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



Rutherford Scattering





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 (n⁰) are very close to the same size and mass. Both have a much, much larger mass than the electron (e⁻)

Carbon





The Nucleus: Summary Video



The Nucleus: Crash Course Chemistry

CrashCourse

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

TOTAL SOLAR ECLIPSE 11/07/2010 EASTER ISLAND. CHILE

FLASH SPECTRUM VIA SPECTROGRAPH 300lines/mm Voulgaris A., Seiradakis J., Economou T.



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

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**.

- 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).









Overlapping Orbitals = Electron Cloud



The Electron: Summary Video



The Electron: Crash Course Chemistry

CrashCourse

Organizing Elements: The Periodic Table



The Periodic Table: Crash Course Chemistry

CrashCourse

The Periodic Table of the Elements



Michael Dayah

For a fully interactive experience, visit www.ptable.com.

michael@dayah.com

Our Periodic Table



Electrons In Each Energy Level

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
<u>Average Atomic Mass</u>: 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.

- I 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 These types of questions are not on ▶30 your practice sheet, but you need ▶54 to know how to do them. ▶56 ▶92 ▶99

The Periodic Law

When elements are tabled in order of increasing atomic number, there is a periodic repetition of chemical and physical properties.

- Groups: The vertical columns; elements in the same column have similar chemical and physical properties (boiling points, luster, conductivity, reactivity, etc.).
- Periods: The horizontal rows. As you read left to right, elements get properties of non-metals.

The Periodic Table of the Elements



Michael Dayah

For a fully interactive experience, visit www.ptable.com.

michael@dayah.com

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.

H	2											13	14	15	16	17	He
³ L	i ⁴ Be	Metal			Vietal	Metalloid Nonmeta			etal	a			⁶ C	7 N	°	۶	Ne
¹¹ Na	a Mg	3	4	5	6	7	8	9	10	11	12		¹⁴ Si	¹⁵ P	¹⁶ S	¹⁷ CI	¹⁸ Ar
¹⁹ K	Ca	Sc	Ti	23 V	Cr	²⁵ Mn	Fe	27 Co	²⁸ Ni	²⁹ Cu	³⁰ Zn	Ga	Ge	As	³⁴ Se	³⁵ Br	³⁶ Kr
37 RI	b Sr	³⁹ Y	^{₄₀} Zr	Nb	Mo	Тс	Ru	Rh	Pd	Ag	48 Cd	49 In	50 Sn	Sb	52 Te	53 	Xe
55 C	s Ba	57-71	Hf	Та	⁷⁴ W	Re	⁷⁶ Os	⁷⁷ lr	Pt	Au	Hg	TI	Pb	Bi	⁸⁴ Po	At	Rn
87 F	r Ra	89-103	Rf	105 Db	¹⁰⁶ Sg	¹⁰⁷ Bh	Hs	¹⁰⁹ Mt	110 Ds	Rg	¹¹² Cn	Uut	FI	Uup	¹¹⁶ Lv	Uus	Uuo

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
⁸⁹ Ac	⁰Th	Pa Pa	92 U	93 Np	⁹⁴ Pu	95 Am	96 Cm	97 Bk	⁹⁸ Cf	99 Es	¹⁰⁰ Fm	¹⁰¹ Md	¹⁰² No	103 Lr

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.

