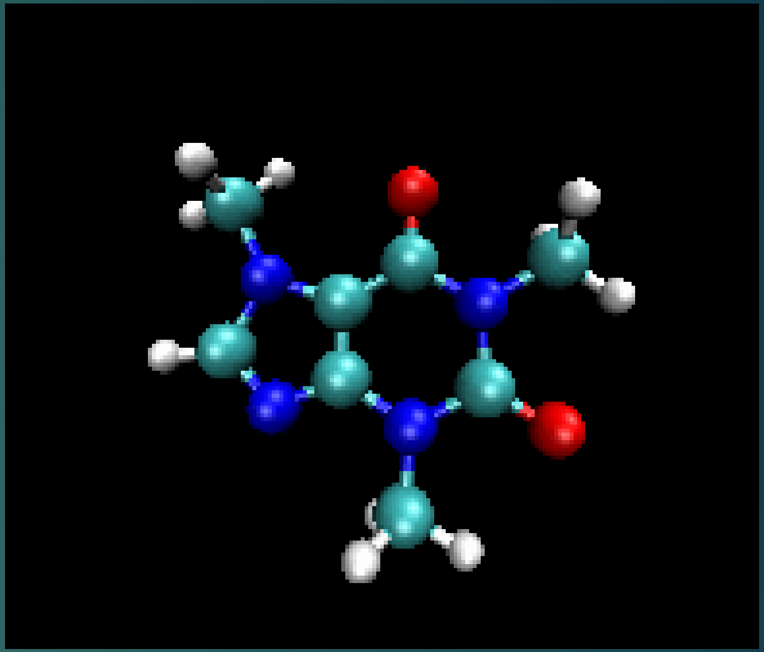
Science 10 Chemistry Unit



THE PERIODIC TABLE, ATOMS, COMPOUNDS AND CHEMICAL REACTIONS

TEXTBOOK REFERENCE: CHAPTERS 5 & 6

Unit 1: The Atom & Periodic Table

- Learn the development of the understanding of the atom from 1803 to the present day.
  - The Nucleus
  - The Electron Cloud
- Learn the structure of the atom.
- Learn the subatomic particles and their properties.
- Learn the information available on the standard periodic table.
  - Key elemental information
  - Group properties on the periodic table

Brief History of Chemistry

The Creation of Chemistry - The Fundamental Laws: Crash Course Chemistry #3

CrashCourse

Chemistry

- The study of matter, its properties, and its changes or transformations.

- ***Matter***: Anything that has mass and takes up space.

The Atom

- The smallest part of an element.
  - If you could zoom in on elements, like iron, oxygen, helium, plutonium, etc., you would see the atoms that make up that element.

- Theorized by Democritus around 2500 years ago.
  - Not based on a scientific investigation.
  - Could not explain chemical properties of matter.
  - Would remain undeveloped until the early 1800s.

John Dalton’s Atomic Theory: 1803

1. All elements are composed of tiny indivisible particles called atoms.

2. Atoms of the same element are identical. The atoms of any one element are different from those of any other element.

John Dalton's Atomic Theory: 1803

3. Atoms of different elements can physically mix together or chemically combine in simple whole-number ratios to form compounds (like H_2O, CO_2).

4. Chemical reactions occur when atoms are separated, joined, or rearranged. Atoms of one of the element, however, are never changed to atoms of another element as a result of a chemical reaction. (Nuclear reactions change atoms from one type to another – happens in the naturally in the Sun and on Earth.

Incorporation of Electrons

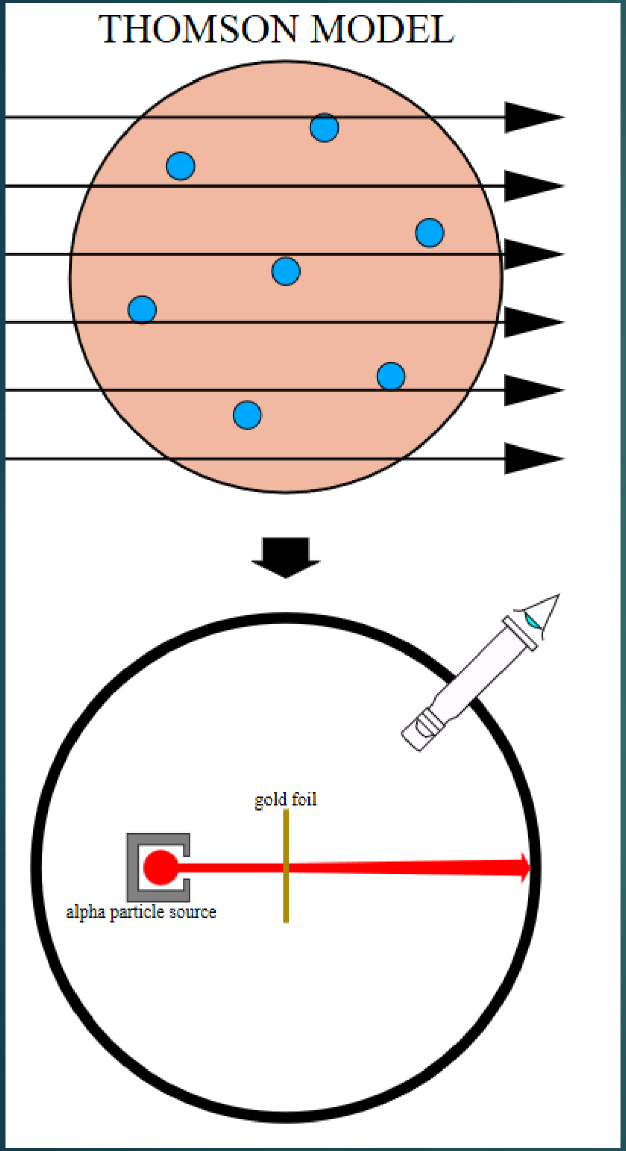
- Electrons, as particles, were first theorized in 1897 by English physicist J.J. Thompson. He invented the cathode ray tube to test for charges. That work eventually became the CRT television.

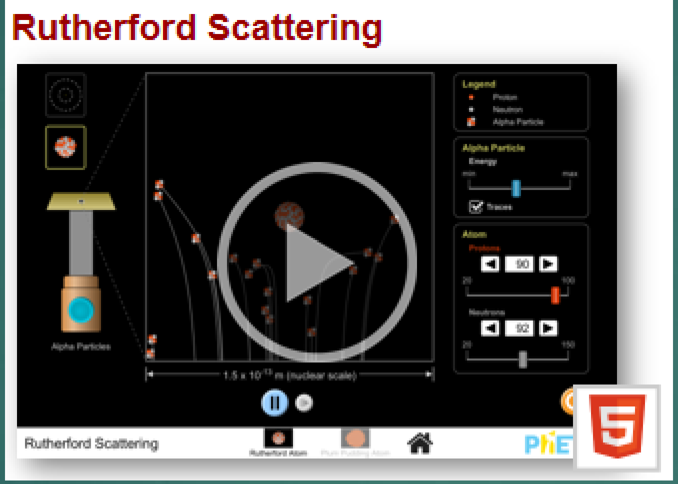
- Thompson adjusted the model of the atom to incorporate electrons; he proposed the atom is a lump of positive charge with electrons evenly spaced within it – dubbed the "plum pudding" model of the atom.

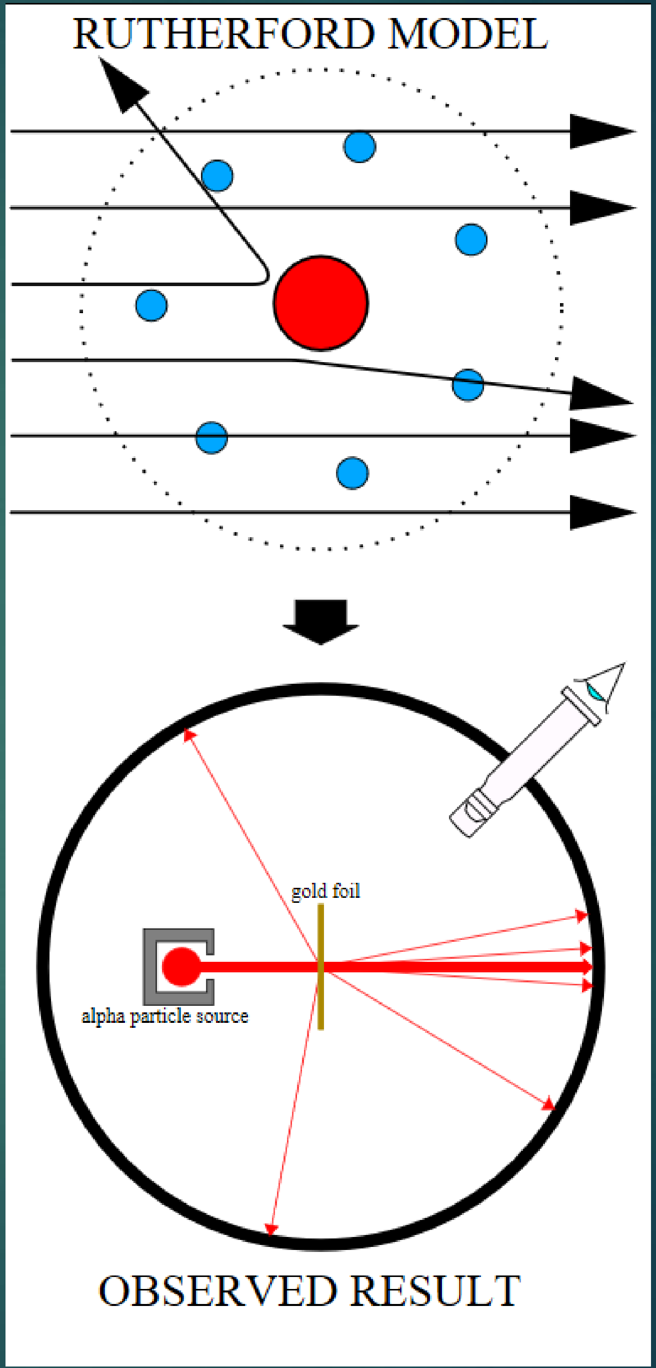
Discovery of the Nucleus

- Earnest Rutherford and coworkers at University of Manchester, England, were the first to theorize, based on experimental evidence, the existence of the atomic nucleus.
- In 1911 he performed the "Gold-Foil" experiment.
- His discovery changed the model of the atom significantly – the first evidence of the atomic nucleus and that atoms are mostly empty space.

Rutherford Experiment

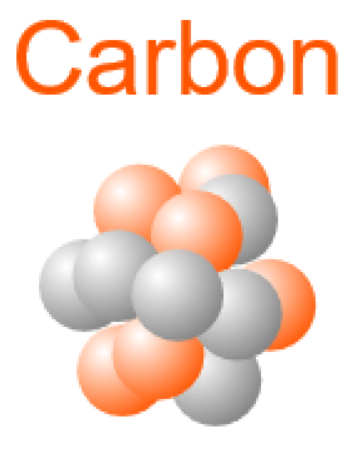


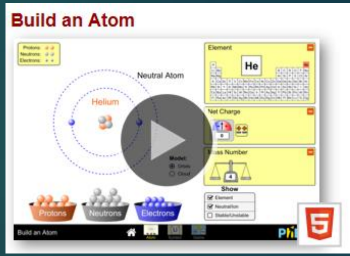




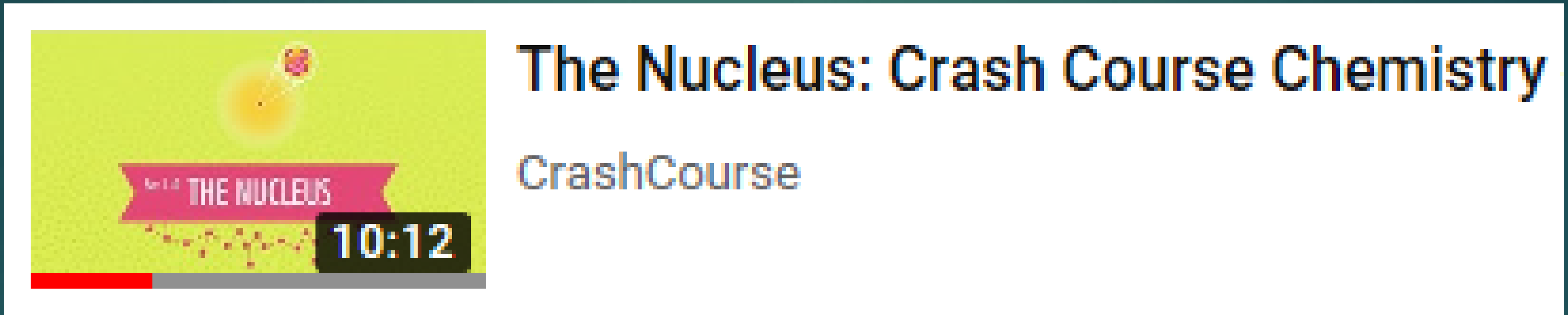
The Atomic Nucleus

- Rutherford's experiment confirmed the presence of a small, dense, area of positive charge. The term ***proton*** was used to name the unseen positive particles. Also, that atoms are mostly empty space.
- It would be 21 years later, in 1932, when physicist James Chadwick discovered the ***neutron***, which also exists within the nucleus to keep protons apart. The neutron is neutral in charge (a charge of zero). The # of neutrons does not have to equal the # of protons in an atom.
- Protons (p^+) and neutrons (n^0) are very close to the same size and mass. Both have a much, much larger mass than the electron (e^-)





The Nucleus: Summary Video



- But what about ***electrons***?
- Chemical and physical properties are the result of electrons in the atom.

Atomic Structure – Electron Orbitals

- 1897: Thompson theorized electrons were static in a clump of positive charge.
- 1904: Japanese physicist suggests a central nucleus exists and electrons travel around it like the rings around the planet Saturn.
- 1911: Rutherford's experimental results support the nucleus and he agreed that electrons orbit the nucleus like planets around the Sun. However, it could not explain properties of elements, like why heated metal glowed red/orange.
- 1913: New Zealand physicist Niels Bohr adjusts the model such that electron's have fixed distances from the nucleus, but that electrons can change where they are located in the atom by gaining/losing energy.

Bohr Model of the Atom

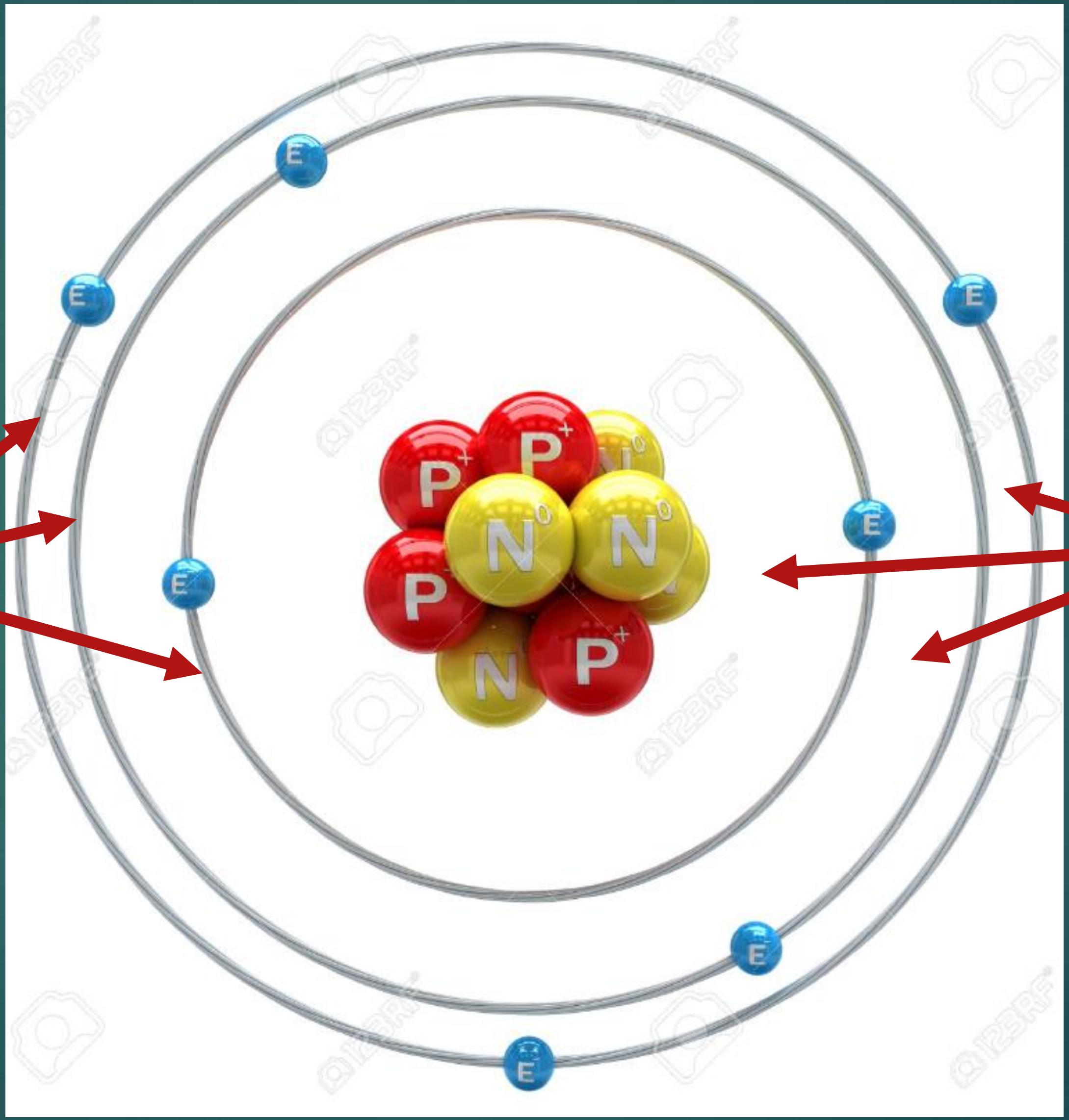
- Explains observations of light coming from the simplest element, hydrogen, but failed for larger atoms, like metallic elements change color when heated.

