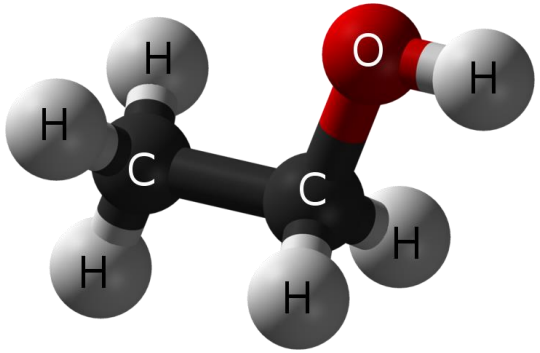
2302106 – Basic Organic Chemistry for ISE – Part II

Lecture 2-1

Alcohols - Structures and Properties



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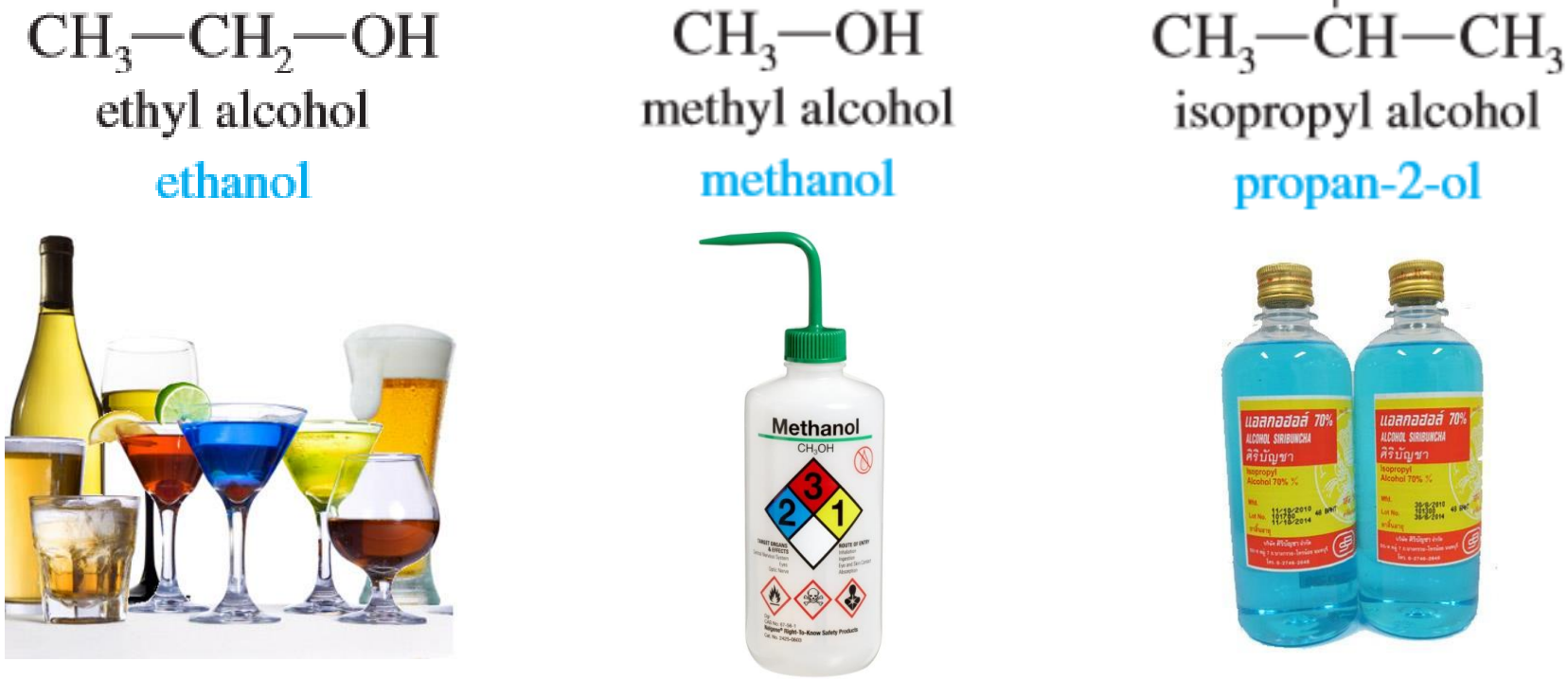
Recommended Textbook:

