

Saturday, 12 June 2021

PLI Extra Practice for PLI #1 (Problems taken from *Chemical Principles*, Zumdahl)

1. Fill in the missing information (Note. I could not figure out how to write isotopes in word and gave up and went to bed)

Symbol	Element	Protons	Neutrons	Electrons	Charge
$^{14}_6\text{C}$	carbon	6	8	6	0
$^{235}_{92}\text{U}$	uranium	92	143	92	0
$^{32}_{16}\text{S}^{2-}$	sulfur	16	16	18	-2
$^{137}_{56}\text{Ba}^{2+}$	barium	56	81	54	+2
$^{37}_{17}\text{Cl}^{-}$	chlorine	17	20	18	-1

2. A mass spectrum tells us that 60.10% of a metal is present as  $^{69}\text{M}$ , and 39.90% is present as  $^{71}\text{M}$ . The mass values for  $^{69}\text{M}$  and  $^{71}\text{M}$  are 68.93 amu and 70.92 amu, respectively. What is the average atomic mass of the element? What is the element?

\*assume 100 atoms\*

• mass of 100 atoms  $\text{M} = \text{mass of } ^{69}\text{M} + \text{mass of } ^{71}\text{M}$

$$= (60.10 \text{ atoms})(68.93 \text{ amu}) + (39.90 \text{ atoms})(70.92 \text{ amu})$$

$$= 69.72 \text{ amu}$$

• average atomic mass of  $\text{M} = \text{mass of 1 atom of M}$

$$\rightarrow \frac{\text{mass of 100 atoms M}}{100 \text{ atom}} \Rightarrow \frac{69.72 \text{ amu}}{100 \text{ atoms}} = \boxed{69.72 \text{ amu/atom}} = \underline{\text{Ga, gallium}}$$

3. Indium exists as two isotopes.  $^{113}\text{In}$  has a mass of 112.9043 amu, and  $^{115}\text{In}$  has a mass of 114.9041 amu. The average atomic mass of indium is 114.82 amu. Calculate the percent relative abundance of the two isotopes of indium.

use system of equations for % abundance!

$$\begin{array}{c} x + y = 1 \\ \swarrow \quad \searrow \\ ^{113}\text{In} \quad ^{115}\text{In} \end{array} \quad y = 1 - x$$

$$112.9043x + 114.9041y = 114.82$$

$$112.9043x + 114.9041(1-x) = 114.82$$

$$112.9043x + 114.9041 - 114.9041x = 114.82 \Rightarrow -0.0841 = -1.9998x$$

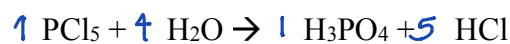
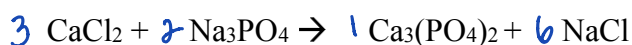
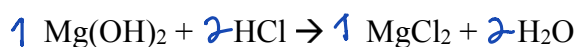
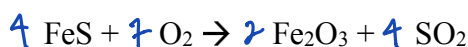
$$x = 0.042 \quad 0.042 \times 100\% = 4.2\% \quad , \quad 100 - 4.2 = 95.8$$

$$\boxed{^{113}\text{In} = 4.2\%}$$

$$\boxed{^{115}\text{In} = 95.8\%}$$

## 4. Strategies for balancing equations:

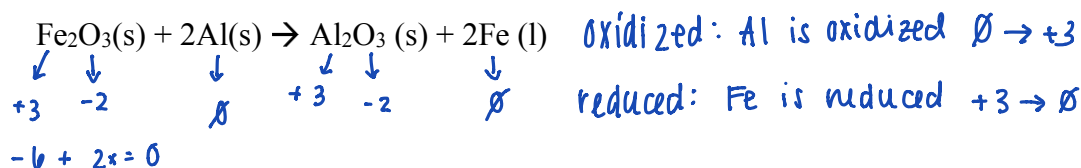
- Find atoms that are only in one compound on the reactant side; balance those first.
- Generally, leave oxygen and hydrogen until the end. They appear many times, and balancing other atoms will often force O and H to become balanced.
- Double check after balancing.



