Recall:

The lower the pKa the more acidic the compound

Examples of strong acids:

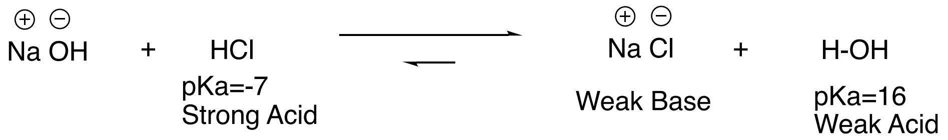
Acid	**pKa**
HI	-10
HBr	-9
HCl	-7
HF	-10
H_3O^+	-1.74

Can go up to +3.17 in a diluted sol'n (in water)

Two factors that affect acidity of the above acids:

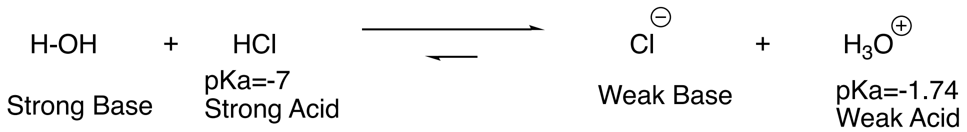
1) Electronegativity – the more electronegative the atom, the better it can hold a negative charge
2) Solvation – the larger the ion, the better solvated it can be and so the more acidic it's conjugate acid will be

Ex #1)



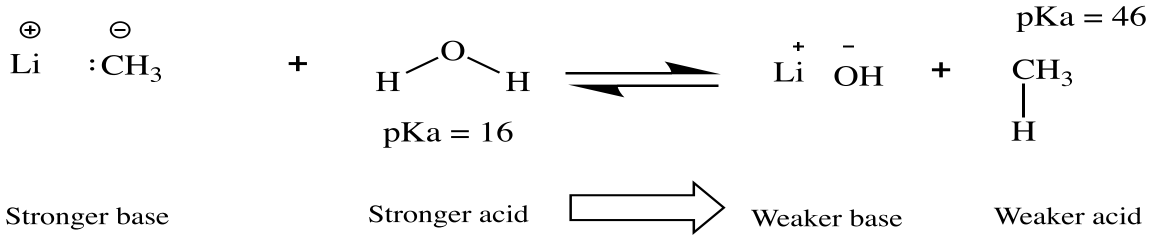
A strong acid and a strong base will quickly react with each other to drive the reaction to the weak acid and the weak base.

Ex #2)

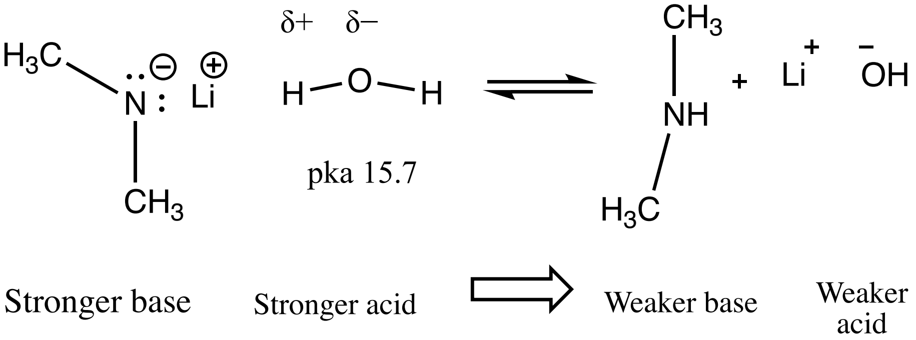


While water is not actually a strong base, it is in comparison to C^-. HCl is the strong acid, and so the equilibrium lies to the right. Hence H_3O^+ is the strongest acid that will exist in an aqueous solution of HCl.

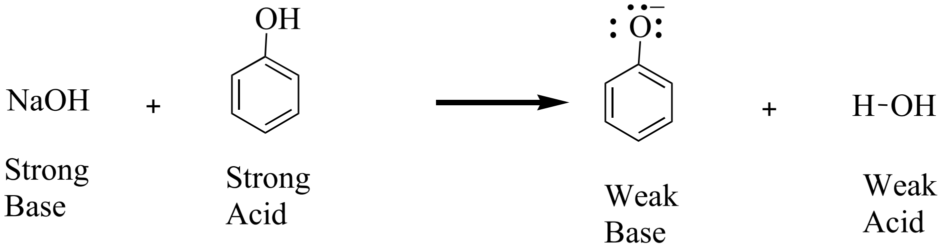
Ex #3)