- The energy electrons have is ***quantized***, they can only have a specific amount of energy at each orbit and they cannot be found at any other orbit.

- Electrons gain or lose a ***quantum*** of energy to change orbital locations around the nucleus.

Bohr Model of the Atom

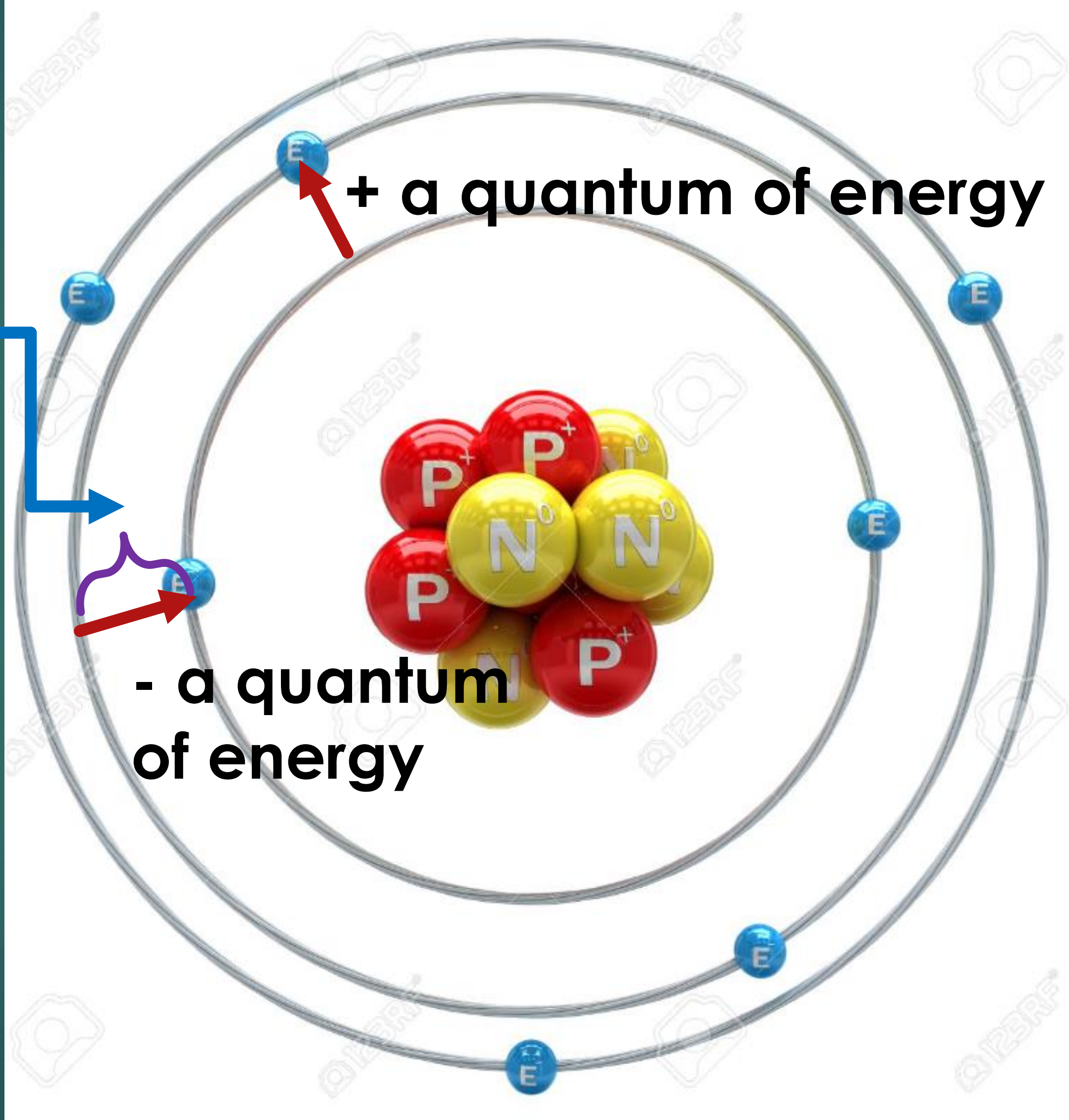
Quantized energy orbitals



Electrons can't be here!

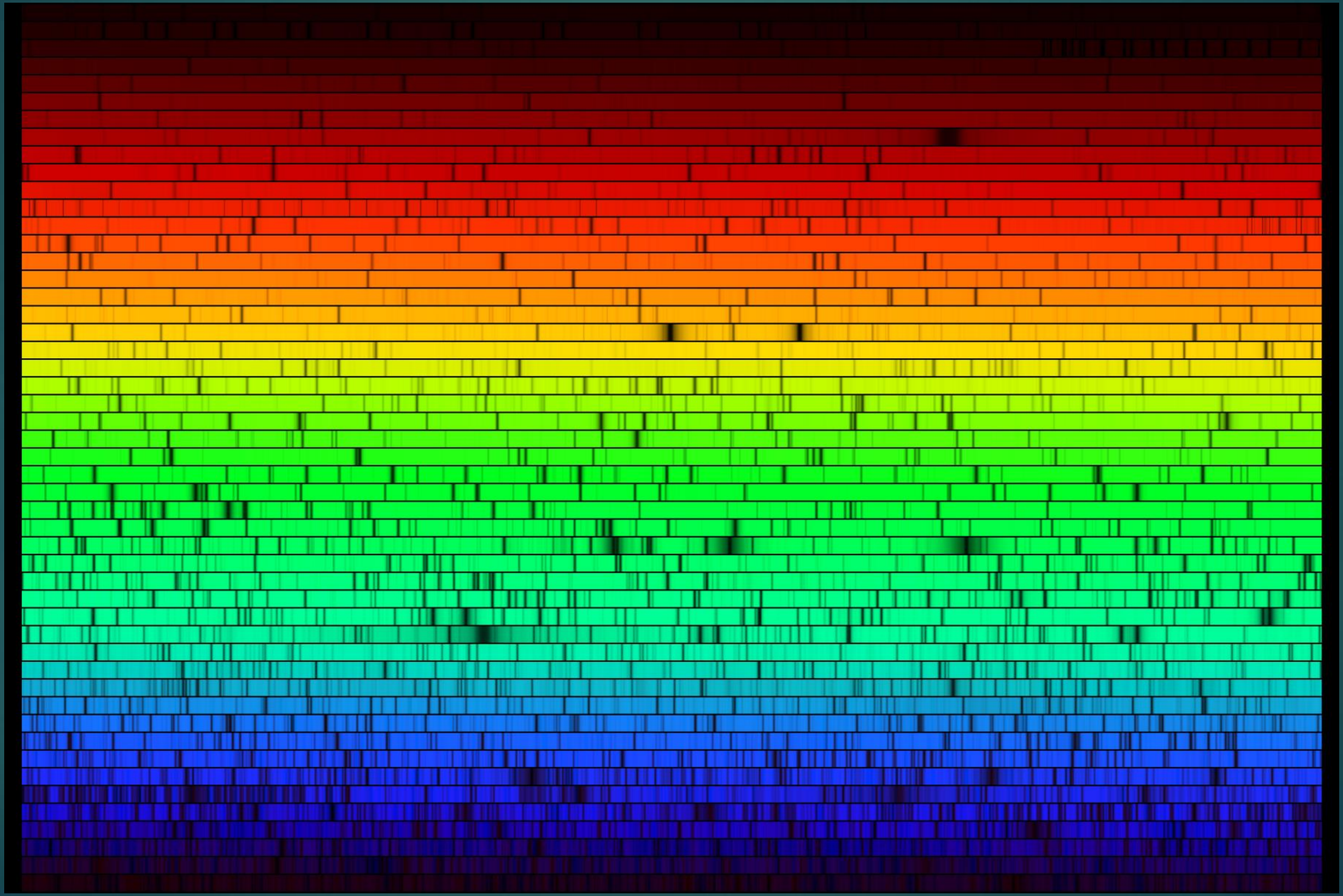
Bohr Model of the Atom

Change in energy is released as radiation, in the case of metals, it could be orange light!



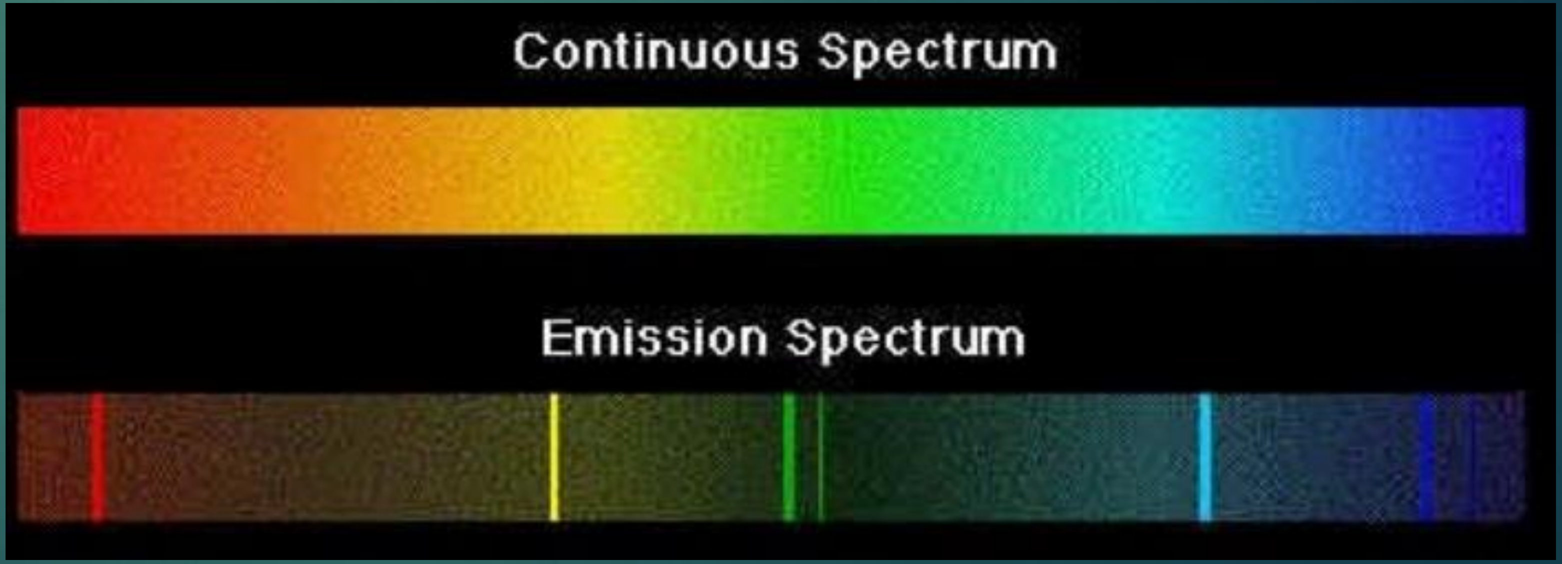
- Again, this model explained hydrogen, but failed for the larger atoms.
- This theory was refined by Erwin Schrodinger in 1926.

Absorbing Energy: Absorption Spectra

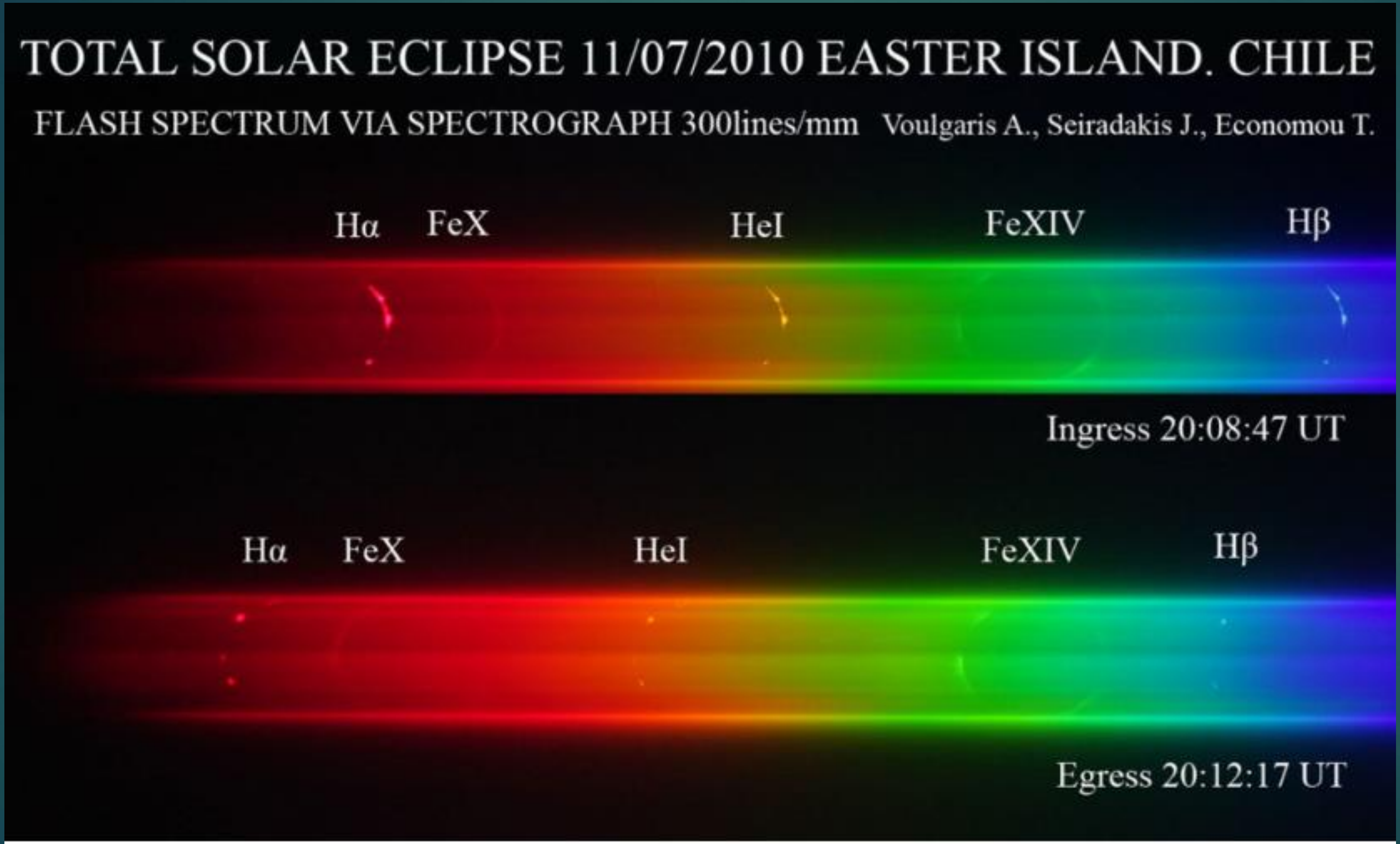


Emitting Energy: Emission Spectrum

- Helium was discovered on the Sun before it was found on Earth.
- During a solar eclipse, extra energies were found being emitted from the hot gas, called the solar corona, surrounding the Sun.



