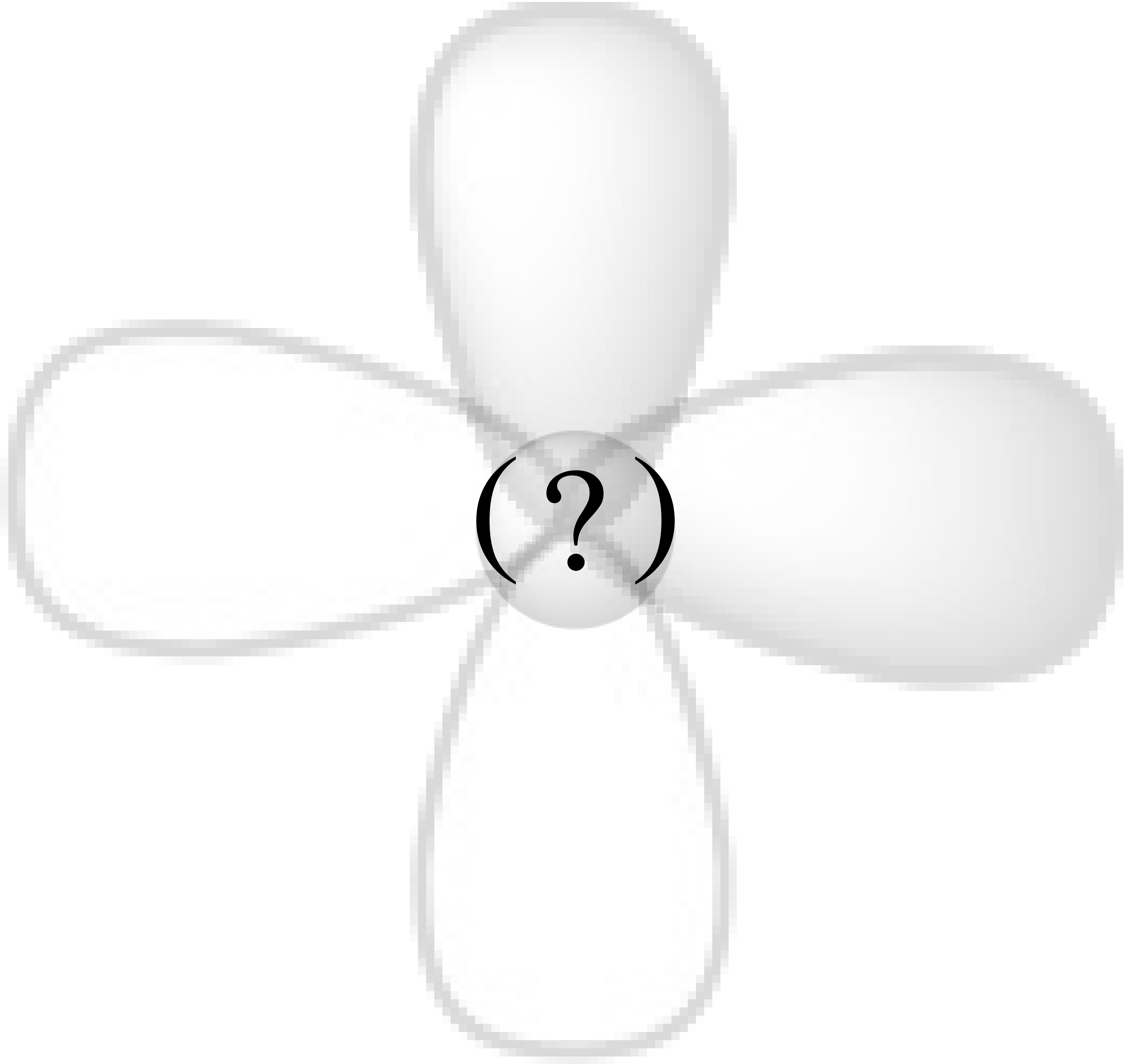
	Covalent Bonding	Ionic Bonding
Species Involved	atoms	Ions (cations and anions)
Electrons	shared	Taken by the more electronegative participant
Interactions	Balance of attractive and repulsive forces between atoms Can be polar or nonpolar depending on atoms' electronegativities	Weak electrostatic forces keep ions bonded together
Examples	H_2O (water) Cl_2 (chlorine gas)	NaCl (sodium chloride) $CaCO_3$ (calcium carbonate)