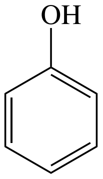
Ex #4)



Ex #5)



NB: Oxygen is more electron withdrawing than Carbon and can stabilize negative charge so removing a proton from the oxygen is preferable than from the Carbon on the phenol compound



Phenol

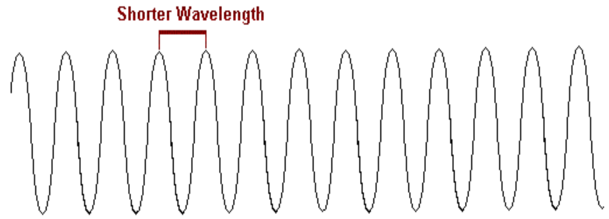
Phenol pKa = 10

Electromagnetic Radiation:

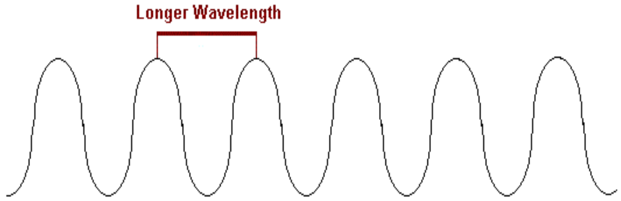
Infrared (IR) Spectroscopy – Background only:

$E = hc/\lambda = h\nu$, energy is quantized

E = Energy
h = Planck's Constant= 6.6×10^{-34} joules/sec
ν = Frequency
λ = Wavelength
c = Speed of light = 3.0×10^{10} cm/sec



- Shorter Wavelength
- Higher Energy
- Higher Frequency

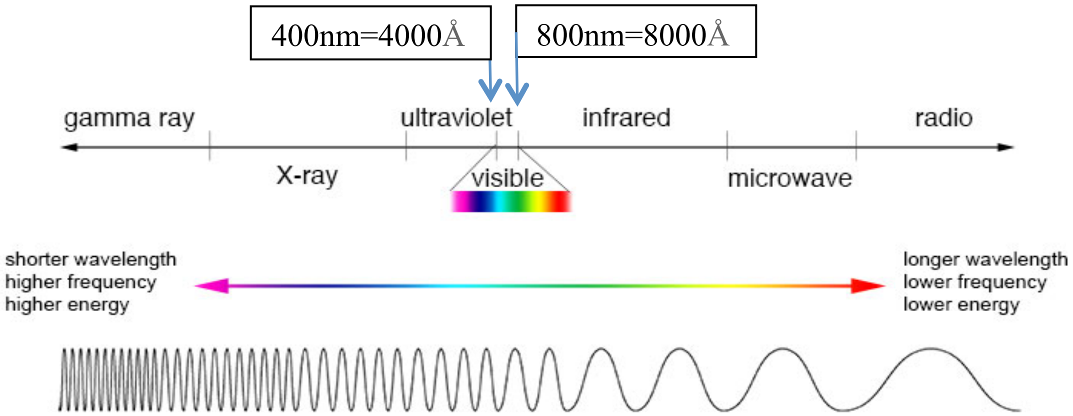


- Longer Wavelength
- Low Energy
- Low Frequency

NB: There is an inverse relationship between wavelength and frequency.

Electromagnetic Spectrum:

NB: 1nm = 10 angstrom

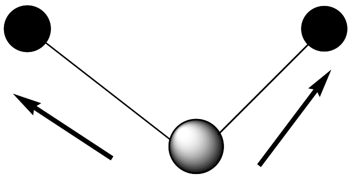


UV and visible light: conjugated double bond systems

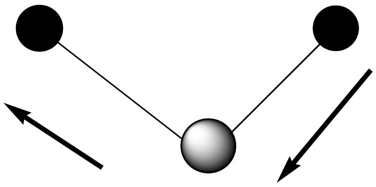
e.g. C=C bonds absorb UV light and some visible light

Infrared Radiation: bond stretching and bending modes

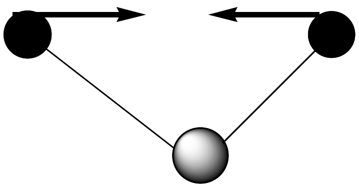
-Measured in wavenumbers (cm^{-1})
- Defined as cycles/second
  - e.g. O-H bond can be seen around ~3400cm^{-1} in an IR spectrum



