Isotopes Class name: ________________________________

Today we will work in groups of 4, reading, thinking, working together. By the end of class (or for HW) you will produce a few paragraphs and do the 3 problems that follow. In class today we will discuss in groups, and with your teacher, everything you need to learn about concerning isotopes. Please read this text silently, marking it where you may have questions, and then you may begin to discuss this with your team. Each of you are required to produce your own report on isotopes as a classwork assignment. It is due by TOMORROW at the latest.

ISOTOPES

In 1803 when John Dalton created modern chemistry by outlining his Atomic Theory, one of his points was that ALL ATOMS OF AN ELEMENT ARE IDENTICAL. He was only partly true on this point. In the early 1800's, the knowledge of chemistry, and his measuring ability limited his ability to even imagine isotopes. It turns out that *every atom of an element is chemically identical*, that is, it bonds exactly the same way as all the other atoms of the same name. It creates all the same compounds, and forms the same properties in compounds. But, there is a fact that he could not know, that you are about to learn.

Let's examine the atom cobalt. Look at your white periodic table now, find cobalt. Cobalt's atomic mass is averaged to 59 amu. It has a total of 59 protons plus neutrons. It has an atomic number of 27, which means cobalt has 27 protons, (and 27 electrons). From this data, we can determine that with mass of 59 ($p^+ + n°$) – 27 p^+ = 32 n°.

Today we will see why the atomic mass of cobalt is actually 58.9332 (not really 59). We'll also find out that there is a cobalt atom with a mass of 60 as well. That isotope of cobalt, cobalt-60, is radioactive.

All atoms of an element are chemically identical. Some atoms have different numbers of neutrons in their nucleus. These are isotopes of an element. All isotopes have a whole number mass in amu. When we round the atomic mass on the periodic table to the nearest whole number: that is the mass of the most common isotope of that element. Other isotopes, or other atoms of these elements exist with a few more or less neutrons. Neutrons do not play much part of our chemistry or bonding, but they do change the overall mass of the atoms.

Isotopes are chemically identical atoms with different numbers of neutrons (different masses) than others of the same name. Cobalt has 5 isotopes with these masses: 56, 57, 58, 59 and 60. Some of these isotopes are stable but cobalt 59 is radioactive, or unstable. Each isotope of cobalt has a whole number of protons (all have 27) and a whole number of neutrons as well. They each have a whole number mass in amu.

The proportions of each isotope are not "even", rather they exist in the proportions that they just exist in. Scientists measure these proportions that are naturally occurring, and use their masses and proportions to calculate the weighted average atomic mass, which works out with many decimal places rather than a whole number. Every few years, after measuring all over the world, the IUPAC, or International Union of Physical and Applied Scientists may reformulate the weighted average atomic mass for an element, and all the periodic tables in the world will need updating. New isotopes can be found, or different proportions of the known isotopes may be discovered.

There are about 114 known types of elements, but there are well over 1000 kinds of isotopes. All atoms have multiple isotopes, chemically identical atoms with differing numbers of neutrons. Sometimes the balance of protons to neutrons is stable, sometimes it is funky. If it's out of the normal synch these isotopes are unstable, which means that these are radioactive. Radioactive isotopes emit parts of their nucleus to get a more stable ratio of protons to neutrons. Radioactive isotopes will emit radiation, which is energy and/or particles, in an attempt to get more stable.

There are 3 common isotopes of neon. Each is detailed here:		
Neon-20 (mass = 20) $10p^+$ $10e^-$ 10n°	Neon-21(mass = 21) $10p^+$ $10e^-$ 11n°	Neon-22 (mass = 22) $10p^+$ $10e^-$ 12n°
The difference between each of these is just how many neutrons are in each nucleus. Each atom is chemically identical, but has a different mass.		

Let's look at the three isotopes of hydrogen. Do you see how is the average atomic mass calculated?

Isotope	Atom makeup	Mass of isotope	Naturally occurring proportions	Convert proportion to decimals	Mass X decimal =
H-1	1 p^+, 1 e^- zero n°	1 amu	99.984%	0.99984	0.99984
H-2	1 p^+, 1 e^- 1 n°	2 amu	0.0015%	0.000015	0.00030
H-3	1 p^+, 1 e^- 2 n°	3 amu	0.001%	0.00001	0.00003
The weighted average atomic mass, the mass of the atom on the periodic table, is the average sum of the masses of the naturally occurring isotopes:					1.00017 amu

Doing this math is called calculating the weighted average atomic mass. You must multiply the fraction (or decimal) part of the whole each isotope makes up, but its atomic mass, then sum them to get a total.

