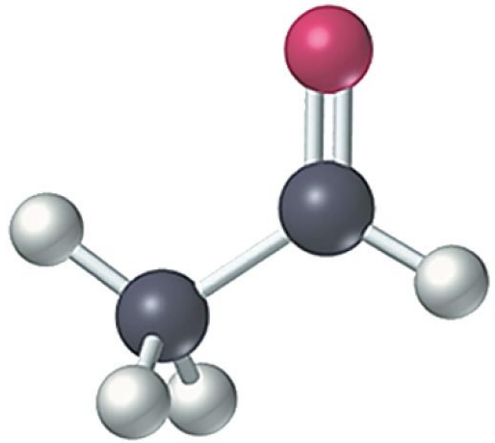
2302106 – Basic Organic Chemistry for ISE – Part II

Lecture 4-1

Aldehydes & Ketones – Structure & Property



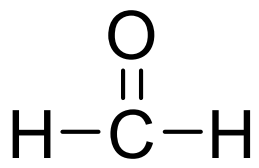
Instructor: Asst. Prof. Dr. Tanatorn Khotavivattana
E-mail: tanatorn.k@chula.ac.th

Recommended Textbook:

Chapter 18 in *Organic Chemistry*, 8th Edition, L. G. Wade, Jr., **2010**, Prentice Hall (Pearson Education)

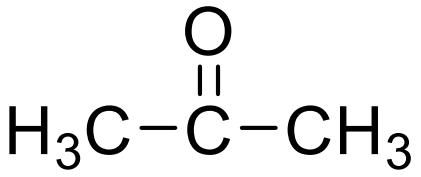
Aldehyde = Latin *“alcohol dehydrogenatus”* (dehydrogenated alcohol)

Ketone = *“Aketon”* (an old German word for acetone)



formaldehyde

methanal

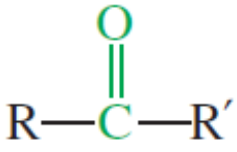
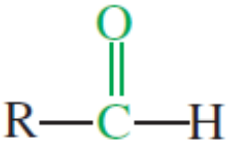
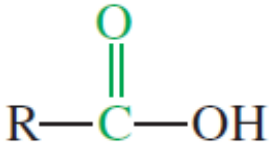
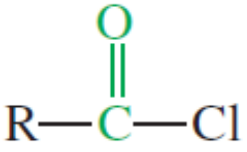
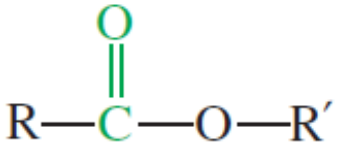
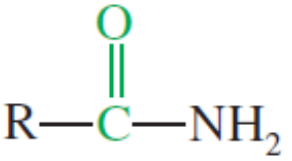


acetone

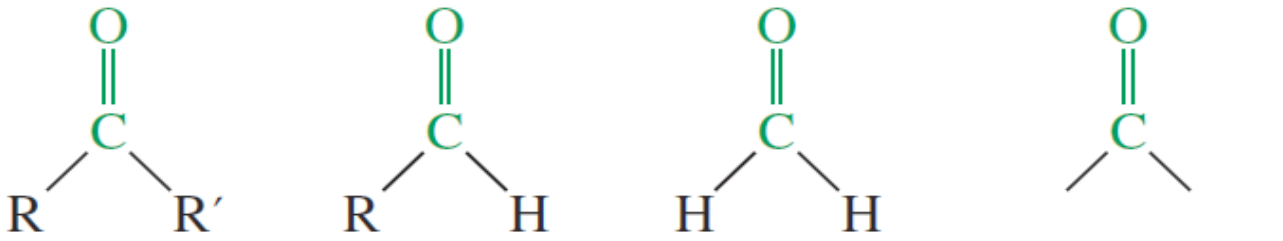
propanone

Compounds containing a carbonyl group

TABLE 18-1 Common Classes of Carbonyl Compounds

Class	General Formula	Class	General Formula
ketones		aldehydes	
carboxylic acids		acid chlorides	
esters		amides	

Aldehydes and Ketones



Ketone: Two alkyl groups bonded to a carbonyl group.

Aldehyde: One alkyl group and one hydrogen bonded to a carbonyl group.

