NAME\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ NOTES: **UNIT 2 ATOMIC STRUCTURE (PART 1)** &

 ELECTRON CONFIGURATION (PART 2)

**Summary Learning Goals**: The expected outcomes of your work, are listed. Goal 1 lists important vocabulary terms. You want to know each term's definition.

Goal 1) You must be able to **define / compare / contrast / interpret** the vocabulary terms:

atom \* the smallest representative, neutral unit of an element (in which the number of protons equals the

 number of electrons) capable of participating in chemical reactions

isotope \*a representative atom (species) of an element, having the same atomic number as all other atoms of

 the element, but having a different mass number, due to a different number of neutrons.

subatomic particle \*any species that comprises the nucleus or electron cloud of an atom or ion.

mass number \* the unitless, whole number sum of the protons and neturons of a nucleus. The number of

 nucleons (mass number) of a specific isotope

nucleons \* subatomic particles comprising the nucleus (generally the protons and neutrons)

atomic number \*the number of protons of a nucleus …referred to sometimes as “Z”

nuclear charge \*equivalent to the total number of protons (the atomic number) of a nucleus

ion \* any species in which the number of protons does not equal the number of electrons

Goal 2) **explain**: why all **atoms** may be considered to be **neutral** particles (or 0 in overall charge)

 and how an atom of an element compares/contrasts to (an) ion(s) of that element.

 \*Atoms are neutral, because the number of positive protons are equal to the number of the negative

 electrons. The ion of an atom has lost or gained electron(s), and thus the proton number does not equal the

 electron number.

Goal 3) list facts of an atom's 3 major subatomic particles with respect to the :

* + - name
		- physical characteristics (mass, charge)
		- location within the atom

Goal 4) interpret an isotopic notation:

Note: **There is no “official”** system of isotopic notation. (I know! …odd!) Different websites/texts may use slightly different formats to impart the exact same information, regarding atomic number, mass number etc. You must rise above this issue and learn how to integrate other formats with the format in this packet. I find the following, however, quite valuable for learning.

 The four corners of an element’s symbol may be used to designate different information.

Mass Number

Oxidation State

Atomic Number

Subscript

X

 This goal focuses only upon the upper left and lower left corners of a symbol.

 The # of nucleons = Mass Number = #p + #n (the upper left corner)

 Atomic number = # p = nuclear charge ∴# e- X

 (the lower left corner)

 **For example:**

 Given the isotopic notation for an atom of: $$ you will need to identify:

 the # of nucleons is 63 or rather, the atom has a mass # of 63 ... due to 30 protons  **+** 33 neutrons
 $ $

 the atomic # = 30 which means there are 30 protons and thus a nuclear charge of +30

 and **since this is an atom, one may infer** that there are also 30 electrons

 And, using the periodic table you can tell that the above represents an atom of

 zinc and its specific name is zinc-63 (pronounced as: ***zinc sixty three***)

Goal 5) write the isotopic notation (as in Goal 4 above) for any atom or ion using information provided in a

 a question and/or information.

Goal 6) interpret the charge of simple positive ions (cations) and negative ions (anions) relative to the

 ion's atom (or neutral, in charge, form).

 e.g) Ca**2+** is an ion. It has an unequal number of protons and electrons. The charge of +2 indicates

 that it has 2 more protons (or 2 more + charges) relative to its atom (Ca0) because 2 electrons

 (or 2 negative charges) have been removed/lost [Ca**2+** is the oxidized form of the element

 calcium]

NAME\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ NOTES: **UNIT 2 ATOMIC STRUCTURE (PART 1)** &

 ELECTRON CONFIGURATION (PART 2)

**You need know these ideas about Atomic Theory:**

⮊the location, charge, and mass of a proton, neutron and electron

⮊atomic notation and the concept of charge

⮊ isotopes

⮊ the role of valence electrons in reaction chemistry (part 2)

⮊ the commonality of reactions between family members of the periodic table (part 2)

⮊ the four basic categories of elements (part 2)

⮊ that the ion(s) of an element behave differently than the atom of the element

⮊ metal atoms are oxidized, and nonmetal atoms tend to be reduced in a reaction when reacted against a metal

⮊ the production of light energy (part 2)

⮊ the interpretation of a ground state configuration and excited state configuration (part 2)

**Part 1: Basic Atomic Structure:**

Websites which may help:

➊ <http://www.chemguide.co.uk/atoms/properties/gcse.html#top> (very good)

➋ <https://www.registerednursing.org/teas/basic-atomic-structure/#atoms> (only okay …but may be a site for later use)

➌ <https://courses.lumenlearning.com/boundless-chemistry/chapter/the-structure-of-the-atom/> (okay)

➍ <https://www.youtube.com/watch?v=h6LPAwAmnCQ> (not bad!)

➎ <https://www.youtube.com/watch?v=P-wDdFyeLpM> (not bad)

I) Atoms are the smallest neutral particles of an element that can participate in a chemical reaction. For our

 class, we shall generally interpret the term, atom, as referring to a singular element-species which is neutral in

 overall charge. Atoms have an overall charge of zero (0), because the number of protons (positive (+)

 charges) are offset by or equal to the number of electrons (negative (**-**) charges).

***definition***

 A) The term most students confuse with the word, ***atom***, is the term, ***ion***.

***definition***

 1) An ion is a particle in which the number of protons and electrons are UNequal.

 Thus, ions are species that have an overall positive or negative charge, depending upon the

 difference in protons and electrons.

 A generalized image of an atom is a small, relatively dense, positively charged nucleus, surrounded by a

 relatively larger, far less dense (virtually empty), and negatively charged “cloud” of electrons.

 B) Atoms are made of many kinds of smaller particles. Any particle found making up an atom is an

 example of a **subatomic** particle. There are possibly, hundreds of different types of subatomic

 and elementary particles.

***definition***

 1) The three most commonly studied subatomic particles are **electrons, protons,** and **neutrons.**

When we discuss the three major subatomic particles, we'll speak in terms of their:

 **charge, location in the atom, and mass**.

Around the turn of the 19th century, JJ Thomson discovered and named the electron. He proposed the Plum Pudding Model of the atom by suggesting that protons and electrons were spread evenly throughout what was being termed, the atom. (For those of us, in the USA, think of the plum pudding idea as sort of like fruit held in a Jell-O mold)

Rutherford was a former student of Thomson's and Rutherford was trying to prove JJ Thomson’s model of the atom to be correct. The Rutherford Gold Foil experiment is a classic example of discovering the unexpected. It all went wrong … Rutherford ended up proving his teacher’s ideas were pretty off-base …and changed how we see the universe.

In 1911, Ernest Rutherford led a team of scientists (including Hans Geiger and Ernest Marsden) in the now famous Gold Foil Experiment. The Rutherford team developed a new vision of the atom after conducting experiments in which very thin gold foil was bombarded with alpha particles ($$).

