Acid-Base Ka, Kb, pKa & pKb Worksheet Solutions

1. a) 0.50 M HCN Ka for hydrocyanic acid = 4.9 X 10-10

HCN + H2O <=====> H3O+1 + CN-1

i	0.50 M	------	-----
c	-x	+x	+x
e	0.5 -x	x	x

$$Ka = \frac{[H3O+1][CN-1]}{[HCN]}$$

$$4.9 \times 10^{-10} = \frac{(x)(x)}{(0.50 - x)}$$

$2.45 \times 10^{-10} - 4.9 \times 10^{-10}x = x^2$

$x^2 + 4.9 \times 10^{-10}x - 2.45 \times 10^{-10} = 0$ (solve with the quadratic equation)

$x = 1.57 \times 10^{-5}$ therefore $[H3O+] = 1.57 \times 10^{-5}$ mole/L

b) pH = 4.805

c) $\frac{1.57 \times 10^{-5}}{0.5} \times 100\% = 0.00314\%$

2. a) First the NH4NO3 dissociates into its ions. NH4NO3(aq) ----> NH4+1(aq) + NO3-1(aq)

Then the NH4+1(aq) acts like an acid in the water.

NH4+1(aq) + H2O(l) <=====> NH3(aq) + H3O+1(aq)

i	0.1 M	-----	------
c	-x	+x	+x
e	0.1 - x	x	x

$$Ka = \frac{[NH3][H3O+1]}{NH4+1}$$

Ka = 5.6 X 10-10 = x2 / 0.1 - x

5.6 X 10-11 - 5.6 X 10-10x = x2

x2 + 5.6 X 10-10x - 5.6 X 10-11 = 0

x = 7.48 X 10-6 therefore [H3O+] = 7.48 X 10-6 mol/L

b) pH = - log [H3O+] = 7.48 X 10-6 mol/L = 5.13

c) pOH = 14- pH = 14 - 5.13 = 8.87

d) the % dissociation is 7.48 X 10-6 / 0.1 * 100 % = 0.0075%

3. a) KOH -----> K+1 + OH-1

b) first ionization H3AsO4 + H2O <=====> H3O+1 + H2AsO4-1

second ionization H2AsO4-1+ H2O <=====> H3O+1 + HAsO4-2

third ionization HAsO4-2 + H2O <=====> H3O+1 + AsO4-3

c) HClO4 + H2O <=====> H3O+1 + ClO4-1

d) HCN + H2O <=====> H3O+1 + CN-1

e) C6H5NH2 + H2O <=====> C6H5NH3+1 + OH-1

4. C6H5COOH(aq) + H2O(l) <=====> C6H5COO-1(aq) + H3O+1(aq)

Ka = [C6H5COO-1][H3O+1] / [C6H5COOH]

5. HCN pKa = 9.21 [H3O+1] = 6.17 X 10-10 stronger base

HF pKa = 3.17. [H3O+1] = 6.76 X 10-4 stronger acid

6. 0.15 M HF Ka for hydrofluoric acid = 5.6 X 10-4

	HF	+	H2O	<=====>	H3O+1	+	F-1
i	0.15 M				------		-----
c	-x				+x		+x
e	0.15 -x				x		x

$$Ka = \frac{[H3O+1][F-1]}{[HF]}$$

$$5.6 \times 10^{-4} = \frac{(x)(x)}{(0.15 - x)}$$

$8.4 \times 10^{-5} - 5.6 \times 10^{-4}x = x^2$

$x^2 + 5.6 \times 10^{-4}x - 8.4 \times 10^{-5} = 0$ (solve with the quadratic equation)

$x = 8.88 \times 10^{-3}$ therefore $[H3O+] = 8.88 \times 10^{-3}$ mole/L

pH = 2.05 % ionization = 5.92%

7.

	HIO4(aq)	+	H2O(aq)	<=====>	H3O+1(aq)	+	IO4-1(aq)
i	0.10 M				--------		--------
c	-3.8×10^{-2} M				$+3.8 \times 10^{-2}$ M		$+3.8 \times 10^{-2}$ M
e	6.2×10^{-2} M				3.8×10^{-2} M		3.8×10^{-2} M

$Ka = [H3O+1(aq)][IO4-1(aq)] / [HIO4(aq)]$

$= (3.8 \times 10^{-2})^2 / 6.2 \times 10^{-2}$

$= 2.33 \times 10^{-2}$

pKa =1.63

8. pKa for barbituric acid = 4.01

$Ka = 9.77 \times 10^{-5}$

	HBar	+	H2O	<=====>	H3O+1	+	Bar-1
i	0.50 M				------		-----
c	-x				+x		+x
e	0.5 -x				x		x

$$Ka = \frac{[H3O+1][Bar-1]}{[HBar]}$$

9.77 X 10-5 = (x)(x)

(0.50 -x)

