

The Combustion of Hydrocarbons

(Ch 5)

Combustion - a chemical reaction in which a fuel burns in oxygen to produce combustion products and often a flame.

- Coal, propane and gasoline are common fuels
 - ↳ these are sources of chemical energy

Combustion releases this chemical energy as thermal energy and light.

Common Products of Combustion Reactions:

CO_2 , H_2O and sometimes CO

CO is a greenhouse gas

Greenhouse gas - any atmospheric gas (H_2O vapor, CO_2 , CH_4) that allow solar radiation to pass through the atmosphere but absorb infrared radiation emitted by Earth, thereby trapping thermal energy and making Earth warmer.

Organic Compounds - a molecular compound

that contains one or more carbon-carbon bonds and often one or more carbon-hydrogen bonds
Most fuels are organic compounds.

①

Air Pollution - chemicals and particles in the atmosphere that harm living organisms or damage the environment

Many fuels contain sulfur compounds and heavy metals. Combustion releases them as air pollution

Types of Combustion

- Complete - the combustion (burning) of a hydrocarbon in a plentiful supply of oxygen to produce CO_2 , H_2O and energy



Natural gas is methane: $\text{CH}_4(\text{g})$



* balanced

The blue flame on a gas stove as an example of complete combustion

• Incomplete - the combustion (burning) of a hydrocarbon in a limited supply of oxygen;

○ products may include:



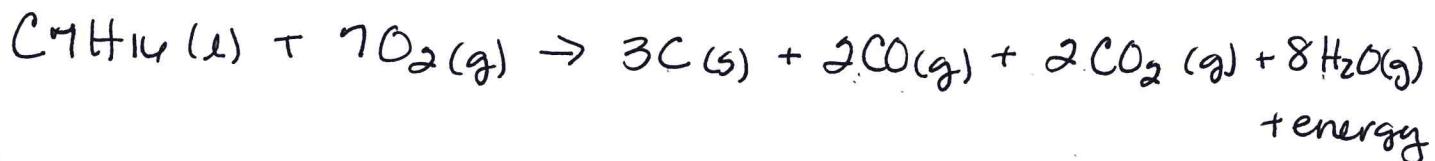
(Soot is usually represented as C(s))

• Usually occurs in uncontrolled or less than ideal conditions.

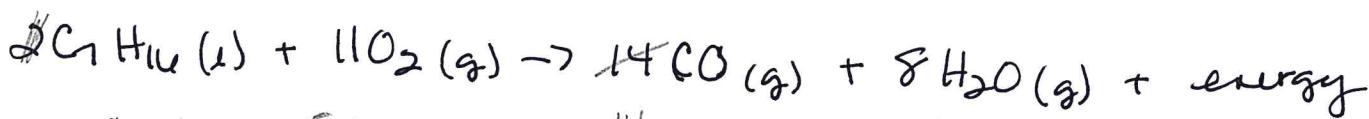
• flames are sooty, yellow and cooler than flames from complete combustion

• incomplete combustion reactions cannot be shown by a single chemical equation because many possible reactions are possible.

Incomplete combustion of heptane

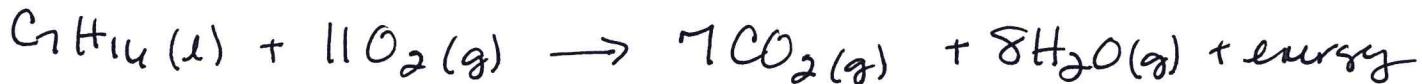


or



Complete combustion of heptane

$\begin{array}{c} 16 \\ | \\ 14 \\ | \\ 30 \end{array}$



(3)

Concerns of Incomplete Combustion

- Releases only a portion of the energy that may be obtained from hydrocarbon fuels such as gasoline.
- Soot particles from incomplete combustion are an inhalation hazard. Many are toxic.
- CO is a toxic hazard. Odorless, colorless, & no taste. Silent killer if released.
Binds tightly with hemoglobin in the blood - this prevents hemoglobin from binding with O_2

Elements and Their Oxides

(H^+)

ACID - a compound that produces hydrogen ions when mixed with water, forming a solution that conducts electricity, tastes sour, turns blue litmus red and neutralizes bases.

BASE - a compound that produces hydroxide ions (OH^-) when mixed with water, forming a solution that conducts electricity, turns red litmus blue, tastes bitter and neutralizes acids.

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Properties of Oxides

oxide - a compound composed of oxygen and one other element

acidic oxides - an oxide that forms an acidic solution when dissolved in H₂O

non-metallic oxides such as sulfur dioxide, nitrogen monoxide are acidic oxides

basic oxide - an oxide that forms a basic solution when dissolved in H₂O

metals, such as magnesium and calcium form metal oxides. These metal oxides.

