## Last Week

we are currently in Chapter 7

- on Acid/Base
  - Recognize Acid/Base Rxns
- Stoichiometry of reactions
  - % yield
  - limiting reagent

} today

- RedOx oxidation/Reduction } today

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* - Gas Laws
  - Energy & Equilibrium
* - Acid Base
  - pH

} Tuesday ↓ Thursday

— Open Final Exam Wednesday night → Sat night
Same structure as last exam
also a few questions that need to be done on paper & submitted as pdf.
ex. Solubility question

- Everything needs to be turned in by Sat night

# Reaction Stoichiometry

Ex How many grams of Carbon dioxide are obtained when 132.7 g of octane are burned? (Combustion)
(Octane = $C_8H_{18}$ Carbon dioxide = $CO_2$)

① Balanced Chem Eq

$$2\left\{C_8H_{18} + \frac{25}{2}O_2 \longrightarrow 8CO_2 + 9H_2O\right\}$$

C 8 — C ✗ 8
H 18 — H ✗ 18
O ✗ 25 — O ✗ ✗ 25

Molar Ratios

$$2\,C_8H_{18} + 25\,O_2 \longrightarrow 16\,CO_2 + 18\,H_2O$$

132.7 g — ? g

② Parce problem using the eq as a template

③ Road Map

g A → mole A → mole B → g B

g $C_8H_{18}$ —(molar mass $C_8H_{18}$)→ mole $C_8H_{18}$ —(?)→ mole $CO_2$ —(molar mass $CO_2$)→ g $CO_2$

2 mole $C_8H_{18}$ = 16 mole $CO_2$

④ Any molar masses

$C_8H_{18}$ = $8 \times 12.01 + 18 \times 1.008 =$

$$\begin{array}{r} 96.08 \\ +\ 18.144 \\ \hline 114.224 \end{array} = 114.22\ g/mole$$

$CO_2$ = $12.01 + 2 \times 16.00$

$$\begin{array}{r} 12.01 \\ 32.00 \\ \hline 44.01 \end{array} = 44.01\ g/mole$$

⑤ Calculation

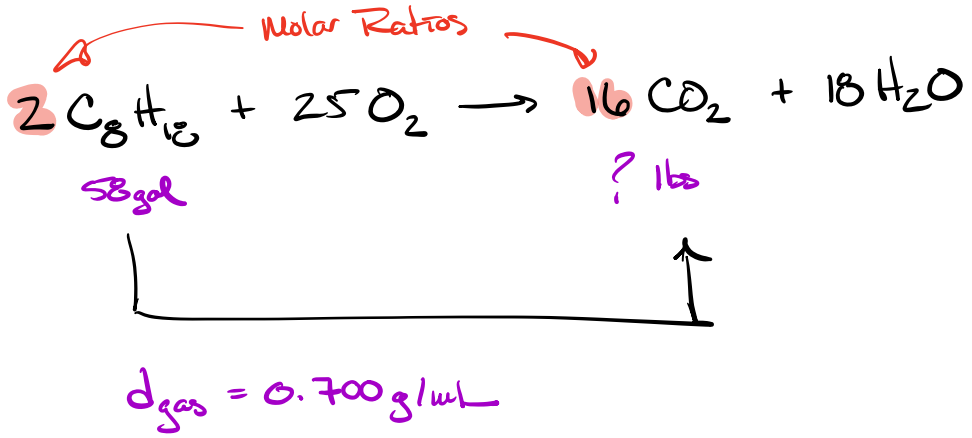
Exact Coefficients

$$4\ 132.7\ g\ C_8H_{18} \times \frac{1\ mole\ C_8H_{18}}{114.22\ g\ C_8H_{18}} \times \frac{16\ mole\ CO_2}{2\ mole\ C_8H_{18}} \times \frac{4\ 44.01\ g\ CO_2}{1\ mole\ CO_2} =$$

