Announcements – Lecture XVII – Thursday, Nov 12th

1. **Fifth Lab – Saturday, November 14th … 1-4pm … ISB 155/160 (A-E)**

   a) Print lab prior to coming to lab -- use the 'Print Friendly Version' located on the top left hand side of the page – this is the version that contains the 'Data Sheet' that you will hand in upon completing the lab.

   b) Final set of Lab Owls will appear in Owl after this lab. There are worth 25% of the Lab Grade.

2. 

iClicker:
Choose any letter: A-E

8.1 What Are Acids and Bases?

ACID: A substance that produces H_3O^+ ions in aqueous solution.

$$HA(aq) + H_2O(l) \longrightarrow H_3O^+ + A^-$$
$$\text{OR} \quad \rightleftharpoons$$

BASE: A substance that produces OH^- ions in aqueous solution.

$$B(aq) + H_2O(l) \longrightarrow BH^+ + OH^-$$
$$\text{OR} \quad \rightleftharpoons$$

8.2 How Do We Define the Strength of Acids and Bases?

Acids:

Strong: $HA(aq) + H_2O(l) \rightarrow H_3O^+ + A^-$ ~100% ... only 6

HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$

Weak: $HA(aq) + H_2O(l) \Leftrightarrow H_3O^+ + A^-$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Bases:

Strong: $B(aq) + H_2O(l) \rightarrow BH^+ + OH^-$ ~100% ... only 4 soluble

$NaOH(aq) \rightarrow Na^+ + OH^-$

$LiOH$, $NaOH$, KOH, $Ba(OH)_2$

Weak: $B(aq) + H_2O(l) \Leftrightarrow BH^+ + OH^-$

$NH_3(aq) + H_2O(l) \Leftrightarrow NH_4^+ + OH^-$

$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

8.2 How Do We Define the Strength of Acids and Bases?

K_a Values			K_a Values		
Name of Acid	**Acid**	**K_a**	**Name of Acid**	**Acid**	**K_a**
Sulfuric acid	H_2SO_4	large	Hexaaquaaluminum ion	$Al(H_2O)_6^{3+}$	7.9×10^{-6}
Hydrochloric acid	HCl	large	Carbonic acid	H_2CO_3	4.2×10^{-7}
Nitric acid	HNO_3	large	Hydrogen sulfide	H_2S	1×10^{-7}
Hydronium ion	H_3O^+	1.0	Dihydrogen phosphate ion	$H_2PO_4^-$	6.2×10^{-8}
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}	Hypochlorous acid	HClO	3.5×10^{-8}
Phosphoric acid	H_3PO_4	7.5×10^{-3}	Ammonium ion	NH_4^+	5.6×10^{-10}
Hexaaquairon(III) ion	$Fe(H_2O)_6^{3+}$	6.3×10^{-3}	Hydrocyanic acid	HCN	4.0×10^{-10}
Hydrofluoric acid	HF	7.4×10^{-4}	Hexaaquairon(II) ion	$Fe(H_2O)_6^{2+}$	3.2×10^{-10}
Formic acid	HCO_2H	1.8×10^{-4}	Hydrogen carbonate ion	HCO_3^-	4.8×10^{-11}
Benzoic acid	$C_6H_5CO_2H$	6.3×10^{-5}	Hydrogen phosphate ion	HPO_4^{2-}	3.6×10^{-13}
Acetic acid	CH_3CO_2H	1.8×10^{-5}	Water	H_2O	1.0×10^{-14}
			Hydrogen sulfide ion	HS^-	1×10^{-19}

For weak acids ... the greater the Ka ... the stronger the acid.

