Chemistry 115 – Exam 2 Study Guide

* Understand Dalton’s, Thomson, and the Nuclear atomic theory
* Know the components of an atom and some of the experiments that helped to identify these components.
* Know how to determine protons, neutrons, electrons, and mass number for and element from the isotopic notation for the element.
* Know the definitions/meaning of mole, aqueous, Avogadro’s number, molecule, formula unit. Know your nomenclature.
* Know how to convert from grams to moles to molecules/formula units/ atoms and back.
* Know how to determine empirical formulas and molecular formulas from percent composition and molar mass data.
* Know how to balance chemical equations and identify the type of chemical reaction.
* Be able to predict products
1. Element X has two naturally occurring isotopes with 69X at 60.10% (68.926 amu) and 71X at 39.90% (70.925 amu).
2. What is the atomic mass of X?

$$atomic mass=\left(689.926 amu\right)\left(\frac{60.10}{100}\right)+\left(70.925 amu\right)\left(\frac{39.90}{100}\right)$$

atomic mass = 41.424526 amu + 28.299074 amu

atomic mass = 69.723601 amu

atomic mass = 69.72 amu

1. What is the name and symbol of element X

name: Galluim symbol: Ga

1. Fill in the following table for four neutral atoms or ions. Include any charges appropriate.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| Mass number | **93** | 46 | **71** | **177** |
| Atomic number | **42** | 21 | **32** | **53** |
| Number of protons | **42** | **21** | **32** | **53** |
| Number of neutrons | **51** | **25** | **39** | 124 |
| Number of electrons | **51** | 18 | **34** | 53 |
| Elemental symbol | **Mo** | **Sc** | **Ge** | I |

1. Name the following compounds

|  |  |  |  |
| --- | --- | --- | --- |
| Al(MnO4)3 | aluminum permanganate | Li2SO4  | Lithium sulfate |
| Cr(OH)3 | Chromium (III) hydroxide | HI (aq)  | Hydroiodic acid  |
| CsClO  | Cesium hypochlorite | Al2(CrO4)3  | aluminum chromate |
| (NH4)3PO3 | ammonium phosphite | PbO2 | Lead(IV) oxide |
| HC2H3O2 (aq) | Acetic acid | Ni(HCO3)2 | nickel(II) bicarbonate |
| As2S5  | Diarsenic pentasulfide  | Cd(CN)2 | cadmium cyanide |
| FeCl2 | iron(II) chloride | ZnF2·4 H2O | zinc fluoride tetrahydrate |
| Latin  | ferrous chloride | SF6  | sulfur hexafluoride |

1. Write formulas for the following compounds

|  |  |  |  |
| --- | --- | --- | --- |
| Vanadium(III) chlorate | V(ClO3)3 | Mercury(II) phosphate | Hg3(PO4)2 |
| trichlorine heptoxide | Cl3O7 | Manganese(V) oxide | Mn2O5 |
| potassium acetate | KC2H3O2 | Cupric perchlorate | Cu(ClO4)2 |
| Zinc nitrite | Zn(NO2)2 | Xenon tetrafluoride  | XeF4 |
| Chromium(III) carbonate | Cr2(CO3)3 | Oxalic acid  | H2C2O4 (aq) |
| Copper (II) nitride | Cu3N2 | ammonium selenide | (NH4)2Se |
| Nitrous acid | HNO2 (aq) | Nickel(II) fluoride tetrahydrate  | NiF2 · 4 H2O |

1. Succinic acid is a byproduct of the fermentation of sugar. It is often added to soft drinks to give them a sweet/salty taste. Succinic acid is 40.7% C, 5.12% H, and 54.2% O. What is the empirical formula of succinic acid?

$$40.7 g C×\frac{1 mol C}{12.01 g C}=3.39 mol C$$

$$5.12 g H×\frac{1 mol H}{1.008 g H}=5.08 mol H$$

$$54.2 g O×\frac{1 mol O}{16.00 g O}=3.39 mol O$$

$$C\_{\frac{3.39}{3.39}}H\_{\frac{5.08}{3.39}}O\_{\frac{3.39}{3.39}}$$

$$C\_{1}H\_{1.5}O\_{1} or C\_{2}H\_{3}O\_{2} $$

1. Pyrogallol, a developer used in photography has an empirical formula of C2H2O and a molar mass of 126 g/mol. What is the molecular formula of the compound?

