LIMITING REAGENT PROBLEMS BY TYPE- ANSWER KEY

.

1) MASS/MASS:

The problem reads: How many grams of carbon dioxide can be produced from the reaction of 1.00 kg of Octane (C_8H_{18}) with 1.00 kg of oxygen?

Broken down into parts:

i. Write the balanced equation: $2C_8H_{18(l)} + \mathbf{25}O_{2(g)} \rightarrow \mathbf{8}H_2O + \mathbf{9}CO_2$

ii. What is the molar mass of octane: 114.24 g/mol

iii. What is the molar mass of oxygen: 32.00 g/mol

iv. What is the limiting reagent: Oxygen

v. Grams of carbon dioxide is produced: 440. g CO_2

2) SOLUTION/SOLUTION YIELDING A SOLID OR A LIQUID

Formation of a solid:

What is the ionic and net ionic equation for the reaction?

$6\ K^+_{(aq)} + 2PO_4^{3-}{}_{(aq)} + 3Fe^{2+}{}_{(aq)} + 6Cl^-_{(aq)} \rightarrow Fe_2PO_{4(s)} + 6\ K^+_{(aq)} + 6Cl^-_{(aq)}$

$2PO_4^{3-}{}_{(aq)} + 3Fe^{2+}{}_{(aq)} \rightarrow Fe_2PO_{4(s)}$

i. Moles of phosphate ions are in 125.0mL of 0.1100 M $K_3PO_{4(aq)}$ solution? 0.01375 moles $PO_4^{3-}{}_{(aq)}$, 13.75 mmoles PO_4^{3-}

ii. Moles of potassium ions are in 125.0 mL of 0.1100 M $K_3PO_{4(aq)}$ solution? 0.04125 moles $K^+_{(aq)}$, 4.125 mmol $K^+_{(aq)}$

iii. Moles of of iron(II) ions are in 150.0mL of 0.09500 M $FeCl_{2(aq)}$? 0.01425 moles $Fe^{2+}{}_{(aq)}$, 14.25 mmol $Fe^{2+}{}_{(aq)}$

iv. Moles of chloride ions are in 150.0 mL of 0.09500 M $FeCl_{2(aq)}$ 0.0285 mol $Fe^{2+}{}_{(aq)}$, 28.5 mmol $Fe^{2+}{}_{(aq)}$

v. What is the limiting reagent?$Fe^{2+}{}_{(aq)}$, $FeCl_{2(aq)}$, not the chloride though

vi. What mass of iron(II) phosphate is produced? 1.698 g $Fe_3(PO_4)_2$

vii. What is the concentration of the potassium ion, phosphate ion, iron(II) ion, and chloride ion that remains after the reaction is completed? [hint: you need to find the moles of excess reagent in the form of an ion for this part $[Cl^-]$ = 0.1036 MCl^-, $[K^+]$ = 0.05000 MK^+, $[PO_4^{3-}]$ = 0.1545 MPO_4^{3-}

Now solve these:

1. A solution of 100.0 mL of 0.200 M sodium chromate is mixed with a solution of 200.0 mL of 0.150 M strontium nitrate.
    a. What is the limiting reagent or reacting? Sodium chromate
    b. How many grams of precipitate form? 0.293 g strontium chromate
    What is the concentration of spectator ions in the final mixture? Sodium ion = 0.1333 M Na^+, nitrate ion = 0.100 M NO_3^-,
    c. What is the concentration of the excess ion? strontium ion = 0.0333M Sr^{2+}

2. 25.0 mL of 0.235 *M* $Mg(NO_3)_2$ are combined with 30.0 mL of 0.260 *M*KOH. How many grams of magnesium hydroxide form? 0.455 g magnesium hydroxide

Formation of a liquid: Problems of this nature are generally titration reactions. The product is usually an aqueous salt and water.

What is the molarity of sodium perchlorate produced and the molarity of the excess reagent that remains when 25.00 mL of 0.230 *M* $HClO_{4(aq)}$ reacts with 50.00-mL of 0.1750 M $NaOH_{(aq)}$?

$$HClO_{4(aq)} + NaOH_{(aq)} \rightarrow NaClO_{4(aq)} + H_2O_{(l)}$$

Broken into parts:

i. What is the ionic and net ionic equation for the reaction?

$$H^+_{(aq)} + ClO_4^-{}_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow ClO_4^-{}_{(aq)} + Na^+_{(aq)} + H_2O_{(l)}$$

$$OH^-_{(aq)} + H^+_{(aq)} \rightarrow H_2O_{(l)}$$

ii. How many moles of NaOH are present? 0.008750 mol NaOH
iii. How many moles of perchloric acid are present? 0.00575 mol $HClO_4$
iv. What is the limiting reagent? $HClO_4$
v. How many moles of sodium perchlorate are produced? 0.00575 mol $NaClO_4$
vi. What is the final volume of the mixture after the reaction? 75.00 mL
vii. What mass of molarity of sodium perchlorate produced? 0.0767 M $NaClO_4$
viii. What molarity of excess remains after the reaction is finished? OH^-
ix. Is the remaining solution acidic or basic? Basic because excess is OH^-

3) SOLUTION/SOLID PRODUCING A SOLID, LIQUID, GAS, OR AQUEOUS PRODUCT

Formation of a solid:

What is the mass of chromium(III) sulfide produced and the mass of the excess reactant remains in a reaction mixture consisting of 1.54 g of $Cr(NO_3)_3$ dissolved in 120. mL of 0.10 M $H_2S_{(aq).}$

$$2Cr(NO_3)_{3(s)} + 3\ H_2S_{(aq)} \rightarrow Cr_2S_{3(s)} + 6\ HNO_{3(aq)}$$

Broken into parts:

i. What is the ionic and net ionic equation for the reaction? Remember that the chromium is soluble.

