

Appendix C - Reaction-Map of Organic Chemistry

The article on the *Reaction-Map of Organic Chemistry* was originally published in the *Journal of Chemical Education* (Murov, S. *J. Chem. Ed.*, **2007**, 84(7), 1224). The supporting information including the Reaction-Map were published online only. Portions of the supporting information are reprinted in *Appendix C* and in *Exercise 16* with permission from *J. Chem. Ed.* **2007**, 84(7), 1224. Copyright 2007 American Chemical Society. The following web sites are available to *J. Chem. Ed.* subscribers.

<http://pubs.acs.org/doi/pdf/10.1021/ed084p1224>

http://pubs.acs.org/doi/suppl/10.1021/ed084p1224/suppl_file/jce2007p1224w.pdf

The *Reaction-Map of Organic Chemistry* has been designed to give organic chemistry students an overview of most of the reactions needed for the organic chemistry course. The chart has been partially organized according to the periodic table on the horizontal axis and according to carbon oxidation level on the vertical axis. In addition the carboxyls are grouped vertically according to decreasing reactivity and carbon - carbon bond forming reactions are emphasized with bold arrows. The chart provides a study aide for students and should help students develop synthetic routes from one functional group to another. The chart should be especially useful for students studying for the final examination for the two semester organic chemistry course. In addition to the chart, three keys are available that organize the reactions according to mechanism, functional group preparations and functional group reactions. These keys are available in the Instructor's manual for this text. It is suggested that students develop their own keys in accordance with *Exercise 16*. Chemistry can be thought of a search for order in matter and this chart attempts to provide some insight into the order that exists in organic chemistry.

Many of the experiments in the text include reactions used for the synthesis of organic compounds. The Prelaboratory sections of the synthetic experiments commonly contain questions that place the reactions on the *Reaction-Map* and hopefully strengthen the connections between lecture concepts and laboratory operations.

AppC-2

General Organization

Left to right, compounds in the shaded regions are arranged according to the periodic table. Organolithium and Grignard reagents are under lithium and magnesium but these reagents are used elsewhere on several bold arrows for the synthesis of C-C bonds. Carbon compounds that do not contain other elements are under carbon, carbon - nitrogen (and C, N, O) compounds are under nitrogen, carbon - oxygen compounds are under oxygen and carbon - halogen (and C, O, X) compounds are under fluorine and the halogens. From top to bottom, within groups, the compounds are arranged according to the oxidation level of the compound.

The oxidation level of organic compounds is somewhat of a complex concept. Even for propane, the carbons technically have different oxidation states. For the purposes of grouping compounds by oxidation level for this chart, the general guideline used has been that oxidation involves a decrease in the number of bonds to carbon from an atom less electronegative than carbon (most frequently hydrogen) and/or an increase in the number of bonds from carbon to atoms more electronegative than carbon (most frequently N, O, X). Reduction is the reverse. If two carbons change, then the sum of the changes must be considered. When water is added to a double bond, one carbon gains a hydrogen and the other an oxygen and the net oxidation level of the molecule does not change. The increase in oxidation level is indicated by the degree of darkness on the next page and in color in the online version.

This organization results in five groups including: 1. alkanes (and organometallics), 2. alkenes (and alkene addition products such as alcohols, ethers and halides), aromatics and amines, 3. alkynes (and alkyne addition products such as carbonyls), 4. carboxyls and 5. carbon dioxide and tetrahalomethane.

The two crosshatched areas to the left and right of the shaded region contain products of carbon - carbon bond forming reactions. These reactions are also emphasized by bold arrows.

For the purposes of organizing the numbering of the reactions for this key, the reactions have been grouped according to mechanism of the first step of the reaction. Many reactions fall into more than one group. The addition of hydrogen to π bonds is usually discussed in texts along with electrophilic additions to π bonds but here the hydrogen additions have been placed in the reduction category. Reductions with hydrides such as LiAlH_4 are often grouped with nucleophilic additions but here have also been included in the reduction category. The reactions are listed in the order substitution, addition, elimination, addition-elimination, oxidation, reduction, concerted and miscellaneous. To facilitate the finding of reactions from any of the keys that follow, a roadmap grid has been included. For example, the addition of HX to an alkene is represented by reaction 30 which is in grid position *B11*.