Emitting Energy: Emission Spectrum



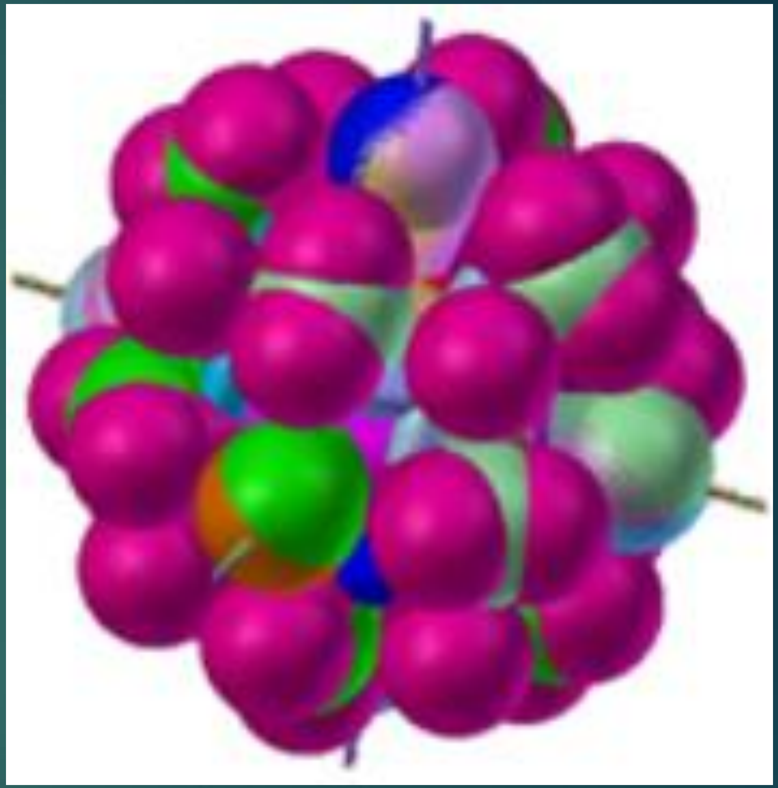
The Flash Spectrum after the 2nd and before 3rd contact from TSE 2010, Easter Island

Quantum Mechanical Model

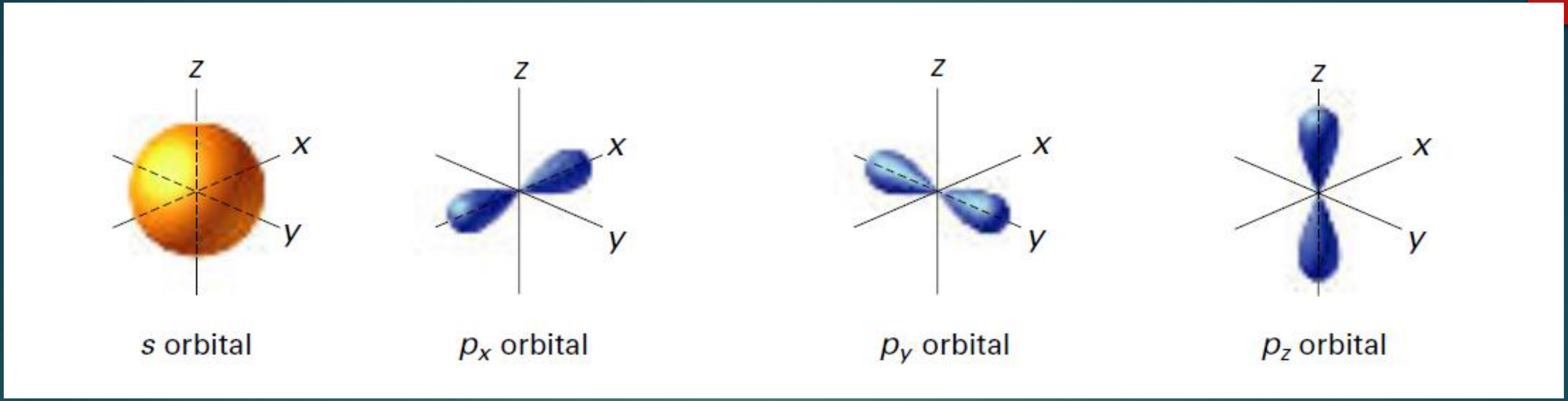
- In 1926 Austrian physicist Erwin Schrodinger spearheaded the development of the basis for our current model of the atom, the ***Electron Cloud Model*** or ***Quantum Mechanical Model***.
- His model of the atom was mathematical. A mathematical representation of the atom based on all know numerical and scientific information at the time.
- This resulted in a model where electrons have a high probability of being found in a specific region around the nucleus, called an ***atomic orbital***.

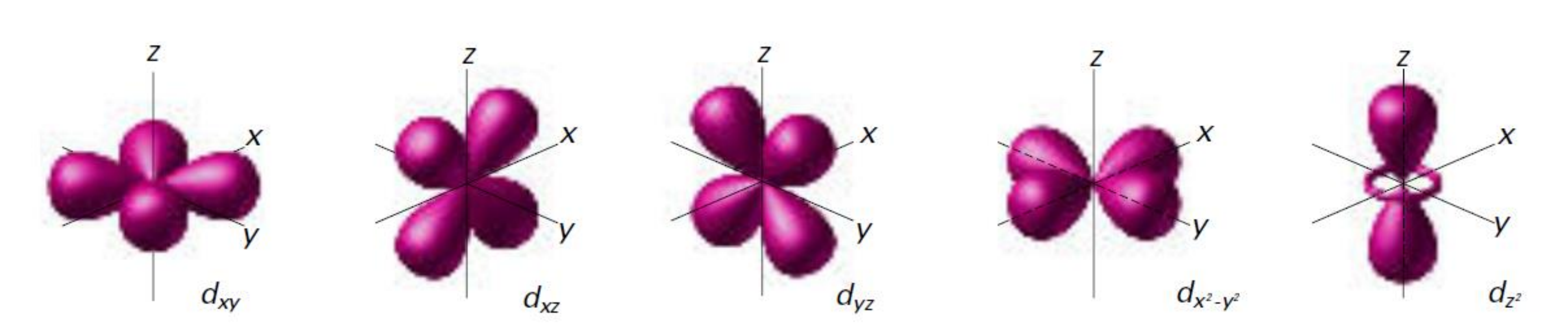
Quantum Mechanical Model

- The regions were not circular orbitals, but blob-shaped 3D spaces.
- Electrons were found to have wave and particle properties.
- Expanded upon Bohr's work and explained the properties of all elements (to a degree, they did not have any electronically powered computers for calculations).

