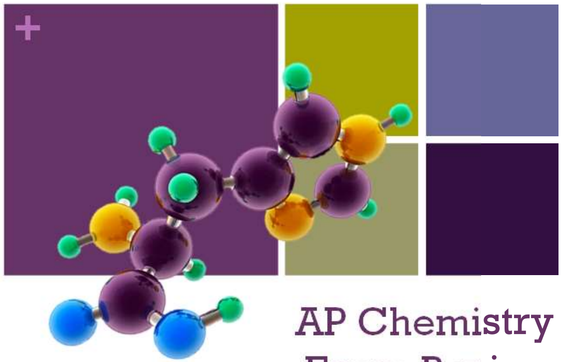
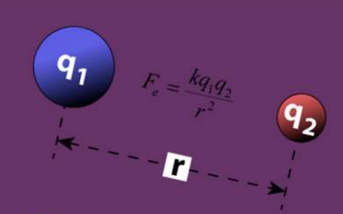


AP Chemistry Exam Review



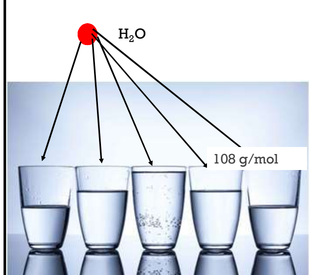
$$F_e = \frac{kq_1q_2}{r^2}$$

Big Idea #1
Properties of Matter

Ratio of Masses in a Pure Sample

Source

Video

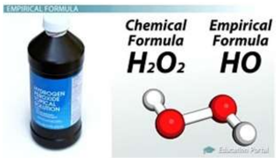


- All elements and molecules are made up of atoms
- Substances with the same atomic makeup will have same average masses
- The ratio of masses of the same substance is independent of size of the substance
- Molecules with the same atomic makeup (ex: H_2O) will have the same ratio of average atomic masses
  - H_2O_2 ratio would be different than H_2O due to the different chemical makeup

LO 1.1: Justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.

Source

+ Composition of Pure Substances and/or Mixtures



- Percent mass can be used to determine the composition of a substance
  - % mass can also be used to find the empirical formula
- The empirical formula is the simplest formula of a substance
  - It is a ratio between the moles of each element in the substance
  - Quick steps to solve!
    - % to mass, mass to moles, divide by the smallest and multiply 'til whole!)
  - The molecular formula is the actual formula of a substance
    - It is a whole number multiple of the empirical formula

Video

LO 1.2: Select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.

Source

+ Identifying Purity of a Substance

- Impurities in a substance can change the percent composition by mass
- If more of a certain element is added from an impurity, then the percent mass of that element will increase and vice versa
- When heating a hydrate, the substance is heated several times to ensure the water is driven off
  - Then you are simply left with the pure substance and no excess water

Video

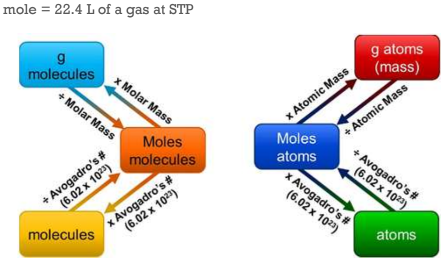
LO 1.3: The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.

Source

+ Mole Calculations

- 1 mole = 6.02 x 10^{23} representative particles
- 1 mole = molar mass of a substance
- 1 mole = 22.4 L of a gas at STP

Video



LO 1.4: The student is able to connect the number of particles, moles, mass and volume of substances to one another, both qualitatively and quantitatively.

Source

+ Electronic Structure of the Atom: Electron Configurations

Video

Electron Configurations

	At #	Increasing Energy ⟶ 1s 2s 2p 3s	Electron Configuration
H	1	↑	$1s^1$
He	2	↑↓	$1s^2$
Li	3	↑↓ ↑	$1s^2 2s^1$
Be	4	↑↓ ↑↓	$1s^2 2s^2$
B	5	↑↓ ↑↓ ↑	$1s^2 2s^2 2p^1$
C	6	↑↓ ↑↓ ↑ ↑	$1s^2 2s^2 2p^2$
N	7	↑↓ ↑↓ ↑ ↑ ↑	$1s^2 2s^2 2p^3$
O	8	↑↓ ↑↓ ↑↓ ↑ ↑	$1s^2 2s^2 2p^4$
F	9	↑↓ ↑↓ ↑↓ ↑↓ ↑	$1s^2 2s^2 2p^5$
Ne	10	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	$1s^2 2s^2 2p^6$
Na	11	↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑	$1s^2 2s^2 2p^6 3s^1$ ([Ne]$3s^1$)
Mg	12	↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ↑↓	$1s^2 2s^2 2p^6 3s^2$ ([Ne]$3s^2$)

