SCH4U TEST – Unit 2: Equilibrium
Pierre Elliott Trudeau High School

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TIME ALLOTED: 75 minutes **DATE:** Oct 28 2014

K/U: 8/12	COM: 8/9	T/I: 10/10	APPL: 8/10

Communication - *Answer the following questions in the spaces provided.* **(9 marks)**

13. Can an Arrhenius base also be considered a Bronsted-Lowry base? Explain. (2 marks)

Yes. Arrhenius bases are considered as Bronsted-Lowry base, but not all Bronsted-Lowry is considered Arrhenius. Arrhenius is more specific, it says bases give off OH^- but NH_3 is also a base. It doesnt fit Arrhenius requirments so another more general way was used to tell the diff between Acids and Bases. Bronsted Lowry's Base is when the base gains an $[H^+]$ ion

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

BL (Arr)

14. Is the strength of an acid determined by its concentration? Explain. (3 marks)

No. The strength of an acid is not determined by its concentration. It is determined by whether they are strong or not. Only less than 1% of the acid dissociates for weak acids like $CH_3COOH_{(aq)}$. But almost all of HCl dissociate making it strong

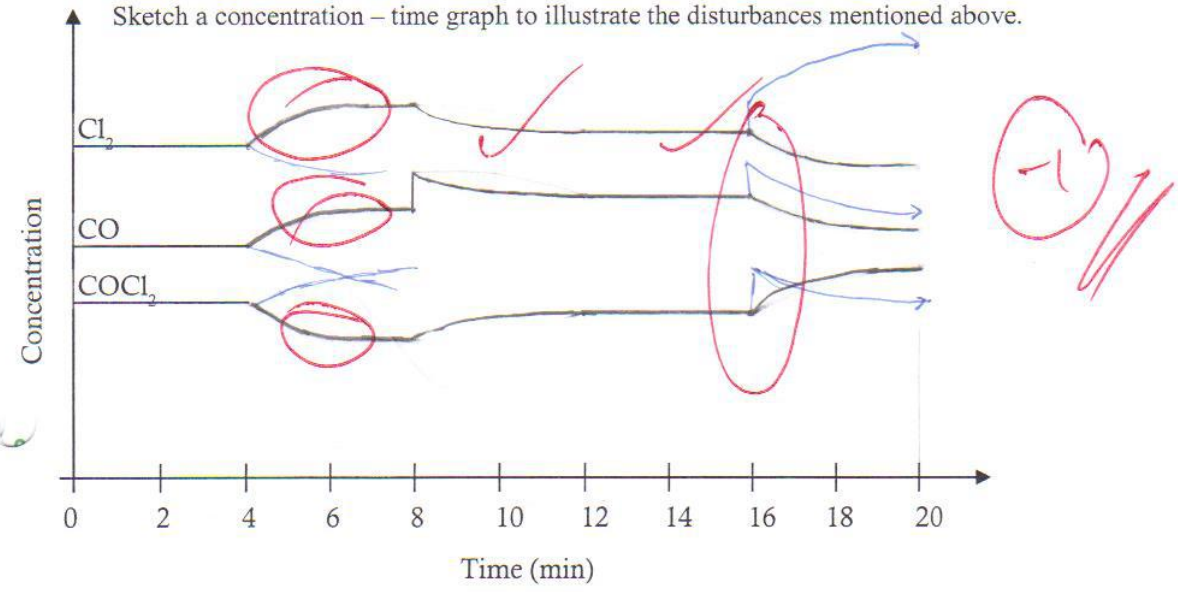
0.0001M $HCl_{(aq)}$	10M $HCl_{(aq)}$	10M $CH_3COOH_{(aq)}$	0.0001M $CH_3COOH_{(aq)}$
-Strong Acid	-Strong Acid	-Weak Acid	-Weak Acid
-Low concentration	-High concentration	-High concentration	-Low concentration

15. $108\ kJ + COCl_{2\,(g)} \rightleftharpoons Cl_{2\,(g)} + CO_{(g)}$ (4 marks)

The equilibrium system shown above was subjected to FOUR separate disturbances:

a) The temperature was decreased at the 4 minute mark
b) Some $CO_{(g)}$ was added at the 8 minute mark
c) Some $Ar_{(g)}$ was added at the 12 minute mark
d) The volume of the system was decreased at the 16 minute mark

Sketch a concentration – time graph to illustrate the disturbances mentioned above.



-1

Thinking / Inquiry - *Answer the following questions in the spaces provided.* **(10 marks)**

16. Consider the following reaction:

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \quad (K_b \text{ ammonia} = 1.8 \times 10^{-5})$$

At equilibrium, the concentrations of $NH_{3(aq)}$, $NH_4^+{}_{(aq)}$, and $OH^-{}_{(aq)}$ are 1.00 M, 0.00100 M, and 0.0180 M respectively. To 500.0 mL of this equilibrium mixture, 0.0500 mol of OH^- ions are added.