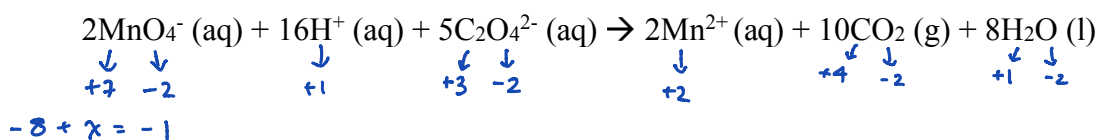
## 5. Oxidation-Reduction:

- OIL RIG  $\rightarrow$  oxidation involves loss of electrons (increase in charge), reduction involves gain of electrons (decrease in charge)
- Something that is reduced is called an oxidizing agent. Something that is oxidized is called a reducing agent.

Assign oxidation states to each atom in the following equation. Then state which elements have been reduced/oxidized and list the oxidizing and reducing agents.



-  $\text{Fe}_2\text{O}_3$  is oxidizing agent  
 - Al is reducing agent



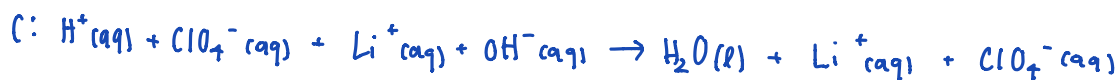
oxidized: C in  $\text{C}_2\text{O}_4^{2-}$  is oxidized  $+3 \rightarrow +4$   $\therefore \text{C}_2\text{O}_4^{2-}$  is reducing agent  
 reduced: Mn in  $\text{MnO}_4^-$  is reduced  $+7 \rightarrow +2$   $\therefore \text{MnO}_4^-$  is oxidizing agent

6. Write the molecular, complete ionic, and net ionic forms for the following equations:

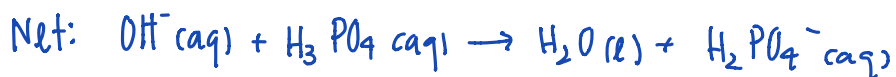
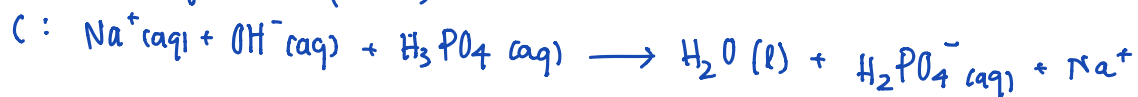
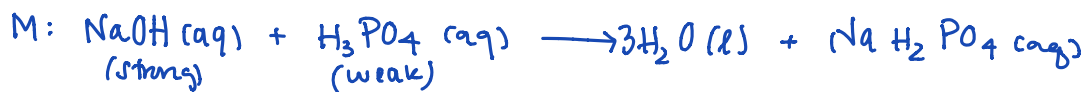
a. Aqueous acetic acid reacts with aqueous ammonia.



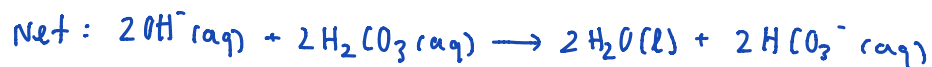
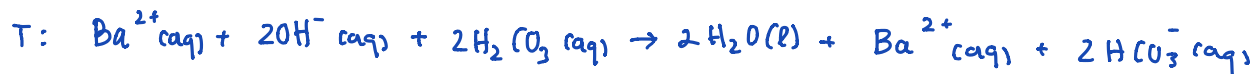
b. Aqueous perchloric acid reacts with aqueous lithium hydroxide.



c. Aqueous sodium hydroxide reacts with aqueous phosphoric acid.



d. Aqueous barium hydroxide reacts with aqueous carbonic acid.



# Step 1 - balanced chemical equation

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7. Sodium hydroxide reacts with phosphoric acid to give sodium phosphate and water. If 17.80g of NaOH is mixed with 15.40g of  $\text{H}_3\text{PO}_4$ : 1. How many grams of  $\text{Na}_3\text{PO}_4$  can be formed, 2. How many grams of excess reactant remains unreacted, 3. If actual yield of  $\text{Na}_3\text{PO}_4$  was 15.00g, what is the percent yield of  $\text{Na}_3\text{PO}_4$ ? *\*NB: treat  $\text{H}_3\text{PO}_4$  like strong acid here\**

