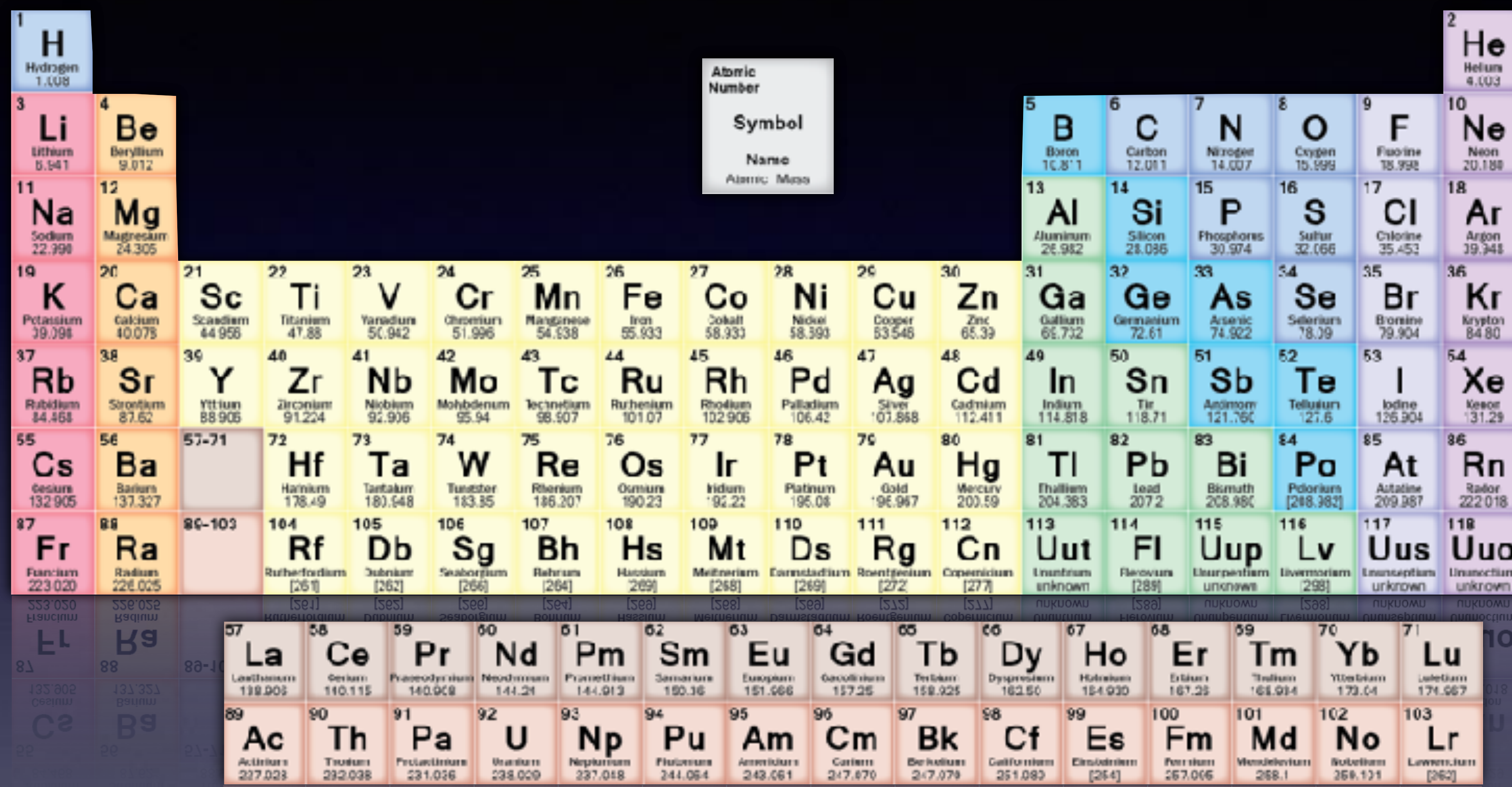
Previously in Molecularity…

Periodic trend in IE, EA, EN

Increasing or decreasing?



Increasing or decreasing?

Do you understand the rules and exceptions?

Here endeth Chapter 3

- §3.2 Periodic Law, Table
- §3.3 Electronic configuration: How electrons occupy orbitals
- §3.4 Electronic configuration: Valence electrons & the periodic table
- §3.5 Electronic configuration and elemental properties
- §3.6 Periodic trends in atomic size and Z_{eff}
- §3.7 Ions: electron configurations, magnetic properties, radii, and ionization energy
- §3.8 Electron affinities and metallic character
- §3.9 Periodic trends summary

Here starteth Chapter 4 and 5

- §4.2 Types of chemical bonds
- §4.3 Representing compounds: Chemical formulas and molecular models
- §4.4 The Lewis model: Representing valence electrons with dots
- §4.5 Ionic bonding: the Lewis model and lattice energies
- §4.6 Ionic compounds: formulas and names
- §4.7 Covalent bonding: simple Lewis structures
- §4.8 Molecular compounds: formulas and names
- §4.9 Formula mass and the mole concept for compounds
- §4.10 Composition of compounds
- §4.11 Determining a chemical formula from experimental data
- §4.12 Organic compounds

Here starteth Chapter 4 and 5

- §4.2 Types of chemical bonds (today)
- §4.3 Representing compounds: Chemical formulas and molecular models
- §4.4 The Lewis model: Representing valence electrons with dots (tomorrow)
- §4.5 Ionic bonding: the Lewis model and lattice energies (not strong focus in class)
- §4.6 Ionic compounds: formulas and names
- §4.7 Covalent bonding: simple Lewis structures (tomorrow)
- §4.8 Molecular compounds: formulas and names
- §4.9 Formula mass and the mole concept for compounds
- §4.10 Composition of compounds (near the end of the course, not exam #2)
- §4.11 Determining a chemical formula from experimental data (near end, not E2)
- §4.12 Organic compounds

Here starteth Chapter 4 and 5

- §5.2 Electronegativity and bond polarity (percent ionic character)
- §5.3 Writing Lewis structures for molecular compounds and polyatomic ions
- §5.4 Resonance and formal charge
- §5.5 Exceptions to the octet rule: odd-electrons, incomplete/expanded octets
- §5.6 Bond energies and bond lengths (out of order)
- §5.7 VSEPR theory: the five basic shapes
- §5.8 VESPR theory: lone pairs are fat
- §5.9 VSEPR theory: predicting molecular geometries
- §5.10 Molecular shape and polarity

Where are we going today?

Ch1010-A17-A03 Lecture 11

- The nature of the chemical bond
- §4.2 Types of chemical bonds
- §5.2 Electronegativity and chemical bonds