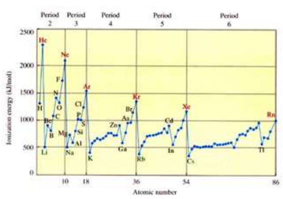
- Electrons in occupy orbitals whose energy level depends on the nuclear charge and average distance to the nucleus
- Electron configurations & orbital diagrams indicate the arrangement of electrons with the lowest energy (most stable):
  - Electrons occupy lowest available energy levels
  - A maximum of two electrons may occupy an energy level
    - Each must have opposite spin (±½)
  - In orbitals of equal energy, electrons maximize parallel unpaired spins

LO 1.5: The student is able to explain the distribution of electrons in an atom or ion based upon data.

Source

+ Electronic Structure of the Atom: 1st Ionization Energy

Video



- 1st Ionization Energy Energy (IE) indicates the strength of the coulombic attraction of the outermost, easiest to remove, electron to the nucleus:

  $X(g) + IE \longrightarrow X^+(g) + e^-$

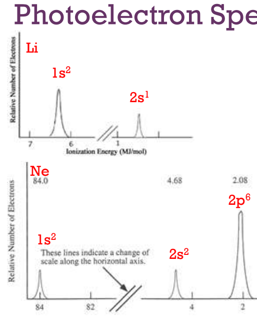
  - 1st IE generally increases across a period and decreases down a group
    - IE generally increases as #protons increases in same energy level
    - IE decreases as e^- in higher energy level: increased shielding, e^- farther from nucleus

LO 1.6: The student is able to analyze data relating to electron energies for patterns and relationships.

Source

+ Electronic Structure of the Atom: Photoelectron Spectroscopy (PES)

Video



- PES uses high-energy (X-ray) photon to excite *random* e^- from atom
- KE of ejected electron indicates *binding energy* (coulombic attraction) to nucleus:

  $$BE = h\varpi_{photon} - KE$$

- Direct measurement of energy and number of each electron
  - Lower energy levels have higher BE
  - Signal size proportional to number of e^- in energy level
- Elements with more protons have stronger coulombic attraction, higher BE at each energy level

LO 1.7: The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb's law to construct explanations of how the energies of electrons within shells in atoms vary.

Source

+ Electronic Structure of the Atom: Higher Ionization Energies

Video

Ionization Energies (kJ/mol)								
	1st	2nd	3rd	4th	5th	6th	7th	8th
H	1312							
He	2372	5250						
Li	520	7297	11810					
Be	899	1757	14845	21000				
B	800	2426	3659	25020	32820			
C	1086	2352	4619	6221	37820	47260		
N	1402	2855	4576	7473	9442	53250	64340	
O	1314	3388	5296	7467	10987	13320	71320	84070
F	1680	3375	6045	8408	11020	15160	17860	92010
Ne	2080	3963	6130	9361	12180	15240	20000	23070
Na	496	4563	6913	9541	13350	16600	20113	25666
Mg	737	1450	7731	10545	13627	17995	21700	25662

Inner Core Electrons

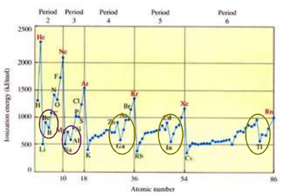
- 2^{nd} & subsequent IE's increase as coulombic attraction of remaining e^-'s to nucleus increases
  - $X^+ + IE \longrightarrow X^{2+} + e^-$
  - $X^{2+} + IE \longrightarrow X^{3+} + e^-$
- Large jump in IE when removing less-shielded core electrons

LO 1.8: The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.

Source

+ Electronic Structure of the Atom: 1^{st} Ionization Energy Irregularities

Video



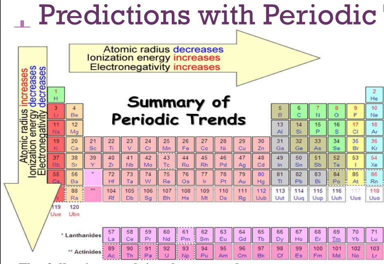
- 1^{st} Ionization Energy Energy (IE) decreases from Be to B and Mg to Al
  - Electron in 2p or 3p shielded by $2s^2$ or $3s^2$ electrons, decreasing coulombic attraction despite additional proton in nucleus.
  - Same effect seen in $3d^{10}$-4p, $4d^{10}$-5p and $5d^{10}$-6p
- 1^{st} Ionization Energy decreases from N to O and P to S
  - np^4 contains first paired p electrons, e^--e^- repulsion decreases coulombic attraction despite additional proton

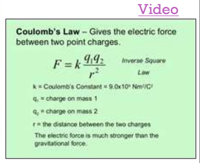
LO 1.8: The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.