- Ketones and aldehydes are similar in structure, and they have **similar properties**
- In most cases, aldehydes are **more reactive** than ketones

Industrial of Aldehydes and Ketones

TABLE 18-4 Ketones and Aldehydes Used in Household Products

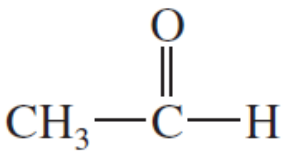
	butyraldehyde	vanillin	acetophenone	*trans*-cinnamaldehyde
	$CH_3—CH_2—CH_2—C(=O)—H$	CH_3O, HO, CHO	$C(=O)—CH_3$	CHO
Odor:	buttery	vanilla	pistachio	cinnamon
Uses:	margarine, foods	foods, perfumes	ice cream	candy, foods, drugs

	camphor	pyrethrin	carvone	muscone
	O	O, H, O, C=O, H, H	O	O
Odor:	"camphoraceous"	floral	(−) enantiomer: spearmint (+) enantiomer: caraway seed	musky aroma
Uses:	liniments, inhalants	plant insecticide	candy, toothpaste, etc.	perfumes

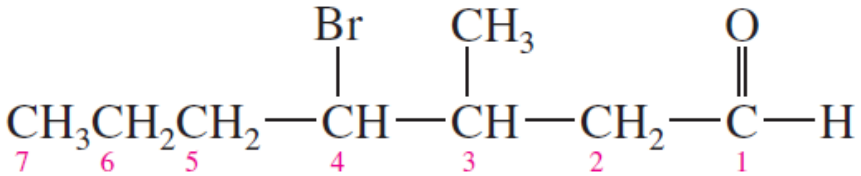
Nomenclature – IUPAC Names of Aldehydes

Suffix = **-al**

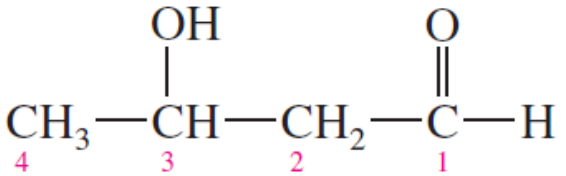
- Replace **-e** of alkane name with **–al**
- Aldehyde C is at the end of a chain: (almost) always **number 1**



ethanal

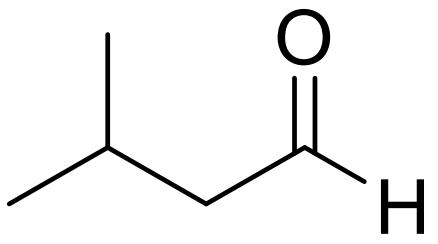


4-bromo-3-methylheptanal



3-hydroxybutanal

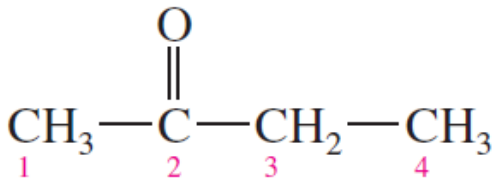
Example



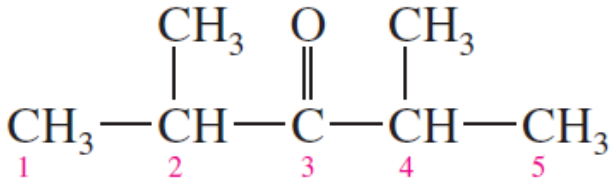
Nomenclature – IUPAC Names of Ketones

Suffix = **-one**

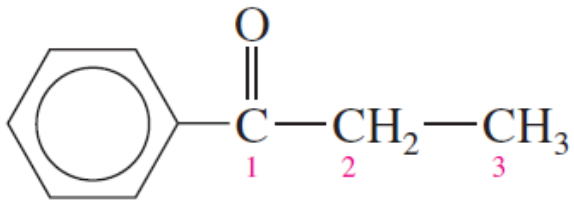
- Replace **-e** of alkane name with **–one**
- Number longest chain containing C=O from the end **closest to C=O**
- Indicate position of the C=O by a number