SYMMETRIC STRETCHING

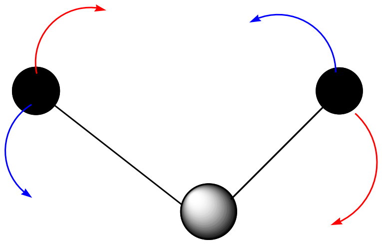


ASYMMETRIC STRETCHING



IN PLANE BENDING

(SCISSORING)



OUT OF PLANE BENDING

(TWISTING)

NEXT SECTION: Lecture Outline 2: ALKANES

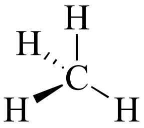
<u>Hydrocarbons</u> – Compounds that contain only C and H

- Alkanes contain only single bonds (C-H, C-C)
- Alkenes = Olefins (C=C)
- Alkynes =Acetylenes (C≡C)

<u>Alkanes</u>

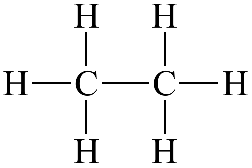
- All carbons are sp^3 hybridized (optimal bond angle of 109^{o})
- Single bonds (σ bonds).
- Tetrahedral geometry at every carbon
- Held together by London (dispersion) forces

Ex #1) CH_4, methane



Bp = -161^{o}C

Ex #2) C_2H_6, ethane



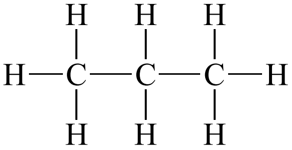
$$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$$

Bp = -88^{o}C

CH_4 H_4C CH_3-H

C_2H_6 CH_3-CH_3 H_3C-CH_3

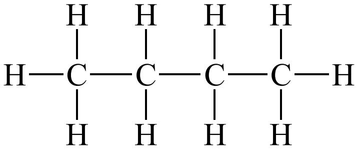
Ex #3) C_3H_8, propane



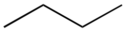
$$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$$

Bp = -42^{o}C

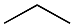
Ex #4) C_4H_{10}, butane

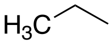


$$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$$



C_3H_8 $CH_3CH_2CH_3$



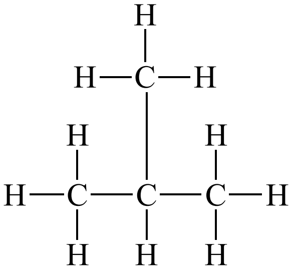


C_4H_{10}, $CH_3CH_2CH_2CH_3$

n-Butane: normal straight chain butane

NOTE: Propane has a boiling point of -42°C, which is higher than methane because it's chain-like structure allows for more surface area for London dispersion forces to take effect.

Ex #5) C_4H_{10} , isobutene or i-Butane

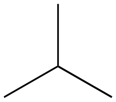


$$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{\overset{H}{H-C-H}}{C}}-\underset{H}{\overset{H}{C}}-H$$

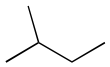
- Isomers are different compounds that have the same molecular formula and different structure. They have different physical properties (e.g. mp, bp, odour, biological effects)

\- iso - meros
same - parts

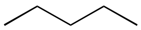
one type: structural (same as constitutional)



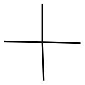
structural isomer = constitutional isomer



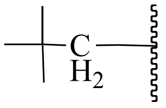
isopentane



n - pentane



Neopentane

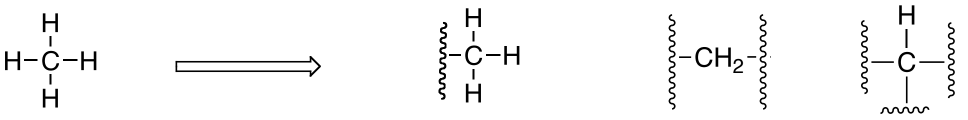


Neo Group

Groups (part of an alkane structure)

- In naming the particular group, drop the "ane" part and add "yl" to the name
- For example, meth<u>ane</u> → meth<u>yl</u>

