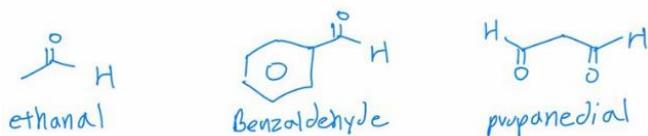


## Carbonyl Compounds



## Preparation of Carbonyl Compounds

### Oxidation of Primary Alcohol -> Aldehyde

- Refer to Hydroxy Compound Masterclass

### Oxidation of Secondary Alcohol -> Ketone

- Refer to Hydroxy Compound Masterclass

## Reaction of Carbonyl Compounds

### Oxidation of Aldehyde -> Carboxylic Acid



Reagent & Condition

$K_2Cr_2O_7$  aq /  $KMnO_4$  aq,  $H_2SO_4$  aq, heat  
 ↳ Obs: Orange to Green      ↳ Obs: Purple to Colourless

Note: Ketones cannot be oxidised

## Reduction

- Refer to Hydroxy Compound Masterclass

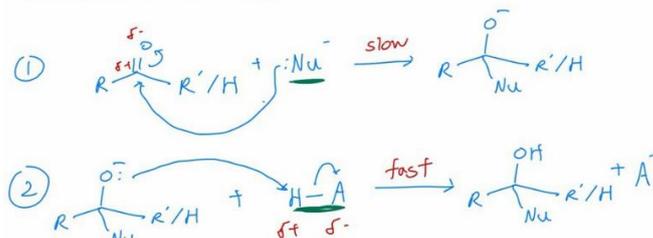
Functional Groups	Can be Reduced by		
	$H_2, Ni, r.t$	$LiAlH_4, \text{dry ether}$	$NaBH_4, \text{ethanol}$
$C=C, C\equiv C$	✓	X**	X**
$R-C\equiv N$	✓	✓	X
$R-\overset{\text{O}}{\parallel}{C}-H$	✓	✓	✓
$R-\overset{\text{O}}{\parallel}{C}-R'$	✓	✓	✓
$R-\overset{\text{O}}{\parallel}{C}-OH$	X	✓	X**
$R-\overset{\text{O}}{\parallel}{C}-OR'$	X	✓	X**
$R-\overset{\text{O}}{\parallel}{C}-NH_2$	X	✓	X**

\*\* Both  $LiAlH_4$  and  $NaBH_4$  provide  $H^-$  nucleophile to attack  $e^-$  deficient C atom.  $C=C$  and  $C\equiv C$  are  $e^-$  rich, so no reduction

\*\*  $LiAlH_4$  is stronger reducing agent than  $NaBH_4$   
 ↳ Al more electropositive than B, Al-H more polar than B-H  
 ↳ Greater  $\delta^-$  on H in  $LiAlH_4$  compared to  $NaBH_4$

## Mechanism of Nucleophilic Addition

Mechanism: Nucleophilic Addition

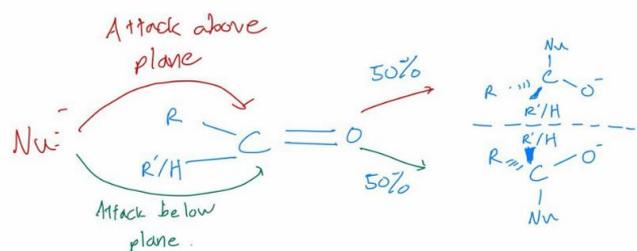


Rate =  $k[\text{carbonyl}][Nu^-] \Rightarrow$  Both involved in slow step

$H-A$ : Brønsted-Lowry acid / Proton Donor

Note: Racemic mixture can be produced when the C in  $C=O$  becomes a chiral carbon in final product.

- Due to equal probability of Nu attacking either side of the trigonal planar C in  $C=O$ .



Note: Carbonyl Compound  
 ↳ Trigonal Planar

Note: Aldehyde undergo nucleophilic addition faster than ketone

- C in aldehyde less electron-deficient than C in ketone
  - o Ketone has more electron-donating R group than Aldehyde
- Ketone has more bulky R groups, sterically hinders approach of nucleophiles



### Nucleophilic Addition with HCN



Reagent & Condition

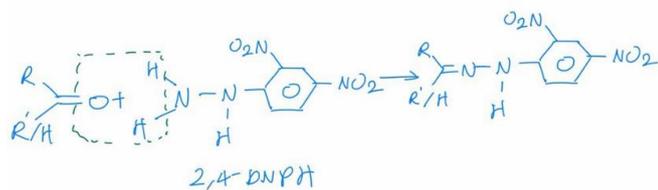
HCN, trace NaCN / NaOH, cold

Nu:  $CN^-$   
H-A: HCN

!  $\Rightarrow$  Prevent poisonous HCN gas from escaping to environment

### Distinguishing Test for Carbonyl Compounds

#### Condensation with 2,4-DNPH

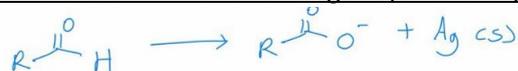


Reagent & Condition

2,4-dinitrophenylhydrazine (2,4-DNPH), r.t.

!  $\Rightarrow$  Obs: Orange ppt

#### Silver Mirror Test with Tollen's Reagent (Oxidation)



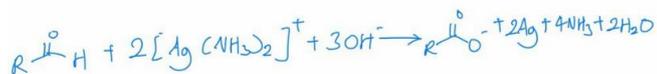
R = alkyl OR  $\text{C}_6\text{H}_5$

Reagent & Condition

Tollen's Reagent  $([Ag(NH_3)_2]^+)$  aq, heat

!  $\Rightarrow$  Obs: Silver Mirror OR Grey/Black ppt

Balanced Equation



### Fehling's solution (Oxidation)



R = alkyl

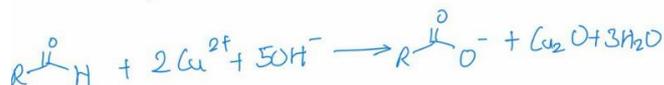
Reagent & Condition

Fehling's solution, heat

!  $\Rightarrow$  Alkaline  $Cu^{2+}$  complex

!  $\Rightarrow$  Obs: Brick-red ppt

Balanced Equation



### Tri-iodomethane (Iodoform) Test



Reagent & Condition

$I_2$  in NaOH aq, heat

!  $\Rightarrow$  Obs: Brown  $I_2$  aq decolourise, pale yellow ppt form

Balanced Equation