3.0–4.0
2.0–2.9
1.5–1.9
< 1.5
Electronegativity values have no units
Increasing electronegativity
Increasing electronegativity

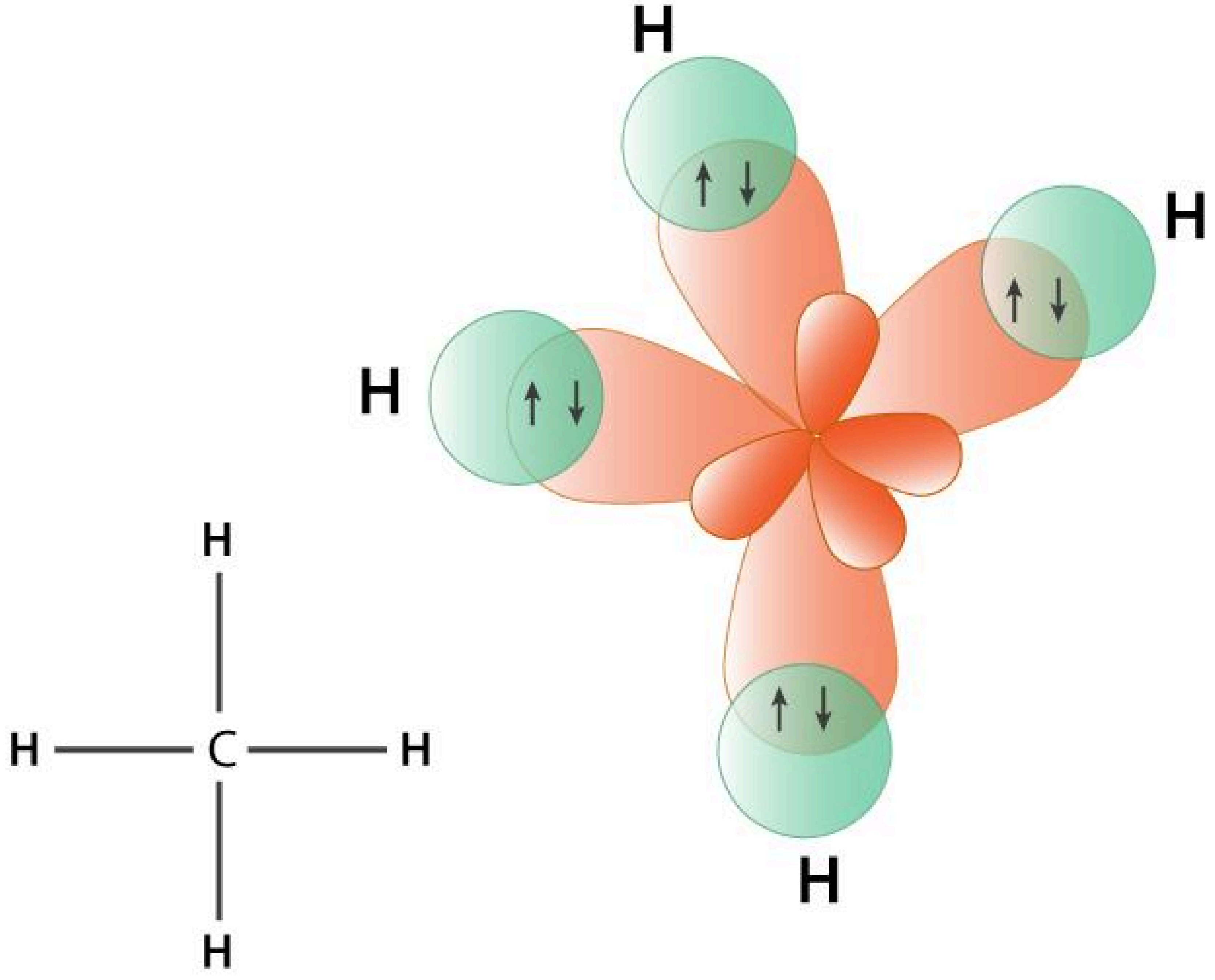


