Name: ________________________________  Period: ____  Date: _____

ATOMIC STRUCTURE NOTES
HONORS CHEMISTRY

Directions: This packet will serve as your notes for this chapter. Follow along with the PowerPoint presentation and fill in the missing information. Important terms / ideas are in all capitals and bolded!

• ATOM:

- __________________ are composed of only _____ type of atom

- __________________ formed when ______ or more atoms are __________________ bonded to form a new substance

- Atoms first suggested and named by __________________... believed that atoms were __________________ and indestructible

- His ideas were limited because they did not explain __________________ and lacked __________________ support

- ___________________ used experiments to explain Democritus' ideas over 2,000 years later...

• Dalton's ATOMIC THEORY

1) ALL elements are made of ______, _____________ atoms

2) Atoms of the SAME element are ______________... atoms of DIFFERENT elements are ______________

3) Atoms can mix together or combine ______________ in simple whole number ratios to form ______________

4) Chemical ______________ occur when atoms are separated, joined, or rearranged... but atoms are __________ changed into atoms of another ___________ as a result

• LAW OF DEFINITE PROPORTIONS:

- Proposed by Joseph __________

- Known as the Law of ________________________________

- Ex: _____ or _____

• LAW OF MULTIPLE PROPORTIONS:

- Proposed by John __________

- Ex: _____ (14:16 = 1:1), _____ (14:32 = 1:2)

1
Subatomic Particles

-Dalton was proved mostly right except... **ATOMS ARE ______________!**

-Three Subatomic Particles
  - **PROTONS:**
  - **NEUTRONS:**
  - **ELECTRONS:**

Electrons

-Discovered by __________________ in 1897

-Passed a __________ through gases at low pressure in a vacuum tube, producing a glowing beam or ______________

**CATHODE RAYS**

-Originate at the ______________ end of the electrode

-Act the _______ regardless of the __________ used

-Deflected by ______________ magnetic fields

Cathode Ray Experiment

-The ray is a beam of __________ traveling from the cathode to the anode!

-When the __________ end of a magnet is applied, the beam is __________... ELECTRONS MUST BE ______________ CHARGED!!

-No matter what gas or metals were used, the charge-to-mass ratio remained the _______ ... ______________ ARE PART OF ALL ATOMS!!

Oil Drop Experiment

-___________________ calculated the charge and mass of the electron

-Charge: one unit of __________ charge (-1)

-Mass: 1/1840 the mass of a ________ atom (_______________ SUBATOMIC PARTICLE)

Protons and Neutrons

-**EUGENE GOLDSTEIN** discovered ________ (1,840 times ________ than an electron)

-**JAMES CHADWICK** confirmed the existence of __________ (about the same size as a proton)
• Gold Foil Experiment

- ERNEST RUTHERFORD shot _____ particles (positively charged) at a thin sheet of _____ foil

- HYPOTHESIS: alpha particles will pass through the foil _________ changing direction because _________ charged particles spread out in the atoms of the foil will _____ stop or deflect the alpha particles

- RESULTS: most went straight __________, some __________, and some came straight ______

- CONCLUSIONS: most of the atom is ______________ with a dense, positively charged ______________ (protons and neutrons)!!!

- Use labels / lines to show what happened:

• Models of the Atom

- Various ______________ contributed to our understanding of the atom

- Discoveries made between ______________ shaped the current model

• Dalton’s Model

- 1803: Views atoms as _____ and ______________ particles with ____ internal structure

- Draw it:

• Thomson’s Model

- 1897: Negatively charged particles (__________) are distributed throughout a __________ positive charge

- "__________________" Model

- Draw it:
• **Rutherford’s Model**

- **1911**: Small, dense, positively charged ________ with the __________ moving around the nucleus (mostly ______________________)

- Did _____ explain the __________________________ of elements!!