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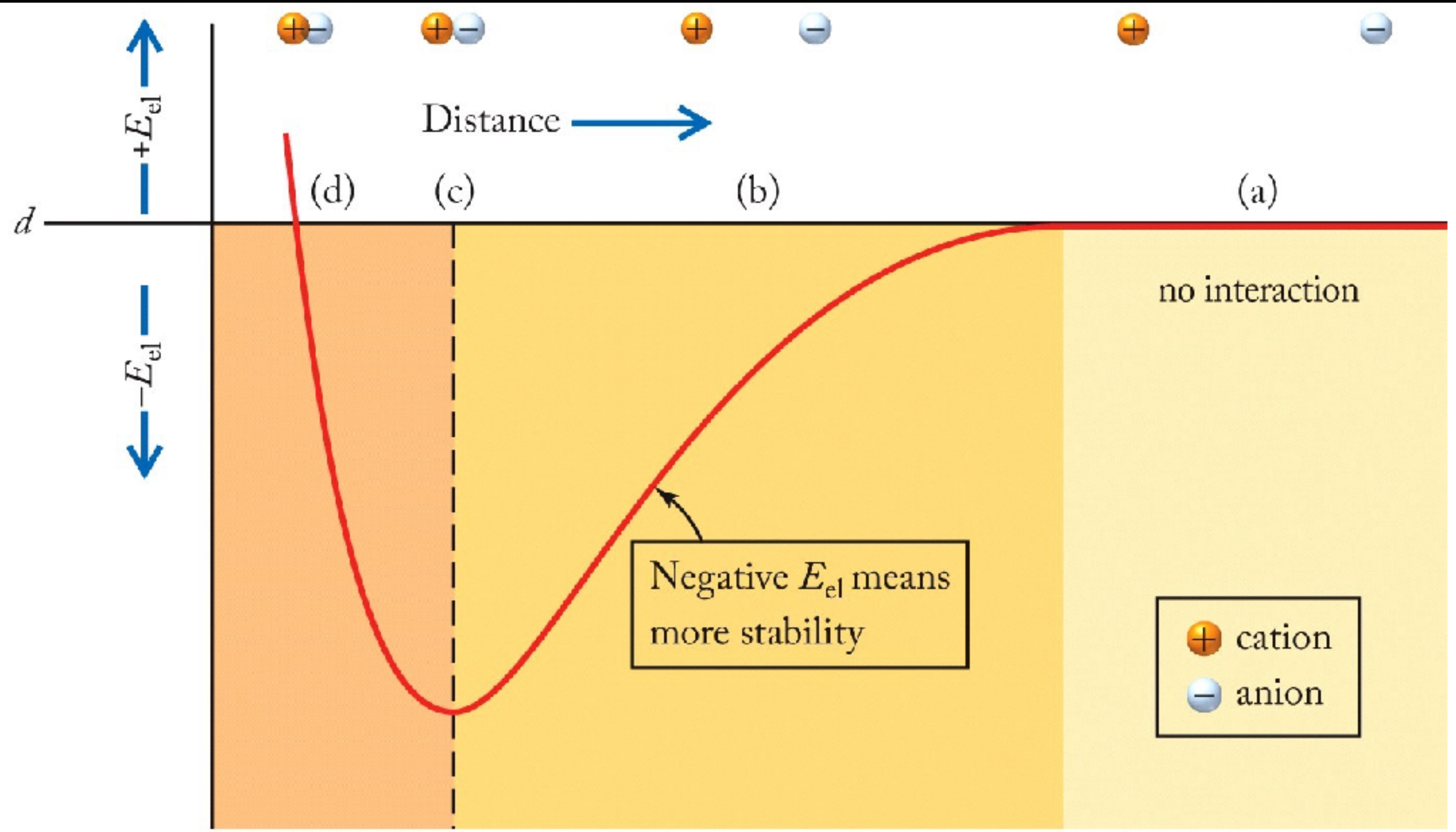
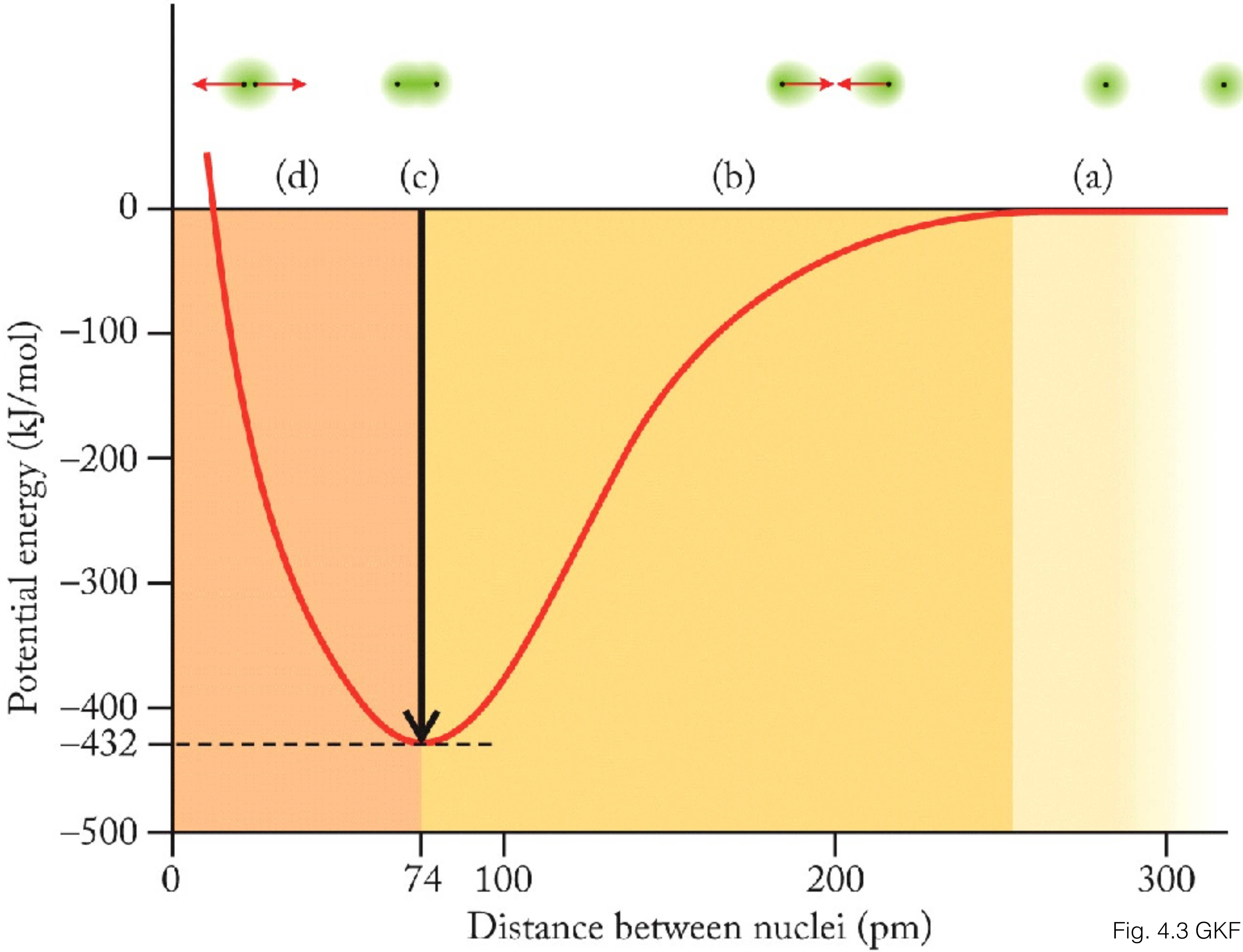


$+E_{el}$
$-E_{el}$
d
Distance
(d)
(c)
(b)
(a)
no interaction
Negative E_{el} means more stability
cation
anion

Fig. 4.1 GKF



(d)
(c)
(b)
(a)
Potential energy (kJ/mol)
0
−100
−200
−300
−400
−432
−500
0
74
100
200
300
Distance between nuclei (pm)

Fig. 4.3 GKF

- Which atom “wins” the electrons in a bond?
- Are they shared equally?
- Does one atom take all of the electrons?
- Is there any way to predict this?

