CHEM 106

Chemical Reactions & Stoichiometry

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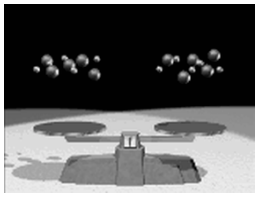
Chemical Reactions

Atoms, Moles, Mass, & Balance: eg. Zn(s) + S(s) ⟶



Stoichiometry connects atoms/molecules, moles and mass in chemical reactions. It interrelates both reactants and products, which are conserved.

Chemical Equation

Representation of a chemical reaction:

$$\_\ C_2H_5OH + \_\ O_2 \rightarrow \_\ CO_2 + \_\ H_2O + \text{energy}$$

Reactants *Products*

- *C=2; H =5+1=6; O=2+1 C=1; H=2; O=2+1*
- $1\ C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

Chemical Equation

$$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$$

+energy

The balanced equation can be completely stated as:

- *1 mole of ethanol reacts with 3 moles of oxygen to produce 2 moles of carbon dioxide and 3 moles of water.*

The Chemical Equation: Mole & Masses

$$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$$

+energy

- *46g (1 mole) of ethanol reacts with 3 moles of oxygen (96g) to produce 2 moles of carbon dioxide and 3 moles of water.*
- *How many grams of carbon dioxide and water are respectively produced from 46g (1 mole) of ethanol ?*

2 mol x 44 g/mol = 88g *3 mol x 18 g/mol = 54 g*

The Chemical Equation: Moles & Masses

- $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

+energy

- *How many grams of oxygen are needed to react with 15.3g of ethanol in a 12oz. beer ?*

$15.3g_{ethanol} \times mol_{ethanol}/46.0g_{ethanol} = 0.333mol_{ethanol}$

$0.333mol_{ethanol} \times 3mol_{oxygen} / 1mol_{ethanol} = 0.999mol_{oxygen}$

$32.0g_{oxygen}/mol_{oxygen} \times 0.999mol_{oxygen} = 32.0g_{oxygen}$

NOTE: It takes approximately 1 hour for the biologically equivalent amount of oxygen available from cytochrome p450 to consume the alcohol in a human in 1 beer to a level below the legal limit of 0.08%.

Chemical Equation

All Balanced Equations relate on a mole basis.

For example the combustion of octane:

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

***2 moles** of octane react with **25 moles** of oxygen to produce **16 moles** of carbon dioxide and **18 moles** of water.*

Mass Calculations

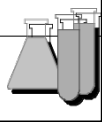
All Balanced Equations relate on a mole and also a mass basis through Molar Mass.

For example the combustion of octane:

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

*228 g of octane (**2 moles)*** *will react with 800 g of oxygen (**25 moles**) to produce (**16 moles**) 704 g of carbon dioxide and (**18 moles**) 324 g of water.*

***(2 moles octane x 114 g/mol = 228 g)**



Mass Calculations: Reactants ⟷ Products

Chemically Relate:

Something (S) ⟶ Another Thing (AT)

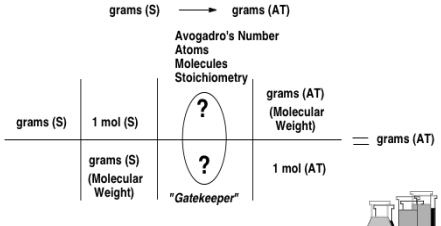
Mass (S) ⟶ Mass (AT)

grams (S) ⟶ grams (AT)

Mass Calculations: Reactants ⟷ Products

1. *Balance the chemical equation.*
2. *Convert mass of reactant or product to moles.*
3. *Identify mole ratios in balanced equation: They serve as the "Gatekeeper".*
4. *Calculate moles of desired product or reactant.*
5. *Convert moles to grams.*

Mass Calculations: Reactants ⟷ Products



QUESTION

The fuel in small portable lighters is butane (C_4H_{10}). After holding a lighter in the air for a few minutes at the end of a rock concert, 1.0 gram (0.017 moles) of fuel was used. How many grams of carbon dioxide did it produce?

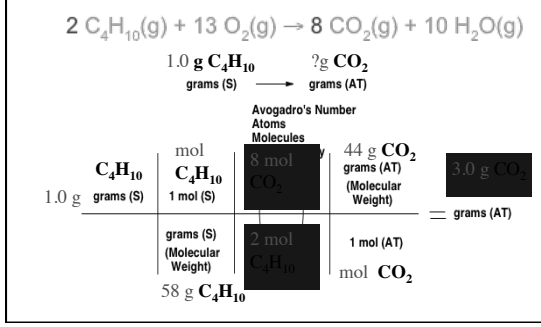
$$2\ C_4H_{10}(g) + 13\ O_2(g) \rightarrow 8\ CO_2(g) + 10\ H_2O(g) + \text{energy}$$

A.) 750 mg B.) 6.0 g

C) 1.5 g D.) 3.0 g

ANSWER

D.) 3.0 g


2 C4H10(g) + 13 O2(g) → 8 CO2(g) + 10 H2O(g)
1.0 g C4H10
grams (S)
?g CO2
grams (AT)
Avogadro's Number
Atoms
Molecules
1.0 g
C4H10
grams (S)
mol
C4H10
1 mol (S)
8 mol
CO2
44 g CO2
grams (AT)
(Molecular
Weight)
3.0 g CO2
=
grams (AT)
grams (S)
(Molecular
Weight)
2 mol
C4H10
1 mol (AT)
58 g C4H10
mol CO2