2-butanone
butan-2-one

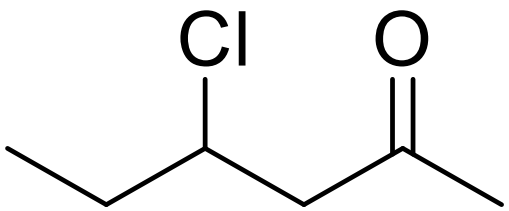


2,4-dimethyl-3-pentanone
2,4-dimethylpentan-3-one



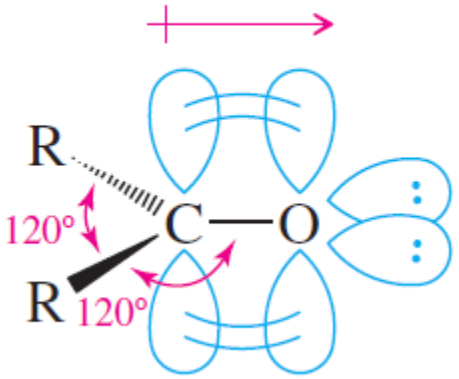
1-phenyl-1-propanone
1-phenylpropan-1-one

Example



Structure of the Carbonyl Group

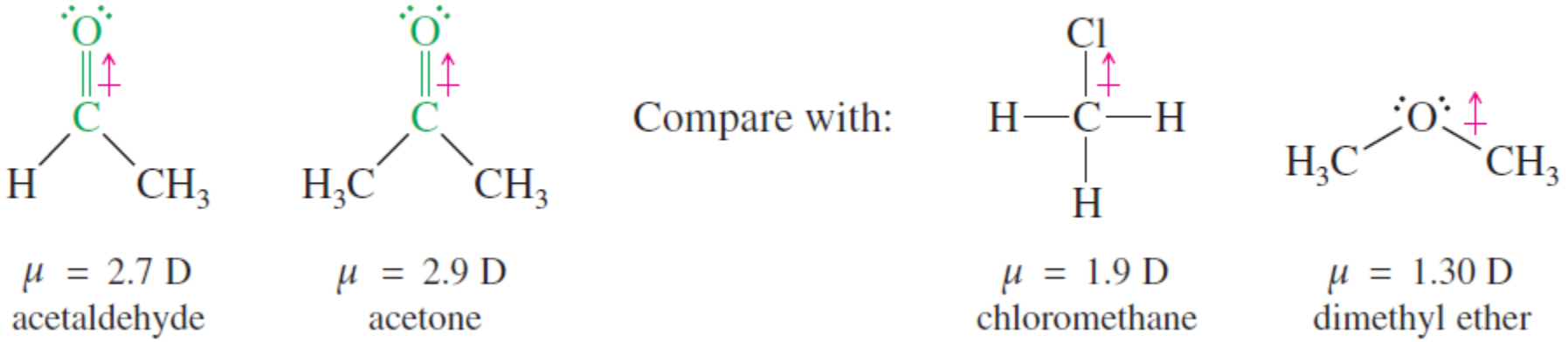
- **sp^2** hybridised carbon
- Bonded to 3 other atoms through coplanar **sigma bonds** oriented about **120°** apart
- Unhybridized p orbital overlaps with a p orbital of Oxygen to form a **pi bond**



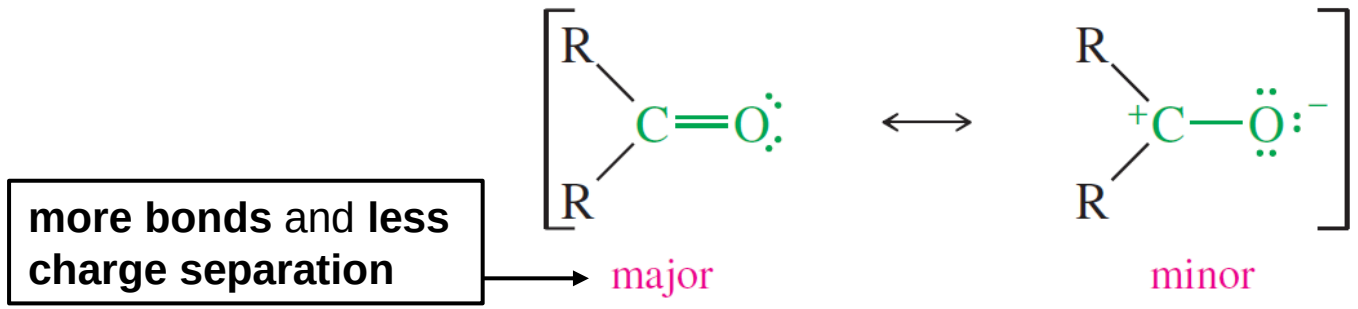
	length	*energy*
ketone C═O bond	1.23 Å	745 kJ/mol (178 kcal/mol)
alkene C═C bond	1.34 Å	611 kJ/mol (146 kcal/mol)

- C=O bond has similar geometry to C=C but C=O bond is **shorter**, **stronger** and **more polarized** than C=C bond