8.5 How Do We Use Acid Ionization Constants?

pKa Versus Ka

$$pK_a = -\log_{10} K_a$$

HF: $K_a = 7.4 \times 10^{-4}$ @ 25°C $\qquad pK_a = -\log_{10}(7.4 \times 10^{-4}) = 3.13$

HCN: $K_a = 4.0 \times 10^{-10}$ @ 25°C $\qquad pK_a = -\log_{10}(4.0 \times 10^{-10}) = 9.38$

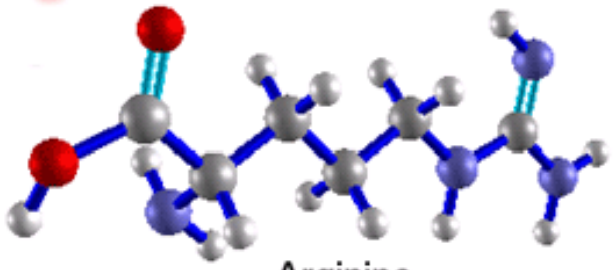
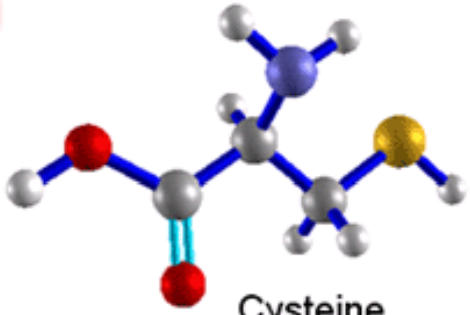
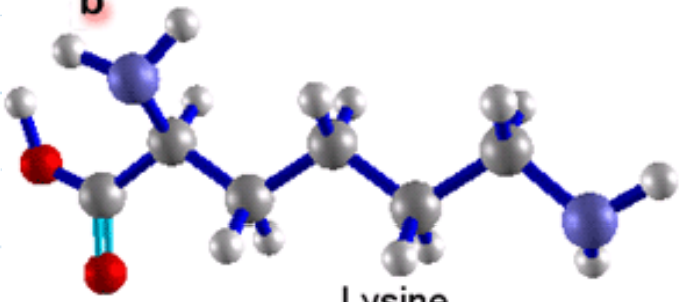
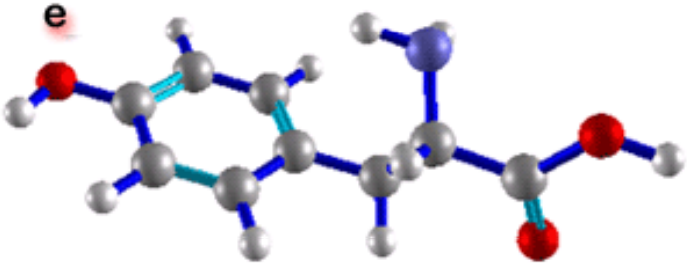
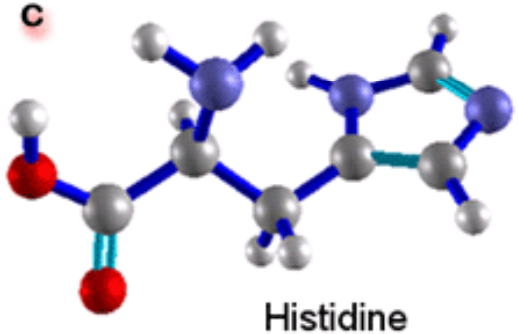
Which is the stronger acid?

