

## CONCEPT: FACTORS AFFECTING ACIDITY- ELEMENT EFFECTS

There are 5 major factors of acidity. We use these factors to determine relative acidity in the *following two situations*:

1. pKa information is \_\_\_\_\_ for a molecule
2. The pKas of two molecules are \_\_\_\_\_ to make a determination of highest acidity.

□ When analyzing these 5 factors of molecules, look at the stability of the \_\_\_\_\_.

- The more stable the \_\_\_\_\_, the more willing the acid will be to donate a proton.

### 1. Element Effects:

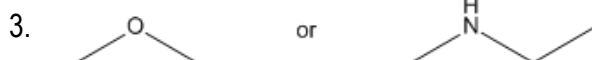
- The element effects determine how loosely or strongly a particular element bonds with \_\_\_\_\_
- We can use these effects to compare different protonated elements to each other. (i.e.  $\text{NH}_3$  vs  $\text{SH}_2$ )
- Consists of two trends:
  1. Electronegativity – the stronger the electronegativity, the more willing to accept a lone pair.
  2. Size – the bigger (squishier) the atom, the more willing it will be to accept a lone pair.

Periodic Table of the Elements																		VIIIA													
IA																		IIA													
1 H Hydrogen 1.008																		2 He Helium 4.003													
3 Li Lithium 6.941	4 Be Beryllium 9.012															5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180										
11 Na Sodium 22.99	12 Mg Magnesium 24.31															13 Al Aluminum 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948										
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80														
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.905	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.905	54 Xe Xenon 131.29														
55 Cs Cesium 132.905	56 Ba Barium 137.33	57 La Lanthanum 138.905	58 Ce Cerium 140.12	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.222	78 Pt Platinum 195.078	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222
87 Fr Francium 223	88 Ra Radium 226	89 Ac Actinium 227	90 Th Thorium 232	91 Pa Protactinium 231	92 U Uranium 238.03	93 Np Neptunium 237	94 Pu Plutonium 244	95 Am Americium 243	96 Cm Curium 247	97 Bk Berkelium 247	98 Cf Californium 251	99 Es Einsteinium 252	100 Fm Fermium 257	101 Md Mendelevium 258	102 No Nobelium 259	103 Lr Lawrencium 260	104 Rf Rutherfordium 261	105 Db Dubnium 262	106 Sg Seaborgium 266	107 Bh Bohrium 264	108 Hs Hassium 277	109 Mt Meitnerium 268	110 Uun Ununium 289	111 Uuu Ununium 288	112 Uub Unbinium 289	113 Uut Untrium 288	114 Uuq Unquadium 289	115 Uup Unpentium 288	116 Uuh Unhexium 292	117 Uus Unseptium 294	118 Uuo Unoctium 294

EXAMPLE: Without using pKa values, which of the following pairs is more acidic?

