

CHEM 103

R&R—extra Exam 1 practice :)

7 June 2024

Adapted from a 12 June 2021 document

1. Fill in the missing information.

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}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?

$$\text{average mass} = (.6010)(68.93 \text{ amu}) + (.3990)(70.92 \text{ amu}) = 69.72 \text{ amu}$$

Element is Gallium

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

Let x, y be abundance of ^{113}In , ^{115}In respectively.

$$x + y = 1; \quad (112.9043 \text{ amu})x + (114.9041 \text{ amu})y = 114.82 \text{ amu}$$

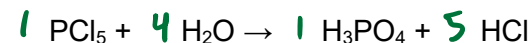
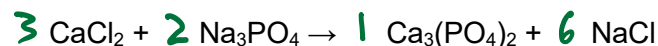
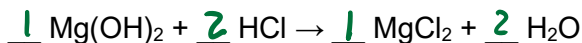
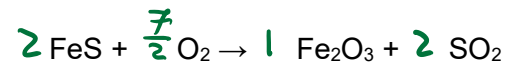
$$\begin{aligned} \swarrow \\ x = 1 - y \end{aligned} \quad 112.9043(1 - y) + 114.9041y = 114.82 \Rightarrow \underbrace{(114.9041 - 112.9043)}_{1.9998}y = \underbrace{114.82 - 112.9043}_{1.9157}$$

$$y = 95.8\% \rightarrow ^{115}\text{In}$$

$$x = 4.2\% \rightarrow ^{113}\text{In}$$

4. Strategies for balancing equations:

- Find atoms that are only in one compound on one 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.

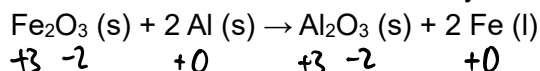


5. Oxidation-Reduction (AKA "Redox")

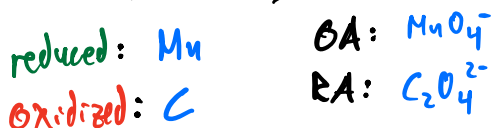
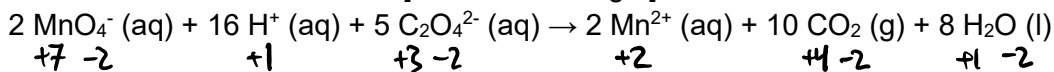
- OIL RIG \rightarrow oxidation is losing (electrons), reduction is gaining (electrons).
- LEO the lion goes "GER" \rightarrow Losing Electrons = Oxidation;
Gaining Electrons = Reduction.
- Something that is reduced is called an *oxidizing agent*. Something that is oxidized is called a *reducing agent*. (What the agent is doing to whatever it reacts with?)

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.

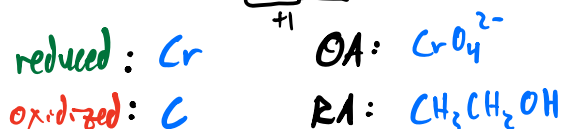
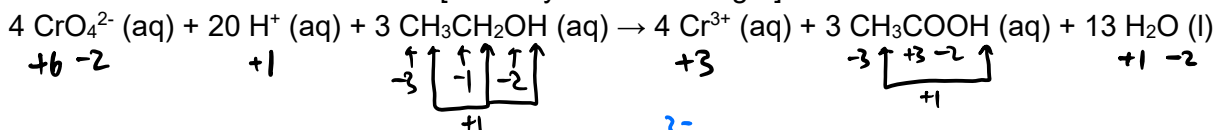
["thermite reaction" often used for railway welding!]



[cool color change!]

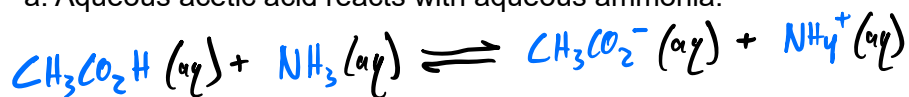


[bad way to make vinegar]



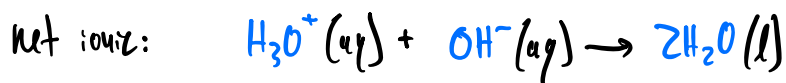
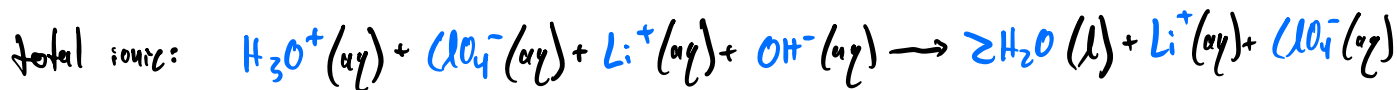
6. Write the molecular, total ionic, and net ionic forms for the following equations:

a. Aqueous acetic acid reacts with aqueous ammonia.

