**Reactions Study Guide**

**(most of the reaction learned this semester)**

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| **Functional group** | **Reagent** | **Name** | **Description of reaction** | **Example** |
| Alkane  (and all functional groups) | O2 | Combustion | All C becomes CO2, all H and O become H2O |  |
| Alkane | Br2, light or Cl2, light | Bromination of alkane Chlorination of alkane | Remove one H from alkane and replace with Br or Cl. |  |
| Alkene | Br2 or Cl2 | Bromination of alkene Chlorination of alkene | Add one Br or Cl to each side of C=C, convert C=C to single bond |  |
| Alkene | H2, Pt | Hydrogen-ation of alkene | Add one H to each side of C=C, convert C=C to single bond |  |
| Alkene | H2O, H2SO4  or  H2O, H+ | Hydration of alkene | Add OH to more substituted side of C=C, add H to less substituted side, convert C=C to single bond |  |
| Alkene | HBr or HCl | Hydro-bromination of alkene Hydro-chlorination of alkene | Add Br or Cl to more substituted side of C=C, add H to less substituted side, convert C=C to single bond |  |
| Aromatic | Br2, FeBr3 or  Br2, AlCl3 | Aromatic bromination | Remove one H from aromatic ring, replace with Br. |  |
| Aromatic | HNO3, H2SO4 | Aromatic nitration | Remove one H from aromatic ring, replace with NO2 |  |
| Aromatic | Fuming H2SO4 | Aromatic sulfonation | Remove one H from aromatic ring, replace with SO3H |  |
| Alcohol (any) | H2SO4, heat or  H+, heat | Dehydration | Remove OH, and remove an H on a carbon next to the one with the OH, make a new C=C |  |

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| **Functional group** | **Reagent** | **Name** | **Description of reaction** | **Example** |
| Alcohol  (Best with primary alcohols) | H2SO4, heat | dehydration | Remove OH from one alcohol C, remove H from other alcohol, bond O of alcohol to C of other alcohol |  |
| Primary alcohol | K2Cr2O7 or Na2Cr2O7 | Oxidation | Remove H from O and H from C, make new C=O. Initial product is aldehyde, which reacts with K2Cr2O7 to make carboxylic acid |  |
| Secondary alcohol | K2Cr2O7 or Na2Cr2O7 or  *CrO3 in pyridine* | Oxidation | Remove H from O and H from C, make new C=O (stop there, ketone is final product) |  |
| Secondary alcohol and Tertiary alcohol | ZnCl2 | Lucas test, or Chloro-dehydroxyl-ation | Remove OH, replace with Cl |  |
| Thiol (sulfide) | [Oxidation]  or O2 | Oxidation to disulfide | Remove H from each of two S, make a bond between two S’s (i.e. makes a disulfide) |  |
| Disulfide | [Reduction] | Reduction | Add H to each S, remove single bond between S’s |  |
| Phenol | NaOH (or other base) | Deproton-ation | Remove H from O, put negative charge on O |  |
| Amines (primary, secondary, or tertiary) | HCl or H2SO4 or any carboxylic acid | Protonation | Attach H to N, put + on N. May write counterion nearby to N |  |
| Ammonium salts | NaHCO3 or NaOH or any base | De-protonation | Remove H from N, erase + charge |  |
| Aldehydes or Ketones | 1)NaBH4 2)H+ | Reduction of aldehyde or ketone | Put one H on each end of C=O, convert to single bond |  |

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| **Functional group** | **Reagent** | **Name** | **Description of reaction** | **Example** |
| Aldehydes | Ag+ and NH3 or  Tollens Reagent | Tollens Test | Remove H from aldehyde, add OH |  |
| Methyl ketone | NaOH, I2 | Iodoform test | Remove CH3, replace with OH |  |
| Aldehydes or Ketone | CH3OH or any primary or secondary alcohol | Hemiacetal equilibrium | Add the ROH across the C=O: the H attaches to O, the RO attaches to C, the C=O becomes single bond |  |
| Aldehydes or Ketone | CH3OH, H**+**  or any primary or secondary alcohol with acid. | Acetal formation | Start same as hemiacetal, then add ROH across the C-O: the H attaches to O, the RO attaches to C, the C-O is erased |  |
| Hydroxy-ketone or hydroxy-aldehyde | No reagent required | Cyclic hemiacetal  equilibrium | Same as hemiacetal, but a ring forms connecting the OH to the aldehyde C |  |
| Cyclic acetal | H+, H2O or enzyme (hydrolase, amylase) | Hydrolysis of cyclic acetal | Reverse of formation of acetal. |  |
| Carboxylic acid | NaHCO3 or NH3 or any amine or base. | De-protonation | Remove H from COOH, give O negative charge |  |
| Carboxylic acid | CH3OH, H+ or  Any alcohol and H+ | Ester formation | Remove OH from acid, H from alcohol, and bond together |  |
| Carboxylic acid | 1)SOCl2 2)Primary amine  or enzyme  (ribosome et.al.) | Amide formation | Remove OH from acid, remove H from amine, and bond together |  |

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| **Functional group** | **Reagent** | **Name** | **Description of reaction** | **Example** |
| Carboxylic acid | LiAlH4 | Reduction | Erase =O, add two H’s to carbon. |  |
| Amide or peptide | H2SO4, H2O, heat or enzyme (protease, peptidase) | Amide or Peptide hydrolysis | Add OH to C=O of amide, H to N of amide, break C-N bond |  |
| Alcohol and PO43- or SO42- acid | Enzyme (Phosphatase or sulfatase) | Phosphoryl-ation or Sulfonation | Remove OH from inorganic acid, remove H from alcohol, form bond. |  |
| Amide or peptide | NaOH, H2O, heat | Amide base hydrolysis |  |  |
| Esters or lipids | NaOH, H2O, heat | Ester base hydrolysis |  |  |
| Esters or lipids | H2SO4, H2O, heat or enzyme | Ester acid hydrolysis | Reverse of formation of ester formation |  |
| Anhydride | amine | Formation of amide and carboxylic acid |  |  |
| Anhydride | Alcohol | Formation of ester and carboxylic acid |  |  |
| Anhydride | Water | Hydrolysis of anhydride |  |  |

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| **Functional group** | **Reagent** | **Name** | **Description of reaction** | **Example** |
| Aldo-hexose | (no reagent) | Pyranose equilibrium | Count six atoms, from aldehyde C to OH. Use that OH to make hemiacetal. For stereochemistry, rotate Fisher projection clockwise. |  |
| Keto-hexose | (no reagent) | Furanose formation | Count five atoms, from ketone C to OH. Use that OH to make hemiacetal. For stereo-chemistry, rotate Fisher projection clockwise. |  |
| Monosaccharide | Alcohol, H+ | Glycosidic bond formation | Remove OH from acetal C, remove H from primary alcohol, bond O of alcohol to acetal C |  |
| Two carbo-hydrates | Enzyme (synthase) | Glycosidic bond formation | Remove OH from acetal C, remove H from an OH of second carbohydrate, bond O to acetal C. |  |