

ORGANIC CHEMISTRY

A. STRUCTURE AND ISOMERISM

1. **Structure**
 - (a) number of bonds to C, H, O, N and halogen
 - (b) chain formation *via* C–C bonds
 - (c) straight and branched chains - isomerism
 - (d) general formulae for alkanes, cycloalkanes, alkenes and alkynes
- units of unsaturation (double-bond equivalents)
2. **Structural isomerism**
 - (a) chain isomerism
 - (b) positional isomerism
 - (c) functional group isomerism
3. **Geometric (*cis-trans*) isomerism**
 - (a) in cycloalkanes
 - (b) in alkenes
4. **Optical isomerism**
in compounds with an asymmetric (chiral) carbon atom

B. FUNCTIONAL GROUPS AND IUPAC NOMENCLATURE

(see also the NAMING program in the Chemistry Lab)

1. **Alkanes and Cycloalkanes**
2. **Alkenes and Cycloalkenes**
3. **Alkynes**
4. **Aromatic compounds**
 - (a) monosubstituted (including toluene, phenol, aniline, benzaldehyde & benzoic acid)
 - (b) disubstituted (1,2-, 1,3, 1,4 *and o*-, *m*-, *p*-)
 - (c) polysubstituted (1,2,4-, etc.)
5. **Halogen derivatives**
6. **Alcohols**
 - (a) monohydric (one OH), dihydric (diols; two OH), trihydric (triols; three OH).
 - (b) primary (1°), secondary (2°), tertiary (3°).
7. **Ethers** (acyclic only)
as dialkyl ethers, alkyl alkyl ethers and alkoxy alkanes
8. **Aldehydes**
9. **Ketones**
10. **Carboxylic acids and derivatives** (salts, esters, anhydrides & amides)
 - (a) monoacids, diacids, etc.
 - (b) esters
11. **Amines**
 - (a) as alkyl amines and alkanamines
 - (b) primary (1°), secondary (2°) and tertiary (3°)

C. ORGANIC REACTIONS (Reaction type in italics; see Section D)

1. **Alkanes**
 - (a) combustion (*oxidation*) - O₂/heat
 - (b) halogenation (*substitution*) - Br₂ or Cl₂/light or heat

2. **Alkenes**
 - (a) hydrogenation (*addition*) - H_2/Pd
 - (b) halogenation (*addition*) - Br_2 or Cl_2
 - (c) hydrohalogenation (*addition*) - HBr or HCl
 - (d) hydration (*addition*) - $\text{H}_2\text{O}/\text{H}^+$
 - (e) hydroxylation (*oxidation*) - cold dil. alkaline KMnO_4
 - (f) oxidation to ketones and acids (*oxidation*) - hot conc. KMnO_4
3. **Alkynes**
 - (a) hydrogenation (*addition*) - H_2/Pd
 - (b) halogenation (*addition*) - Br_2 or Cl_2
 - (c) hydrohalogenation (*addition*) - HBr or HCl
4. **Aromatic compounds**
 - (a) halogenation (*substitution*)- Br_2 or Cl_2/Fe
 - (b) conversion of alkyl substituents to COOH (*oxidation*) - hot KMnO_4
5. **Alcohols**
 - (a) reaction with alkali metals (*reduction*) - Na , Li or K
 - (b) dehydration (*elimination*) - conc. H_2SO_4
 - (c) 1° to aldehydes & acids (*oxidation*) - KMnO_4
 - (d) 2° to ketones (*oxidation*) - KMnO_4
 - (e) ester formation (*substitution*) - acids or anhydrides/ H^+
6. **Aldehydes**
 - (a) conversion to acids (*oxidation*) - KMnO_4
 - (b) conversion to 1° alcohols (*reduction* or *addition*) - H_2/Pd
7. **Ketones**

conversion to 2° alcohols (*reduction* or *addition*) - H_2/Pd
8. **Carboxylic acids**
 - (a) reaction with base (*acid-base*) - NaHCO_3 or NaOH
 - (b) ester formation (*substitution*) - alcohol/ H^+
 - (c) amide formation (*substitution*) - amine or ammonia
9. **Esters**

hydrolysis (*substitution*) - H_2O and H^+ or HO^-
10. **Amides**

hydrolysis (*substitution*) - H_2O and H^+ or HO^-
11. **Amines**
 - (a) reaction with acid (*acid-base*) - e.g. HCl , CH_3COOH , etc.
 - (b) amide formation (*substitution*) - carboxylic acids/heat
12. **Phenols**
 - (a) reaction with strong base (*acid-base*) - NaOH
 - (b) ester formation (*substitution*) - anhydrides/ H^+