Magnesium oxide, are basic oxides.

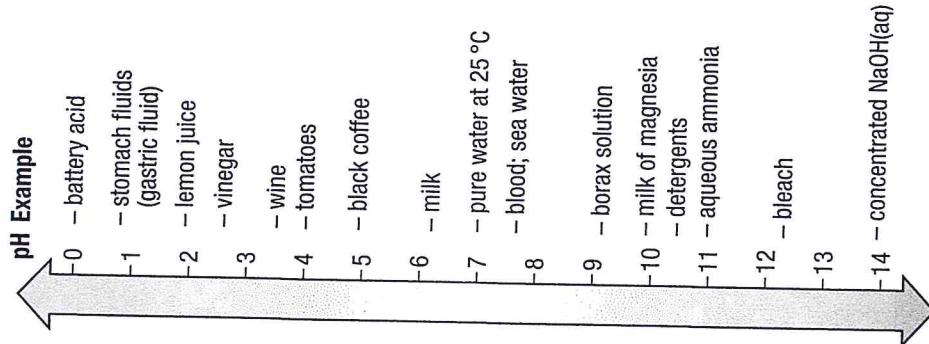


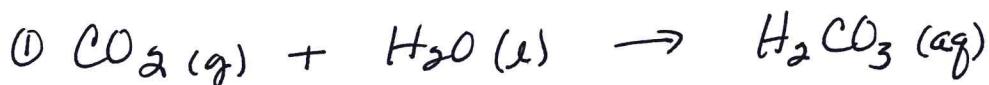
Figure 1 The pH scale is used to compare the acidity of a broad range of solutions.

Acidic Oxides

Oxides of C, S, N can form acids

CO₂

acidification of H₂O by CO₂

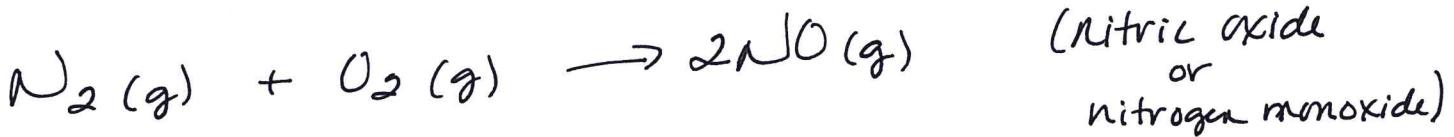


This increases acidity in rain, oceans and lakes. Effects many things in life.

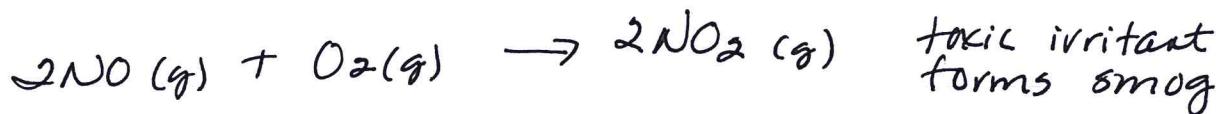
(ACID RAIN)

NO

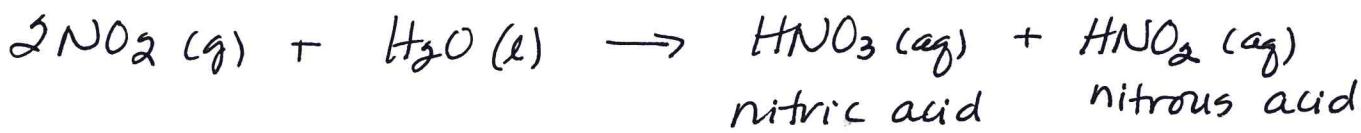
Most Nitrogen in the atmosphere is stable N₂. But when drawn into hot car engines it reacts.



This is released into atmosphere and mixes with O₂



This combines with H₂O



To prevent this reaction cars have catalytic converters.

- interior is coated with platinum, palladium or rhodium catalyst.

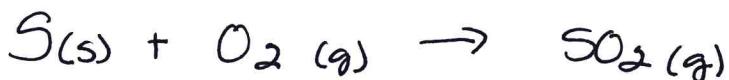
Rxn



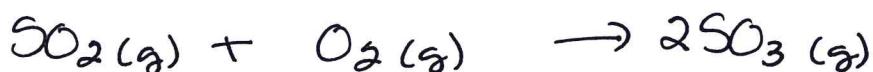
Converts NO(g) back to N_2 and O_2 so less pollution.