- Draw it:

• **Bohr’s Model**

- **1913**: Electrons move in a circular _______ at _______ distances from the nucleus (____________________)

- Draw it:

- **ENERGY LEVELS** (n):

- Positive nucleus “__________” the electrons so they stay in orbit

- Electrons absorb or emit energy as they ______ between levels:
  
  o To an **EXCITED** (higher) orbit = __________ energy
  
  o Return to **GROUND** (lower) orbit = __________ energy

- Imagine the fixed energy levels are like the _________________________: lowest rung is _________ in energy, can move rung to rung, you ________ stand between the rungs just like __________ can’t be in between levels, and to climb you need the right amount of energy

- Levels are **NOT** ________________ apart, so electrons gain or lose different amounts energy

- Higher energy levels are __________ together… it takes ________ energy to move from one to the next near the top!

* Ladder with ________________ spaced rungs is actually a better representation of the model!!
• Bohr Equation

- Bohr model only works for ______ small atoms (ex: ____________)

- Calculate the energy absorbed or emitted by electron using the equation:

\[ \Delta E = -2.18 \times 10^{-18} J \left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) \]

- Example: What is the energy of a photon when an electron moves from \( n = \) ____ to \( n = \) ____? Is the energy absorbed or emitted?

• Schrodinger’s Model

- 1926: Development of a mathematical equation to determine __________ around the nucleus that would have a high __________ of containing an electron (__________________________)

- "__________________" or ____________________________ (current)

- Draw it:

- Protons and neutrons found in the __________

- ELECTRON CLOUD:

  DENSER regions = ___________ probability of finding an electron

• Distinguishing Among Atoms

- Why are atoms of different elements different?
  
  o They contain different number of _____________
  
  o ______________ tell you which element is which

• ATOMIC NUMBER:

- Use the __________________ to determine

- Ex: all Hydrogen atoms have _____ proton, so the atomic # of hydrogen is ____

- What is the Atomic Number for each: Li, Pb, Au, Br?:

• Electrons

*Since atoms are electrically ________, the # of protons must _________ the # of ____________!!

-Atoms with ____________ numbers of protons and electrons are ________ (charged particles)

-Only the ______________ can ______________ or ______________ to give ions, NOT the ______________... WHY?

-Positive (+) charge = __________ electrons, while Negative (-) charge = _______ electrons...
  number of charge indicates how many!

-Examples:

• MASS NUMBER:

  Mass # =

  # of Neutrons =

  -Example: If an element has an atomic number of _____ and a mass number of 78 what is the...
    Number of protons?
    Number of neutrons?
    Number of electrons?
    Symbol for this element?

• Atomic Symbols

  X

  Ex:

  -Example: If an element has _____ protons and 140 neutrons what is the...
    Atomic number?
    Mass number?
    Number of electrons?
    Atomic Symbol for this element?

• Reading the Periodic Table

  -Round the _________________ to get the MASS # of the most common isotope!!
• Problems

-Determine the number of PROTONS, NEUTRONS, and ELECTRONS for each:

  o ____________________:
  o ____________________:
  o ____________________:
  o ____________________:

• ISOTOPES:

- ___________ is different because there are more or less ___________

- ___________ is still the _______... otherwise the ________________ would change!

-Naming: put the ___________ after the element name

-Ex:

-Example: Determine the number of each subatomic particle for ___________.

• ATOMIC MASS:

-Reflects both the _____ and relative ________________ of the isotopes as they occur in nature

-NOT a ________________ because it is an average

-Given on the ________________

-Measured in ___________________ (amu)... 1 amu = 1/12 the mass of a ____________ atom

• Calculating Avg. Atomic Mass

  Average Atomic Mass =

-Example: Calculate the average atomic mass of copper if copper has two isotopes. 69.1% of copper has a mass of _____ amu and 30.9% has a mass of _____ amu.
- Example: The element Gallium has two stable isotopes, Ga-69 and Ga-71. The average atomic mass of Gallium is ___________ amu. Find the percent abundance of each isotope of the element.

