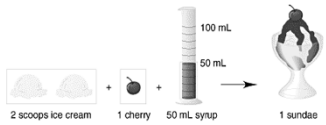
Stoichiometry

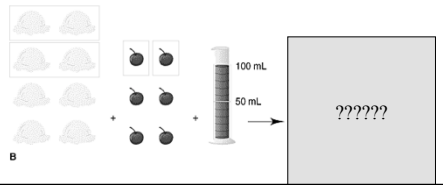
Limiting Reagent (Reactant)

Dr. Ron Rusay

Limiting Reagent

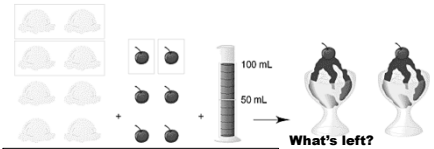
An Ice Cream Sundae





Limiting Reagent

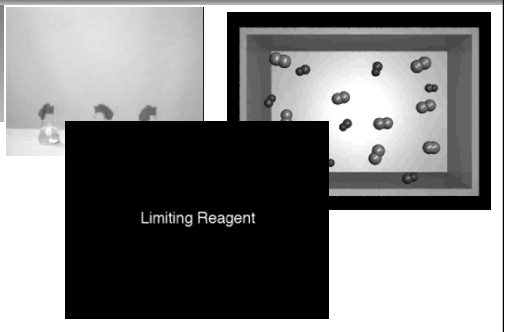
An Ice Cream Sundae



What's left?
What's totally consumed?

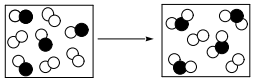
8 scoops ice cream	6 cherries	100 mL syrup

Limiting Reagent



QUESTION

Consider the reaction between AB and B_2 in the gas phase:



Select the correct statement about this reaction.

A) The balanced equation for the reaction is $AB + B_2 \rightarrow AB_3$.

B) AB and B_2 are present in "stoichiometric" (equivalent molar) amounts at the start of the reaction to consume all of both.

C) AB is the limiting reagent.

D) The product of the reaction is A_2B.

QUESTION

The limiting reactant in any reaction:

A. is the reactant for which there is the least amount in grams.
B. is the reactant which has the lowest coefficient in a balanced equation.
C. is the reactant for which there is the most amount in grams.
D. is the reactant for which there is the fewest number of moles.
E. none of these

http://www.cnafun.moa.gov.cn/zl/tjzl/201306/P020130620619849846691.pdf

QUESTION

In less than 50 years, the world's population has doubled to over 7 billion people. The average healthy diet per person is ~2,700 kcal/person/day (very unevenly distributed). Total worldwide food production per year is estimated to be currently equivalent to ~3.04 × 10^{19} Joules (J) / year. (4.184 J = 1 cal)

Therefore food is a limiting reagent in sustaining a healthy world population dynamics.

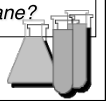
A. TRUE
B. FALSE

Mass Applications: Limiting Reagent

- *How do masses of reactants relate? Is there enough mass of each reactant for the reaction to consume all of both of them or will there be some left of one of them?*

$$2\ C_8H_{18(l)} + 25\ O_{2(g)} \longrightarrow 16\ CO_{2(g)} + 18\ H_2O_{(l)}$$

What would happen if only 600. g of O_2 were available for the reaction of 228 g of octane?



Mass Applications:
Determining a Limiting Reagent

- *Does one of the reactants have fewer stoichiometrically adjusted moles than the other reactant? If so, the reactant with the smaller value is the limiting reagent.*

Calculation:

- *Divide the mass of each reactant by its respective Molar Mass and by its Stoichiometric factor from the balanced equation; then compare the results. The lowest one is the limiting reagent.*

Limiting Reagent Calculation

- *The **reactant** present in the smallest molar amount considering stoichiometry limits the mass basis of any reaction.*

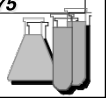
$$\mathbf{2}\ C_8H_{18(l)} + \mathbf{25}\ O_{2(g)} \longrightarrow \mathbf{16}\ CO_{2(g)} + \mathbf{18}\ H_2O_{(l)}$$

228 g octane / 114 g/mol = 2 mol octane

600. g oxygen / 32 g/mol = 18.75 mol oxygen

2 mol octane / 2 mol (stoich.) = 1

18.75 mole oxygen / 25 mol (stoich.) = 0.75



Mass Effects of the Limiting Reagent

What amount of octane remains unreacted in the reaction of 600. g of O_2 with 228 g of octane?

- *600. g O_2 x mol O_2 /32g O_2 x [**2**mol C_8H_{18} /**25**mol O_2] x 114 g / mol C_8H_{18} = 171 g C_8H_{18} are reacted*
- *228 g - 171 g = 57 g C_8H_{18} remain unreacted*

QUESTION

How many grams of $Ca(NO_3)_2$ can be produced by reacting excess HNO_3 with 7.40 g of $Ca(OH)_2$?

A) 10.2 g
B) 16.4 g
C) 32.8 g
D) 8.22 g
E) 7.40 g

Limiting Reagent / Theoretical Yield

The limiting reagent governs the theoretical yield of products. For the reaction of 228 g of octane with 600. g of oxygen, what is the theoretical yield of carbon dioxide?