Sulfur Oxides

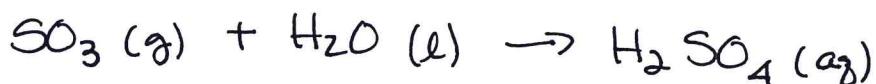
- Major part of acid precipitation
- most result from the combustion of fossil fuels
- SO_2 is produced when coal & crude oil are burned



This reacts with more O_2



This reacts with H_2O in the atmosphere



○ This falls as acid rain - H_2SO_4 sulfuric acid

Basic Oxides

- Metallic elements form basic metallic oxides
- Metallic oxides react with H₂O to form metal hydroxide



NaOH is very useful. One of most widely used industrial chemicals.

- Used in drains



Ca(OH)₂ can be added to lakes to raise pH.

Used to treat acid soil, neutralize acid spills

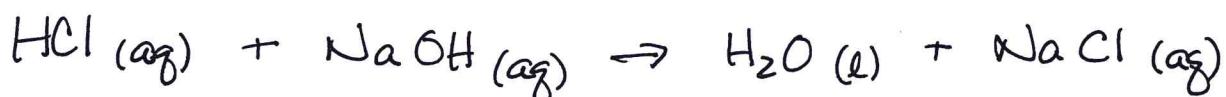
Neutralization Reactions

Remember a neutralization reaction is when an acid reacts with a base to produce a solution with a pH closer to 7 than its reactants.

Neutralizing an Acid

- Hydroxide compounds
 - Carbamate compounds
- ⇒ effective at neutralizing an acid

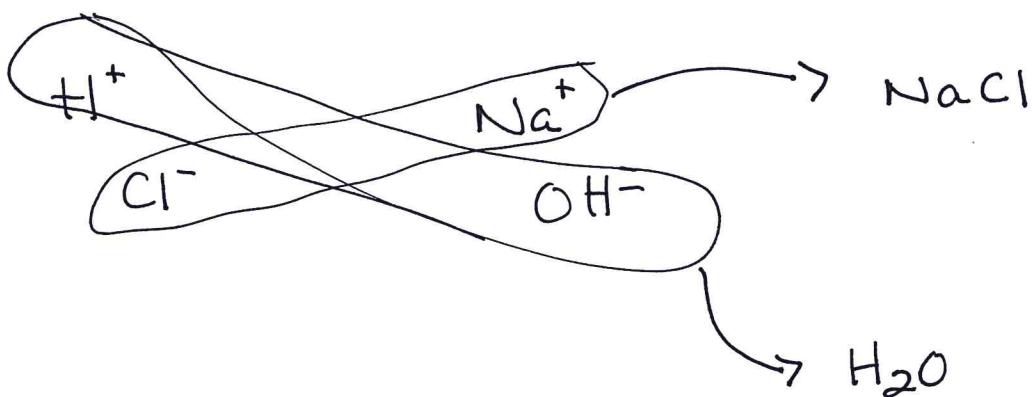
Neutralization with a hydroxide compound



Acid + base → water + ionic compound

For most neutralization reactions, the hydrogen

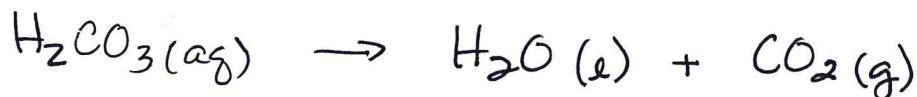
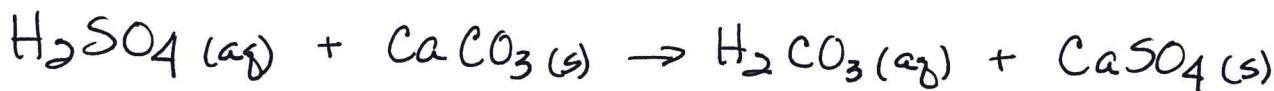
- iions from an acid react with the hydroxide ions from base to form H_2O . The ionic compound is made up of the remaining ions.



Neutralization with a Carbonate Compound

Calcium carbonate is the major component in limestone rock and the shells of clams, snails and coral.

Calcium carbonate reacts with sulfuric acid to produce carbonic acid which immediately decomposes into H₂O and CO₂.