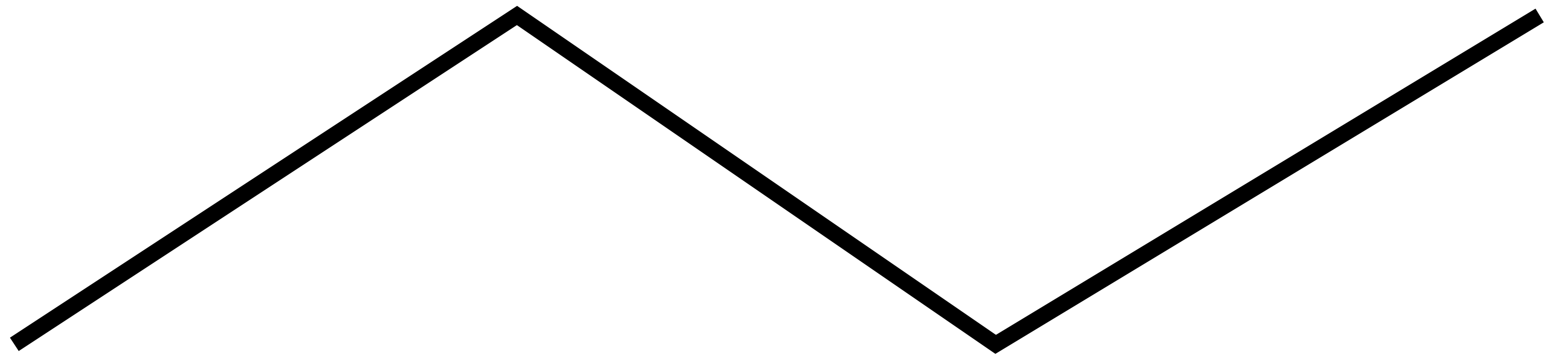
3.3
1.7
0.3
0
100%
50%
5%
0%
Ionic
Polar-covalent
Nonpolar-covalent
Difference in electronegativities
Percentage ionic character