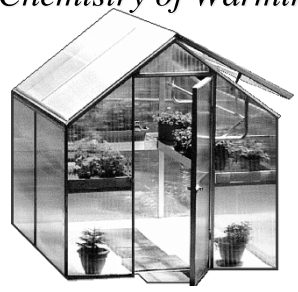
$$\mathbf{2}\ C_8H_{18(l)} + \mathbf{25}\ O_{2(g)} \longrightarrow \mathbf{16}\ CO_{2(g)} + \mathbf{18}\ H_2O_{(l)}$$

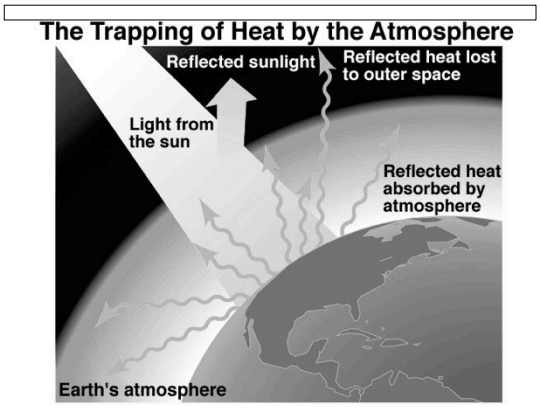
*600. g O_2 x mol O_2 /32g O_2 x **16**mol CO_2 /**25**mol O_2 x 44g / mol CO_2 = 528 g CO_2*

Thoughts to Consider

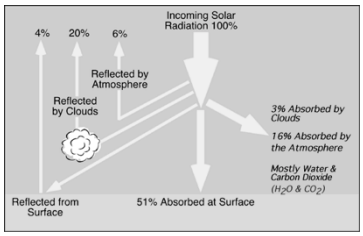
- *How much CO_2 do you produce per gallon of gasoline (octane, d= 0.70 g/ml) when gasoline is combusted?*
- *How much CO_2 do you personally produce from driving every week?.... every month? .... every year? ....from other uses and sources?*
- *Why do people in developed nations, like the U.S., Japan & in the EU, produce tons more of CO_2 per person than people in under developed or developing nations?*
- *Does the increase in "man-made" CO_2 relate to global warming?*

Greenhouse Gases: The Chemistry of Warming





What is a greenhouse gas?
The sun's energy & the molecule's shape decide.



- ***Our atmosphere (air) is 78% nitrogen and 21% oxygen.***
- ***Neither are greenhouse gases. They do not absorb infrared radiation (heat).***
- ***However, H_2O and CO_2 can absorb infrared energy. Without them earth would be very chilly.***

http://zebu.uoregon.edu/1998/es202/l13.html

Percent Yield

- *In synthesis, the actual yield (g) is measured and compared to the theoretical yield (g). This is the percent yield:*
- *% Yield = actual (g) / theoretical (g) x 100*

Theoretical yield is the 100% yield based on calculation. Some DVC Chem 226 students will have percent yields greater than 100% in their first synthesis experiment. Hmmm?..... Why is this not possible?

Percent Yield

- *A reaction was conducted that theoretically would produce 0.0025 moles of quinine, $C_{20}H_{24}N_2O_2$. The actual amount of isolated quinine was 780 mg. What is the percent yield of quinine?*
- *324 g/mol x 0.0025 mol = 81g = 810mg(theoretical)*
- *% Yield = 780 mg/ 810 mg x 100*
- *% Yield = 96%*

QUESTION

- *If a reaction produced 2.45g of Ibogaine, $C_{20}H_{26}N_2O$, a natural product with strong promise in treating heroin addiction, and the theoretical yield was 3.05g, what is the % yield?*

A) 19.7% B) 39.4% C) 80.3% D) 160.6%

QUESTION

Tungsten metal (W), *Wolfram*, has been widely used to make filaments for incandescent light bulbs, which are being phased out globally. *(In 2014, the U.S. stopped the manufacture of some wattages by law.)* If in the reaction below, 25.0 grams of WO_3 produced 18.0 grams of tungsten, what is the percent yield?

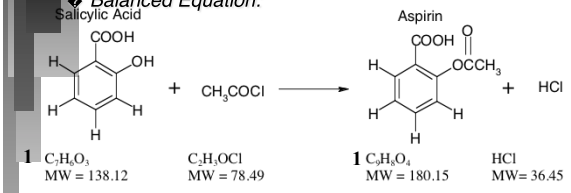
$$WO_3 + 3\ H_2 \rightarrow W + 3\ H_2O$$

A.25.8%
B.10%
C.110%
D.90.8%
E.I have no idea how to do this calculation, but my Congressman does.

The 310 page U.S. Law: "Energy Independence and Security Act of 2007":
http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

Engineering: How many grams of salicylic acid are needed to produce 1.80 kg of aspirin if the process generally produces an 85.0% yield?

- *Balanced Equation:*



1 $C_7H_6O_3$ MW = 138.12 | C_2H_3OCl MW = 78.49 | **1** $C_9H_8O_4$ MW = 180.15 | HCl MW= 36.45

QUESTION

The catalytic formation of $NH_3(g)$ from $N_2(g)$ and $H_2(g)$ generally occurs in ~85.0% yield for a particular catalyst. How many grams of ammonia would be expected experimentally when 12.0 g of H_2 reacts with excess N_2?

A) 57.8 g **B) 66.9 g** **C) 71.5 g** **D) 83.8 g**