

**Academic Honesty:** The answers on this test are my own and I am using only the allowed set of notes as described in the syllabus. I have not discussed the test questions with anyone before or during the test nor have I seen the test questions prior to the exam. If you violate any of the preceding items or do not sign, your semester grade is a F.

Signature: \_\_\_\_\_

1. Write the algebraic expression of  $K_c$  for the below (hypothetical ?) reactions. [15 points]



5 pts  

$$K_c = \frac{1}{[\text{HCl}] [\text{NH}_3]}$$

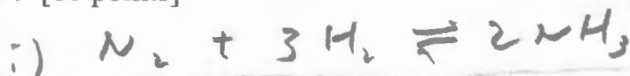


$$K_c = \frac{[\text{H}_2] [\text{MgCl}_2]}{[\text{HCl}]^2}$$



$$K_c = \frac{[\text{C}_6\text{H}_{12}\text{O}_6] [\text{O}_2]^6}{[\text{CO}_2]^6 [\text{H}_2\text{O}]^6}$$

2. In the reaction:  $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$ , the initial partial pressure of  $\text{N}_2$ ,  $\text{H}_2$ , and  $\text{NH}_3$  are 1.0 atm, 2.0 atm, and 3.0 atm, respectively. If the equilibrium partial pressure of  $\text{H}_2$  is 1.0 atm, then what is the value of the  $K_p$ ? [10 points]



2 + 3 pts

I	1	2	3
C	$-\frac{1}{2}$	-1	$+\frac{2}{3}$
E	$\frac{2}{3}$	1	$3\frac{2}{3}$

$$ii) K_p = \frac{P_{\text{NH}_3}^2}{P_{\text{N}_2} P_{\text{H}_2}^3} = \frac{3.67^2}{0.67 (1^3)} = 20$$

3.  $K_p$  of the reaction:  $H_{2(g)} + F_{2(g)} \rightleftharpoons 2 HF_{(g)}$  has a value of 10 and the initial partial pressure of  $H_2$ ,  $F_2$ , and  $HF$  are 1.0, 2.0, and 5.0 atm, respectively. What is the equilibrium partial pressure of  $HF$ ? [10 points]

4 pt

i)  $H_2 + F_2 \rightleftharpoons 2 HF$

	1	2	5
$\Delta$	-x	-x	+2x
$E$	1-x	2-x	5+2x

(guess)

$$P_{HF} = 5 + 2x$$

$$= 5 + 2(-0.099)$$

(2 pt) = 4.8 atm

4

ii)  $K_p = \frac{P_{HF}^2}{P_{H_2} P_{F_2}}$

$$10 = \frac{(5+2x)^2}{(1-x)(2-x)}$$

$$x = 8.43; -0.099$$

4. In the reaction:  $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$  is an endothermic reaction. What is the effect on the number of moles of chlorine gas due to disturbing the preceding reaction at equilibrium? basis/rationale. [15 points]

a. addition of helium, an inert gas, at constant temperature and pressure.

5 pt Q

$$Q = \frac{n_{Cl_2} n_{PCl_3}}{n_{PCl_5} V}$$

+ n He  $\rightarrow$   $\uparrow$  n total  $\rightarrow$   $\uparrow$  P  $\rightarrow$   $\uparrow$  V  $\rightarrow$   $\downarrow$  Q  $\rightarrow$   $\uparrow$  Q to reestablish equilibrium  $\rightarrow$   $\downarrow$  n Cl<sub>2</sub>

b. addition of neon, another inert gas, at constant temperature and volume

no effect b/c constant V  $\rightarrow$   $\pm$  Q  $\rightarrow$  no change n Cl<sub>2</sub> b/c still @ equilibrium

c. cool the reaction container

$\downarrow$  +  $PCl_5 \rightleftharpoons PCl_3 + Cl_2$  b/c  $\Delta H > 0$

$\downarrow$  T = "wait"  $\uparrow$  T = generate  $\rightarrow$   $\uparrow$  n  $\rightarrow$   $\downarrow$  n Cl<sub>2</sub>

5. What is the pH of 275 mL of 5.0 mM of \_\_\_? [20 points]

a. Nitric acid, a strong acid

2+3 pt

$$pH = -\log [H^+] = -\log (HNO_3) = -\log (5 \cdot 10^{-3}) = 2.30$$

b. Potassium hydroxide, a strong base

3 pt

$$i) pOH = -\log [OH^-] = -\log (KOH) = -\log (5 \cdot 10^{-3}) = 2.30$$

2

$$ii) pH + pOH = 14$$

$$pH + 2.30 = 14$$

$$pH = 11.70$$

c. Benzoic acid, a weak acid



I	5 mM	0	0
C	-x	+x	+x
E	5 mM - x	x	x

4

$$ii) K_a = \frac{[H^+][Bz^-]}{[HBz]}$$

$$6.3 \cdot 10^{-5} = \frac{x^2}{0.005 - x}$$

$$x = -0.00059, 0.00053$$

2 pt

$$iii) pH = -\log [H^+] = -\log (0.00053) = 3.276$$

6. Write the chemical equation(s) describing the addition of the salt to water, which shows if it's an acidic or basic salt. [10 points]

a. NaC<sub>6</sub>H<sub>5</sub>COO, sodium benzoate



b. Ammonium nitrate, NH<sub>4</sub>NO<sub>3</sub>



7. Write the net ionic equation that describes the addition of \_\_\_ to a benzoate buffer. [10 points]

a. Hydrochloric acid



b. Sodium hydroxide

