CP Chemistry Worksheet – Basic Atomic Structure **ANSWER KEY**

NEATLY provide complete, detailed, yet concise responses to the following questions and problems. For all problems show equations (variable form), account for all units, labels, significant figures, and work. Use dimensional analysis format whenever possible.

1) Describe the proton, neutron, and electron in terms of mass in grams, mass in a.m.u.'s, standardized charge, and location within the atomic structure.

Particle	**Location**	**Standardized Charge**	**Relative mass in a.m.u.'s**	**Mass in grams**
Electron	Electron cloud/outside the nucleus	-1	0	9.11×10^{-28}
Proton	Nucleus	+1	1	1.673×10^{-24}
Neutron	Nucleus	0	1	1.675×10^{-24}

2) The following descriptions represent the subatomic composition of various particles. Determine the net charge on each particle.

a. 1 proton, 1 neutron, and 1 electron **0**
b. 9 protons, 10 neutrons, and 10 electrons **1-**
c. 23 protons, 28 neutrons, and 18 electrons **5+**

3) Contrast the continuous theory of matter and the discontinuous theory of matter.

a. Who proposed the discontinuous theory of matter?
b. What Greek term was associated with this discontinuous theory?

The continuous theory of matter stated matter was continuous; it could be divided forever without reaching a single smallest unit. The discontinuous theory of matter stated that matter could be divided, but eventually reach a smallest indivisible unit.

a. The discontinuous theory of matter was proposed by Democritus.
b. The term associated with the discontinuous theory was "atomos," meaning indivisible.

4) How does the mass of material at the completion of a chemical reaction compare with the mass of material before the reaction?

a. Who first identified this relationship?
b. What law explains this relationship?

The mass of matter at the end of a chemical reaction or chemical change is equal to the mass of matter prior to the chemical reaction or chemical change.

a. This was identified by Antoine Lavoisier in his Law of Conservation of Mass.
b. The Law of Conservation of Mass/Matter. This was eventually further explained by Dalton's Atomic Theory.

5) Ammonia is a compound of nitrogen and hydrogen.

a. Will samples of ammonia taken from different sources always contain the same percentage, by mass, of nitrogen?

b. What law explains this idea?

a. The mass percentage of nitrogen in the compound ammonia, NH_3, will always be the same regardless of the ammonia's source.

b. The Law of Definite Proportions or the Law of Constant Composition as set forth by Joseph Proust.

6) Every sample of sand consists of silicon atoms and oxygen atoms. A sand sample from a Florida beach was analyzed to be 46.8 % silicon by mass. A sample of sand from the Sahara Desert was reported to contain 0.878 g of silicon for every 1.00 g of oxygen. Show that the reported results are consistent with the law of definite proportions.

Assuming sand is composed of the same compound, the law of definite proportions would state that the composition of that compound is always the same based upon the masses of the combining elements. Therefore, the mass percentage composition of the compound would always be the same.

$$\% \text{ Si} = \frac{M_{Si}}{M_{comp'd}} \times 100 = \frac{M_{Si}}{M_{Si} + M_O} \times 100$$

$$= \frac{0.878 \text{ g Si}}{0.878 \text{ g Si} + 1.00 \text{ g O}} \times 100 = 46.8 \% \text{ Si}$$

Even though the sand is coming from two sources, the percentage of silicon is the same for each as would be expected according to the law of constant composition (or definite proportions).

7) Explain why the law of multiple proportions does not contradict the law of definite proportions.

The law of multiple proportions pertains to the ability to form multiple DIFFERENT compounds by the same two elements. The law of definite proportions pertains to an INDIVIDUAL compound stating the composition of the compound's elements is fixed.

8) The elements carbon and oxygen combine to form two different compounds. If 12.0 g of carbon combines with 16.0 g of oxygen, carbon monoxide is produced. If 12.0 g of carbon combines with 32.0 g of oxygen, carbon dioxide is produced. For these two compounds, what is the small whole number ratio described by the law of multiple proportions? (Support mathematically).

