Organic Chemistry

Chemistry 30 – Ms. Hayduk

Organic Chemistry

- Study of compounds that contain carbon as the main element
- Relevant to pharmaceuticals, petrochemicals, food, explosives, paint, cosmetics, plastics
- Important elements:
  - Hydrogen: one unpaired e^-, makes one bond
  - Oxygen: two unpaired e^-, makes two bonds
  - Nitrogen: three unpaired e^-, makes three bonds
  - Carbon: four unpaired e^-, makes four bonds

Hydrocarbons

- Mainly found in fossil fuels, such as coal, oil sands, crude oil, natural gas, etc.
- Contain carbon atoms bonded to hydrogen atoms
- Fossil fuels are mixtures of HCs - **refined** (physical/chemical) to produce more usable products
- Most of this unit deals with structure/behaviour of hydrocarbons

Alkanes

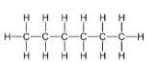
- **Alkanes** – hydrocarbons with C – C bonds
- Naming is based on number of carbons in the longest chain:

1 meth-	4 but-	7 hept-	10 dec-
2 eth-	5 pent-	8 oct-	
3 prop-	6 hex-	9 non-	

- Ends in -ane

Straight-Chain Alkanes

- No "branches", naming is simple
- Three types of drawing:

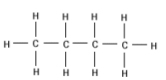
Structural diagram 

Condensed diagram $CH_3CH_2CH_2CH_2CH_2CH_3$

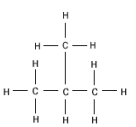
Line diagram 

Branched Alkanes

- One or more carbon is branched off main chain (all single bonds), naming is more complicated
- Example:

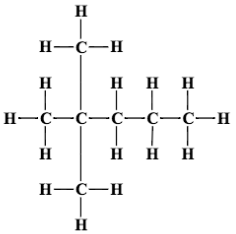


butane



2-methyl-propane

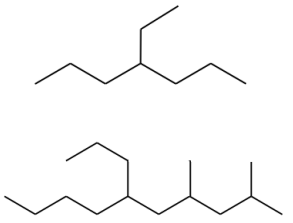
Example: Line Diagrams



Naming

1. Longest continuous carbon chain is alkane
2. Branches are alkyl groups
3. Number longest chain from end that gives lowest number for first branch
4. Give numbers to alkyl branches based on what carbon they are on
5. Use prefixes (di, tri) to indicate number of each type of alkyl group
6. One word with parent chain last and alkyl branches in alphabetical order

Examples: Naming



Examples: Drawing

3-methylpentane

2,3-dimethyl-3-propylheptane

3,3-diethyl-2-methylpentane

Structural Isomers

- Same molecular formula (e.g. C_4H_{10}) but atoms are connected differently
- Different chemical properties, due to changes in intermolecular forces

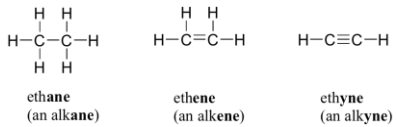
Example 1: Alkanes

1. What types of intermolecular forces are present in alkanes?

2. Which would have a lower boiling point: butane or 2-methylpropane?

Alkenes and Alkynes

- **Alkenes**: hydrocarbons with carbon-carbon double bond
- **Alkynes**: hydrocarbons with carbon-carbon triple bond
- Examples:



Saturated/Unsaturated

- **Saturated**: all carbons have four single bonds
- **Unsaturated**: one or more carbons have multiple bonds
- Unsaturated HC can react with small molecules (H_2, halogens) to make plastics, alkanes

Naming Alkenes and Alkynes

- Double bond is –ene, triple bond is –yne
- Rules for numbering chain are the same (start at end lowest to bond), but multiple bonds must be on main chain

Example: Drawing Unsaturated Hydrocarbons

2-butyne (but-2-yne)

penta-1,3-diene

2,3,4-trimethyl-1-hexene

4-ethyl-4-methyl-2-pentyne

Understanding Crude Oil

1. What conditions need to exist for organisms to turn into fossil fuels, instead of decaying and decomposing?
2. What is kerogen?
3. What process broke the long organic molecules into hydrocarbons?
4. Under what conditions would natural gas be produced instead of petroleum?

Understanding Crude Oil

5. What is the difference between kerogen and petroleum?
6. What does petroleum travel up through the rock? How do deposits form?
7. How is the stored energy in hydrocarbons released?

Dump Crude Oil…

- Crude oil is a mixture of many different hydrocarbon molecules
- Varies depending on location
- Composed of straight chain and ringed hydrocarbons, plus sulfur and nitrogen compounds
- Where does the crude oil go next?

Notes About Boiling

1. What happens when something boils?
2. Does the temperature of a liquid change when it boils?
3. When a liquid is at its boiling point, what is happening?
4. Water boils at 69˚C at the top of Mount Everest. Why is the boiling point lower?

