Chemistry 1010

Fire

Introduction

What happens when a candle burns?

What can you observe?

light and heat are generated

over time, the candle gets smaller

What is being used up? candle wax, oxygen

What is being generated? carbon dioxide, water, soot

What are candles made of?

used to be tallow (beef fat)
now it can be paraffin, beeswax,
stearin (from palm wax),
plant waxes (such as bayberry or soybean)
dyes and scents may be added (increase amount of soot)

What about the wick?

typically made of braided cotton
may contain a zinc core for stiffness

carries melted wax up to the flame

the trail of “smoke” when a candle is blown out is condensed candle wax, can be relit

wicks are treated to make them fire-resistant
turn black but don't burn in the flame
braid causes them to curve so that the end reaches the air and burns; doesn't have to be trimmed

What is the flame?

flames are atoms in the reaction that have been heated up enough to give off light

the color depends on the amount of heat and the atom involved

How hot is a candle flame?

around 1000°C

Uses and Dangers of Fire

What was fire used for anciently?

create light

keep you warm

cook food

as a weapon

When the industrial revolution began, fire was used in a new way: coal was burned to produce heat, and the heat was used to boil water to make steam.

What kinds of things were powered by steam engines?

steam locomotives

steamboats

factories

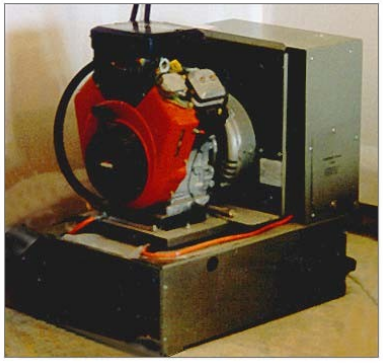
What were they useful for?

transportation of people and goods, manufacturing

What is the downside of steam engines? burning coal creates a lot of pollution

In time, steam engines gave way to internal combustion engines. These burn petroleum products like gasoline or diesel to create thrust that turns the engine.

What kinds of things are powered by internal combustion engines?



Fire is built into our way of life!

Even though fire can be a wonderful tool, it can also be very destructive.

What are some examples?

house fires destroy property, cause injuries, take life

forest fires are a natural part of the environment, but they can destroy recreational area and habitats

How Materials Burn

When we say that something burns, what does that mean?

they combine with oxygen

Consider the following examples:

coal: $C + O_2 \rightarrow CO_2$

butane: $2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

acetylene: $2\ C_2H_2 + 5\ O_2 \rightarrow 4\ CO_2 + 2\ H_2O$

methanol: $2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$

glucose: $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

What do these have in common?

something organic is burned
carbon dioxide and water are formed

If not enough heat or oxygen is present, organic materials may not burn completely.

$2\ C + O_2 \rightarrow 2\ CO$ carbon monoxide is formed

this is what makes car exhaust deadly

never bring a barbeque indoors!

$2\ C_4H_{10} + O_2 \rightarrow 8\ C + 10\ H_2O$ soot is formed

smoky fires with cold or wet wood

black smoke from diesel trucks

Can non-organic materials burn?

yes! most elements will combine with oxygen to give off energy

hydrogen: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

sulfur: $S + O_2 \rightarrow SO_2$

magnesium: $2\ Mg + O_2 \rightarrow 2\ MgO$

$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$

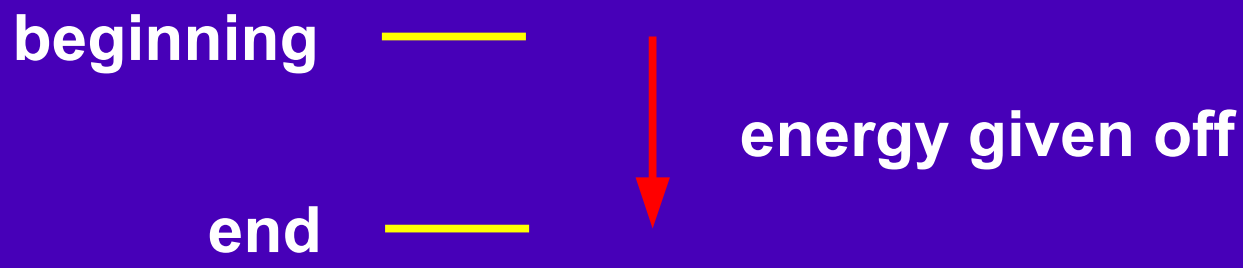
The Energy of Fire

We learned that in nuclear reactions, the energy comes from small amounts of mass that are converted to energy.

So where does the energy of fire come from?