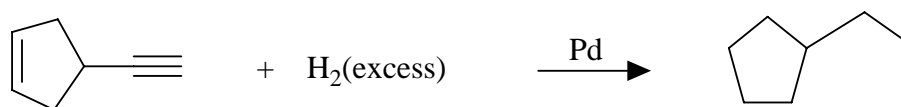
D. TYPES OF ORGANIC REACTIONS

1. Addition

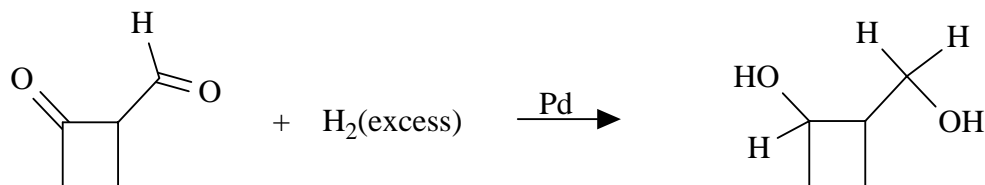
Reaction in which a reagent is added to the double (or triple) bond between two carbon atoms or the double bond between a carbon atom and an oxygen atom.

(a) *hydrogenation* (H_2/Pd)

i) alkene or alkyne to the corresponding alkane

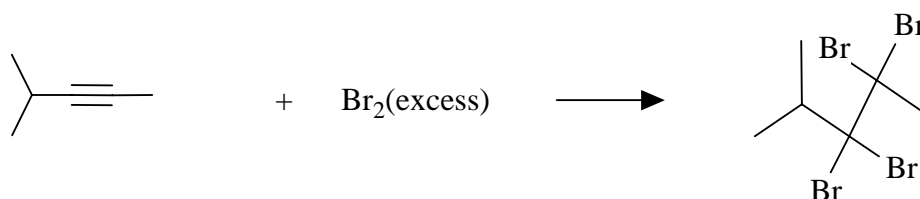
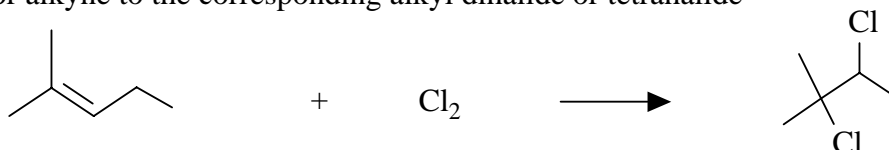


ii) aldehyde or ketone to the corresponding alcohol



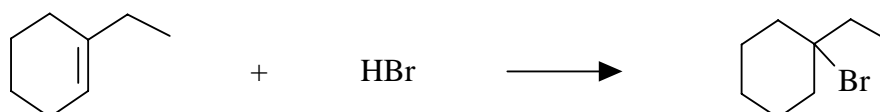
(b) *halogenation* (Cl_2 or Br_2)

alkene or alkyne to the corresponding alkyl dihalide or tetrahalide

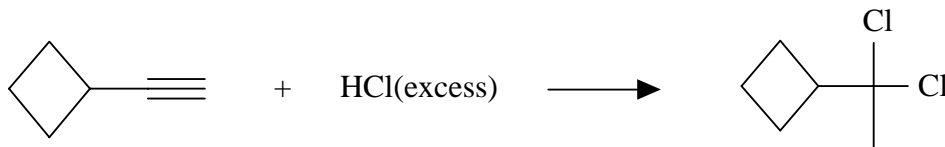


(c) *hydrohalogenation* (HCl or HBr)

i) alkene to the corresponding alkyl halide (Markovnikov)

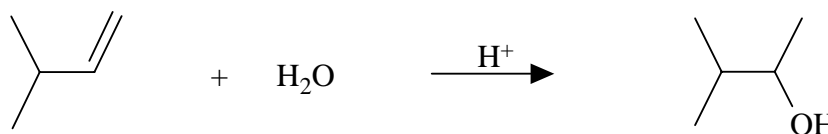


ii) alkyne to the corresponding alkyl dihalide (Markovnikov)



(d) *hydration* ($\text{H}_2\text{O}/\text{H}^+$)

alkene to the corresponding alcohol (Markovnikov)

