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
$^{14}_{6}C$	carbon	6	8	6	Ø
$^{235}_{92}U$	uranium	92	143	92	Ø
$^{32}_{16}S^{2-}$	sulfur	16	16	18	-2
$^{137}_{56}Ba^{2+}$	barium	56	81	54	+2
$^{37}_{17}Cl^{-}$	chlorine	17	20	18	-1

2. A mass spectrum tells us that 60.10% of a metal is present as ^{69}M, and 39.90% is present as ^{71}M. The mass values for ^{69}M and ^{71}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 M = mass of ^{69}M + mass of ^{71}M

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

$= 6972 \text{ amu}$

· average atomic mass of M = mass of 1 atom of M

$\rightarrow \frac{\text{mass of 100 atoms M}}{\text{100 atom}} \Rightarrow \frac{6972 \text{ amu}}{100 \text{ atoms}} = \boxed{69.72 \text{ amu/atom}}$ = Ga, gallium

3. Indium exists as two isotopes. ^{113}In has a mass of 112.9043 amu, and ^{115}In has a mass of 114.9041amu. 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!

$x + y = 1$ (x: ^{113}In, y: ^{115}In) $\quad y = 1 - x$

$112.9043x + 114.9041y = 114.82$

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

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

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

$^{113}In = 4.2\%$

$^{115}In = 95.8\%$

4. Strategies for balancing equations:
    a. Find atoms that are only in one compound on the reactant side; balance those first.
    b. 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.
    c. Double check after balancing.

$\underline{2}$ Ca + $\underline{2}$ C + $\underline{3}$ O_2 → $\underline{2}$ $CaCO_3$

$\underline{4}$ FeS + $\underline{7}$ O_2 → $\underline{2}$ Fe_2O_3 + $\underline{4}$ SO_2

$\underline{1}$ $Mg(OH)_2$ + $\underline{2}$ HCl → $\underline{1}$ $MgCl_2$ + $\underline{2}$ H_2O

$\underline{3}$ $CaCl_2$ + $\underline{2}$ Na_3PO_4 → $\underline{1}$ $Ca_3(PO_4)_2$ + $\underline{6}$ NaCl

$\underline{1}$ PCl_5 + $\underline{4}$ H_2O → $\underline{1}$ H_3PO_4 + $\underline{5}$ HCl

5. Oxidation-Reduction:
    a. OIL RIG→ oxidation involves loss of electrons (increase in charge), reduction involves gain of electrons (decrease in charge)
    b. 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.

$Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(l)$

+3 −2 | 0 | +3 −2 | 0

$-6 + 2x = 0$

oxidized: Al is oxidized 0 → +3

reduced: Fe is reduced +3 → 0

- Fe_2O_3 is oxidizing agent
- Al is reducing agent

$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

+7 −2 | +1 | +3 −2 | +2 | +4 −2 | +1 −2

$-8 + x = -1$

oxidized: C in $C_2O_4^{2-}$ is oxidized +3 → +4 ∴ $C_2O_4^{2-}$ is reducing agent

reduced: Mn in MnO_4^- is reduced +7 → +2 ∴ 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.

M: $CH_3COOH\ (aq)$ (weak) + $NH_3\ (aq)$ (weak) $\rightleftharpoons$ $NH_4^+\ (aq) + CH_3COO^-\ (aq)$

T: " "

Net: " "

   b. Aqueous perchloric acid reacts with aqueous lithium hydroxide.

M: $HClO_4\ (aq) + LiOH\ (aq) \longrightarrow H_2O\ (l) + LiClO_4\ (aq)$

C: $H^+\ (aq) + ClO_4^-\ (aq) + Li^+\ (aq) + OH^-\ (aq) \rightarrow H_2O\ (l) + Li^+\ (aq) + ClO_4^-\ (aq)$

Net: $H^+\ (aq) + OH^-\ (aq) \rightarrow H_2O\ (l)$

   c. Aqueous sodium hydroxide reacts with aqueous phosphoric acid.

M: $NaOH\ (aq)$ (strong) + $H_3PO_4\ (aq)$ (weak) $\longrightarrow 3H_2O\ (l) + NaH_2PO_4\ (aq)$

C: $Na^+\ (aq) + OH^-\ (aq) + H_3PO_4\ (aq) \longrightarrow H_2O\ (l) + H_2PO_4^-\ (aq) + Na^+$

Net: $OH^-\ (aq) + H_3PO_4\ (aq) \rightarrow H_2O\ (l) + H_2PO_4^-\ (aq)$

   d. Aqueous barium hydroxide reacts with aqueous carbonic acid.

M: $Ba(OH)_2\ (aq)$ strong + $2H_2CO_3\ (aq)$ weak $\longrightarrow 2H_2O\ (l) + Ba(HCO_3)_2\ (aq)$

T: $Ba^{2+}\ (aq) + 2OH^-\ (aq) + 2H_2CO_3\ (aq) \rightarrow 2H_2O\ (l) + Ba^{2+}\ (aq) + 2HCO_3^-\ (aq)$

Net: $2OH^-\ (aq) + 2H_2CO_3\ (aq) \longrightarrow 2H_2O\ (l) + 2HCO_3^-\ (aq)$

step 1 - balanced chemical equation

$$3\,NaOH\,(aq) + H_3PO_4\,(aq) \longrightarrow 3H_2O\,(l) + Na_3PO_4\,(aq)$$

7. Sodium hydroxide reacts with phosphoric acid to give sodium phosphate and water. If 17.80g of NaOH is mixed with 15.40g of H_3PO_4: 1. How many grams of Na_3PO_4 can be formed, 2. How many grams of excess reactant remains unreacted, 3. If actual yield of Na_3PO_4 was 15.00g, what is the percent yield of Na_3PO_4? *NB: treat H_3PO_4 like strong acid here*