- Quantum Mechanics
  - There are ______ quantum numbers that represent the address of an electron (n, l, m_l, and m_s)
  - The first three describe an ____________

- PRINCIPAL QUANTUM NUMBER (n):
  - Regions in space around the _______ that contain ____________
  - Tell you how ______ an electron is to the nucleus
  - n = ____-____... with 1 being the ____________ in energy and ____________ to the nucleus

- GROUND STATE (___________ energy) is ____________

- EXCITED STATES (___________ energy) are ____________________.

- Electrons in excited states are ____________ from the nucleus, have _______ orbits, and _______ energy!

- Maximum # of e- in an energy level found using ______
  - ________ on the Periodic Table indicate the energy level!!

- AZIMUTHAL QUANTUM NUMBER (l):
  - Principal energy levels can be divided into energy ____________ or ____________

  - Each energy level can have _______ sublevels with different _______ (showing where an electron is ______ to be found)

  - Sublevels are denoted by letters: ______________

<table>
<thead>
<tr>
<th>Sublevel</th>
<th>s</th>
<th>p</th>
<th>d</th>
<th>f</th>
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<tr>
<td>l =</td>
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<tr>
<td>Max # of e-</td>
<td></td>
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<tr>
<td>Shape Name / Quick Sketch</td>
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• ORBITALS (m):
  - Electrons are spinning in ______________ directions... “_______________”
  - Range of numbers from ____ through ____
  - Each sublevel has a different number of orbitals: s = ___, p = ___, d = ___, and f = ___
  - Since each orbital can hold ___ e-, max # of e- determined by: ______________________

• SPIN (m_s):
  - Only two possible values: ______ or ______ (indicates that the electrons in the pair have ______________ spins)
  - Electrons are shown to have ______________ spins when drawing the electron diagrams

• Summary

<table>
<thead>
<tr>
<th>ENERGY LEVEL (n)</th>
<th># OF SUBS</th>
<th># OF ORBS (n^2)</th>
<th>MAX # OF e^- (2n^2)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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• Electron Configurations: shows distribution of electrons among the orbitals of the atom
  - Three Ways to do this:
    - **Orbital Diagrams** (using ______ with electrons as ________)
    - **SPDF Notation** (_________ and __________ showing levels and electrons)
    - **Kernel Notation** (use ___________ and simplified SPDF)

• Rules
  1) **AUFBAU PRINCIPLE**: add electrons one at a time to the orbitals of _______ energy first
  2) **PAULI EXCLUSION**: e- MUST have ___________ spins and _______ of 2 e- per orbital (each e- has _______ different quantum #s)
  3) **HUND’S RULE**: each orbital in the sublevel must have one e- __________ pairing begins

Ex:
• Orbital Diagrams

-How to draw:

1) Use a box to represent one __________ / Arrows represent __________

2) Find the # of ______________

3) Start with the __________ energy level first (n = 1) and write down all __________ in each

4) Follow all ______ (max 2 e- per orbital, correct # of orbitals for spdf, unpaired first, d is one row behind)

5) Use the __________________ to help!

• Practice

-Example: Draw the orbital diagram for __________. Determine the number of unpaired electrons.

- __________:

- __________:

- __________:

- __________:

• SPDF Notation

-The electron configuration for __________ using this notation is:

-Large numbers represent the ______________

-Letters represent the energy ______________

-Superscript numbers indicate the number of ______________ in the sublevel
*USE THE ____________ TO GUIDE YOU!!*

- Periods (_____) indicate an ENERGY LEVEL (___ sublevels are off by _____) ⇐ WHY?
- Groups (_________) indicate SUBLEVELS
- Example: Write the electron configuration for ________.

**Practice**

Write the electron configurations for ________, ________, ________, and ____________ using spdf notation. How many electrons are in the last energy level?