1.  $\text{NH}_3$  or  $\text{SH}_2$

2.  $\text{H}_2\text{O}$  or  $\text{CH}_4$



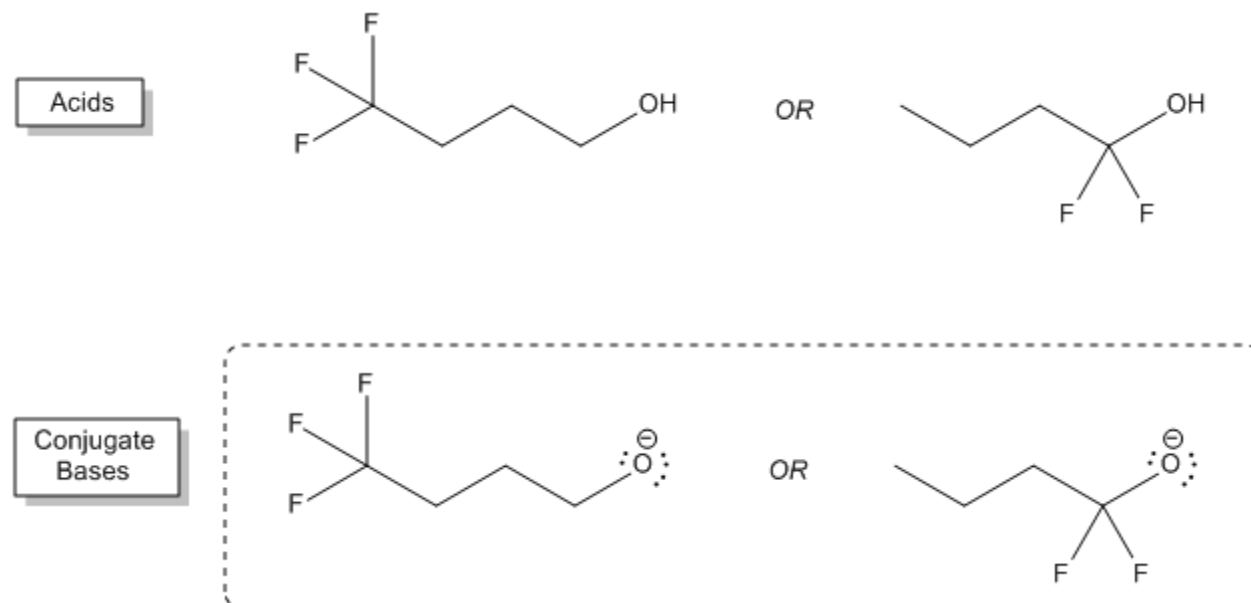
4.  $\text{HI}$  or  $\text{HF}$

## CONCEPT: FACTORS AFFECTING ACIDITY- INDUCTIVE EFFECTS

Inductive effects describe the stabilizing properties that \_\_\_\_\_ atoms **NOT CONNECTED** to the acidic hydrogen have on the overall acidity.

- Whenever a charge can be \_\_\_\_\_ over more than one atom, the more stable that charged species will be .
- Electronegative entities on other parts of the molecule can help “spread out” the negative charge of the conjugate base through inductive effects.

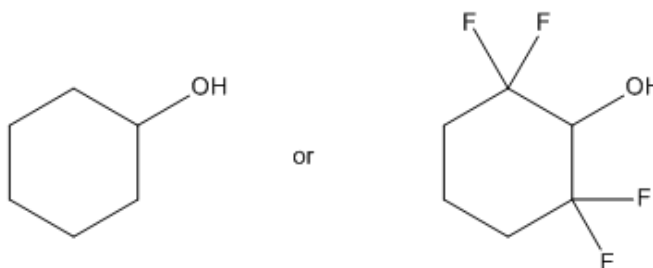
**EXAMPLE:** Draw rough sample electron clouds over the following pairs of conjugate bases of their respective alcohols. Which is more stable? Which alcohol would have had the lower pKa?:



Factors that increase inductive effects:

1. Strength of the electronegative entities \_\_\_\_\_
2. Number of electronegative entities \_\_\_\_\_
3. Proximity of electronegative entities \_\_\_\_\_

**EXAMPLE:** Without using pKa values, which of the following pairs is more acidic?

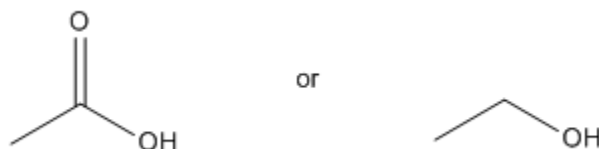


## CONCEPT: FACTORS AFFECTING ACIDITY- OTHER EFFECTS

### Resonance Effects:

Definition: Whenever the donation of a proton leads to the formation of a possible \_\_\_\_\_, that conjugate base will be \_\_\_\_\_ stable, and the molecule will be a \_\_\_\_\_ acid.

**EXAMPLE:** Which of the following pairs of acids would have the lower pKa? Explain why.

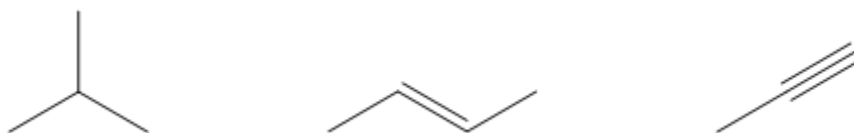


### Hybridization Effects:

Definition: The more s-character in the acid, the closer to the nucleus extra lone pairs will be held to it, making the conjugate base \_\_\_\_\_ stable.

**Acidity Trend =**  $sp\ C-H$  \_\_\_\_\_  $sp^2\ C-H$  \_\_\_\_\_  $sp^3\ C-H$

**EXAMPLE:** Which of the following hydrocarbons is the most acidic?



### Steric Effects:

Particularly with alcohols, the more easily solvated the conjugate base is, the more stable it will be.

- The smaller the R group, the more \_\_\_\_\_ the alcohol
- The bigger the R group, the more \_\_\_\_\_ the alkoxide

**EXAMPLE:** Which of the oxides is the most basic?



**CONCEPT: FACTORS AFFECTING ACIDITY- OTHER EFFECTS**

**PRACTICE:** Would the following reactions go to the right or the left? Draw the products and label ALL species. Provide the full mechanism.