Cl_2

HCl

NaCl

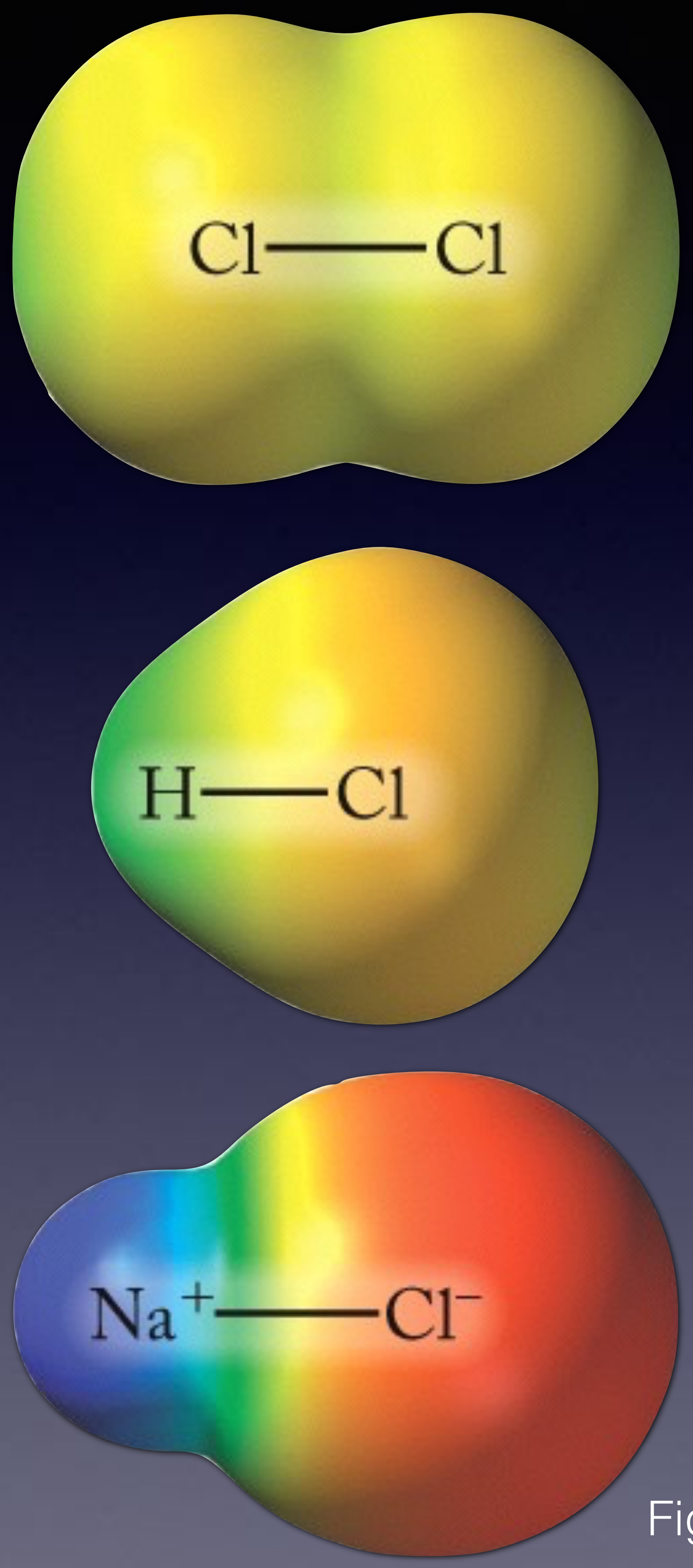
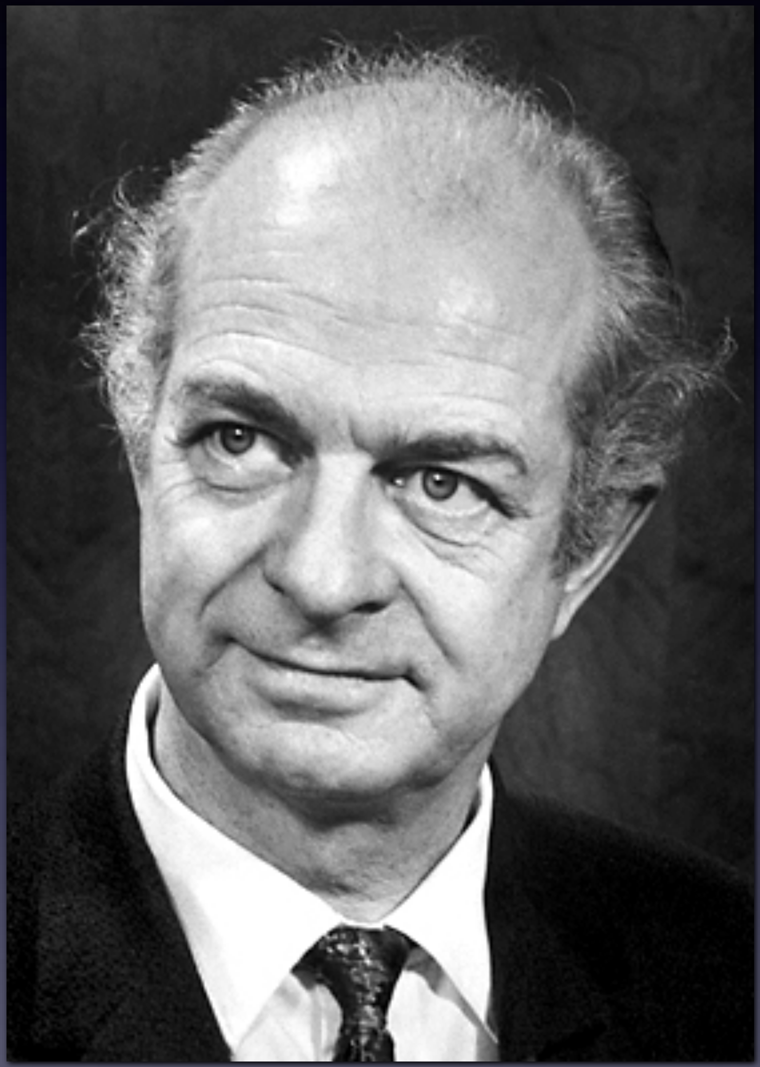


Fig. 4.7 GKF

Electronegativity

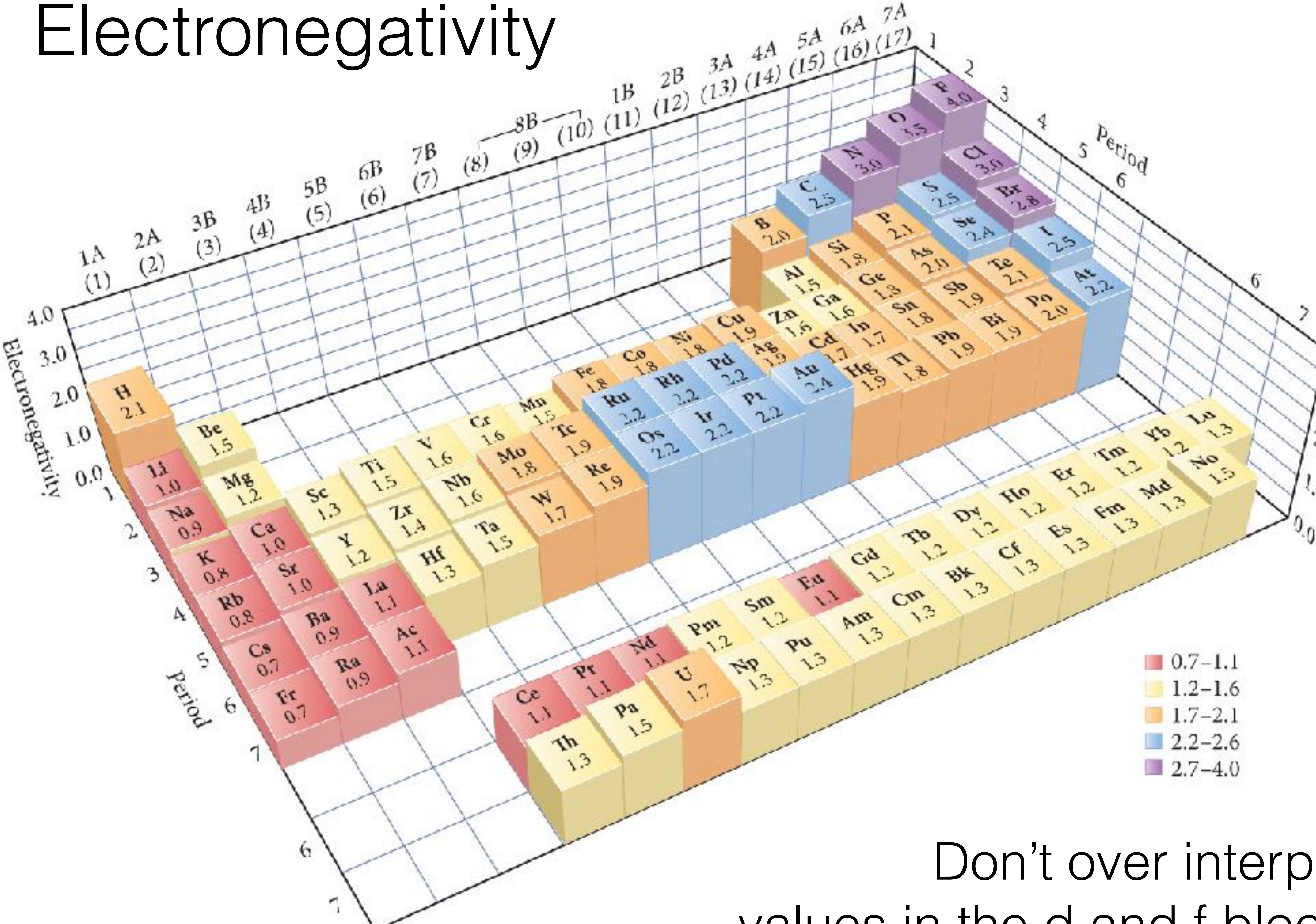
- Describes an atom's preference to gain electrons.
- Scale 1 (low pref.) – 4 (high pref.)
- <u>Qualitatively</u> assigned values based on bond energies, but quantitative definitions exist (see Mullikan)
- Also predicts which atom in a bond would "win" the electrons.