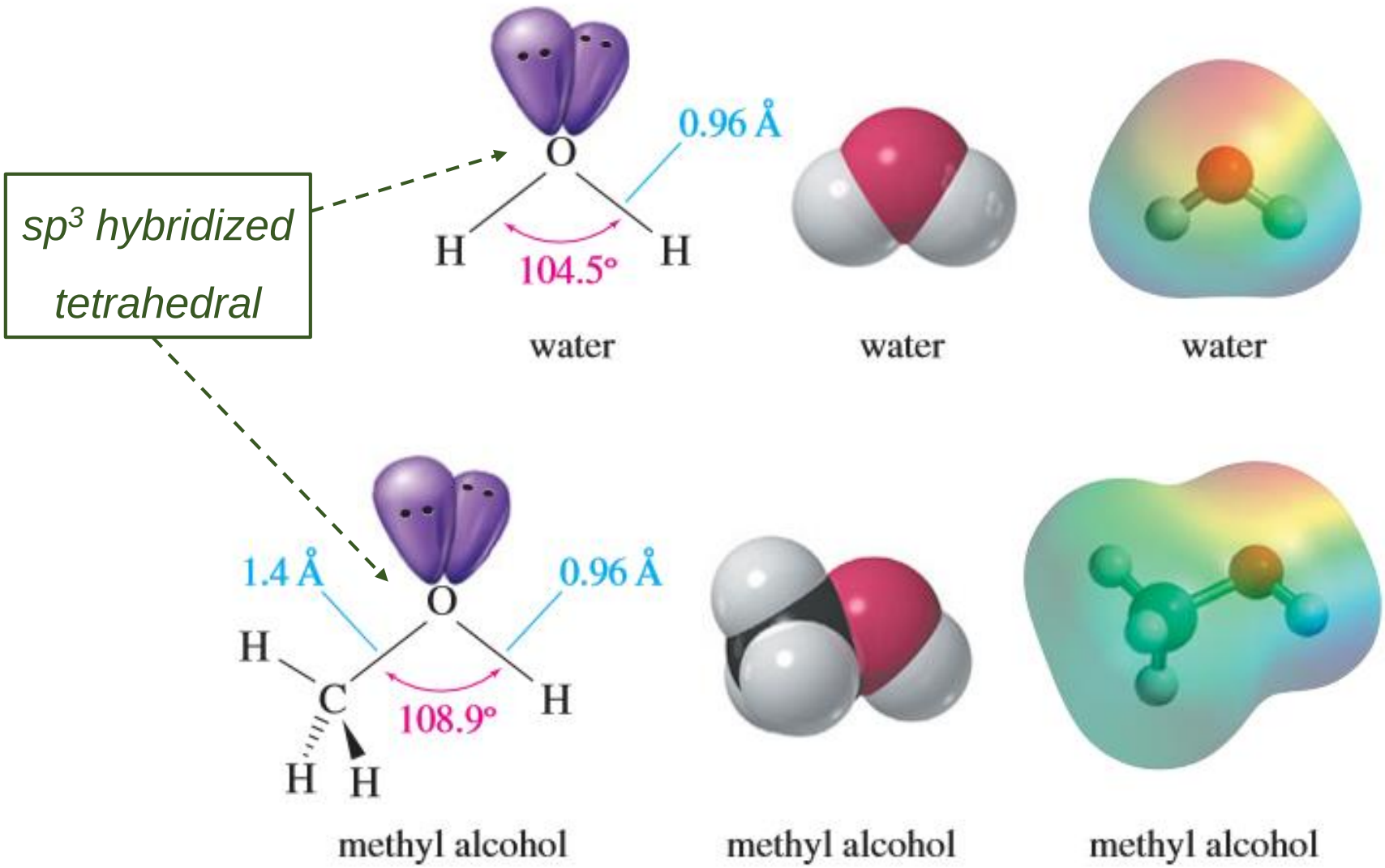
Chapter 10 and 11 in *Organic Chemistry*, 8th Edition, L. G. Wade, Jr., **2010**, Prentice Hall (Pearson Education)

What is alcohol?