CiveScience, www.LiveScience.com																		
Periodic Table of the Elements																		
	Group 1 1A 1 H			11	Atomic num	ber		Alkalai met Alkaline ea	tals irth metals		Post-transitio Metalloids	on metals						18 8A 2 He
<u> </u>	Hydrogen 2 Na Element symbol 1.0078 2A Sodium – Element name				Lanthanides			Other nonmetals			14 4A	15 5A	16 6A	17 7A	Helium 4.0026			
2	3 Li Lithium 6.938	4 Be Berytlium 9.0122	4 22.990 — Atomic weight Se ytlium D122				Actinides Halogens Transition metals Noble gases Unknown properties			5 B Boron 10.806	6 C Carbon 12.009	7 N Nitrogen 14.006	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180			
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 3B	4 48	5 58	6 68	7 7B	8	9 88	10	11 18	12 28	13 Al Aluminum 26.982	14 Si Silicon 28.084	15 P Phosphorus 30.974	16 S Sulfur 32.059	17 Cl Chlorine 35.446	18 Ar Argon 39.948
Period 4	19 K Potassium 39.098	20 Ca Calcium 40.078	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	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85,468	38 Sr Strontium 87,62	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 Sitver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 lodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33		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	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)		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 Damstadtiun (268)	111 Rg Roentgenium (268)	112 Cn (268)	113 Uut Ununtrium (265)	114 FL Flerovium (268)	115 Uup Ununpentium (268)	116 Lv Livermorium (268)	117 Uus Ununseptium (268)	118 Uuo Ununoctium (268)
			Lanthanides	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymiam 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
			Actinides	89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelerium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)
SOURCES: National Institute of Standards and Technology, International Union of Pure and Applied Chamittry KARL TATE / © LiveScience.com																		

Periodic Table: Group Names

AVE SCIENCE,

Periodic Table of the Elements Group 1 18 1A 8A Alkalai metals Post-transition metals 2 Alkaline earth metals Metalloids 11 — Atomic numbe н He Na — Element symbol 2 Lanthanides 13 14 15 16 17 Helium Other nonmetals 5A 7A 1.0078 2A Sodium - Element name 3A 4A 6A 4.0026 Halogens Actinides 22.990 - Atomic weight 5 10 3 4 9 Li Be Transition metals В C Ν 0 F Ne Noble gases Lithium Beryllium Boron Carbon Nitrogen Oxygen Fluorine Neon Unknown properties 6.938 9.0122 10.806 12.009 14.006 15.999 18.998 20.180 11 12 13 14 15 16 17 18 Si P S Na Mg AL Cι Ar 3 3 4 5 7 8 9 10 11 12 Silicon Sulfur Chlorine Sodium 6 luminum agnesiu osphoru Argon 24.305 3B 4B 5B 6**B** 7B 8**B** 2B 26.982 28.084 30,974 32.059 35.446 22.990 1B 39.948 30 32 19 20 21 22 23 24 25 26 27 28 29 31 33 34 35 36 Period Se K Ca Sc Ti V Cr Mn Fe Со Ni Cu Zn Ga Ge As Br Kr Calcium Scandium Vanadium Chromiun Iron Cobalt Nickel Copper Zinc Gallium otassium Titanium Manganese Germaniur Arsenic Bromine Krypton 39.098 40.078 44.956 47.867 50.942 51.996 54.938 55.845 58.933 58.693 63.546 65.38 69.723 72.63 74.922 78.96 79.904 83.798 50 38 39 44 49 52 37 40 41 42 43 45 46 47 48 51 53 54 Y Ru Rb Sr Zr Nb Mo Tc Rh Pd Ag Cd In Sn Sb Te Xe Rubidiun Strontium Yttrium Zirconiur Niobium Rhodium Palladium Cadmium Indium Tin Antimony Tellurium lodine Molvbdenu Technetium utheniun Xenor 85.468 87.62 88.906 91.224 92.906 95.96 98.9062 101.07 102.91 106.42 107.87 112.41 114.82 118.71 121.76 127.60 126.90 131.29 55 56 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 W Pt Hg Tι Cs Ba Hf Ta Re Os Ir. Au Pb Bi Po At Rn Cesium Barium Hafnium Tantalum Tungsten Rhenium Osmium Iridium Platinum Gold Mercury Thallium Lead Bismuth Polonium Astatine Rador 132.91 137.33 178.49 180.95 183.84 186.21 190.23 192.22 195.08 196.97 200.59 204.38 207.2 208.98 (209) (210) (222) 87 88 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 Sg FL Fr Ra Rf Db Bh Hs Mt Ds Rg Cn Uut Uup Lv Uus Uuo 7 Francium Radium Rutherfordium Dubnium Seaborgiun Bohrium Hassium Meitnerium Damstadtiun Roentgenium Copernici Ununtrium Flerovium Ununpentium Livermorium Ununseptium Ununoctiur (226) (223) (261) (262) (266) (264) (269) (268) (268) (268) (268) (268) (268) (268) (268) (268) (268) 60 61 67 63 65 67 69 70 71 66 Dy La Ce Pr Nd Pm Sm Eu Gd Tb Ho Er Tm Yb Lu nthanu Cerium doliniu Terbium Iolmiu Erbium Thulium **Ytterbiu** Lutetiun uropiur sendy odym methi amariu 138.91 140.12 140.91 144.24 151.96 157.25 158.93 162.50 164.93 167.26 168.93 174.97 (145) 150.36 173.04 90 95 97 98 99 100 101 102 103 91 97 93 94 96 -P Pa Pu Bk Cf Ac Th U Np Am Cm Es Fm Md No Lr rotactini Plutonium Californium Einsteiniur Actiniur Uranium Americium Curium Berkelium Fermium awrenciu Thorium Neptuniur ndelevi 232.04 231.04 (247) (247) (258) (262)