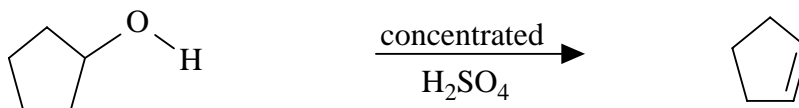


2. Elimination

Removal of a small molecule from a compound to produce a double or triple bond.

dehydration (H_2SO_4)

alcohol plus concentrated acid to the corresponding alkene

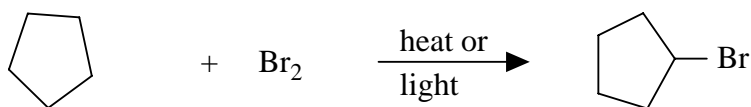


3. Substitution

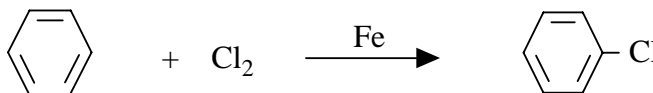
Exchange of an atom (or group of atoms) for another

(a) *halogenation* (Cl_2 or Br_2)

(i) alkane to the corresponding alkyl halide

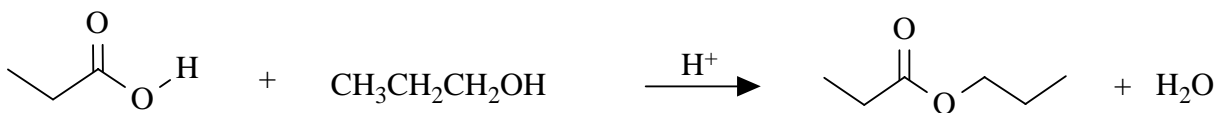


(ii) benzene (with Fe catalyst) to the corresponding aryl halide

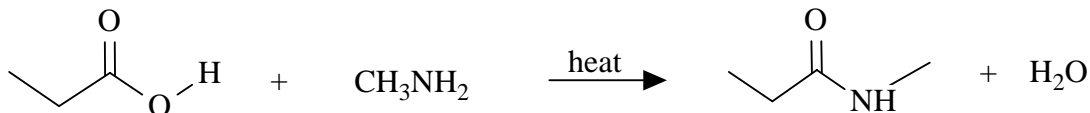


(b) *esterification/amide formation*

(i) alcohol plus carboxylic acid to the corresponding ester

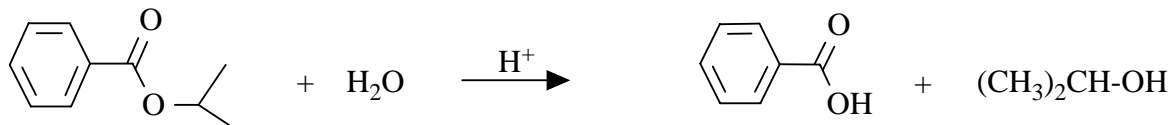


(ii) amine plus carboxylic acid to the corresponding amide

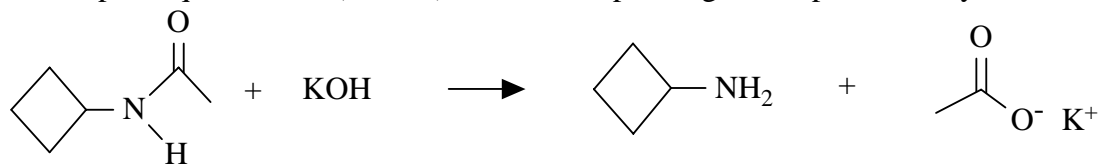


(c) *ester/amide hydrolysis*

(i) ester plus aqueous acid (or base) to the corresponding alcohol plus carboxylic acid



(ii) amide plus aqueous acid (or base) to the corresponding amine plus carboxylic acid