IUPAC naming: suffix = **-ol**

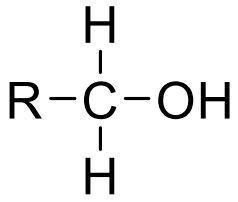
Structure of Water vs. Methanol



Classification of Alcohols

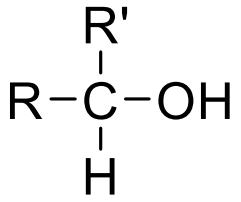
1) Primary alcohol:

carbon with —OH is bonded to **one** other carbon



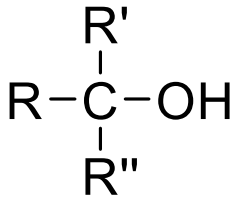
2) Secondary alcohol:

carbon with —OH is bonded to **two** other carbon



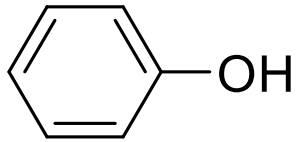
3) Tertiary alcohol:

carbon with —OH is bonded to **three** other carbon

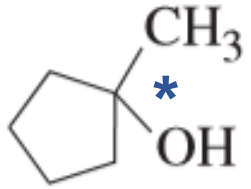


4) Phenols:

—OH is bonded to a **benzene** ring

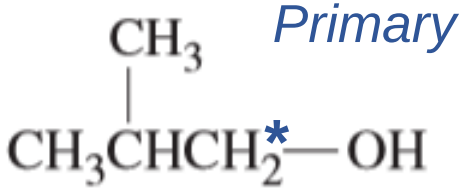


Classification of Alcohols – Examples



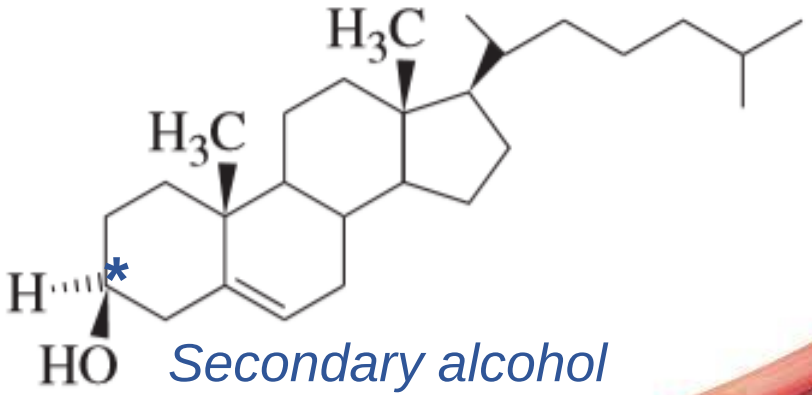
Tertiary alcohol

1-methylcyclopentanol



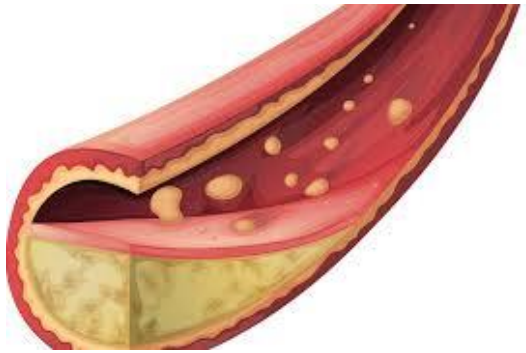
Primary alcohol

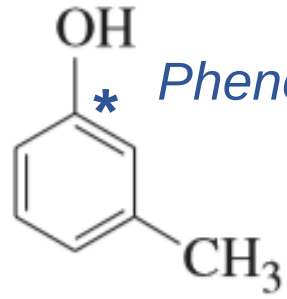
2-methylpropan-1-ol



Secondary alcohol

cholesterol





Phenol

3-methylphenol

Physical Properties

– Boiling Point / Melting Point

– Solubility in Water

Chemical Properties

– Acidity

– Reactivity

Intermolecular Forces !!