Sources

Predictions with Periodic Trends

Video





- The following explains these trends:
  - Electrons attracted to the protons in the nucleus of an atom
    - So the closer an electron is to a nucleus, the more strongly it is attracted (Coulomb's law)
    - The more protons in a nucleus (effective nuclear force), the more stronç its attracts electrons attracts
  - Electrons are repelled by other electrons in an atom. If valence electrons are shielded from nucleus by other electrons, you will have less attraction of the nucleus (again Coulomb's law-greater the atomic radius, the greater the distance)

L.O. 1.9 The student is able to predict and/or justify trends in atomic properties based on location on periodic table and/or the shell model

Source

+ Chemical Reactivity

- **Using Trends**
- Nonmetals have higher electronegativities than metals --> causes the formation of ionic solids
- Compounds formed between nonmetals are **molecular**
  - Usually gases, liquids, or volatile solids at room temperature
- Elements in the 3rd period and below can accommodate a larger number of bonds
- The first element in a group (upper most element of a group) forms pi bonds more easily (most significant in 2nd row, non-metals)
  - Accounts for stronger bonds in molecules containing these elements
  - Major factor in determining the structures of compounds formed from these elements
- Elements in periods 3-6 tend to form only single bonds
- Reactivity tends to increase as you go down a group for metals and up a group for non-metals.

Video

L.O. 1.10: Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity

Source

+ Chemical Properties within a Group and across a Period

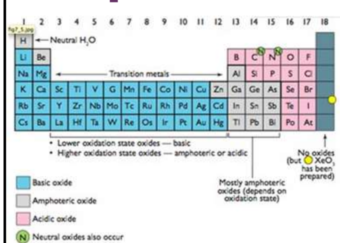


Figure 7.5
The periodic table shows that metallic oxides are mostly basic and that non-metallic oxides are mostly acidic. The elements with amphoteric oxides lie between the attracts two groupings.

- Group 1 metals more reactive than group 2 metals
- Reactivity increases as you go down a group
- Metals on left form basic oxides
  - Ex. $Na_2O + H_2O \rightarrow 2\ NaOH$
- Nonmetals on right form form acidic oxides
  - Ex. $SO_3 + H_2O \rightarrow H_2SO_4$
- Elements in the middle, like Al, Ga, etc can behave amphoterically its
- If SiO_2 can be a ceramic then SnO_2 may be as well since both in the same group

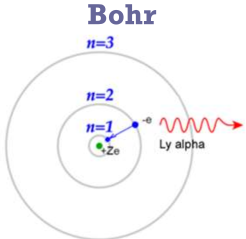
Video

LO 1.11: Analyze data, based on periodicity & properties of binary compounds, to identify patterns & generate hypotheses related to molecular design of compounds

Source

+ Classic Shell Model of Atom vs Quantum Mechanical Model

Shell Model - Bohr



Developed by Schrodinger and the position of an electron is now represented by a wave equation

- Most ***probable*** place of finding an electron is called an **ORBITAL** (90% probability)
- Each orbital can only hold 2 electrons with opposing spins (S, P, D & F orbitals)

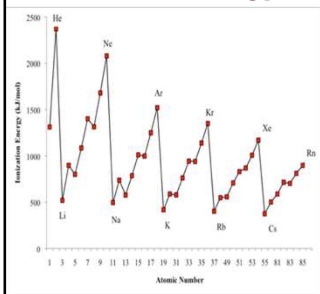
Evidence for this theory:

- Work of DeBroglie and PLanck that electron had wavelike characteristics
- Heisenberg Uncertainty Principle - impossible to predict exact location of electron- contradicted Bohr
- This new evidence caused the Shell Theory to be replaced by the Quantum Mechanical Model of the atom

LO 1.12: Explain why data suggests (or not) the need to refine a model from a classical shell model with the quantum mechanical model

Source

+ Shell Model is consistent with Ionization Energy Data



Video

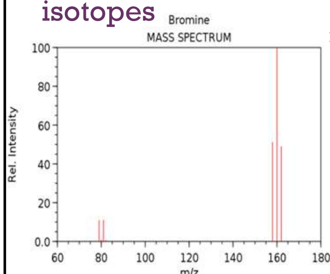
The patterns shown by the IE graph can be explained by Coulomb's law

- As atomic number increases, would expect the ionization energy to constantly increase
- Graph shows that this is NOT observed. WHY NOT?
- The data implies that a shell becomes full at the end of each period
- Therefore the next electron added must be in a new shell farther away from the nucleus.
- This is supported by the fact that the ionization energy drops despite the addition positive charge in the nucleus

