

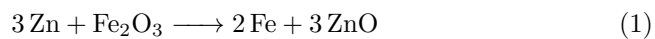
Problem Set #2
CHEM101A: General College Chemistry

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1 Topic A Problem 12

What mass of Fe_2O_3 would react with 20.00 g of Zn? The chemical equation for this reaction is:



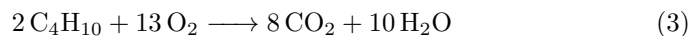
1.1 Solution

The simple stoichiometry is the way to go here.

$$20.00\text{g} \times \frac{1 \text{ mol Zn}}{65.38\text{g}} \times \frac{1 \text{ Fe}_2\text{O}_3}{3 \text{ Zn}} \times \frac{159.7 \text{ g Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} = \boxed{16.28 \text{ g Fe}_2\text{O}_3} \quad (2)$$

2 Topic A Problem 13

x moles of C_4H_{10} reacts with oxygen according to the following equation:



- a) How many moles of water are formed?
- b) How many moles of oxygen are consumed?

2.1 Solution (a)

The ratio of C_4H_{10} used to H_2O created in this reaction is 1:5. With x moles of C_4H_{10} , that would give us $\boxed{5x \text{ mol H}_2\text{O}}$.

2.2 Solution (b)

The ratio of C_4H_{10} used to O_2 consumed in this reaction is 2:13. With x moles of C_4H_{10} , that would give us $\boxed{\frac{13}{2}x \text{ mol O}_2}$.

3 Topic A Problem 14

10.00 g of N_2 is mixed with 33.61 g of F_2 , and the elements react according to the following equation:



- a) Which element is the limiting reactant?
- b) What is the theoretical yield of NF_3 ?
- c) If the reaction goes to completion, how many grams of the excess reactant will remain?
- d) Set up an ICE table for this reaction.

3.1 Solution (a)

First, we calculate the theoretical yields for each for the reactants.

$$m_{\text{N}_2} = 10.00 \text{ g} \times \frac{1 \text{ mol N}_2}{28.02 \text{ g N}_2} \times \frac{2 \text{ NF}_3}{1 \text{ N}_2} \times \frac{71.01 \text{ g NF}_3}{1 \text{ mol NF}_3} = 50.69 \text{ g NF}_3 \quad (5)$$

$$m_{\text{F}_2} = 33.61 \text{ g} \times \frac{1 \text{ mol F}_2}{38.00 \text{ g F}_2} \times \frac{2 \text{ NF}_3}{3 \text{ F}_2} \times \frac{71.01 \text{ g NF}_3}{1 \text{ mol NF}_3} = 41.87 \text{ g NF}_3 \quad (6)$$

With a lower final mass, $\boxed{\text{F}_2}$ is the limiting reactant.

3.2 Solution (b)

The theoretical yield was found in part (a). $\boxed{41.87 \text{ g NF}_3}$

3.3 Solution (c)

Use a similar strategy to part (a).

$$33.61 \text{ g} \times \frac{1 \text{ mol F}_2}{38.00 \text{ g F}_2} \times \frac{1 \text{ N}_2}{3 \text{ F}_2} \times \frac{28.02 \text{ g N}_2}{1 \text{ mol N}_2} = 8.261 \text{ g NF}_3 \quad (7)$$

Subtract this from the available mass of N_2 to get the final N_2 .

$$10.00 \text{ g N}_2 - 8.261 \text{ g N}_2 = \boxed{1.74 \text{ g N}_2} \quad (8)$$

3.4 Solution (d)

I used tabular for this table. Please excuse any poor or improper formatting.

| mol | N_2 | $+ 3 \text{F}_2$ | $\longrightarrow 2 \text{NF}_3$ |
|-----|--------------|------------------|---------------------------------|
| I | 0.3569 | 0.8844 | 0 |
| C | -0.2948 | -0.8844 | 0.5896 |
| E | 0.0621 | 0 | 0.5896 |

For those interested in how I went about getting these values, I can explain. I started with the initial mass of F_2 , which has been previously established to be the limiting reactant, and converted that to moles. I did (roughly) the same thing for the known quantity of N_2 initially. We also start with no NF_3 . Assuming the percentage yield to be 100%, every mole of F_2 would be used, so the Change row for F_2 would be the negative of the initial quantity of F_2 . Multiply that by the ratio of N_2 to F_2 ($\frac{1}{3}$) to get the Change row of N_2 . The same can be done for NF_2 , just taking the negative thereof and with a ratio of $\frac{2}{3}$ instead of $\frac{1}{3}$. With all of this, we only have to add the initial and the change together (respecting the positive or negative signs) to get the values for the End row.