Boiling Points of Hydrocarbons

Look at your table:

1. What changes about the compounds as you look down the table?
2. What changes about the boiling point and melting point as you look down the table?
3. What can you say in general about hydrocarbons and BP/MP?

Boiling Points of Hydrocarbons

4. Why do the boiling points of alkanes change down the table?
5. If all of the alkanes on the table were mixed together, what would happen if the temperature was increased to 250˚C?
6. What temperature would we want it to be at if we wanted to just collect pentane gas?

Combustion

- **Combustion** – burning of organic compounds (hydrocarbons) to produce carbon dioxide, water and energy (heat, light)
- Quality of combustion depends on availability of oxygen
- Yellow flame is sign of incomplete combustion

Combustion

Complete Combustion

hydrocarbon + O_2 (g) → CO_2 (g) + H_2O (g)

Incomplete Combustion

hydrocarbon + O_2 (g) → CO (g) + H_2O (g)

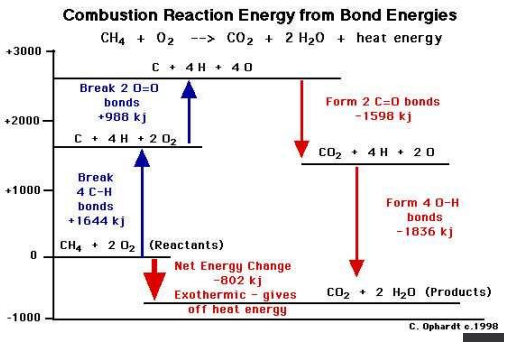
hydrocarbon + O_2 (g) → C (s) + H_2O (g)

Burning Hydrocarbons

- Natural gas is composed mainly of methane – cleanest burning fuel
- Other hydrocarbons are more chemically complex, so produce more by-products when burned

Energy of Combustion

- Energy is stored in chemical bonds; released when they are broken
- Combustion releases energy by rearranging complex hydrocarbons into simpler products
- Larger molecules produce less energy, but are also slower burning
  - e.g. methane vs. octane – why is methane not used in vehicles?



Functional Groups

- Any structure modifications that change an alkane to something else
- Already have looked at two: alkenes (double bond) and alkynes (triple bond)
- Different properties, making them useful in different applications

Halocarbons

- R-X (X = F, Cl, Br, I)
- Hydrocarbon with one or more halogens attached in place of hydrogen
- Higher boiling points than alkanes (why?)
- Example: chloroethane
- Uses: solvents, refrigerants (Freon, CFCs), plastics (PVC, Teflon), sucralose

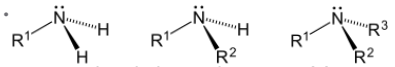
Alcohols

- R – OH (OH = hydroxyl group)
- Hydrocarbon with one or more hydroxyl group
- Polar molecules, so higher boiling point that similar alkanes (what type of IMFs?)
- Example: ethanol
- Uses: alcoholic beverages, fuels, solvents or cleaning products

Ethers

- R-O-R'
- Oxygen bonding two carbon groups (can be same or different)
- Lower boiling points than alcohols of similar size and mass (why?)
- Example: diethyl ether
- Uses: early anaesthetic, in cosmetics (polyethylene glycol), aerosols (dimethyl ether), solvents

Amines

- 
- Nitrogen bonded to carbon group(s) or hydrogens
- Example: ethylamine
- Biology: formed from amino acids, decaying fish, neurotransmitters
- Uses: dyes, drugs (antihistamines, decongestants, amphetamines, antidepressants, opiates)

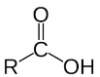
Aldehydes

- R = O or *CHO
- Carbonyl (double bonded oxygen) at the end of a carbon group
- Lower boiling points than similar alcohols, but higher than similar alkanes (why?)
- Example: ethanal (acetaldehyde)
- Uses: formaldehyde, essential oils

Ketones

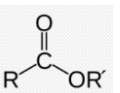
- 
- Carbonyl bonded to a carbon in the middle of a carbon group
- Similar properties to aldehydes, but slightly less reactive
- Example: 2-propanone (acetone)
- Uses: solvents in industry

Carboxylic Acids



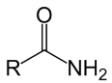
- Carboxyl (carbonyl + hydroxyl) bonded to carbon group
- Polar and reactive
- Example: ethanoic acid (acetic acid)
- Uses: production of polymers, pharmaceuticals, solvents, food additives

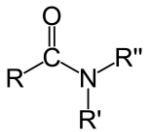
Esters



- Carboxyl bonded to two carbon groups (do not need to be the same)
- Uses: fats, fragrance and flavours, polyester

Amides





- Hydroxyl from carboxyl group replaced with nitrogen
- Uses: nylon, Kevlar, peptide bonds in proteins, drugs (penicillin, LSD)