a) The one with the largest K_a ... HF

b) The one with the smallest pK_a ... HF

8.5 How Do We Use Acid Ionization Constants?

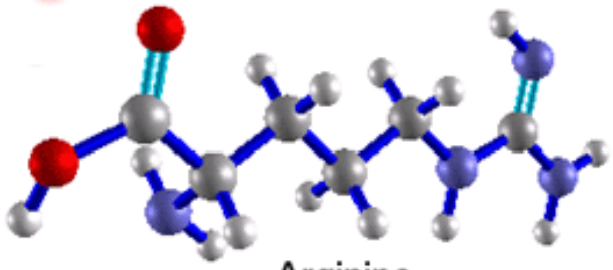
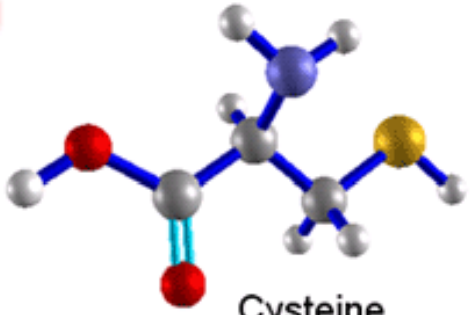
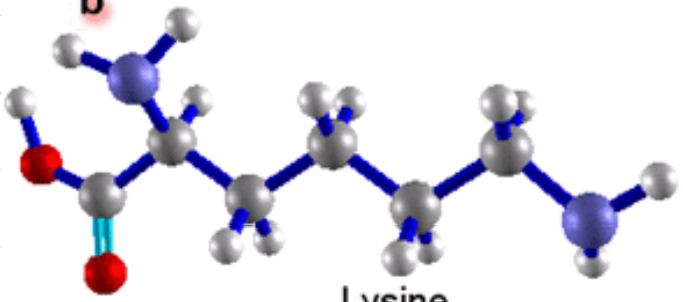
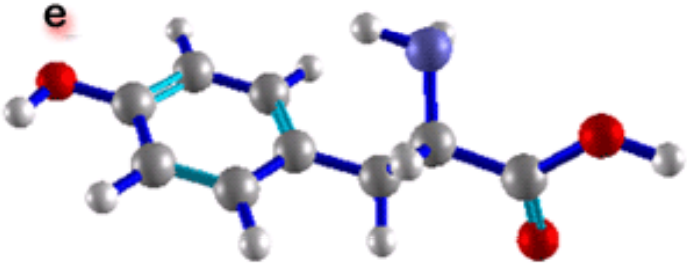
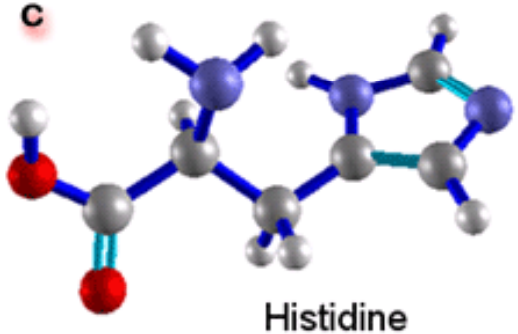
pKa Versus Ka

	pKa		pKa
a  Arginine	12.0	d  Cysteine	8.3
b  Lysine	9.0	e  Tyrosine	9.8
c  Histidine	6.1 → Smallest pKa		

The strongest acid depicted?

8.5 How Do We Use Acid Ionization Constants?

pKa Versus Ka

	pKa		pKa
a  Arginine	12.0	d  Cysteine	8.3
b  Lysine	9.0	e  Tyrosine	9.8
c  Histidine	6.1		

The one with an acid strength closest to that of NH_4^+, Ka = 5.6×10^{-10} @ 25°C?

$pKa = -\log_{10}(5.6 \times 10^{-10}) = 9.25$

8.7 Acid Base Properties of Pure Water

Autoionization of Water

$H_2O_{(l)} + H_2O_{(l)} \Leftrightarrow H_3O^+ + OH^-$

$K = [H_3O^+][OH^-]$

↳ K_W

@ 25°C, $K_W = 1 \times 10^{-14}$

$[H_3O^+][OH^-] = 1 \times 10^{-14}$

$[H_3O^+] = 1 \times 10^{-7}$

$[OH^-] = 1 \times 10^{-7}$

Neutral : $[H_3O^+] = [OH^-]$

Acidic : $[H_3O^+] > [OH^-]$

Basic : $[H_3O^+] < [OH^-]$

8.7 Acid Base Properties of Pure Water

Curiosity!

The autoionization of water is an endothermic process.
$H_2O(l) + H_2O(l) \Leftrightarrow H_3O^+ + OH^-$

Thus as the temperature increases then – the $[H_3O^+]$ should – 

a) Decrease **b) Increase ✓** **c) Remain the same**

$H_2O(l) + H_2O(l) + heat \Leftrightarrow H_3O^+ + OH^-$

↳ Increase T, equivalent to adding a reactant.

→ Equilibrium shift, $[H_3O^+]\uparrow$