Determine the mass of oxygen per unit mass of carbon. $\frac{M_O}{M_C}$

$$\frac{16.0\text{ g O}}{12.0\text{ g C}} = \frac{1.33\text{ O}}{1.00\text{ C}} \div \frac{1.33\text{ O}}{1.00\text{ C}} = 1.00$$

$$\frac{32.0\text{ g O}}{12.0\text{ g C}} = \frac{2.67\text{ O}}{1.00\text{ C}} \div \frac{1.33\text{ O}}{1.00\text{ C}} = 2.00$$

9) How did John Dalton's atomic theory account for the law of conservation of mass?

Atoms are not created, destroyed or converted into other kinds of atoms during chemical reactions or chemical changes. They are simply rearranged resulting in the formation of new compounds.

10) From your twenty-first century vantage point, criticize these statements from Dalton's atomic theory.

a. All atoms are indivisible.
b. All atoms of the same element have the same mass.

a. Atoms are capable of being divided. The discovery of three major subatomic particles; protons, neutrons, and electrons, demonstrates their divisibility.
b. While atoms of the same element are chemically identical, this does not extend to all properties. Elements have isotopes, nuclides with the same atomic number, but different numbers of neutrons and hence different masses.

11) What subatomic particle was the first to be discovered? When was it identified?

The electron was the first subatomic particle to be discovered. Thomson is credited with its discovery in 1897.

12) Compare the contributions of William Crookes with those of J.J. Thomson. Which scientist is credited with the discovery of the electron? (Research as needed).

William Crookes made discoveries and advancements in atomic theory by developing the Crookes Tube. It was with this vacuum tube that he observed a discharge between the electrodes and determined they were affected by a magnetic field.

Thomson, utilizing a Crookes' tube, was able to identify the electron and its negative charge through the use of an electrical field. In addition, Thomson was able to determine the charge to mass ration of the electron. He performed his experiments using a variety of metals for electrodes and various gases (at VERY low pressures) in the CRT.

12) What facts about the electron were determined in 1911 through the experiments of Robert Millikan?

Millikan was able to determine the quantity of electrical charge on an electron after performing his oil drop experiment. The value he obtained was 1.60×10^{-19} C. C is a coulomb. One coulomb equals 6.24×10^{18} elementary charges.

13) Millikan calculated the mass of the electron to be 9.11×10^{-28} g. Determine

a. mathematically the mass of the proton, in grams
b. the charge/mass ratio for the proton, assuming the quantity of charge on the proton is the same as the quantity of charge on the electron
c. the number of electrons in 1.00 gram of electron
d. the number of protons in 1.00 gram of proton

a. $9.11 \times 10^{-28}\ g \times \frac{1{,}837\ p^+}{1\ e^-} = 1.673 \times 10^{-24}\ g$

b. $\frac{\text{charge } p^+}{\text{mass } p^+} = \frac{1.60 \times 10^{-19}\ C}{1.673 \times 10^{-24}\ g} = 9.56 \times 10^{4}\ C/g$

c. $1.00\ g\ e^- \times \frac{1\ \text{electron}}{9.11 \times 10^{-28}\ g} = 1.10 \times 10^{+27}\ \text{electrons}$

d. $1.00\ g\ p^+ \times \frac{1\ \text{proton}}{1.673 \times 10^{-24}\ g} = 5.98 \times 10^{+23}\ \text{protons}$

14) Briefly describe Ernest Rutherford's experiment that provided evidence for the existence of a nucleus.

Rutherford and his colleagues placed a VERY thin piece of gold foil inside a fluor coated shroud. Into this foil, alpha particles were "shot." The points of alpha particle impact on the shroud were observed.

The results:

The vast majority of alpha particles passed through the foil without any deflection from their path

Some of the alpha particles passed through the foil with a minor deflection to their path

A scant few (1 in 8,000) alpha particles were deflected at large angles, in essence bounced backwards

15) Which component of atomic structure was inadequately explained by the Rutherford model?

Rutherford's nuclear model of the atom failed to adequately account for the electrons. Why weren't they pulled into the positively charged nucleus? After all, opposites attract. And, assuming they emitted energy, they would eventually slow down and be captured.