4.89 X 10-6 - 9.77 X 10-5x = x2

x2 + 9.77 X 10-5x - 4.89 X 10-6 = 0 (solve with the quadratic equation)

x = 2.16 X 10-3 therefore [H3O+] = 2.16 X 10-3 mole/L

[H+] = 2.16 X 10-3 ; pH = 2.67

9. pH = 10.70 therefore pOH = 3.3

[OH-1] = 5.01 X 10-4 M

	N2H5(aq) +	H2O(l) <====>	N2H5+1(aq) +	OH-1(aq)
i	0.15		-----	-----
c	-5.01 X 10-4		+5.01 X 10-4	+5.01 X 10-4
e	0.1495		5.01 X 10-4	5.01 X 10-4

Kb = [N2H5+1][OH-1] / [N2H4]

= (5.01 X 10-4)2 / 0.1495

= 1.68 X 10-6

pKb = 5.77

pKa = 8.23

Ka = 5.89 X 10-9

10. pKb = 5.79

Kb = 1.62 X 10-6

	Cod(aq) +	H2O(l) <=====>	HCod(aq) +	OH-1(aq)
i	0.02		---------	----------
c	- x		+x	+x
e	0.02 - x		x	x

1.62 X 10-6 = x2 / (0.02 - x)

3.24 X 10-8 - 1.62 X 10-6x = x2

x2 + 1.62 X 10-6x - 3.24 X 10-8 = 0

x = 1.79 X 10-4

therefore [OH-1] = 1.79 X 10-4 M,

so pOH = 3.75 and pH = 10.25

11. pKb for Quinine chloride = 5.48

pKa for its conjugate = 8.52

Ka = 3.02 X 10-9

	HQCl	+	H2O	<=====>	H3O+1	+	QCl-1
i	0.15 M				------		-----
c	-x				+x		+x
e	0.15 -x				x		x

$$Ka = \frac{[H3O+1][QCl-1]}{[HQCl]}$$

$$3.02 \times 10^{-9} = \frac{(x)(x)}{(0.15 - x)}$$

$4.53 \times 10^{-10} - 3.02 \times 10^{-9}x = x^2$

$x^2 + 3.02 \times 10^{-9}x - 4.53 \times 10^{-10} = 0$ (solve with the quadratic equation)

$x = 2.13 \times 10^{-5}$ therefore $[H3O+] = 2.13 \times 10^{-5}$ mole/L

pH = 4.67

12. Ka for nicotinic acid = 1.4×10^{-5}

	HNic	+	H2O	<=====>	H3O+1	+	Nic-1
i	0.01 M				------		-----
c	-x				+x		+x
e	0.01 -x				x		x

$$Ka = \frac{[H3O+1][Nic-1]}{[HNic]}$$

$$1.4 \times 10^{-5} = \frac{(x)(x)}{(0.01 - x)}$$

$1.4 \times 10^{-7} - 1.4 \times 10^{-4}x = x^2$

$x^2 + 1.4 \times 10^{-4}x - 1.4 \times 10^{-7} = 0$ (solve with the quadratic equation)

x = 3.67 X 10-4 therefore [H3O+] = 3.67 X 10-4 mole/L
so pH = 3.44

13. (a) CN-1 + H2O <=====> HCN + OH-1

Kb = [HCN][OH-1]/[CN-]

(b) C2H3O2-1 + H2O <=====> HC2H3O2 + OH-1

Kb = [HC2H3O2][OH-1]/[C2H3O2-]

(c) C6H5NH2 + H2O <=====> C6H5NH3+1 + OH-1

Kb = [C6H5NH3+1][OH-1]/[C6H5NH2]

(d) H2O + H2O <=====> H3O+1 + OH-1

Kb = [H3O+1][OH-1]/[H2O]2

14. pH = 10.10 therefore pOH = 3.9 and
[OH-1] = 1.26 X 10-4 M

	Mor(aq) +	H2O(l) <=====>	HMor+1(aq) +	OH-1(aq)
i	0.01		---------	----------
c	- 1.26 X 10-4		+1.26 X 10-4	+1.26 X 10-4
e	9.87 X 10-3		1.26 X 10-4	1.26 X 10-4

Kb = [HMor+1][OH-1]
Mor

= (1.26 X 10-4)2 / 9.87 X 10-3

= 1.605 X 10-6