$$(1) 17.80 \text{ g NaOH} \times \frac{1 \text{ mol NaOH}}{40 \text{ g NaOH}} \times \frac{1 \text{ mol Na}_3\text{PO}_4}{3 \text{ mol NaOH}} \times \frac{163.94 \text{ g Na}_3\text{PO}_4}{1 \text{ mol Na}_3\text{PO}_4} = \boxed{24.32 \text{ g Na}_3\text{PO}_4 \text{ made}}^*$$

or \*NaOH = limiting reactant

$$15.40 \text{ g H}_3\text{PO}_4 \times \frac{1 \text{ mol H}_3\text{PO}_4}{98.00 \text{ g H}_3\text{PO}_4} \times \frac{1 \text{ mol Na}_3\text{PO}_4}{1 \text{ mol H}_3\text{PO}_4} \times \frac{163.94 \text{ g Na}_3\text{PO}_4}{1 \text{ mol Na}_3\text{PO}_4} = 25.76 \text{ g Na}_3\text{PO}_4 \text{ made}$$

$$(2) 24.32 \text{ g Na}_3\text{PO}_4 \times \frac{1 \text{ mol Na}_3\text{PO}_4}{163.94 \text{ g Na}_3\text{PO}_4} \times \frac{1 \text{ mol H}_3\text{PO}_4}{1 \text{ mol Na}_3\text{PO}_4} = 0.1483 \text{ mol H}_3\text{PO}_4 \text{ used}$$

$$15.40 \text{ g H}_3\text{PO}_4 \times \frac{1 \text{ mol H}_3\text{PO}_4}{98.00 \text{ g H}_3\text{PO}_4} = 0.1571 \text{ mol H}_3\text{PO}_4 \text{ originally present} \therefore 0.0088 \text{ mol in excess!} =$$

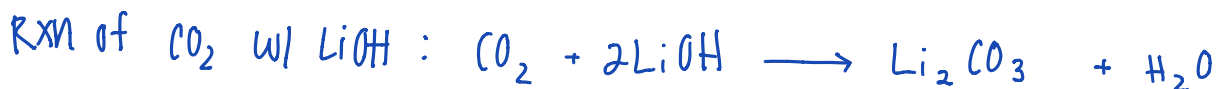
$$0.0088 \text{ mol H}_3\text{PO}_4 \times \frac{98 \text{ g}}{1 \text{ mol H}_3\text{PO}_4} = \boxed{0.86 \text{ g H}_3\text{PO}_4 \text{ in excess}}$$

$$(3) \% \text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100\% \rightarrow \frac{15.00 \text{ g}}{24.32 \text{ g}} \times 100\% = \boxed{61.68\% \text{ yield}}$$

8. The Space Shuttle environmental control system handles excess  $\text{CO}_2$  (which the astronauts breathe out—it is 4% by mass of exhaled air) by reacting it with LiOH pellets to form lithium carbonate and water. If there are 7 astronauts on board the shuttle and each exhales 20 liters of air per minute, how long could clean air be generated if there were 25,000g of LiOH pellets available for each shuttle mission? Assume density of air is 0.0010g/mL.

$$20 \text{ L} = 20000 \text{ mL}$$

$$\frac{0.0010 \text{ g air}}{1 \text{ mL}} \times \frac{20,000 \text{ mL air}}{\text{min} \cdot \text{astronaut}} \times (7 \text{ astronauts}) \times \frac{4 \text{ g CO}_2}{100 \text{ g air}} = 5.6 \text{ g CO}_2/\text{min}$$



$$2.5 \times 10^4 \text{ g LiOH} \times \frac{1 \text{ mol LiOH}}{23.94 \text{ g LiOH}} \times \frac{1 \text{ mol CO}_2}{2 \text{ mol LiOH}} \times \frac{44.01 \text{ g CO}_2}{1 \text{ mol CO}_2} = 22,971 \text{ g CO}_2$$

$$22,971 \text{ g CO}_2 \times \frac{1 \text{ min}}{5.6 \text{ g CO}_2} \times \frac{1 \text{ hour}}{60 \text{ min}} \times \frac{1 \text{ day}}{24 \text{ hr}} = \boxed{2.8 \text{ days of clean air}}$$

9. Predict the products of and balance the following precipitation reactions:



10. What mass of  $\text{Fe}(\text{OH})_3$  is produced with 35mL of a 0.250M  $\text{Fe}(\text{NO}_3)_3$  solution is mixed with 55mL of a 0.180M  $\text{KOH}$  solution?