5

409.044090 g $CO_2$

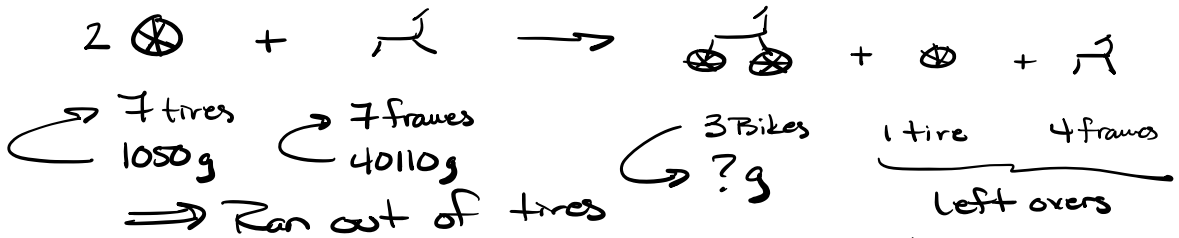
= 409.0 g $CO_2$ produced




gal $C_8H_{18}$ → L $C_8H_{18}$ → mL $C_8H_{18}$ → g $C_8H_{18}$ → mole $C_8H_{18}$ → mole $CO_2$

lbs $CO_2$ ← g $CO_2$

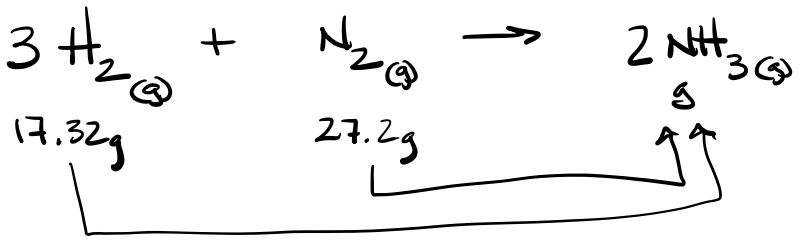
## Limiting Reagent Problem




⇒ Ran out of tires

⇒ Tires are the limiting Reagent

They limit how much product you can make.




If 17.32g $H_2$ is reacted with 27.2 g $N_2$, how many grams of $NH_3$ can be produced? What was the limiting reagent?

2 Road Maps & 2 Stoichiometry problems

Road Map

g $N_2$ → (molar mass $N_2$) → mole $N_2$ → (Ratios) → Mole $NH_3$ → (molar mass $NH_3$) → g $NH_3$

g $H_2$ → (molar mass $H_2$) → mole $H_2$ → (Ratios) → mole $NH_3$ → (molar mass of $NH_3$) → g $NH_3$

which is Smaller

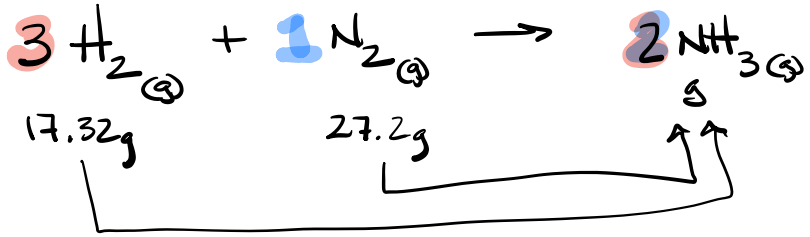
The Smaller one Came from the Limiting Reagent

Molar Masses

$N_2$ = 2 x 14.01 g/mole = 28.02 g/mole

$H_2$ = 2 x 1.008 = 2.016 g/mole

$NH_3$ = 14.01 + 3 x 1.008 = 14.01 + 3.024 = 17.034 g/mole




1st

$$17.32\text{ g } H_2 \times \frac{1\text{ mole } H_2}{2.016\text{ g } H_2} \times \frac{2\text{ mole } NH_3}{3\text{ mole } H_2} \times \frac{17.03\text{ g } NH_3}{1\text{ mole } NH_3} = 98.31986\text{ g } NH_3$$

(4 sig figs; exact; 4 sig figs; 4 sig figs)

$$= 98.32\text{ g } NH_3$$

$$27.2\text{ g } N_2 \times \frac{1\text{ mole } N_2}{28.02\text{ g } N_2} \times \frac{2\text{ mole } NH_3}{1\text{ mole } N_2} \times \frac{17.03\text{ g } NH_3}{1\text{ mole } NH_3} = 33.06324\text{ g } NH_3$$

