Unit E – Review

Name___________________________Per____

This worksheet is set up very systematically. The problems are set up in pairs. #1 and #2 are VERY similar, thus if you have success with #1 move on to #3, do not waste time repeating what you can do − or save til later for another review set. On the other hand, if you struggle with an odd # and you think you want to practice that type of problem again, go on and work the corresponding even # for a very similar problem.

1. Given a flask of oxygen gas, that contained 9.43×10^{24} oxygen atoms, what would be the number of mole of oxygen molecules?

2. Given 4.87×10^{27} formula units (ionicules) of calcium chloride, $CaCl_2$ what is the number of mole of formula units?.

3. How many atoms in 17 mole of water?

4. How many anions (negative ions) in 0.054 mole of magnesium nitrate, $Mg(NO_3)_2$?

5. Calculate the number of fluorine molecules in 76.89 g of fluorine gas, F_2, yes this is a diatomic element.

6. Calculate the number of atoms in 40.0 g of neon gas, Ne.

7. Calculate the % by mass of carbon in gallium cyanide, $Ga(CN)_3$.

8. Calculate the % by mass of hydrogen in ammonium sulfide, $(NH_4)_2S$.

9. How many mole of sulfate would you have in 5 mole of aluminum sulfate, $Al_2(SO_4)_3$?

10. How many mole of permanganate would you have in 0.027 mole of copper(II) permanganate, $Cu(MnO_4)_2$?

11. Calculate how many atoms of oxygen are in 15.0 g of zinc perchlorate, $Zn(ClO_3)_2$

12. Calculate how many atoms of sodium are in 0.0586 g of sodium phosphate, Na_3PO_4

13. Determine the mass of the oxygen in 8.56 g of chromium(VI) sulfate, $Cr(SO_4)_3$

14. Determine the mass of sulfur in 43.5 g of lead(IV) sulfide, PbS_2

15. Calculate the % of water in iron(III) nitrate dihydrate, $Fe(NO_3)_3$ • ___ H_2O If you had 3.75 g of this hydrate, what would it weigh after you heated it to remove all the water.

16. Calculate the % of water in magnesium sulfate heptahydrate, $MgSO_4$ • ___ H_2O. I you heated 4.957 g of this hydrate, what would be the mass of the anhydrate after heating?

17. Suggest the identity of 5.21×10^{21} particles of some gaseous element that weighs 0.173 g. (Hint, determine the molar mass of this gaseous element to help you to identify it.)

18. Determine the identity of 5.63×10^{22} molecules of the gaseous element that weighs 2.99 g.

19. Determine the mass of one single water molecule.

20. Determine the mass of one aluminum atom.

21. A sample of 0.234 moles of a metal, M reacts completely with excess fluorine to form 19.66 grams of MF_3.

    a. How many moles of F are in the sample of MF_3?

    b. What is the mass of F in this sample?

    c. How many grams of M are in this sample?

    d. If you knew the molar mass of metal M you could make a prediction as to what metal M might be. From the info above calculate the molar mass of M and predict the element. (In other words, make a ratio of mass to moles for M)

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22. A sample of 0.0784 moles of a metal, X reacts completely with excess iodine to form 35.18 grams of XI_2.

    a. How many moles of I are in the sample of XI_2?

    b. What is the mass of I in this sample?

    c. How many grams of X are in this sample?

    d. If you knew the molar mass of metal X you could make a prediction as to what metal X might be. From the info above calculate the molar mass of X and predict the element. (In other words, make a ratio of mass to moles for X)

23. Analysis of a carbohydrate, a molecular compound made of carbon, hydrogen and oxygen determined it to be 62.07 % carbon, 10.34 % hydrogen, and the rest oxygen. The molar mass of this compound is 232 g/mole. Determine the molecular formula of this compound.

24. Analysis of a molecular compound made of iodine and oxygen determined it to be 76.0 % iodine. The molar mass of this compound is 668 g/mole. Determine the molecular formula and the name of this compound.