**Note: An alpha particle** is just 2 protons and 2 neutrons. An alpha particle is essentially a He-4 nucleus and has **no electrons**. Because there are NO negative charges associated with the alpha particle, an alpha particle possesses an overall positive charge (+2) …So, alpha particles are positive (as are the nuclei of all atoms) because of the protons

**Rutherford hypothesized** that if the electrons and protons were spread evenly throughout the atom, the positive alpha particles should pass right through the atom, in a straight line. The alpha particles would not be deflected very much because evenly dispersed protons and electrons would provide a “push me, pull me” effect and keep the alpha particle in a relatively straight path.

What they **thought** would happen:

 Key:

 **The Hypothesis**

 an atom of gold with + and – charges evenly distributed

∝+2

∝+2

 ∝+2

 ∝+2 an alpha particle with a +2 charge

*Hypothesized* path of the alpha particle

**Due to a (false) belief that + charges and – charges were distributed evenly in an atom, Rutherford hypothesized that positive alpha particles would pass right through the gold foil, in straight line paths.**

Well, they were shocked at what they discovered. **They realized that their hypothesis was wrong!**

The results of the experiment are depicted (very roughly) in the following diagram.

 **Most** (but not all) of the alpha particles passed

 through the gold atoms, with very minor deflections

of their hypothesized path.

But WOW! When a few of the positive alpha

particles bounced back towards the source of the

alpha particles, the scientists were

**dumfounded**!

It took virtually 2 years to crunch the data and

 make the above-mentioned conclusions.

Because most of the positive alpha particles sailed right through the atoms … Rutherford concluded ★**most of**

**the atom must be empty space.**

Secondly, because of the large angle of the deflection paths of some alpha particles (a few as much as 90°), Rutherford concluded that ★**there must be a high concentration of positive charge in an atom, capable of repelling the positive alpha particles from their hypothesized path ... and that most of the atom's mass must be concentrated with that charge.**

Rutherford *knew that as two positive charges approach each other, they are repelled*. Since the alpha particle was classified as positive, whatever caused an alpha particle to veer so radically off course must itself be positive! (This was a big discovery!)

Eventually, the physicists took a cue from biology and called the **positive center of an atom … a nucleus!** They also called the positive charge of the nucleus, the “**nuclear charge**”.

***definition***

**Assignment**: Summarize the conclusions or the consequences of the Gold Foil experiment. I can think of 2 or 3

 The atom is mostly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 By far, the mass of an atom \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 The nucleus of an atom \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Research what an alpha particle is. Should an alpha particle be classified as an ***atom***?

 Defend your reasoning based on these readings and your research. (answers are on the next page)

 **Check Out:** <http://www.youtube.com/watch?v=IXs61QYyU5o&feature=related>

 Watch animation of the Gold Foil Experiment (sometimes called the Rutherford Gold Foil Experiment, and

 sometimes called the Geiger-Marsden Experiment ....Geiger and Marsden were the graduate students who

 worked for/with Rutherford and did all the dirty work....)

 Now, for something utterly cruel ... watch this somewhat twisted version, if you dare!

 <http://www.youtube.com/watch?v=gO9CKkbLUiI>



Niels Bohr added to Rutherford’s work. Bohr made a series of measurements and determined that, not only did every atom have a positive nucleus of protons but, well beyond this nucleus were whirling electrons possessing (essentially) negative charge and highly specific amounts of energy.

It is the Bohr Model of the atom that has the; “shells containing electrons”, moving around the nucleus, like the way the planets (electrons) revolve around the sun (the nucleus). He won the Nobel Prize in Physics in 1922 for his vision.

In 1920, Rutherford predicted the existence of the neutron … and 12 years later, in 1932, a student of his proved the neutron existed. James Chadwick in a series of mind-boggling experiments swam against the popular opinions of at least three Nobel laureates and proved the existence of the neutron. He won the Nobel Prize in Physics in 1935.

**So, by the mid-1930s, the following is what we knew (or thought we knew) about the atom…**

Ans to p 29: …empty space,

 …is due to the p and n of the nucleus,

 …is positive because of positive protons

An alpha particle is the equivalent of a He-4 nucleus, with

2 protons and 2 neutrons. There are no electrons, so it has an overall charge of +2. It should not be called an atom, because, according to the reading, atoms, by definition are neutral or 0 in overall charge due to the equality between the protons and electrons.

Via ingenious experimentation, oodles of thinking, and exquisite mathematics, by (the):

early 1900’s: scientists deduced that the matter of the known universe **was made up of atoms. Atoms were**

 **themselves made of positive, negative, and *probably* neutral subatomic particles**.

1920’s: Rutherford showed that the atom was a **neutral particle** of mostly empty space, made from a positive

 nucleus and surrounding **negative** electrons. ★★**Because atoms were neutral in overall charge, the**

 **number of positive protons MUST equal the number of negative electrons.**

1935 : scientists knew that the nucleus was made of positive protons and neutral neutrons. Any subatomic

 particle of the nucleus is called a **NUCLEON**. The surrounding electron cloud was made of

 negatively charged electrons. They had reason to believe that electrons were found in specific areas

 (shells) outside the nucleus (although, this was being debated hotly by now). And, atoms were neutral

 in terms of charge, because **the number of** **protons and electrons were equal**.

and by 1939, some of this would be changed **dramatically... And the way we see the universe, will have been changed *AGAIN*** …but that is a different story…for another day.

**Visualization1: Complete the following concept map by filling in the 5 blanks with the correct terms. The answers are at the end of this packet...**

|  |  |  |
| --- | --- | --- |
|  | The ATOM |  |
|  | Made of small particles referred to as **1**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles |  |
| 2 different types of subatomic particles make up the |  | Only one type of subatomic particle makes up the  |
| | |  | | |
|  **2** |  | **Electron cloud** |
| **|** |  | **|** |
| The general term given to any particle of the nucleus is  |  | made of only  |
| | |  |  |
| **Nucleons** |  |  **5** |
| | |
| specifically, there are two types |
| | |
|  **3**  **&** **4** |

 C) **The electron** is the fundamental unit of **negative** charge in an atom. Electrons are found outside of the nucleus

 in the **electron cloud.** This outer "cloud" represents the **negative area of the atom.**

 ***Translation*: \*** The electron (and thus, the electron cloud region) is negative.

 1) Electrons are so small, that the mass of a single electron is negligible when calculating the mass of the

 atom.

 a) The mass of an electron equals approximately **1/1836** the mass of a proton.

 b) If you consider that the mass of a proton approximates 1 atomic mass unit (The gram

 equivalent of 1 atomic mass unit [μ] = 1.66 x 10-24 grams), the above means it takes about

 1,836 electrons to equal this same mass. So, it comes as no surprise that when scientists

 discuss the masses of the particles in an atom, they say that the **relative mass of a single electron is equal to 0 *atomic mass units.***

 ***Take home message* \*** Electrons have the same “oomph” as a proton, but that “oomph” is opposite in charge. Despite

 its equality of power with the proton, the electron is so small in mass, it is viewed to be without mass.

 Scientists DO NOT count the number of electrons when determining the mass number of an atom.

 It’s like saying, I have the same punch as WWF wrestler, even though I am so tiny!

 The actual mass of 1 electron is close to a mere 9.1093897 x 10-28 grams or 0.000548 μ *(that's small)*
 and that makes the protons and neutrons at approximately 1μ, seem absolutely massive!