**Kernel (Shorthand) Notation**

- Write the symbol of the ____________ (FARTHEST RIGHT column on the table) that ____________ the element on the Periodic Table and put in [ ]
- Then write the remaining electrons using spdf notation
- Example:
  - Aluminum:
  - Ne:
  - So... Al is:
- Try ___ and ___ on your own:

**Exceptions**

- Some electron configurations will be ____________ than what is expected from the rules
- ____________ OR ______ SUBLEVEL CONFIGURATIONS ARE MORE ____________!!!
- Examples: ____________ and ____________ (one electron is ______ for added stability)
  - ___:
  - ___:
• **BOHR DIAGRAMS:**

- Protons and neutrons are shown in the center, representing the ______________

- Electrons surround the nucleus in the ______________

- How to Draw:

  1) Find the ___________ on the Periodic Table to determine the # of ___________ you will draw and the # of protons and neutrons in the ___________

  2) The _______ determines how many energy levels (RINGS) you draw (ex: if the element is in ______, only ______ energy level is needed)

  3) Label the # protons and neutrons in the ___________ and put the correct # of energy levels

  4) Draw the electrons as _______ in the energy levels

  5) Watch the _______________ that each level can hold... 1\textsuperscript{st} = 2 e-, 2\textsuperscript{nd} = 8 e-, 3\textsuperscript{rd} = 18 e-, etc.

- Example: Draw the Bohr Diagram for ____________.

- Example: Draw the Bohr Diagram for ____________.

- Example: Draw the Bohr Diagram for ____________.

• **VALENCE ELECTRONS:**

- Usually _______________ energy level _____ AND _____ electrons added together

- Ex:
- More Ex:

- **ELECTRON DOT STRUCTURES:**
  - How to draw:
    1) Determine the # of ________________
    2) Write the element ___________
    3) Add one ____ at a time to each side of the symbol... show as ______
    4) Until they are forced to _____________ (____ e- max)
      - EXAMPLE:

- More Practice:

- Light
  - Study of light by __________ helped lead to the quantum mechanical model
  - All light exhibits ________ properties
    - AMPLITUDE:
    - WAVELENGTH:
    - FREQUENCY:
  - All light (in a vacuum) moves at the speed of light... __________________________

- Parts of a Wave (Draw Below)

- Electromagnetic Spectrum
  - _____ Regions
- Ranked with respect to their ______________

- As the wavelengths become __________ the frequency decreases (__________ relationship)

- Equation to explain this: \( c = \lambda \nu \)

\[
c = \frac{3 \times 10^8 \text{ m/s}}{}
\]

\[
\lambda = \text{measured in meters}
\]

\[
\nu = \text{measured in hertz or s}^{-1}
\]

- Visible Spectrum

  - We are only able to see a very limited portion of the electromagnetic spectrum (__________)

  - Visible light is an example of a continuous spectrum (__________________________)

  - Ranges from _______ (long \( \lambda \)) to _________ (short \( \lambda \))

- Problems

  - What is the wavelength of radiation with a frequency of ______________ Hz?

  - What is the frequency of radiation with a wavelength of _______ nm?
• Prisms
  - White light is made of ______________ of the spectrum (CONTINUOUS)
  - Colored light only gives ________________ (NOT CONTINUOUS)...

• ATOMIC EMISSION SPECTRUM:
  - Gives a pattern of color that is ____________ for each element
  - Adding energy __________ an atom’s electrons... so they jump from the ________________ (lowest energy) to an ________________ (higher energy)
  - When electrons move from a higher energy level back to a lower one, a quantum of energy (__________) is given off that has a frequency _____________ to the energy change...

• Energy
  - Energy absorbed or emitted by an atom can be calculated using: ______________
    \[ E = h \nu \]
    \[ h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s} \]
    \[ \nu = \text{____________} \text{ of light wave} \]
  - Using the \( c = \lambda \nu \) equation and substitution, we know that: ______________

• Problems
  - What is the energy of blue light with a wavelength of ______________ m?

  - What is the ______________ of the photon from above?

• HEISENBERG’S UNCERTAINTY PRINCIPLE:
  - Does _____ apply to ________ objects (trains, cars, etc.) but critical in finding the position of electrons due to their _________________