25. Determine the empirical formula of a carbon chlorine compound made of 8.53×10^{22} carbon atoms and 3.41×10^{23} chlorine atoms.

26. Determine the empirical formula of a nitrogen oxygen compound made of 1.53×10^{22} nitrogen atoms and 7.63×10^{21} oxygen atoms.

27. Determine the formula for of a hydrate that was heated and determined to be 21.7% water. The anhydrate was further analyzed and determined to be 13.8 % aluminum, 49.3 % sulfur, and 36.9 % oxygen. What is the prefix for the amount of water in this hydrate?

28. Determine the formula for 7.65 g of a hydrate that was heated until it had a mass of 5.14 g. The anhydrate was further analyzed and determined to be 32.2 % cobalt, 15.3 % nitrogen, and 52.5 % oxygen.

29. Determine the empirical formula for nickel oxygen compound if 18.8 g of nickel was burned with oxygen. The product had a mass of 23.92 g.

30. Determine the empirical formula for chromium oxide if 0.5152 g of chromium was burned with oxygen gas and the product had a mass of 0.7530 g.

31. What mass of sodium chloride, NaCl must be dissolved to produce 250 ml of a 0.50 M solution?

32. What mass of barium choride dihydrate $BaCl_2 \cdot$ ___ H_2O must be dissolved to produce 100. ml of a 0.0350 M solution?

33. Given 25 ml of 0.64 M sodium chloride, NaCl and 50 ml of 0.45 M sodium sulfate, Na_2SO_4 how many millimoles of sodium ions would be in this combined solution?

34. Given 100. ml of 1.25 M magnesium nitrate, $MgNO_3$ and 100. ml of 1.64 M aluminum nitrate, $Al(NO_3)_3$ how many millimoles of nitrate ions, NO_3^- would be in this combined solution?

35. If you had 100. ml of 3.0 M HCl solution and added 50. ml of water (assume the volumes are additive) what would be the new molarity?

36. What is the molarity of a salt water solution if 75 ml of water is added to 55 ml of 0.87 M NaCl solution.

37. What are the units on avogadro's number? What are the units on any molar mass?

1. You should recognize that there is NO need for the molar mass of oxygen in this problem.

$$9.43\times10^{24}OxygenAtoms\times\frac{1mol}{6.02\times10^{23}OxygenAtoms}\times\frac{1O_2molecule}{2OxygenAtoms}=7.83molO_2molecules$$

2. You should recognize that there is NO need for the formula mass of calcium chloride.

$$4.87\times10^{27}\times\frac{1mol}{6.02\times10^{23}FormulaUnits}=8,090FormulaUnits$$

3. Again, you should recognize that there is NO need for molar masses in this problem. Simply change moles of water to molecules of water, and then convert to the total number of atoms, given that H_2O has 3 atoms in the molecule.

$$17molH_2O\times\frac{6.02\times10^{23}molecules}{1mol}\times\frac{3atoms}{1H_2Omolecule}=3.07\times10^{25}atoms$$

4. Again, you should recognize that there is NO need for molar masses in this problem. Simply change moles of magnesium nitrate to formula units (ionicules) of $Mg(NO_3)_2$, and then recognize that there are two nitrate anios per formula unit.

$$0.054molMg(NO_3)_2\times\frac{6.02\times10^{23}FormulaUnits}{1mol}\times\frac{2anions}{1Mg(NO_3)_2FormulaUnit}=65\times10^{22}anions(NO_3^{2-})$$

5. Now, this problem requires the molar mass of the moleucule, do not forget that fluorine is a diatomic gas.

$$76.89gF_2gas\times\frac{1molF_2gas}{38g}\times\frac{6.02\times10^{23}molecules}{1mol}=1.22\times10^{24}molecules$$