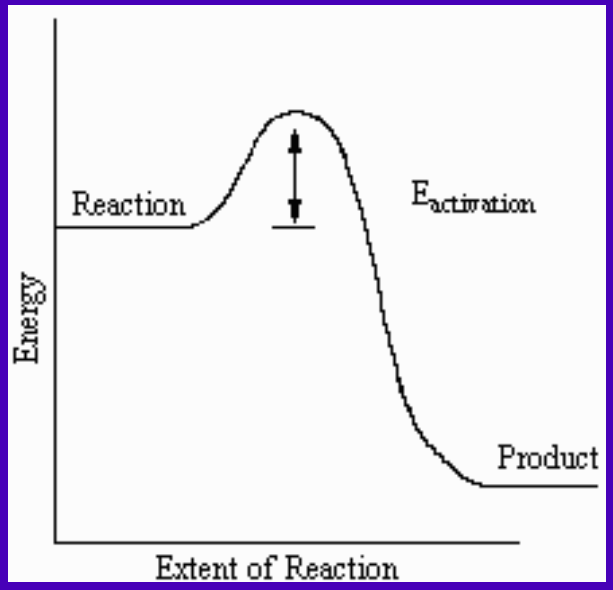
The energy released during any chemical reaction comes from the energy in the chemical bonds.

If the bonds at the beginning have more energy than the bonds at the end, the reaction gives off energy.



Why doesn't everything combustible burst into flame?

chemical reactions have an activation energy
(the energy that it takes to get started)



Having bonds partly formed and partly broken is higher in energy than either the chemical bonds at the beginning or the end.

Combustion reactions release a lot of energy, so once one molecule reacts, it creates enough energy for more to react.

Putting Fires Out

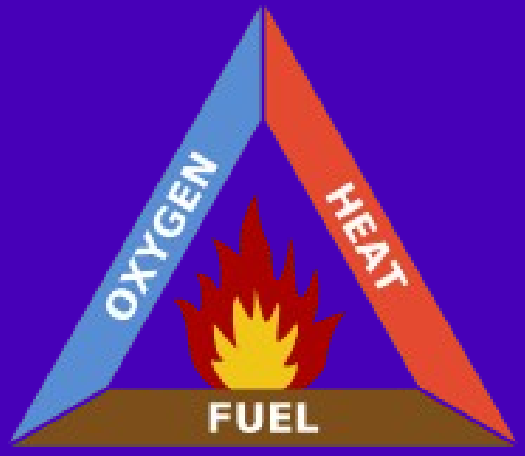
There are three things that are needed for a fire to keep burning:

fuel needed to combine with the oxygen

oxygen needed to combine with the fuel

heat needed to provide energy to get over the activation energy barrier

This is called the fire triangle. If you remove any of these three things, the reaction stops. The fire goes out.



Why does a match burn out?

no more wood to burn (fuel runs out)

Why does putting water on a campfire put it out?

water turns to steam, cools it off

Why will a CO_2 fire extinguisher work?

it smothers the fire, so that it can't get any oxygen

Why does blowing on the coals in a campfire make it burn more, but blowing on a candle makes it burn out?

blowing on a campfire adds oxygen

blowing on a candle takes away too much heat

Fires are categorized into four types according to what is burning and the kind of materials that can be used to put it out.

Type A fires:	wood, paper, plastic, cardboard	forest fires house fires
Type B fires:	flammable liquids	gasoline, kerosene grease fire
Type C fires:	electrical fires	electrical insulation
Type D fires:	metal fires	magnesium flares fireworks

Types of fire extinguishers:

APW: air-pressurized water

for class A fires only!

Dry Chemical: ABC – monoammonium phosphate

BC – sodium bicarbonate

leave a residue which must be cleaned off

Carbon Dioxide: pressurized CO_2

may flare up again when CO_2 dissipates

Metal fire Extinguishers:

used only for metal fires ($305)

Why is it dangerous to use water on a type B, C, or D fire?

Type B: it spreads the fire

when water hits hot grease, it expands rapidly and turns to steam, carrying grease with it

Type C: water conducts electricity

the pool of water spreads the electrical current from exposed wires

Type D: metals fires can use water as a source of oxygen

magnesium flares burn under water!

Things that don't burn:

1 – compounds containing lots of oxygen

Why? can't combine with oxygen any further

2 – halogens, or compounds that contain lots of halogen atoms

Why? halogen-oxygen bonds are high in energy
(most other elements form low energy bonds with oxygen)

3 – noble gases

Why? don't form compounds at all

Fire-suppression systems often contain gaseous organic compounds with halogens replacing the hydrogens or noble gases.

Children's fire-proof pajamas are made from polymers with halogens attached to the carbon chain, but lately some questions have arisen about their chemical safety.