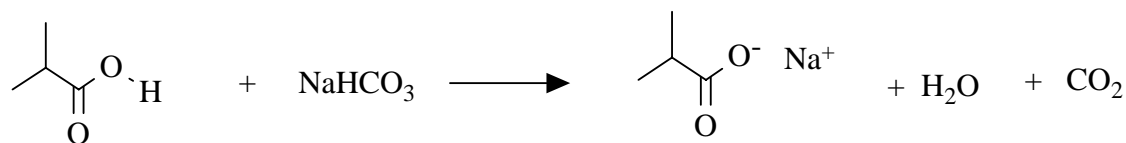


4. Acid/Base

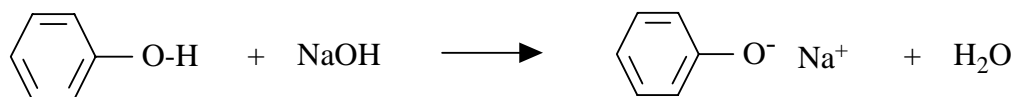
Transfer of H^+ ion from an acidic compound to a basic compound

neutralization

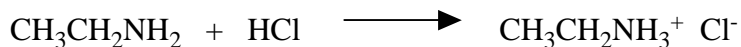
(i) carboxylic acid plus a base to the corresponding salt



(ii) phenol plus a strong base to the corresponding salt



(iii) amine plus an acid to the corresponding salt



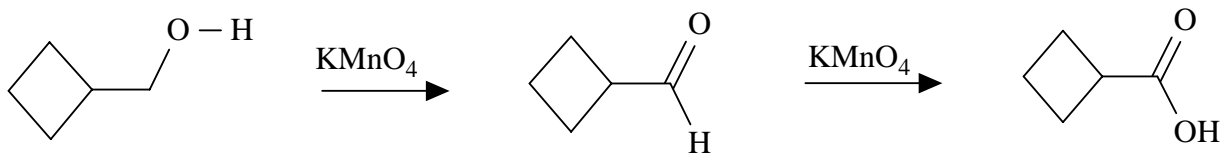
5. Oxidation-Reduction

1. *Oxidation*

Reaction with an oxidizing agent to produce a compound which, in many cases, contains a carbon oxygen double bond

(a) *oxidation of alcohols*

(i) primary alcohol to the corresponding aldehyde (mild conditions) or the corresponding carboxylic acid (hot)

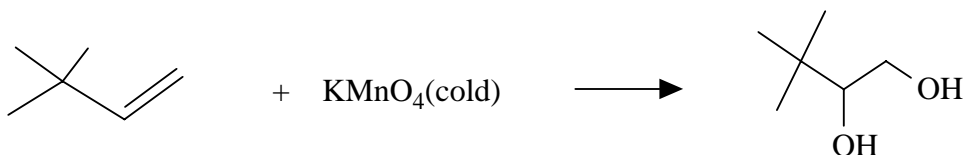


(ii) secondary alcohol to the corresponding ketone

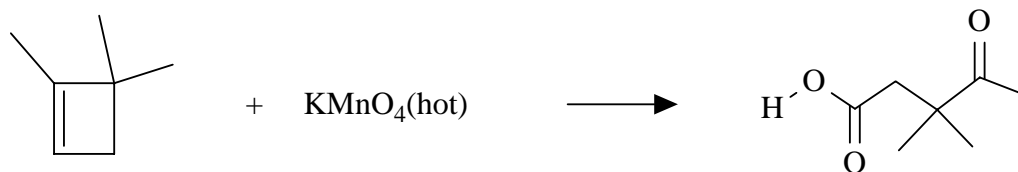
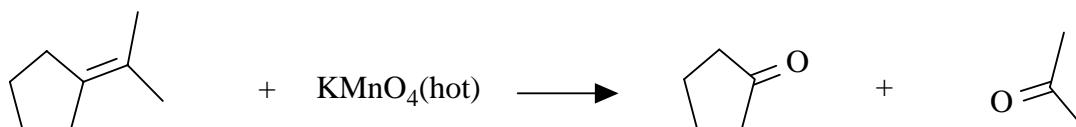


(b) *oxidation of alkenes*

(i) alkene to the corresponding diol

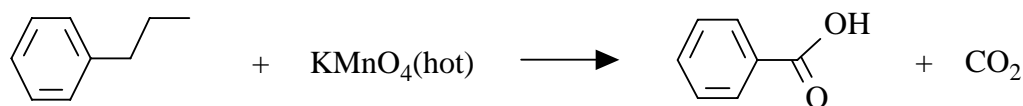


(ii) alkene to the corresponding carboxylic acid or ketone



(c) *oxidation of alkylbenzenes*

alkyl benzene to the corresponding benzoic acid



2. **Reduction**

(a) *reduction of aldehydes and ketones to alcohols*

see 1 (a) (ii) (hydrogenation of aldehyde or ketone)

(b) *active metal plus alcohol to the corresponding salt*