6. Convert grams to moles, then to atoms of neon.

$$40.0gNeonGas\times\frac{1molNeonGas}{20.18g}\times\frac{6.02\times10^{23}atoms}{1mol}=1.19\times10^{24}atoms$$

7. You need to write out the correct formula for gallium cyanide and then calculate the molar mass

$Ga(CN)_3$ 69.72 + 3(12.01) + 3(14.01) = 147.78 g/mol

$$\frac{36.03gC}{147.78Ga(CN)_3}\times100=24.38\%Carbon$$

8. You need to write the formula for ammonium sulfide, and calculate the molar mass.

$(NH_4)_2S$ 2(14.01) + 8(1.01) + 32.07 = 68.17 g/mol

$$\frac{8.08gH}{68.17g(NH_4)_2S}\times100=11.85\%Hydrogen$$

9. No mass involved here. Don't make this problem any harder than necessary. Write out the formula: $Al_2(SO_4)_3$

$$5molAl_2(SO_4)_3\times\frac{3SO_4^{2-}}{1Al_2(SO_4)_3}=15molSO_4^{2-}$$

10. No mass involved here. Don't make this problem any harder than necessary. Write out the formula: $Al_2(SO_4)_3$

$$5molAl_2(SO_4)_3\times\frac{3SO_4^{2-}}{1Al_2(SO_4)_3}=15molSO_4^{2-}$$

11. Be sure and write the formula and add the molar mass for zinc perchlorate. $Zn(ClO_4)_2$ 65.39 + 2(35.45) + 8(16) = 264.29

$$15.0gZn(ClO_4)_2\times\frac{1molZn(ClO_4)_2}{264.29g}\times\frac{8Oatoms}{1Zn(ClO_4)_2}\times\frac{6.02\times10^{23}atoms}{1mol}=2.73\times10^{23}Oatoms$$

12. Be sure and write the formula and add the molar mass for sodium phosphate. Na_3PO_4 3(22.99) + 30.97 + 4(16) = 140.95

$$0.0586 gNa_3PO_4 \times \frac{1molNa_3PO_4}{140.95g} \times \frac{3NaAtoms}{Na_3PO_4} \times \frac{6.02\times10^{23} atoms}{1mol} = 7.51\times10^{20} NaAtoms$$

13. You need write the formula $Cr(SO_4)_3$ then calculate the amount of oxygen in this compound.

52 + 3(32.07) + 12(16) = 271.34 g/mol

$$8.56gCr(SO_4)_3 \times \frac{192gO}{340.21gCr(SO_4)_3} = 4.83gO$$

14. You need write the formula PbS_2 then calculate the amount of sulfur in this compound.

207.2 + 2(32.07) = 340.21 g/mol

$$43.5gPbS_2 \times \frac{64.14gS}{271.34gPbS_2} = 10.3gS$$

15. First you must be able to write the correct formula ad calculat the correct molar mass.

$Fe(NO_3)_3 \cdot 2\,H_2O$ 55.85 + 3(14.01) + 9(16) + 2(18.02) = 277.9

$$\frac{36.04gH_2O}{277.92gFe(NO_3)_3 \cdot 2H_2O} \times 100 = 12.97\%H_2O$$

12.97% water indicates that 100% − 12.97% tell us that 87.03 % of the compound is anhydrate.

3.75 g × 0.8703 (the percentage od anhydrate represented as a decimal) = **3.26 g of anhydrate would remain after heating**

16. First you must be able to write the correct formula ad calculat the correct molar mass.

$MgSO_4 \cdot 7\,H_2O$ 24.31 + 32.07 + 4(16) + 7(18.02) = 277.9

$$\frac{126.14gH_2O}{246.52gMgSO_4 \cdot 7H_2O} \times 100 = 51.17\%H_2O$$

51.17% water indicates that 100% − 51.17% tell us that 48.83% of the compound is anhydrate.