Molar mass of C2H2O = 2(12) + 2(1) + 16 = 42 g/mol

 There are 126/42 or 3 units of this in the compound

Molecular formula = C6H6O3

1. Cacodyl, which has an intolerable garlicky order and is used in the maufacture of cacodylic acid, a cotton herbicide, has the mass composition 22.88% C, 5,76% H, 71.36% As, and a molar mass of 209.96 g/mol. What is the molecular formula of cacodyls ?

$209.96\frac{g}{mol}×\frac{22.88 }{100}=48.03 g C×\frac{1 mol C}{12.01 g C}=\frac{3.9990408 mol C}{1.999832568 mol}=1.999687806≈2$

$209.96\frac{g}{mol}×\frac{5.76 }{100}=12.1 g H×\frac{1 mol H}{1.01 g H}=\frac{11.97395644 mol H}{1.999832568 mol}=5.987458521≈6$

$$209.96\frac{g}{mol}×\frac{71.36 }{100}=149.8 g As×\frac{1 mol As}{74.92 g As}=\frac{1.999832568 mol As}{1.999832568 mol}=1$$

Empirical formula is C2H­6As

$$Ratio= \frac{molecular mass}{empirical mass}=\frac{209.96 g/mol}{105.00 g/mol}=1.999619048≈2$$

Molecular formula is C4H12As2

1. Oil of wintergreen is the methyl ester of hydroxybenzoic acid. Its chemical formula is C8H8O3.
	1. Calculate the molar mass of oil of wintergreen.

$$molar mass=8\left({12.01 g}/{mol}\right)+8\left({1.008 g }/{mol}\right)+3\left({16.00 g}/{mol}\right)$$

$$=96.08+8.064+48.00$$

$$={152.14 g}/{mol}$$

* 1. Calculate the mass of 3.82 moles of oil of wintergreen.

$$?g C\_{8}H\_{8}O\_{3}=3.82 mol C\_{8}H\_{8}O\_{3}×\frac{152.14 g C\_{8}H\_{8}O\_{3}}{1 mol C\_{8}H\_{8}O\_{3}}=581 g C\_{8}H\_{8}O\_{3}$$

* 1. Calculate the number of molecules of oil of wintergreen in a sample containing 8.36 x 10-4 mol of oil of wintergreen.

$$?molec C\_{8}H\_{8}O\_{3}=8.36×10^{-4} mol C\_{8}H\_{8}O\_{3}×\frac{6.022×10^{23}molec C\_{8}H\_{8}O\_{3}}{1 mol C\_{8}H\_{8}O\_{3}}=5.03×10^{20} molec C\_{8}H\_{8}O\_{3}$$

* 1. Calculate the number of moles of carbon in a 8.35 mol sample of oil of wintergreen.

$$?mol C=8.35 mol C\_{8}H\_{8}O\_{3}×\frac{8 mol C}{1 mol C\_{8}H\_{8}O\_{3}}=66.8 mol C$$

* 1. Calculate the mass of oxygen in a 4.29 g sample of oil of wintergreen.

$$?g O=4.29 g C\_{8}H\_{8}O\_{3}×\frac{1 mol C\_{8}H\_{8}O\_{3}}{152.14 g C\_{8}H\_{8}O\_{3}}×\frac{3 mol O}{1 mol C\_{8}H\_{8}O\_{3}}×\frac{16.00 g O}{1 mol O}=1.35 g O$$

* 1. Calculate the mass of a sample of oil of wintergreen that contains 6.58 x 1019 atoms of hydrogen.

$$?g C\_{8}H\_{8}O\_{3}=6.58×10^{19}atoms H×\frac{1 mol H}{6.022×10^{23} atom H}×\frac{1 mol C\_{8}H\_{8}O\_{3}}{8 mol H}×\frac{152.14 g C\_{8}H\_{8}O\_{3}}{1 mol C\_{8}H\_{8}O\_{3}}=2.08×10^{-3} g C\_{8}H\_{8}O\_{3}$$

1. (tougher mole question) A dandruff shampoo contains pyrithion, C10H8N2O2S2, which acts as an antibacterial and antifungal agent.
2. What is the empirical formula of pyrithion?