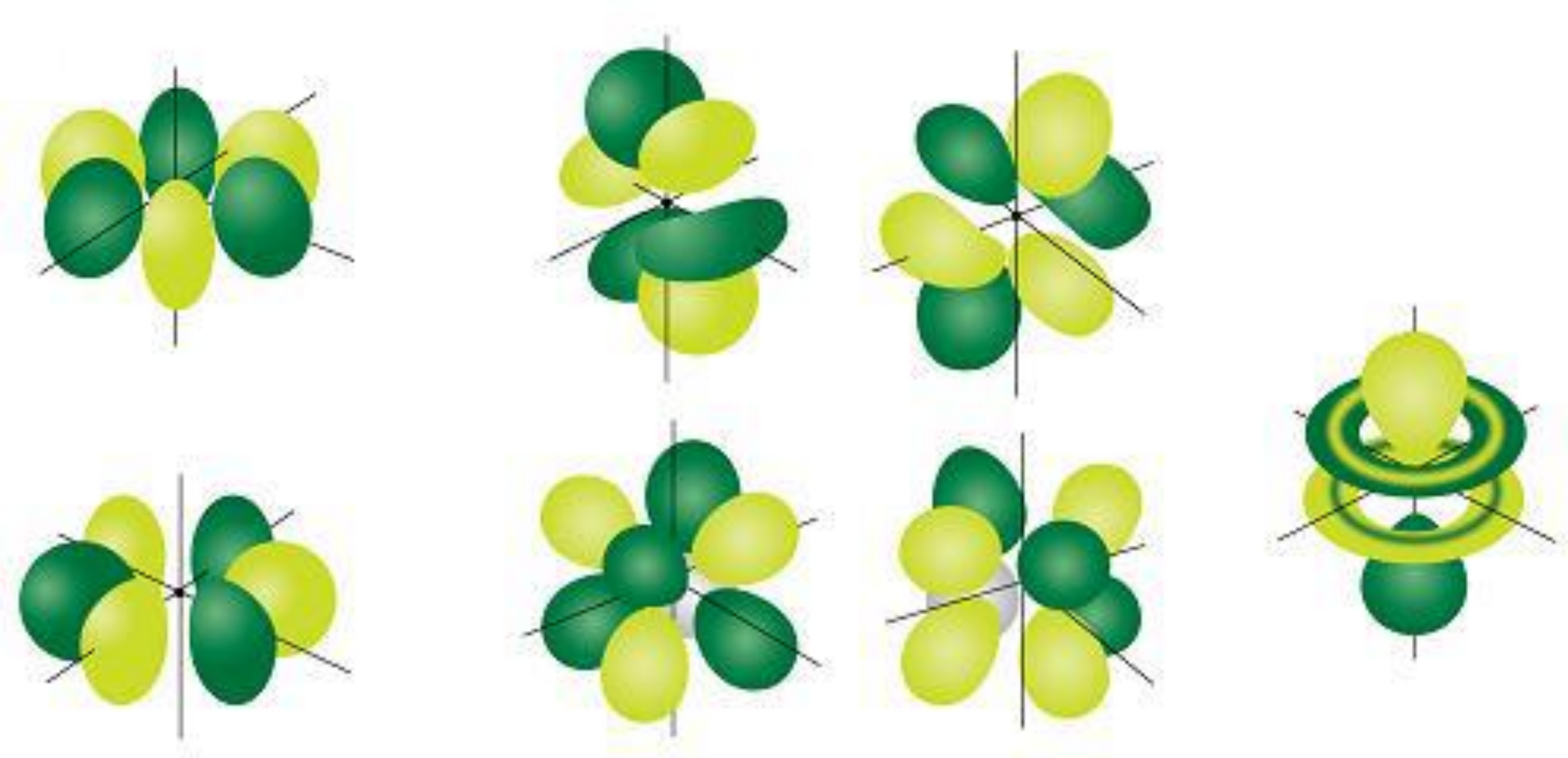


Quantum Mechanical Model

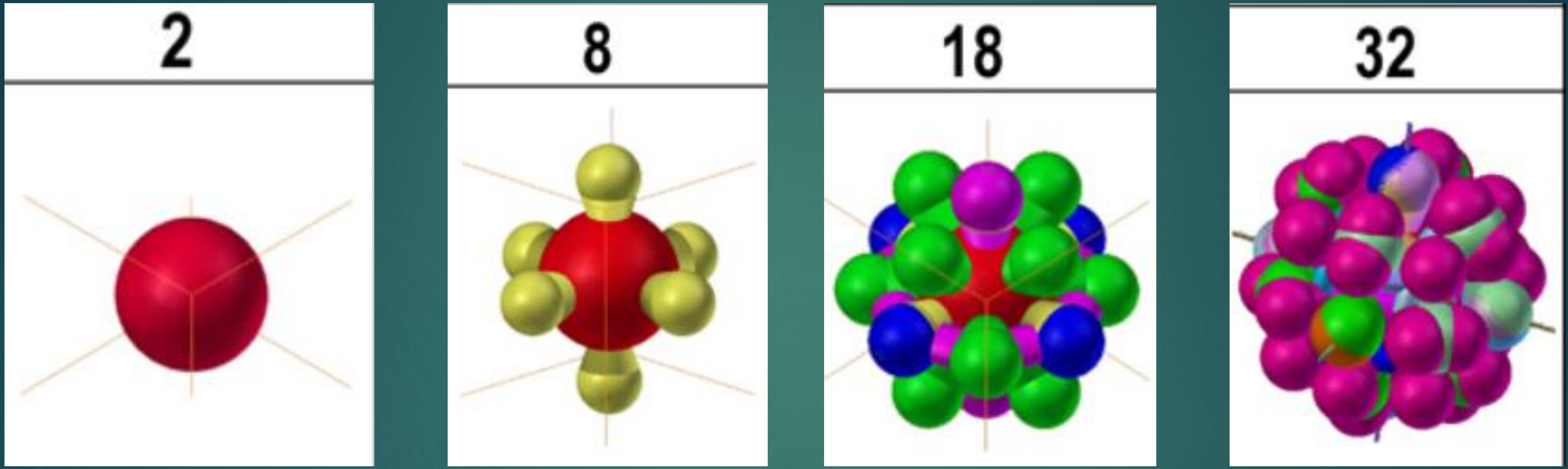




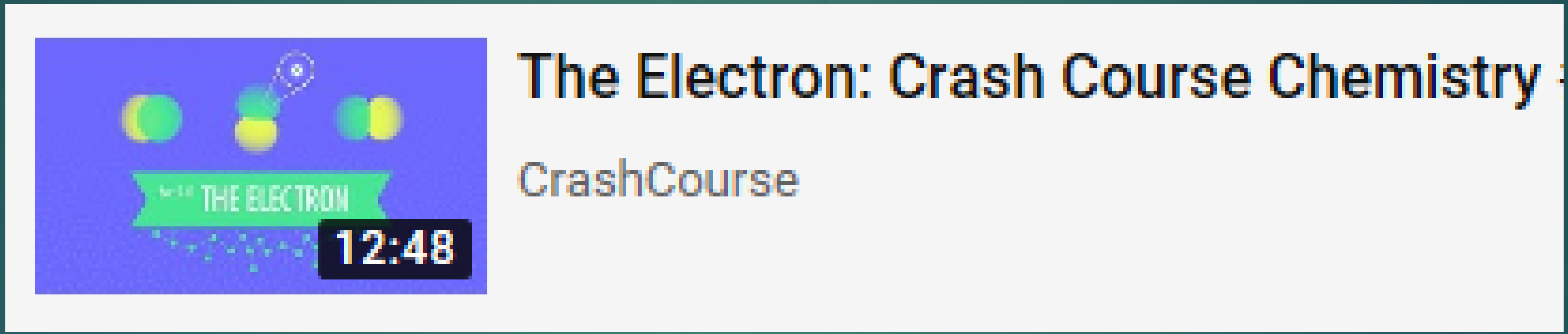
Quantum Mechanical Model



Overlapping Orbitals = Electron Cloud



The Electron: Summary Video

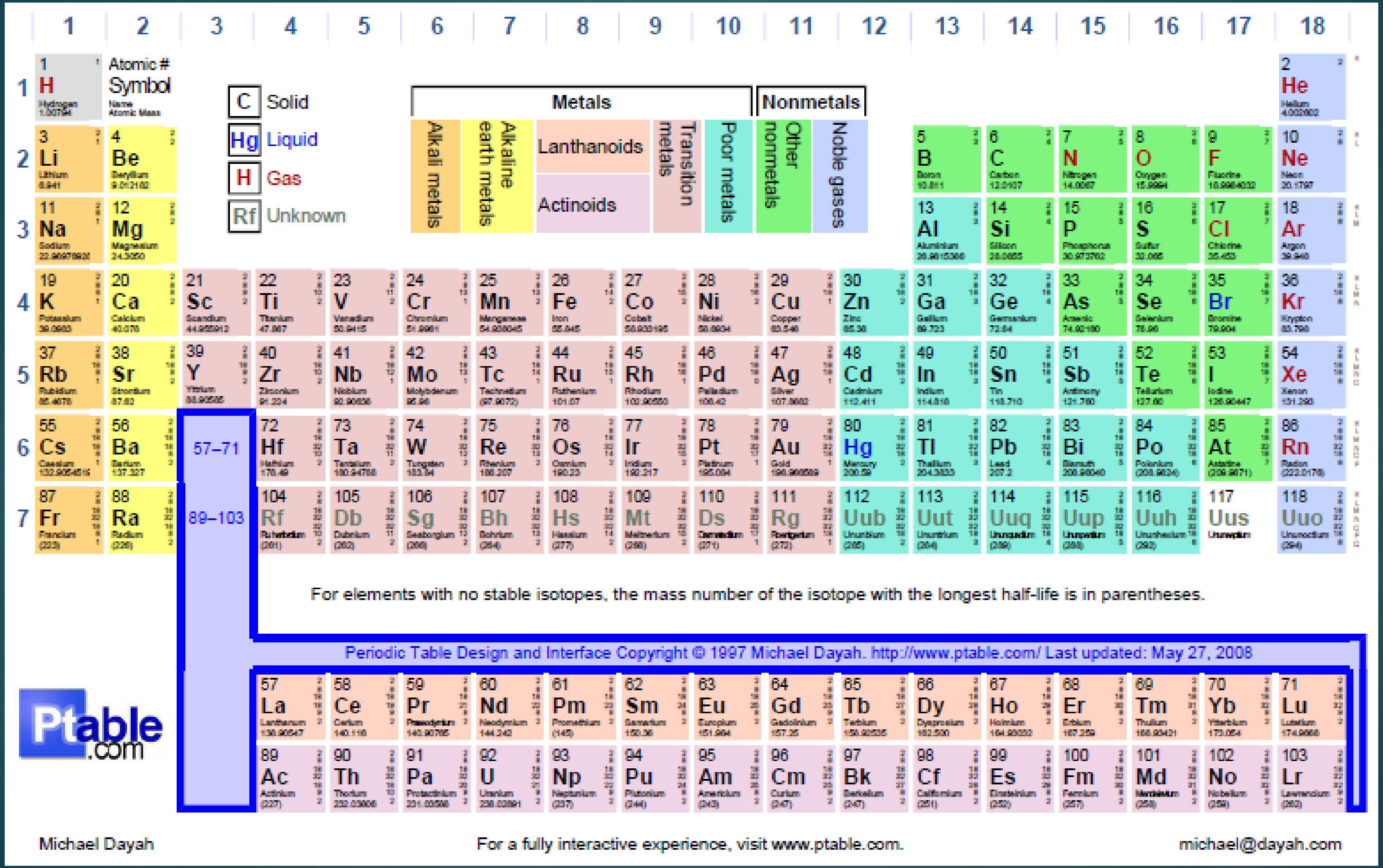


Organizing Elements: The Periodic Table

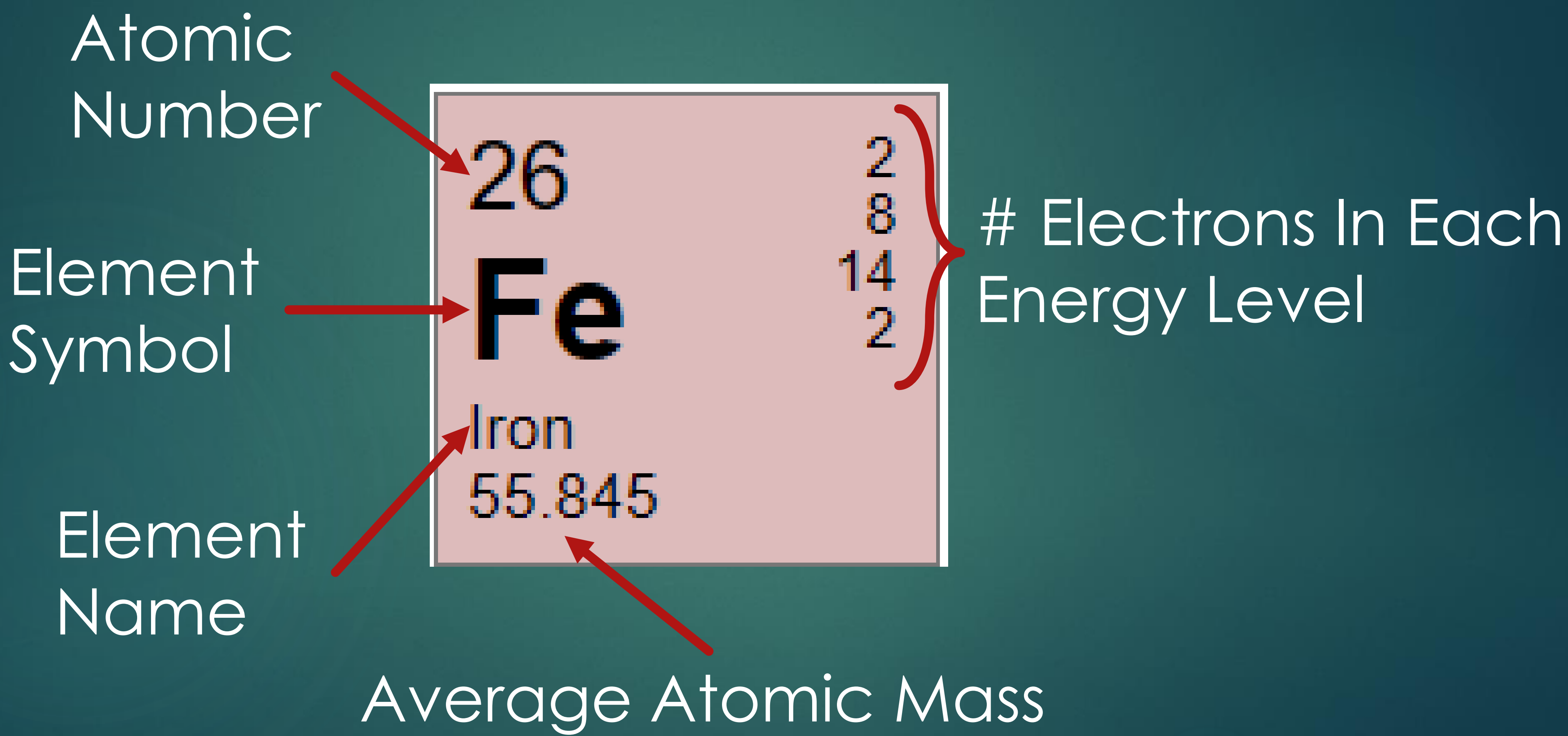
The Periodic Table: Crash Course Chemistry

CrashCourse

The Periodic Table of the Elements



Our Periodic Table



Periodic Table: Element Information

- **Element Symbol**: First letter is always a capital letter. If there is a second letter it is lower case. Two letters maximum.
- **Atomic Number**: The number of ***protons*** in the nucleus; how the table is organized. The number of protons defines the element.

Periodic Table: Element Information

- **Average Atomic Mass**: The mass of the element taking into account its various ***isotopes*** (atoms of the same element but a different number of neutrons). The unit is the *atomic mass unit, amu*.
- 1 amu is defined as exactly one-12th (1/12) the mass of the Carbon-12 atom (6 protons and 6 neutrons).
- Rounded Atomic Mass – Atomic Number ≈ # of Neutrons
  - For example, approximately how many neutrons in one atom of iron?
  - 56 – 26 = 30. Approximately 30 neutrons in an atom on iron.

Approximating Neutrons Practice Questions

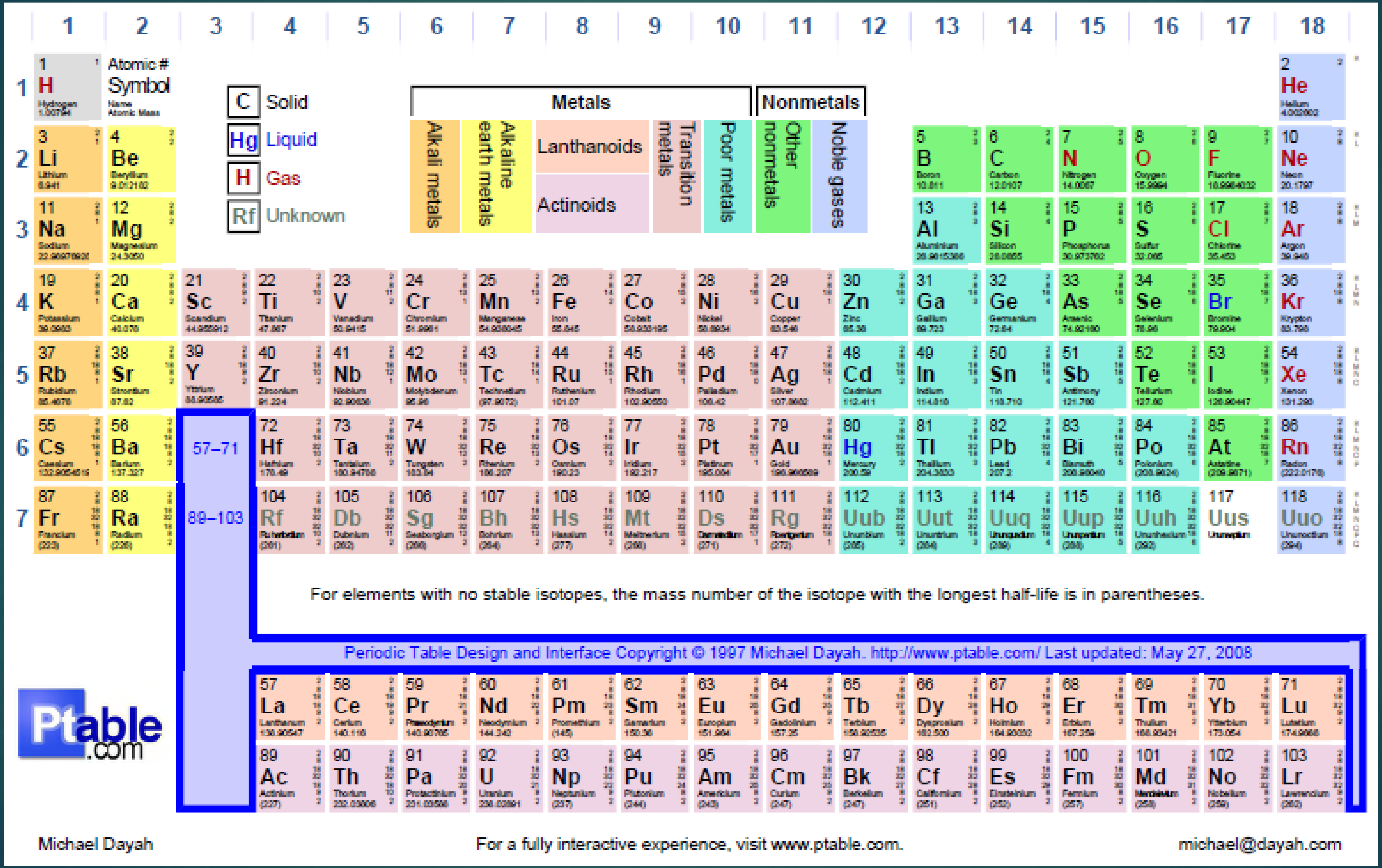
- Calculate the approximate number of neutrons in each of the following atoms with atomic #s:
  - 9
  - 30
  - 54
  - 56
  - 92
  - 99

These types of questions are not on your practice sheet, but you need to know how to do them.

The Periodic Law

- When elements are tabled in order of increasing atomic number, there is a periodic repetition of chemical and physical properties.
- **<u>Groups</u>**: The vertical columns; elements in the same column have similar chemical and physical properties (boiling points, luster, conductivity, reactivity, etc.).
- **<u>Periods</u>**: The horizontal rows. As you read left to right, elements get properties of non-metals.

The Periodic Table of the Elements

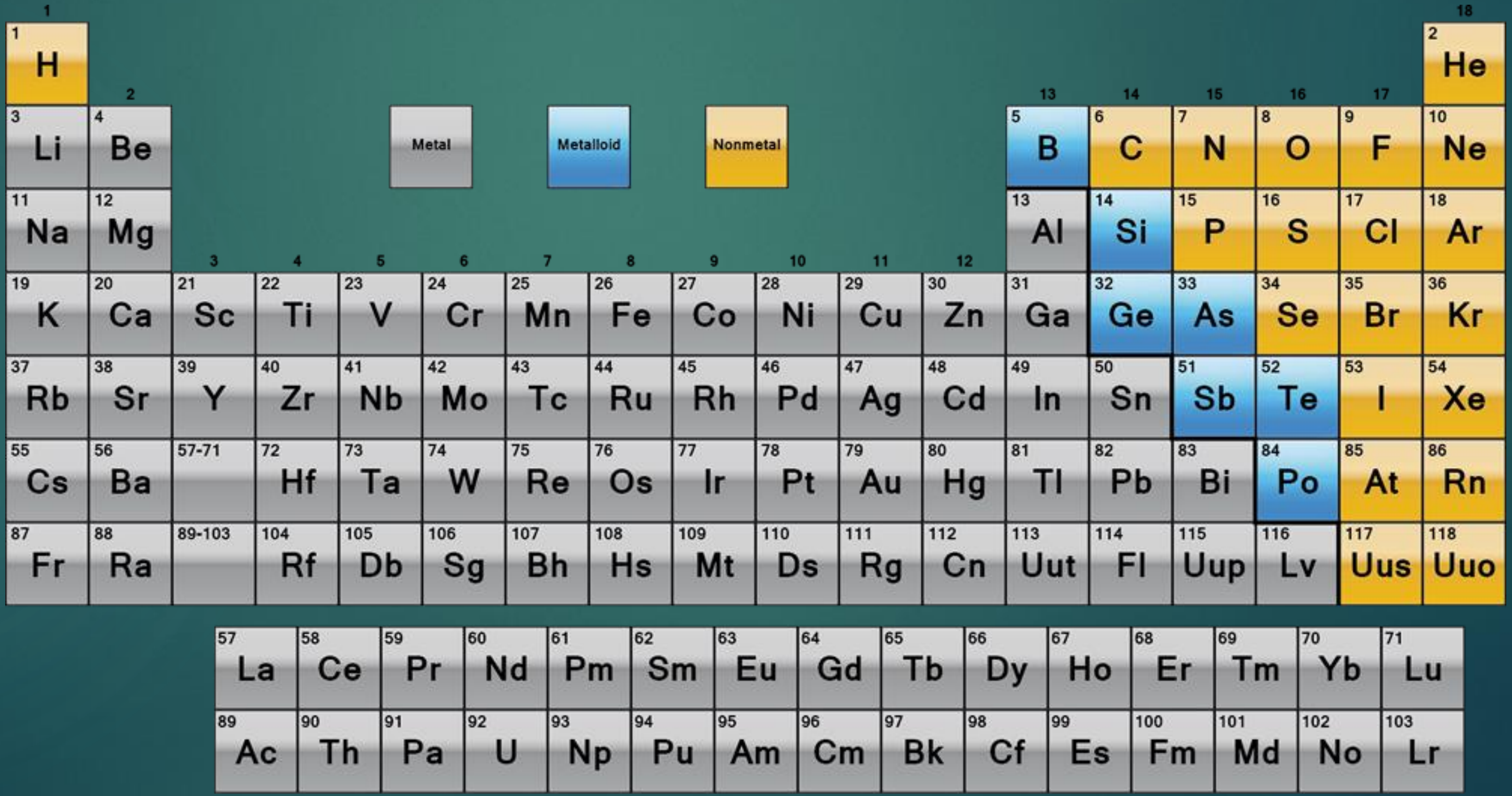


Using the Periodic Table

- What element is atomic number 74?
- What is the symbol for the element with atomic number 82?
- What is the atomic mass of cesium (located in group 1)?
- How many electrons in the 3rd energy level of cadmium?
- What element has the most electrons in group 2?
- What element is located in period 4 group 11?
- How many protons in an atom of carbon?
- How many electrons in the highest energy level of group 1? 17? 18?
- Approximately how many neutrons in one atom of Zinc?

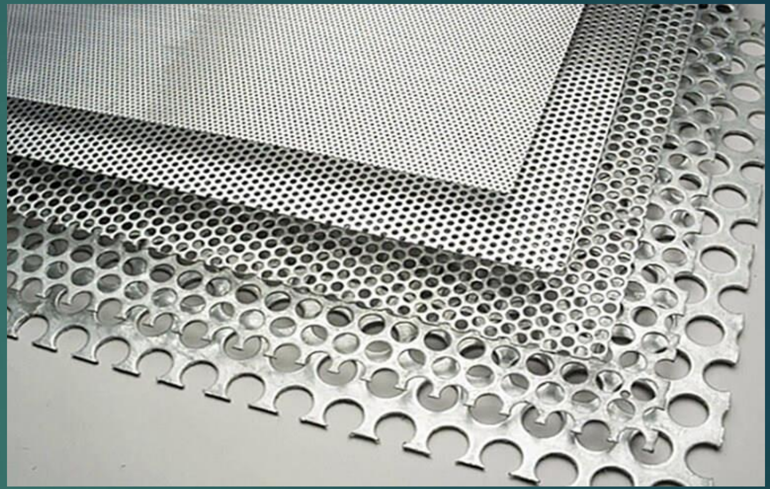
Metals, Nonmetals & Metalloids

- The periodic table classifies/divides elements into one of three groups: **metals**, **non-metals** and **metalloids**.
- Scanning across the periodic table (from left-to-right), the properties of elements becomes less metallic and more nonmetallic.