4.957 g × 0.4883 (the percentage od anhydrate represented as a decimal) = **2.421 g of anhydrate would be left.**

17. Recognize that you are given a mass for a particular amount of particles, in other words, grams per particles, so you can set up a ratio.

$$\frac{0.173g}{5.21\times10^{21} particles} \times \frac{6.02\times10^{23} particles}{1mol} = 19.99g/mol$$

This gas must be Neon (can't be F, because F is diatomic, F_2 which would weighs 38 g/mol)

18. Recognize that you are given a mass for a particular amount of particles, in other words, grams per particles, so you can set up a ratio.

$$\frac{2.99g}{5.63\times10^{22} particles} \times \frac{6.02\times10^{23} particles}{1mol} = 32g/mol$$

because the problem tells you that this substance is an element of which the particles are molecules, then you know the substance must be one of the diatomic gases with a molar mass of 32 g/mol. Thus it must be **O_2**

19. H_2O You know the molar mass of water: 2(1)+(16) = 18g/1mole. Use this to start your dimensional analysis.

$$\frac{18.02g}{1mol} \times \frac{1mol}{6.02\times10^{23} molecules} = 2.99\times10^{-23} g/1molecule$$

20. For the substance aluminum, you know that the molar mass is 26.98 g/1mole. Use this to start your dimensional analysis.
$$\frac{26.98g}{1mol}\times\frac{1mol}{6.02\times10^{23}molecules}=4.48\times10^{-23}g/1molecule$$

21. Take this problem one step at a time with the calculation skills you already know.
    a. Recognize that for 0.234 moles of the metal M, given the formula MF_3, there must be three times as many moles of F, thus 3 × 0.234 = 0.702 mol F
    b. Then a simple calc from moles to grams: $0.702mol\times\frac{19g}{1mol}=13.34gF$
    c. Since the M and F must add to the total mass of the compound: 19.66 g − 13.34 g = 6.32 g of M
    d. Since we know that this 6.32 g of M is 0.234 mol, we can make a ratio to get the molar mass: $\frac{6.32g}{0.234mol}=27.0g/mol$ which appears to be aluminum.

22. Take this problem one step at a time with the calculation skills you already know.
    a. Recognize that for 0.0784 moles of the metal X, given the formula XI_2, there must be two times as many moles of I, thus 2 × 0.0784 = 0.157 mol I
    b. Then a simple calc from moles to grams: $0.157mol\times\frac{126.9g}{1mol}=19.92gI$
    c. Since the M and F must add to the total mass of the compound: 35.18 g total − 19.92 g I = 15.26 g of X
    d. Since we know that this 15.26 g of X is 0.0784 mol, we can make a ratio to get the molar mass:
    $\frac{15.26g}{0.0784mol}=194.6g/mol$ which seems close enough to platinum.

23. Determine the percentage of oxygen in the compound: 100% − 62.07% – 10.34% = 27.59 % oxygen
$$Carbon: 62.07g\times\frac{1mol}{12.01g}=5.1725 \qquad \frac{5.1725}{1.724}=3$$
$$Hydrogen: 10.34g\times\frac{1mol}{1.01g}=10.24 \qquad \frac{10.24}{1.724}=6$$
Which gives an empirical formula of C_3H_6O
$$Oxygen: 27.59g\times\frac{1mol}{16g}=1.724 \qquad \frac{1.724}{1.724}=1$$
Calculate the molar mass of the empirical formula: 3(12.01) + 6(1.01) + 16 = 58 $\frac{232g}{58.09g}=4$ thus: $\mathbf{C_{12}H_{24}O_4}$

24. Determine the percentage of oxygen in the compound: 100% − 76% = 24 % oxygen
$$Iodine: 76g\times\frac{1mol}{126.9g}=0.599 \qquad \frac{0.599}{0.599}=1\times2=2$$
Which gives an empirical formula of I_2O_5
$$Oxygen: 24g\times\frac{1mol}{16g}=1.5 \qquad \frac{1.5}{0.599}=2.5\times2=5$$
Calculate the molar mass of the empirical formula: 2(126.9) + 5(16) = 333.8 $\frac{668g}{333.8g}=2$ thus: $\mathbf{I_4O_{10}}$