C10H8N2O2S2 = (C5H4NOS)2 🡪 empirical formula is C5H4NOS

1. What is the molar mass of pyrithion?

C: (12.011 g/mol)(10) = 120.11 g/mol

H: (1.008 g/mol)(8) = 8.064 g/mol

N: (14.007 g/mol)(2) = 28.014 g/mol

 O: (15.999 g/mol)(2) = 31.998 g/mol

 S: (32.061 g/mol)(2) = 64.122 g/mol

 252.308 g/mol ≈ 252.31 g/mol

1. What is the percent composition of pyrithion?

$$\%C=\frac{120.11 g/mol}{252.31 g/mol}×100\%=47.604\% C$$

$$\%H=\frac{8.064 g/mol}{252.31 g/mol}×100\%=3.196\% H$$

$$\%N=\frac{28.014 g/mol}{252.31 g/mol}×100\%=11.103\% N$$

$$\%O=\frac{31.998 g/mol}{252.31 g/mol}×100\%=12.682\% O$$

$$\%S=\frac{64.122 g/mol}{252.31 g/mol}×100\%=25.414\% S$$

1. How many moles of pyrithion contain 8.2 x 1024 atoms of nitrogen?

$8.2×10^{24} atoms N ×\frac{1 mol N}{6.022×10^{23} atoms N}×\frac{1 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}}{2 mol N}=6.8 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}$

or

$$8.2×10^{24} atoms N ×\frac{1 mol N}{6.022×10^{23} atoms N}×\frac{14.007 g N}{1 mol N}×\frac{100 g C\_{10}H\_{8}N\_{2}O\_{2}S\_{2} }{11.103 g N}×\frac{1 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}}{252.31 g C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}}=6.8 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}$$

1. How many grams of S are in 4.56 moles of pyrithion?

$$4.56 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}×\frac{2 mol S}{1 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}}×\frac{32.061 g S}{1 mol S}=292 g S$$

1. How many atoms of C are in 25.0 g pyrithion?

$$25.0 g C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}×\frac{1 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}}{252.31 g C\_{10}H\_{8}N\_{2}O\_{2}S\_{2} }×\frac{10 mol C}{1 mol C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}}×\frac{6.022×10^{23}atoms C}{1 mol C}=5.97×10^{23} atoms C $$

or

$$25.0 g C\_{10}H\_{8}N\_{2}O\_{2}S\_{2}×\frac{47.605 g C}{100 g C\_{10}H\_{8}N\_{2}O\_{2}S\_{2} }×\frac{1 mol C}{12.011 g C}×\frac{6.022×10^{23}atoms C}{1 mol C}=5.97×10^{23} atoms C $$

1. Write balanced chemical equations for each of the following:
	1. Solid copper reacts with solid sulfur(S8) to form solid copper(I) sulfide(Cu2S).

16 Cu(s) + S8 (s) ----> 8 Cu2S(s)

* 1. Sulfur dioxide gas(SO2) reacts with oxygen gas(O2) to form sulfur trioxide gas(SO3)

2 SO2 (g) + O2 (g) --> 2 SO3.

* 1. Aqueous hydrochloric acid(HCl) reacts with solid manganese(IV) oxide (MnO2) to form aqueous manganese(II) chloride(MnCl2), liquid water, and chlorine gas.

MnO2(s) + 4HCl(aq) →MnCl2(aq) + Cl2(g) + 2H2O(l)

* 1. Liquid benzene(C6H6) reacts with gaseous oxygen(O2) to form carbon dioxide(CO2) and liquid water(H2O).

2 C6H6 (l) + 15 O2 (g) 🡪 12 CO2 (g) + 6 H2O (l)

* 1. Solid magnesium reacts with aqueous copper(I) nitrate to form aqueous magnesium nitrate and solid copper.

Mg(s)+2CuNO3(aq) ---> Mg(NO3)2(aq)+2Cu(s)

* 1. Gaseous dinitrogen pentoxide decomposes to form nitrogen dioxide and oxygen gas.

