Name: _____ period: ____ date: _____

ch. 18 & 19 equilibrium & acid / base / pH **test** 70 points (5 ec) honors chemistry

In problems involving any calculation, show your work in an organized manner, include (i) any relevant equation (or formula), (ii) conversion factor(s), (iii) put the proper units in your calculations and answer, and (iv) have the proper number of significant figures in your answer.

1. In regards to the reaction; $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ at equilibrium is disturbed by ___; what is the effect on the number of moles of NH3 & N2 ? Basis / rationale ? [20 points]

   a. Addition of neon at constant volume

   2 pt, 2: no change in n_{N_2} & n_{NH_3} b/c Q is not a function of n_{Ne}

   b. Addition of neon at constant pressure

   2: i) add Ne → ↑ n_{total} → ↑ P_{total}, but ↑ V b/c @ constant P

   2: ii) $Q = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{n_{NH_3}^2 (\frac{1}{V})^2}{n_{N_2} n_{H_2}^3 (\frac{1}{V})^{4}} = \frac{n_{NH_3}^2 V^2}{n_{N_2} n_{H_2}^3}$

   2: iii) ↑ V → ↑ Q → ↓ Q to reestablish equil → ↓ n_{NH_3} → ↑ r_f → ↑ n_{N_2}

   c. Addition of hydrogen gas — hmm @ constant V

   5 pt: i) ↑ n_{H_2} → ↓ Q → ↑ Q to reestablish equilib → ↑ n_{NH_3} → ↑ r_f → ↓ n_{N_2} (① ① ① ① ①)

   free for 5° only

   d. Increase in temperature

   2 pt, 1, 2: i) $\Delta H = 2\Delta H_f(NH_3) - [\Delta H_f(N_2) + 3\Delta H_f(H_2)] < 0$ b/c $\Delta H_f NH_3 < 0$, ΔH_f of $N_2 = 0$

   ii) $N_2 + 3H_2 \rightleftharpoons 2NH_3 + q$ b/c $\Delta H < 0$

   iii) ↑ T → "want" ↓ T → consume q → ↑ r_f → ↓ n_{NH_3} & ↑ n_{N_2}

2. In regards to the reaction: : $N_{2(g)}$ + $H_{2(g)}$ ⇄ $NH_{3(g)}$, the initial partial pressure of N_2, H_2, and NH_3 are 1.0 5.0, and 1.0 atm, respectively. At equilibrium, the partial pressure of N2 is 0.5 atm; what is the numeric value of the equilibrium constant ? [10 points]

i) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

I	1	5	1
C	-.5	-1.5	+1
E	0.5	3.5	2

ii) $K_p = \frac{P_{NH_3}^2}{P_{N_2} P_{H_2}^3} = \frac{2^2}{0.5 (3.5)^3} = \frac{4}{21.4} = 0.047$

3. Sodium chloride is added to a 125 mL aqueous solution of 1.0 mM lead (II) nitrate and 1.0 μM silver nitrate; what is the first precipitate to form ? basis /rationale ? Assume that the addition of sodium chloride does not change the concentration of lead (II) nitrate or silver nitrate. [10 points]

ppt @ $Q > K_{sp}$

(i) for $PbCl_2$

$[Pb^{+2}][Cl^-]^2 > K_{sp}(PbCl_2)$

1mM $[Cl^-]^2 > 1.6 \cdot 10^{-5}$

$[Cl^-] > \sqrt{\frac{1.6 \cdot 10^{-5}}{10^{-3}}} = 0.126$ M Cl^-

(ii) for AgCl

$[Ag^+][Cl^-] > K_{sp}(AgCl)$

$10^{-6} [Cl^-] > 1.8 \cdot 10^{-10}$

$[Cl^-] > 1.8 \cdot 10^{-4}$ M Cl^-

(iii) 1st ppt b/c lower [Cl] to form ppt

4. What is the net ionic equation that describes how a sodium benzoate (NaC_6H_5COO) – benzoic acid (C_6H_5COOH) buffer responds to the addition of ___. [10 points]

a. Strong acid, HNO_3

$H^+ + C_6H_5COO^- \rightarrow HC_6H_5COO$

b. Strong base, KOH

$OH^- + HC_6H_5COO \rightarrow H_2O + C_6H_5COO^-$

5. What is the pH of a 125 mL aqueous solution of 1.0 mM sodium benzoate ? [15 points]

i) $NaBz \rightarrow Na^+ + Bz^-$; basic salt

$Bz^- + H_2O \rightleftharpoons HBz + OH^-$; $K_b(Bz^-)$

ii)

	Bz^-	HBz	OH^-
I	1mM	0	0
C	$-x$	$+x$	$+x$
E	$1mM - x$	x	x

iii) $K_b(Bz^-) = \dfrac{[HBz][OH^-]}{[Bz^-]}$

$\dfrac{K_w}{K_a(HBz)} = \dfrac{x^2}{0.001 - x} \approx \dfrac{x^2}{0.001}$

3 pts

$\dfrac{10^{-14}}{6.5 \cdot 10^{-5}} = \dfrac{x^2}{0.001} \rightarrow \sqrt{x^2} = \sqrt{1.538 \cdot 10^{-10}(10^{-3})}$

$x = 3.92 \cdot 10^{-7}\ M$

iv) $[H^+][OH^-] = K_w$

$[H^+](3.92 \cdot 10^{-7}) = 10^{-14}$

$[H^+] = 2.55 \cdot 10^{-8}$

v) $pH = -\log[H^+]$

$= -\log(2.55 \cdot 10^{-8})$

$= 7.59$

6. What is the pH of mixing 25 mL of 1.0 mM HCl (a strong acid) and 75 mL of 3.0 mM HNO_3 (a strong acid) ? [10 points]

2 pts i) $[H^+] = \dfrac{n_{H^+}}{V} = \dfrac{n_{H^+} \text{ from } HCl + n_{H^+} \text{ from } HNO_3}{V}$

2 $= \dfrac{n_{HCl} + n_{HNO_3}}{V} = \dfrac{[HCl]V_{HCl} + [HNO_3]V_{HNO_3}}{V_{HCl} + V_{HNO_3}}$

2 $= \dfrac{1mM(25mL) + 3mM(75mL)}{100mL} = 2.5 \times 10^{-3}\ M$

2 2 ii) $pH = -\log[H^+]$

$= -\log(2.5 \cdot 10^{-3})$