CHEMISTRY 11 UNIT REVIEW: ATOMIC THEORY & PERIODIC TRENDS

Atoms

Atoms have protons and neutrons located in the nucleus of the atom. Electrons orbit around the nucleus in well-defined paths. Protons have positive charge, electrons have negative charge, and neutrons are neutral.

Greek Philosophers (Democritus and Aristotle 400-500 BC)

Democritus, develop the idea of atoms. Democritus thought that if you break matter it will reach the smallest possible particle of matter. He called these basic matter particles, **atomos**.

Unfortunately, the atomic ideas of Democritus had no lasting effects on other Greek philosophers, including Aristotle. In fact, Aristotle dismissed the atomic idea as worthless. People considered Aristotle's opinions very important and if Aristotle thought the atomic idea had no merit, then most other people thought the same also. (Primates have great mimicking ability.)
Not until the early 1800's did people begin again to question the structure of matter.

John Dalton (1766 – 1844):

John Dalton was an English chemist. His ideas form the atomic theory of matter. Here are his ideas.

- All elements are composed (made up) of atoms. It is impossible to divide or destroy an atom.
- All atoms of the same elements are alike. (One atom of oxygen is like another atom of oxygen.)
- Atoms of different elements are different. (An atom of oxygen is different from an atom of hydrogen.)
- Atoms of different elements combine to form a compound. These atoms have to be in definite whole number ratios. For example, water is a compound made up of 2 atoms of hydrogen and 1 atom of oxygen (a ratio of 2:1). Three atoms of hydrogen and 2 atoms of oxygen cannot combine to make water.

1. What is the name of John Dalton's theory? _____ATOMIC THEORY OF MATTER_____

2. What are elements made of? _____ATOMS_____

3. An atom of hydrogen and an atom of carbon are __MADE OF HYDROGEN & CARBON RESPECTIVELY___.

4. What are compounds made of? _____DIFFERENT ELEMENTS THAT COMBINE TO FORM NEW SUBSTANCES_

5. The ratio of atoms in HCl is: a) 1:3 b) 2:1 c) 1:1

J. J. Thompson (Late 1800s):

J. J. Thompson was an English scientist. He discovered the electron when he was experimenting with electron gun or gas discharge tubes. He noticed a movement in a tube. He called the movement cathode rays. The rays moved from the negative end of the tube to the positive end. He realized that the rays were made of negatively charged particles – electrons.

Thomson suggested a model of the atom called the Plum Pudding model. Its name is supposed to make you think of a lump of stuff with little pieces floating inside it. This model of the atom is that small negatively charged electrons are floating around inside a
evenly spaced positively charged material.

1. What did J.J. Thompson discover? _____ He discovered the electron _____

2. What is the charge of an electron? _____-1_____

3. What are cathode rays made of? _____ made of negatively charged particles – electrons._ _____

4. Why do electrons move from the negative end of the tube to the positive end? _____electrons are negatively charged and will repel from the negative end, they are attracted to the + charge at the other end of the cathode tube_____

5. What was Thompson working with when he discovered the cathode rays? _____ he was experimenting with electron gun or gas discharge tubes _____

Lord Ernest Rutherford (1871 – 1937):

J.J. Thompson asked Rutherford to conduct further experiments to prove Plum Pudding model. Ernest Rutherford conducted a famous experiment called the gold foil experiment. He used a thin sheet of gold foil. He also used special equipment to shoot alpha particles (positively charged particles) at the gold foil. Most particles passed straight through the foil like the foil was not there. Some particles went straight back or were deflected (went in another direction) as if they had hit something. The experiment shows:

- Protons are concentrated in dense nucleus; based on the observation that positive nucleus repels (pushes away) positive alpha particles
- Atoms are mostly empty space

1. If the plum pudding model was correct depiction of the structure of atom what would have Rutherford found when he performed the Gold Foil experiment.

   If the plum pudding model was correct the majority of the alpha particles would have been repelled. The plum pudding model suggested that aside from electrons floating around inside, the entire rest of the atom was + positively charged. Which would mean that any alpha particle hitting any space other than an electron would hit a + charge and be repelled. This of course what not the case. Rutherford found that most particles passed straight through the foil like there was nothing there….