 D) **The proton** is the fundamental unit of **positive** charge in an atom.

 1) Protons are one of the two major subatomic particles comprising the nucleus of most atoms.

 a) Protons are the only positively charged type of nucleon.

***definition***

 b) **The number of protons is called the atomic number.**

 i) The atomic number is sometimes symbolized as Z

 2) In a multi-proton nucleus, the average mass of a proton is approximately equal to

 1 atomic mass unit (1μ) or 1.66 x 10**-24** grams.

 a) A free or un-bound proton is closer to 1.6726 x 10**-24** grams. Now, that is odd …a proton has

 a different mass when it is alone vs. when it is associated with other protons, in a

 formed nucleus! **No, really … huh?**

 ★The fact that the mass of a proton in a nucleus is bit different from an unbound proton **helps to explain why the mass number and actual mass of an atom are not the same thing.** As the proton is bound up

 into a nucleus, a very small amount of mass is converted to energy (thus a bound proton is slightly lower

 in mass than an unbound proton)

 And, don’t forget, that while the proton is significantly larger in mass, than the electron, the **magnitude**

of their charges is identical. This means that the **positive nature** of 1 proton may be counteracted

 completely by the **negative nature** of a single electron.

 3) Since protons are the only charged subatomic particle of the nucleus the nucleus has an overall

 positive charge.

***definition***

 **a) This charge of the nucleus is called the nuclear charge and it is equal to the number of**

 **protons.** For instance, every lithium atom has an atomic number of 3 (that is, three protons).

 thus, the **nuclear charge** of lithium equals +3.

***Take home message:* An atom,** by definition is considered to be electrically NEUTRAL overall because**: \*the *negative***

**electron cloud region (charge) precisely balances the positive nuclear charge.**

 4) When you know the number of protons of an atom, then you can determine the number of electrons

 or vice versa.

The atomic number is written in the lower left corner of a symbol

 Atomic number = # p = nuclear charge *thus* # e-X

 29Cu

 **Copper (Cu) has an atomic number of 29.**

 **Each atom of Cu has 29 protons, a nuclear charge of +29**

 **and thus, every *atom* of Cu has 29 e-**

 ★★★**Don't confuse an ATOM with an ION. Ions have an UNequal number of protons and electrons,**

 **resulting in an overall positive (+) *or* negative (–) charge.**  When an atom loses electrons, it becomes

 a positive ion (a cation). When an atom gains electron, it becomes a negative ion (an anion). For instance, when

 an aluminum atom (Al-27) loses three electrons it becomes an aluminum cation (Al+3) due to the loss of e-.

 Al0 has 13 protons and 13 e-. Lose 3 electrons and the result is a species with 13 p and 10 e- or Al+3

 When a sulfur-32 atom gains two electrons, it becomes a S-2 anion, for, there are now two more electrons than

 protons. S0 has 16 protons and 16 e-. Add 2 more electrons and the result is a species with 16 p and 18 e- or

 S-2

 **Thus the charge of an ion indicates what subatomic particle is in the greater number. But it is**

 **always a reference to the number of protons in the nucleus (which don’t really change in a reaction**

 **chemistry reaction) and the number of electrons that has changed due to a loss or gain. Thus: Reaction**

 **chemistry is all about electrons!** (There is more on this topic, coming up)

**Check your grasp:**

 **\_\_\_**1) When an **atom** has an atomic number of 10, then how many electrons must the atom have in the electron cloud?

 \_\_\_2) When an atom has a nuclear charge of +7, then how many electrons must the atom have?

 \_\_\_3) When an atom has 29 electrons, how many protons must the atom possess?

 \_\_\_4) What is the overall charge of any atom?

5) In what ways does an ion differ from an atom? List at least two differences. These differences will be related to each

 other. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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 Ans: 1. 10 e- 2. 7 e- 3. 29 p 4. 0 or neutral 5 Ions have a charge of + or -. Ions have an unequal number of

 protons and electrons resulting in an overall charge.

 E)  **The neutron** has no charge. The **neutron** is a **neutral** subatomic particle and it is the other major "nucleon".

 1) For our course, a neutron has a mass of 1μ. In truth, the neutron is actually a wee bit larger than a

 proton.

 We "say" the mass is 1μ, but really an unbound neutron is 1.6749 x 10-24 grams ... just a bit different

 from a proton's mass and the mass of 1 atomic mass unit ... but we round.

 2) Neutrons (along with protons) make up what is termed the Mass Number of an atom. The number of

 neutrons is NOT written directly in the symbol of an atom. We will see more of this with our

 work on isotopes.

 a) The number of neutrons is NOT the same for every atom of an element.

 b) The number of neutrons is NOT included (directly) with an atomic notation. You

 must calculate the number of neutrons using the equation Mass# = # p + #n OR its

 rearranged form:

  **#neutrons = Mass # - # p** **(memorize this)**

**Visualization:** You have just reviewed the basics of the atom. Below is an ***atom*** of uranium-235.

 the #of nucleons ∴ Mass # = protons + #neutrons ⮱

 U

 Atomic # = # of protons which gives the # of electrons **and** the nuclear charge ⮳

 3) Isotope: \* a representative atom (species) of an element, having \*the same atomic number as

 all other atoms of the element, but having a different mass number, due to a different number of

 neutrons.

Before we begin this discussion, take a minute to reflect about the existence of "isotopes" of an element. **Why do they exist?** Well, consider the problem that Rutherford and then Chadwick had in conceiving of a nucleus made up of **only positive** protons. They should repel each other and burst the nucleus apart ... but that is observed far less often than it should be. **Thus, there must be a second (but different) type** of nucleon reducing the repulsive forces of the protons. Hence, Rutherford gave us the theory of neutrons, and Chadwick proved their existence.

Take Home Message**: The neutral charge of the neutron stabilizes the nucleus by reducing the repulsive force of protons that would (without neutrons) be too close to each other and repulse each other due to their like charges. (sounds like a test question, to me...)**

You see there is a challenge with grasping how a group of “just positive” particles can group together. Like charges repel ... opposites attract. **So, What’s Up With The Nucleus?**

Some of the “glue” that holds the nucleus together is due to the exchange of a subatomic particle called a meson between nucleons and the strong nuclear force created by that exchange. The strong nuclear force is one of four nuclear forces (and the strongest of them). It is however very, short range (acting only over a distance of about the diameter of a proton)

Protons must be really close to have meson exchange occur. So, the protons must be under really high pressure of some sort, or be moving terribly fast (so as to reduce the effects of the repulsive force). **Or**, as Rutherford thought, there could be a second type of nucleon ... a neutral one, which could help.

According to work found at: <http://aether.lbl.gov/elements/stellar/strong/strong.html>

***One thing that helps reduce the repulsion between protons within a nucleus is the presence of any neutrons. Since they have no charge, they don't add to the repulsion already present, and they help separate the protons from each other, so they don't feel as strong a repulsive force from any other nearby protons. Also, the neutrons are a source of more strong force for the nucleus since they participate in the meson exchange. These factors coupled with the tight packing of protons in the nucleus so that they can exchange mesons creates enough strong force to overcome their mutual repulsion and force the nucleons to stay bound together***

*Okay, But Why Are There Different Versions (Isotopes) Of The Same Element?*

So, do you understand that we believe the neutron helps mitigate the repulsive forces of a proton-based nucleus, in addition to encouraging meson transfer (strong force development)?

