Basic Chemistry of Fossil Fuels

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Difference in how different FF are formed

- https://www.youtube.com/watch?v=zaXBVYr9Ij0
- To 1:11

Fossil Fuel Chemistry Basics

- Hydrocarbons combust in the presence of oxygen.

- $C_xH_y + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

- Exothermic; once initiated proceeds by the heat it generates.

- Generation of greenhouse gas carbon dioxide aswell as other unwanted byproducts.

Chemical Composition

Hydrocarbon	Average	Range
Alkanes (paraffins)	30%	15 to 60%
Naphthenes	49%	30 to 60%
Aromatics	15%	3 to 30%
Asphaltics	6%	remainder

Element	Percent range
Carbon	83 to 85%
Hydrogen	10 to 14%
Nitrogen	0.1 to 2%
Oxygen	0.05 to 1.5%
Sulfur	0.05 to 6.0%
Metals	< 0.1%

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Formation

- Microscopic organisms die and are buried in anoxic conditions.

- High molecular weight polymers called kerogens are formed from the breakdown products carbohydrates and proteins.

- Over millions of years, under high heat and pressure, kerogens break down into hydrocarbons through a process known as catagenisis.
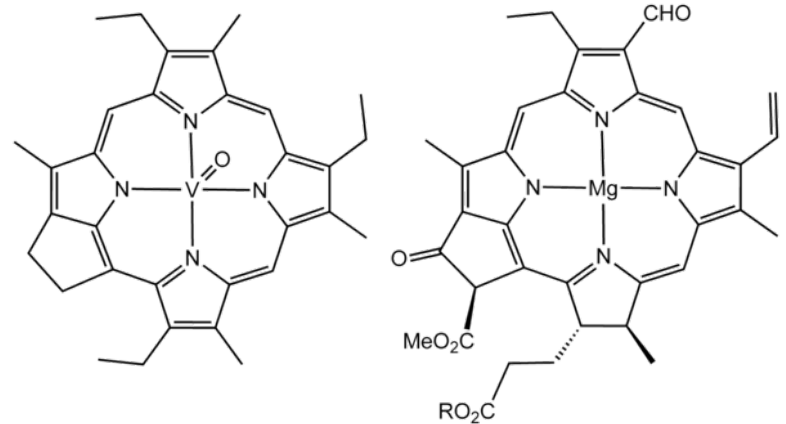
Types of Oil

- Heavy oil found in Orinoco belt and Athabasca oils sands have large carbon/hydrogen ratio.
  - Must be cracked to be made into conventional petroleum products.
  - More difficult to mine bc greater viscosity.
- Oil shale, kerogens trapped in shale, can be used to make hydrocarbons by pyrolysis.

Total World Oil Reserves

Oil Sands Bitumen 30%

Conventional Oil 30%
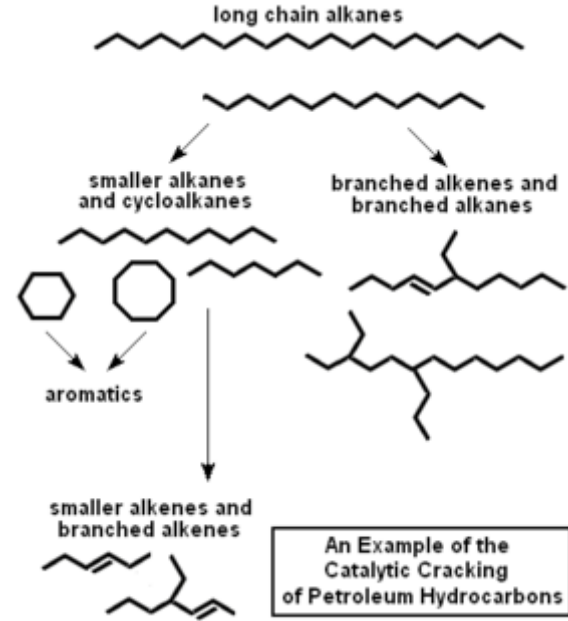
Extra Heavy Oil 25%

Heavy Oil 15%
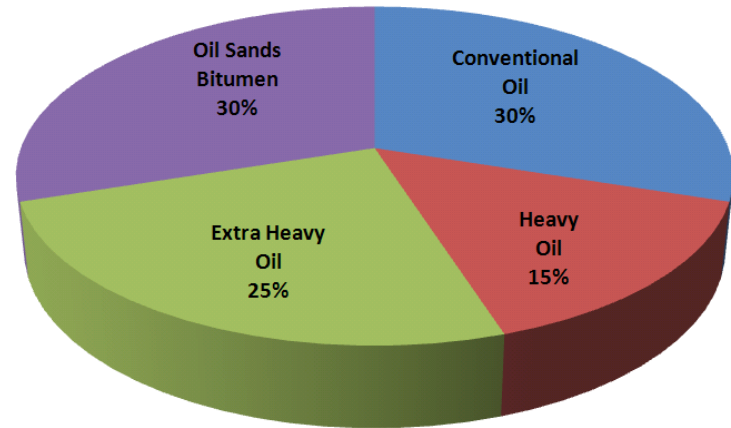
Refining Oil

- Fractional distillation to separate hydrocarbons by boiling point.