Linus Pauling

www.nobelprize.org
pauling_postcard.jpg

Electronegativity

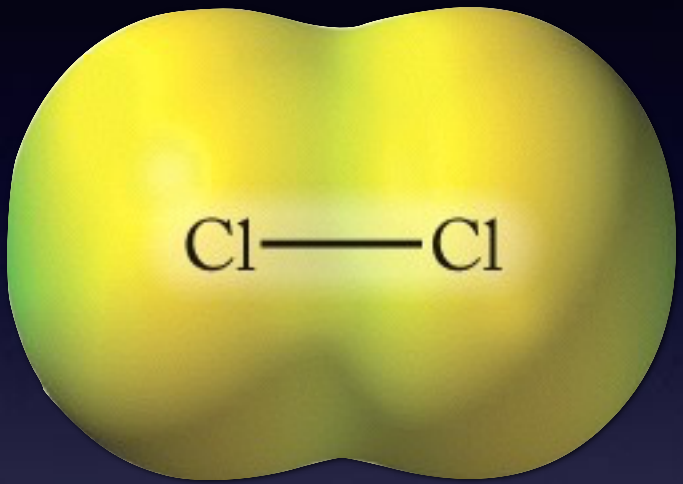


Don't over interpret values in the d and f blocks

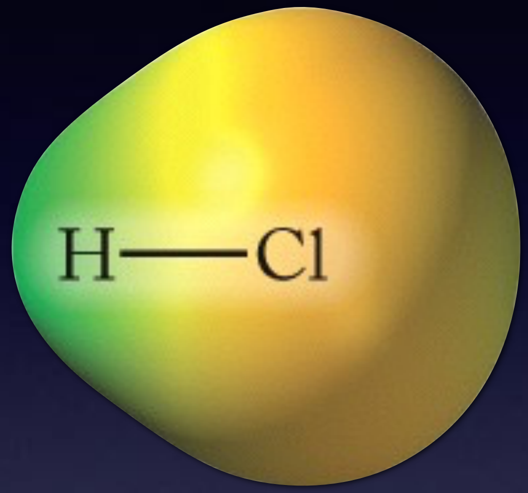
Tro
Fig 9.8

The nature of the chemical bond

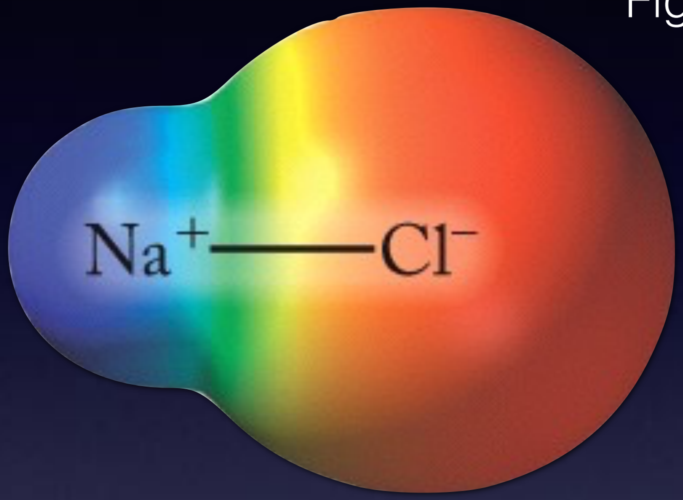
Fig. 4.7
GKF



Cl_2
Nonpolar covalent
Δ EN < 0.5



HCl
Polar covalent
0.5 < Δ EN < 1.6

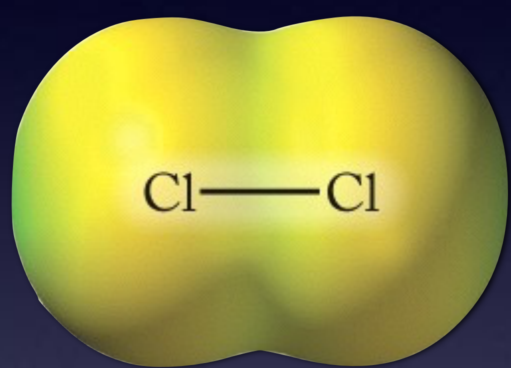


NaCl
Ionic bonds
Δ EN ≥ 2.0

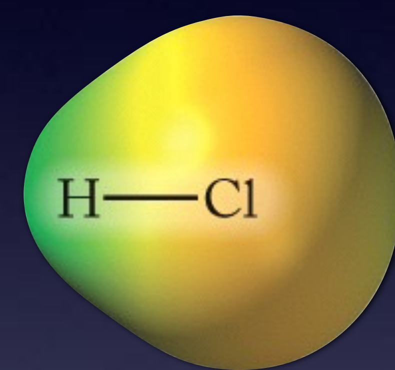
Also metallic bonds.

Using EN to predict bond type…

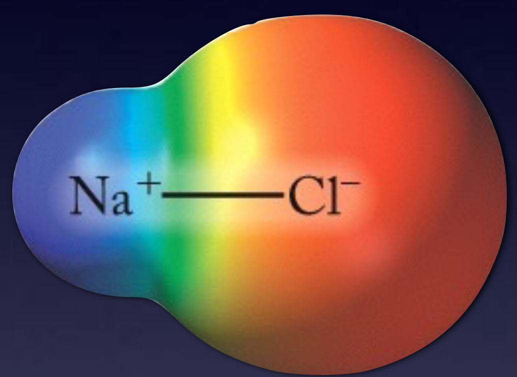
- Predict the bond type (nonpolar covalent, polar covalent, ionic, metallic) of the following molecules / compounds



Nonpolar covalent
Δ EN < 0.5



Polar covalent
0.5 < Δ EN < 1.6



Ionic bonds
Δ EN ≥ 2.0

- Calcium oxide
- Nitrogen monoxide
- Hydrochloric acid
- Hydrofluoric acid
- Lithium chloride
- Copper

Nonpolar covalent bonds

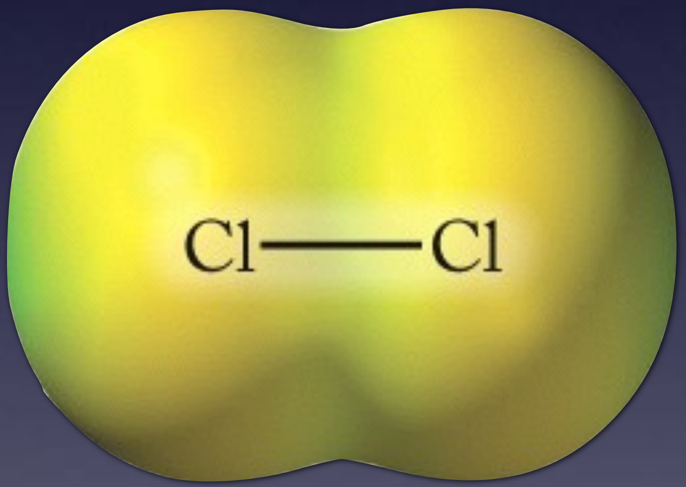


Fig. 4.7 GKF

Nonpolar covalent bonds

- Discrete molecules, and electrons are **shared ~equally**
- Well defined bond energies and bond strengths
- Typical example molecules:
  hydrocarbons
  homonuclear diatomics