(3 sig figs; Limiting; 4 sig figs; exact; 4 sig figs)

$$= 33.1\text{ g } NH_3$$

Smaller of the two calcs

$\Rightarrow$ 33.1 g $NH_3$ can be produced

& $N_2$ is Limiting reagent

How much Hydrogen is left over?

$$3\,H_2 + N_2 \rightarrow 2\,NH_3$$

? g consumed  27.2 g

$$27.2\text{ g } N_2 \times \frac{1\text{ mole } N_2}{28.02\text{ g } N_2} \times \frac{3\text{ mole } H}{1\text{ mole } N_2} \times \frac{2.016\text{ g } H_2}{1\text{ mole } H_2} = 5.87100\text{ g } H_2$$

(3 sig figs; 4 sig figs; exact; 4 sig figs)

$$= 5.87\text{ g } H_2 \text{ used.}$$

17.32 g $H_2$ initial

− 5.87 g $H_2$ used

11.45 g

Remaing g $H_2$ unused

Percent yield = $\frac{\text{Actual mass or moles}}{\text{Theoretical mass or moles}} \times 100$

(part: isolated from experiment; whole: calculate from stoichiometry)

$\frac{\text{part}}{\text{whole}} \times 100$

If a chemical reaction affords 3.72 g of ammonia and the theoretical expected amount was 7.62 g ammonia, what was the % yield of the rxn?

$$\%\text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{3.72\text{ g}}{7.62\text{ g}} \times 100$$

$$= 48.818897\%$$

$$= \boxed{48.8\%\text{ yield}}$$

ex

In the reaction of hydrogen & nitrogen to form ammonia

$$3\,H_2 + N_2 \longrightarrow 2\,NH_3$$

27.2 g of $N_2$ was reacted with excess hydrogen. If 28.3g of $NH_3$ was produced, what was the % yield of the rxn?

Actual = 28.3g of $NH_3$

Theoretical = $27.2\,g\,N_2 \rightarrow$ mole $N_2 \rightarrow$ mole $NH_3 \rightarrow$ g $NH_3$

$$27.2\,g\,N_2 \times \frac{1\text{ mole } N_2}{28.02\,g\,N_2} \times \frac{2\text{ mole } NH_3}{1\text{ mole } N_2} \times \frac{17.03\,g\,NH_3}{1\text{ mole } NH_3} = 33.1\,g\,NH_3$$

$$\%\text{ yield} = \frac{\text{actual}}{\text{Theoretical}} \times 100 = \frac{28.3\,g\,NH_3}{33.1\,g\,NH_3} \times 100$$