25. This problem may seem dramatically different, however, it is just another empirical formula problem, however, in this case, you need to convert items − instead of grams or percentages − to moles.
$$Carbon: 8.53\times10^{22}atoms\times\frac{1mol}{6.02\times10^{23}atoms}=0.142mol \qquad \frac{0.142}{0.142}=1$$
therefore the formula is $\mathbf{CCl_4}$
$$Chlorine: 3.41\times10^{23}atoms\times\frac{1mol}{6.02\times10^{23}atoms}=0.566mol \qquad \frac{0.566}{0.142}=4$$
You may notice above that the calculation for the conversion to moles from atoms is exactly the same for both elements, thus you could immediately convert to an atom:atom ratio by dividing the number of atoms by the smaller of the two values. This would let you see the 1:4 ratio without performing the first calculation.

26. This problem may seem dramatically different, however, it is just another empirical formula problem, however, in this case, you need to convert items − instead of grams or percentages − to moles.

$$Nitrogen: 1.53\times10^{22}\,atoms\times\frac{1mol}{6.02\times10^{23}\,atoms}=0.0254\,mol \qquad \frac{0.0254}{0.01267}=2$$

$$Oxygen: 7.63\times10^{21}\,atoms\times\frac{1mol}{6.02\times10^{23}\,atoms}=0.01267\,mol \qquad \frac{0.01267}{0.01267}=1$$

therefore the formula is **N_2O**

You may notice above that the calculation for the conversion to moles from atoms is exactly the same for both elements, thus you could immediately convert to an atom:atom ratio by dividing the number of atoms by the smaller of the two values. This would let you see the 2:1 ratio without performing the first calculation.

27. First determine the formula of the anhydrate

$$Aluminum: 13.8g(\%)\times\frac{1mol}{26.98g}=0.511mol \qquad \frac{0.511}{0.511}=1\times2=2$$

$$Sulfur: 49.3g(\%)\times\frac{1mol}{32.07}=1.537mol \qquad \frac{1.537}{0.511}=3\times2=6$$

$$Oxygen: 36.9g(\%)\times\frac{1mol}{16}=2.306mol \qquad \frac{2.306}{0.511}=4.5\times2=9$$

Thus **$Al_2S_6O_9$** **$Al_2(S_2O_3)_3$**

Next you must proceed on to the hydrate part of the problem.

100% − 21.7% = 78.3% g anhydrate $Al_2(S_2O_3)_3$ 2(26.98) + 6(32.07) + 9(16) = 390.38 g/mol water = 18.02 g/mol

$$anhydrate: 78.3g\times\frac{1mol}{390.38g}=0.201mol \qquad \frac{0.201}{0.201}=1$$

$$water: 21.7\times\frac{1mol}{18.02g}=1.20mol \qquad \frac{1.20}{0.201}=6$$

$Al_2(S_2O_3)_3 \cdot 6\,H_2O$ aluminum thiosulfate hexahydrate

28. First determine the formula of the anhydrate

$$Cobalt: 32.2g(\%)\times\frac{1mol}{58.93g}=0.5464mol \qquad \frac{0.5464}{0.5464}=1$$

$$Nitrogen: 15.3g(\%)\times\frac{1mol}{14.01}=1.092mol \qquad \frac{1.092}{0.5464}=2$$

$$Oxygen: 52.5g(\%)\times\frac{1mol}{16}=3.281mol \qquad \frac{3.281}{0.5464}=6$$

Thus **CoN_2O_6 which is $Co(NO_3)_2$**

Next you must proceed on to the hydrate part of the problem.