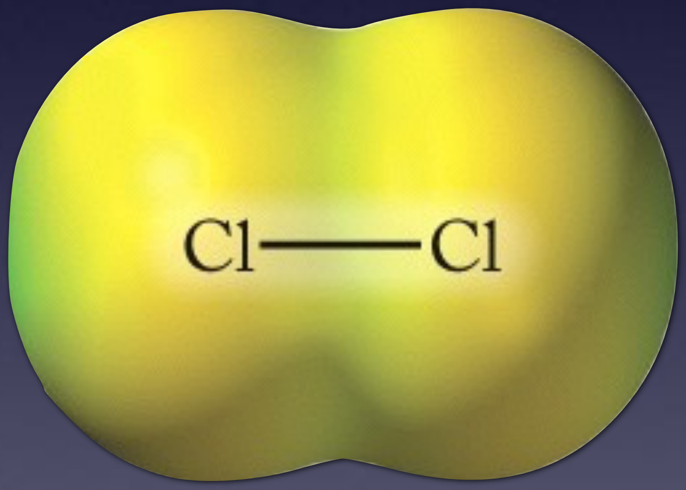


Fig. 4.7 GKF

Polar covalent molecules

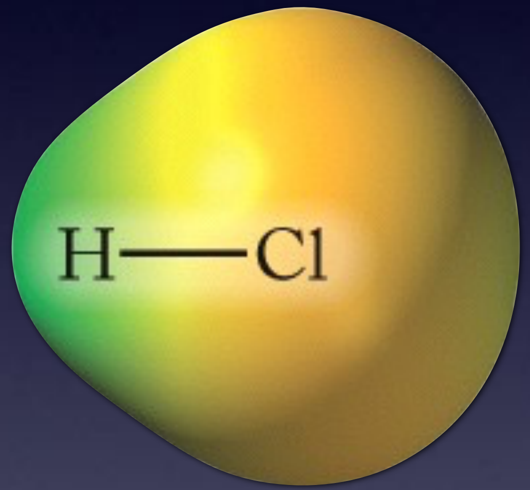


Fig. 4.7 GKF

Polar covalent molecules

- Discrete molecules, electrons **shared unequally**
- Atom with larger negativity has a partial negative charge, other atom has a partial positive charge
- Typical example molecules:
  water
  hydrochloric acid

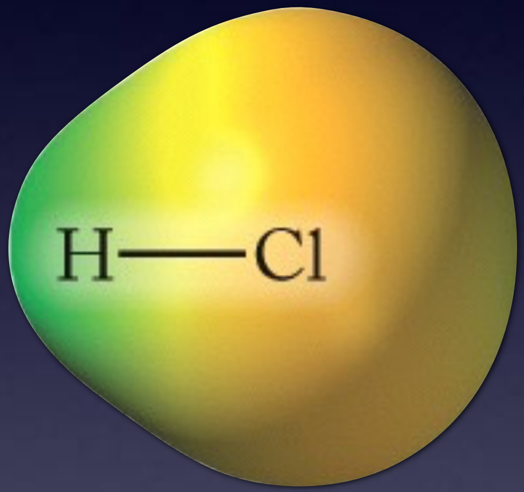


Fig. 4.7 GKF

Ionic bonds

- Nearly complete electron transfer from one atom to the other
- Usually between metals and strongly electronegative compounds (e.g. halogens).
- Compounds rarely exist as distinct molecules and often fall apart in water (i.e. solvation).

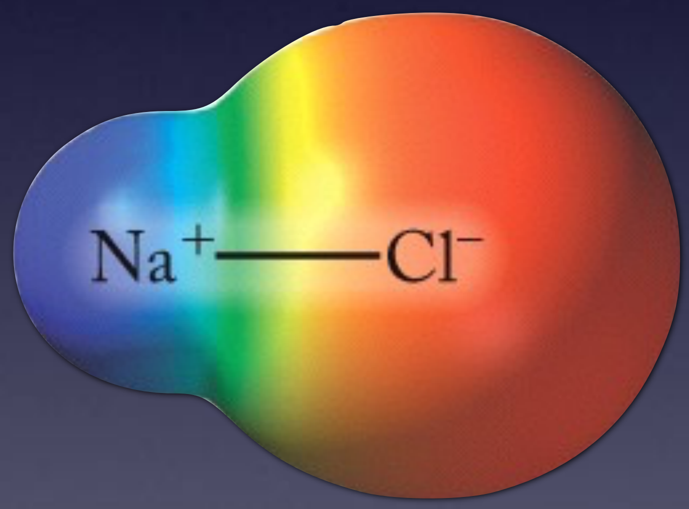
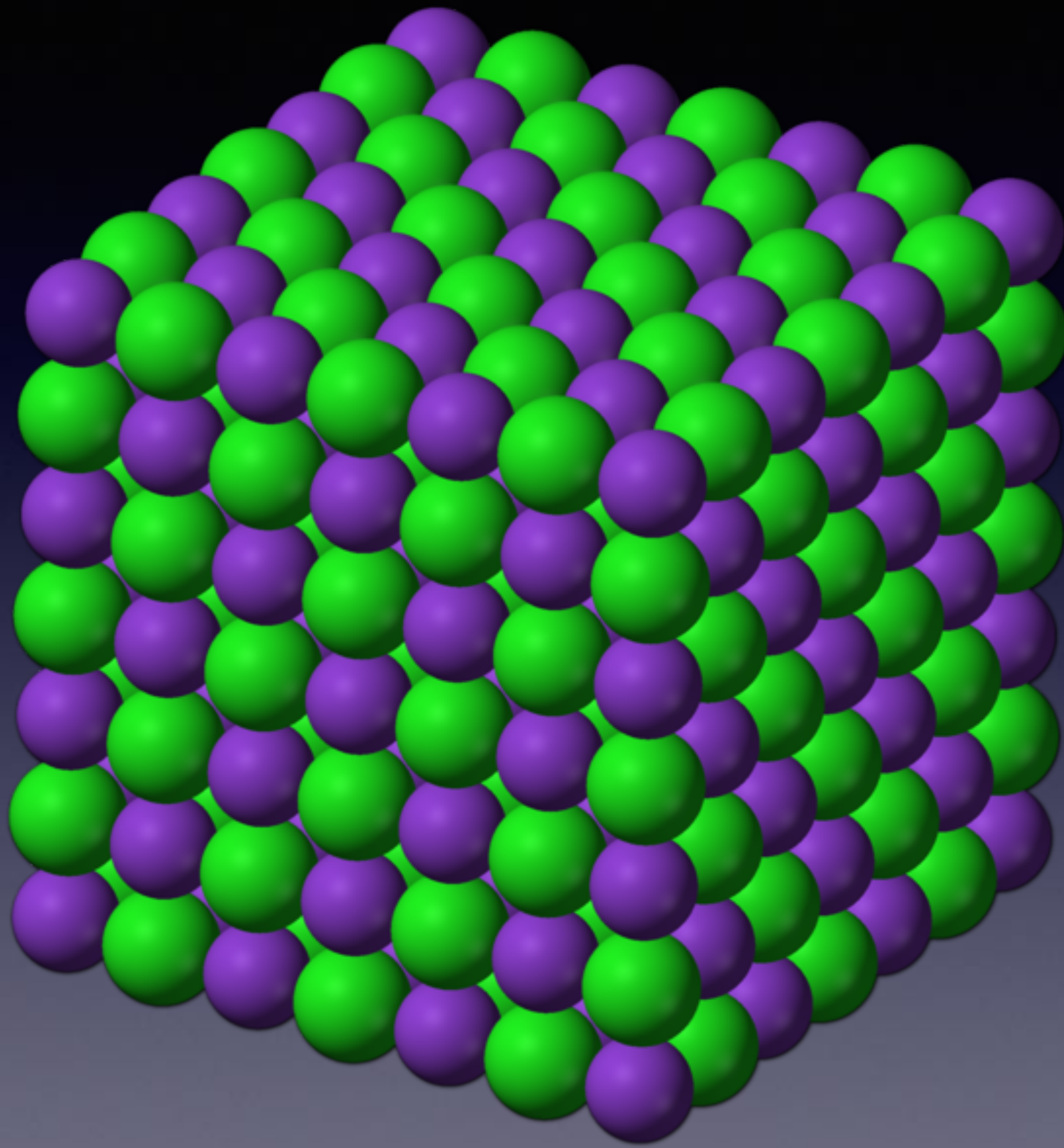