Physical Properties of Metals

- Most elements are metals.
- Good conductors of heat and electricity.



- High luster and sheen; shiny.
- Malleable – hammered into thin sheets.
- Ductile – drawn into wires.

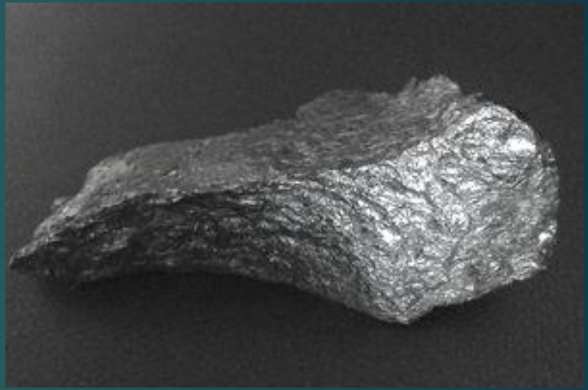
- Solids at room temperature (except for mercury).

Physical Properties of Nonmetals

- State at room temperature varies as many are gases but some are liquids and a few are solids.
- Properties opposite of metals.
- Not good conductors of electricity and heat (carbon is an exception to this)
- Not shiny, so they are dull.
- Not malleable.
- Not ductile.

Physical Properties of Metalloids

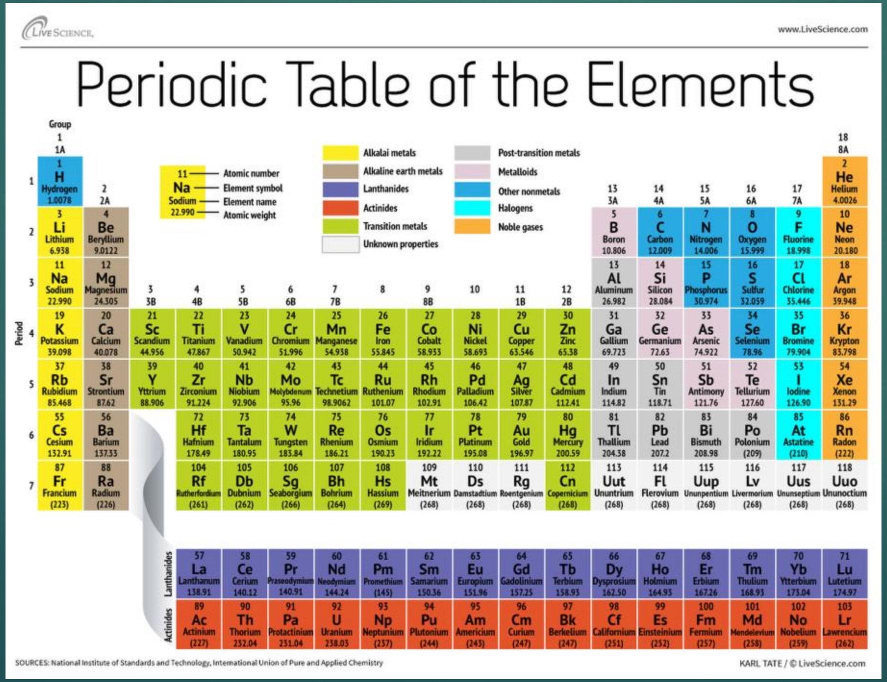
- There is a heavy staircase, bolded line that separates metals and nonmetals.
- The metals that border the line are the metalloids.
- Metalloids tend to have some properties of metals and nonmetals; this depends on the conditions the element is under.



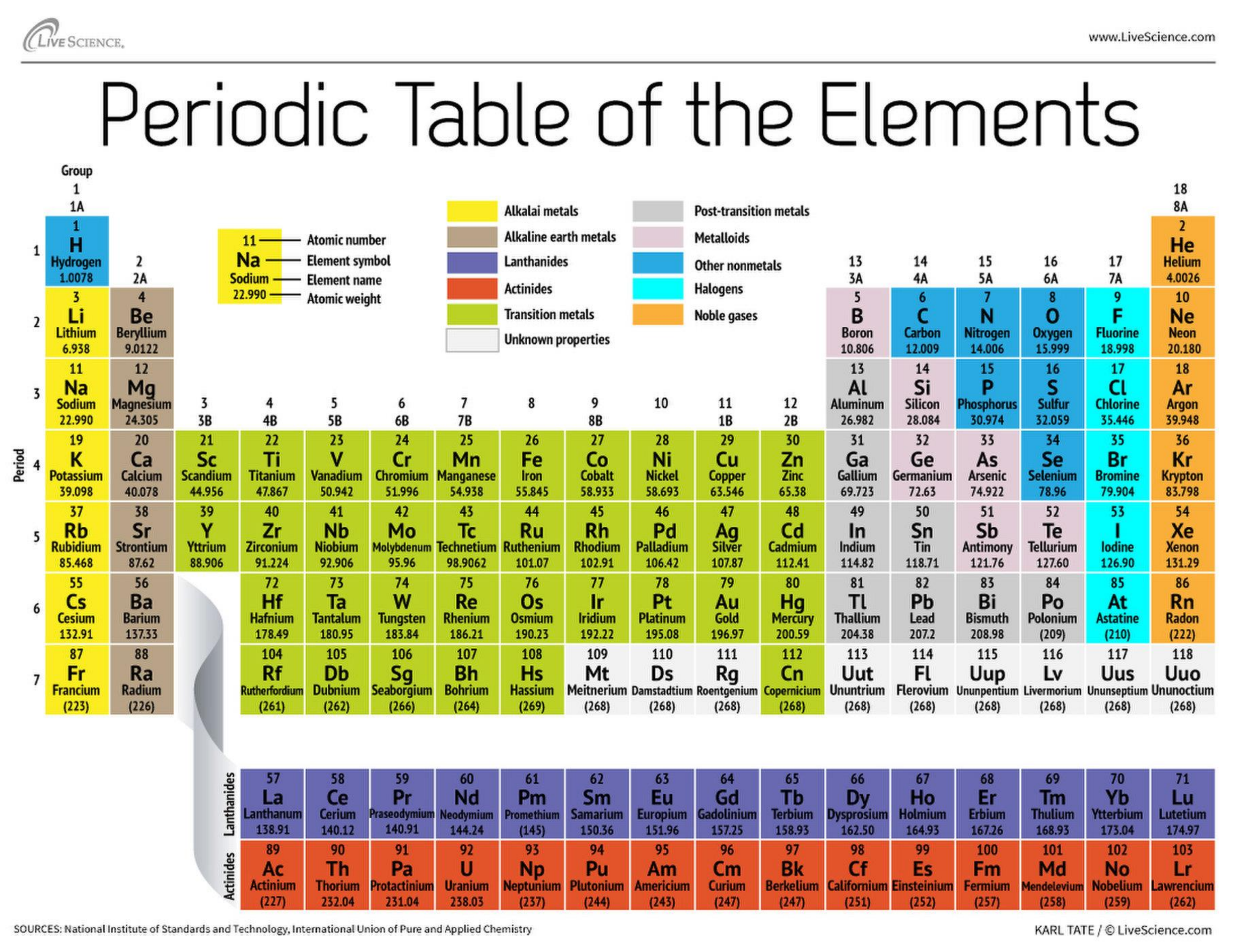
- For example, silicon is a poor conductor of electric current, but mix in a small amount of boron and the mixture is a good conductor of electricity (used in electronics).

Groups on the Periodic Table

- Many groups on the periodic table are given a unique name, based on the properties of the elements in that group.

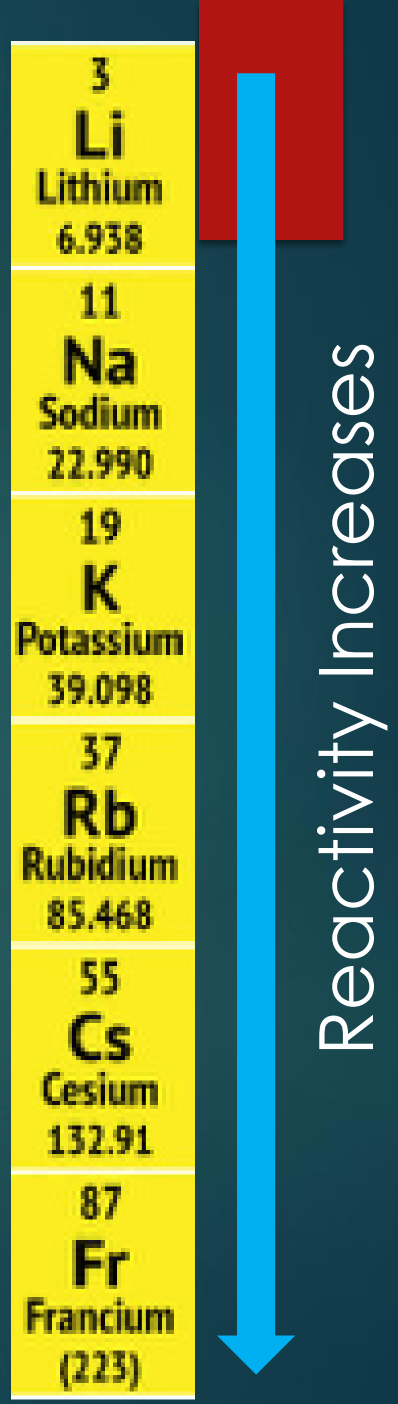


Periodic Table: Group Names



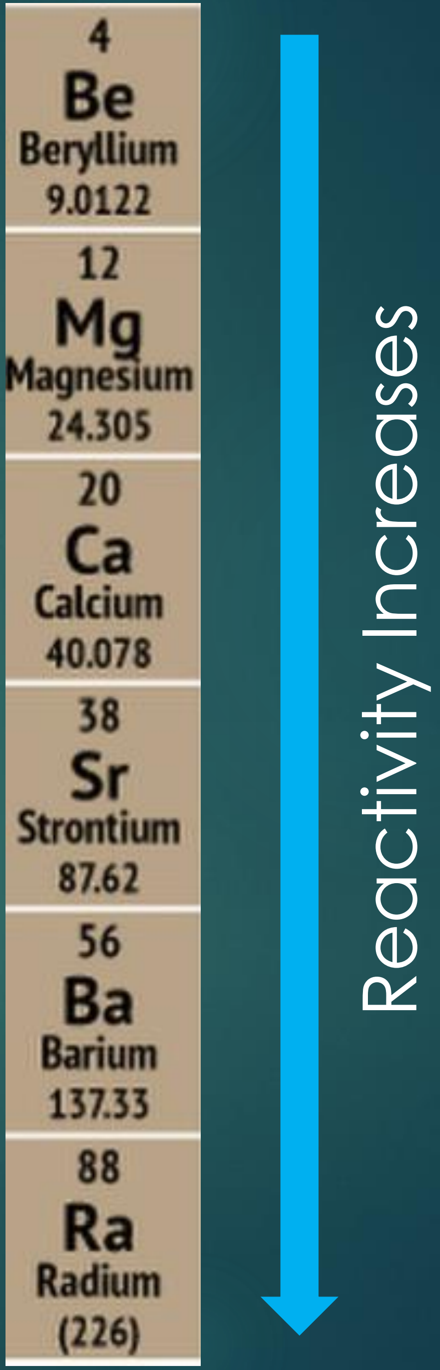
Group 1: Alkali Metals

- All shiny, soft, and silvery metals.
- Very violently reactive with water, releasing H gas – which also burns!
- Forms basic compounds with water (baking soda, soaps are bases)
- Form compounds that are mostly white solids and those compounds are very soluble in water (table salt – NaCl).
- Francium is so large an atom it has weakest hold on its valence e^-, so its very reactive.



Group 2: Alkaline Earth Metals

- Also shiny, soft, silvery metals.
- Reactive with water.
- Forms solids, most of with won't dissolve in water.



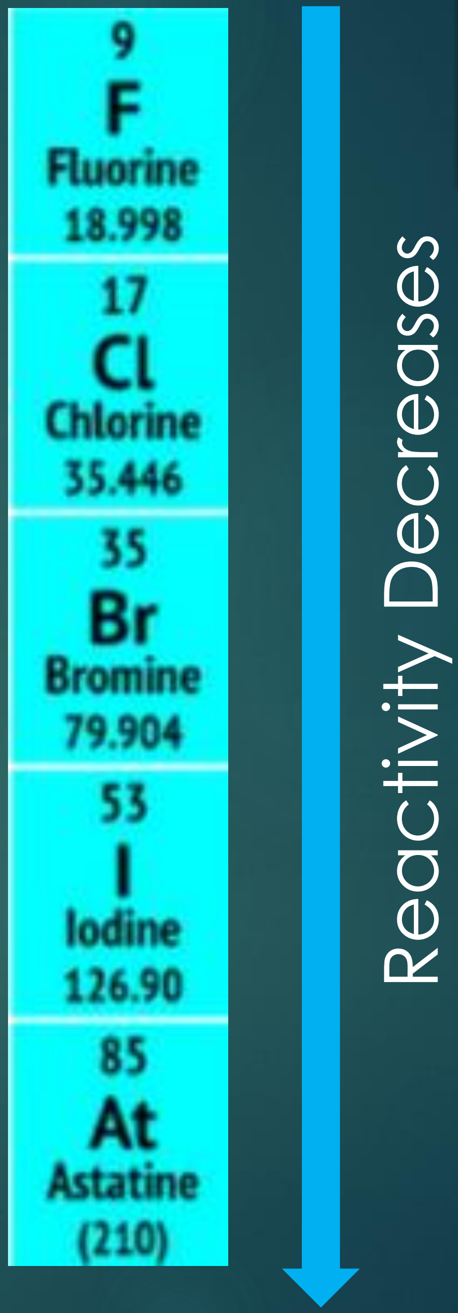
Groups 3 – 12: Transition Metals

21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38
39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.96	43 Tc Technetium 98.9062	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41
	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59
	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Damstadtium (268)	111 Rg Roentgenium (268)	112 Cn Copernicium (268)

- Contains many of our common, every day metals like iron, copper, tungsten, platinum, gold, silver, mercury, etc.
- They elements *transition* towards having properties less metallic.

Group 17: The Halogens

- Nonmetallic elements.
- Poisonous
- React easily with group 1, alkali metals, forming "*salts*".
  - Which is what the word "*halogen*" comes from – meaning salt forming.



Group 18: The Noble Gases

- They are all inert, or non-reactive.
- Their atoms contain just the right amount of electrons so they do not want to lose, gain or share them.
  - Chemical reactions happen by atoms gaining, losing, or sharing electrons.
  - The have 8 valence electrons (in the highest energy level). Which is the goal of all atoms in chemical reactions.

Remainder of the Review Questions and prepare for your first test.

Unit 2: From Elements to Compounds

- Learn to represent valence electrons with dot diagrams.
- Learn what the octet rule is for creating compounds.
- Learn how ionic compounds are created.
  - Definition and properties of an ionic compound
  - Cations
  - Anions
- Names and formula units for ionic compounds.
- Learn how molecular compounds are created.
  - Definition of molecular compounds
- Names and formulas molecular compounds.

Ions

- An ***ion*** is an atom, or group of atoms, that have an unequal number of protons and electrons.
  - It has a positive or negative charge.
- ***Monatomic*** ions: one atom that has a charge.
  - K^+, P^{3-}
- ***Polyatomic*** ions: a group of two or more atoms (a compound) that has a charge.
  - CO_3^{2-}, PO_4^{3-}

Cations

- Positively charged atoms, or compounds, are called ***cations***.
  - There are many, but we will use the ones found on the back of your periodic table.
- Since electrons are negative, cations are formed when one or more electrons are removed, or transferred to another atom or compound.

Anions

- Negatively charged atoms, or compounds, are called ***anions***.
  - There are many, but we will use the ones found on the back of your periodic table.
- Since electrons are negative, anions are formed when one or more electrons are gained from another atom or compound.

