Name:_____ **Score:**_____**/100**

Part I. Multiple choice. Write the letter of the correct answer for each problem. 3 points each

1. Which of the following is a member of the group of elements called the *halogens*?
   A) potassium
   B) calcium
   C) bromine
   D) argon
   Answer __C___

2. When beryllium forms an ion, what charge will the ion have?
   A) +1
   B) -1
   C) +2
   D) -2
   Answer __C___

3. The electron configuration for manganese is:
   A) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
   B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$
   C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$
   D) $1s^2 2s^2 2p^6 3s^2$
   Answer __B___

4. Below are four statements about protons, only one is true. Identify the true statement.
   A) Protons have about the same mass as electrons.
   B) Protons have about the same mass as neutrons.
   C) Some atoms don't have any protons.
   D) Protons have the same magnitude of charge as neutrons, but opposite sign
   Answer __B___

5. Which of these bonds to you expect to be the most polar?
   A) F-F
   B) O-F
   C) N-F
   D) C-F
   Answer __D___

6. Which of the following is a **physical** change?
   A) Water is decomposed by electricity into hydrogen and oxygen.
   B) A red substance is decomposed by heat to mercury and oxygen.
   C) Ice melts at 0°C.
   D) Carbon combines with oxygen to form carbon dioxide.
   Answer __C___

7. The observation that 20 g of hydrogen gas always combines with 160 g of oxygen gas to form 180 g of water, even when there is more than 160 g of oxygen present in the reaction container, illustrates the law of
   A) excess reactants.
   B) definite proportions.
   C) ideal gases.
   D) multiple proportions.
   Answer __B___

8. The **maximum** number of electrons that may reside in the n=3 energy level is
   A) 8. B) 18. C) 2. D) 3.
   Answer __B___

9. If a central atom has a total of three groups and no lone pairs attached to it, the electron pair geometry about the central atom is
   A) linear.
   B) tetrahedral.
   C) triangular (aka trigonal planar).
   D) pyramidal (aka trigonal pyramidal).
   Answer __C___

10. Mg^{2+} has the same electronic structure as

A) Mg. B) C. C) Ne. D) Ar.

Answer __C___

11. The element tin (Sn) occurs naturally as ten isotopes. Each of these isotopes has

A) 50 electrons. C) a different number of neutrons.
B) 50 protons. D) all of the above Answer __D___

12. A ring that is 18-karat gold, contains 75.0 % gold by mass. What mass of gold is present in an 18-karat gold ring weighing 6.0 grams?

A) 1.5 g B) 3.0 g C) 4.5 g D) 6.0 g

Answer __C___

13. Covalent bonds generally form between

A) non-metals. C) ions.
B) metals and non-metals. D) metals. Answer __A___

14. 3.2×10^5 nm is equivalent to _____ mm.

A) 3.2×10^2 C) 3.2×10^{-4}
B) 3.2×10^{-1} D) 3.2 Answer __B___

15. In the hydrogen chloride molecule, HCl, the chlorine end of the molecule is more negative than the hydrogen end because

A) hydrogen is more electronegative than chlorine.
B) hydrogen and chlorine have the same electronegativity. Answer __C___
C) chlorine is more electronegative than hydrogen.
D) hydrogen transfers an electron to chlorine.

Part II. Complete each of the following. Point values are noted by each question.

16. Complete the following table. (5 points)

symbol	# protons	# neutrons	# electrons	charge	mass #	atomic #
$^{12}_{6}C$	6	6	6	0	12	6
$^{55}_{26}Fe^{2+}$	26	29	24	+2	55	26

17. Complete the table below: (8 points)

Formula	Name
$Fe_2(CO_3)_3$	iron (III) carbonate
N_2O_5	dinitrogen pentoxide
PF_6	phosphorous hexafluoride
Na_2O	sodium oxide

18. Complete the following table for the element barium. (6 points)

_____**1120**_____ g Ba	=	8.14 mol Ba	=	____**4.90 x 10^{24}** ___ atoms Ba

The conversion between moles and grams requires the atomic mass:

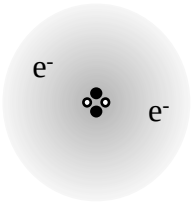
$$8.14 \text{ ~~mol Ba~~} \times \frac{137.328 \text{ g Ba}}{1 \text{ ~~mol Ba~~}} = 1117.8 \text{ g} = \mathbf{1120 \text{ g Ba}}$$

To convert between moles and atoms, we use Avogadro's number that tells us that 1 mol = 6.022 x 10^{23} atoms.

$$8.14 \text{ ~~mol Ba~~} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ ~~mol Ba~~}} = 4.9019 \times 10^{24} \text{ atoms} = \mathbf{4.90 \times 10^{24} \text{ atoms Ba}}$$

19. Describe what an individual helium-4 atom ($^4_2$He) looks like. Be as detailed as you can. You may wish to include a sketch. (6 points)