If, Yes! ... Great! Now, all you need to understand to answer the above question is that ***Nature is not always neat and tidy.*** As nuclei form, the ratio between protons and neutrons can vary. It’s like making dozens of tuna fish sandwiches, in a hurry ... One sandwich could have a different number of leaves of lettuce from some of the others. They are all the same tuna (same atomic number), but different number of lettuce leaves....

Think about it ... Because there are probably multiple ways neutrons could be arranged to stabilize a set of protons, we often see a different number of neutrons in the atoms of a specific element.

VISUALIZE: Let be 1 proton

 Let be 1 neutron

 **Rutherford was always thinking about this positive nucleus of his. Something didn’t make**

 **sense. Here’s how he began to think about the existence of the neutron. Chadwick proved**

 **his teacher (Rutherford) was right, about 20 years later…**

 Now, imagine a nucleus made up of only positive protons. Even with the strong forces

 as positive particles approach each other, **they should repel** each other!

I repulse YOU?!!

No, you repulse ME! **PUH-LEESE**

If this were true, then either his math about

 the gold foil experiment was wrong, or

 matter as we know it shouldn’t exist (because large nuclei could never form) OR, **there is a-yet-**

 **unknown neutral subatomic particle** that helped reduce the repulsive forces!

 So, the neutron is the subatomic particle that comes to our repulsive rescue! Now, Nature is hardly

 perfect, and the repulsive forces may be mollified (ameliorated … Holy SAT word, Batman) with

 a differing number of neutrons, **thus the atoms of most elements have a slightly different**

 **number of neutrons … and this gives us isotopes of the element!**

Ahh! **Muuuuuuch** Better! *A fence between yards* can be a nice addition….

 **5 protons 5 protons 5 protons**

 **4 neutrons 6 neutrons 5 neutrons**

 **Because Nature might organize protons and neutrons, a bit differently, in order to reduce**

 **repulsive forces in a nucleus, various isotopes of an element are produced .... These versions**

 **of an element have: the same atomic number, but a different number of stabilizing neutrons**

II) Isotopic Notation

 mass number

X

 A) When we write the symbols of atoms, we generally include ONLY 2 NUMBERS

 atomic number

 1) The number of protons is called the **atomic number (memorize this)**

 3Li

 6C

 It is written in the lower left corner of an atomic symbol

 You can **infer** the number of electrons from this number or

 2) The **Mass Number** is a combination of the number of protons and the number of neutrons

 a) **Mass Number = # p + # n (memorize this)**

 b) The Mass Number is always a whole number, and it *tends* to be written in the

 upper left-hand corner. There is another way to record the mass number and we will

 see this in just a few minutes ….

 3) The mass number refers to **a specific atom (a specific isotope). There is no unit,** for the

 mass number. The mass number is **just another means of referring to the total number of**

 **nucleons in the nucleus of a specific atom.**

 **a) So, when we write the notation for a specific atom …**

 $$ or $$

 pronounced: Nitrogen fourteen Nitrogen fifteen

 $$ or $$ or $$ or $$ or $$

b) An alternate way to write the notation of an isotope, assumes you know the

 atomic number (the number of protons)

 N-14 vs. N-15

 Zn-64 vs. Zn-66 vs. Zn-67 vs. Zn-68 vs. Zn-70



 **May I suggest ….**When given a notation in a form like Al-27 ... Look up Al on the periodic table and re-write the notation **with the atomic number**:$$ ... This notation

 gives you the most information, and is probably the most useful notation for a first-year

 student

 c) The mass number is NOT the mass of the specific atom, either.

 The actual mass of the atom is determined from the mass number and the actual

 masses of the protons and neutrons which are only, *approximately* 1μ (and this little

 fact matters). As protons and neutrons merge into a nucleus, some of the matter is

 converted into energy via a nuclear reaction. Thus, the actual mass of an

 isotope tends to be a bit less than the mass number (which is just the sum of the

 protons and neutrons).

 e.g)

|  |  |  |
| --- | --- | --- |
| Isotope  | Isotopic Mass[or measured mass] (μ) | Percent Abundance (%) |
| Mg-24  | 23.985045 | 78.99  |
| Mg-25  | 24.985839  | 10.00  |
| Mg-26  | 25.982595 | 11.01  |

 e.g.)

|  |  |  |
| --- | --- | --- |
| Isotope | Isotopic Mass[or, measured mass] (μ) | PercentAbundance (%) |
| O-16 | 15.994915 | 99.7587 |
| O-17 | 16.999131 | 0.03740 |
| O-18 | 17.999159 | 0.2039 |

**Try This:**

 You will notice the number of electrons is NOT included in the mass number. Hmm, I wonder why???

 Think about that ... Think about the definition of mass number ... there ya' go!

 \* Electrons aren’t nucleons and the mass number accounts only for the number of nucleons

 c) The mass number IS **NOT** LISTED on the Periodic Table. There isn't room to list all

 the mass numbers of all the isotopes of every element ... so we list the ***relative* atomic**

 **mass** on the periodic tables.

 The *relative atomic mass* represents a weighted average of all actual atomic masses of the

 naturally occurring isotopes of an element. The mass number is a simply a whole number

 representing the total of protons and neutrons making the nucleus of a specific atom (the total

 number of nucleons). (Levere, Trevor H. Transforming Matter: *A History of Chemistry from*

 *Alchemy to the Buckyball* p 108 2001 The Johns Hopkins University Press. Baltimore and London)

 Take for example, Magnesium (Mg) with its 3 naturally occurring isotopes:

|  |  |  |
| --- | --- | --- |
| Isotope  | Isotopic Mass[or measured mass] (μ) | Percent Abundance (%) |
| Mg-24  | 23.985045 | 78.99  |
| Mg-25  | 24.985839  | 10.00  |
| Mg-26  | 25.982595 | 11.01  |

 On the periodic table you see something like:

24.3050

 Mg

 12

 Note that the 24.3050 value, ***has a unit of 𝝁*** , as it is a mass … and the value is a

 weighted average of the naturally occurring isotopes of Mg. There is no single isotope

 with such a mass.

III) One of the ideas that escapes most students is what is meant by symbols like: Na**+1**or S**-2**. As you know by now ... these symbols represent specific **ions.** **Ions are charged species**. The number of protons and the number of electrons are **NOT** equal.

Fact1: Under normal chemical circumstances the ONLY subatomic particle that can change in quantity is

 the electron!!!! The atomic number of an element (the number of protons) DOES NOT CHANGE

 under normal chemical circumstances. Thus when you have an ion, **it is because electrons were lost**

 **or electrons were gained.**

 As long as the **letter symbol is the same, then the number of protons is the same ... so just electrons**

 **changed in number.**

Fact2: The charge tells you which type of charged subatomic particle (proton or electron) is in EXCESS

 and by how many.