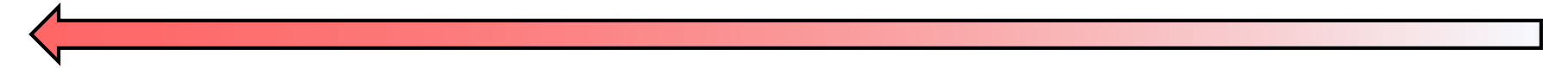
– London Dispersion Forces

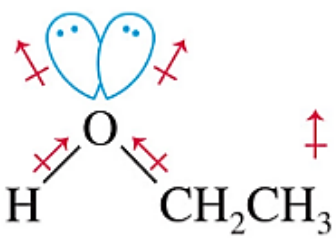
– Dipole-Dipole Interaction

– Hydrogen bond

Physical Properties – Boiling Point

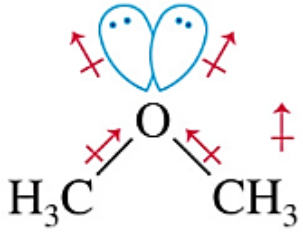
Higher dipole moment; Higher boiling point





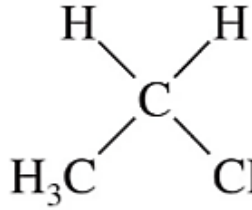
$\mu = 1.69$ D

ethanol, MW 46
bp 78 °C



$\mu = 1.30$ D

dimethyl ether, MW 46
bp −25 °C

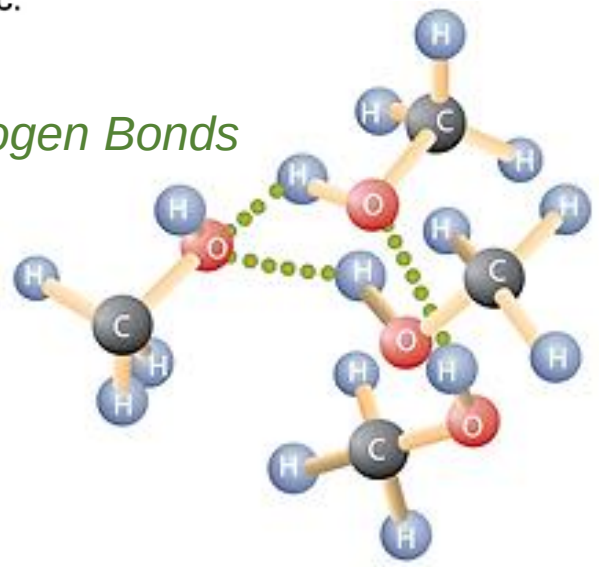


$\mu = 0.08$ D

propane, MW 44
bp −42 °C

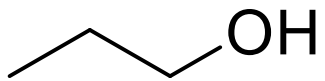
- Alcohols have higher boiling points than ethers and alkanes because alcohols can form **hydrogen bonds**
- The *stronger interaction* between alcohol molecules will *require more energy to break* them resulting in a higher boiling point

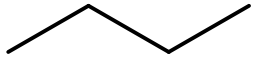
Hydrogen Bonds

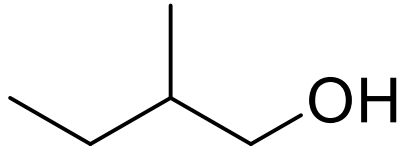


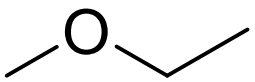
Physical Properties – Boiling Point

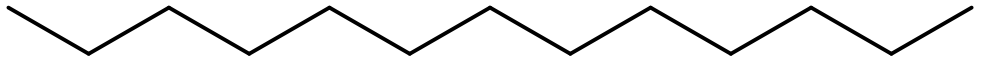
Example: Rank the compound from the one with lowest to highest boiling point