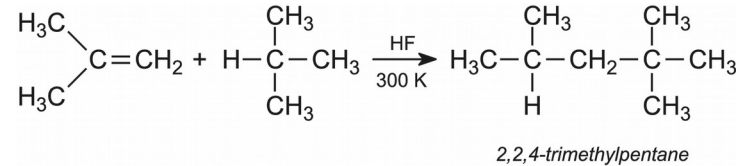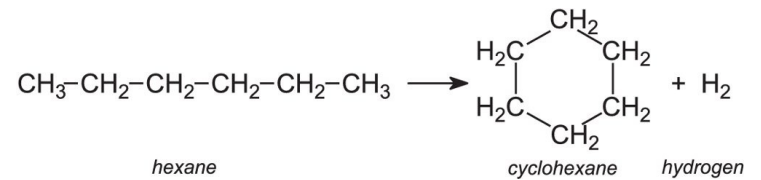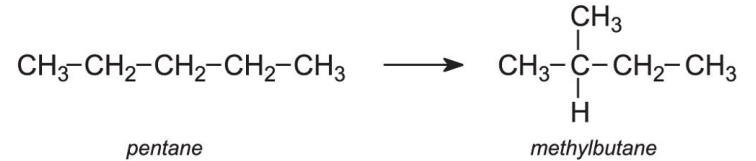- Longer chain hydrocarbons and aromatics have higher boiling points.
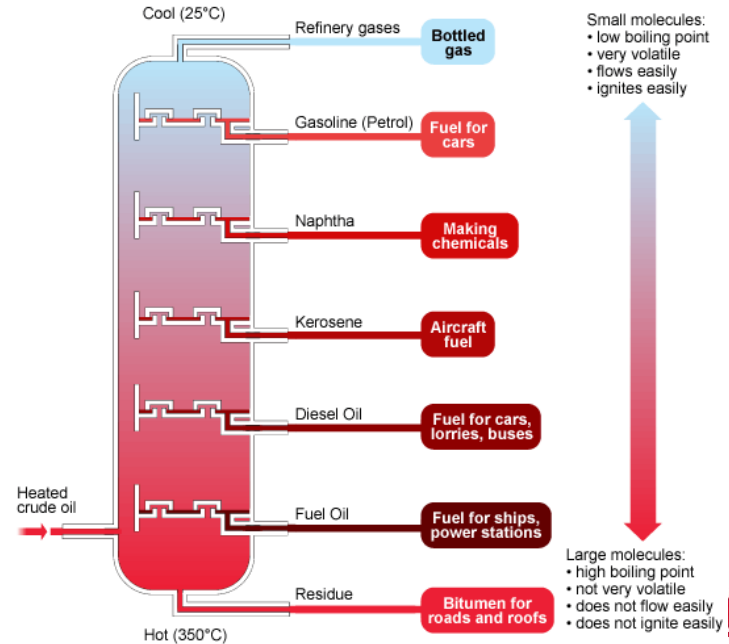
Cracking

- Cracking is used to turn longer chain alkanes into smaller alkanes and alkenes which are useful in chemical industry or as fuel.

- Steam cracking (1000-1150K) vs. catalytic cracking (700-800K).

- Hydrocracking: catalytic cracking done under high hydrogen pressure.

long chain alkanes

smaller alkanes and cycloalkanes

branched alkenes and branched alkanes

aromatics

smaller alkenes and branched alkenes

An Example of the Catalytic Cracking of Petroleum Hydrocarbons

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Other Important Refining Processes

Octane Rating

- Most combustion engines are designed to run on a mixture of octane and pentanes.

- High octane decreases knocking because it does not ignite without a spark.

- Octane rating refers to a fuel with a tendency to knock equal to that of a fuel of that percent octane. Does not have to be that percent.


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Fracking Background

- https://www.youtube.com/watch?v=Uti2niW2BRA
- 0:24-end

Natural Gas

- Used for heating, cooking, electricity generation
- Natural Gas is a mixture of hydrocarbon gases, primarily Methane
- Can be found either isolated or in oil fields
- Was burned off prior to early 20th century
  - Now it is injected back into reservoir if unwanted to either await future market or to repressurize and enhance extraction efficiency