SOURCES: National Institute of Standards and Technology, International Union of Pure and Applied Chemistry

KARL TATE / © LiveScience.com

www.LiveScience.com

Group 1: Alkali Metals All shiny, soft, and silvery metals. Very violently reactive with water

- 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.

ithium 6.938 11 Na Sodium 22.990 19 Potassium 39.098 37 Rb Rubidium 85.468 55 C C Cesium 132.91 87 Fr Francium (223)

Reactivity Increases

Group 2: Alkaline Earth Metals

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

Be Beryllium 9.0122 12 Ma Magnesium 24.305 20 Ca Calcium 40.078 38 Sr Strontium 87.62 56 Ba Barium 137.33 88 Ra Radium (226)

Reactivity Increases

Groups 3 – 12: Transition Metals

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

Fluorine 18.998 35.446 35 Bromine 79.904 lodine 126.90

Reactivity Decreases

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.

4.0026 10 Ne Neon 20.180 18 Ar Argon 39.948 36 Kr Krypton 83.798 54 Xe **Remainder of the** Xenon **Review Questions** 131.29 and prepare for 86 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.

lons

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⁺, P³⁻

Polyatomic ions: a group of two or more atoms (a compound) that has a charge.

►CO₃²⁻, PO₄³⁻

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.



Iron

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-.

• Br •



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





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

of electrons gained Gains a valence e Same # of e⁻ as the Fluorine noble gas Neon ame Change Fluoride

Anion Example #2

of electrons gained

Gains 2 valence e

Oxygen

Same # of e⁻ as the noble gas Neon

Oxide

Name Change

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 viceversa. Visualizing Electron Transfer Take, for example, the ionic compound formed with sodium and chlorine. First look at the dot diagrams. Na •

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.



Positive and negative charges hole the compound together!

Ionic Compound between Sodium and Oxygen

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

Na⁺

Na+

A sodium atom only has one to give. Formula Unit

Sodium Oxide

Ionic Compound between Cadmium and Sulfur

 Cd^{2+}

Cd has 2 valence e⁻, Sulfur wants 2 more.

Formula Unit CdS Cadmium Sulfide

Ionic Compound between **Nickel and Phosphorus** •.2+ 2+ 3_ • 2+ NIi•

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 Ni₃P₂ Nickel Phosphide

Practice Questions

Ionic Compounds Review # 1 – 14

Naming lons

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
Be²⁺ is beryllium ion
O²⁻ is oxide
CO₃²⁻ 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.

- ►Fe²⁺ is Iron (II)
- ► Fe³⁺ 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

 \blacktriangleright Name the following: AlBr₃ Identify the ions in the formula unit by looking at the element symbols. ► A³⁺ and Br Write the name of each of them down. Aluminum Bromide one.

