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Department of Chemistry
CHM 1220/1225
Exam IV – B
March 31, 2016

Directions

1. Skim the entire exam before you begin so that you have a sense of the whole: what parts you can do quickly and what parts will require more time. The points for each problem are shown in parenthesis in the left margin. Try to use your time in proportion to the points assigned for each question.
2. You must show all the work necessary to arrive at your answer. **No credit will be given for numerical answers unless your work is shown.** (We want to be able to follow your thought process in order to be able to help make corrections and allot partial credit.)
3. Be sure to include the correct number of significant figures and the appropriate unit when reporting your answers.

Academic Integrity Pledge

During the exam I will

- turn off my cell phone and put it away (out of sight and not on my person)
- close all books, notebooks, etc. and put them under the seat in which I sit
- use only a permitted calculator (no graphing or programmable calculators are permitted)
- keep my eyes down and focused on my own paper
- keep my answers covered
- write only in ink
- sit in the area assigned to my section
- stop writing and submit my exam promptly when told to do so

During the exam I will not

- have any papers other than those provided
- have any writing on my clothing or person or desk
- talk to anyone other than a TA or the instructor

I understand that the ***minimum consequence*** of any behavior contrary to this pledge is that I will receive a ***zero on this exam*** that will not be replaced by the percent earned on my final exam.

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Scoring

1	08 / 15	5	13 / 15	Problems	90 /120
2	15 / 15	6	13 / 15	Multiple Choice	20 / 30
3	13 / 15	7	15 / 15		
4	3 / 15	8	10 / 15	**Total**	110 / 150

Multiple Choice Answers:

1.	C	3.	B	5.	E
2.	A	4.	E	6.	C

ICE table

1. Given: $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

a. 2.35 mol of H_2 and 2.35 mol I_2 are placed in a 20.0 L vessel. At equilibrium, there are 3.76 mol HI. What is K_c for this equilibrium?

$$\frac{[HI]^2}{[I_2][H_2]} = K_c$$

$[HI] = n/v = 3.76/20 = 0.188\ M$

$[I_2] = n/v = 2.35/20 = 0.1175\ M$

$[H_2] = n/v = 2.35/20 = 0.1175\ M$

$$K_c = \frac{(0.188)^2}{(0.1175)(0.1175)}$$

$K_c = 2.56$ ✗ 02

b. A mixture has [HI] = 0.18 *M* and $[H_2] = [I_2] = 0.11$ *M*. In which direction will the reaction proceed?

They didn't say it's at eq'l.

$$Q = \frac{[HI]^2}{[I_2][H_2]} = \frac{(0.18)^2}{(0.11)^2} = 2.67768$$

$Q = 2.67768$

$K = 2.56$

$Q > K \rightarrow$ reaction proceeds to the left

06

2. Given: $2NH_3(g) + 4H_2O(g) \rightleftharpoons 2NO_2(g) + 7H_2(g)$; $\Delta H = -993$ kJ (6 moles → 9 moles)

Predict the direction in which the reaction will shift for each of the following changes. Explain your answer.

memorize

Moles:

↑P, ↓V → Shifts to less moles of gas

Exothermic rxn → ↓T, shifts right

a. Increase the volume of the container

decr pres

Right → If you increase volume it only affects gases and it shifts to more moles

b. Increase temperature

left → exothermic reaction. System shifts so that the heat is not absorbed because you increased it

c. Remove NH_3

left → There is less NH_3, system shifts to counteract that and goes to make more NH_3

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d. Add a catalyst

Nothing → because a catalyst increases the rate at which EQ is reached but doesn't affect the EQ itself

e. Add 0.15 mol He(g) → Nothing, He is an inert substance and it decreases the chance for reactants to collide, but doesn't affect the EQ

3. a. Predict the direction that is favored for the reactions:

i. $H_2CO_3(aq) + Cl^- \rightleftharpoons HCl(aq) + HCO_3^-$

(Reaction proceeds from strong acid to weak acid)

Reverse → HCl is a strong acid and H_2CO_3 is not.

ii. $H_2O + H_2O_2 \rightleftharpoons H_3O^+ + HO_2^-$

These are all weak acids and bases so there is no favored direction. It will go equally backwards and forwards after initially going forward

b. Circle the stronger acid in each of the following pairs. Explain your answer.

i. AsH_3 or PH_3 Binary acids in same column. Look at atomic size. As has a larger atomic radius

ii. H_2S or HCl (Cl is already a strong known acid) Binary acids in the same row look at higher EN (Cl > S), Cl has higher EN

iii. HSO_4^- or H_2SO_4 H_2SO_4 Has more hydrogens but same species otherwise, and it's no charge

iv. $H_2PO_4^-$ or H_3PO_3 More oxygens (oxyacid)

v. $HTeO_4^-$ or $HSeO_4^-$ Oxyacids in the same column with the same # of oxygens → higher EN is stronger. Se has a ↑ EN.