2. What is the charge of an alpha particle? _____alpha particles are + charged_____

3. Why is Rutherford's experiment called the gold foil experiment?

_____he used a thin sheet of gold foil to shoot alpha particles at_____

4. How did he know that an atom was mostly empty space?

Most particles passed straight through the foil like the foil was not there. Some particles went straight back or were deflected (went in another direction) as if they had hit something

_____

5. What happened to the alpha particles as they hit the gold foil? _____alpha particles either passed straight through hitting nothing, or were repelled or deflected when they hit an electron or the + protons in the nucleus_____

6. How did he know that the nucleus was positively charged? _____ Protons are concentrated in dense nucleus; based on the observation that positive nucleus repels (pushes away) positive alpha particles_____

Niels Bohr (Early 1900s):

Niels Bohr was a Danish physicist. He proposed a model of the atom that is similar to the model of the solar system. The electrons go around the nucleus like planets orbit around the sun. All electrons have their energy levels – a certain distance from the nucleus. Each energy level can hold a certain number of electrons. Level 1 can hold 2 electrons, Level 2 - 8 electrons, Level 3 - 18 electrons, and level 4 – 32 electrons. The energy of electrons goes up from level 1 to other levels. When electrons release (lose) energy they go down a level. When electrons absorb (gain) energy, they go to a higher level.

1. Why could Bohr's model be called a planetary model of the atom? _____ The electrons go around the nucleus like planets orbit around the sun _____
2. How do electrons in the same atom differ? ___electrons in the SAME atom are at different energy levels, a certain distance from the nucleus_____
3. How many electrons can the fourth energy level hold? _____32 electrons_____

4. Would an electron have to absorb or release energy to jump from the second energy level to the third energy level? _____electrons must absorb (gain) energy to move to a higher energy level_____

5. For an electron to fall from the third energy level to the second energy level, it must _____an electron will emit (lose) energy when they move down an energy level_____ energy.

Name KEY!

Chemistry 11 - Atomic Theory, Periodic Table, and Bonding Theory Review

1. Give the number of protons, neutrons and electrons in the following:

Isotope	*Protons*	*Neutrons*	*Electrons*
$^{177}Hf^{3+}$	72	105	69
$^{209}Po^{2+}$	84	125	82
$^{212}At^{-}$	85	127	86

2. Give the nuclear notation of the following:

Isotope	*Protons*	*Neutrons*	*Electrons*
$^{96}_{42}Mo^{3+}$	42	54	39
$^{74}_{32}Ge$	32	42	32
$^{265}_{108}Hs^{3+}$	108	157	105

3. What is the name of the element, **X**, which has the following mixture of isotopes:
^{192}X = 35.5%, ^{194}X = 34.9%, ^{198}X = 20.3%, ^{209}X = 9.3%

At. Mass = (0.355)(192) + (0.349)(194) + (0.203)(198) + (0.093)(209)
= 195.50 g/mol – Pt

4. Each single orbital can hold a maximum of 2 electrons.

5. An "s" subshell (1 orbital) can hold a maximum of 2 electrons
A "p" subshell (3 orbitals) can hold a maximum of 6 electrons
A "d" subshell (5 orbitals) can hold a maximum of 10 electrons
An "f" subshell (7 orbitals) can hold a maximum of 14 electrons

When electrons in an atom are filling energy levels, they fill the lowest possible energy levels first.

6. Give the electron configuration for each of the following atoms and ions: (You may use core notation)

Si	$[Ne]3s^2 3p^2$	Cr	$[Ar]\ 4s^2 3d^4$
Br	$[Ar]4s^2 3d^{10} 4p^5$	Sr	$[Kr]5s^2$
K	$[Ar]4s^1$	Fe	$[Ar]4s^2 3d^6$
Ge	$[Ar]4s^2 3d^{10} 4p^2$	P	$[Ne]3s^2 3p^3$
Na^+	$[He]2s^2 2p^6$	Mg^{+2}	$[He]2s^2 2p^6$
Br^-	$[Ar]4s^2 3d^{10} 4p^6$	As^{-2}	$[Ar]4s^2 3d^{10} p^6$
O^{-2}	$[He]2s^2 2p^6$	Te^{-2}	$[Kr]5s^2 4d^{10} 5p^6$