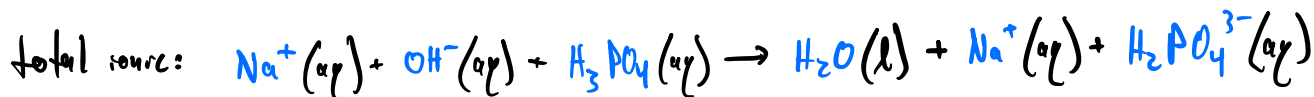


total ionic is same
net ionic is same

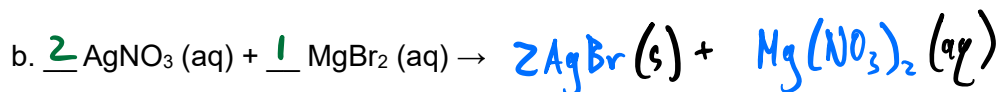
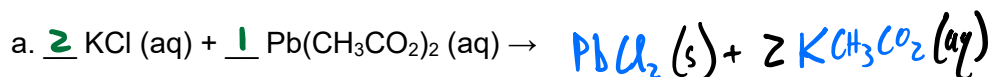
b. Aqueous perchloric acid reacts with aqueous lithium hydroxide.



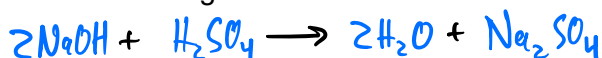
c. Aqueous sodium hydroxide reacts with aqueous phosphoric acid.



7. Predict the products and balance the following reactions:



8. Sodium hydroxide reacts with sulfuric acid to give sodium sulfate and water. If 17.80 g NaOH is mixed with 15.40 g H₂SO₄,



a. How many grams of Na₂SO₄ can be formed?

$$\begin{array}{l} 17.80 \text{ g NaOH} \cdot \frac{\text{mol NaOH}}{39.997 \text{ g NaOH}} = 0.4450 \text{ mol NaOH} \\ 15.40 \text{ g H}_2\text{SO}_4 \cdot \frac{\text{mol H}_2\text{SO}_4}{98.078 \text{ g H}_2\text{SO}_4} = 0.1570 \text{ mol H}_2\text{SO}_4 \end{array} \quad \left| \quad \begin{array}{l} 0.1570 \text{ mol Na}_2\text{SO}_4 \cdot \frac{142.042 \text{ g H}_2\text{SO}_4}{\text{mol}} \\ = 22.30 \text{ g Na}_2\text{SO}_4 \end{array} \right.$$

Limiting reactant

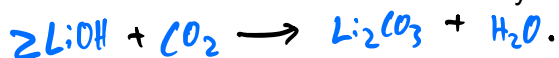
b. How many grams of excess reactant remains unreacted?

$$\begin{aligned} \text{Remaining: } & (0.4450 \text{ mol NaOH} - 2 \cdot 0.1570 \text{ mol NaOH}) \cdot \frac{39.997 \text{ g NaOH}}{\text{mol NaOH}} \\ & = 5.240 \text{ g NaOH} \end{aligned}$$

c. If the actual yield of Na₂SO₄ was 15.00 g, what is the percent yield of Na₂SO₄?

$$\frac{15.00 \text{ g Na}_2\text{SO}_4}{22.30 \text{ g Na}_2\text{SO}_4} = 67.26 \% \text{ yield}$$

9. The Space Shuttle environmental system handles excess CO₂ (which the astronauts breathe out—it is 4% of exhaled air by mass) by reacting it with LiOH pellets to form lithium carbonate and water. If there are seven 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 kg of LiOH pellets available for each shuttle mission? Assume the density of air is 0.0010 g/mL.