Ionic Compounds

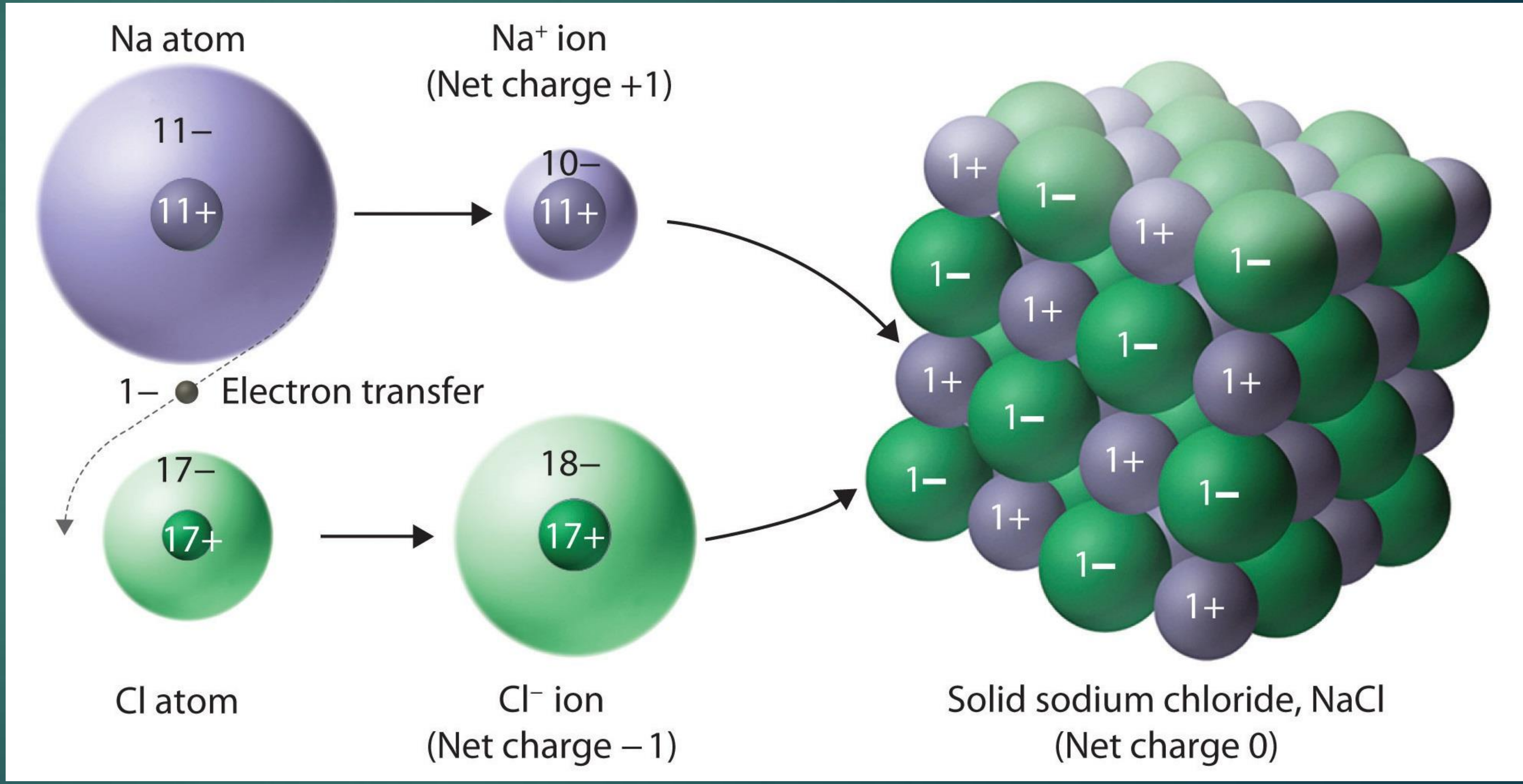
- Formed when cations and anions are held together by electrostatic forces (opposite charges attract).
  - Cations transfer electrons to the anion.
- They must form in a way to create a compound with zero total charge.
- The lowest ratio of the ions to create a zero charge is called the ***formula unit***.
  - Ex: $NaCl$, Fe_2O_3, K_3PO_4

Properties of Ionic Compounds

- Crystalline solids at room temperature.
  - The alternating of + and – ions results in a very stable structure.
  - The electrostatic force between the ions is very strong.
- Very high melting points.
- Conduct electric current when melted or dissolved in water.

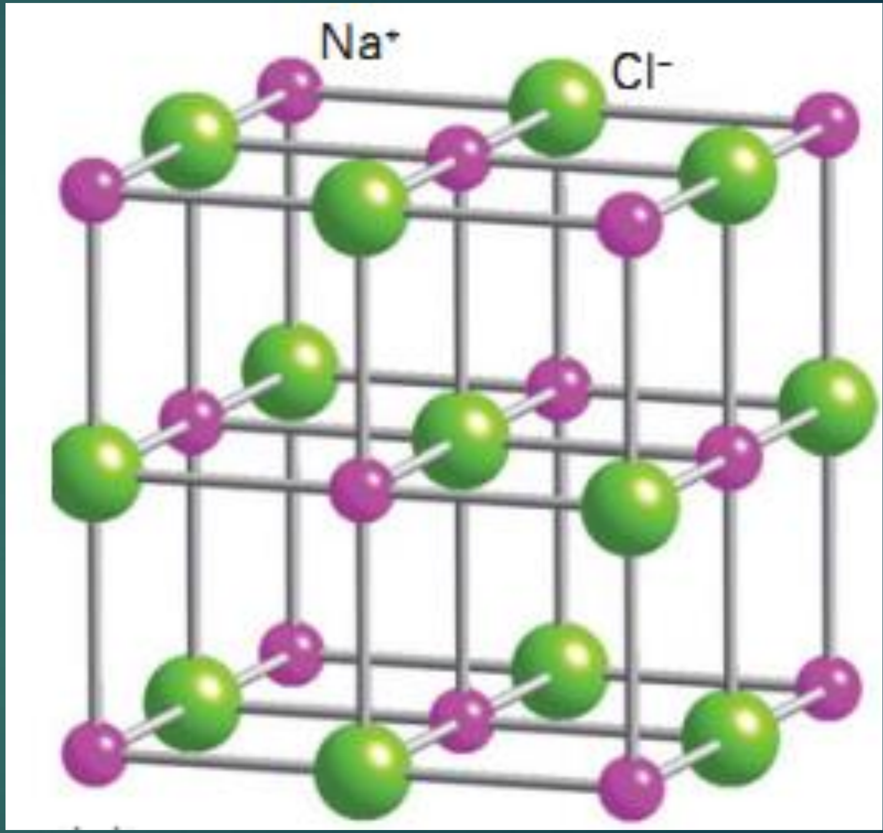
Structure of Ionic Compounds

- Exist as a crystalline solid – a regular repeating arrangement of ions.

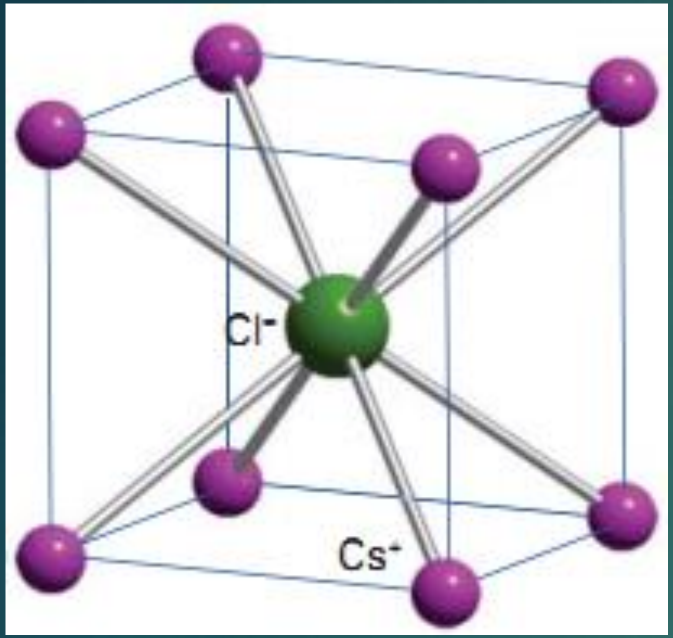


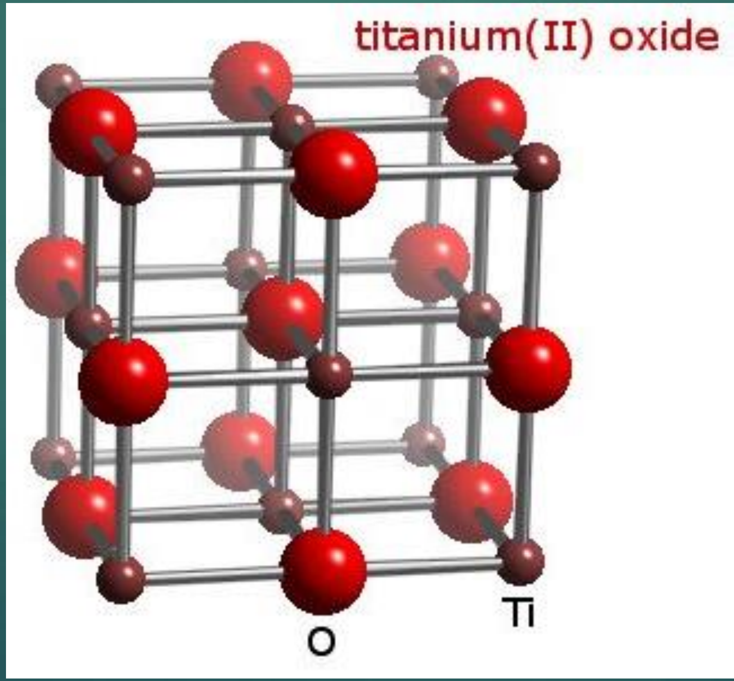
Crystalline Structure

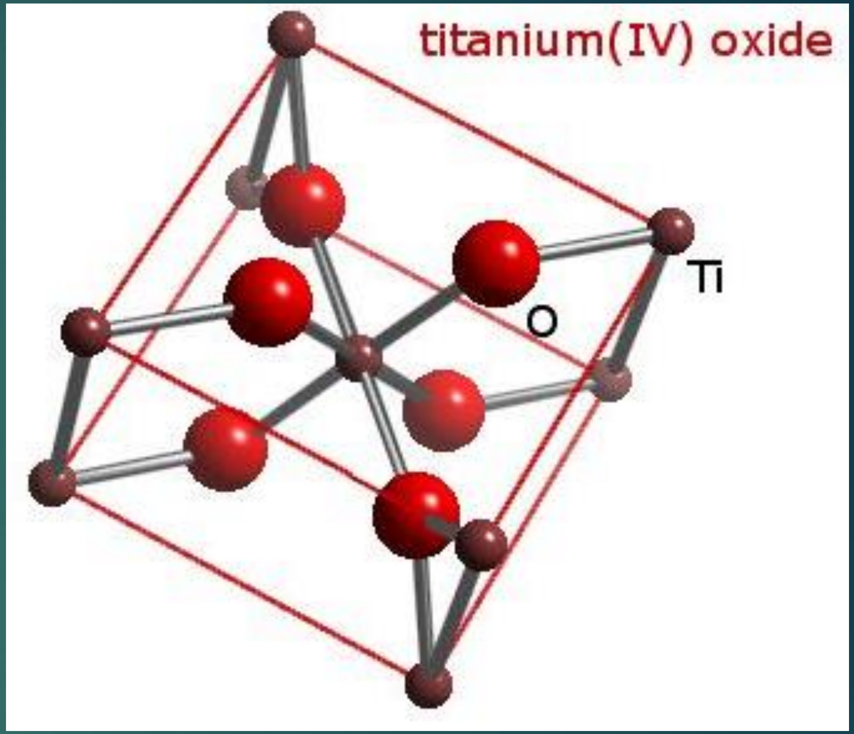
- The arrangement of ions in ionic compounds is an alternating of + and – ions, but the varying sizes of the atoms the number of electrons involved lead to varying internal structures.
- The ratio of cations to anions is not always 1:1 so a variety of structures exist.
- Structure depends on the size and number of ions. Difficult to predict.



Other Crystalline Structures

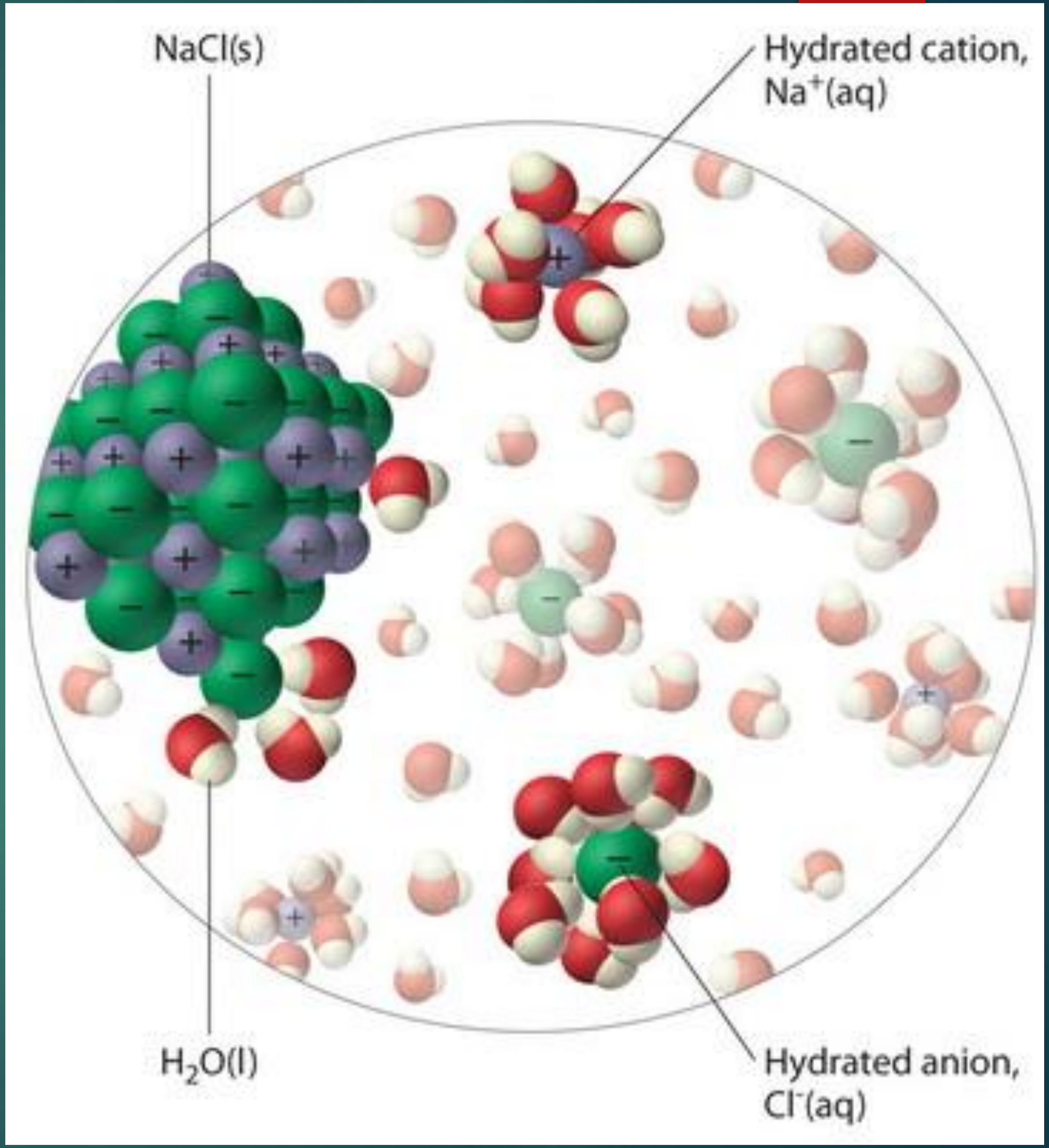






Conductivity When Melted and Dissolved

- Ionic compound separate into their ions when placed in water or melted.
- The ions are then capable of conducting an electric current.