First the molar mass of the anhydrate: $Co(NO_3)_2$ 52 + 2(14.01) + 6(16) = 182.93 g/mol

Calculate the mass of the compound that is water: 7.65 g – 5.14 g = 2.51 g water water = 18.02 g/mol

$$anhydrate: 5.14g\times\frac{1mol}{182.93}=0.0281mol \qquad \frac{0.0281}{0.0281}=1$$

$$water: 2.51\times\frac{1mol}{18.02g}=0.139mol \qquad \frac{0.139}{0.0281}=5$$

$Co(NO_3)_2 \cdot 5H_2O$ cobalt(II) nitrate pentahydrate

29. 23.92 g – 18.8 g = 5.12 g oxygen

$$Oxygen: 5.12g\times\frac{1mol}{16}=0.32mol \qquad \frac{0.32}{0.32}=1$$

$$Nickel: 18.8\times\frac{1mol}{58.69g}=0.32mol \qquad \frac{0.32}{0.32}=1$$

thus **NiO nickel(II) oxide**

30. Since you know the starting mass of chromium, and the final mass of the chromium oxide, you can calculate the mass of oxygen that would be present in this compound

0.7530 g – 0.5152 g = 0.2378 g Then change the mass of each element into moles.

$$Oxygen: 0.2378g \times \frac{1mol}{16} = 0.0149mol \qquad \frac{0.0149}{0.00991} = 1.5 \times 2 = 3$$

$$Chromium: 0.5152g \times \frac{1mol}{52g} = 0.00991mol \qquad \frac{0.00991}{0.00991} = 1 \times 2 = 2$$

Thus **Cr_2O_3**

31. NaCl MM = 22.99 + 35.45 = 58.44 g/mol

$$0.50M\left(\frac{mol}{L}\right) \times 0.250L = 0.125mol \qquad 0.125mol \times \frac{58.44g}{1mol} = 7.3g \qquad 8.75g \times \frac{1mol}{53.5g} = 0.164mol \qquad \frac{0.164mol}{0.2L} = 0.818M$$

32. $BaCl_2 \cdot 2H_2O$ MM = 137.32 + 2(35.45) + 2(18.02) = 244.26 g/mol

$$0.0350M\left(\frac{mol}{L}\right) \times 0.100L = 0.00350mol \qquad 0.00350mol \times \frac{244.26g}{1mol} = 0.855g$$

33. First calculate the moles of each solution, then the moles of sodium ions in each solution, then add them up.

$$NaCl: 0.64M \times 25ml = 16mmolNaCl \times \frac{1Na}{1NaCl} = 16mmolNa^+$$

$$Na_2SO_4: 0.45M \times 50ml = 22.5.molNaCl \times \frac{2Na}{1Na_2SO_4} = 45mmolNa^+$$

Thus 16 + 45 = 61 mmol of Na^+ ions in solution

34. First calculate the moles of each solution, then the moles of sodium ions in each solution, then add them up.

$$Mg(NO_3)_2: 1.25M \times 100ml = 125mmolMg(NO_3)_2 \times \frac{2NO_3^-}{Mg(NO_3)_2} = 250mmolNO_3^-$$

$$Al(NO_3)_3: 1.64M \times 100ml = 164mmolAl(NO_3)_3 \times \frac{3NO_3^-}{Al(NO_3)_3} = 492mmolNO_3^-$$

Thus 250 + 492 = 742 mmol of nitrate ions in solution

35. This is a simple dilution problem: $M_cV_c = M_dV_d \quad 3.0M \times 100.ml = M_d \times 150.ml \quad M_d = 2.0M$

36. This is a simple dilution problem: $M_cV_c = M_dV_d \quad 0.87M \times 55ml = M_d \times 130.ml \quad M_d = 0.37M$

37. Avogadro's number, $\frac{6.02 \times 10^{23} items}{1mol}$ the units are $\frac{items}{mol}$ and those items are likely to be atoms, molecule, ions, electrons, formula units, protons….whatever is in the problem

and molar mass, $\frac{grams}{1mol}$ and of course the number of grams depends on the substance.