2N2O5(g)🡪 4NO2+O2(g)

* 1. Solid calcium reacts with aqueous nitric acid to form aqueous calcium nitrate and hydrogen gas.

Ca(s) + 2HNO3(aq) -> Ca(NO3)2(aq) + H2(g).

1. Balance the following chemical equations
	1. Na2S + Cu(NO3)2 🡪 2 NaNO3 + CuS
	2. 4 HCl + O2 🡪 2 H2O + 2 Cl2
	3. 2 H2 + O2 🡪2 H2O
	4. FeS + 2 HCl 🡪 FeCl2 + H2S
	5. BaO2 + H2SO4 🡪 BaSO4 + H2O2
	6. 2 Co(NO3)3 + 3 (NH4)2S 🡪 Co2S3 + 6 NH4NO3
	7. Li2O + H2O 🡪2 LiOH
	8. Hg2(C2H3O2)2 + 2 KCl 🡪 Hg2Cl2 + 2 KC2H3O2
	9. 2 C6H14 + 19 O2 🡪 12 CO2 + 14 H2O
	10. C3H8 + 5 O2 🡪 3 CO2 + 4 H2O
2. Below are some reactions, please balance and identify the type of reaction that is taking place:

2 Al (s) + 3 MnSO4 (aq) 🡪 Al2(SO4)3 (aq) + 3 Mn (s)  Single Replacement

2 LiNO3 (s) + heat 🡪 2 LiNO2 (s) + O2 (g)  Decomposition

H2SO4 (aq) + 2 NH4OH (aq) 🡪 (NH4)2SO4 (aq) + 2 H2O (l) Neutralization

4 Co (s) + 3 O2 (g) 🡪 2 Co2O3 (s) Combustion

1. *Predict the Products and Balance:*
2. C10H16 (l) + **14** O2 (g) 🡪 **10 CO2** (g) **+ 8 H2O** (g)

 Type of Reaction: **combustion**

1. **2** MgO (s) 🡪 **2 Mg** (s) **+ O2** (g)

 Type of Reaction: **decomposition**

1. Ca (s) + CuCl2 (aq) 🡪 **Cu** (s)  **+ CaCl2** (aq)

 Type of Reaction: **single displacement**

1. **2** Al(OH)3 (s) + **3** H2SO4 (aq) 🡪 **Al2(SO4)3** (aq) **+ 6 H2O** (l)

 Type of Reaction: **neutralization**

1. **2** Rb (s) + Br2 (l) 🡪 **2 RbBr** (aq)

 Type of Reaction: **combination**

1. **2** Na (s) + **2** H2O (l) 🡪 **H2** (g) **+ 2 NaOH** (aq)

 Type of Reaction: **single displacement**

1. **2** Ca (s) + O2 (g) 🡪 **2 CaO** (s)

 Type of Reaction: **combination**

1. Zn (s) + NaOH (aq) 🡪 no reaction (Na is above Zn in the activity series)

 Type of Reaction: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **3** Hg(OH)2 (s) + **2** H3PO4 (aq) 🡪 **Hg3(PO4)2**(s)  **+ 6 H2O** (l)

 Type of Reaction: **neutralization**

1. C2H5OH (l) + **3** O2 (g) 🡪 **2 CO2** (g) **+ 3 H2O** (g)

 Type of Reaction: **combustion**

1. **2** Al (s) + **3** FeO (s) 🡪 **Al2O3**(s)  **+ 3 Fe** (s)

 Type of Reaction: **single displacement**

1. **2** Ca3(PO4)2 (s) + **3** SiO2 (s) 🡪 **6 CaO** (s) **+ Si3(PO4)4** (s)

 Type of Reaction: **double displacement**

1. Fe2(SO4)3 (aq) + **6** KOH (aq) 🡪 **3 K2SO4** (aq) **+ 2 Fe(OH)3** (s)

 Type of Reaction: **double displacement**

1. **2** Ca3(PO4)2 (s) + **3** Si(CO3)2 (s) 🡪 **6 CaCO3** (s)  **+ Si3(PO4)4** (s)

 Type of Reaction: **double displacement**