Fossil Fuels, Chemistry of Fuels

Energy sources
- Wood—chemical energy stored by plants
- Kinetic energy—
  - Water power to grind grain
  - Wind to pump water
- Fossil fuels

Sun’s Energy
- Radiant energy
  - Released by fusion
  - Hydrogen fused into Helium
- 1.73 x 10^{17} watts received by Earth from Sun
- 99+% of Earth’s energy
- Converted by plants into chemical energy

Photosynthesis
6 CO\textsubscript{2} + 6 H\textsubscript{2}O + sun energy \rightarrow C\textsubscript{6}H\textsubscript{12}O\textsubscript{6} + 3 O\textsubscript{2}
- Converts CO\textsubscript{2} and H\textsubscript{2}O to sugar and O\textsubscript{2}
- Created the level of oxygen present in today’s atmosphere
- Ancient algae in Archean and Proterozoic oceans released O\textsubscript{2} by photosynthesis

Energy and Chemical Reactions
- Heat released or consumed in chemical reactions
- Measured in calories
  - Food ‘calorie’ is a kilocalorie (kcal)
  - 1 Joule = 0.24 calories
- Energy shown in equation
  - C\textsubscript{3}H\textsubscript{8} + 5 O\textsubscript{2} \rightarrow 3 CO\textsubscript{2} + 4 H\textsubscript{2}O + 526 kcal

Reaction energy
EXOTHERMIC
heats up environment
ENDOTHERMIC
absorbs heat from environment

Conservation of Energy
- Energy is not created or destroyed
- First Law of Thermodynamics

Heat Flow
- From objects with higher temperature to those with lower temperature
- Second law of thermodynamics

Implications of laws
- Change form from high quality to lower quality
  - Chemical energy to heat energy
  - Friction: mechanical to heat
- Energy wasted as frictional heat
- Need to put energy in to ‘make’ cold
**Fossil fuels**
- Burn readily
- Reaction is oxidation
- Release heat energy

**Fossil fuels**
- Coal
- Petroleum
- Natural Gas

**First law of thermodynamics**
- Conservation of energy
- Cannot create or destroy energy
- (But we can convert to less-useful form)

**Fossil fuels**
- Non renewable
- From ancient organisms
- Extracted from Earth

**Carboniferous Period Forest**

Coal formation 1

Coal formation 2

Coal formation 3

Coal formation 4

http://palaeos.com/Paleozoic/Carboniferous/Carboniferous.htm
Coal

\[ C + O_2 \rightarrow CO_2 \]

- Anthracite
- Bitumen
- Lignite

Coal

- Incompletely decayed plants
- Burial pressure releases \( O_2 \) and \( H_2 \)
- Carbon remains
- Paleozoic—Pennsylvania coal, Carboniferous Period

Coal

- Must be mined
- Pollutants in coal
  - Sulfur leads to acid rain
  - Also contains mercury, arsenic, nitrates

Hydrocarbon System

- Shale with organic material
- Gooey sludge on ocean floor

SOURCES

- Zooplankton
  - Planktonic organisms
  - Probable source of petroleum

COOKING

- Just right temperature
- Just right pressure
- Just right time

RESERVOIR

- Porous
- Permeable
- Usually a sedimentary rock

POROUS

- Has open space
- Sponge
**PERMEABLE**
- Permits fluid throughflow
- Nylon scrubbie

**RESERVOIR**
- Permeable
- and Porous

**TRAP**
- Almost no permeability or pore space
- Shale (Usually not source shale)

**STYLES OF TRAPS**
- Structural
- Stratigraphic

**STRUCTURAL TRAP**
- Reservoir sand
- Capping shale
- Arched fold

**STRUCTURAL TRAP**
- Reservoir exists
- Fault creates trap

**STRATIGRAPHIC TRAP**
- Channel sand
- Shifting channel of river
- Shale above caps reservoir

**STRATIGRAPHIC TRAP**
- Deposition of sand
- Shale deposited above sand
  - Deltas
  - Invading seas
**UNCONFORMITY TRAP**
- Reservoir rock tilted and eroded
- Impermeable rock deposited above erosion surface

**Natural Gas**
- Mostly methane
  \[ \text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O} + \text{heat} \]
- Excellent, clean-burning fuel
- Raw material for plastics and other chemicals

**Petroleum**
- Replaced coal by about 1950
- Complex hydrocarbon molecules
- Derived from fats
- Combustion products are carbon dioxide and water

**Petroleum**
- \[ 2\text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow 16 \text{CO}_2 + 18 \text{H}_2\text{O} \]
- Also contains some sulfur compounds
- Fuel oil is fairly clean
- Burning gasoline results in smog
  - Internal combustion engines inefficient

**Petroleum Requirements**
- Source
- Cooking
- Reservoir
- Trap

**TITUSVILLE, PA**
- Oil Creek Valley in the 1860s
- Phillips well (rt) 4000 bbl/day
- Woodford well (lt) 1500 bbl/day

**Texas Oil**
- Lucas Gusher, 1901
- Initial production 100,000 bbl/day
- Salt dome traps

**Spindletop Salt Dome**
- Lucas Gusher, 1901
- Initial production 100,000 bbl/day
- Salt dome traps
**Boiler Avenue**
On Spindletop salt dome at Beaumont, Texas

**Signal Hill, Long Beach, CA**
1932

**Drilling on the North Slope**

**Drilling in the North Sea**

**Top 10 Countries—Oil Statistics**
- Reserves
- Consumption
  - [http://www.nationmaster.com/graph/T/ene_oil_con&int=10](http://www.nationmaster.com/graph/T/ene_oil_con&int=10)

**Source of energy not from Sun**
- Rare deep sea vent communities
- Sulfurous hot springs supports bacteria
- Other organisms subsist on bacteria
- Larger creatures can survive on the bacteria-eating organisms