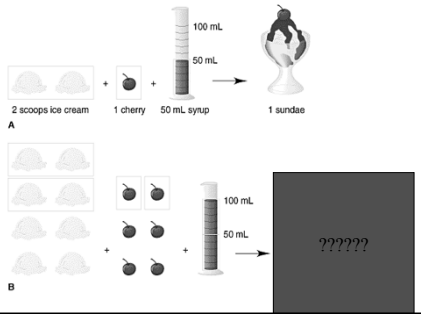
Stoichiometry II

Limiting Reactant (Reagent)

Dr. Ron Rusay

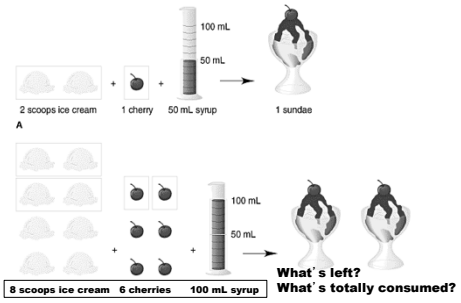
Limiting Reactant

An Ice Cream Sundae

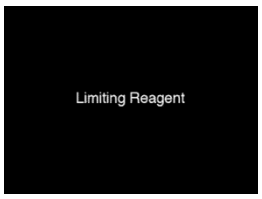


Limiting Reactant

An Ice Cream Sundae



Limiting Reactant



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

Answer

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

Answer

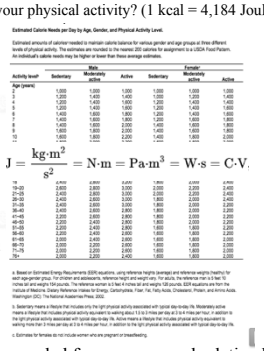
Food is currently a limiting reagent in sustaining a healthy world population dynamics.

False

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^{15} kcal (per year)

Do you consume more or less than 2700 Cal/day (kcal/day) based on your physical activity? (1 kcal = 4,184 Joules)



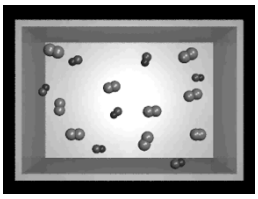
$$J = \frac{kg \cdot m^2}{s^2} = N \cdot m = Pa \cdot m^3 = W \cdot s = C \cdot V$$

Should intellectual activity be considered?

2700 Cal = 52.3 hrs of 60W light

What is recommended for your age and relative life style?
http://www.cnpp.usda.gov/publications/usdafoodpatterns/estimatedcalorieneedsperdaytable.pdf

Limiting Reactant

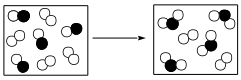


$NO\ (g) + Cl_2\ (g) \longrightarrow NOCl$

$2\ NO\ (g) + Cl_2\ (g) \longrightarrow 2\ NOCl$

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 $AB + B_2 \rightarrow AB_3$.

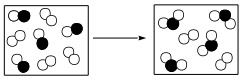
B) AB and B_2 are present in "stoichiometric" (equivalent molar) amounts at the start of the reaction to consume all of both.

C) AB is the limiting reagent.

D) The product of the reaction is A_2B.

ANSWER

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.

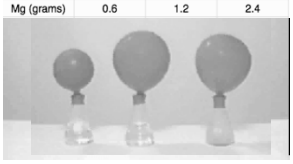
C) AB is the limiting reagent.

D) The product of the reaction is A_2B.

Limiting Reactant

1.00 mol/L x 100 mL x 1 L / 1000 mL = 0.100 mol

	A	B	C
HCl (mol)	0.100	0.100	0.100
Mg (grams)	0.6	1.2	2.4



A B C

Limiting: Mg HCl HCl

Quantitative Mass Applications:

Determining a Limiting Reactant

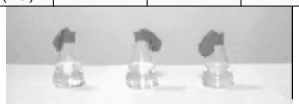
- *Does one of the reactants have fewer stoichiometrically adjusted moles than the other reactant? If so, the reactant with the smaller value is the **limiting reactant**.*

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**.*

Limiting Reactant

	A	B	C
HCl (mol)	0.100	0.100	0.100
Mg (grams)	0.6	1.2	2.4
Mg (mol)	?	?	?

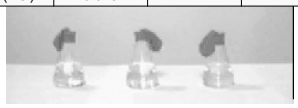


A B C

$0.6g_{Mg}$ X mol/$24g_{Mg}$ = 0.025 mol_{Mg}

Limiting Reactant

	A	B	C
HCl (mol)	0.100	0.100	0.100
Mg (grams)	0.6	1.2	2.4
Mg (mol)	0.025	?	?

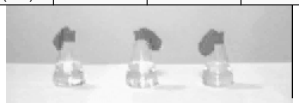


A B C

$0.6g_{Mg}$ X mol/$24g_{Mg}$ = 0.025 mol_{Mg}

Limiting Reactant

	A	B	C
HCl (mol)	0.100	0.100	0.100
Mg (grams)	0.6	1.2	2.4
Mg (mol)	0.025	0.050	0.10



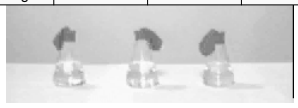
A B C

$1.2g_{Mg}$ X mol/$24g_{Mg}$ = 0.050 mol_{Mg}

Limiting Reactant

$2\ HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2\ (aq)} + H_{2\ (g)}$

	A	B	C
HCl (mol)	0.100	0.100	0.100
Mg (mol)	0.025	0.050	0.10
limiting	?	?	?