7. Write the configuration and then find the number of valence electrons for the following atoms:

N (configuration) $[He]2s^2 2p^3$ (# of valence e⁻'s) 5

Si (configuration) $[Ne]3s^2 3p^2$ (# of valence e⁻'s) 4

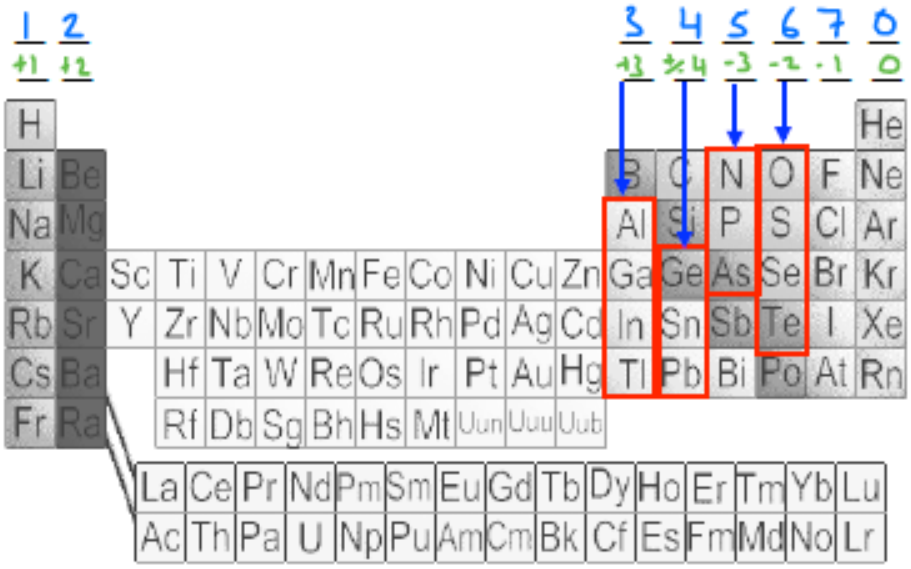
Ca (configuration) $[Ar]4s^2$ (# of valence e⁻'s) 2

P (configuration) $[Ne]3s^2 3p^3$ (# of valence e⁻'s) 5

Al (configuration) $[Ne]3s^2 3p^1$ (# of valence e⁻'s) 3

On the following diagram of the Periodic Table, list the number of valence electrons and the most common ion charge in Groups 1,2 & 13-18

# of Valence e⁻s
Ion Charge



8. In order to become stable,

an atom of Ca will donate 2 electrons and become the ion Ca^{2+}

an atom of Se will gain 2 electrons and become the ion Se^{2-}

an atom of K will donate 1 electrons and become the ion K^{+}

an atom of Br will gain 1 electrons and become the ion Br^{-}

an atom of N will gain 3 electrons and become the ion N^{3-}

an atom of As will gain 3 electrons and become the ion As^{3-}

an atom of Al will donate 3 electrons and become the ion Al^{3+}

an atom of Te will gain 2 electrons and become the ion Te^{-2}

9. What is the general trend in atomic radius (size of atoms) as you move from left to right across any Period? (*increase/decrease*) decrease

10. As you move from Li to Ne, electrons are filling (*the same/different*) Same energy levels(s). This may help explain why atoms ***don't*** get bigger as you move to the right within a period.
q protons while NO increase in shielding (no more core electrons)

11. As you move across from Li to Ne, what is happening to the number of *protons* in the nucleus? increases. What do the protons do to the electrons? attracted. Suggest a reason why the atoms in a period actually get ***smaller*** as you move from left to right.

12. What is the general trend in atomic radius (size of atoms) as you move *down* a vertical column (group)? (*increase/decrease*) Increase

13. Suggest a reason for this trend. (*Hint: are electrons filling up the same energy level (orbitals) as you move down a column?*) No! Every new row means +1 energy level!

