SCH 4U

PART 1: TYPES of ORGANIC REACTIONS

① *ADDITION REACTIONS* -- Add atoms to a double bond or triple bond

$$A + B \rightarrow C$$

② *SUBSTITUTION REACTIONS* -- Usually alcohols, alkyl halides, aromatic compounds

$$A + B \rightarrow C + D$$

③ *ELIMINATION REACTIONS*

$$A \rightarrow B + C$$

- Single bonds form double bonds
- Reactant heated in presence of a strong acid catalyst (eg. H_2SO_4)

④ *OXIDATION/REDUCTION REACTIONS*

A. OXIDATION

From reactants to products, carbon has MORE bonds to oxygen & FEWER bonds to hydrogen. Reactions involve an "oxidizing agent", represented by [O].

- **alcohol** + oxidizing agent $\rightarrow$ aldehyde or ketone
- **aldehyde** + oxidizing agent $\rightarrow$ carboxylic acid

B. REDUCTION – [also addition reactions OR hydrogenation reactions]

From reactants to products, carbon has FEWER bonds to oxygen & MORE bonds to hydrogen. Reactions involve a "reducing agent", represented by [H].

- **aldehyde or ketone** + reducing agent $\rightarrow$ alcohols
- **alkenes or alkynes** + reducing agent $\rightarrow$ alkanes

⑤ *ESTERIFICATION*

A. CONDENSATION

$$A + B \rightarrow C + H_2O$$

Carb. acid + alcohol $\rightarrow$ ester + water

B. HYDROLYSIS

$$A + H_2O \rightarrow B + C$$

Ester + water $\rightarrow$ carb. Acid + alcohol

EXAMPLES:

1. ethene combined with hydrobromic acid.

2. 1-butyne with limited bromine

3. 1-propanol with hydrochloric acid

4. 2-bromobutane and ammonia

5. benzene with nitrous acid

6. 2-propanol with sulfuric acid catalyst

7. bromoethane with heat and a catalyst

8. 2-methyl-1-propanol + [O]

9. propyne + [H]

10. 3-nitropentanal + [O]

11. 2-methylcyclopentanone + [H]

11. ethanoic acid + 3-methyl butanol

12. tert-butyl cyclopentanoate + water

PART 2: REACTIONS OF FUNCTIONAL GROUPS

① ALKENES & ALKYNES

- ***ADDITION REACTIONS*** are common due to reactive double/triple bonds

$-\mathrm{C}=\mathrm{C}- \; + \; \mathrm{H_2O} \; \rightarrow$

$-\mathrm{C}=\mathrm{C}- \; + \; \mathrm{HX} \; \rightarrow$ [X is a halide]

$-\mathrm{C}=\mathrm{C}- \; + \; \mathrm{X_2} \; \rightarrow$ [X_2 is a halogen]

$-\mathrm{C}=\mathrm{C}- \; + \; \mathrm{H_2} \; \rightarrow$

ALKENES

- ***symmetrical*** – identical groups on each side of double bond
- ***asymmetrical*** – different groups on each side of double bond
- ***ADDITION SUBSTANCE*** → symmetrical – eg. Cl_2 -- [Cl – Cl]
  → asymmetrical -- eg. H_2O -- [H – OH]

IF either alkene or addition substance is symmetrical → ONLY 1 product

EG 1: 2-butene + water →
(symmetrical) (asymmetrical)

EG 2: 1-butene + chlorine →

IF both reactants are asymmetrical → MORE THAN 1 product

EG: 1-butene + hydrobromic acid →

***MARKOVNIKOV'S RULE*:**

- **Major & minor products are formed.**
- ***MAJOR PRODUCT*:** The **H** of the **added substance** goes to the carbon with the **greater number of H atoms;** the rest of the added substance goes to the carbon with the fewer H atoms. This is a case of "The rich get richer!"

EG: Draw and label only the major product for the reaction:

2-methyl-2-pentene + hydrochloric acid $\rightarrow$

ALKYNES

- If addition substance is limited, alkyne → alkene
- If addition substance is unlimited, alkyne → alkene → alkane
- Follows Markovnikov's rule for asymmetrical reactants

EG 1: propyne + 2 Br_2 $\rightarrow$

EG 2: 1-butyne + hydrobromic acid $\rightarrow$

AROMATIC COMPOUNDS

- ONLY Substitution reactions, NOT addition reactions

EG: benzene + bromine (with ferric bromide catalyst)

② ALCOHOLS

[A] SUBSTITUTION REACTIONS (with HX)

EG: ethanol with hydrochloric acid

[B] ELIMINATION REACTIONS (forms alkenes)

- Heated with strong acid catalyst

EG: ethanol $\xrightarrow[\Delta]{H_2SO_4}$

[C] OXIDATION REACTIONS (forms aldehyde or ketone)

- 1^o alcohol + oxidizing agent $\rightarrow$ aldehyde + oxidizing agent $\rightarrow$ carb. acid

- 2^o alcohol + oxidizing agent $\rightarrow$ ketone

- 3^o alcohol + oxidizing agent $\rightarrow$ NR

EXAMPLES: Complete each reaction.

1. 2-butanol + [O]

2. 2-propanol $\xrightarrow[\Delta]{H_2SO_4}$

3. 2-propanol + hydrobromic acid

③ ALDEHYDES & KETONES

[A] OXIDATION REACTIONS -- only aldehydes, NOT ketones

- Aldehyde + oxidizing agent $\rightarrow$ carb acid

[B] REDUCTION REACTIONS -- aldehydes and ketones

- Aldehyde + reducing agent $\rightarrow$ 1^{o} alcohol

- Ketone + reducing agent $\rightarrow$ 2^{o} alcohol

EXAMPLES: Complete each reaction.

1. ethanal + [H]

2. propanone + [O]

3. butanone + [H]

4. pentanal + [O]

④ CARBOXYLIC ACIDS

[A] NEUTRALIZATION REACTIONS:

- **CARB ACID with a BASE → SALT & WATER**

[B] ESTERIFICATION REACTIONS (special type of CONDENSATION REACTION)

- **CARB ACID WITH ALCOHOL → ESTER & WATER**

⑤ **ESTERS & AMIDES** -- undergo hydrolysis reactions

[A] ACID HYDROLYSIS

- **ESTER + WATER** $\xrightarrow{\text{acid}}$ **CARB ACID + ALCOHOL**

- **AMIDE + WATER** $\xrightarrow{\text{acid}}$ **CARB ACID + AMINE**

[B] BASIC HYDROLYSIS

- **ESTER + BASE** $\xrightarrow{\text{acid}}$ **SALT OF CARB ACID + ALCOHOL**

- **AMIDE + BASE** $\xrightarrow{\text{acid}}$ **CARB ACID + SALT OF AMINE**