(1) $17.80\,g\,NaOH \times \frac{1\,mol\,NaOH}{40\,g\,NaOH} \times \frac{1\,mol\,Na_3PO_4}{3\,mol\,NaOH} \times \frac{163.94\,g\,Na_3PO_4}{1\,mol\,Na_3PO_4} = \boxed{24.32\,g\,Na_3PO_4\ \text{made}}$ ✗

or * NaOH = limiting reactant

$15.40\,g\,H_3PO_4 \times \frac{1\,mol\,H_3PO_4}{98.00\,g\,H_3PO_4} \times \frac{1\,mol\,Na_3PO_4}{1\,mol\,H_3PO_4} \times \frac{163.94\,g\,Na_3PO_4}{1\,mol\,Na_3PO_4} = 25.76\,g\,Na_3PO_4$ made

(2) $24.32\,g\,Na_3PO_4 \times \frac{1\,mol\,Na_3PO_4}{163.94\,g\,Na_3PO_4} \times \frac{1\,mol\,H_3PO_4}{1\,mol\,Na_3PO_4} = 0.1483\,mol\,H_3PO_4$ used

$15.40\,g\,H_3PO_4 \times \frac{1\,mol\,H_3PO_4}{98.00\,g\,H_3PO_4} = 0.1571\,mol\,H_3PO_4$ originally present ∴ 0.0088 mol in excess! =

$0.0088\,mol\,H_3PO_4 \times \frac{98\,g}{1\,mol\,H_3PO_4} = \boxed{0.86\,g\,H_3PO_4\ \text{in excess}}$

(3) % yield : $\frac{\text{actual}}{\text{theoret.}} \times 100\%$ → $\frac{15.00\,g}{24.32\,g} \times 100\% = \boxed{61.68\%\ \text{yield}}$

8. The Space Shuttle environmental control system handles excess 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 L = 20000 mL

$\frac{0.0010\,g\,air}{1\,mL} \times \frac{20{,}000\,mL\,air}{min \cdot astronaut} \times (7\ astronauts) \times \frac{4\,g\,CO_2}{100\,g\,air} = 5.6\,g\,CO_2/min$

Rxn of CO_2 w/ LiOH : $CO_2 + 2LiOH \longrightarrow Li_2CO_3 + H_2O$

$2.5 \times 10^4\,g\,LiOH \times \frac{1\,mol\,LiOH}{23.949\,g\,LiOH} \times \frac{1\,mol\,CO_2}{2\,mol\,LiOH} \times \frac{44.01\,g\,CO_2}{1\,mol\,CO_2} = 22{,}971\,g\,CO_2$

$22{,}971\,g\,CO_2 \times \frac{1\,min}{5.6\,g\,CO_2} \times \frac{1\,hour}{60\,min} \times \frac{1\,day}{24\,hr} = \boxed{2.8\ \text{days of clean air}}$

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

a. $2KCl(aq) + Pb(NO_3)_2(aq) \rightarrow 2KNO_3\ (aq) + PbCl_2\ (s)$

b. $2AgNO_3(aq) + MgBr_2(aq) \rightarrow 2AgBr\ (s) + Mg(NO_3)_2\ (aq)$

10. What mass of $Fe(OH)_3$ is produced with 35mL of a 0.250M $Fe(NO_3)_3$ solution is mixed with 55mL of a 0.180M KOH solution?

Step 1: write balanced chemical equation! : $Fe(NO_3)_3\ (aq) + 3KOH\ (aq) \longrightarrow 3KNO_3\ (aq) + Fe(OH)_3\ (s)$

Before rxn:

$0.035\,L \times \frac{0.250\ mol\ Fe(NO_3)_3}{1\,L} = 0.00875\ mol\ Fe(NO_3)_3$

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

Determine Limiting Reactant

$0.00875\ mol\ Fe(NO_3)_3 \times \frac{1\ mol\ Fe(OH)_3}{1\ mol\ Fe(NO_3)_3} = 0.00875\ mol\ Fe(OH)_3$

- vs -

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

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

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 *

$HA + NaOH \longrightarrow H_2O + NaA$ OR $H^+ + OH^- \rightarrow H_2O$

(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 mol ratio of acid : base $\therefore$ 7.251×10^{-3} mol HA = 2.879g 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 $KMnO_4$ solution was used to titrate a solution containing 0.8329g of impure calcium oxalate, CaC_2O_4. If 30.25mL of the $KMnO_4$ solution was required to reach the titration endpoint, calculate the percent purity of the CaC_2O_4. This reaction takes place in acidic solution.

$$MnO_4^-(aq) + C_2O_4^{2-}(aq) \rightarrow Mn^{2+}(aq) + CO_{2(g)} \text{ (Unbalanced)}$$

balanced: $2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H_3O^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 24H_2O(l)$

$0.03025\ L \times \frac{0.0483\ mol\ MnO_4^-}{1L} = 1.46\times10^{-3}\ mol\ MnO_4^-$ used

$1.46\times10^{-3}\ mol\ MnO_4^- \times \frac{5\ mol\ C_2O_4^{2-}}{2\ mol\ MnO_4^-} = 0.00365\ mol\ C_2O_4^{2-}$ used

$0.00365\ mol\ C_2O_4^{2-} \times \frac{1\ mol\ CaC_2O_4}{1\ mol\ C_2O_4^{2-}} \times \frac{128.10g\ CaC_2O_4}{1\ mol\ CaC_2O_4} = 0.467\ g\ CaC_2O_4$ in sample

$\frac{0.467\ g\ CaC_2O_4}{0.8329\ g\ crude\ sample} \times 100\% = \boxed{56.2\%\ CaC_2O_4}$