Fact3: When the charge is "+" there are more protons than electrons, BECAUSE electrons (or negative

 charges) have been lost. A positive ion is called a ca**t**ion (I think of the “**t**” as a positive or plus sign)

Fact4: When the charge is "-" there are more electrons than protons, BECAUSE electrons (or negative

 charge) have been GAINED. A negative ion is called an anion (*a* *n*egative *ion*)

Fact5: As a rule, the number of protons does not change ... only the number of electrons changes.

 So, compare an ***atom*** of Na0 with an ***ion*** of Na+1

 Each has the same number of protons (the **letter symbol is the same**!!!!)

 Na+1 however has one MORE proton. BUT since the number of protons did not change,

 the number of electrons must have changed. It must be that an electron was lost.

 Na0 has 11 protons and 11 electrons

 Na+1 has 11 protons but only 10 electrons (so there is one more proton than electron)

 Compare an atom of S0 with the ion S-2

 Each has the same number of protons (the letter symbol is the same: S vs. S) You may infer that they

 have the same number of protons or atomic number, when the letter symbol is the same)

 S-2 however has two MORE electrons ... since the number of protons did not change,

 thus, the number of electrons must have changed. It seems two electrons were gained

 S0 has 16 protons and 16 electrons

 S-2 anion has 16 protons and 2 extra electrons making 18 electrons

 Don't worry *yet*, from where the extra 2 electrons came. Just concern yourself

 with being able to interpret the meaning of the symbolism.

The key is to remember that **the charge tells you which subatomic particle is in EXCESS.** You need to remember that under normal chemical conditions, the proton number doesn’t change! Thus, **the charge must be due to lost or gained electrons.**

Compare F0 to F**-1** Check your periodic table. Note that fluorine *atom and ion* each has 9 protons.

 9 protons vs. 9 protons

 9 electrons vs. 10 electrons (The charge of -1, indicates there is one more electron: the negative "-" is a symbol

 for electron and the 1 is for the number of extra electrons)

Compare Cu0 to Cu**+2** Check your periodic table. You will note that copper has 29 protons

 29 protons vs. 29 protons

 29 electrons vs. 27 electrons (The charge tells you that there are two more protons than electrons and since the

 protons can't change in number, two electrons must have been lost... The "+"

 symbolizes protons and the 2 indicates the excess)

*So some students like to think of it this way.... When the ion is negative, you must add the number to the number of electrons. When the ion is positive, you must subtract the number from the number of electrons.*

Try This...

1) Consider the calcium cation, Ca+2 How many protons and electrons does the ion have?

 step 1: Look up Ca on Table S or the Periodic Table. Do you understand that the tables

 list only atoms? Thus Ca0 It has 20 p and 20 e-

 step 2: Look at the charge of the ion. Do you see that it is a +2? This means there are 2 more

 protons than electrons ... and since protons numbers don't change you can assume that

 2 of the 20 original electrons were lost.

 Thus Ca+2 has 20 protons and only 18 e- *(reference Goal 6)*

2) Consider the aluminum cation, Al**+3** How many protons and electrons doe the ion have?

 Step 1: How many protons does and atom of Al0 have? How many electrons then? (13 and 13)

 Step 2: Notice the charge is +3 which means that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ The ion has 3 fewer electrons

 than proton s compared to Al0

 So... Al+3 has 13 protons and 10 electrons

3) Consider the iodide anion, I**-1** How many protons and electrons does it have?

 Step 1: How many protons does and atom of I0 have? How many electrons then? (53 and 53)

 Step 2: Notice the charge is -1 which means that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ there is 1 more electron

 than protons….

 So... I-1 has 53 protons and 54 electrons

NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ PRACTICE PROBLEMS

Complete each practice problem. All answers are given at the end. Check your work.

 MEMORIZE THIS and USE THIS!

 # of nucleons Mass Number = #p + #n ⮱

X

 Atomic number = # p = nuclear charge  # e- ⮳

1) Example: Given the isotopic notation for an atom of Cr you can tell that there are:

 a mass # of 52 OR the # p + # n = 52 OR it has 52 nucleons

Cr

 24 + 28

 an atomic number of 24 OR 24 protons OR a nuclear charge of +24

 and since it has 24 protons and is an *atom*, it has 24 electrons

 **The key here is the term "atom". When we use that word in this class, then you may assume, #p=#e-**

 \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

2) According to the isotopic notation of an atom of Ge, the number of **nucleons** (not neutrons), equals \_\_\_\_\_\_\_\_

3) Given: the following atom: Na (The term, atom is used ...Why is that important?)

 a) \_\_\_\_\_ What is the mass number of this atom? How do you know? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 b) \_\_\_\_\_ What is the atomic number of this atom? How do you know? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4) Given the following atom: Zr (The term, atom is used ...why is that important?)

 a) \_\_\_\_\_ What is the mass number of this atom ?

 b) \_\_\_\_\_ What is the atomic number of this atom ?

 c) \_\_\_\_\_ How many **neutrons** (not nucleons) comprise this atom's nucleus? How do you know?

5) An atom has an atomic number of 13 and a mass number of 27.

 *(HINT: The term, atom is used, what can you infer? Think about using the information in the problem to first write out the*

 *isotopic notation, as was given in problems 1-4)*

 a) \_\_\_\_\_ How many protons comprise the nucleus of this atom ?

 b) \_\_\_\_\_ How many **nucleons**  (not neutrons) comprise the nucleus of this atom ?

 c) \_\_\_\_\_ How many neutrons comprise the nucleus of this atom ?

 d) \_\_\_\_\_ To what is the nuclear charge equal ? (include a + sign) How do you know? \_\_\_\_\_\_\_\_\_\_\_\_

 e) \_\_\_\_\_ How many electrons surround the nucleus of this atom ?

 f) \_\_\_\_\_ What is the overall charge of this atom (the charge of the atom)?

6) An atom has 76 electrons and a mass number of 190

 *(HINT: The term, atom is used, what can you infer? Think about using the information in the problem to first write out the*

 *isotopic notation, as was given in problems 1-4)*

 a) \_\_\_\_\_ How many protons comprise the nucleus of this atom?

 b) \_\_\_\_\_ How many nucleons (not neutrons) comprise the nucleus of this atom ?

 c) \_\_\_\_\_ How many neutrons comprise the nucleus of this atom ?

 d) \_\_\_\_\_ To what is the nuclear charge equal ?

 e) \_\_\_\_\_ What is the atomic number of this atom ?

 f) \_\_\_\_\_ What must be the overall charge of this atom? How do you know? \_\_\_\_\_\_\_\_

 g) \_\_\_\_\_\_\_\_ This is an atom of which element? Just give the letter symbol (use the periodic table)

 h) What is the relationship between the terms atomic number and number of protons in any atom? \_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***How are you doing with the practice? Do you need to send an email?***

7) An atom has a nuclear charge of +12 and 14 neutrons.

 a) \_\_\_\_\_ How many protons comprise the nucleus of this atom?

 b) \_\_\_\_\_ How many nucleons comprise the nucleus of this atom?

 c) \_\_\_\_\_ How many electrons surround the nucleus?

 d) \_\_\_\_\_ What is the mass number of this atom?

 e) \_\_\_\_\_ What is the atomic number of this atom?

 f) \_\_\_\_\_ What must be the overall charge of this atom (atomic charge)?

 g) \_\_\_\_\_\_\_\_\_\_\_\_\_ What is the isotopic notation of this element?

 h) \_\_\_\_\_ What is the nuclear charge of this atom?