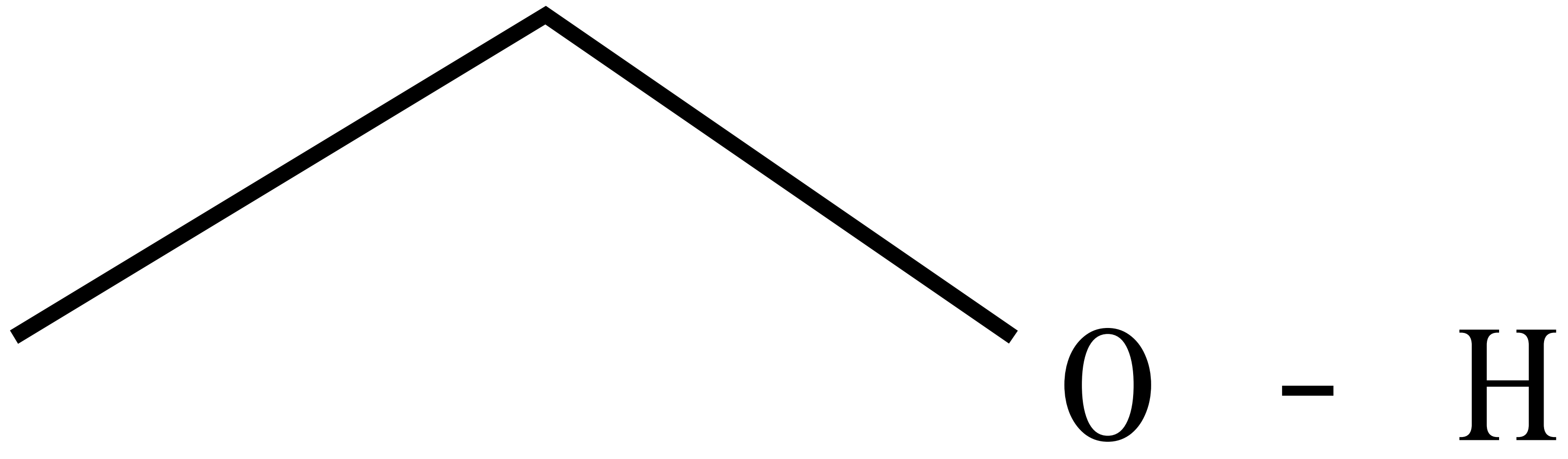


Example: Carbon

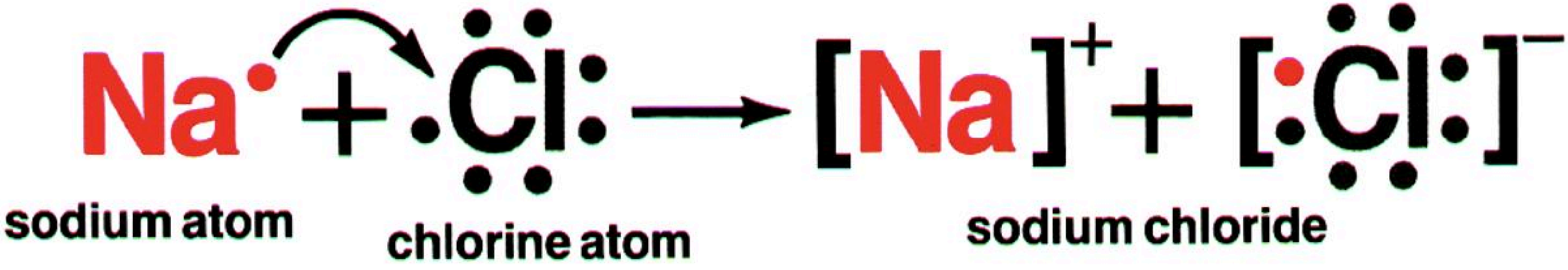
Hybridization of CH_4



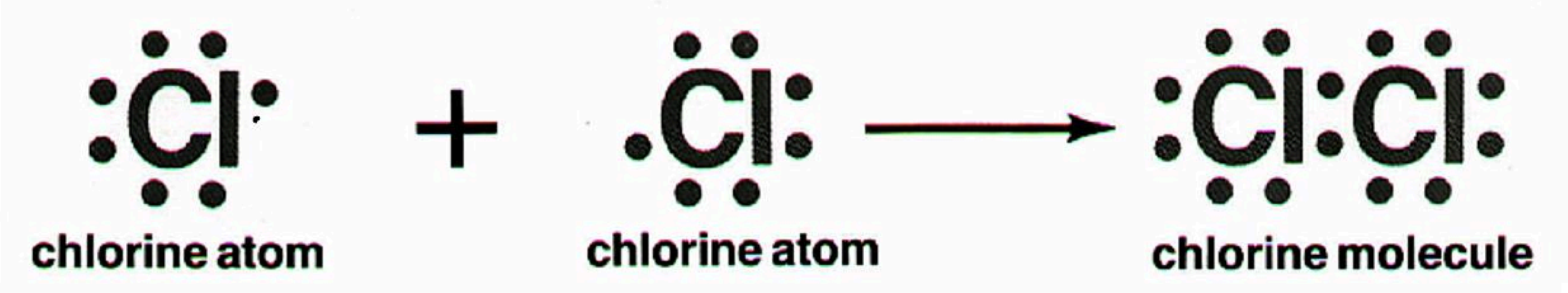



O - H

- **Ionic** – show transfer of e-

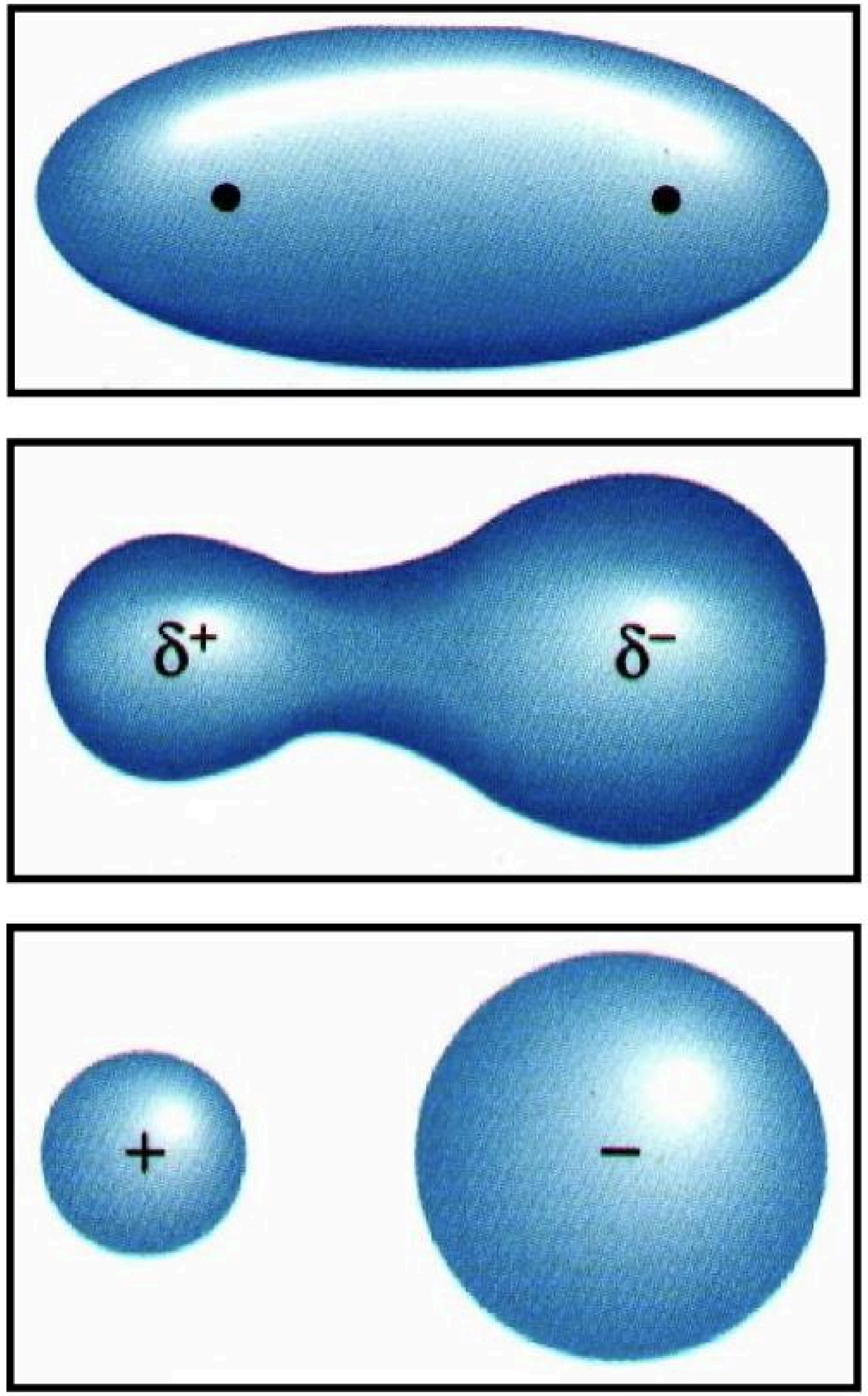


- **Covalent** – show sharing of e-



- Nonpolar
- Polar
- Ionic

View [Bonding Animations]



- **Nonpolar Covalent Bond**
  - e^- are shared equally
  - symmetrical e^- density
  - usually identical atoms

- **Polar Covalent Bond**
  - e^- are shared unequally
  - asymmetrical e^- density
  - results in partial charges (dipole)

