“A” students work (without solutions manual)  
~ 10 problems/night.

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FITCH Rules

G1: Suzuki is Success  
G2. Slow me down  
G3. Scientific Knowledge is Referential  
G4. Watch out for Red Herrings  
G5. Chemists are Lazy

C1. It’s all about charge  
C2. Everybody wants to “be like Mike”  
C3. Size Matters  
C4. Still Waters Run Deep  
C5. Alpha Dogs eat first

$E = h \nu$  
Note that we can measure the light either by frequency (energy) or by wavelength.  

$\nu \lambda = c$

$\lambda = \frac{c}{\nu}$

E allows us to  
Measure energy  
Of electrons and  
Identify elements  
In a gas phase  
How we know solar system composition

Visible

Expand this region

Region our “eyes” sense

Virtual light

Split light

Aurora

Allows us to  
Measure energy  
Of electrons and  
Identify elements  
In a gas phase  
How we know solar system composition

$E_{mi} = \frac{q_1 q_2}{r_1 + r_2}$
The hydrogen atom, analyzed by Bohr

The Bohr Model

Based on an electrostatic model

1. Protons in the nucleus
   \[ Z = \text{atomic number} = \# \text{ of protons in nucleus} \]
   \[ q_z = \left( \pm Z_{\text{charge charge}} \right) \frac{1.6022 \times 10^{-19} \text{Coulomb}}{\text{charge charge}} \]

2. Electrons (Z) in orbit at some
   \[ q_z = \left( Z_{\text{electric charge}} \right) \frac{1.6022 \times 10^{-19} \text{Coulomb}}{\text{electric charge}} \]

3. Distance between + and – charge, d
   \[ d \text{ related to orbit, } n \]

Energy electrostatic = \[ k \left( \frac{q_z q_z}{d} \right) \]

angular momentum \( \equiv L = m u r \)

Bohr said angular momentum

Has to have fixed multiple values:

\[ L = n=1,2,3,4,5... \left( \frac{\hbar}{2\pi} \right) = mur \]

Solve the centripetal force (electrostatic attraction) with Bohr’s

Constraint on angular momentum

\[ \frac{\mu u^2}{r} = \left( \frac{Z e}{4\pi e_o r^2} \right) \]

Bohr inferred that only certain angular momenta, \( L \), were allowed

which meant that only certain radii orbitals were allowed

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which meant that only certain radii orbitals were allowed
Energy_{electrostatic} = \frac{(Ze)(-e)}{4\pi\epsilon_0 r}

Just solved for r

r = \left(\frac{n_1,2,3}{Z}\right) a_o

Combine

\begin{align*}
\text{Energy}_{electrostatic} &= -\frac{Z e^2}{4\pi\epsilon_0 \left(\frac{n^2}{Z}\right) a_o} \\
\text{Energy}_{electrostatic} &= -\frac{e^2}{4\pi\epsilon_0 a_o} \left(\frac{Z^3}{n^2}\right)
\end{align*}

For the hydrogen nucleus Z=1

Energy_{electrostatic} = -\frac{4.359\times10^{-18} \left(\frac{1}{n^2}\right)}{

1854-1919

Johannes Rydberg

Swedish mathematical physicist

I hate derivations

So what’s the bottom line?
What do you need to know?
That this model is based on
The electrostatic attraction of an
Electron orbiting (circular) a
Proton. Only discrete orbits allowed

Only discrete, quantized,
(n=unit values) of energy
are allowed for electrons.
This accounts for lines as opposed
To range of energy

\[ E = -\frac{R_H}{n^2} \]

\[ R_H = 2.180\times10^{-18} J \quad \text{Rydberg constant} \]

\begin{align*}
\Delta E &= h \nu = E_{hi} - E_{low} \\
\Delta E &= h \nu = \frac{-R_H}{(n_{hi})^2} - \frac{-R_H}{(n_{low})^2} \\
\Delta E &= h \nu = -R_H \left[ \frac{1}{(n_{hi})^2} - \frac{1}{(n_{low})^2} \right]
\end{align*}

n=1 is the ground state
Where electron really wants to be
n=2,3,…. Are excited states
Energy in the form of light
is released when an
electron drops from
n=2,3,…to n=1 state
Example: Prove that the Bohr model works by calculating the wavelength associated with an electron dropping from \( n=3 \) to \( n=2 \) and comparing that value to wavelengths in the Balmer series.