8) An atom has a mass number of 30 and 16 neutrons in the nucleus.

 a) \_\_\_\_\_ How many protons comprise the nucleus of this atom?

 b) \_\_\_\_\_ How many nucleons comprise the nucleus of this atom?

 c) \_\_\_\_\_ How many electrons surround the nucleus?

 d) \_\_\_\_\_What is the nuclear charge of this atom?

 e) \_\_\_\_\_What is the atomic number of this atom?

 f) \_\_\_\_\_ What is the overall charge of this atom?

 g) \_\_\_\_\_\_\_\_\_ What is the isotopic notation of this atom?

9) The nucleus of an atom has a total of 58 nucleons and there are 28 electrons surrounding the nucleus.

 a) \_\_\_\_\_ How many protons comprise the nucleus of this atom?

 b) \_\_\_\_\_ How many neutrons comprise the nucleus of this atom?

 c) \_\_\_\_\_ What is the mass number of this atom?

 d) \_\_\_\_\_ What is the nuclear charge of this atom? How do you know ? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 e) \_\_\_\_\_ What is the atomic number of this atom ?

\_\_\_\_10. The unit of mass called an "atomic mass unit" is based upon a fraction of the mass of isotopes of

 which element?

 a) C-14 c) Na-11

 b) O-16 d) C-12

\_\_\_\_\_11. Study a copy of the periodic table thoroughly. Based upon this study, the elements are organized:

 (Hint: look carefully at the information for indium and tin ... and tellurium and iodine...)

 a) according to increasing mass c) according to increasing atomic number

 b) alphabetically d) by the dates of discovery

\_\_\_\_\_12. Which of the following is the least in mass?

 a) a proton b) an electron c) a neutron d) an atom of H-2

\_\_\_\_\_13. Which of these subatomic particles is described as having a charge of +1 ?

 a) proton b) neutron c) electron

\_\_\_\_\_14. Which subatomic particle is described as the fundamental unit of negative charge?

 a) proton b) neutron c) electron

15. The following is an answer from a student on a test. The underlined part has something wrong. She would

 get 0 of 1 point. What should it read?

 "If an atom had 30 protons and 35 neutrons it would have a mass number of 35."

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

16. The following is an answer from a student on a test. The underlined part has something wrong.

 He would get 0 out of 1 point. What should it read, when corrected?

 "Given 20 protons and 20 electrons, it is clear that the ion must have an overall charge of 0."

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

17. The following is an answer from a student on a test. The underlined part has something wrong. She would

 get 0 out of 1 point. What should be written?

 "An atom has a mass number of 31 and a proton number of 16. The number of electrons must be 31."

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

18) Why are electrons not included in the mass number of an isotope, in our course? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

19) Define the term: isotopes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

20) Which choice is an example of the isotopes of the same element?

 a)$ $ and $$ c) $$ and $$

 b) $ $ and $$ d) $$ and $$

21) Use a periodic table to help you with this:

 Given the **ion**: F-1 (note this is an ion...not an atom...Why is that important?)

 How many protons are in the nucleus? \_\_\_\_

 How many electrons surround the nucleus? \_\_\_\_\_\_

22)  is an isotope of the element sodium, while 1+ is a second isotope of sodium, but also a cation.

 Compare and contrast the two species in terms of: atomic number, overall charge, number of electrons,

 and number of neutrons.

|  |  |  |
| --- | --- | --- |
|  | an atom of Na-23 | a +1 cation of Na-22 |
| atomic number |  |  |
| overall charge |  |  |
| number of electrons |  |  |
| number of neutrons |  |  |

Answers to Questions 1-22 **If you were to have problems, consider checking out one of the websites listed on the front of this packet, or writing me. When you think there is an error … definitely contact me! I would thoroughly appreciate it.**

1. 24 and 52. The atomic number is in the lower left corner and the mass number is in the upper left

2. 73 The term "nucleons" may be considered to be a synonym for mass number

3. a) 23 b) 11 4. a) 91 b) 40 c) 51

5. a) 13 b) 27 c) 14 d) +13 e) 13 f) 0

6. a) 76 b) 190 c) 114 d) +76 e) 76 f) 0 g) Os (osmium) h) They are synonyms

7. a) 12 b) 26 c) 12 d) 26 e) 12 f) 0 g) Mg h) +12

8. a) 14 b) 30 c) 14 d) +14 e) 14 f) 0 g) Si

9. a) 28 b) 30 c) 58 d) +28 e) 28

10. d This fact is in your reading as well as noted on your periodic table (Top-center "key" using Carbon)

11. c The PT is organized by ascending atomic number (number of protons). While it may SEEM to be organized by what is

 called the relative atomic mass … it is not … there are some glaring exceptions … check out elements 52Te and 53I

12. b 13. a 14. c

15) The mass number is the sum of the number of protons and neutrons. Therefore, the mass number should be 65 (no unit!)

16) 20 protons and 20 electrons make a neutral ATOM, not ion. IONS are charged. The term ion should not have been used.

17) The number of electrons of an atom equals the number of protons, **not** the mass number.

18) Electrons have so little mass, that no atom has a sufficient number of electrons to alter the mass. They are, for our course,

 effectively 0 atomic mass units.

19) Isotopes are atoms with the same atomic number (of the same element), but with a different number of neutrons (or different

 mass number due to a difference in the number of neutrons)

20) d same symbol, same atomic number, different mass number (due to a different number of protons)

21) 9 protons, 10 electrons (the -1 indicates one more electron than in the atom)

22) The two species have the same number of protons (atomic number of 11), different charges, in that Na-23 is written in such a

 way as to indicate an overall 0 charge (#p = #e-), and the second isotope Na-22 has a positive charge of +1 indicating 11 protons

 but only 10e-. Thus their charges are different, due to the cation having 1 fewer electron (or the atom, having 1 more electron).

 The number of neutrons are different (11 vs. 12), proven by employing #p + #n = mass number.

PRE-QUIZ 1: BASIC ATOMIC STRUCTURE

*Since this is a pre-quiz you may, of course, use your notes. Do try however, to "wean " yourself away from them. Learn the material.*

DIRECTIONS: For questions in this section, one or more of the responses given are correct. Using your notes and understanding of the periodic table, decide which of the responses is (are) correct. Then choose:

 1) when only choice I is correct

 2) when only choice II is correct

 3) when only choices I and II are both correct

 4) when only choices II and III are both correct

 5) when I, II, and III are each correct

\_\_\_\_\_1) Which of the following applies to an atom of Mg-25? (hint .. look up Mg on the periodic table to find the

 atomic number. Then re-write the symbol as in # 2 below

 and answer the question)

 I) 24 protons II) 13 neutrons III) 12 electrons

\_\_\_\_\_2) Which of the following is true for these two different atoms of phosphorus? P and P

 I) The have different mass numbers

 II) They have the same number of protons

 III) They have a different number of neutrons

\_\_\_\_\_3) The symbol: X most probably represents an isotope of the element(s)

 I) gold II) silver III) tin

\_\_\_\_\_4) It requires approximately 1,836 \_\_\_\_\_\_\_\_\_\_\_ to equal the mass of 1 proton.