$$= 85.498489\,\%$$

$$= 85.5\,\%\text{ yield}$$

# RedOx

## Oxidation & Reduction

### Traditional Definition

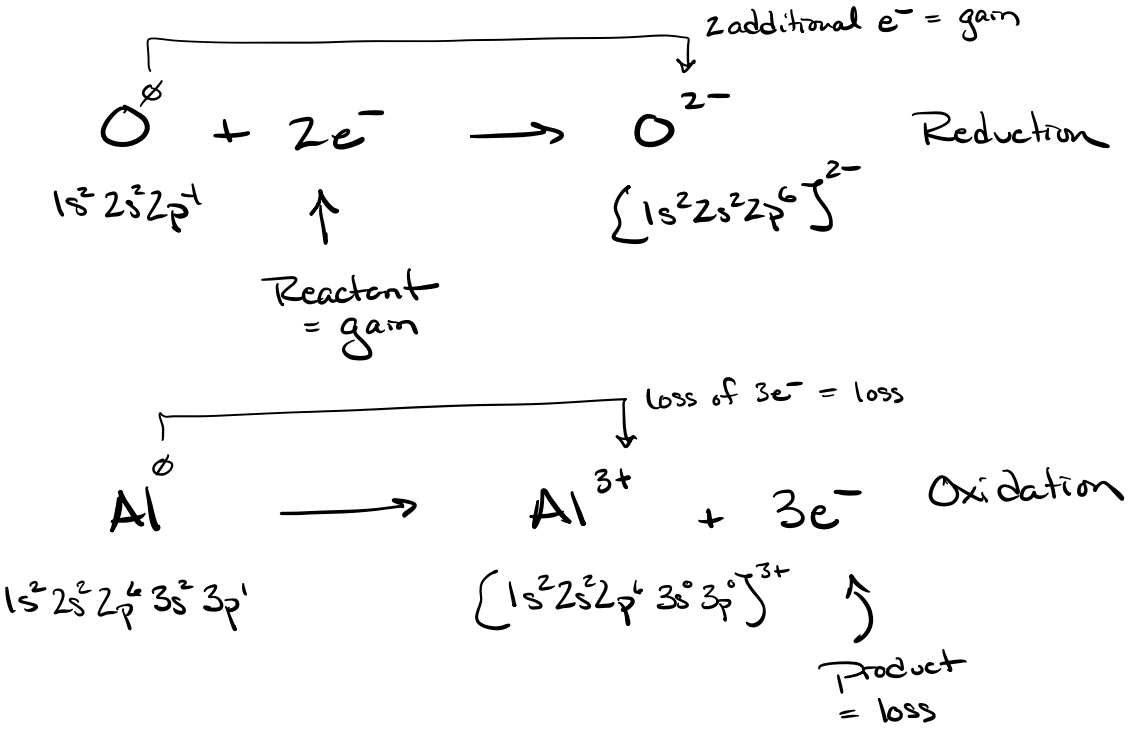
Oxidation = Gain of Oxygen or loss of Hydrogen

Reduction = Gain of Hydrogen or loss of Oxygen

### Better more Inclusive Def

Oxidation is loss of $e^-$

Reduction is gain of $e^-$



OiL  Oxidation is Loss

RiG  Reduction is gain

How do we track who is gaining or losing when no ions?

$$2\,C_8H_{18} + 25\,O_2 \longrightarrow 16\,CO_2 + 18\,H_2O$$

⇒ Oxidation Numbers

A set of roles for assigning an oxidation number

Book keeping method for $e^-$

## Rules

- Elements in elemental state are zero

$\overset{0}{H_2}$ , $\overset{0}{O_2}$ , $\overset{0}{Na}$ , $\overset{0}{S_8}$ , $\overset{0}{Fe}$

- The oxidation number on a monatomic ion is the same value as charge state

oxidation # / Charge: $\overset{-2}{O^{2-}}$ , $\overset{-3}{N^{3-}}$ , $\overset{+3}{Fe^{3+}}$ , $\overset{+2}{Fe^{2+}}$ , $\overset{+2}{Mg^{2+}}$ ← ± before value

- Combined H (in a polyatomic or molecule) is always +1

$H\overset{+1}{C}O_3^-$ , $C_8\overset{+1}{H}_{18}$ , $\overset{+1}{H_3}PO_4$ , $\overset{+1}{H}C_2\overset{+1}{H}_3O_2$

- Combined Oxygen is always -2, except peroxide -1

$\overset{-2}{CO_2}$ , $\overset{-2}{CO_3^{2-}}$ , $HC_2H_3\overset{-2}{O_2}$ , $\overset{-1}{H}-\overset{-1}{O}-\overset{-1}{O}-H$

peroxide

Rare ⇒ Chem 1A

- Combined fluorine is always -1

$\overset{-1}{CH_2F_2}$ , $\overset{-1}{CF_3}CO_2H$

- The sum of the oxidation numbers must add to ∅ for a molecule or to the charge on a polyatomic ion.