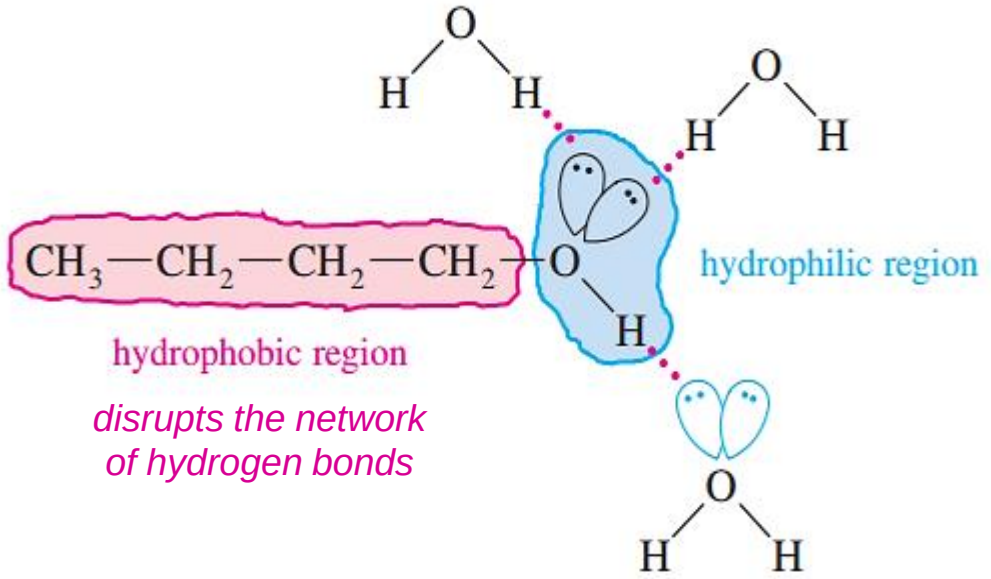




Physical Properties – Solubility in Water

Larger alkyl group; Lower solubility

Alcohol	Solubility in Water
methyl	miscible
ethyl	miscible
n-propyl	miscible
tert-butyl	miscible
isobutyl	10.0%
n-butyl	9.1%
n-pentyl	2.7%
cyclohexyl	3.6%
n-hexyl	0.6%
phenol	9.3%
hexane-1,6-diol	miscible

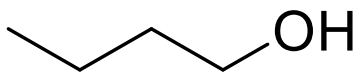


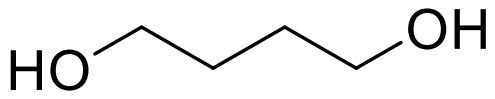
← two hydrogen-bonding groups

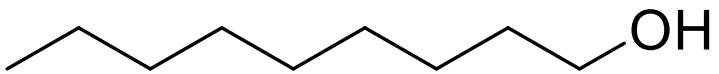
miscible = soluble in any proportions

Physical Properties – Boiling Point

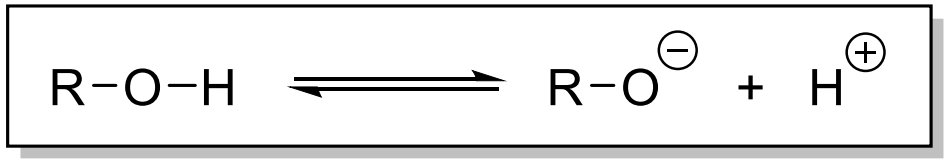
Example: Rank the compound from the one with lowest to highest solubility in water







Chemical Properties – Acidity



Alcohol	pK_a
methanol	15.5
ethanol	15.9
2-chloroethanol	14.3
2,2,2-trichloroethanol	12.2
isopropyl alcohol	16.5
tert-butyl alcohol	18.0
cyclohexanol	18.0
phenol	10.0
water	15.7
acetic acid	4.8
hydrochloric acid	−7

$$K_a = \frac{[RO^{\ominus}]\,[H^{\oplus}]}{[ROH]}$$

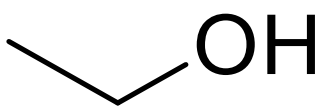
$pK_a = -\log K_a$ (Lower pKa = more acidic)