 I) neutrons II) electrons III) nucleons

\_\_\_\_\_5) The term "nucleons" refers to

 I) electrons II) protons III) neutrons

\_\_\_\_\_6) Ultimately, the nuclear charge of an atom is

 I) the number of neutrons

 II) the atomic number

 III) equivalent in magnitude to the charge of the electron cloud

\_\_\_\_\_7) Which of the following applies to an atom of Al-28?

 I) 13 protons II) 28 neutrons III) 15 electrons

\_\_\_\_\_8) Assume each following symbol represents an atom. Which has (have) a zero number of neutrons?

 I)  II)  III) 

DIRECTIONS : For questions 9 – 12 use the following choices :

 ASSERTION REASON

1) True True statement and correctly explains (or predicts) the assertion

2) True True statement but does NOT correctly explain the assertion

3) True False

4) False True

5) False False

For example:

 Assertion Reason

 Mr. D. is a science teacher. because Mr. D. is wearing glasses.

 *ANSWER: Both statements are true. However, the wearing of glasses has NOTHING TO DO*

 *with Mr. D being a science teacher.* *Therefore, the BEST answer is “b”.*

|  |  |  |  |
| --- | --- | --- | --- |
|  | ASSERTION |  | REASON |
| 9.\_\_\_\_ | Based on the Periodic Table, you know that each atom of potassium (K) has 19 protons in its nucleus | Because | According to the periodic table, potassium is atomic number 19 and the atomic number is a synonym for the number of protons. |
| 10.\_\_\_ | The mass of an atom is generally attributed to the number of protons and neutrons. | Because | The magnitude of an electron's negative charge is equal to the magnitude of a proton's positive charge. |
| 11.\_\_\_ | Atoms are the smallest unit of matter | Because | Atoms are made of subatomic particles |
| 12.\_\_\_ | The nuclear charge of an atom must be equal in magnitude, but opposite in charge to the total charge due to the atom's electrons | Because | By definition, an atom must be neutral. The number of positive charges must equal the number of negative charges |

 \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

13 Correct this statement so that the underlined portion is correct.

 An atom with 12 protons, 14 neutrons, and 12 electrons has a mass number of 38.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14) How many protons and how many electrons does one ion of Fe+3 have? (Are you using your periodic table?)

15) How many electrons are in an ion of Cl-1 ?

Answers to Pre-Quiz 1:  **If you were to have problems, consider checking out one of the websites listed at the start of this packet, or writing me. When you think there is an error … definitely contact me! I would thoroughly appreciate it.**

1. 4 2. 5 3. 2 4. 2 5. 4 6. 4 7. 1 8) 1

9. 1 The reason is an excellent explanation as why you, as a student, may assert that K has 19 protons in each atom.

10. 2 Both statements are pretty accurate ...but the reason does not explain, predict or account for the truth value of the

 assertion

11. 4 Please !! Atom's are not the smallest matter and they're mostly empty space . An atom can’t be the smallest unit

 of matter if it is made of smaller pieces of matter … An atom IS the smallest unit of an element that can react

 chemically ... but not the smallest unit of matter.

12. 1 In order to be called an atom, the assertion must be true. The Reason clearly recognizes this.

13 An atom with 12 protons, 14 neutrons and 12 electrons has a mass number of 26.

 The mass number is just #p + #n …. or the sum of the nucleons of an atom. Electrons are not included, due to their

 relatively small mass. Recall it requires approximately 1,836 e- to equal the mass of 1 proton. No atom of any known

 element has so many electrons.

15) 26 protons and 23 electrons

16) 18 electrons. I like to start by analyzing the atom and then the ion. So, according to the periodic table, Cl0 has 17 protons and

 thus it has 17 electrons. The anion’s symbol of Cl-1 indicates that there is one more electron than proton. Since the proton

 number does not change under normal chemical circumstances, and the symbol is still Cl … then the proton number is still 17.

 Thus the number of electrons must have increased to 18, in order to give a charge of -1

PRE-QUIZ 2: BASIC ATOMIC STRUCTURE

DIRECTIONS: For questions in this section, one or more of the responses given are correct. Using your knowledge of chemistry and understanding of the periodic table, decide which of the responses is (are) correct. Then choose:

 1) when only choice I is correct

 2) when only choice II is correct

 3) when only choices I and II are both correct

 4) when only choices II and III are both correct

 5) when I, II, and III are each correct

\_\_\_\_\_1) Which of the following applies to an atom of C-14? (hint...use your Periodic Table & re-write using the more classic

 isotopic notation format … then answer the question)

 I) 14 nucleons II) 8 neutrons III) 6 protons

\_\_\_\_\_2) Which of the following is true the atoms: O-18 and F-19 ?

 I) They have a different atomic number

 II) They have the same number of neutrons

 III) They have the same mass numbers

\_\_\_\_\_3) The symbol :  could represent an atom of

 I) iron II) zinc III) barium

\_\_\_\_\_4) It requires approximately 1 proton to equal the mass of \_\_\_\_\_\_\_\_\_\_\_

 I) 1 neutron II) 1,836 electrons III) 1 atom of tritium

\_\_\_\_\_5) The term, *atomic number*, refers to

 I) protons II) all nucleons III) neutrons

\_\_\_\_\_6) Regarding the overall charge of any atom,

 I) the number of protons must equal the number of neutrons

 II) the number of electrons must equal the number of protons

 III) it must be equal to zero

\_\_\_\_7) Which of the following is accurate for an atom with an isotopic notation of $$

 I) There are 86 protons

 II) There are 222 nucleons

 III) There are 136 neutrons

DIRECTIONS : For questions 8- 11 use the following choices :

 ASSERTION REASON

1) True True statement and correctly explains (or predicts) the assertion

2) True True statement but does NOT correctly explain the assertion

3) True False

4) False True

5) False False

For example:

 Assertion Reason

 Mr. D. is a science teacher . because Mr. D. is wearing glasses.

 *ANSWER: Both statements are true. However, the wearing of glasses has NOTHING TO DO*

 *with Mr. D being a science teacher.* *Therefore, the BEST answer is “2”.*

 ASSERTION REASON

\_\_\_\_\_8. The magnitude of 1 electron's charge because A proton is much larger than an electron.

 is equal to the magnitude of a It takes almost 1,836 electrons to equal

 single proton's charge the mass of 1 proton.