14. What is meant by **ionization energy**?
The amount of E required to remove an e⁻ from the outter most shell

15. What is the general trend in first ionization energy as you move from left to right across any Period? (eg. from Li→Ne or from Na→Ar) (*increase/decrease*) increase

16. Keeping in mind the trend in atomic radius as you move from left to right across a period, suggest a reason for this trend in ionization energies. (Hint: *What happens to the distance and the force of attraction between the nucleus and the outer electron as atoms get smaller?*)
q protons increase attractive force ∴ harder to remove e⁻

17. What is the trend in ionization energy as you move down a vertical column, like from Li→Na→K or from He→Ne→Ar→Kr? (*increase/decrease*) decrease

Suggest a reason for this trend based on atomic radius (size) and the distance and force of attraction between the nucleus and the outer electron.
while attract increases so does shelding + distance
overall attractive force goes ↓

18. Compare the following particles:

sodium ion	oxide	neon	Magnesium atom	Fluorine atom

a. Arrange the particles using **chemical formulas** from **smallest atomic radii** to **largest atomic radii**:

b. On your answer above, using **arrows** show the trend of **electronegativity, ionization energy** and **electron affinity**.

Subatomic Particles in Ions

The table below contains information about several ions. Use the information given to fill in the blanks.

Element Name	Ion Symbol	Atomic Number	Mass Number	# of Protons	# of Neutrons	# of Electrons
1. **chlorine**	Cl^-	**17**	**35**	**17**	18	**18**
2. silver	**Ag^+**	**47**	107	**47**	**60**	46
3. **oxygen**	**O^{2-}**	**8**	**16**	8	8	10
4. **aluminum**	Al^{3+}	**13**	27	**13**	**14**	**10**

Subatomic Particles in Neutral Atoms

The table below contains information about several isotopes. Use the information given to fill in the blanks. Assume all atoms are neutral.

Isotope Name	Nuclear Symbol	Atomic Number	Mass Number	# of Protons	# of Neutrons	# of Electrons
5. calcium-40	$^{40}_{20}Ca$	**20**	**40**	**20**	**20**	**20**
6. **iron-56**	$^{56}_{26}Fe$	26	56	**26**	**30**	**26**
7. **oxygen-18**	$^{18}_{8}O$	**8**	**18**	8	10	**8**
8. **gold-197**	$^{197}_{79}Au$	**79**	**197**	**79**	**118**	**79**

Average Atomic Mass

9. Calculate the average atomic mass for neon if its abundance in nature is 90.5% neon-20, 0.3% neon-21, and 9.2% neon-22.

$$\frac{\textbf{(90.5)(20 amu) + (0.3)(21 amu) + (9.2)(22 amu)}}{\textbf{100}} = \textbf{20.18 amu}$$

10. Calculate the average atomic mass of silver if 13 out of 25 atoms are silver-107 and 12 out of 25 atoms are silver-109.

$$\frac{\textbf{(13)(107 amu) + (12)(109 amu)}}{\textbf{25}} = \textbf{107.96 amu}$$

Reviewing Concepts

11. The mass of an atom is contained mainly in its **protons** and **neutrons**.

12. The identity of an element is determined by its number of __**protons**__.

13. Isotopes are atoms with the same number of __**protons**__ and different number of __**neutrons**__.

14. The charge of an atom or ion is determined by its number of __**electrons**__.

15. __**B**__ Particle X contains 9 protons, 10 neutrons, and 9 electrons. Particle Y contains 9 protons, 10 neutrons, and 10 electrons. What is the relationship between particles X and Y?
    A. Particles X and Y are isotopes of the same element.
    B. Particle X is an atom, and particle Y is an ion of the same element.
    C. Particle X and Y are atoms of different elements.
    D. There is no significant difference between particles X and Y.

16. Briefly explain your answers to question 15.

    Same number of protons = same element. Same number of neutrons = same isotope. Different number of electrons = different charge. X is a neutral atom. Y is a negative ion.

17. Please use the following table to **calculate the average atomic mass of chlorine**.

Isotope	% Abundance	Mass (amu)
^{35}Cl	75.78%	34.969
^{37}Cl	24.22%	36.966

34.969 amu x 0.7578 + 36.966 amu x 0.2422 = 35.4527 amu

18. Raiderium (Cv) has three naturally occurring isotopes. Raiderium is 74.655% ^{44}Cv, which has an atomic mass of 43.064 amu, 24.958% ^{46}Cv, which has a mass of 46.125 amu, and 0.387% ^{48}Cv, which has an atomic mass of 47.982 amu. **Please calculate the average atomic mass of Raiderium**.

43.064 amu x 0.74655 + 46.125 amu x 0.24958 + 47.982 amu x 0.00387 = 43.859 amu