Department of Chemistry
University of Texas at Austin

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Atomic Theory UNIT - READINESS ASSESSMENT QUIZ (RAQ)
THIS QUIZ WILL BE PACED WITH CLICKER QUESTIONS
Using a separate sheet of paper is highly suggested.

1. A laser pulse shines for 10 s delivering a total energy of 4 mJ of 633 nm light. Another laser delivers the same amount of energy with a wavelength of 408 nm.

   a) Which laser is delivering more photons to the sample? Red laser, 633 nm laser – because the total energy delivered for the two lasers is the same so we would need more photons of lower energy to get up to 4 mJ.

   b) How much energy per photon (in units of eV) will be delivered for the red laser versus the blue laser? (1eV = 1.602×10^{-19} J)

   RED: $E = hc/\lambda = hc/633x10 \times 1.602 \times 10 = 1.96$ ev

   BLUE: $E = hc/\lambda = hc/408x10_{-9} \times 1.602 \times 10_{-19} = 3.04$ ev

   The red laser provides less energy per photon, so that is why we would need more photons per second to end up with the same amount of energy given off by the blue laser during the 10 second pulse.

   c) Each of these lasers shines on calcium (Φ = 2.90 eV). What will happen when a 10 s pulse of red laser shines on calcium? Nothing, photons don't have enough energy to eject the electrons. What will happen when a 10 s pulse of the blue laser shines on calcium? Electrons will be ejected with some KE that can be calculated.

2. Please explain the change in effective nuclear charge, Z_{eff} , as you move across a row in the periodic table from left to right. Indicate how this change in Z_{eff} affects the ionization energy and the atomic radii of the atoms as you move across a row. Use the elements calcium and selenium as specific examples predicting which would have the smaller atomic nucleus and why.

   Z_{eff} = (nuclear charge) – (inner shell e_-)

   From left to right across the periodic table, Z_{eff} INCREASES

   As we go from left to right, we add protons (increase the nuclear charge), yet since we are in the same row, we have not added any inner shell electrons, only valence electrons to the same energy level. Thus, Z_{eff} increases.

   As Z_{eff} increases, there is a stronger pull on all of the electrons.
   Ca has a $Z_{eff} = 20 – (2 + 2 + 6 + 2 + 6) = 2$
   Se has a $Z_{eff} = 34 – (2 + 2 + 6 + 2 + 6 + 10) = 6$

   Selenium has a larger Z_{eff}, and is in the same row as Ca. Even though there are more valence electrons in Se, there is a larger Z_{eff} holding them in. This larger Z_{eff} will hold the electrons closer to the nucleus, thereby creating a smaller radius.

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A larger Z_{eff} holds the electrons tighter. The tighter the electrons are held to the atom, the more energy it takes to remove an electron. This is ionization energy!

The higher the Z_{eff}, the smaller the atomic radius, the higher the ionization energy.

3. Please write out the electron configuration for Germanium, Ge, using two different methods, the orbital notation (including using dashes and arrows, no noble gas shorthand), and the noble gas short hand method (don't need to use dashes and arrows, just superscript numbers will do). State the number of valence electrons in Ge.

Orbital Notation:
1s↿⇂ 2s↿⇂ 2p↿⇂ ↿⇂ ↿⇂ 3s↿⇂ 3p↿⇂ ↿⇂ ↿⇂ 4s↿⇂ 3d↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ 4p↿ ↿