4. You have a 0.0038 *M* of the strong acid H_3X. You must show work to receive credit.

a. The solution is (*circle one*) ACIDIC BASIC NEUTRAL

b. $[H_3O^+]$ = 0.0038 M (Strong acid completely dissociates)

c. $[OH^-] = 10^{-pOH} = 10^{-11.5798} = 2.632 \times 10^{-12}$ M

d. pH = $-\log[0.0038] = 2.4202$ (4 SD after decimal)

e. pOH = $14 - 2.42021643 = 11.5798$ (4 SD after decimal)

$H_2O_{(l)} + H_3X_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + H_2X^-_{(aq)}$

Multiply by 3

$K = \frac{[H^+][X^-]}{[HX]}$

$K = \frac{[H^+]^3[X^{3-}]}{[H_3X]}$

base

5. What is the pH of a 0.70 *M* solution of trimethyl amine, $(CH_3)_3N$, ($K_b = 6.3 \times 10^{-5}$) at 25°C?

$(CH_3)_3N_{(aq)} + H_2O_{(l)} \rightleftharpoons OH^-_{(aq)} + (CH_3)_3NH^+_{(aq)}$

I	0.70	0	0
C	$-x$	$+x$	$+x$
E	$0.70-x$	$+x$	$+x$

$$K_b = \frac{[OH^-][(CH_3)_3NH^+]}{[(CH_3)_3N]}$$

$$6.3\times10^{-5} = \frac{x^2}{0.70-x} \rightarrow \sqrt{(6.3\times10^{-5})(0.70)} = x$$

$x = 0.006640783 = [OH^-]$

Can we cancel x? $\frac{0.70}{6.3\times10^{-5}}$ = 11111.111... yes, it's greater than 100!

$pOH = -\log[0.006640783]$

$pOH = 2.177780705 \rightarrow PH = 14 - 2.1777 = 11.8222$

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6. What is the pH of a 0.35 *M* solution of sodium nitrite, $NaNO_2$, at 25°C? (For nitrous acid, HNO_2, $K_a = 4.5 \times 10^{-4}$ at 25°C.)

$NaNO_2 \rightarrow Na^+ + NO_2^-$ (Na^+ is neutral ion so it does not go in the EQ)

2 SD after decimal

$NO_2^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HNO_2{}_{(aq)} + OH^-_{(aq)}$

I	0.35	0	0
C	$-x$	$+x$	$+x$
E	$0.35-x$	$+x$	$+x$

$$K_b = \frac{K_w}{K_a}$$

$$K_b = \frac{1.0\times10^{-14}}{4.5\times10^{-4}}$$

$K_b = 2.222\times10^{-11}$

$$K_b = \frac{[OH^-][HNO_2]}{[NO_2^-]}$$

$$2.222\times10^{-11} = \frac{x^2}{0.35-x}$$

$x = \sqrt{(2.222\times10^{-11})(0.35)}$

$x = 0.000002788 = [OH^-]$

Can we cancel x? $\frac{0.35}{2.222\times10^{-11}} = 1.575\times10^{10}$ ✓ yes, it's over 100!

$pOH = -\log[OH^-] = -\log(0.000002788) = 5.554593$

$PH = 14 - 5.554593$

$PH = 8.4454 = 8.4$

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7. What is the pH of a solution that contains 0.325 M NH_3 and 0.400 M NH_4Cl? K_b of NH_3 is 1.8×10^{-5}.

$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+ + OH^-$

	NH_3		NH_4^+	OH^-
I	0.325		0.400	0
C	$-x$		$+x$	$+x$
E	$0.325-x$		$0.400+x$	$+x$

$$K_b = \frac{[OH^-][NH_4^+]}{[NH_3]} = \frac{(0.400+x)(x)}{(0.325-x)} \Rightarrow 1.8\times10^{-5} = \frac{0.400x}{0.325}$$

Can we cancel x?

$\frac{0.325}{K_b = 1.8\times10^{-5}}$, $\frac{0.400}{\text{ka reaction}}$ yes

$x = 0.00001425 = [OH^-]$

$pOH = -\log[OH^-] = 4.834904125$

$pH = 14 - 4.834904 = 9.165095875 = \boxed{9.17}$

8. Given: $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$
The oxygen is collected over water at 23°C. The vapor pressure of water at 23.0°C is 21 mmHg. The molar mass of $KClO_3$ is 112.650 g/mol.
If 1.500 g $KClO_3$ react completely at 755 mmHg, what is the volume of the O_2 alone?

$T = 23°C + 273.15K = 296.15K$

$M_{KClO_3} = 112.650\ g/mol$

$m_{KClO_3} = 1.500g$

~~$P = 755\ mmHg \times \frac{1\ atm}{760\ atm} = 0.993421052\ atm$~~

Moles of O_2

$n_{KClO_3} = \frac{1.500}{112.650} = 0.013315579$

$\frac{0.013315579}{2} \times 3 = 0.019973368$

$V_{O_2} = ?$

P of $O_2 = 755 - 21 = \frac{734\ mmHg}{760} = 0.965789473\ atm$

Find moles

$PV = nRT$

$(0.965789473)(V) = (0.019973368)(0.08205783)(296.15)$

$n = 0.019973368$

$V = 1259.789528L$

$= \boxed{1260L}$