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Use appropriate units and significant figures for results of calculations!

JBA 2019 – Chemistry Exam 1

Name:_____ Score:_____/100 = _____/80

1. Which of the following is a member of the group of elements called the *halogens*? (2 points)
   a. potassium
   b. calcium
   c. bromine — Answer _____c_____
   d. argon

2. When beryllium forms an ion, what charge will the ion have? (2 points)
   a. +1
   b. -1
   c. +2 — Answer _____c_____
   d. -2

3. The electron configuration for manganese is: (2 points)
   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. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$ — Answer _____b_____
   d. $1s^2 2s^2 2p^6 3s^2$

4. Which item below IS NOT part of Dalton's atomic theory? (2 points)
   a. All atoms of a particular element are identical
   b. Atoms combine in whole number ratios to form compounds. — Answer _____c_____
   c. Atoms can be split into protons, neutrons and electrons
   d. Reactions involve the rearrangement of atoms.

5. Below are four statements about protons, only one of which is true. Identify the true statement. (2 points)
   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. — Answer _____b_____
   d. Protons have the same magnitude of charge as neutrons, but opposite sign

6. Which of these bonds to you expect to be the **most** polar? (2 points)
   a. F-F
   b. O-F
   c. N-F — Answer _____d_____
   d. C-F

7. Which of the following elements occurs naturally as a diatomic molecule? (2 points)
   a. sulfur
   b. helium
   c. carbon — Answer _____d_____
   d. oxygen

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8. Match the term with its definition. (8 points)

__B_ electron	A. a dumb bell shape in space where an electron or a pair of electrons can be found
__I__mass number	B. a subatomic particle with a mass of 1/1824 and a charge of -1
__F__electronegativity	C. negatively charged species that forms when an atom gains one or more electrons
__E__compound	D. a generalization that in most stable molecules, many atoms will share in eight outer electrons to fill their valence shell.
__H__covalent bond	E. a pure substance made up of two or more elements in a fixed characteristic chemical combination and composition
__D__octet rule	F. the tendency for an atom to attract electrons toward itself in a bond.
__C__ anion	G. atoms of the same element, but with different number of **neutrons**
__G__ isotopes	H. a chemical bond created when two atoms share electrons.
	I. the number of protons and neutrons that atom contains.
	J. positively charged species that forms when an atom loses one or more electrons

9. Complete the following table. (6 points)

___147_ g H_2O	=	8.14 mol H_2O	=	4.90×10^{24} molecules H_2O

In order to relate moles and mass, we need to use the molar mass, so we must calculate the molar mass of water:

$$\frac{2\ \cancel{\text{mol H}}}{1\ \text{mol } H_2O} \times \frac{1.01\ \text{g}}{1\ \cancel{\text{mol H}}} + \frac{1\ \cancel{\text{mol O}}}{1\ \text{mol } H_2O} \times \frac{16.00\ \text{g}}{1\ \cancel{\text{mol O}}} = \frac{18.02\ \text{g}}{1\ \text{mol } H_2O}$$

Therefore, the molar mass of H_2O is 18.02 g/mol

Now the conversion between moles and grams:

$$8.14\ \cancel{\text{mol } H_2O} \times \frac{18.02\ \text{g}}{1\ \cancel{\text{mol } H_2O}} = 146.68\ \text{g} = \mathbf{147\ g\ H_2O}$$

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

$$8.14\ \cancel{\text{mol } H_2O} \times \frac{6.022 \times 10^{23}\ \text{molecules}}{1\ \cancel{\text{mol } H_2O}} = 4.9019 \times 10^{24}\ \text{molecules} = \mathbf{4.90 \times 10^{24}\ molecules\ H_2O}$$

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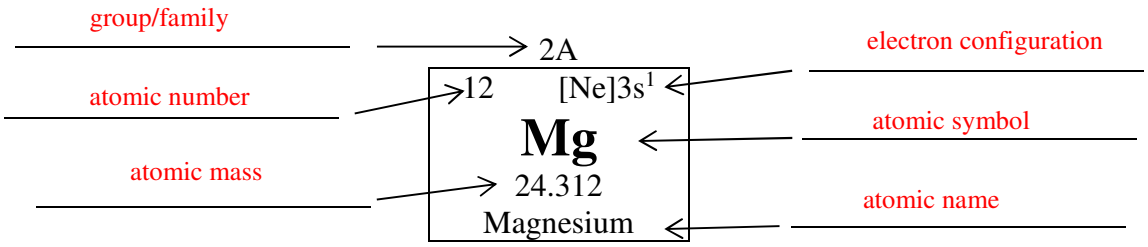
10. Complete the following table. (10 points)

Symbol	$^{12}_{6}C$	$^{55}_{26}Fe$	$^{40}_{20}Ca^{2+}$
# of protons	6	26	20
# of neutrons	6	29	20
# of electrons	6	26	18
Charge	0	0	+2
Mass #	12	55	40
Atomic #	6	26	20