Fig. 4.7 GKF

Ionic bonds



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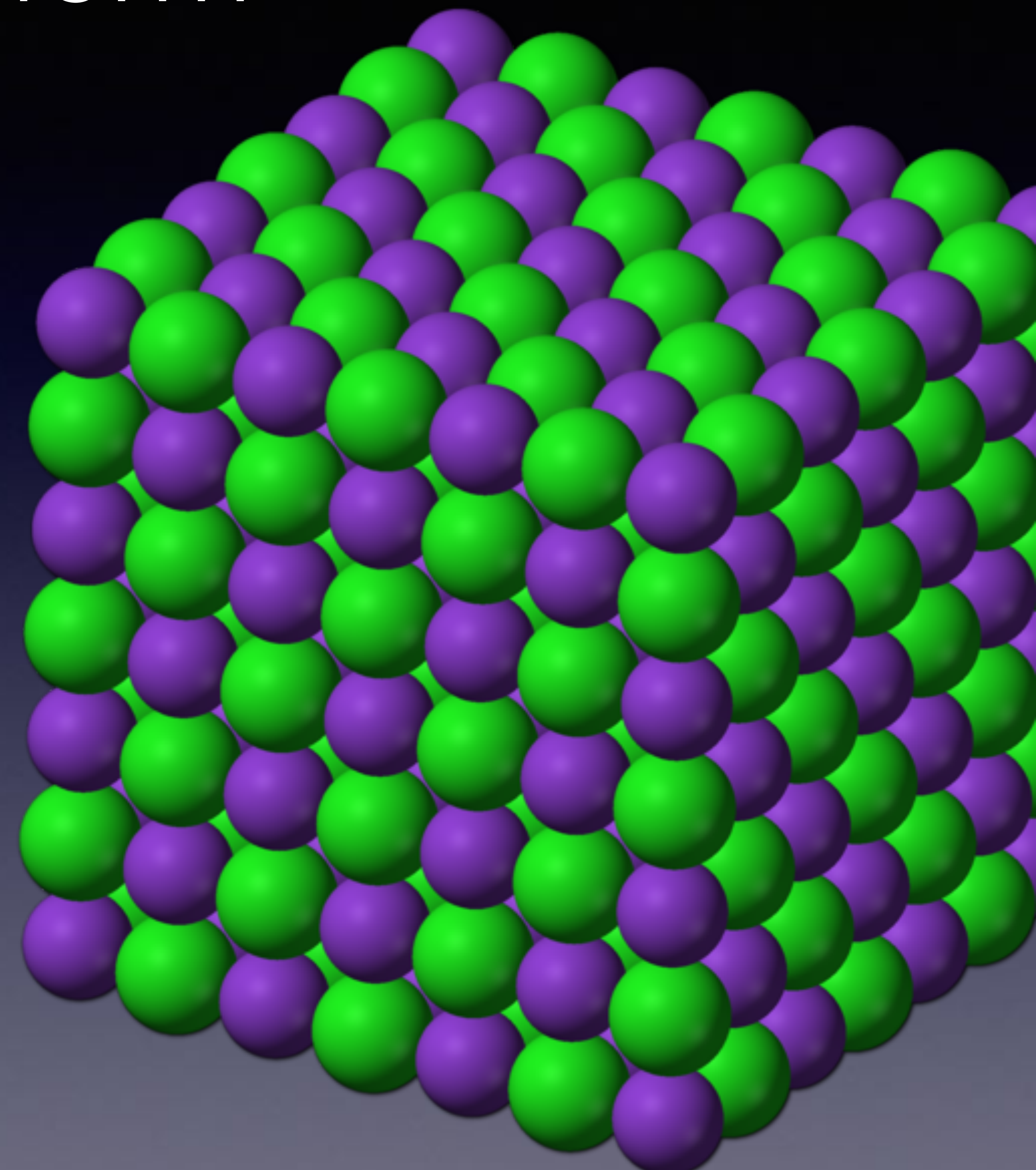
600px-Potassium-chloride-3D-ionic.png

Ionic bonds often form 3D networks

- In ionic bonds electrons are **transferred**
- What is the e^{-} configuration of K^{+}? Cl^{-}? Which ion is larger?
- We call this 3D network a lattice, and the solid is an *ionic crystal*
- Wavefunctions are largely contained on each atom



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600px-Potassium-chloride-3D-ionic.png

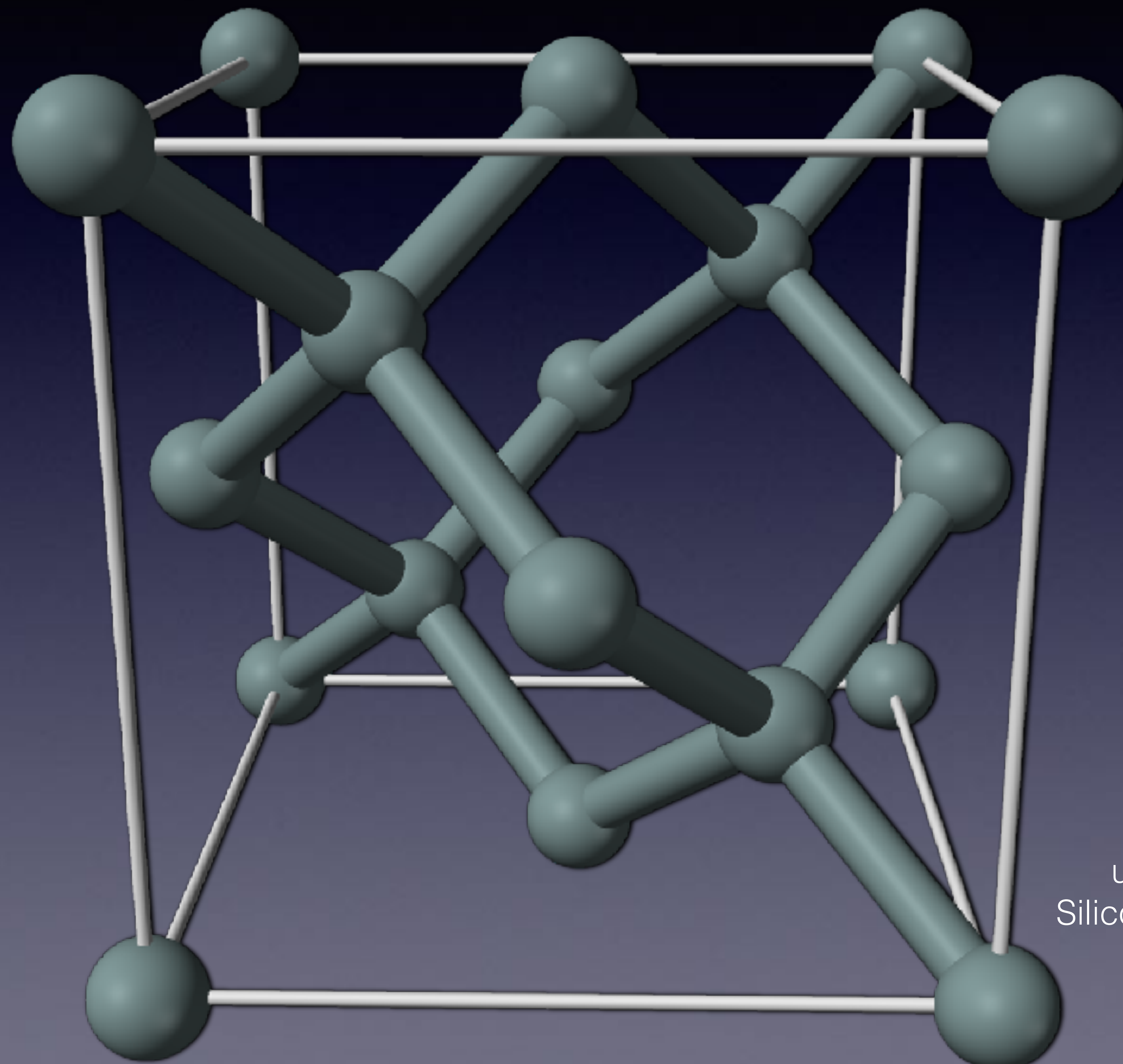
Periodic trends in lattice energies

- What is the periodic trend in lattice energy, U?