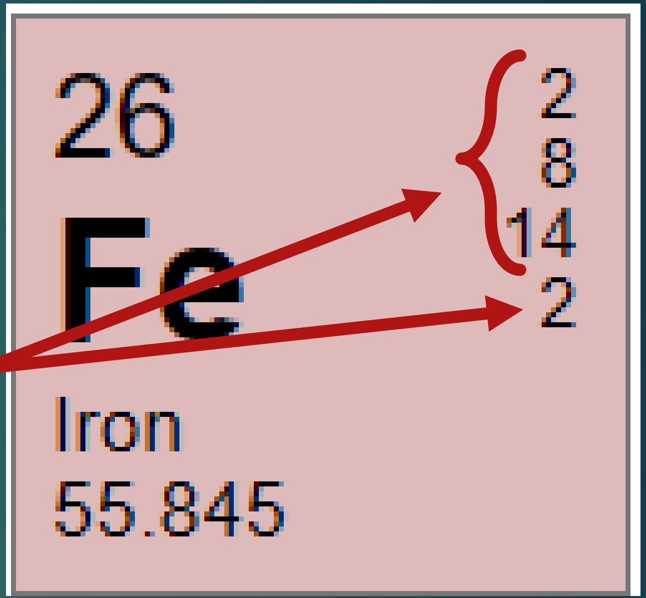


Practice Questions

- Ionic Compounds Review
  - # 1 – 10

Core and Valence Electrons

- The electrons are responsible for chemical properties of atoms are those in the **outer/highest** energy level.
- ***Valence e^-***: The electrons in the highest energy level (bottom of the list of electrons on your periodic table).
- **Core e^-**: All the electrons in the energy levels below the highest.



Octet Rule

- When forming compounds, atoms tend to achieve a noble gas configuration; 8 e- in the outer/highest energy level is the most stable.
  - There are exceptions, but we will only work with compounds that obey this rule.
- Metals lose valence electrons to achieve this.
- Nonmetals gain (or share) one or more electrons to fill their highest energy level.

Modeling Valence Electrons: Electron Dot Structures

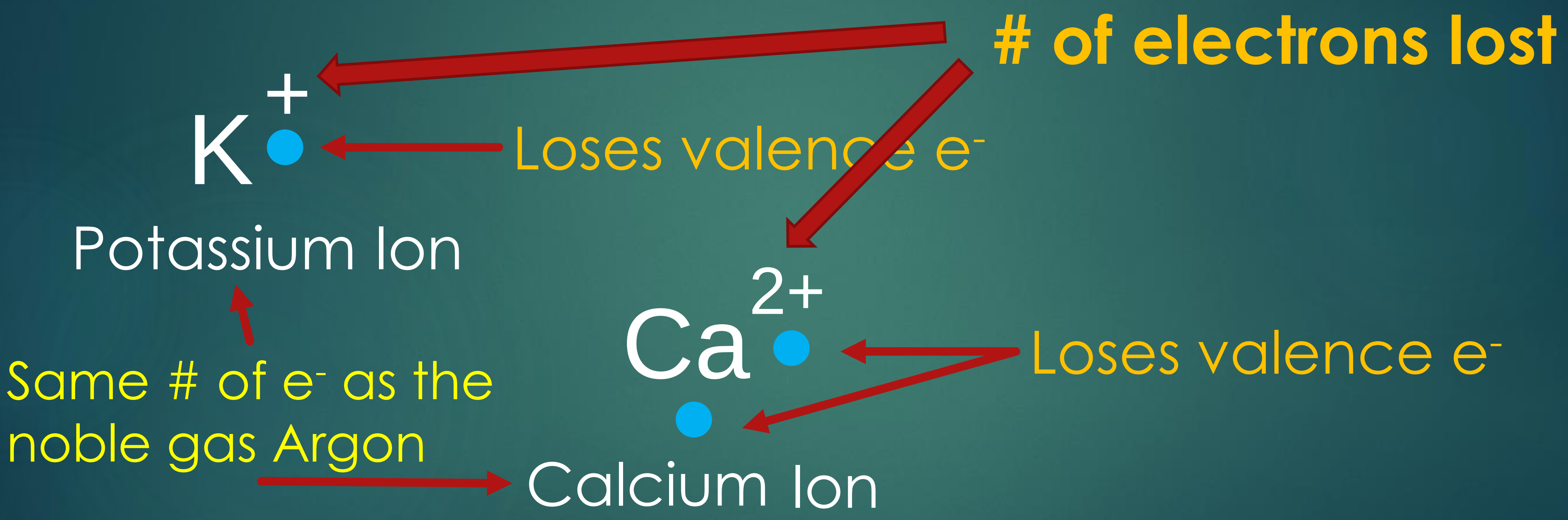
- Electron dot structures are used to represent the valence electrons in an atom.
  - They are represented as dots on the top, bottom and sides of an element symbol.
- When creating an electron dot structure, place a dot at one of the sides of the element and continue placing dots around the symbol but not pairing them up until you have to (that's what electrons do).
  - This is very important because the bonds that form incorporate paired and unpaired electrons in different ways.

Electron Dot Structure/Diagram

- Place first dot.
- Next dot is placed at an adjacent side.
- Continue the pattern.
- Never more than 8 dots.
- Use Periodic Table for the number of valence e^-.

Cation

- A positive ion, formed by losing one or more electrons.



Anion

- A negative ion, formed by gaining one or more electrons.

# of electrons gained

Gains a valence e^-

Fluorine

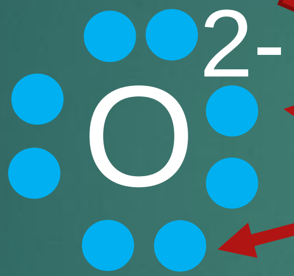
Name Change

Fluoride

Same # of e^- as the noble gas Neon

Anion Example #2

# of electrons gained



Gains 2 valence e^-

Oxygen

Name Change

Oxide

Same # of e^- as the noble gas Neon

Formation of Ionic Compounds

- Ionic compounds are formed when valence electrons of cations are transferred to, and become, valence electrons of anions.
  - The electrostatic forces keep the compound together.
- You will learn to write their formula units form dot diagrams, given their names and vice-versa.

Visualizing Electron Transfer

- Take, for example, the ionic compound formed with sodium and chlorine.
  - First look at the dot diagrams.

- Each atom wants to have 8 electrons in its highest energy level.
  - Sodium will lose one electron.
  - Chlorine will gain one electron.

Visualizing Electron Transfer

- In this case, you can see how the one e^- from Na can complete the octet for Cl.

Forms the ions → Na^+ Cl^-

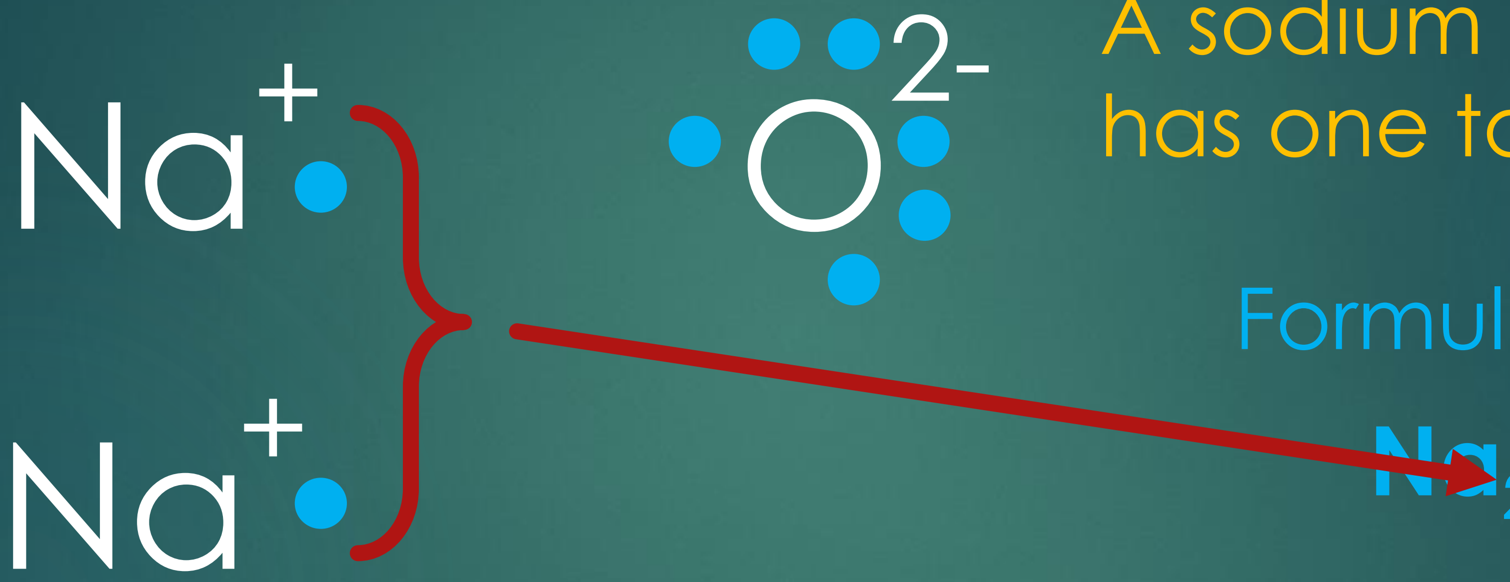
Formula Unit

NaCl

Sodium Chloride

Positive and negative charges hold the compound together!

Ionic Compound between
Sodium and Oxygen



A sodium atom only has one to give.

Formula Unit

Na_2O

Sodium Oxide

Oxygen needs a total of eight! Where does another electron come from?!

From another sodium atom!

Ionic Compound between ***Cadmium and Sulfur***

Cd has 2 valence e^-, Sulfur wants 2 more.

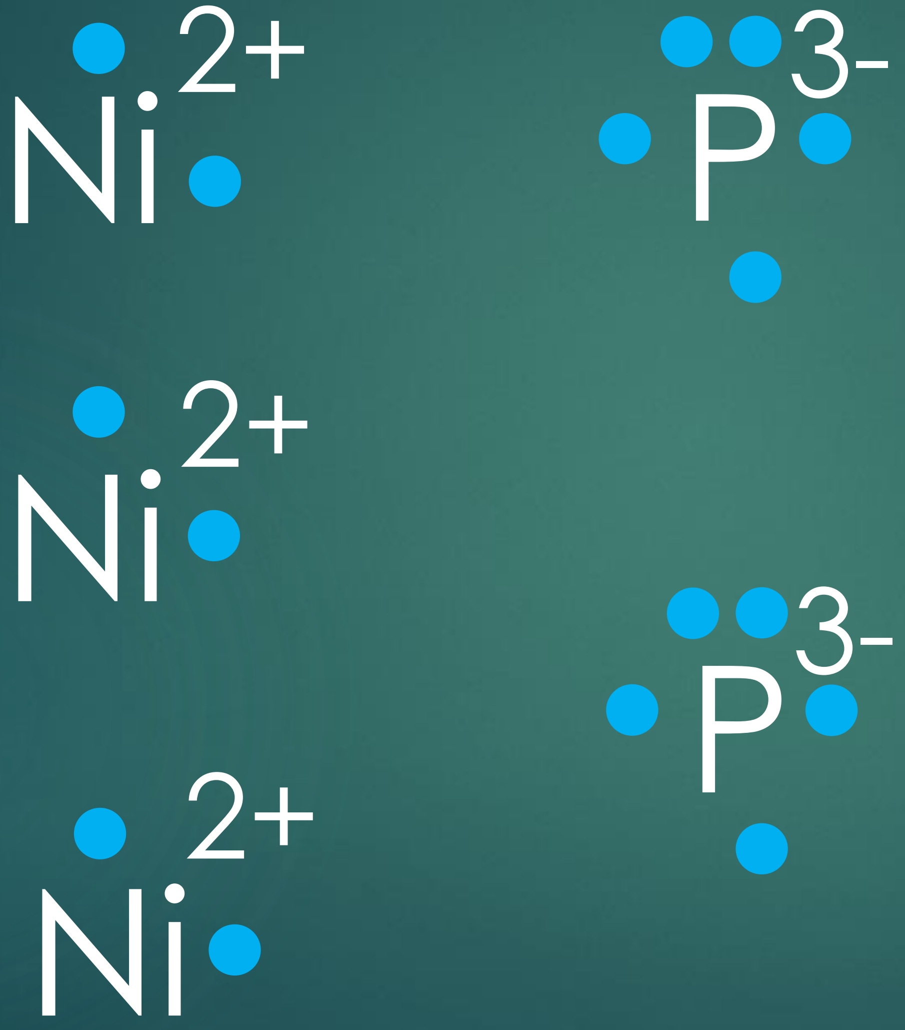
Formula Unit

CdS

Cadmium Sulfide

Ionic Compound between

Nickel and Phosphorus



Ni has 2 valence e^-,

Phosphorus wants 3 more.

P still needs 1 more e^-!

P is full! Ni has one more!

Ni needs to give this e^-!

Same problem as before!

Formula Unit

$\mathbf{Ni_3P_2}$

Nickel Phosphide

Practice Questions

- Ionic Compounds Review
  - # 1 – 14

Naming Ions

- Cations keep the name of their element.
- Anions change the ending of their element to –ide.
- For us, find the symbol on the chart and write the name given.
- Examples:
  - Cs^{+} is cesium ion
  - Be^{2+} is beryllium ion
  - O^{2-} is oxide
  - CO_3^{2-} is carbonate

Stock Naming System

- Some elements form more than one ion.
- The stock naming system communicates the charge in roman numerals (I, II, III, IV) in brackets after the element name.
  - Fe^{2+} is Iron (II)
  - Fe^{3+} is Iron (III)
- You will also see the names ferrous and ferric, they are from the classical system, and since it does not communicate the charge, we don't use it.

Practice Questions

- Ionic Compounds Review
  - # 15

Naming Ionic Compounds

- Name the following: $AlBr_3$
- Identify the ions in the formula unit by looking at the element symbols.
  - Al^{3+} and Br^-
- Write the name of each of them down.

  Aluminum Bromide
- Done.

Naming Ionic Compounds

- Name the following: Ag_2O
- Identify the ions in the formula unit by looking at the element symbols.
  - Ag^+ and O^{2-}
- Write the name of each of them down.

  Silver Oxide
- Done.

Naming Ionic Compounds

- Name the following: Cs_2CO_3
- Identify the ions in the formula unit by looking at the cation. Everything else is the anion.
  - Cs^+ and CO_3^{2-}
- Write the name of each of them down.

Cesium Carbonate

- Done.

Naming Ionic Compounds

- Name the following: NH_4PO_3
- Identify the ions in the formula unit by looking at the cation. Everything else is the anion.
  - NH_4^+ and PO_3^{3-}
- Write the name of each of them down.

  Ammonium Phosphite
- Done.

Naming Ionic Compound: More than one Choice for the Cation

- Name the following: $PbCl_4$
- Identifying the cations results in two options:
  - Pb^{2+}, Lead (II) or Pb^{4+}, Lead (IV)
  - Use the anion to figure it out: Cl^-, since four Cl^- is needed for one lead, it must be Pb^{4+} because there must be a net charge of zero.
- Name: Lead (IV) Chloride

Naming Ionic Compound: More than one Choice for the Cation

- Name the following: Cu_3N_2
- Identifying the cations results in two options:
  - Cu^+, Copper (I) or Cu^{2+}, Copper (I1)
  - Use the anion to figure it out: N^{3-}, since there are two N^{3-} that totals a -6 charge.
  - To balance it with a +6 using 3 Cu atoms, it must be Cu^{2+}
- Name: Copper (II) Nitride

Practice Questions

- Ionic Compounds Review
  - # 16

Formula Units for Ionic Compounds: Crisscross Method

- Write the formula unit for Calcium Phosphide
  - From the name, write the ions.
  - The numerical charge on one ion becomes the subscript of the other.

$$Ca^{2+} \quad P^{3-}$$

  - Put it all together:

$$Ca_3P_2$$

Formula Units for Ionic Compounds: Crisscross Method

- Write the formula unit for Iron (II) Oxide
  - From the name, write the ions.
  - The numerical charge on one ion becomes the subscript of the other.

$$Fe^{2+} \quad O^{2-}$$

  - Put it all together with the lowest ratio:

$$Fe_2O_2 \longrightarrow FeO$$

Formula Units for Ionic Compounds: Crisscross Method

- Write the formula unit for Magnesium Phosphate
  - From the name, write the ions.

$$Mg^{2+} \quad (PO_4)^{3-}$$

  - Place polyatomic ions in parentheses.
  - Put it all together with the lowest ratio:

$$Mg_3(PO_4)_2$$

Practice Questions

- Ionic Compounds Review
  - # 17

Chemical Reactions

CHEMICAL CHANGES, FACTORS AND EQUATIONS

Chemical Reactions

- ***Chemical Reactions*** are what happens when new compounds are produced.
- They are represented by a ***chemical equation***.
- A chemical equations summarizes what compounds are reacting and what compounds are produced.

$$\text{Reactants} \longrightarrow \text{Products}$$

Chemical Reactions

- Represented by three types of chemical equations:
  - Word Equation – uses the chemical names
  - Skeleton Equation – uses the chemical formulas
  - Balanced Equation – upholds the law of conservation of mass
- Law of Conservation of Mass
  - Atoms in a chemical reaction can not be created nor destroyed, but they can be transferred to, or exchanged, with other atoms to produce new compounds.