11. Complete the table below: (8 points)

Formula	**Name**
ZnS	zinc (II) sulfide
N_2O_5	dinitrogen pentoxide
PF_6	phosphorous hexafluoride
Na_2O	sodium oxide

12. Fill-in the proper term for each item indicated on the diagram below. The terms are group/family, electronic configuration, atomic number, atomic mass, atomic symbol, atomic name. (6 points)



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13. Consider the ethanol we burned in class in the Petri dish on the benchtop. If 3.50 grams of ethanol burned, how much oxygen gas must have been consumed? The balanced reaction for the combustion of ethanol is shown below. (8 points)

$$C_2H_6O\,(g) + 3\,O_2\,(g) \rightarrow 2CO_2\,(g) + 3H_2O\,(g)$$

a. If 2.5 moles of ethanol is burned, how many moles of oxygen gas must have been consumed? (4 points)

Using the balanced reaction, we can do the mol ethanol → mol oxygen conversion:

$$2.5\ \text{mol } C_2H_6O \times \frac{3\ \text{mol } O_2}{1\ \text{mol } C_2H_6O} = \mathbf{7.5\ mol\ O_2}$$

b. If 3.50 grams of ethanol burned, how much oxygen gas must have been consumed? (4 points)

Our general scheme will be: g ethanol → mol ethanol → mol oxygen → g oxygen
First the conversion of mass of ethanol to moles of ethanol:

$$3.50\ \text{g } C_2H_6O \times \frac{1\ \text{mol } C_2H_6O}{46.07\ \text{g } C_2H_6O} = 0.07597\ \text{mol } C_2H_6O$$

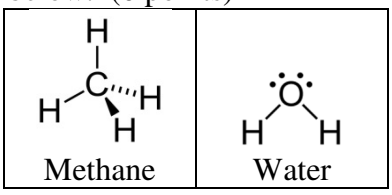
Now the mol ethanol → mol oxygen conversion:

$$0.07597\ \text{mol } C_2H_6O \times \frac{3\ \text{mol } O_2}{1\ \text{mol } C_2H_6O} = 0.2279\ \text{mol } O_2$$

Finally, converting mol oxygen → g oxygen:

$$0.2279\ \text{mol } O_2 \times \frac{31.998\ \text{g } O_2}{1\ \text{mol } O_2} = 7.292\ \text{g } O_2 = \mathbf{7.29\ g\ O_2}$$

14. Use your understanding of molecular structure and intermolecular forces to explain why methane (CH_4) is a gas at room temperature and water (H_2O) is a liquid. The structures for methane and water are shown below. (6 points)



Methane | Water

You should talk about the fact that methane is a nonpolar molecule, but water is polar, due to the electronegativity differences of atoms in the bonds and the orientation of the bonds in the molecule. As a result, water can undergo stronger intermolecular forces (like dipole-dipole interactions), that methane cannot. These stronger intermolecular forces require more energy to disrupt, making it more difficult to cause water to go from the liquid phase to the gas phase (that is, to boil).

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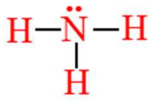
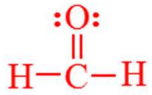
15. Draw Lewis structures for the following compounds and determine their shape and polarity. (12 pts)

Species	Draw the Lewis Structure	Molecular Shape Circle the correct shape. (You may build a model)	Polar Molecule? Circle yes or no.
NH_3		**Linear** **Bent** **Trigonal Planar** **Trigonal Pyramidal** **Tetrahedral**	**Yes** **No**
CH_2O		**Linear** **Bent** **Trigonal Planar** **Trigonal Pyramidal** **Tetrahedral**	**Yes** **No**
O_2		**Linear** **Bent** **Trigonal Planar** **Trigonal Pyramidal** **Tetrahedral**	**Yes** **No**

16. Balance the following reactions: (12 points)

a. $\_\_2\_\_C_2H_6 + \_\_7\_\_O_2 \rightarrow \_\_\_4\_\_CO_2 + \_\_6\_\_H_2O$

b. $\_\_\_\_PCl_5 + \_\_4\_H_2O \rightarrow \_\_\_\_H_3PO_4 + \_\_5\_\_HCl$

$\_\_\_\_Sn + \_\_2\_\_NaOH \rightarrow \_\_\_\_Na_2SnO_2 + \_\_\_\_H_2$

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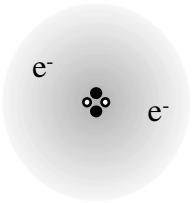
17. Describe what an individual helium atom ($^{4}_{2}He$) looks like. Be as detailed as you can. You may wish to include a sketch. (5 points)

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:



18. You purchased a bottle of imitation vanilla containing 150 mL of solution. If the solution contains 1.5% V/V of vanillin (the active ingredient), how many mL of vanillin does the bottle contain? (5 Points)

1.5 % V/V means 1.5 mL vanillin per 100 mL of solution, therefore:

$$150\ \cancel{\text{mL solution}} \times \frac{1.5\text{ g vanillin}}{100\ \cancel{\text{mL solution}}} = 2.25\text{ mL vanillin} = \mathbf{2.2\ mL\ vanillin}$$