\[
\Delta E = h\nu = -R_h \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right)
\]

\[
\nu = -\frac{R_H}{h} \left( \frac{1}{3^2} - \frac{1}{2^2} \right)
\]

\[
\nu = 4.569 \times 10^{14} \text{ s}^{-1}
\]

\[
\nu = -\frac{R_H}{h} [-0.1388]
\]

\[
\nu = \frac{h\nu}{\lambda} = \frac{hc}{\lambda}
\]

\[
\lambda = \frac{hc}{\nu} = \frac{2.998 \times 10^8 \text{ m s}^{-1} \times 10^{-78} \text{ m}}{4.569 \times 10^{14} \text{ s}^{-1}} = 656.08 \text{ nm}
\]

The "fly in the ointment" of Bohr's successful model of the Hydrogen model is that it does not account for any other element!

The reason is that the electron does not really occupy a specific Orbital around the nucleus. It has a "probability" of being in that Space that is high, but with some Probability of not being in that space.

Math Phobic
Can sleep

Just keep track of ideas
Example: What is the wavelength of an electron (mass of $9.11 \times 10^{-28}$ g) moving at $5.97 \times 10^6$ m/s?

\[
\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.11 \times 10^{-28} \times 5.97 \times 10^6} \left( \frac{1 \text{kg} - m^2}{s} \right) \left( \frac{10^3 \text{g}}{\text{kg}} \right)
\]

\[
\lambda = 1.22 \times 10^{-10} \text{m} = 0.122 \text{nm}
\]

\[\Delta x \geq \frac{h}{4\pi (\Delta mv)}\]

9.11x10^{-31} kg mass of an electron
5x10^6 m/s average velocity of an electron
1% uncertainty in the velocity

Can we measure where an electron around the nucleus is?

\[
\Delta x \geq \frac{6.63 \times 10^{-34} J \cdot s}{4(3.14)(9.11 \times 10^{-31} \text{kg})(0.01)(5 \times 10^6 \frac{m}{s})} \left( \frac{1 \text{kg} - m^2}{s^2} \right) \left( \frac{10^3 \text{g}}{\text{kg}} \right)
\]

\[
\Delta x \geq 1 \times 10^{-9}
\]

We can know the position of the electron to within $10^{-9} \text{ m} = 1 \text{ nm}$

Radius of hydrogen = 200 pm = 0.2 nm

1. Electron is a particle
2. Electron is a wave

Mutually contradictory statements Which are resolved by saying:

A particle which has probability of occupying different locations simultaneously

Werner Heisenberg (1901-1976) formulated the **Uncertainty Principle**

\[\frac{\Delta x}{\Delta \lambda} \geq \frac{h}{4\pi} \quad \text{OR} \quad \frac{\Delta x}{\Delta \lambda} \geq \frac{h}{4\pi}\]

Can we measure where a 57 g tennis ball moving at 60 m/s is?

\[
\Delta x \geq \frac{6.63 \times 10^{-34} J \cdot s}{4(3.14)(57 \text{g})(60 \frac{m}{s})} \left( \frac{1 \text{kg} - m^2}{s^2} \right) \left( \frac{10^3 \text{g}}{\text{kg}} \right)
\]

\[
\Delta x \geq 1.54 \times 10^{-35}
\]

We can know the position of the ball to within $10^{-35} \text{ m}$

We actually don’t know where the electron is!
We only know the probability of finding an electron at one place!
Snork, Bst, huh? Math Phobic wake up here

Electron has Light-like properties
Electron has a probability of occupying a certain volume

Quantum mechanical models describe the probability of electron density; from these we get possible energy states for the electron “Cloud”

Quantum mechanical models postulate several quantum Numbers
1. describe the allowed energy levels of the electrons
2. Energy levels are related to probability of finding electron density (SHAPE of orbital)
   \[
   \psi
   \]

   1. Look at math
   2. Look at shapes
   3. See relationship to periodic table

   \[
   \frac{d^2\psi}{dx^2} + \frac{8\pi^2 m(E - V)}{\hbar^2} \psi = 0
   \]
   An equation to inhabit your worst Nightmares

   Schrodinger equation is solved by the physical Chemists and physicists to give us allowed orbitals governed by Principal quantum numbers

