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Organic chemistry

Organic chemistry refers to the chemistry involving carbon atoms.

Organic chemistry is complex and varied
pesticides, textiles, fuels, food, adhesives etc.
all depend on organic chemistry.

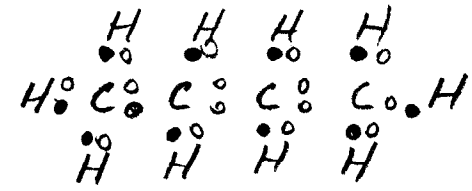
In this presentation we make only a brief introduction and some naming conventions

Lewis Structures is one way of representing atomic bonds that are present in molecules of compounds of interest

Diagrams have the symbol of atom surrounded by outermost orbital electrons

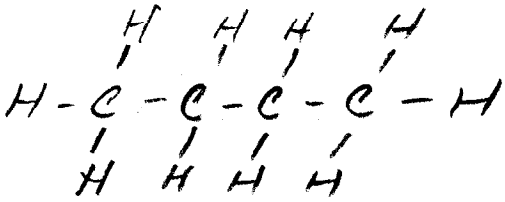
In covalent bonding Heavy atoms share electrons to achieve configuration of a noble element (8 electrons in outer orbital)

Thus butane (4 carbon gas)



Sharing is obvious

To simplify use a line to represent electron pairs



Another way is to represent carbons as vertices in line segments and not show H.

 (ends are vertices)

In the example shown, the compond is n-butane (all in a straight line) or alternate structure (isomer) with same chemical formula, but different chemical and physical properties is iso-butane

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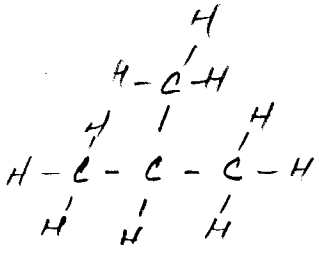

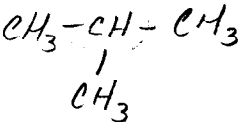

Butane is an example of a compound that contains only carbon C & hydrogen H. These
→ are called hydrocarbons.

If the hydrocarbon's carbon forms single bonds with other atoms it is called a saturated hydrocarbon, parrafin, or alkane

Fane refers to a series of hydrocarbons starting with methane (CH_4), ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10})...

$C_1 - C_4$ are gasses
$C_5 - C_{20}$ are liquids (includes components of gasoline & diesel)
$C_{21} - up$ waxy solids (parrafin)

Hydrocarbons are building blocks of many compounds

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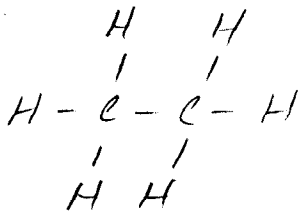
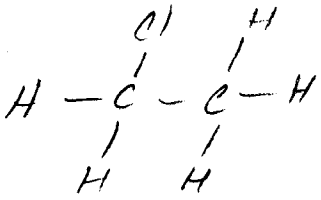


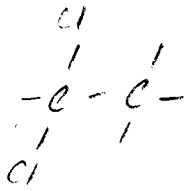
Ethane

Substitute Cl for one hydrogen



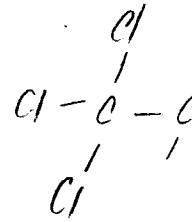
chloroethane

Substite a second Cl on same C



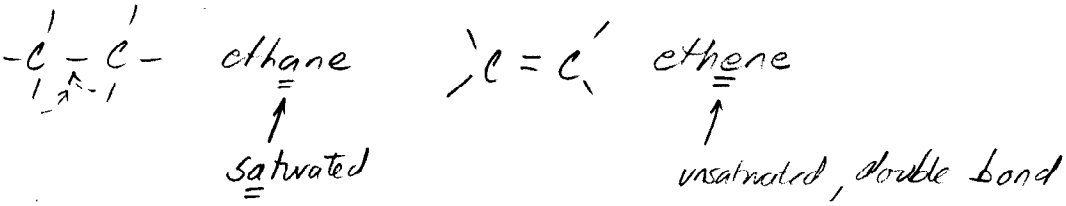
1,1 dichloroethane

Substitute a third Cl on same C



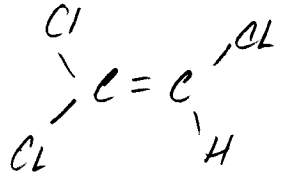
1,1,1 Trichloroethane (TCA)
(solvent, common in industry and in contaminated groundwater)

These are all called saturated hydrocarbons. Unsaturated HC have at least 2 C atoms joined by a multiple bond



The double bond series starting with ethene is called the alkene series.

If active group substituents are made such as 3 Cl on ethene



tri-chloro ethylene
(TCE)

common solvent, found in waters everywhere.