(i) Methyl group – CH_3



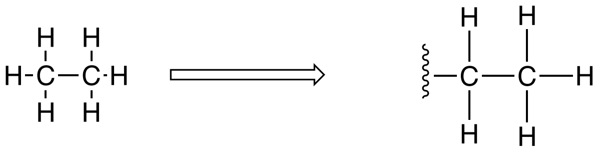
methane

methyl group

methylene

methine

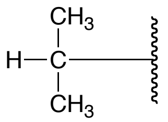
(ii) Ethyl group – CH_2CH_3



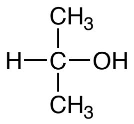
ethane

ethyl

(iii) Isopropyl group

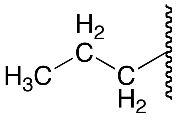


iso-propyl
group

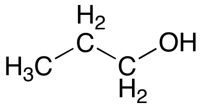


iso-propyl
alcohol

(iv) *n*-Propyl group

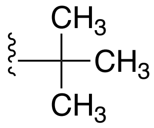


n-propyl chain

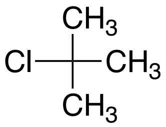


n-propyl alcohol

(v) *tert*-Butyl group



tert-Butyl chain

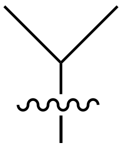


tert-Butyl chloride

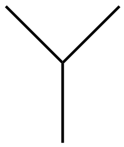
Systematic Nomenclature

RULES:

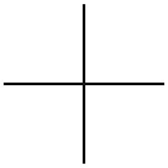
1. Find the longest chain
2. Number from end of the chain, so that the 1st branch point has the lowest number
3. Name the chain, then add prefixes (for the groups attached) with number and name the groups attached
4. Separate numbers and names by dash



isopropyl



isobutane
2-methylpropane

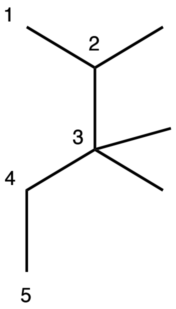


neopentane
2,2-dimethylpropane

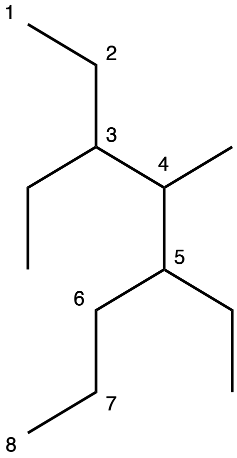
Note: iso = second-to-last carbon of the chain is disubstituted (2 methyl groups)
neo = second-to-last carbon of the chain is trisubstituted (3 methyl groups)

Prefixes for naming:
Di (2), Tri (3), Tetra (4), Penta (5), Hexa (6) etc.

Naming Examples:



2,3,3-trimethylpentane



3,5-diethyl-4-methyloctane

Cycloalkanes:

General Molecular Formula of Alkanes

- No rings: general formula is C_NH_{2N+2}
- Each deviation of 2 hydrogens from the C_NH_{2N+2} formula is a **degree of unsaturation**
- Cylcoalkanes always have at least 1 degree of unsaturation

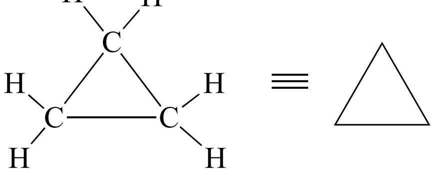
  e.g.

  - 1 Degree of unsaturation : C_NH_{2N} Alkanes with one ring or double bond
  - 2 Degrees of unsaturation : C_NH_{2N-2} Alkanes with two rings or double bonds, or one each

Note: Ring Structure Naming

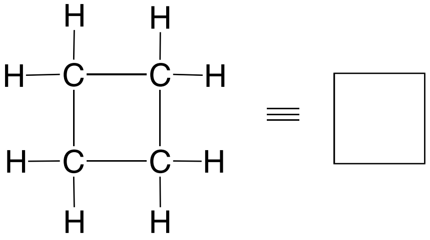
- Prefix with "cyclo"
- Start with numbering at point of maximum branching/most important functional group
- Number so as to give next branch/functional group lowest number

Cyclopropane, C_3H_6

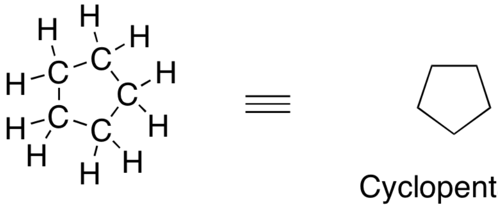


- One degree of unsaturation (*n*-propane is C_3H_8)
  - Not a structural isomer (different molecular formula)
- C-C-C bond angle (60 °)
- Highly reactive due to ring strain

Cyclobutane, C_4H_8



Cyclopentane, C_5H_{10}



Cyclopentane

Cyclohexane, C_6H_{12}