   Erwin Schodinger Austrian 1887-1961

<table>
<thead>
<tr>
<th>Principal n</th>
<th>Azimuthal</th>
<th>Magnetic</th>
<th>Spin</th>
<th>Total Allowed e</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \ell = 0 )</td>
<td>( m_{\ell} = 0 )</td>
<td>( m_s = \pm \frac{1}{2} )</td>
<td>2x1</td>
</tr>
<tr>
<td>2</td>
<td>( \ell = 0, 1 )</td>
<td>( m_{\ell} = 0 )</td>
<td>( m_s = \pm \frac{1}{2} )</td>
<td>2x1</td>
</tr>
<tr>
<td></td>
<td>( \ell_0 = s )</td>
<td>( m_{\ell_0} = 0 )</td>
<td>( m_s = \pm \frac{1}{2} )</td>
<td>2x1</td>
</tr>
<tr>
<td></td>
<td>( \ell_1 = p )</td>
<td>( m_{\ell_1} = 1, 0, -1 )</td>
<td>( m_s = \pm \frac{1}{2} )</td>
<td>2x3</td>
</tr>
<tr>
<td></td>
<td>( \ell_2 = d )</td>
<td>( m_{\ell_2} = 2, 1, 0, -1, -2 )</td>
<td>( m_s = \pm \frac{1}{2} )</td>
<td>2x5</td>
</tr>
</tbody>
</table>

Distance  Orbit shape  Orientation in space  Electron spin

Quantum mechanical models describe the probability of electron density; from these we get possible energy states for the electron “Cloud”

Quantum mechanical models postulate several quantum Numbers
1. describe the allowed energy levels of the electrons
2. Energy levels are related to probability of finding electron density (SHAPE of orbital)
   \[
   \psi
   \]

   1. Look at math
   2. Look at shapes
   3. See relationship to periodic table

   Each element is described by a unique set of quantum numbers

   the Pauli Exclusion Rule (no two electrons can have the same quantum mechanical numbers)

Wolfgang Pauli
1900-1958
Vienna, theoretical physicist
There are some "odd" things happening here. For example, Quantum model says that $n=3$ level should have these five orbitals, but we don’t see these showing up until We get to what appears to be $n=4$.

**Expected**

Quantum model: 1s, 2s, 2p, 3s, 3p, 3d, 4s, 4p, 4d, 4f, 5s, 5p, 5d, 5f, 6s…

```
<table>
<thead>
<tr>
<th>n</th>
<th>1s</th>
<th>2s</th>
<th>3s</th>
<th>3d</th>
<th>4s</th>
<th>4p</th>
<th>4d</th>
<th>5s</th>
<th>5p</th>
<th>5d</th>
<th>5f</th>
<th>6s</th>
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<td>4</td>
<td>1s</td>
<td>2s</td>
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<td>2s</td>
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<td>6</td>
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</tr>
</tbody>
</table>
```

"first in, first out"

4d appears after 4s
3d appears after 4s

Quantum model refined
1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 5p, 5d, 6s…

- Big jump in Energy to create These elements
- Most stable (most negative)

Energy of electron Increases as does distance From nucleus

$n = \infty$

Energy of electron

- First in, first out

Big jump in Energy to create These elements

Most stable (most negative)
Writing electron Configurations

Number of electrons within those shaped orbitals

\[ n \ell \text{#} \] 

Numerical value of principle quantum number
(row in periodic table = distance from nucleus of orbit)

Letter of azimuthal quantum number
(shape of orbital)

\[ \ell = 1 = s \] 
\[ \ell = 2 = p \] 
\[ \ell = 3 = d \] 
\[ \ell = 4 = f \]

Transition elements often have electron configurations
Different than we have predicted

they try to get to a stable \( \frac{1}{2} \) filled or fully filled d orbital
by shifting s electrons around

Example: Write the electron configuration of the atoms carbon, iron, and lead.

Invoke Rule G5: Chemists are Lazy

\[ C = 1s^2 2s^2 2p^2 \] 
\[ Fe = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6 \] 
\[ Pb = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5 \]

Abbreviated Electron configuration

4f = lanthanides, 14 elements (7 m, 2 per orbital)

My daughter and son
Do not like to be in
The same room unless
Forced to be so

Correct model

Unfilled orbitals

Hund’s rule: when several orbitals of equal energy
Are available, electrons enter singly with parallel Spins

1896-1997
German physicist
Friedrich Hermann Hund
Orbital diagrams of Atoms

Fe = [Ar] 4s² 3d⁶

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

Fe²⁺  Fe³⁺  Fe⁴⁺  Fe⁵⁺  Fe⁶⁺

4s  3d

[Ar]  4s  3d

Invoke Rule #C2
Everyone wants to be like Mike

F⁻ = [He] 2s² 2p⁶

Ne = [He] 2s² 2p⁶ = [Ne]

Mg = [Ne] 2s²

Mg²⁺ = [Ne] 2s² = [Ne]

Be Like Mike  →  Competing Rules  →  It’s all about Charge

Transition Metal Cations

Atoms try to get to the noble gas configuration
Every electron they lose/gain makes them charged and “unstable”
eventually the “cost” is too high and they no longer try to make it to
the noble gas configuration – e.g. the transition metals.