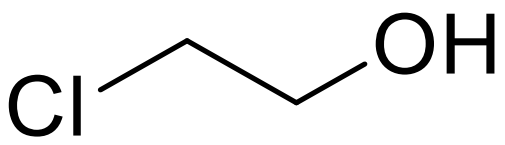
Electron withdrawing groups; More acidic (help stabilize the alkoxide ion)

Larger alkyl group; Less acidic (decreased solvation of the alkoxide ion)

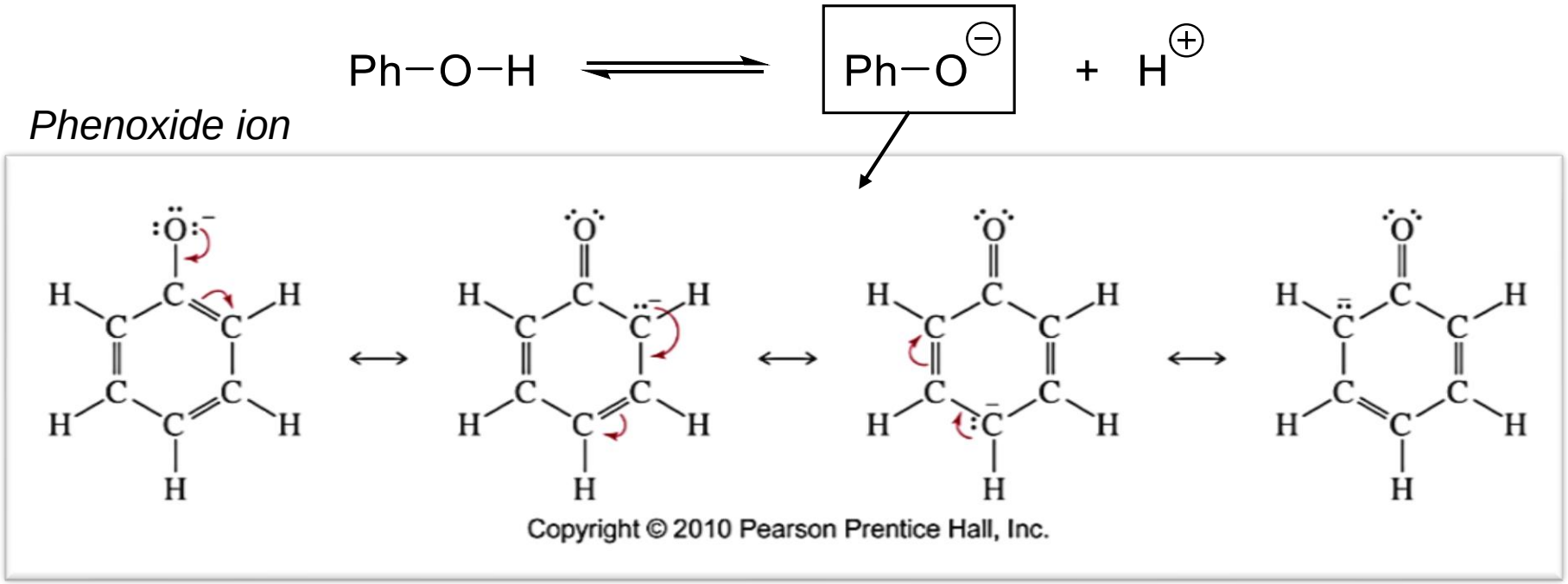
Phenol is 100 million times more acidic than cyclohexanol !

Chemical Properties – Acidity





Chemical Properties – Acidity



- The negative charge of the oxygen can be delocalized over **four atoms** of the phenoxide ion
- The true structure is a hybrid between the four resonance forms

Chemical Properties – Acidity

Example: Rank the compound from the one with lowest to highest acidity