Helium atoms are comprised of a nucleus that contains two protons and two neutrons and comprises most of the mass of the atom. The remainder of the atom consists of an electron cloud containing two electrons and mostly empty space. A sketch might look something like this:



- Proton
- Neutron

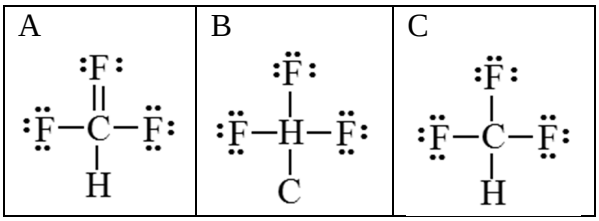
20. Outline three of the main points of Dalton's atomic theory. Identify one area of his theory that we now understand to be incorrect and required modification. (8 points)

Components of Dalton's theory are below. Items in parentheses are "errors" or inaccuracies that are included in our modern atomic models.

1. matter is made up of atoms, which are indivisible (we now know that atoms are made of smaller particles
2. atoms of the same element are identical (we now know about isotopes)
3. compounds are formed when atoms of different elements combined is certain proportions
4. during chemical reactions, atoms are rearranged, not destroyed (we now know about nuclear reactions)

Part III. ***Complete 3 of the following 4 problems.*** Clearly mark the problem you do not want graded. Each problem is worth eight (8) points. You must show you work on calculations to receive partial credit. Report numerical results to the correct number of significant figures and with the appropriate units.

21. Below are three potential Lewis structures for the compound CHF_3. Identify the correct structure and explain why the other structures are incorrect.



The molecule CHF_3 contains a total of 26 valence electrons (4 from C, 1 from H and 7 each from F), therefore a reasonable Lewis structure must represent 26 valence electrons. All three structures have 26 electrons, so we need to look a little further.

Correct structures must fill the valence shells of all of the atoms. In structure A, the central carbon atom has 10 electrons, two each from each of the bonds. This overfills the octet for carbon and is unlikely. This allows us to rule out structure A. In structure B, the carbon atom only has two electrons, therefore an unfilled valence shell. Also, the H atom has 8 electrons, which overfills its valence shell. This allows us to rule out structure B as a correct structure. Examining structure C shows that all atoms have filled valance shells and all valence electrons are shown, indicating that C is a correct structure.

22. In a butane lighter, 9.7 g of butane react completely with 34.7 grams of oxygen to form carbon dioxide and water. (4 points each part)
    a. If 29.3 grams of carbon dioxide are produced, how many grams of water are formed?

    Since the law of conservation of matter must be obeyed, the total mass of butane and oxygen must be equal to the total mass of carbon dioxide and water produced (since the butane and oxygen react completely).

    Mass butane + mass oxygen = mass carbon dioxide + mass water

    9.7g + 34.7g = 29.3g + g water

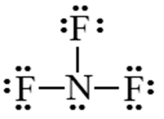
    g water = (9.7 + 34.7) – 29.3 = **15.1 grams water produced**

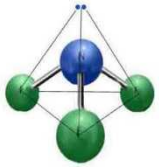
    b. How many grams of carbon dioxide would be produced if 15.6 grams of butane were allowed to react with 34.7 grams of oxygen?

    Here we have increased the mass of butane but left the mass of oxygen alone. Therefore, the oxygen will be our limiting reactant and it will be consumed completely when 9.7g of butane has been reacted. As a result, the mass of carbon dioxide produced would be the same as in part a, **29.3 grams.**

23. Valence shell electron pair repulsion theory (VSEPR) predicts that the molecule NF_3 would have a trigonal pyramidal shape. Why is this so?

Whenever considering the shape of a molecule as predicted by VSEPR, it is useful to consider the Lewis structure. The Lewis structure for NF_3 is shown at the right. Focusing on the nitrogen atom, we see four things around that atom, three fluorine atoms and one unshared pair (aka lone pair) of electrons. Those four things will distribute themselves in a tetrahedral electron pair geometry around the nitrogen. For the molecular geometry, we only consider where the atoms are. Because of the presence of the unshared pair of electrons, the three fluorine atoms are pushed out of the same plane and form a trigonal pyramidal shape.





24. Describe the similarities and differences in the electronic structures of fluorine and bromine. Include an electron configuration for each of the atoms. Why do both atoms tend to form anions with a charge of negative one (1-)?

Consider the electron configurations for both atoms. For fluorine, the configuration is $1s^2 2s^2 2p^5$ and for bromine is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$. So, both of the atoms have seven valence electrons in a configuration $ns^2 np^5$. Bromine, however has electrons in a d orbital as well, but fluorine doesn't. Since each atom is one electron short of a filled valence shell, it is not surprising that they undergo reduction reactions, gaining a single electron to achieve a filled valence shell. In order to attain noble gas configuration by an oxidation process, the atoms would need to lose seven electrons, which is very unfavorable.