Answer all questions. Be careful to give your final answer to the correct sig. figs.

1. a) **(3 points)** The K_a of benzoic acid (C_6H_5COOH) at 25°C is 6.3 x 10^{-5}. What is the K_b of its conjugate base, benzoate ($C_6H_5COO^-$)?

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{6.3 \times 10^{-5}} = 1.6 \times 10^{-10}$$

b) **(5 points)** What are $[H_3O^+]$ and pOH in a 0.11 M solution of H_2CO_3? What is $[CO_3^{2-}]$? (K_{a1} = 4.5 x 10^{-7} and K_{a2} = 4.7 x 10^{-11} for H_2CO_3)

	H_2CO_3 (aq) ⇌	HCO_3^- (aq) +	H_3O^+ (aq)
[init]	0.11	0	0
change]	-x	+x	+x
[equil]	(0.11-x)	x	x

$$K_{a1} = \frac{x^2}{(0.11 - x)} \approx \frac{x^2}{0.11} = 4.5 \times 10^{-7}$$

$$\therefore x = [H_3O^+] = 2.2 \times 10^{-4}$$

$\therefore$ pH = 3.66 $\therefore$ pOH = 10.34

$[CO_3^{2-}] = K_{a2}$ $\therefore$ $[CO_3^{2-}]$ = 4.7 x 10^{-11}

c) **(3 points)** K_c for the reaction below is 6.4 x 10^{-7}. Identify each compound as the stronger acid, the stronger base, the weaker acid, or the weaker base.

HSO_3^- (aq) + H_2CO_3 (aq) ⇌ HCO_3^- (aq) + H_2SO_3 (aq)

weaker base **weaker acid** **stronger base** **stronger acid**

d) **(2 points)** Which one of the following salts will give a basic solution when dissolved in water? Circle your choice.

$CaCl_2$, NH_2Et_2Cl, **$KClO_3$**, $NaNO_3$, KI

(2 points) Write an equation for the reaction that occurs when the salt dissolves in water and makes the solution basic.

ClO_3^- (aq) + H_2O (l) ⇌ $HClO_3$ (aq) + OH^- (aq)

e) Will a solution of the salt NH_4F be acidic, neutral or basic? (K_a for HF is 6.8 x 10^{-4}, and K_b for NH_3 is 1.8 x 10^{-5})

(2 point) Write your answer here: The solution will be __**acidic**__

(4 points) Show how you reached your answer.

K_a (NH_4^+) = (1.0 x 10^{-14})/(1.8 x 10^{-5}) = 5.6 x 10^{-10}

K_b (F^-) = (1.0 x 10^{-14})/(6.8 x 10^{-4}) = 1.5 x 10^{-11}

Since K_a > K_b, the acid will produce more $[H_3O^+]$ than the base will produce $[OH^-]$, Therefore, the solution is acidic

f) **(4 points)** Calculate the pH of a 0.40 M solution of NH_2Me (K_b = 4.4 x 10^{-4})

	NH_2Me (aq) + H_2O (l) ⇌	NH_3Me^+ (aq) +	OH^- (aq)
[init]	0.40	0	0
[change]	-x	+x	+x
[equil]	(0.40-x)	x	x

$$K_b = \frac{x^2}{(0.40 - x)} \approx \frac{x^2}{0.40} = 4.4\times10^{-4} \quad \therefore x = [OH-] = 1.3 \times 10^{-2} \quad \therefore \text{pOH} = 1.88 \quad \therefore \text{pH} = 12.12$$

3. a) **(8 points)** What is the pH of a buffer solution prepared from adding 60.0 mL of 0.22 M nitrous acid (HNO_2) solution to 50.0 mL of 0.24 M sodium nitrite ($NaNO_2$) solution? (K_a for HNO_2 is 7.1×10^{-4}).

$$[HNO_2] = \frac{(60.0mL)(0.22M)}{110.0mL} = 0.120M \text{ (extra sig. fig.)}$$

$$[NO_2^-] = \frac{(50.0mL)(0.24M)}{110.0mL} = 0.109M$$

	HNO_2 (aq) ⇌	H^+ (aq) +	NO_2^- (aq)
[init]	0.120	0	0.109
[change]	-x	+x	+x
[equil]	(0.120-x)	x	(0.109+x)

$$Ka = \frac{x(0.109 + x)}{(0.120 - x)} \approx \frac{0.109x}{0.120} = 7.1 \times 10^{-4}$$

∴ x = 7.82×10^{-4}

∴ $[H^+]$ = x = 7.82×10^{-4} M = 7.8×10^{-4} M (sig. figs.)

∴ pH = -log (7.8×10^{-4})

pH = 3.11

OR pH = pK_a + log $\frac{[base]}{[acid]}$

pH = 3.15 + (-0.04)

pH = 3.11

b) **(12 points)** What is the new pH if 10.0 mL of a 0.20 M solution of NaOH is added?

$n(HNO_2)$ = mv = (0.120 M)(110.0×10^{-3} L) = 0.0132 mol

$n(NO_2^-)$ = mv = (0.109 M)(110.0×10^{-3} L) = 0.0120 mol

$n(OH^-)$ added = mv = (0.20 M)(10.0×10^{-3} L) = 0.0020 mol

	HNO_2	+ OH^- →	NO_2^-	+ H_2O
n(init)	0.0132		0.0120	
addition		0.0020		
n(new)	0.0112	0	0.0140	

new $[HNO_2]$ = $\frac{0.0112mol}{120 \times 10^{-3}}$ = 0.0933M

new $[NO_2^-]$ = $\frac{0.0140}{120 \times 10^{-3}}$ = 0.1167M

	HNO_2 ⇌	H^+	+ NO_2^-
[init]	0.0933	0	0.1167
[change]	-x	+x	+x
[equil]	(0.0933)-x	x	(0.1167)+x

$$Ka = \frac{x(0.1167 + x)}{(0.0933 - x)} \approx \frac{0.1167x}{0.0933} = 7.1 \times 10^{-4}$$

∴ x = $[H^+]$ = 5.67×10^{-4} **∴ pH = 3.25** (now rounded to 2 decimal places because 0.20 M above was 2 sig. figs)

OR use pH = pK_a + log $\frac{[base]}{[acid]}$

or the version with moles

pH = pK_a + log $\frac{n(base)}{n(acid)}$

∴ pH = 3.15 + 0.097

∴ **pH = 3.25**

3. **(5 points)** What is the molar solubility of Ag_2SO_4 in a 0.22 M solution of Na_2SO_4? K_{sp} for Ag_2SO_4 is 1.5×10^{-5}.

Ag_2SO_4 (s) $\rightleftharpoons$	2 Ag^+ (aq) +	SO_4^{2-} (aq)
solid	0	0.22
-x	+2x	+x
solid	2x	(0.22+x)

$K_{sp} = 1.5\times10^{-5} = [Ag^+]^2[SO_4^{2-}] = (2x)^2\ (0.22+x) \approx (4x^2)(0.22)$

$\therefore x^2 = \dfrac{(1.5\times10^{-5})}{4(0.22)}$ $\therefore$ x = solubility of Ag_2SO_4 = **4.1×10^{-3} M**