Step 1: write balanced chemical equation!  
 $\text{Fe}(\text{NO}_3)_3(\text{aq}) + 3\text{KOH}(\text{aq}) \rightarrow 3\text{KNO}_3(\text{aq}) + \text{Fe}(\text{OH})_3(\text{s})$

Before rxn:

$$0.035\text{ L} \times \frac{0.250\text{ mol Fe}(\text{NO}_3)_3}{1\text{ L}} = 0.00875\text{ mol Fe}(\text{NO}_3)_3$$

$$0.055\text{ L} \times \frac{0.180\text{ mol KOH}}{1\text{ L}} = 0.0099\text{ mol KOH}$$

Determine Limiting Reactant

$$0.00875\text{ mol Fe}(\text{NO}_3)_3 \times \frac{1\text{ mol Fe}(\text{OH})_3}{1\text{ mol Fe}(\text{NO}_3)_3} = 0.00875\text{ mol Fe}(\text{OH})_3$$

- vs -

$$0.0099\text{ mol KOH} \times \frac{1\text{ mol Fe}(\text{OH})_3}{3\text{ mol KOH}} = 0.0033\text{ mol Fe}(\text{OH})_3 = \text{LR}$$

$$0.0033\text{ mol Fe}(\text{OH})_3 \times \frac{106.9\text{ g}}{1\text{ mol Fe}(\text{OH})_3} = \boxed{0.353\text{ g Fe}(\text{OH})_3}$$

11. You want to determine the molar mass of an acid. The acid contains one acidic hydrogen per molecule. You weigh out a 2.879g sample of the pure acid and dissolve it, along with 3 drops of phenolphthalein indicator, in distilled water. You titrate the sample with 0.1704M NaOH. The pink endpoint is reached after addition of 42.55mL of base. Calculate the molar mass of the acid. \*remember molar mass = g/mol\*



(1) determine mols of base used:

$$0.04255 \text{ L NaOH} \times \frac{0.1704 \text{ mol NaOH}}{1 \text{ L}} = 7.251 \times 10^{-3} \text{ mol NaOH used} = \text{mols } OH^-$$

(2) now determine mols of HA present that reacted completely...

$$1:1 \text{ mol ratio of acid: base} \quad \therefore 7.251 \times 10^{-3} \text{ mol HA} = 2.879 \text{ g HA}$$

$$\text{molar mass of acid} = \frac{2.879 \text{ g}}{7.251 \times 10^{-3} \text{ mol}} = \boxed{397.1 \text{ g/mol}}$$

## 12. Redox titration:

- a. Strategy: 1. Balance the redox equation (we recommend using the half reaction method. Good videos on youtube are Organic Chemistry Tutor and Khan Academy), 2. Determine moles of titrant, 3. Use balanced redox equation to determine moles of unknown and then convert to grams, percent, molarity, etc.

A 0.0483M  $\text{KMnO}_4$  solution was used to titrate a solution containing 0.8329g of impure calcium oxalate,  $\text{CaC}_2\text{O}_4$ . If 30.25mL of the  $\text{KMnO}_4$  solution was required to reach the titration endpoint, calculate the percent purity of the  $\text{CaC}_2\text{O}_4$ . This reaction takes place in acidic solution.



$$0.03025 \text{ L} \times \frac{0.0483 \text{ mol MnO}_4^-}{1 \text{ L}} = 1.46 \times 10^{-3} \text{ mol MnO}_4^- \text{ used}$$

$$1.46 \times 10^{-3} \text{ mol MnO}_4^- \times \frac{5 \text{ mol C}_2\text{O}_4^{2-}}{2 \text{ mol MnO}_4^-} = 0.00365 \text{ mol C}_2\text{O}_4^{2-} \text{ used}$$

$$0.00365 \text{ mol C}_2\text{O}_4^{2-} \times \frac{1 \text{ mol CaC}_2\text{O}_4}{1 \text{ mol C}_2\text{O}_4^{2-}} \times \frac{128.10 \text{ g CaC}_2\text{O}_4}{1 \text{ mol CaC}_2\text{O}_4} = 0.467 \text{ g CaC}_2\text{O}_4 \text{ in sample}$$

$$\frac{0.467 \text{ g CaC}_2\text{O}_4}{0.8329 \text{ g crude sample}} \times 100\% = \boxed{56.2\% \text{ CaC}_2\text{O}_4}$$