[Ar] $4s^2$ $3d^{10}$ $4p^2$

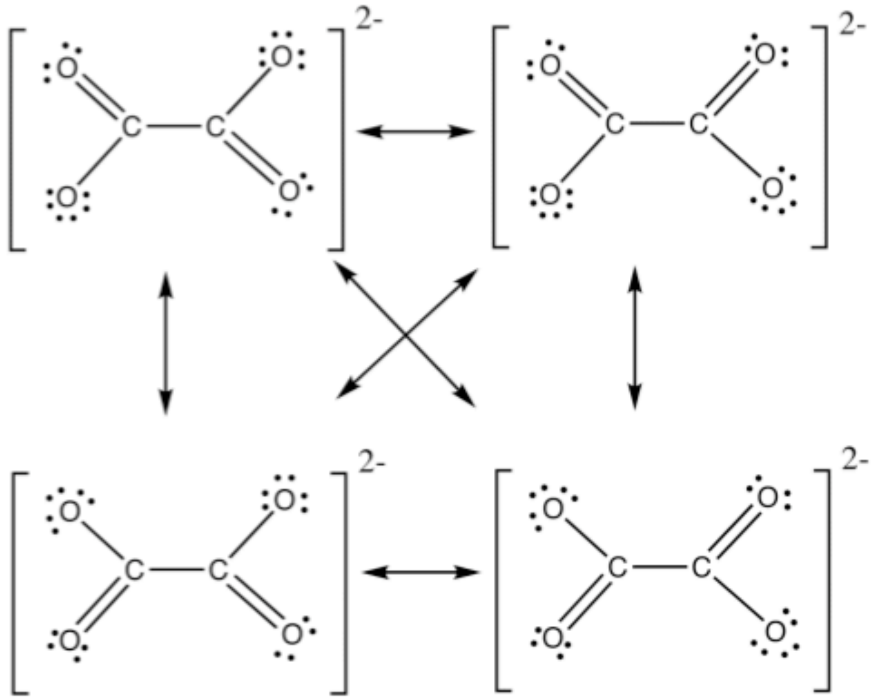
Valence electrons: 4 (2 from the 4s subshell, 2 from the 4p subshell)

4. Please draw the Lewis structure for the molecule, oxalate ion, $C_2O_4^{2-}$. State whether or not you expect all the CO bond lengths to be the same or different, and explain your answer. Calculate the formal charge for each atom in the structure. The sum of the formal charges is what?

S = N – A
Needed: 2C x 8 = 16
4O x 8 = 32
Total Needed: 16 + 32 = 48

Available: 2C x 4 = 8
4O x 6 = 24
Total Available: 8 + 24 = 32

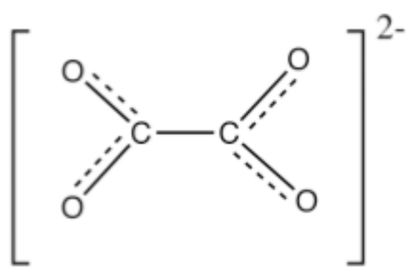
Shared electrons = 48 – 32 = 14
14/2 = 7 bonds



Formal Charge = Valence Electrons–(Lone electrons+½Shared electrons)
OR FC = Group Number–(Lone electrons+number of bonds)
Lone electrons NOT the number of lone pairs

For either carbon: F = 4 – (0 + 4) = 0
For double bonded oxygen: F = 6 – (4 + 2) = 0
For single bonded oxygen: F = 6 – (6 + 1) = -1
So two of the oxygens have a formal charge of -1, giving the ion its total overall charge of -2

All CO bond lengths should be the same. Each Lewis structure is one resonance structure. The actual structure is an average of all of these.



5. Using a drawing and your own words, articulate to the best of your ability, the difference between an ionic compound and a covalent compound.

In an ionic compound, atoms or polyatomic ions have opposite charges

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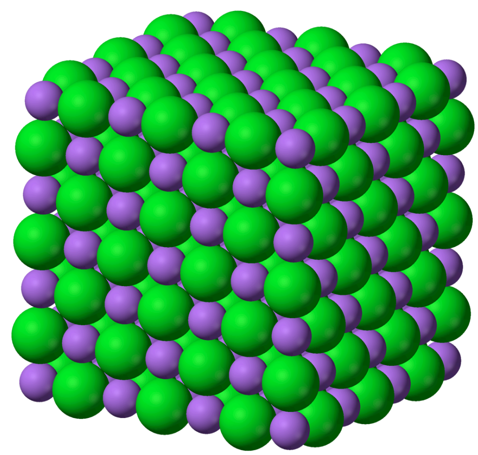
and form a crystal lattice, and the chemical formula is truly a formula unit, or a ratio of the elements.

Remember, when we think about ionic compounds, we are thinking about a solid crystal, not the individual ions (we do not consider what happens when salt dissolves in water when describing an ionic bond).

The atoms actually have opposite charges. No electrons are shared. Therefore, dashes are not used in drawings of ionic compounds, because no electrons are shared.
Example: NaCl crystal (Purple is Na^+ and Green is Cl^-)



In a covalent compound, electrons are actually shared between atoms, forming a chemical bond. The sharing may not be equal between the two atoms (based on their electronegativity) but the electrons are always shared between the atoms. We use dashes in covalent compound drawings to represent a pair of shared electrons.
Example: A water molecule (H_2O)