Word Equations

- Word equations tell you what reacts and what is produced.

All the reactants ⟶ all the products

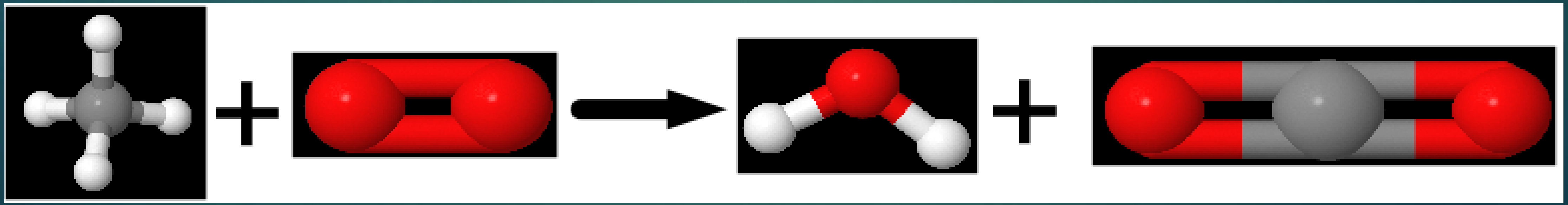
Reactant 1 + Reactant 2 + … ⟶ Product 1 + Product 2 + …

Word Equations: Examples

Iron + Oxygen ⟶ Iron (III) Oxide

Methane + Oxygen ⟶ Water + Carbon Dioxide

Reactants | Products

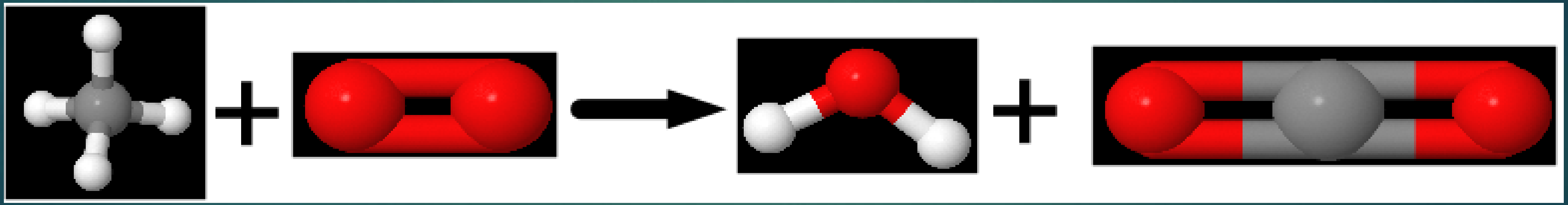


Law of Conservation of Mass

- In a non-nuclear chemical reaction, the total mass of the reactants is always equal to the total mass of the products.
- Atoms are not destroyed, just rearranged.

Methane + Oxygen ⟶ Water + Carbon Dioxide

$$CH_4 + O_2 \longrightarrow H_2O + CO_2$$

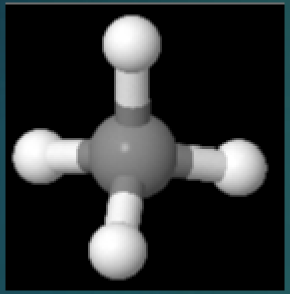
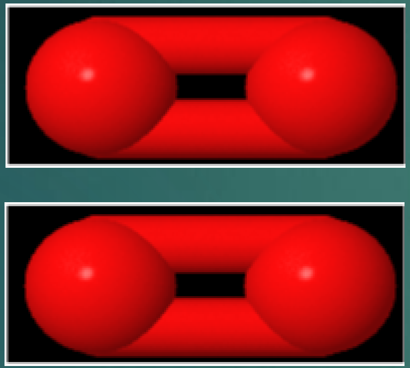
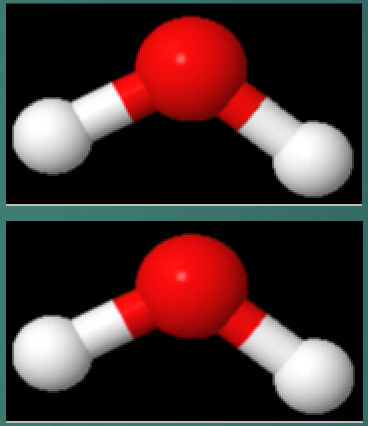
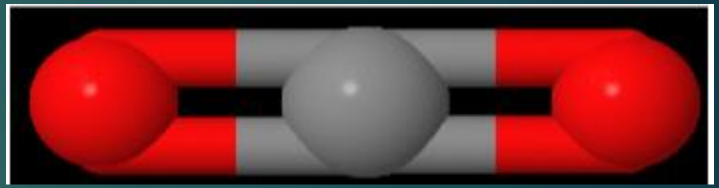


- Not possible to "lose" two hydrogen atoms and gain a third oxygen.

Law of Conservation of Mass

- To conserve mass we need more molecules!

Methane + Oxygen → Water + Carbon Dioxide

 +  →  + 

$$CH_4 + 2O_2 \longrightarrow 2H_2O + CO_2$$

- This chemical equation is now ***balanced***.

Balancing Chemical Equations

- Refers to the act of conserving mass.
- We use a ***skeleton equation*** to represent the reaction.
- Skeleton equations are balanced by changing the coefficients until mass is conserved.

Skeleton Equation

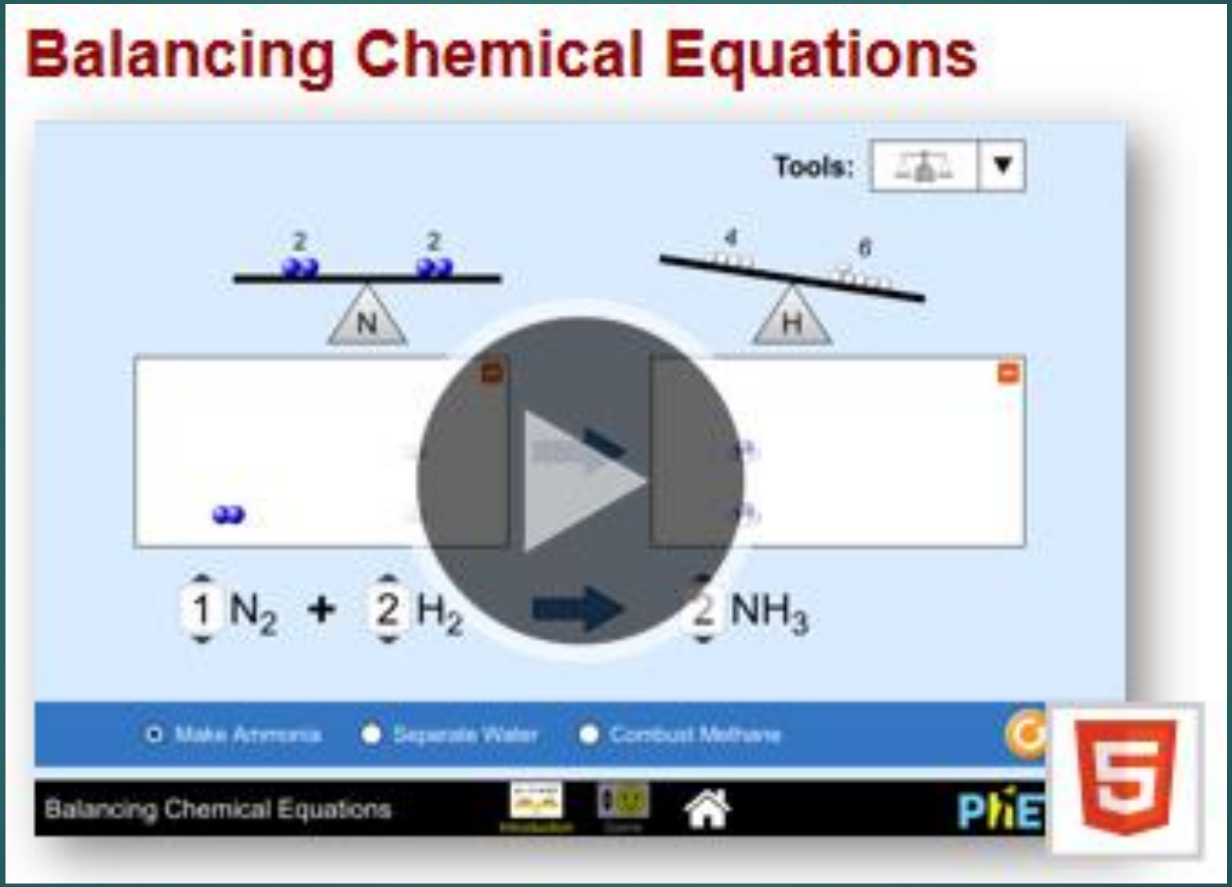
$$CH_4 + O_2 \longrightarrow H_2O + CO_2$$

Balanced Equation

$$CH_4 + 2O_2 \longrightarrow 2H_2O + CO_2$$

coefficients

Balancing Chemical Equation



Types of Chemical Reactions: Synthesis and Decomposition

- **Synthesis** reactions: The combination of smaller atoms and/or molecules into larger molecules.
  - Two or more reactants combine to create one product.
- Example: $2H_2 + O_2 \rightarrow 2H_2O$
- **Decomposition**: Splitting a large molecule into elements or smaller compounds.
  - One reactant produces two or more products.
  - $NH_4NO_3 \rightarrow N_2O + 2H_2O$

Balancing Chemical Equations: Examples

$2Fe + 3S \rightarrow Fe_2S_3$

$2MgO \rightarrow 2Mg + O_2$

$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

Balancing Chemical Equations: Examples

$Na_2CO_3 + Ca(OH)_2 \rightarrow \mathbf{2}NaOH + CaCO_3$

$\mathbf{3}BaBr_2 + \mathbf{2}Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + \mathbf{6}NaBr$

Balancing Chemical Equations

- Practice with your review questions #1 - 6

Combustion Reactions

- The very rapid reaction of a substance with oxygen that produces oxides and heat.
  - Many substances do this, but we will focus on the combustion of ***hydrocarbons***.
- Hydrocarbons are compounds of carbon and hydrogen and sometimes oxygen. For example:
  - Butane: C_4H_{10}, Butanol: C_4H_9OH
  - Propane: C_3H_8, Propanol: C_3H_7OH
  - Methane: CH_4, Methanol: CH_3OH

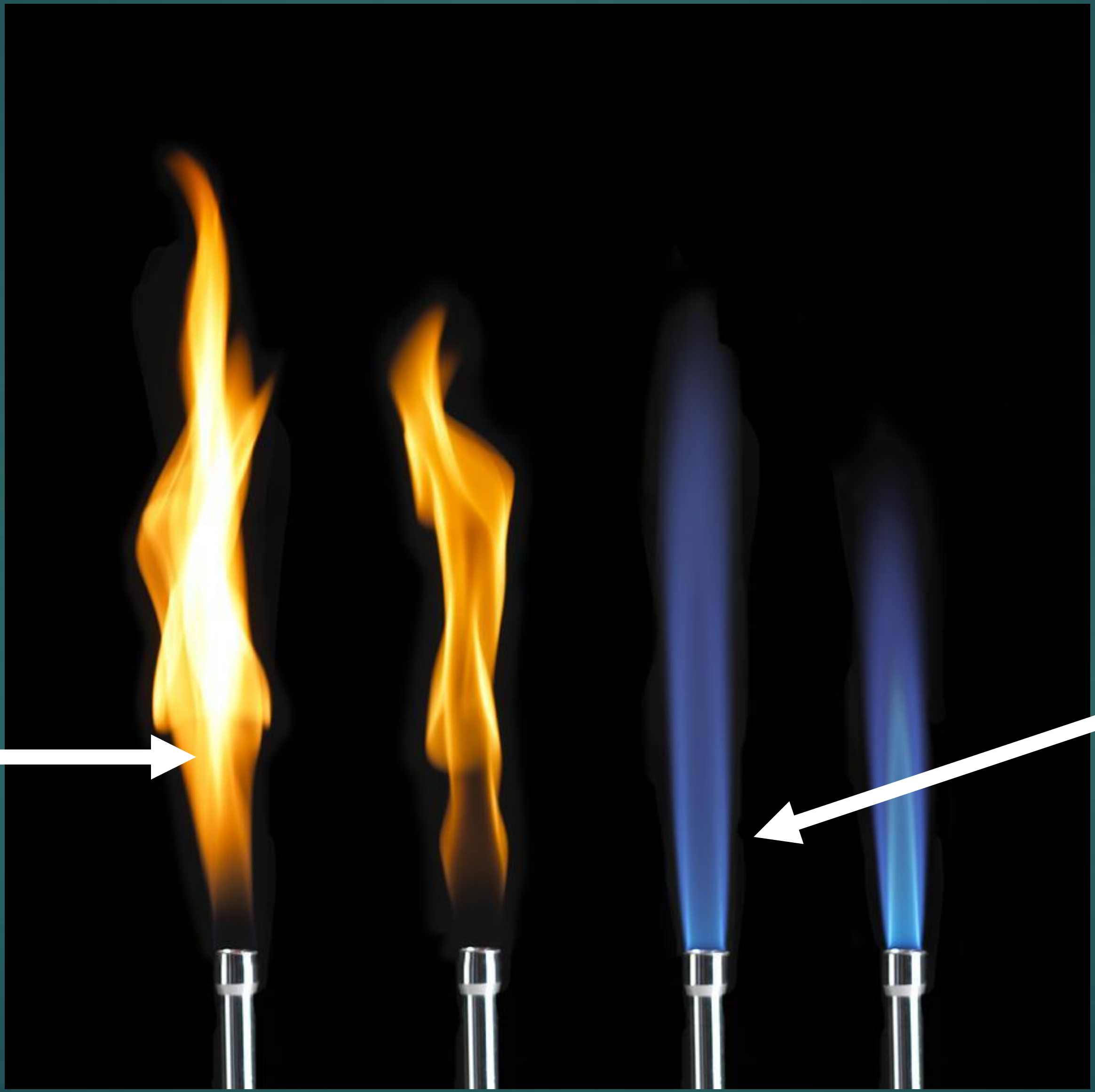
Combustion Reactions

- **Complete Combustion:**
  - hydrocarbon + oxygen → carbon dioxide + water
  - $CH_4 + O_2 \rightarrow CO_2 + H_2O$
- **Incomplete Combustion (low O_2 levels or cold) – 2 Types:**
  - hydrocarbon + oxygen → carbon monoxide + water
  - $CH_4 + O_2 \rightarrow CO + C + H_2O$
  - hydrocarbon + oxygen → carbon + water
  - $CH_4 + O_2 \rightarrow C + H_2O$

Incomplete vs Complete Combustion: Butane

Incomplete:

- Orange flame
- Releases CO or C.
- Releases less heat



Complete:

- Blue flame
- Releases CO_2
- Releases more heat

Balancing Combustion Reactions

- These can be tricky as there are a high number of atoms. One strategy is to balance the O_2 term last by using a fraction coefficient (if necessary), then multiplying to remove the fraction.

Complete Combustion of Propane:

$$C_3H_8 + \mathbf{5}O_2 \rightarrow \mathbf{3}CO_2 + \mathbf{4}H_2O$$

Balancing Combustion Equations

- Complete Combustion of Ethane:

$$\left\{ C_2H_6 + \frac{7}{2} O_2 \rightarrow 2CO_2 + 3H_2O \right\} \times 2$$

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

Balancing Combustion Reactions

- Incomplete combustions of methane: Same Strategy
  - Carbon atoms
  - Hydrogen atoms
  - Oxygen atoms

$$CH_4 + \frac{3}{2}O_2 \rightarrow CO + 2H_2O$$

Double Every Coefficient!

$$2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$$

Balancing Combustion Reactions

- Incomplete combustions of methane: Same Strategy
  - Carbon atoms
  - Hydrogen atoms
  - Oxygen atoms

$$CH_4 + O_2 \rightarrow C + \mathbf{2}H_2O$$

Balancing Combustion Equations

- Work sheet review #7
- Test next week…