- **Minute paper**:
Predict the lattice energy for potassium fluoride in kJ mol^{-1}

Compound	U (kJ/mol)
LiF	–1049
LiCl	–864
NaF	–930
NaCl	–786
KCl	–720
NaBr	–754
KBr	–691

Metallic bonding



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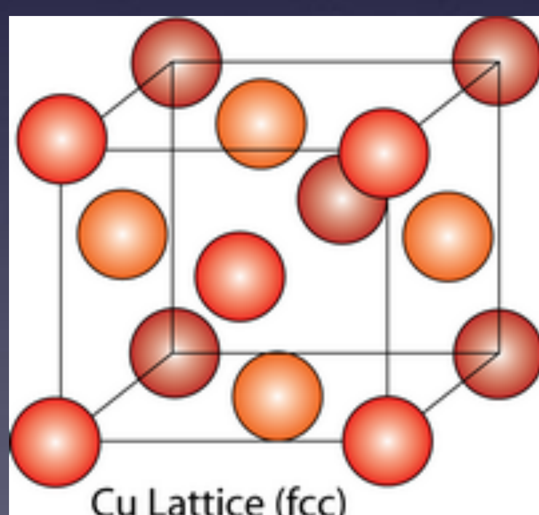
Silicon-unit-cell-3D-balls.png

Metallic bonding

1s 2s 2p 3s 3p 4s 3d

Cu

Cu is $1s^2\ 2s^2\ 2p^6$…



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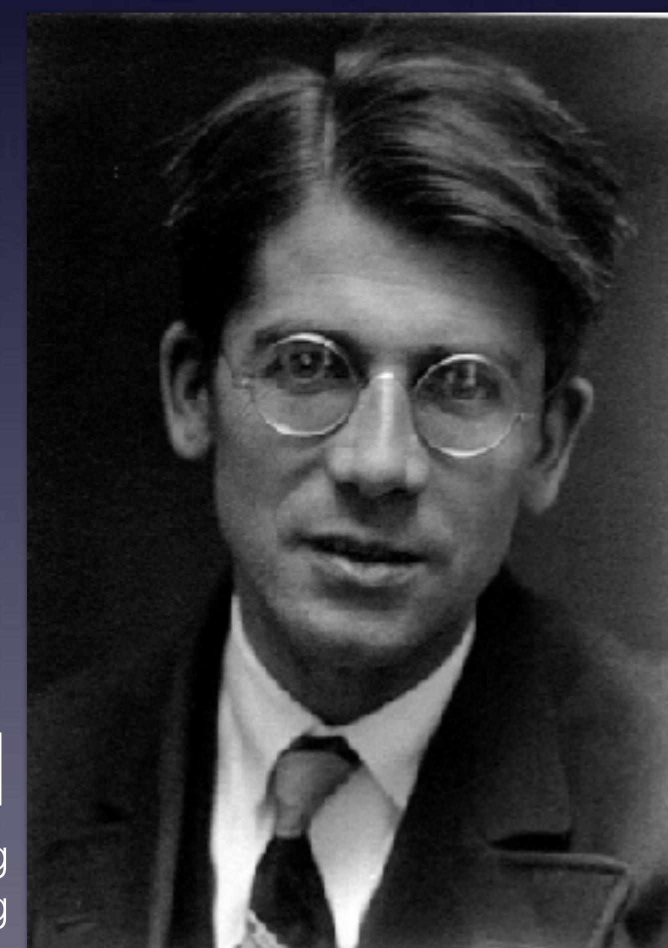
Cu_lattice.png



Fredrich Hund

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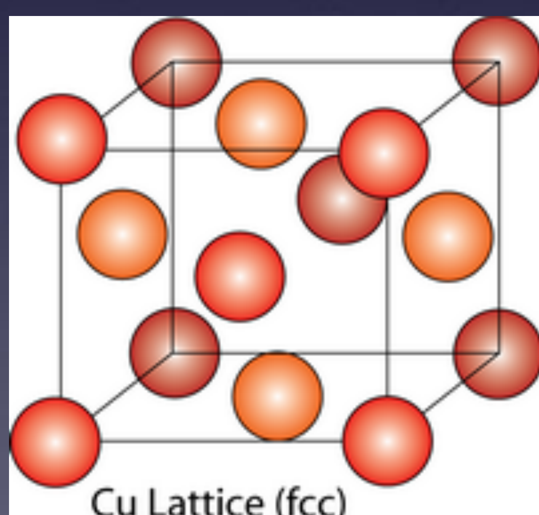
Hund%2CFriedrich_1920er_Göttingen.jpg

Metallic bonding

	1s	2s	2p			3s	3p			4s	3d				
Cu	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑↓	↑↓	↑↓	↑↓	↑↓

Cu is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$



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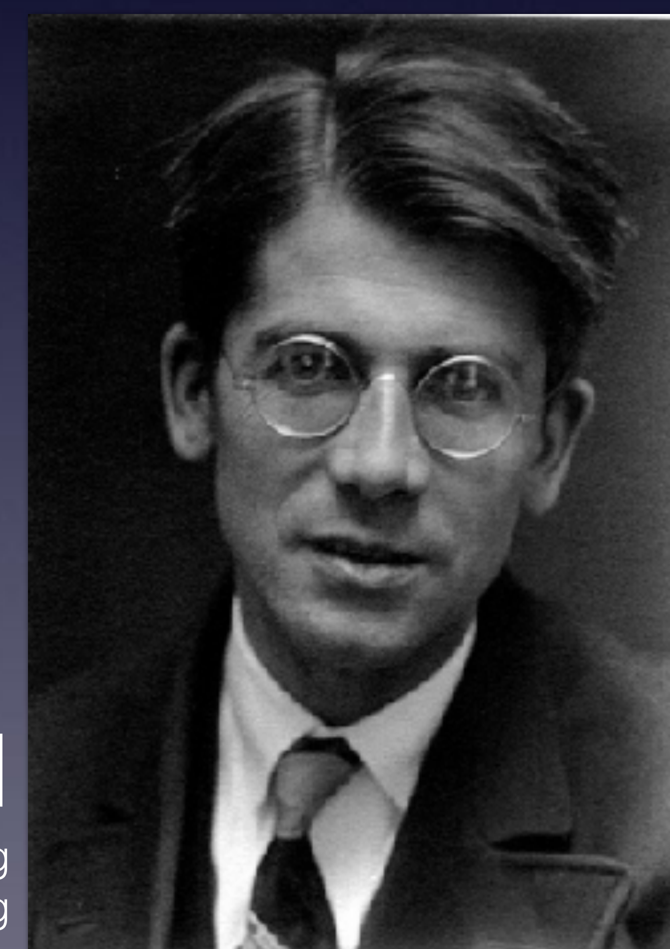
Cu_lattice.png