\_\_\_\_\_9. Na-23 has the same number of because Atoms of Na-23 and Mg-24 have the

 neutrons as an atom of Mg-24 same number of electrons

\_\_\_\_\_10 The number of neutrons must be because A neutron has no overall charge and is

 equal to the number of protons in therefore considered to be a neutral

 every nucleus subatomic particle

\_\_\_\_\_11 By definition, an atom must be because The nuclear charge of any atom is equal

 neutral in overall charge in magnitude but opposite in charge to the

 total charge due to the atom's electrons

 of the electron cloud

12) Define: Nuclear Charge: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13) Define: Atom: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_14) What is the one value every ion as well as every atom of a specific element must have in common?

 a) number of electrons c) number of neutrons

 b) charge d) number of protons

\_\_\_\_\_15) How many neutrons are in an atom of Zn-65?

17) In what way to isotopes of an element compare / contrast to each other? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Answers to Pre-Quiz 2: **If you were to have problems, consider checking out one of the websites listed at the front of this packet, or writing me. When you think there is an error … definitely contact me! I would thoroughly appreciate it.**

1. 5 2. 3 3. 1 4. 3 5. 1 6. 4 7. 5

8. 2 The facts regarding the sizes of these subatomic particles has no direct application to the reason why their charges are equal in

 magnitude. Both statements are true... but not really related.

9. 3 The assertion is true. If you use Mass # = # p + # n, you can prove that each nucleus has 12 neutrons. However, they do NOT

 have the same number of electrons (they are atoms of different elements or the number of electrons for an atom is equal to the

 number of protons. These are atoms of different elements & have different numbers of protons, thus different numbers of e-.

10 4 The assertion is just false. The number of neutrons and protons MAY NOT equal each other.. (The two values may be equal

 but they do not have to be equal) But, a neutron is neutral and therefore 0 in charge.

11 1

12 the number of protons of a nucleus OR the total charge of an atom's nucleus, which is equal to the atomic number

13 The smallest neutral (in charge) species of an element that can take part in a chemical reaction. 14 d 15 35

17) All isotopes of a specific element have the same atomic number, but they differ in the number of neutrons and thus mass

 number.

PRE-QUIZ 3: BASIC ATOMIC STRUCTURE

\_\_\_1) The atomic number of an atom is always equal to the number of its

(1) protons, only (2) neutrons, only (3) protons plus neutrons (4) protons plus electrons

2) Consider: *“When an atom loses electrons, it becomes a positive ion. When an atom gains electrons, it*

 *becomes a negative ion.”*

 1) Using an atom of N-16 how many protons make up the nucleus of the atom? \_\_\_\_\_\_\_\_

 2) How many electrons must be in the same atom of N-16? \_\_\_\_\_\_

 3) When the atom gains 3 more electrons from some other source, what is the probable charge on the ion? \_\_\_\_

 4) If the atom of N-16 were to lose two electrons, what is the probable charge of the ion? \_\_\_\_\_\_

Elements in the Periodic Table are arranged according to their

(1) atomic number (3) relative chemical activity

(2) atomic mass (4) relative size

\_\_\_3)

When a lithium atom (Li), forms a lithium ion (Li+1), the atom

(1) gains a proton (3) loses a proton

(2) gains an electron (4) loses an electron

\_\_\_4)

Which two notations represent atoms that are isotopes of the same element?

\_\_\_5)

Which statement best describes the **nucleus** of an aluminum atom? The nucleus has a charge of:

(1) +13 and is surrounded by a total of 10 electrons

(2) +13 and is surrounded by a total of 13 electrons

(3) -13 and is surrounded by a total of 10 electrons

(4) -13 and is surrounded by a total of 13 electrons

\_\_\_6)

\_\_\_7)

Which two subatomic particles each have a mass approximately equal to 1 atomic mass unit (1μ)?

(1) electron and neutron

(2) electron and meson

(3) proton and electron

(4) proton and neutron

\_\_\_8) What is the total number of neutrons in an atom of: 

 (1) 26 (2) 31 (3) 57 (4) 83

\_\_\_9) An oxide ion (O2-) formed from an oxygen-18 atom, contains exactly:

 1) 8 protons, 8 neutrons, 10 electrons

 2) 8 protons, 10 neutrons, 8 electrons

 3) 8 protons, 10 neutrons, 10 electrons

 4) 10 protons, 8 neutrons, 8 electrons

10) Using the following table, compare the subatomic particles of the isotopes O-16 and O-18

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species | massnumber | atomicnumber | numberof neutrons | numberof electrons |
| O-16 |  |  |  |  |
| O-18 |  |  |  |  |

11) The chemical reactions of an atom depend on the number of electrons. Make a prediction about the

 reactions atoms of oxygen-16 and oxygen -18 undergo.

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

12) Account for the slightly different mass, in grams, between a proton and a neutron. \_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13) What is the difference between an atom (such as Na0) and its ion (such as Na+1)? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14) An atom has 9 protons, 10 neutrons and 9 electrons. The atom gains one more electron. What is the

 charge of the resulting ion? \_\_\_\_\_\_\_\_\_\_

15) An atom has 12 protons, 11 neutrons and 12 electrons. The atom loses two of its electrons. What is the

 charge of the resulting ion? \_\_\_\_\_\_\_\_\_

16) Using the following table, compare the subatomic particles of the atom 56Fe0 to its ion, 55Fe+3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species | massnumber | atomicnumber | numberof neutrons | numberof electrons |
| 56Fe0 |  |  |  |  |
| 55Fe+3 |  |  |  |  |

17) List one major conclusion of the Rutherford Gold Foil experiment. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Answers to Pre Quiz 3: **If you were to have problems, consider checking out one of the websites listed at the front of this packet, or writing me. When you think there is an error … definitely contact me! I would thoroughly appreciate it.**

1) 1 definition

2) 1) 7 you need to use the periodic table

 2) 7 they must be equal in an **atom**

 3) -3 there would be three more electrons than protons or: 10 e- vs. 7 p for a difference of -3

 4) +2 there would be two more p than e- or: 5 e- vs. 7 p for a difference of +2

3) 1 4) 4 When an atom loses e- (loses negative charge), the resulting ion is positive.

5) 1 same element (same atomic number or # of protons) but a different mass number (therefore a different

 number of neutrons)

6) 2 7) 4 8) 2 mass # = #p + #n

9) 3 choice 1 is a close answer … but the mass is 18 for the atom in question, not 16.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species | massnumber | atomicnumber | numberof neutrons | numberof electrons |
| O-16 | 16 | 8 | 8 | 8 |
| O-18 | 18 | 8 | 10 | 8 |

10)

11) Since the number of electrons is equal, it is reasonable to assume that the isotopes undergo the same chemical reactions.

12) A neutron is slightly heavier due, to the fact that it is made, in part from a proton and an electron.

13) I like to check out the atom, first …it has an equal number of protons and neutrons. The ion has lost 1 electron, hence the atom

 has 11 protons & 11 electrons, and the ion has 11 protons and only 10 electrons; There is one more electron in the atom (one

 fewer electron in the ion)

14) -1 15) +2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species | massnumber | atomicnumber | numberof neutrons | numberof electrons |
| 56Fe0 | 56 | 26 | 30 | 26 |
| 55Fe+3 | 55 | 26 | 29 | 23 |

16)

17) The atom is mostly empty space ...or... The mass of an atom is found primarily making up the nucleus ....or.... The positive

 charge of the atom is concentrated in the nucleus while the negative charge is in the electron cloud outside of the nucleus