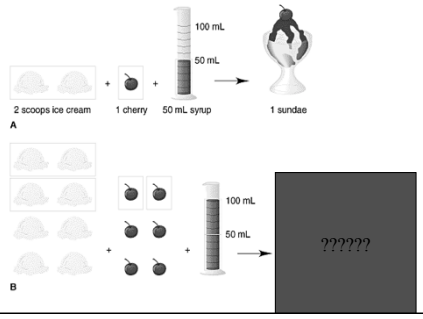
Stoichiometry II

Limiting Reactant (Reagent)

Dr. Ron Rusay

Limiting Reactant

An Ice Cream Sundae



Limiting Reactant

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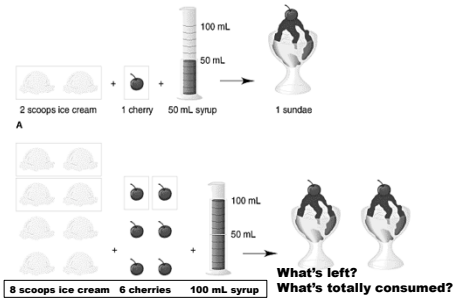
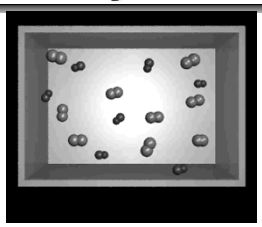
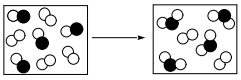


Limiting Reactant



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 that still remains after the reaction stops.
E. is the reactant that has completely reacted and is no longer present after the reaction stops

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

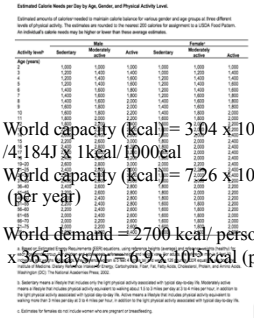
QUESTION

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

Do you consume more or less than 2700 Cal/day (kcal/day)?



World capacity (kcal) = 3.04 x 10^{19} J x 1cal /4.184J x 1kcal/1000cal

World capacity (kcal) = 7.26 x 10^{15} kcal (per year)

World demand = 2700 kcal/ person x 1/day x 365 days/yr = 6.9 x 10^{5} kcal (per year)

What is recommended for your age and relative life style?

http://www.cnpp.usda.gov/publications/usdafoodpatterns/estimatedcalorieneedsperdaytable.pdf

Mass Applications:
Determining a Limiting Reactant

- *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 reactant**.*

Calculation:

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

QUESTION

0.40 moles of HNO_3 was reacted with 7.40 g of $Ca(OH)_2$, Molar Mass = 74 g/mol, which reactant is limiting?

A) HNO_3
B) $Ca(OH)_2$

The balanced equation is $Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$. Water is the other product for an acid/base reaction.

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 fuel injectors only provided 600. g of O_2 to react with 228 g of octane in the combustion chambers of your car?

Limiting Reagent Calculation

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

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

This car failed it's smog test.
The owner was told that it needs a $500 ring job!

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?

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

QUESTION

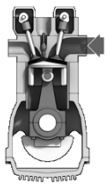
How many grams of $Ca(NO_3)_2$, Molar Mass = 164 g/mol, can be produced by reacting 0.40 moles of HNO_3 with 7.40 g of $Ca(OH)_2$, Molar Mass = 74 g/mol?

A) 10.2 g
B) 16.4 g
C) 32.8 g
D) 65.6 g
E) 7.40 g

The balanced equation is $Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$. Water is the other product for an acid/base reaction.

Calculate how much CO_2 is produced per gallon of gasoline (octane, C_8H_{18}, d= 0.70 g/ml) when gasoline is fully combusted with excess oxygen.

1.0 **gal** C_8H_{18} ⟶ ? lb CO_2



$2\ C_8H_{18}(g) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$

1.0 **gal** C_8H_{18} ⟶ ? lb CO_2

1.0 **gal** x 3.785 L/gal x 1000 mL/L x 0.70 g/mL = 2649.5 g

grams (S) ⟶ grams (AT)

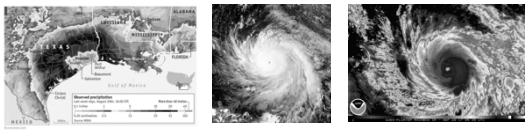
Avogadro's Number
Atoms
Molecules

2650 g **C_8H_{18}** grams (S) | mol **C_8H_{18}** 1 mol (S) | 16 mol CO_2 | 44 g **CO_2** grams (AT) (Molecular Weight) | = 8181 g CO_2 grams (AT)

grams (S) (Molecular Weight) | 2 mol C_8H_{18} | 1 mol (AT) | mol **CO_2** | 18 lbs

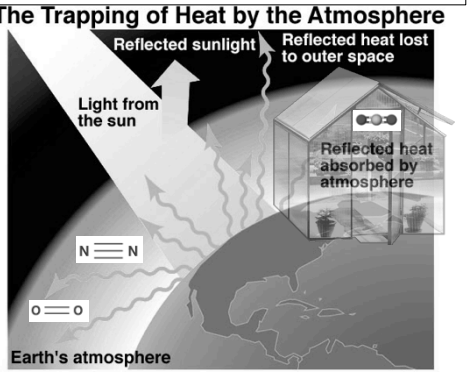
114 g **C_8H_{18}**

Does the increase in "man-made" CO_2 affect global climate? ……. Harvey, Irma, Maria?
How much CO_2 do you personally produce every week from just getting around? … every month? …. every year? …from other uses (lights, cell phones, computers?)
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 in most of the developing nations?



Greenhouse Gases

The Trapping of Heat by the Atmosphere



What is a greenhouse gas?

The sun's energy & the molecule's shape (polarity) decide.

Chemical Composition of Air		
Name	**Symbol**	**% by volume**
Nitrogen	N2	78.084 %
Oxygen	O2	20.9476 %
Argon	Ar	0.934 %
Carbon Dioxide	CO2	0.0314 %
Neon	Ne	0.001818 %
Methane	CH4	0.0002 %
Helium	He	0.000524 %
Krypton	Kr	0.000114 %
Hydrogen	H2	0.00005 %
Xenon	Xe	0.0000087 %

- ***Our atmosphere (air) is 78% nitrogen and 21% oxygen. (BOTH are not polar.)***
- ***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