${}^1\text{H}$ 1.0079

REACTION-MAP OF ORGANIC CHEMISTRY

${}^2\text{He}$ 4.003

${}^3\text{Li}$ 6.941
 ${}^{11}\text{Na}$ 22.990

${}^4\text{Be}$ 9.012
 ${}^{12}\text{Mg}$ 24.305

${}^5\text{B}$ 10.81
 ${}^{13}\text{Al}$ 26.982

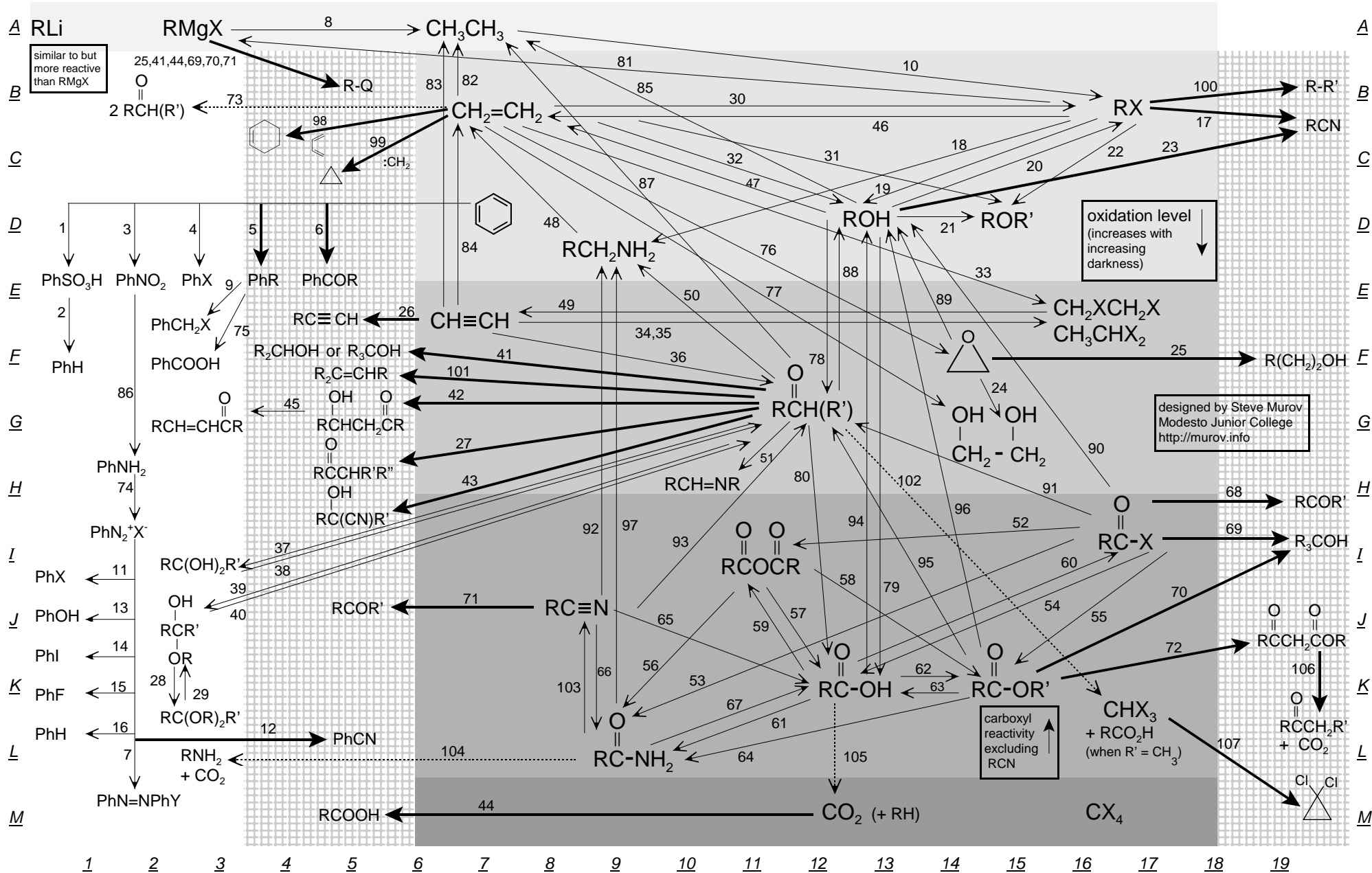
${}^6\text{C}$ 12.011
 ${}^{14}\text{Si}$ 28.086

${}^7\text{N}$ 14.007
 ${}^{15}\text{P}$ 30.974

${}^8\text{O}$ 15.999
 ${}^{16}\text{S}$ 32.066

${}^9\text{F}$ 18.998
 ${}^{35}\text{Br}$ 79.904
 ${}^{53}\text{I}$ 126.90

${}^{10}\text{Ne}$ 20.18
 ${}^{18}\text{Ar}$ 39.948



oxidation level
(increases with
increasing
darkness)

designed by Steve Murov
Modesto Junior College
<http://murov.info>

carboxyl
reactivity
excluding
RCN

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REACTION-MAP OF ORGANIC CHEMISTRY

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${}^4\text{Be}$ 9.012

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${}^6\text{C}$ 12.011

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${}^8\text{O}$ 15.999

${}^9\text{F}$ 18.998

${}^{10}\text{Ne}$ 20.18

${}^{11}\text{Na}$ 22.990

${}^{12}\text{Mg}$ 24.305

${}^{13}\text{Al}$ 26.982

${}^{14}\text{Si}$ 28.086

${}^{15}\text{P}$ 30.974

${}^{16}\text{S}$ 32.066

${}^{17}\text{Cl}$ 35.453

${}^{35}\text{Br}$ 79.904
 ${}^{53}\text{I}$ 126.90

${}^{18}\text{Ar}$ 39.948