Structure of the Carbonyl Group



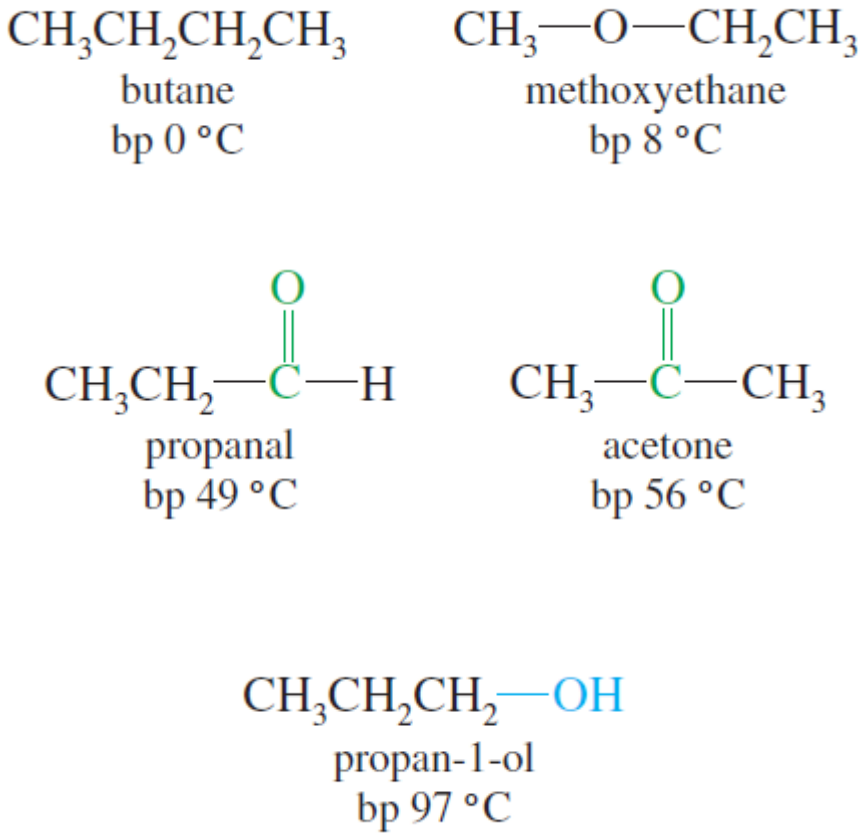
- C=O has a **large dipole moment** because O is **more electronegative** than C and the bonding electrons are not shared equally (**resonance**)



Physical Properties of Aldehydes and Ketones

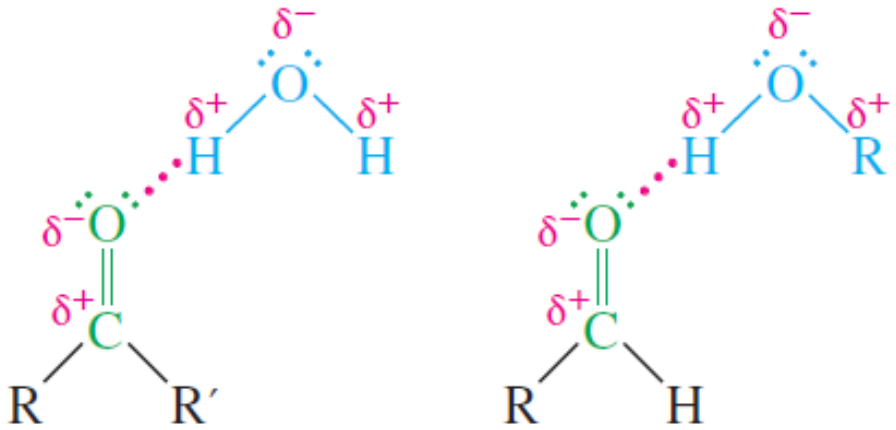
- Polarization of the carbonyl group creates **dipole–dipole attractions** between the molecules

- Higher boiling points than for hydrocarbons and ethers of similar M.W.



Physical Properties of Aldehydes and Ketones

- Pure aldehydes or ketones cannot form H bonding with each other
- They can form H bonding with compounds having O-H or N-H bonds



- Aldehydes and ketones are good solvents for **polar hydroxylic compounds** (eg. Alcohols)

Physical Properties of Aldehydes and Ketones

Example

a) Rank the compound from the one with lowest to highest boiling point