LO: 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence

Source

+ Mass Spectrometry - evidence for isotopes



NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)

Video

Mass spectrometry showed that elements have isotopes

- This contradicted Dalton's early model of the atom which stated that all atoms of an element are identical
- 3 Br_2 & two Br isotopes shown in diagram
- The average atomic mass of the element can be estimated from mass spectroscopy

$$\text{Average Atomic Mass} = \frac{\sum(\text{mass of isotope} \times \%\ \text{natural abundance})}{100}$$

LO 1.14: The student is able to use the data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element

Source

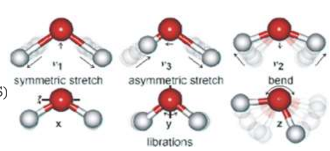
+ Using Spectroscopy to measure properties associated with vibrational or electronic motions of molecules

IR Video
UV Video

IR Radiation - detects different types of bonds by analyzing molecular vibrations

UV or X-Ray Radiation

- Photoelectron Spectroscopy(PES)
- Causes electron transitions
- Transitions provides info on electron configurations

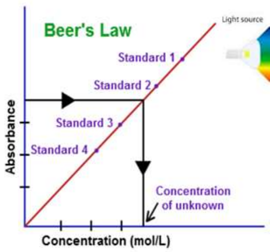


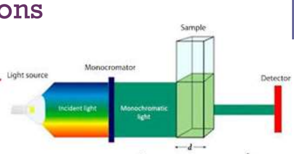
LO: 1.15 Justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules

+ Beer-Lambert Law - used to measure the concentration of ***colored*** solutions

Source 1, 2

Video





$$A = abc$$

A = absorbance
a = molar absorptivity (constant for material being tested)
b = path length (cuvette = 1 cm)
c = concentration

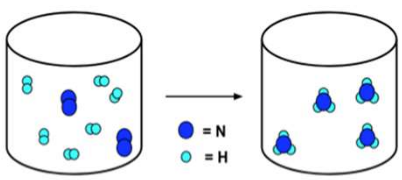
- Taken at fixed wavelength

LO1.16: Design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in solution

+ Law of Conservation of Mass

Source

Video



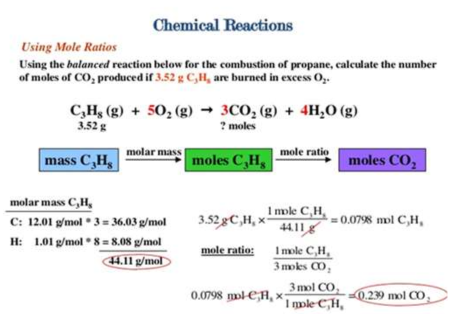
$$N_2 + 3H_2 \rightarrow 2NH_3$$

LO1.17: Express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings

+ Use Mole Ratio in balanced equation to calculate moles of unknown substance

Source

Video



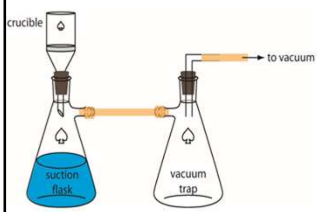
LO1.18: Apply the conservation of atoms to the rearrangement of atoms in various processes.

Source

+ Gravimetric Analysis

Buchner Filtration Apparatus

Video



How much lead (Pb^{2+}) in water?

$Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow PbCl_2\ (s)$

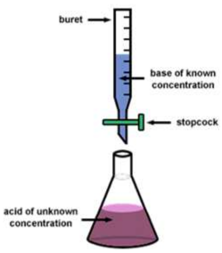
- By adding excess Cl- to the sample, all of the Pb^{2+} will precipitate as $PbCl_2$
- Solid product is filtered using a Buchner Filter and then dried to remove all water
- Mass of $PbCl_2$is then determined
- This can be used to calculate the original amount of lead in the water

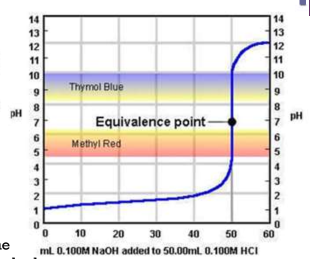
LO 1.19: Design and/or interpret data from, an experiment that uses gravimetric analysis to determine the the concentration of an analyte in a solution.

Source

+ Using titrations to determine concentration of an analyte

Video





At the equivalence point, the stoichiometric molar ratio is reached

LO1.20: Design and/or interpret data from an experiment that uses titration to determine the concentration of an analyte in a solution.