“first in, first out”
electrons are removed from the sublevel of the highest “n”

Example: Fe²⁺, Fe³⁺

Be Like Mike  →  Competing Rules  →  It’s all about Charge

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Example: Fe²⁺, Fe³⁺

Fe²⁺  Fe³⁺  Fe⁴⁺  Fe⁵⁺  Fe⁶⁺

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

For first half of transition metals
Most common oxidation state is to “be like Mike”

Mn can have +1, +2, +3, +4, +5, +6 oxidation states
To avoid the +6 state it will try and maintain a ½ filled d block
It does this by losing the 2s electrons
Periodic Properties of the Elements

\[ E_{el} = \frac{\kappa Q_1 Q_2}{d} \]

\[ k = \frac{8.99 \times 10^9 \text{ J} - m}{(C)_{\text{Coulomb}}}^2 \]

Chemistry Rule #1: it’s all about Charge and How To Balance Positive and Negative Charge

Nuclear Positive charge affects

1. Atomic size (pull on atom’s own electrons)

Periodic Properties of the Elements: Pull on own electrons

\[ E_{el} = \frac{\kappa Q_1 Q_2}{d} \]

\[ \kappa = \frac{8.99 \times 10^9 \text{ J}m}{C^2} \]

Diameter \( \text{hydrogen} = 52 \text{ pm} \)

\[ E_{el} = \left( \frac{8.99 \times 10^9 \text{ J}m}{C^2} \right) \left( \frac{-1.60 \times 10^{-19} C}{+1.60 \times 10^{-19} C} \right) \left( \frac{52 \times 10^{-12} m}{2} \right) \]

\[ \Delta E = -4.48 \times 10^{-18} \text{ J} / \text{hydrogen atoms} \]

The thing that attracted me to science is the ability to come at a problem from a multitude of directions and get confirmation.
Difficult to make a “real” calculation of Electron attraction to proton beyond Hydrogen

For Mg – 3s\(^2\) electrons “shielded” from positive charge by [Ne] core electrons

To deal with this a concept of

Effective nuclear charge is introduced

Charge experienced by added electrons is reduced by Inner electrons

\[
Z_{\text{eff}} = Z - S \quad \text{SIMPLE MODEL}
\]

\(Z\) = number of protons in nucleus

\(S\) = average number of electrons between nucleus and electron

\(Mg = 3s^2\quad Z_{\text{eff}} = 12 - 10_{\text{Neon}} = +2\)

Do we expect Similar shielding From an s vs p orbital Electron?

Expanded model

Effective Nuclear Charge

\[
Z^* = Z - 0.35\left(\sum x_p\right) - 0.85\sum x_p = 12 - 0.35(2 - 1) - 0.85(8) - 2 = 2.85
\]

Mg: [Ne]3s\(^2\)

Z = 12

Fully shields

Mg: [Ne]3s\(^2\)

Shields only a little (0.35)

Shields a lot (0.85)
**Effective Nuclear Charge**

1. Decreases with increased orbital distance from nucleus
2. Within a row (general orbital distance from nucleus) increases with electrons because they do not fully shield increasing positive charge of protons added.
3. Effect depends greatly on the orbital type so the rule (2) is not perfect.

---

Adding 1e to each of any three d orbitals results in pretty good shielding – next electron not held as tightly.

---

Remember in any given row we are at some approximate orbit from the center of the positively charged nucleus. As we add more protons for each element we increase positive charge. This draws the electrons within that ‘n’ value in.