$$\begin{aligned} & 25000 \text{ g LiOH} \cdot \frac{\text{mol LiOH}}{23.948 \text{ g LiOH}} \cdot \frac{\text{mol CO}_2}{2 \text{ mol LiOH}} \cdot \frac{44.01 \text{ g CO}_2}{\text{mol CO}_2} \cdot \frac{100 \text{ g air}}{4 \text{ g CO}_2} \cdot \frac{\text{mL}}{0.0010 \text{ g}} \cdot \frac{\text{L}}{1000 \text{ mL}} \\ & = 574291 \text{ L air} \end{aligned}$$

$$574291 \text{ L air} \cdot \frac{\text{min}}{140 \text{ L air}} = 4100 \text{ min (approx. 68 hours)}$$

10. What mass of $\text{Fe}(\text{OH})_3$ is produced when 35.0 mL of 0.250 M $\text{Fe}(\text{NO}_3)_3$ solution is mixed with 55.0 mL of 0.180 M KOH solution?

$$(35.0 \text{ mL})(0.250 \text{ M Fe}(\text{NO}_3)_3) \cdot \frac{\text{mol Fe}^{3+}}{\text{mol Fe}(\text{NO}_3)_3} = 8.75 \text{ mmol Fe}^{3+}$$

$$(55.0 \text{ mL})(0.180 \text{ M KOH}) \cdot \frac{\text{mol OH}^-}{\text{mol KOH}} = 9.90 \text{ mmol OH}^- \quad \text{limiting reactant}$$

$$9.90 \text{ mmol OH}^- \cdot \frac{\text{mol Fe}(\text{OH})_3}{3 \text{ mol OH}^-} \cdot \frac{106.866 \text{ g Fe}(\text{OH})_3}{\text{mol Fe}(\text{OH})_3} = 0.353 \text{ g Fe}(\text{OH})_3$$

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

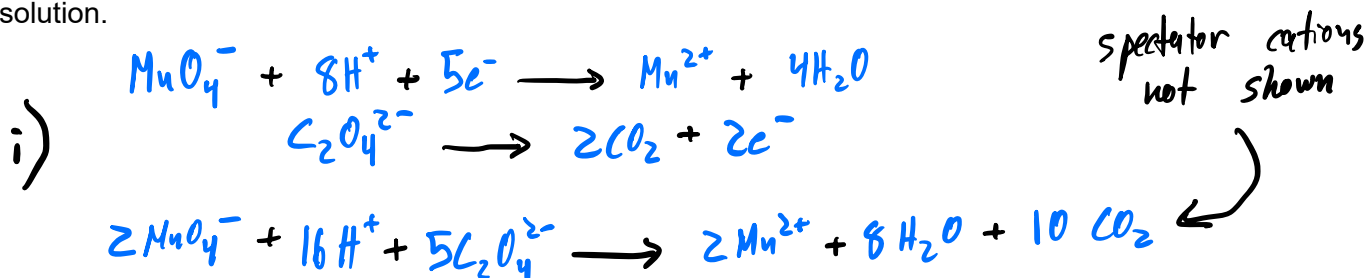
$$(42.55 \text{ mL})(0.1704 \text{ M NaOH}) \cdot \frac{\text{mol acid}}{\text{mol NaOH}} = 7.2505 \text{ mmol acid}$$

$$\frac{2.879 \text{ g}}{7.2505 \times 10^{-3} \text{ mol}} = 397.1 \frac{\text{g}}{\text{mol}}$$

12. Redox titration strategy:

- Balance the redox equation (recommended: half-reaction method)
- Determine moles of titrant
- Use balanced redox equation to determine moles of unknown
- Convert moles of unknown to whichever quantity is requested

A 0.0483 M KMnO_4 solution was used to titrate a solution containing 0.8329 g impure calcium oxalate, CaC_2O_4 . If 30.25 mL 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.



ii) $(30.25 \text{ mL})(0.0483 \text{ M MnO}_4^-) = 1.461 \text{ mmol MnO}_4^-$

iii, iv) $1.461 \text{ mmol MnO}_4^- \cdot \frac{5 \text{ mol CaC}_2\text{O}_4}{2 \text{ mol MnO}_4^-} \cdot \frac{128.10 \text{ g CaC}_2\text{O}_4}{\text{mol CaC}_2\text{O}_4} = 467.9 \text{ mg CaC}_2\text{O}_4$

$$\frac{467.9 \text{ mg CaC}_2\text{O}_4}{832.9 \text{ mg sample}} = 56.2\% \text{ CaC}_2\text{O}_4$$