Name: ______________________________ period: _____ date: ______________

ch. 18 & 19 equilibrium & acid, base, pH, buffer **test** 80 points 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.

Below Rx @ equilibrium then its disturbed by ...

1. Answer the below questions. Basis / rationale of your answer ? [15 points]

a. the effect of cooling on the solubility of lead (II) nitrate in water ?

2 pt | i) $\Delta H = \Delta H_f\ Pb(NO_3)_2(aq) - \Delta H_f\ Pb(NO_3)_2(s)$

$= -421 - -452 > 0$

1 | ii) solid + g ⇌ aq

2 | iii) ↓T → "want" ↑T = gaining → ↑r_b → ↓aq, ↑solid → ↓ solubility

b. the effect on the number of moles of hydrogen gas on the reaction: $H_{2(g)}$ + $Cl_{2(g)}$ ⇌ $HCl_{(g)}$ by increasing the volume of the container at constant temperature ?

1 pt | i) $H_2 + Cl_2 \rightleftharpoons 2HCl$

2 | ii) $Q = \frac{[HCl]^2}{[H_2][Cl_2]} = \frac{n^2_{HCl}}{n_{H_2}\ n_{Cl_2}}$

2 | as Q is not function of V

↓

Rx still @ equilibrium

↓

no change n_{H_2}

c. the effect on the number of moles of nitrogen gas on the reaction: $N_{2(g)}$ + $H_{2(g)}$ ⇌ $NH_{3(g)}$ by adding an inert gas, neon, at constant temperature and constant pressure ?

1 pt | i) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

2 | ii) $Q = \frac{n^2_{NH_3}}{n_{N_2}\ n^3_{H_2}} V^2$

2 | iii) add Ne → ↑n_{total} → ↑P_{total} but as $\Delta P = 0$ → ↑V → ↑Q

to reestablish equilibrium, ↓Q → ↑r_r → ↑n_{N_2}

2. Write the algebraic expression for the equilibrium constant, Kc, for the reaction. [10 points]

a. $N_{2(g)}$ + 3$H_{2(g)}$ ⇄ 2$NH_{3(g)}$ | 2 pt

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$ 3

5 pt @

b. 2$C_2H_{6(g)}$ + 7$O_{2(g)}$ ⇄ 4$CO_{2(g)}$ + 6$H_2O_{(l)}$ 2

$$K_c = \frac{[CO_2]^4}{[C_2H_6]^2[O_2]^7}$$ 3

3. What is the numeric value of the equilibrium constant, Kp, for the reaction: $N_{2(g)}$ + $H_{2(g)}$ ⇄ $NH_{3(g)}$, where the partial pressure of N_2 and H_2 are 225 kPa atm and 725 kPa, respectively before the reaction happens, while the partial pressure of N_2 is 125 kPa at equilibrium. [15 points]

i) $P_{N_2} = 225\text{ kPa} \cdot \frac{atm}{101.3\text{ kPa}} = 2.22\text{ atm}$; $P_{N_2,e} = 125\text{ kPa} \cdot \frac{atm}{101.3\text{ kPa}} = 1.23\text{ atm}$

$P_{H_2} = 725\text{ kPa} \cdot \frac{atm}{101.3\text{ kPa}} = 7.16\text{ atm}$

5 pt @

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

	N_2	H_2	NH_3
I	2.22	7.16	0
C	(-0.99)	(-2.97)	(+1.98)
E	(1.23)	(4.19)	(1.98)

iii) $K_p = \frac{P^2_{NH_3}}{P_{N_2}P^3_{H_2}} = \frac{1.98^2}{1.23(4.19^3)} = \frac{3.92}{(1.23)\,73.56} = \boxed{0.0433}$

4. The first precipitate by adding sodium chloride to an aqueous solution of 1.0 mM $Pb(NO_3)_2$ and 1.0 µM $AgNO_3$ is _____. Assume that the addition of sodium chloride does not affect the concentration of $Pb(NO_3)_2$ and $AgNO_3$. basis / rationale ? [10 points]

i) ppt @ $Q > K_{sp}$; $PbCl_2$

$PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^-$

4 pt

$Q = [Pb^{2+}][Cl^-]^2 > K_{sp}$

$10^{-3}[Cl^-]^2 > 1.6 \cdot 10^{-5}$

$[Cl^-] > \sqrt{\frac{1.6 \cdot 10^{-5}}{10^{-3}}} = \sqrt{1.6 \cdot 10^{-2}} = 0.13\text{ M}$

4

ii) AgCl ppt @ $Q > K_{sp}$

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

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

2 pt

$[Cl^-] > \frac{1.8 \cdot 10^{-10}}{10^{-6}} = 1.8 \cdot 10^{-4}\text{ M}$ → AgCl 1st ppt ble

5. What is the pH of 275 mL aqueous solution of 75 mg HCl and 125 mg HNO3 ? [15 points]

i) $[HCl] = \frac{75 \text{ mg HCl}}{275 \text{ mL}} \cdot \frac{g}{10^3 \text{ mg}} \cdot \frac{10^3 \text{ mL}}{L} \cdot \frac{mol}{36 g} = 7.58 \cdot 10^{-3} M$

$[HNO_3] = \frac{125 \text{ mg } HNO_3}{275 \text{ mL}} \cdot \frac{g}{10^3 g} \cdot \frac{10^3 \text{ mL}}{L} \cdot \frac{mol}{63 g} = 7.22 \cdot 10^{-3} M$

5 pts Q

ii) $[H^+] = \frac{n_{H^+} \text{ fm HCl} + n_{H^+} \text{ fm } HNO_3}{V} = \frac{[HCl] V_{HCl} + [HNO_3] V_{HNO_3}}{V}$

$= \frac{7.58 \cdot 10^{-3} M (275 mL) + 7.22 \cdot 10^{-3} M (275 mL)}{275 mL}$

$= 14.8 \cdot 10^{-3} M$

iii) $pH = -\log[H^+] = -\log(14.8 \cdot 10^{-3}) = \boxed{1.83}$

free for 10

6. What is the pH of 275 ~~mL~~ mM aqueous solution of potassium benzoate, C_6H_5COOK ? [15 points]

i) $KBz \longrightarrow K^+ + Bz^-$; let $Bz = C_6H_5COO$

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

I	275		0	0
C	−x		+x	+x
E	275−x		x	x

3 pts Q

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

$\frac{K_w}{K_a(HBz)} = \frac{x^2}{0.275 - x} \approx \frac{x^2}{0.275}$ b/c $0.275 - x \approx 0.275$ b/c $K_b << 1$

$\frac{10^{-14}}{6.5 \cdot 10^{-5}} = 1.54 \cdot 10^{-10} = \frac{x^2}{0.275}$

$x = \sqrt{0.275 (1.54 \cdot 10^{-10})} = 6.5 \cdot 10^{-6} M$

iv) $pOH = -\log[OH^-] = -\log(6.5 \cdot 10^{-6}) = 5.19$

v) $pH + pOH = \boxed{8.81}$