4 Topic A Problem 15

- a) If 58.26 g of iodine reacts with excess aluminum, what is the theoretical yield of aluminum iodide? The reaction is $2 \text{Al} + 3 \text{I}_2 \longrightarrow 2 \text{AlI}_3$.
- b) If 56.11 g of aluminum iodide is actually formed in the reaction in part a, what is the percent yield of aluminum iodide?

4.1 Solution (a)

Watch me use the power of Stiochiometry Magic.

$$58.26 \text{ g} \times \frac{1 \text{ mol I}_2}{253.8 \text{ g I}_2} \times \frac{2 \text{ AlI}_3}{3 \text{ I}_2} \times \frac{407.68 \text{ g AlI}_3}{1 \text{ mol AlI}_3} = \boxed{62.39 \text{ g AlI}_3} \quad (9)$$

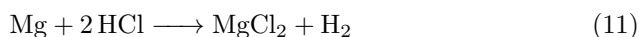
4.2 Solution (b)

Here we use the formula for the pecent yield.

$$\text{PY} = \frac{\text{AY}}{\text{TY}} \times 100\% = \frac{56.11 \text{ g}}{62.39 \text{ g}} \times 100\% = 0.8994 \times 100\% = \boxed{89.94\%} \quad (10)$$

5 Topic A Problem 16

A chemist mixes 16.00 g of HCl with 10.00 g of Mg and obtains an 81.3% yield of MgCl_2 . What mass of MgCl_2 did the chemist obtain? The chemical reaction is:



5.1 Solution

First calculate the theoretical yield of MgCl_2 in the cases of HCl and Mg being the limiting reactants.

$$MM(\text{MgCl}_2) = 24.31 \text{ g/mol} + 2 * 35.45 \text{ g/mol} = 95.21 \text{ g/mol} \quad (12)$$

$$MM(\text{HCl}) = 1.008 \text{ g/mol} + 35.45 \text{ g/mol} = 36.458 \text{ g/mol} \quad (13)$$

$$m_{\text{Mg}} = 10.00 \text{ g} \times \frac{1 \text{ mol Mg}}{24.31 \text{ g Mg}} \times \frac{1 \text{ MgCl}_2}{1 \text{ Mg}} \times \frac{95.21 \text{ g MgCl}_2}{1 \text{ mol MgCl}_2} \quad (14)$$

$$= 39.16 \text{ g MgCl}_2 \quad (15)$$

$$m_{\text{HCl}} = 16.00 \text{ g} \times \frac{1 \text{ mol HCl}}{36.458 \text{ g HCl}} \times \frac{1 \text{ MgCl}_2}{2 \text{ HCl}} \times \frac{95.21 \text{ g MgCl}_2}{1 \text{ mol MgCl}_2} \quad (16)$$

$$= 20.89 \text{ g MgCl}_2 \quad (17)$$

The latter is lower, so the HCl would be the limiting reactant and 20.89 g MgCl_2 would be the theoretical yield. Multiplying this by the (decimal version of) the percentage yield to get the actual yield.

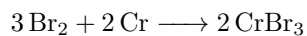
$$20.89 \text{ g MgCl}_2 * 0.813 = \boxed{17.0 \text{ g MgCl}_2} \quad (18)$$

6 Topic A Problem 17

How many milliliters of liquid Br_2 (density = 3.1 g/mL) will react with 6.143 g of Cr, if the product of this reaction is CrBr_3 ?

6.1 Solution

First write a chemical equation for this and balance it.