$\overset{? \; +1}{CH_4}$ ∅

| | # of | ox # | |
|---|---|---|---|
| C | 1 | × ? = | −4 |
| H | 4 | × +1 = | + 4 |
| | | | ∅ |

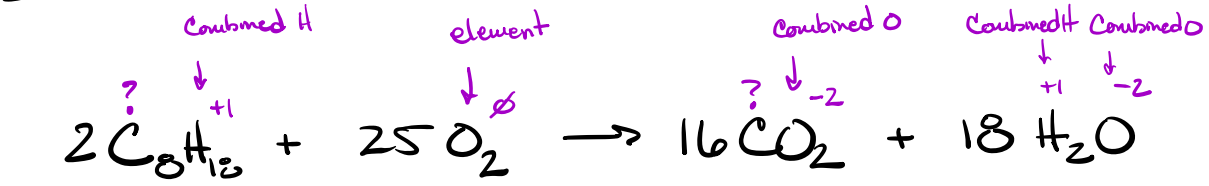
$\overset{-4 \; +1}{CH_4}$

$\overset{? \; -2}{CO_3^{2-}}$

| | # of | ox # | |
|---|---|---|---|
| C | 1 | × ? = | +4 |
| O | 3 | × −2 = | + −6 |
| | | | −2 |

$\overset{+4 \; -2}{CO_3^{2-}}$

Ex




① Assign oxidation # based on rules

② Calculate those with no rules

$C_8H_{18}$ (-9/4, +1, ∅)

$8C + 18(+1) = \emptyset$

$8C + 18 = 0$

$8C = -18$

$C = \frac{-18}{8} = \frac{-9}{4}$

$CO_2$ (+4, -2, ∅)

$C + 2(-2) = \emptyset$

$C - 4 = \emptyset$

$C = +4$

$SO_4^{2-}$ (+6, -2)

$S + 4(-2) = -2$ Poly atomic Charge

$S - 8 = -2$

$S = +6$

extra  less

$-9/4$ to $+4$ ⇒ Loss

oxidation

All Ox #

$$\overset{-9/4\ +1}{2\,C_8H_{18}} + \overset{0}{25\,O_2} \rightarrow \overset{+4\ -2}{16\,CO_2} + \overset{+1\ -2}{18\,H_2O}$$

Reduction

0 to −2

equal  2 extra = Gain

$$\overset{+1\ -1}{2\,NaCl_{(aq)}} + \overset{+2\ +5\ -2}{Pb(NO_3)_{2(aq)}} \rightarrow \overset{+1\ +5\ -2}{2\,NaNO_{3(aq)}} + \overset{+2\ -1}{PbCl_{2(s)}}$$

$$\overset{+1\ -1}{Na^+\ Cl^-} \quad \overset{+2}{Pb^{2+}} \quad \overset{+5\ -2}{NO_3^-} \qquad \overset{+1}{Na^+} \quad \overset{+5\ -2}{NO_3^-} \quad \overset{+2}{Pb^{2+}} \quad \overset{-1}{Cl^-}$$

$\overset{+5\ -2}{NO_3}$ (−)  $N + 3(-2) = -1$

$N - 6 = -1$

$N = +5$

No change in oxidation number from products to reactants

⟹ not a RedOx reaction

Acid/Base
Double Displacement — Never Redox

Single Replacement
Combustion — Always Redox

Decomposition
Combination — Sometimes Redox

element = Single element Symbol with or without subscript & no charge

$$\overset{\emptyset}{Zn}_{(s)} + 2\overset{+1\ -1}{HCl}_{(aq)} \rightarrow \overset{+2\ -1}{ZnCl_2}_{(aq)} + \overset{\text{element}\ \emptyset}{H_{2(g)}}$$

$Zn^{2+}\ Cl^-$

$\overset{+1\ -1}{HCl}^{\emptyset}$

$+1 + Cl = \emptyset$

$Cl = -1$

lost $2e^-$
oxidation

oxidizing Agent

$$\overset{\emptyset}{Zn}_{(s)} + 2\overset{+1\ -1}{HCl}_{(aq)} \rightarrow \overset{+2\ -1}{ZnCl_2}_{(aq)} + \overset{\emptyset}{H_{2(g)}}$$

Reducing Agent = Reducing Reagent Reactant

gains $1e^-$
Reduction

Redox Reaction

⇒ Need to be able to assign ox #

⇒ Need to identify if reaction is oxidation/Reduction (Redox) or not.

⇒ Identify oxidation half & Reduction half