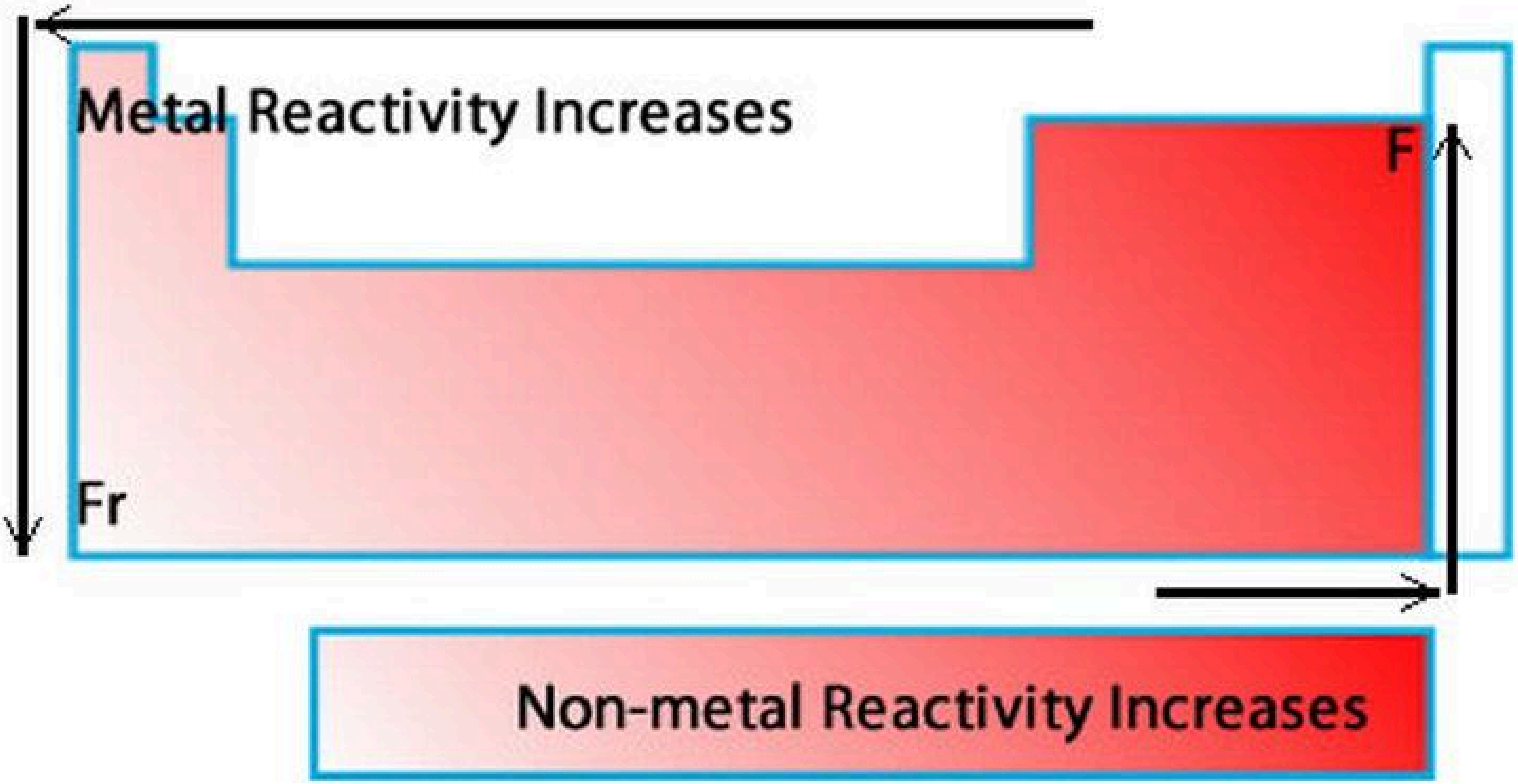
Ionic Bond

- e- are not shared
- asymmetrical e- density
- real charges, not partial charge

INCREASING ELECTRONEGATIVITY

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

INCREASING ELECTRONEGATIVITY


Metal Reactivity Increases
F
Fr
Non-metal Reactivity Increases

Activity: Defining Relationships as Chemical Bonds

Look at the two individuals described in the prompt

Think about electronegativity

- Think about imbalance around taking and receiving in the pair relationship
  - What are the magnitudes of taking and receiving?

Based on the electronegativity of each atom and the difference in electronegativity in the pair, label the type of bond relationships

Defining Relationships through Chemical Bonds Activity

Example

Prompt: Your Best Friend

Jerome Wang	&	Danny Dang

( ) Ionic

(x) Polar Covalent

( ) Non-polar Covalent

Danny has been my best friend since middle school and have remained good friends 15 years later. Although our relationship has been strong, there is definitely an energy imbalance and I tend to be emotionally needy and demanding of him when I need someone. For example, I will call him expecting him to pick up irregardless of where he is or what he is doing, even though talking on the phone is his least preferred form of communication.