Overall rxn

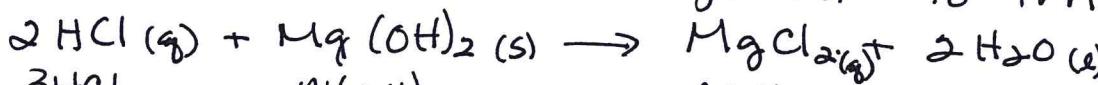


Acid + carbonate \rightarrow water + carbon dioxide + ionic compound

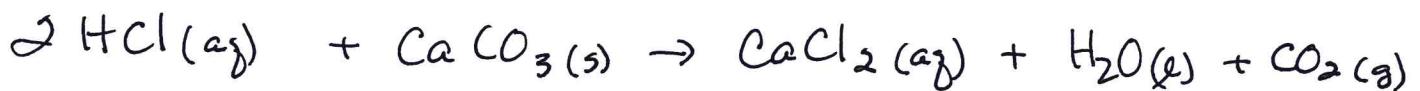
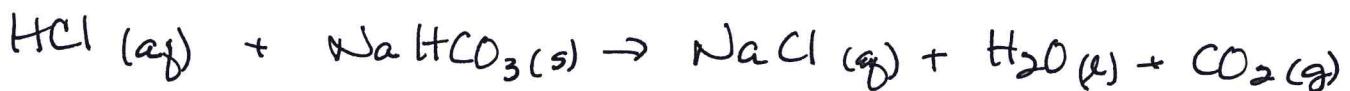
Neutralizing Stomach Acids

- HCl is in your stomach
- pH \approx 1.5
- too much acid can build up
- get into esophagus - heartburn
- to neutralize the acid use an antacid
 - contains hydroxide or carbonate compounds
 - need enough hydroxide or carbonate to neutralize acid but not irritate tissue

Magnesium hydroxide and aluminum hydroxide are weakly basic substances. Slightly soluble, so there is not enough OH⁻ to irritate mouth.



Sodium hydrogen carbonate and calcium carbonate are also used.



Neutralizing Lakes

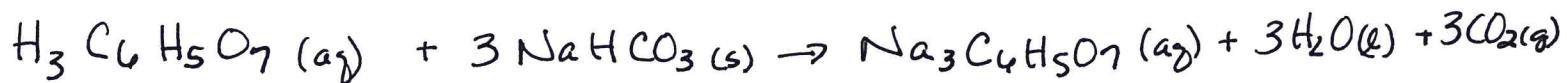
- Emissions of sulfur oxide and nitrogen oxide are mostly responsible for the acidification of our lakes.
- To help neutralize lakes - add calcium oxide or lime.

This is only a short term solution.

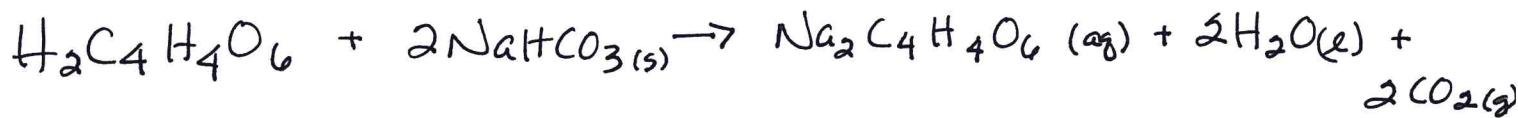
Baking

Substances that make bread dough rise are called leavening agents. They produce bubbles of CO_2 , as they expand they push the dough up.

Baking soda is pure sodium hydrogen carbonate. This reacts with an acid, like vinegar or citric acid found in fruit juice.



Baking powder is baking soda + tartaric acid



Choosing a neutralizing Reagent

- safety
 - cost
 - chemical properties
- * sulfuric acid would be very effective at neutralizing a base but not always best choice because may be a lot of H^+ left over - so left with very acidic area.
- ethanoic acid - $HC_2H_3O_2(aq)$ is better choice
- * sodium hydroxide is very basic - lots of OH^- ions. So may leave area too basic.
Also very corrosive.
- calcium hydroxide - $Ca(OH)_2$ is better choice

Mining, Metallurgy & Environment

- Mining removes minerals from the ground
- Metallurgy is the technology of obtaining and refining metals
 - Flotation is used to concentrate ore
 - Smelting is the chemical process used in metallurgy to extract a metal from its ore.
 - Flash smelting is more efficient than traditional smelting.
 - Acidic mine drainage can contaminate ground water and aquatic ecosystems

Detox for Contaminated land

- Remediation is the process of removing contaminants from land or H₂O so there is no longer a threat to human health or the environment
- Remediation technologies can be physical, chemical, or biological
 - Physical soil remediation includes flushing. Chemical remediation includes stabilization, solidification, oxidation and electrolysis.
- Bioremediation uses living things to treat contaminated soil or H₂O
 - Phytoremediation uses plants to decontaminate soil

Green Chemistry in Industry

- A manufacturing process that uses chemicals can be both profitable and environmentally responsible
- Main theme of green chemistry:
Why generate pollution if there is a green alternative?
- The principles of green chemistry are being used to design effective industrial processes that are environmentally responsible.