---

Organize the following atoms in order of increasing size by referring to the periodic table:

P, S, As, Se

As>P, Se>S
As>Se
As>P, Se>S
But P vs Se?
Eg. As>>P and As>Se
Or As>P and As>>Se

---

1. Size increases down table as we increase ‘n’ effective nuclear charge is lower
2. Size decreases as we move Across the periodic table. Effective nuclear charge increases due to incomplete electron shielding.
Organize the following atoms in order of increasing size by Referring to the periodic table

\[
P, \ S, \ As, \ Se
\]

**As > P, Se > S**

Question which trend is greater? Horizontal or Down (with exceptions)

\[
As > P \text{ and } As > Se \\
Or \ As > P \text{ and } As > Se
\]

**As > Se > P > S**

---

**Periodic Properties of the Elements**

\[
E_{el} = \frac{kQ_1Q_2}{d} \\
k = \frac{8.99 \times 10^9 \ J \cdot m}{(C_{\text{durch}})^2}
\]

---

**Chemistry Rule #1** = it’s all about Charge and How To Balance Positive and Negative Charge

---

Nuclear Positive charge affects

1. Atomic size (pull on atom’s own electrons)
2. Ionic size (more pull on atom’s remaining electrons)
Arrange in order of decreasing size Mg\(^{2+}\), Ca\(^{2+}\), Ca

Cations smaller than their atoms: Ca\(^{2+}\) < Ca

Ca is lower in periodic table than Mg: Mg < Ca and Mg\(^{2+}\) < Ca\(^{2+}\)

Ca > Ca\(^{2+}\) > Mg\(^{2+}\)

Order the size of the Following:
Fe, Fe\(^{2+}\), Fe\(^{3+}\)

Fe > Fe\(^{2+}\) > Fe\(^{3+}\)

Order the size of the Following:
Fe, Fe\(^{2+}\), Fe\(^{3+}\)

Fe > Fe\(^{2+}\) > Fe\(^{3+}\)

Chemistry Rule #1 = it’s all about Charge and How To Balance Positive and Negative Charge

1. Atomic size (pull on atom’s own electrons)
2. Ionic size (more pull on atom’s remaining electrons)
3. Ability to attract somebody else’s electrons into forming a covalent bond (electronegativity)
4. Ability to lose electrons (ionization potentials)
Pauling’s Electronegativity scale

A measure of ability of an element to attract via Electrostatic charge the electrons of a second atom And hence, engage in covalent bonding

\[ \Delta E.N. = (E.N._2 - E.N._1) = \text{measure of } \Delta \text{Polarity} \]

Separation of charge

<table>
<thead>
<tr>
<th>Covalent, non-polar</th>
<th>0 to 0.5</th>
<th>2.2-2.2=0</th>
<th>H-H</th>
<th>very high bond energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covalent, polar</td>
<td>0.5 to 2.0</td>
<td>4-2.2=1.7</td>
<td>HF</td>
<td>Weak Acid (F holds onto H)</td>
</tr>
<tr>
<td>Ionic</td>
<td>2.0-4.0</td>
<td>4-1=3.0</td>
<td>LiF</td>
<td>Electrolyte</td>
</tr>
</tbody>
</table>

Electronegativity increases across
And up towards F

Linus Pauling
U.S.A.
CalTec 1901-1994
Chemist
Electronegativity 1934

Properties and Measurements

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Reference State</th>
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</thead>
<tbody>
<tr>
<td>Size</td>
<td>m</td>
<td>size of earth</td>
</tr>
<tr>
<td>Volume</td>
<td>cm³</td>
<td>m</td>
</tr>
<tr>
<td>Weight</td>
<td>gram</td>
<td>mass of 1 cm³ water at specified Temp (and Pressure)</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C, K</td>
<td>boiling, freezing of water (specified Pressure)</td>
</tr>
<tr>
<td>1.66053873x10⁻²⁴g</td>
<td>amu</td>
<td>(mass of 1C-12 atom)/12</td>
</tr>
<tr>
<td>Pressure</td>
<td>atm, mm Hg</td>
<td>earth’s atmosphere at sea level</td>
</tr>
</tbody>
</table>

Energy, General

electronic states in atom Energy of electron in vacuum
Electronegativity F

Allred-Rochow method

Relate Pauling’s Electronegativity to Effective Nuclear Charge (It’s all about charge!)

\[ E_{el} = \frac{kQ_1Q_2}{d} \]

\[ E_{\text{electronegativity}} = 3590 \left( \frac{Z^+}{R} \right)^2 + 0.744 \]

\[ Z^+ = \text{effective nuclear charge} \]
\[ R = \text{covalent radius of atom in pm} \]

\[ Z^+ = Z - 0.35 \sum s, p - 0.85 \sum s, p, d, f - \sum s, p, d, f \]

Outer valence shielding
First inner Valence shell
innermost Valence shells

Energy general Snork, Bst, huh? Math Phobic wake up here
Periodic Properties of the Elements

\[ E_{\text{el}} = \frac{\kappa Q_i Q_j}{d} \]

\[ k = \frac{8.99 \times 10^9 J}{(C_{\text{electro}})^2} \]