Fredrich Hund
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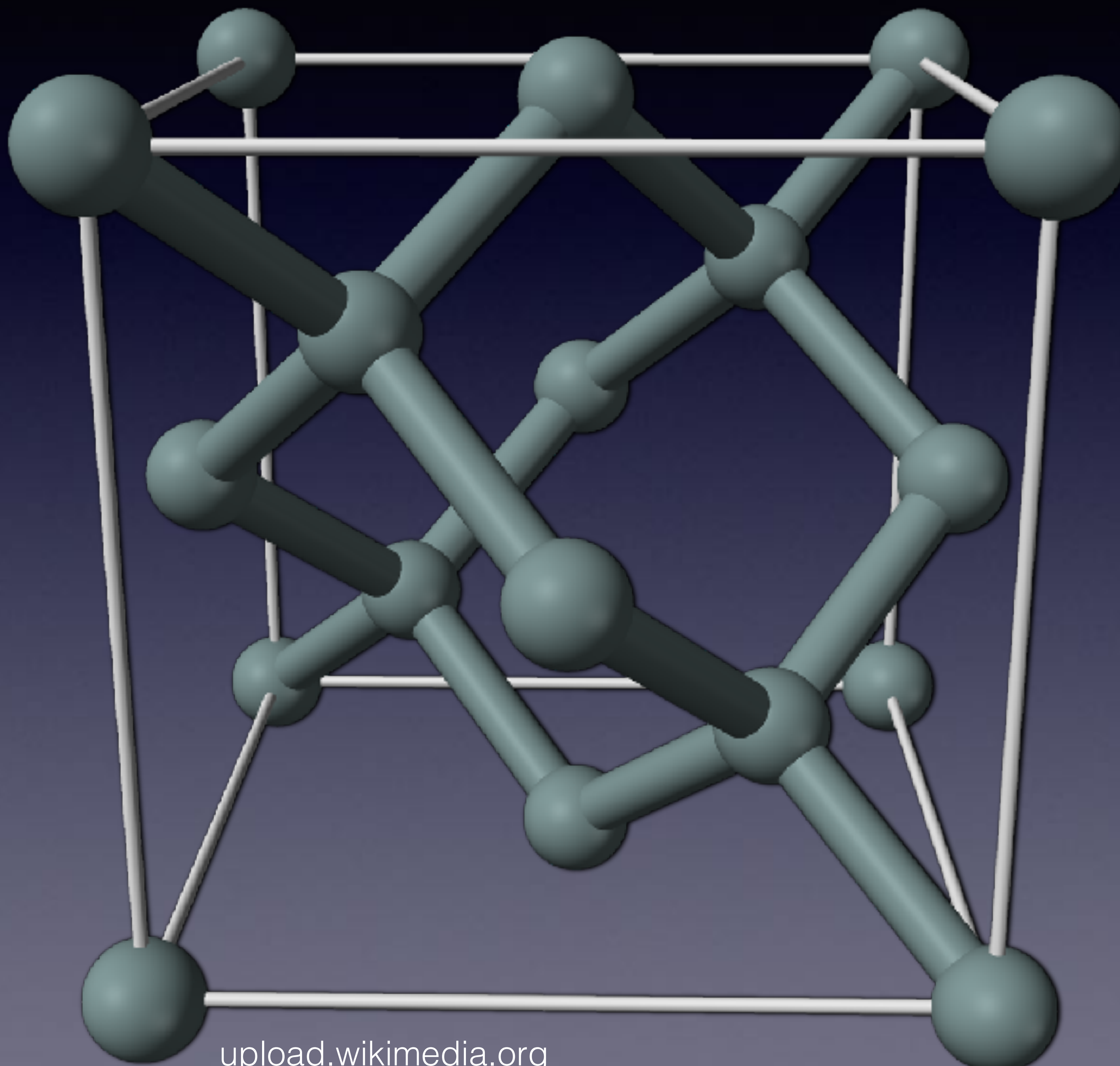
Metallic bonding

- Large lattice like ionic crystals … but …
- … small Δ EN like nonpolar covalents.
- Wavefunctions are distributed across the **entire crystal**
- Electrons are **pooled** together and flow!



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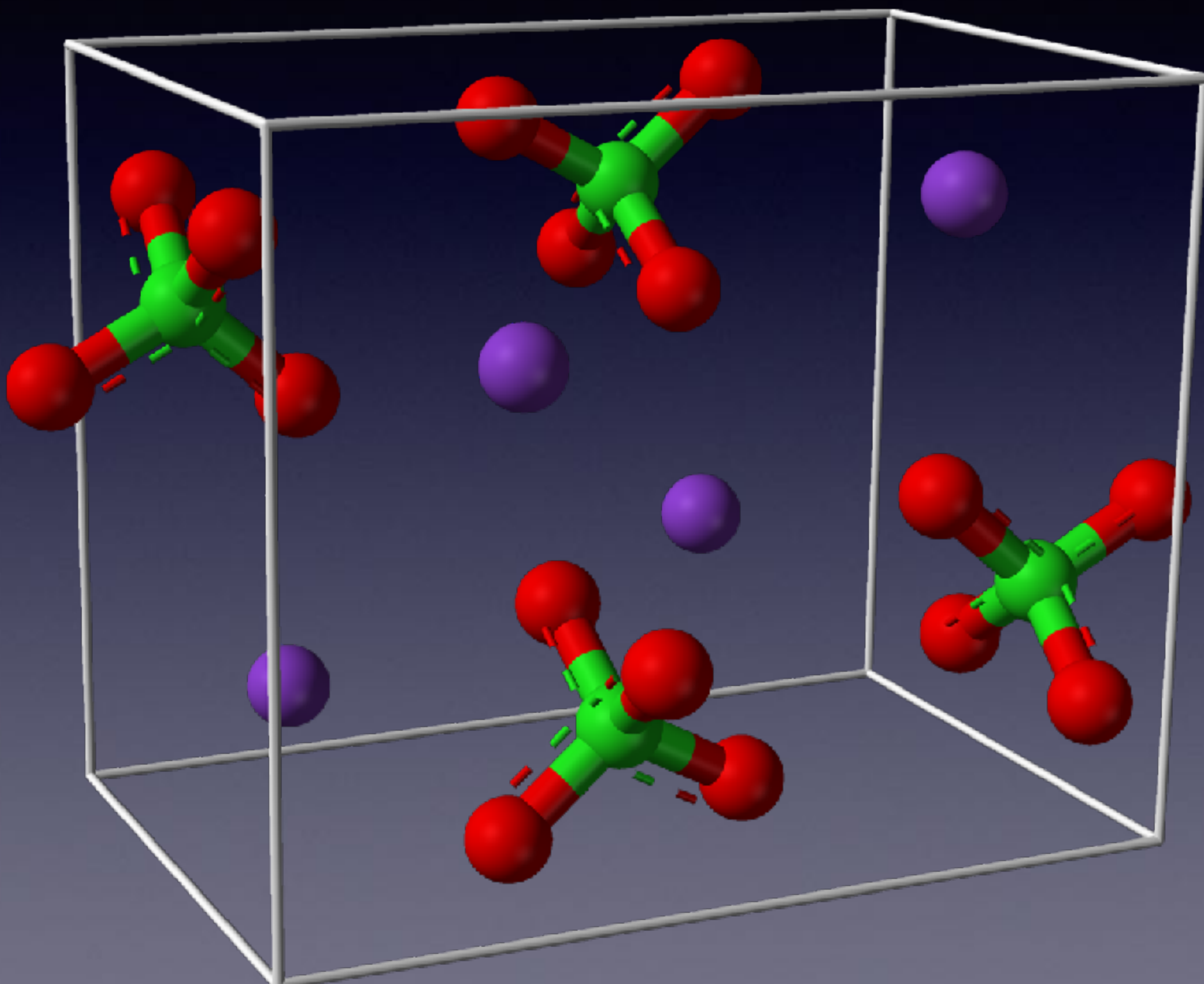
unit-cell-3D-balls.png

Both ionic and covalent bonds?



- Potassium permanganate, $KMnO_4$
- Permanganate anions, MnO_4^- are covalently bound
- Anions and potassium cations bond ionically

Now you try…

- Classify compounds as forming ionic/covalent/metallic bonds. If covalent, specify polar or nonpolar. If multiple, explain.

Nitric acid (consider bonding between H and nitrate)
Sodium nitrate
Cesium bromide
Hydrobromic acid
Ammonia

Understanding / predicting covalent bonding

- Gilbert Newton Lewis developed a dot notation to understand and predict covalent bonding
- We will focus on **molecular** compounds in class, but …
- …you are also responsible for understanding Lewis dot structures of **ionic** compounds (Tro §4.5)

G. N. Lewis

www.atomicheritage.org
Gilbert%20Lewis.jpg

Where did we go today?

Ch1010-A17-A03 Lecture 11

- The nature of the chemical bond
- §4.2 Types of chemical bonds
- §5.2 Electronegativity and chemical bonds

Next time…

- §4.4–5, 4.7, 5.3 Gilbert gets the measles

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