Name the following: Ag_2O Identify the ions in the formula unit by looking at the element symbols. ► Ag⁺ and O²⁻ Write the name of each of them down. Silver Oxide Done.

- Name the following: Cs_2CO_3
- Identify the ions in the formula unit by looking at the cation. Everything else is the anion.
 - \blacktriangleright Cs⁺ and CO₃²⁻
- Write the name of each of them down.
 - Cesium Carbonate
- Done.

Name the following: NH_4PO_3 Identify the ions in the formula unit by looking at the cation. Everything else is the anion. $\blacktriangleright NH_4^+$ 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: PbCl₄ Identifying the cations results in two options: ▶ Pb²⁺, Lead (II) or Pb⁴⁺, Lead (IV) ► Use the anion to figure it out: CL, since four CL is needed for one lead, it must be Pb⁴⁺ 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 (I) ▶ 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.



►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.



 $Fe_2O_2 \longrightarrow FeO$

Put it all together with the lowest ratio:

Formula Units for Ionic Compounds: Crisscross Method

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



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.

Reactants ---- 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 \longrightarrow all the products

Reactant 1 + Reactant 2 + ... \longrightarrow Product 1 + Product 2 + ...



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 \longrightarrow 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! CH₄ $\rightarrow 2H_2O$ + $+ 20_{2}$ 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 $CH_4 + 2O_2 \longrightarrow 2H_2O + CO_2$ \downarrow coefficients

Balancing Chemical Equation

Balancing Chemical Equations



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.

 $\blacktriangleright \text{Example: } 2H_2 + O_2 \rightarrow 2H_2O$

Decomposition: Splitting a large molecule into elements or smaller compounds.

One reactant produces two or more products.

 $\mathbb{NH}_4 \mathbb{NO}_3 \to \mathbb{N}_2 \mathbb{O} + 2\mathbb{H}_2 \mathbb{O}$

Balancing Chemical Equations: Examples

> 2Fe +3S \rightarrow Fe₂S₃ 2MgO \rightarrow 2Mg + O₂ Fe₂O₃ + 3C \rightarrow 2Fe + 3CO

Balancing Chemical Equations: Examples

 $Na_{2}CO_{3} + Ca(OH)_{2} \rightarrow 2NaOH + CaCO_{3}$ $3BaBr_{2} + 2Na_{3}PO_{4} \rightarrow Ba_{3}(PO_{4})_{2} + 6NaBr$

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: C₄H₁₀, Butanol: C₄H₉OH
 Propane: C₃H₈, Propanol: C₃H₇OH
 Methane: CH₄, Methanol: CH₃OH

Combustion Reactions Complete Combustion: \blacktriangleright hydrocarbon + oxygen \rightarrow carbon dioxide + water $\blacktriangleright CH_4 + O_2 \rightarrow CO_2 + H_2O$ \blacktriangleright Incomplete Combustion (low O₂ levels or cold) – 2 Types: \blacktriangleright hydrocarbon + oxygen \rightarrow carbon monoxide + water $\blacktriangleright CH_4 + O_2 \rightarrow CO + C + H_2O$ $\blacktriangleright hydrocarbon + oxygen \rightarrow carbon + water$ $\blacktriangleright CH_4 + O_2 \rightarrow C + H_2O$

Incomplete vs Complete Combustion: Butane

Incomplete:

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

Complete:

- Blue flame
- Releases CO₂
- Releases more heat

Balancing Combustion Reactions

These can be tricky as there are a high number of atoms. One strategy is to balance the O₂ term last by using a fraction coefficient (if necessary), then multiplying to remove the fraction.

Complete Combustion of Propane: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ Balancing Combustion Equations ► Complete Combustion of Ethane: $\left\{ C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O \right\} \rightleftharpoons 2$

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

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

$CH_4 + O_2 \rightarrow C + 2H_2O$

Balancing Combustion Equations

Work sheet review #7Test next week...