Chemistry Rule #1 = it’s all about Charge and How To Balance Positive and Negative Charge

Nuclear Positive charge affects
1. Atomic size (pull on atom’s own electrons)
2. Ionic size (more pull on atom’s remaining electrons)
3. Ability to attract somebody else’s electrons into forming a covalent bond (electronegativity)
4. Ability to lose electrons (ionization potentials)

Ionization energies increase
a) with greater effective nuclear charge
b) \( I_3 > I_2 > I_1 \)
c) \( I_{\text{inner shell electrons}} > I_{\text{outer shell electrons}} \)

**Table 7.2**

<table>
<thead>
<tr>
<th>Element</th>
<th>( I_1 )</th>
<th>( I_2 )</th>
<th>( I_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>965</td>
<td>4560</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>738</td>
<td>1450</td>
<td>7720</td>
</tr>
<tr>
<td>Al</td>
<td>578</td>
<td>1620</td>
<td>7920</td>
</tr>
<tr>
<td>Si</td>
<td>786</td>
<td>1580</td>
<td>3230</td>
</tr>
<tr>
<td>P</td>
<td>1012</td>
<td>1900</td>
<td>2910</td>
</tr>
<tr>
<td>S</td>
<td>1000</td>
<td>2270</td>
<td>3600</td>
</tr>
<tr>
<td>Cl</td>
<td>1250</td>
<td>2300</td>
<td>4020</td>
</tr>
<tr>
<td>Ar</td>
<td>1521</td>
<td>2670</td>
<td>3990</td>
</tr>
</tbody>
</table>

Who has the least ability to hold onto it’s electrons?

Ionization energy follows size trends; which are a function of \( Z_{\text{eff}} \).

Predict the which of the circled elements has the largest **second ionization energy**

For Li to lose a second electron would have to come from an inner shell.
Ionization energies increase

a) with greater effective nuclear charge
b) I_3 > I_2 > I_1 (because Z_{eff} increases!)
c) I_{inner} shell electrons > I_{outer} shell electrons

d) Within a period, harder as the size falls across the period

Organize the following atoms in order of increasing first ionization energy: Ne, Na, P, Ar, K

Ar > P > Na
Ne > Ar
Na > K
"A" students work (without solutions manual) ~ 10 problems/night.

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I WANT YOU TO PRACTICE EVERY DAY!

The ions are very similar in size and charge (identical marshmallows from a distance). But differ in electronic configuration:

- \( \text{Ca}^{2+} = [Ar]4s^2 \)
- \( \text{Pb}^{2+} = [Xe]6s^24f^{14}5d^{10}6p^2 \)

\( 1f = \text{lanthanides, 14 elements (7 ml, 2 per orbital) } \)

\( \text{Pb}^{2+} \) has:
1. more electrons, and
2. two lose cannons (the 2s electrons) which require space and orientation.

From a distance both \( \text{Ca}^{2+} \) and \( \text{Pb}^{2+} \) behave similarly. They both experience a similar electrostatic attraction.

\[ E_{el} = \frac{kQ_1Q_2}{d} \]

But when they dock at the docking bay, \( \text{Pb}^{2+} \) has:

- 94-99% of lead attached to external surfaces of erythrocytes
- 1-6% lead in plasma, of which 99% attached to proteins
- ~0.1 to 0.6% of lead is as the free cation

Passive Uptake from stomach to blood
Active uptake of calcium, apparently to lesser extent other divalent similar sized cations, including lead.

Calcium uptake is controlled by Vitamin D and growth regulators parathyroid hormone (PTH)

An estimated 40% of lead in blood plasma bound to ALAD


ALAD dehydratase with lead binding site

Calcium is closely monitored by kidney because it plays a large role in various signalling processes
Calcium serves as a trigger for muscle contractions: troponin C

1. Low lead turns on triggers
2. High lead turns off triggers

Seizures can result from lead due to Ca triggers of the synapses

Because lead affected ALAD resulting in overproduction of ALA
ALA may also affect the function of GABA but a close similarity in molecular structure

GABA controls leaf tip growth, and brain development. Function changes with time, so growing tips and infants differentially affected from adults
Certain portions of the brain more greatly affected:
prefrontal cortex: problem solving
hippocampus (memory)
cerebellum (motor coordination, body movement, posture and balance)

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