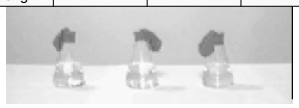


A B C

Limiting Reactant

$2\ HCl_{(aq)} + 1\ Mg_{(s)} \longrightarrow MgCl_{2\ (aq)} + H_{2\ (g)}$

	A	B	C
HCl (mol)	0.100/2	0.100/2	0.100/2
Mg (mol)	0.025/1	0.050/1	0.10/1
limiting	?	?	?

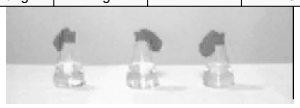


A B C

Limiting Reactant

$2\ HCl_{(aq)} + 1\ Mg_{(s)} \longrightarrow MgCl_{2\ (aq)} + H_{2\ (g)}$

	A	B	C
HCl (mol)	0.050	0.050	0.050
Mg (mol)	0.025/1	0.050	0.10
limiting	Mg	=	HCl

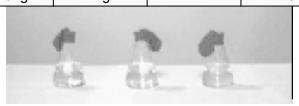


A B C

Limiting Reactant

$2\ HCl_{(aq)} + 1\ Mg_{(s)} \longrightarrow MgCl_{2\ (aq)} + H_{2\ (g)}$

	A	B	C
HCl (mol)	0.050	0.050	0.050
Mg (mol)	0.025/1	0.050	0.10
limiting	Mg	=	HCl



A B C

How much magnesium theoretically remains in case #C?

$0.10\ mol_{Mg} - 0.050\ mol_{HCl} = 0.050\ mol_{Mg} = 1.2 g_{Mg}$

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) $Ca(OH)_2$

0.1 mol/ 1 0.4 mol/ 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.

Answer

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

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

0.1 mol/ 1 0.4 mol/ 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.

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.

Answer

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?

0.1 mol/ 1 | 0.4 mol/ 2

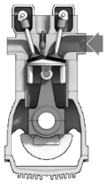
A) 10.2 g
B) 16.4 g
C) 32.8 g
D) 65.6 g
E) 7.40 g

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. (octane is limiting)

1.0 gal C_8H_{18} ⟶ ? lb CO_2

1



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

Limiting Reagent Calculations

(Chem 120)

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

2 $C_8H_{18(l)}$ ***+ 25*** $O_{2(g)}$ ⟶ ***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*

If there is less than 25 moles of O_2 then the octane is limiting, eg. 18.75 moles O_2 & gasoline is left over.

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. (octane is limiting)

1.0 gal C_8H_{18} ⟶ ? lb CO_2

1.0 gal C_8H_{18} ⟶ ? grams C_8H_{18}

3.785 L= 1 gal 1000 mL = 1 L

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

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

1

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. (octane is limiting)

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

grams (S) ⟶ grams (AT)

Avogadro's Number
Atoms
Molecules
Stoichiometry

2649.5 g C_8H_{18}				? lb CO_2
grams (S)	1 mol (S)	?	grams (AT) (Molecular Weight)	= grams (AT)
grams (S) (Molecular Weight)		?	1 mol (AT)	

"Gatekeeper"

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

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

1

grams (S) ⟶ grams (AT)

Avogadro's Number
Atoms
Molecules

	mol C_8H_{18}	16 mol CO_2	44 g CO_2	8181 g CO_2
2649.5 g C_8H_{18} grams (S)	1 mol (S)		grams (AT) (Molecular Weight)	= grams (AT)
	grams (S) (Molecular Weight)	2 mol C_8H_{18}	1 mol (AT)	
	114 g C_8H_{18}		mol CO_2	18.02 lbs

Consider

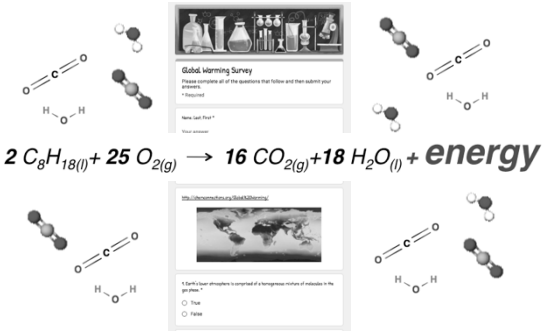
- *How much CO_2 do you personally produce from transportation/ (driving or riding) every week?…. every month? …. every year?*
- *…from other sources: air conditioning. heating, lighting, cooking, clothing, purchases, etc. ?*
- *Why do people in developed & developing nations, like the U.S., China, Japan, the EU, & India have higher carbon footprints per person than people in under developed nations?*
- *How is the global increase in "man-made" CO_2 related to personal habits?*

Carbon Molecules

ENERGY & Global Warming

#4
https://www.youtube.com/watch?v=EvphJO8VKlc&list=PLE7B4FAD08F1EBCE2&index=4

Greenhouse Gases



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

What is a greenhouse gas?

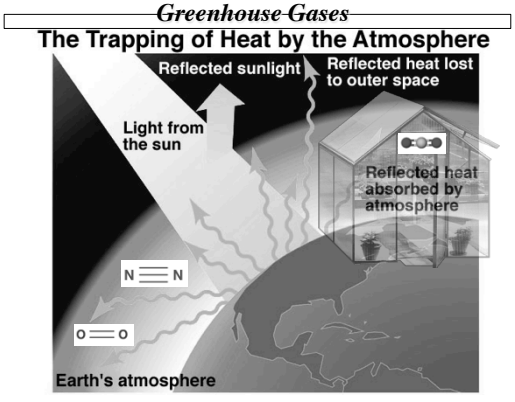
The sun's energy & the molecule's shape (polarity) decide.

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

Greenhouse Gases



http://chemconnections.org/Global%20Warming/