$2Cr^{3+}_{(aq)} + 6\ NO_3^-{}_{(aq)} + 3\ H_2S_{(aq)} \rightarrow Cr_2S_{3(s)} + 6\ H^+_{(aq)} + 6NO_3^-{}_{(aq)}$

$2Cr^{3+}_{(aq)} + 3\ H_2S_{(aq)} \rightarrow Cr_2S_{3(s)} + 6\ H^+_{(aq)}$

ii.

iii. How many moles of chromium (III) ions are in 1.54 g of $Cr(NO_3)_3$? 0.00541

iv. How many moles of nitrate ions are in 1.54 g of $Cr(NO_3)_3$? 0.0162 mol NO_3^-

v. How many moles of hydrosulfuric acid are in 120. mL of 0.10 M $H_2S_{(aq).}$? 0.012 mol H_2S

vi. What is the limiting reagent? $Cr(NO_3)_{3(s}$

vii. What mass of chromium(III) sulfide produced? 0.542 g Cr_2S_3

viii. What moles of excess remains after the reaction is finished? 0.00389 mol H_2S remain

Now solve this one:

3. A solution of 100.0 mL of 0.200MKOH is mixed with a 46.4 g $NiSO_4$.

Solve the following to complete the problem:

a. Write the balanced equation for the reaction. Include correct state suspects and coefficients.

$$2KOH_{(aq)} + NiSO_{4(aq)} \rightarrow K_2SO_{4(aq)} + Ni(OH)_{2(s)}$$

b. How many moles of precipitate form? 0.100 mol

c. What is the final volume of the solution? 100. mL

d. What are the moles of the spectator ions remaining? 0.02 mol K^+ & 0.300 mol SO_4^{2-}

e. What is the concentration of the spectator ions remaining? ? 0.200 MK^+ & 3.00 M SO_4^{2-}

f. One of the ions involved in the reaction is in excess. What is the concentration of this remaining ion? 0.290 M Ni^{2+} is in excess. Remember, the nickel sulfate is soluble, so even though you added it as a solid, it will for aqueous ions. That is why it is in the aqueous phase in the equation.

Formation of a gas:

Still a double displacement, as above, but now one of the reactants is a gas. Because one of the reactants is a solid, these types of problems can also be worked in the mole. The unit the mmol (No, this is not a typo!) is often used for solution work because when divided, mmol/mL=M.

What is the mass of carbon dioxide produced and the mass of the excess reactant remains in a reaction mixture consisting of 1.54 g of $KHCO_3$ is dissolved in 120. mL of 0.10 M $H_2SO_{4(aq).}$

[**unbalanced]** $KHCO_{3\,(s)} + H_2SO_{4(aq).} \rightarrow K_2SO_{4(aq)} + H_2O_{(l)+}\, CO_{2(g)}$

Broken into parts:

i. What is the ionic and net ionic equation for the reaction?

$2K^+_{(aq)} + 2HCO_3{}^{2-}_{(aq)} + 2H^+_{(aq)} + SO_4{}^{2-}_{(aq).} \rightarrow 2K^+_{(aq)} + SO_4{}^{2-}_{(aq).} + 2H_2O_{(l)+}\, 2CO_{2(g)}$

$2HCO_3{}^{2-}_{(aq)} + 2H^+_{(aq)} \rightarrow 2\, H_2O_{(l)+}\, 2CO_{2(g)}$

ii. How many moles of sulfuric acid? 0.012 mol sulfuric acid

iii. How many moles of carbon dioxide are produced? 0.0154 mol carbon dioxide

iv. What is the limiting reagent? Potassium carbonate

v. What mass (if solid) or molarity (if aqueous) of excess remains after the reaction is finished? 0.0359 M sulfate

GAS/GAS PRODUCING SOLID, LIQUID, GAS, OR AQUEOUS PRODUCT

Save this problem for Chapter 10, Gases. We will solve it then.

a) The problem reads: A 15.0 mL sample of ammonia gas at 100 torr and 30. °C is mixed with 25 mL of hydrogen chloride at 150. torr and 25°C and the reaction

$NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}.$

Calculate the mass of ammonium chloride that forms. Identify the gas in excess and determine its pressure (in the combined volume of the original two flasks) at 27°C.

Broken down into parts:

i. Convert pressures to atmospheres

ii. Convert milliliters to liters

iii. Convert temperatures from Celsius to kelvin

iv. Use the ideal gas law to find the individual moles of reactants

Now you solve this:

1. Sulfur tetrafluoride (SF_4) reacts slowly with oxygen to form sulfur tetrafluoride monoxide (OSF_4) according to the following unbalanced reaction:

$$2SF_{4(g)} + O_{2(g)} \rightarrow 2OSF_{4(g)}$$

What is the mass of the OSF_4 produced after a reaction of 100.0 mL of oxygen at 25.7°C and 200.00 torr is mixed and reacted with 150. mL of sulfur tetrafluoride at 28.5°C and 300.0 torr.

Are there other types of limiting reagent problems? To give you an answer with no hedging, "Maybe, maybe not". Without overwhelming you, these examples should help you navigate many of your limiting reagent problems.