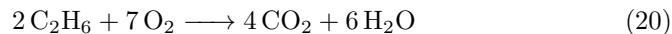


The rest of the path is paved with the magic of Stoichiometry.

$$6.143 \text{ g Cr} \times \frac{1 \text{ mol Cr}}{52.00 \text{ g Cr}} \times \frac{3 \text{ Br}_2}{2 \text{ Cr}} \times \frac{159.8 \text{ g Br}_2}{1 \text{ mol Br}_2} \times \frac{1 \text{ mL}}{3.1 \text{ g}} = \boxed{9.1 \text{ mL Br}_2} \quad (19)$$

7 Topic A Problem 18

Ethane (C_2H_6) reacts with oxygen according to the following chemical equation:

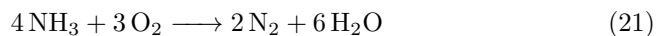


- a) If you mix 5 moles of C_2H_6 with 13 moles of O_2 , how many moles of each substance will you end up with, assuming the reaction goes to completion? Include an ICE table in your answer.
- b) If you mix 81.43 g of C_2H_6 with 194.60 g of O_2 , how many grams of each substance will you end up with, assuming the reaction goes to completion? Include an ICE table in your answer. (Note: your ICE table should be in terms of moles.)
- c) A chemist mixes 3.414 moles of O_2 with an unknown number of moles of C_2H_6 . The chemist obtains 1.657 moles of O_2 . How many moles of C_2H_6 must have been present originally, assuming the reaction went to completion? Include an ICE table in your answer.

7.1 Solution

8 Topic A Problem 19

Ammonia reacts with oxygen according to the following chemical equation:



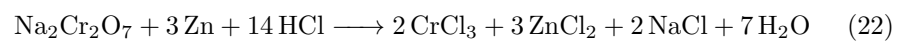
Suppose you mix x moles of NH_3 with y moles of O_2 .

- a) If NH_3 is the limiting reactant, how many moles of each substance will you end up with, assuming the reaction goes to completion? Include an ICE table in your answer.
- b) If O_2 is the limiting reactant, how many moles of each substance will you end up with, assuming the reaction goes to completion? Include an ICE table in your answer.
- c) If you end up with $0.4y$ moles of O_2 , what must the relationship be between x and y , assuming the reaction goes to completion?

8.1 Solution

9 Topic A Problem 20

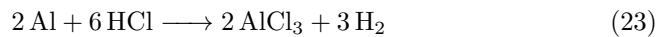
You have x grams of $\text{Na}_2\text{Cr}_2\text{O}_7$. How many grams of CrCl_3 will be formed if the $\text{Na}_2\text{Cr}_2\text{O}_7$ undergoes the reaction below? Express your answer in terms of x .



9.1 Solution

10 Topic A Problem 21

A metal sample weighing 1.410 g contains a mixture of copper and aluminum. When excess HCl is added to this sample, the aluminum reacts as follows:

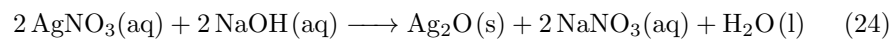


849 mL of H_2 (density 0.08264 g/L) is produced. Calculate the mass percentage of each element in the original sample. Note that copper does not react with HCl.

10.1 Solution

11 Topic A Problem 22

A chemist has a mixture of AgNO_3 and KNO_3 that weighs a total of 4.177 g. The chemist dissolves the mixture in water and then adds a solution of NaOH . The AgNO_3 reacts with the NaOH as follows:



The chemist finds that 1.080 grams of Ag_2O were formed. Calculate the mass percentages of AgNO_3 and KNO_3 in the original mixture. (Note that KNO_3 does not react with NaOH .)

11.1 Solution

12 Topic A Problem 23

A 25.000 g sample of sulfur is burned. Some of the sulfur reacts to form SO_2 :



The rest of the sulfur reacts to form SO_3 :



The total mass of products (SO_2 and SO_3) is 58.723 g. Calculate the masses of SO_2 and SO_3 in this mixture.

12.1 Solution

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