In addition to single atom substituents, functional group substituents are also possible

-OH group produces an alcohol
-O- between carbons produces ethers

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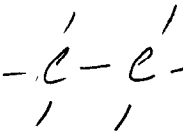
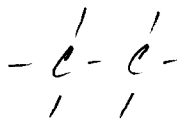
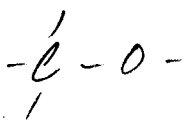
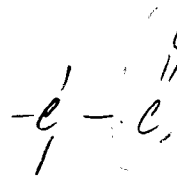
H-C=O group produces <u>aldehydes</u>

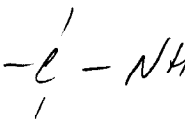
-OH to C=O produces <u>carboxylic acid</u>
$-NH_2$ group produces <u>amines</u>.


ethanol alcohol (drinkable)


propyl alcohol (rubbing alcohol)

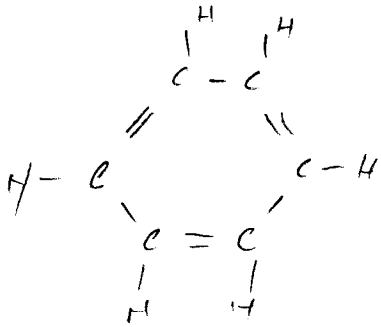

dimethyl ether


Acetic acid


Methyl amine

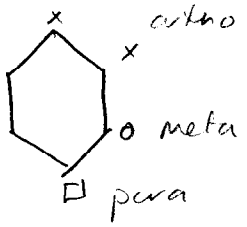
Hydrocarbons have linear, branched, or loop (ring) structures.

benzene is an example of a ring structure



Molecules with a ring structure are called aromatic compounds.

The benzene ring when part of a larger molecule is called a phenyl group (not the same as phenol)



attachment locations determine ortho-, meta-, para-

Naming compounds is complex and important. The names identify functional groups which can be exploited in many environmental processes.

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Nuclear Chemistry.

A last class of compounds are those that undergo radioactive decay - the chemistry & physics of decay is called nuclear chemistry

n - neutrons
p - protons
e - electrons

mass number = protons + neutrons
atomic number = protons

$^{235}_{92}U$ $^{238}_{92}U$ isotopes of uranium

$^{238}_{92}U$ has three more neutrons than U-235.

Many isotopes are unstable, and discard excess particles & energy in an attempt to reach a stable compound. Such "decay" is called radioactive decay.

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There are three recognized kinds of atomic radiation
alpha – 2 proton, 2 neutron (Helium nucleus) ${}^{4}_{2}\alpha$
beta – electrons (created by $n \rightarrow p + e$)
gamma – photons (high energy photon)

Range of penetration is inversely proportional to mass
alpha -> heavy → low penetration

gamma → no mass → high penetration

Decay chain is a list of decay particles and compounds an unstable atom passes through

$${}^{239}_{94}Pu \rightarrow {}^{235}_{92}U + {}^{4}_{2}\alpha + \gamma$$

$${}^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + \beta$$

Not all atoms of a compound decay simultaneously or instantly the spontaneous decay happen randomly (with respect to time and which atom decays). The time required for half the atoms in a sample to decay to other elements is called the half-life of the sample.

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A given isotope has a unique half-life, but the half lives range from seconds to millenia.

Units of radioactivity

Ci (curie) $3.7 \cdot 10^{10}$ decay events/second } rates

Bq (becquerel) 1 decay event/second } rates

R (roentgen) ionizations produced by X or γ rays. } dose/effect

rad (radiation absorbed dose) 100 ergs/gram

rem (roentgen equivalent man) - effect of a particular rate * time on humans.
(rate * time = dose)

<u>Fission</u> (artificial & live bait)

Fission is energy released when atoms are split in a nuclear reaction.

heavy atoms $\longrightarrow$ lighter atoms + energy

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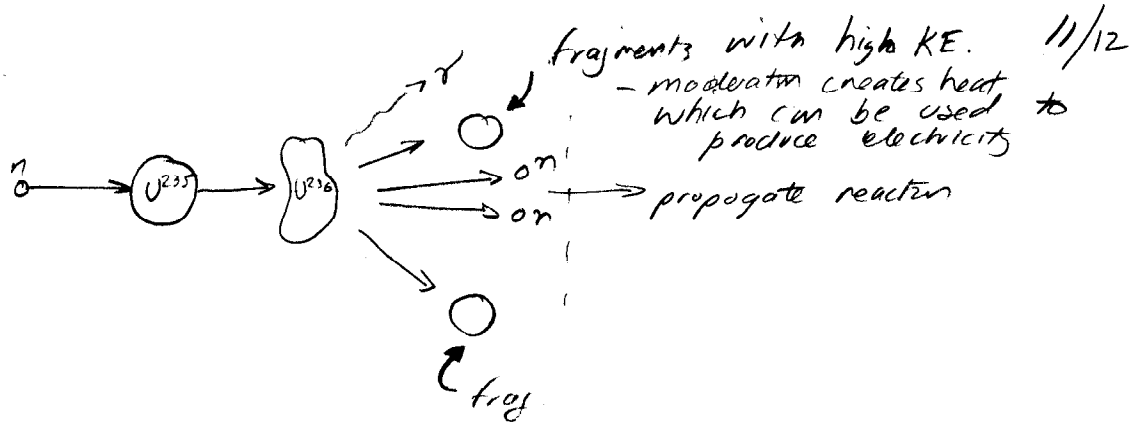

Fusion -

Fusion is energy released when atoms are joined.

lighter atoms + lighter atms ⟹ heavy atms + energy

To date no successful sustained fusion reactions that produced net energy for very long.

Fuel Cell

No discussion of energy is complete without introduction of a fuel cell (non-nuclear)

$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$ + heat (rocket engine)

However if the reaction is performed in an electrolytic cell the energy is released not as heat, but as useful work as the electron transfer in the reaction is passed through

a resistive load (motor, lamp, ect.)

Check the thermodynamics of a fuel cell

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

$0 + 0 \rightarrow (-285.8)2$ Change in entropy

$\Delta H (-571.8\ kJ/mol)$, exothermic reaction

Fuel cells will become available in the next decade, and will probably be common by 2024. The only engineering challenges are ① storage of the hydrogen and ② conversion of hydrocarbons and waste gasses into hydrogen rich fuels.