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Natural Gas Processing
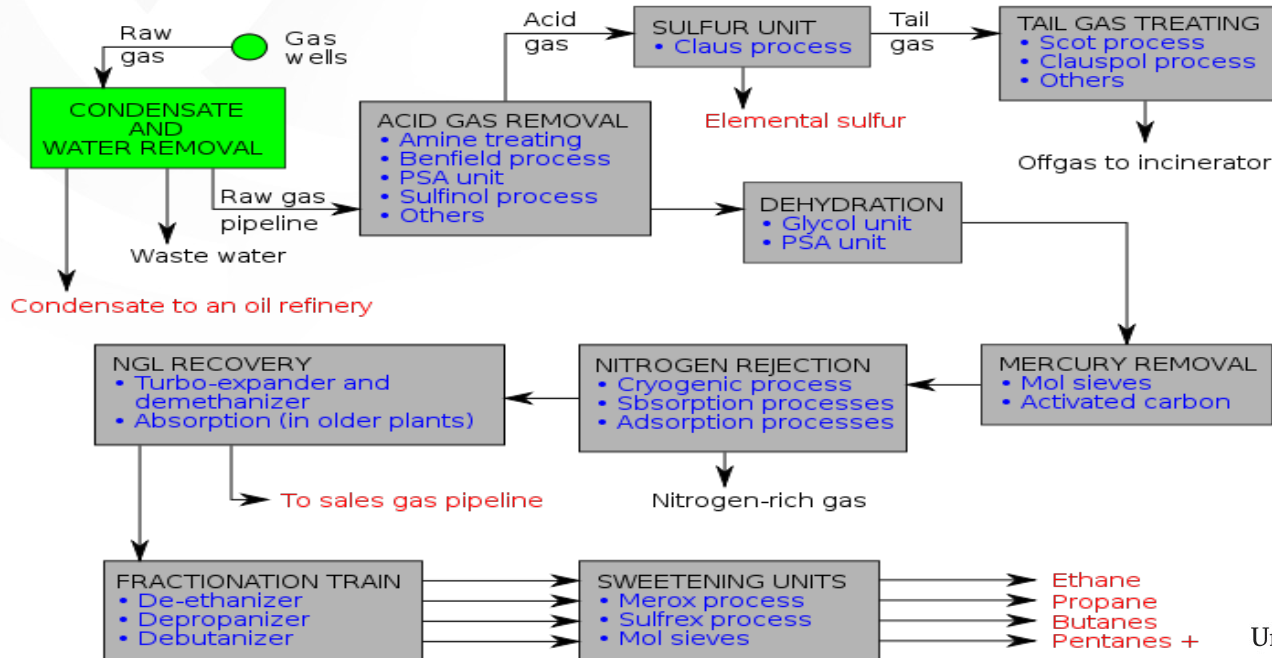
Natural Gas Reaction

- Combustion Reaction
- $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
- If not careful this can happen inside of the pipes if the natural gas is not cooled due to friction

Largest Natural Gas Field

- The world's largest gas field is the offshore South Pars/ North Dome Gas-Condensate field shared between Iran and Qatar. It is estimated to have 51 000 cubic kilometers of natural gas and 50 billion barrels of natural gas condensates

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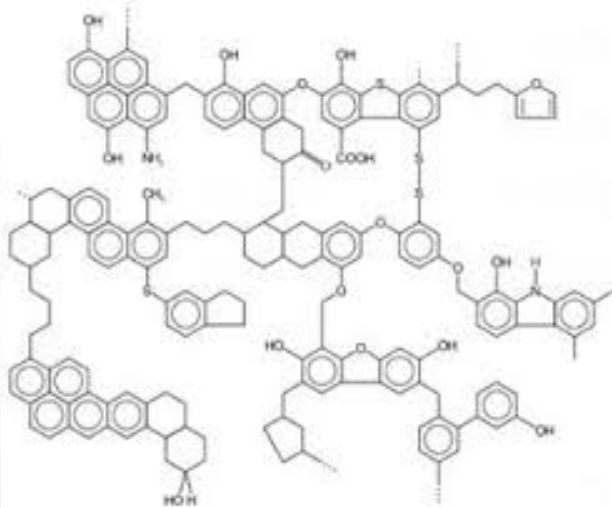
Coal

German Classification	English Designation	Volatiles %	C Carbon %	H Hydrogen %	O Oxygen %	S Sulfur %	Heat content kJ/kg
Braunkohle	Lignite (brown coal)	45–65	60–75	6.0–5.8	34-17	0.5-3	<28,470
Flammkohle	Flame coal	40-45	75-82	6.0-5.8	>9.8	~1	<32,870
Gasflammkohle	Gas flame coal	35-40	82-85	5.8-5.6	9.8-7.3	~1	<33,910
Gaskohle	Gas coal	28-35	85-87.5	5.6-5.0	7.3-4.5	~1	<34,960
Fettkohle	Fat coal	19-28	87.5-89.5	5.0-4.5	4.5-3.2	~1	<35,380
Esskohle	Forge coal	14-19	89.5-90.5	4.5-4.0	3.2-2.8	~1	<35,380
Magerkohle	Nonbaking coal	10-14	90.5-91.5	4.0-3.75	2.8-3.5	~1	35,380
Anthrazit	Anthracite	7-12	>91.5	<3.75	<2.5	~1	<35,300

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