Let's look at an imaginary problem (slowly). A new isotope of a new metal named Arbuiso is found in the following proportions. Calculate it's weighted average atomic mass. (how to do this is below)

Isotope	Atom makeup	Mass of isotope	Naturally occurring proportions	Convert proportion to decimals	Mass X decimal =
A-72	36 p^+, 36 e^- 36 n°	72 amu	83.15%	0.8315	59.868
A-73	36 p^+, 36 e^- 37 n°	73 amu	6.05%	0.0605	4.4165
A-75	36 p^+, 36 e^- 39 n°	75 amu	10.80	0.1080	8.1
The weighted average atomic mass, the mass of the atom on the periodic table, is the average sum of the masses of the naturally occurring isotopes: These numbers also indicate that the most common isotope is 72 amu, since the average weighted atomic mass rounds to the nearest whole number of 72 amu.					72.3845

Your job today (and tonight) is to write up 200-300 words that answer all of these questions and discusses all of these points. You are also to do the 3 problems that follow. Paper is cheap, spelling is important, as is grammar. GO!

Your essay should be titled Isotopes in Chemistry. Define isotopes, give an example or two of isotopes, explain what "naturally occurring" means. Are there man made isotopes? How is it determined what proportions are found in nature? Who decides? What is the difference between a stable and an unstable isotopes? What's another name for unstable isotopes? Two important isotopes that are unstable are Co-60, and C-14. What do scientists use these for? What unstable isotope did Rutherford use in the Gold Foil Experiment? Why are the atomic masses on the Periodic Table most often with decimals masses while the atoms themselves have whole number masses? What are the masses (in HS Chem) of the 3 subatomic particles? What is the atom that is used as the standard mass atom?

Problems:

1. The atomic masses and the natural abundances of the two most common naturally occurring isotopes of lithium are shown at right.
   Calculate the average weighted atomic mass for Li

Isotope	Atomic Mass (amu)	Natural abundance
Li-6	6	7.5%
Li-7	7	92.5%

2a. The weighted average atomic mass of chromium is 51.996. What is the most common isotope of chromium? How many protons, neutrons and electrons in an atom of this most common isotope?

2b. The weighted average atomic mass of mercury is 200.59. What is the most common isotope of mercury? How many protons, neutrons and electrons in an atom of this most common isotope?

3a. The measured data for the isotopes of krypton is below. Calculate the weighted average atomic mass for Kr.

3b. What is your percent error compared to the actual value with decimals, from the periodic table?

Isotope	Naturally occurring proportions	Convert to decimal	Atomic mass
Kr-80	2.6%		
Kr-82	11.6%		
Kr-83	11.5%		
Kr-84	57.0%		
Kr-86	17.3%		
(calculated) weighted average atomic mass =			

Problems:

1. The atomic masses and the natural abundances of the two most common naturally occurring isotopes of lithium are shown. Calculate the average weighted atomic mass for Li

   (6 amu)(0.075) = 0.45 amu = (7 amu)(0.925)= 6.475 amu EQUALS: 6.925 amu
   This does not equal the total of 6.941 amu which is on the periodic table, which may be due to percent error in the measurements, or more likely, the rounding of percentages due to omission of some smaller percentage isotopes that are naturally occurring.

2a. The weighted average atomic mass of chromium is 51.996. What is the most common isotope of chromium? How many protons, neutrons and electrons in an atom of this most common isotope?
The most common isotope would be Cr-52. Chromium has 24 p^+, 24 e^-, and 52-24 = 28n^o.

2b. The weighted average atomic mass of mercury is 200.59. What is the most common isotope of mercury? How many protons, neutrons and electrons in an atom of this most common isotope?
The most common isotope would be Hg-201. Mercury has 80 p^+, 80 e^-, and 201-80 = 121 n^o.

3a. The <u>measured</u> data for the isotopes of nickel is below. Calculate the weighted average atomic mass for nickel.

Isotope	Naturally occurring proportions	Convert to decimal	Atomic mass
Kr-80	2.6%	0.026	2.08
Kr-82	11.6%	0.116	9.512
Kr-83	11.5%	0.115	9.545
Kr-84	57.0%	0.570	47.88
Kr-86	17.3%	0.173	14.878
(calculated) weighted average atomic mass =			83.895 amu

3b. What is your percent error compared to the <u>actual value</u> on the periodic table?

$$\%E = \frac{MV - AV}{AV} \text{ X } 100\% = \frac{83.895 \text{ amu} - 83.798 \text{ amu}}{83.798 \text{ amu}} \text{ X } 100\% =$$

$$= 0.11575\% \text{ with 5 SF}$$