Calculate the new equilibrium concentrations for $NH_4^+{}_{(aq)}$ and $OH^-{}_{(aq)}$ (5 marks)

	$NH_{3(aq)}$	+ $H_2O_{(l)}$ ⇌	$NH_{4(aq)}$	+ $OH^-_{(aq)}$
E_1	1 M		0.001 M	0.018 M
	0.5 mol		0.0005 mol	0.009 mol
C				+ 0.05 mol
I_2	0.5 mol		0.0005 mol	0.059 mol
C_2	+x		-x	-x
E_2	0.5 + x (1M + x)		0.0005 - x (0.001 M - x)	0.059 - x (0.118 M - x)

$V = 0.5\ L$

$K_b = \frac{[NH_4][OH^-]}{NH_3}$

$1.8 \times 10^{-5} = \frac{(0.001 - x)(0.118 - x)}{1 + x}$

$1.8 \times 10^{-5} + 1.8 \times 10^{-5}x = 1.18 \times 10^{-4} - 0.001x - 0.118x + x^2$

$= x^2 - 0.119018x + 0.0001$

Quad Formula

0.11811... rejected. can't subtract larger number

8.462576 × 10⁻⁴

$[NH_4] = 1.537 \times 10^{-4}\ M$

$[OH^-] = 0.117\ M$

Therefore, new $[NH_4] = 1.5\ldots \times 10^{-4}\ M$ and $[OH^-] = 0.117\ M$

17. A 1.00L solution of 0.100M acetic acid is prepared and 5.00g of sodium acetate is added to the acid. Determine the pH of the solution. (K_a acetic acid = 1.8×10^{-5}) units (5 marks)

$CH_3COOH_{(aq)}$ $NaCH_3COO_{(aq)}$

$NaCH_3COO_{(aq)}$

82 g/mol

$CH_3COOH_{(aq)} + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$ $NaCH_3COO + H_2O \rightarrow NaOH + CH_3COOH$

	$CH_3COOH_{(aq)}$	H_3O^+	CH_3COO^-
I	0.1 mol/L	∅	0.06097 mol/L
C	-x	+x	+x
E	0.1 - x	x	0.06097 + x

$\frac{5g}{82\ g/mol} = 0.06097\ mol/L$

$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$

$1.8 \times 10^{-5} = \frac{(x)(0.06097 + x)}{(0.1 - x)}$

$1.8 \times 10^{-6} - 1.8 \times 10^{-5}x = x^2 + 0.06097x$

$\emptyset = x^2 + 0.060988x - 1.8 \times 10^{-6}$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$x = 2.9499 \times 10^{-5}$ $x = -0.06101$ rejected

$pH = -\log [H_3O^+]$

$= -\log [2.9499 \times 10^{-5}]$

$= 4.53$

∴ the pH of this solution is 4.53

Application - *Answer the following questions in the spaces provided.* **(10 marks)**

titrated

18. 25.0 mL of 0.150M HCN is titrated with 0.100M NaOH. Calculate the pH of the solution at the equivalence point. (K_a HCN = 4.9 x 10^{-10}) (5 marks)

$HCN_{(aq)} + NaOH_{(aq)} \rightarrow HOH_{(l)} + NaCN_{(aq)}$

Volume Total = 0.0625 L

V	0.025 L	0.0375 L
c	0.15 mol/L	0.1 mol/L
n	0.00375 mol	0.00375 mol

0.00375 mol

$NaCN_{(aq)}^{B} + HOH_{(l)}^{A} \rightleftharpoons NaOH_{(aq)}^{CB} + HCN^{CA}$

I	0.00375 mol	Ø	Ø
C	-x	+x	+x
E	0.00375 - x	x	x

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

$= \frac{1 \times 10^{-14}}{4.9 \times 10^{-10}}$

$= 2.0408 \times 10^{-5}$

$K_b = \frac{[NaOH][HCN]}{NaCN}$

$2.0408 \times 10^{-5} = \frac{x^2}{0.06 - x}$

$2.0408 \times 10^{-5} = \frac{x^2}{0.06}$ (assumption) RULE

$x = 1.10656 \times 10^{-3}$ mol/L

$\frac{0.00375 \text{ mol}}{0.0625 \text{ L}} = 0.06$ mol/L

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

$= -\log [1.10656 \times 10^{-3} \text{ mol/L}]$

$= 2.956...$

$pH = 14 - pOH$

$= 14 - 2.956...$

$= 11.044...$

$\doteq 11.0$

∴ the pH of the solution is about 11.0 (3 sig Digits)

19. 20.00 mL of 1.100 X 10^{-4} mol/L $Pb(NO_3)_2$ is mixed with 80.00 mL of 4.450 X 10^{-2} mol/L CaI_2. Determine, using calculations, if a precipitate will form. (K_{sp} PbI_2 at 25°C = 8.5 X 10^{-9}). (5 marks)

$Pb(NO_3)_{2\,(aq)} + CaI_{2\,(aq)} \rightleftharpoons Ca(NO_3)_{2\,(aq)} + PbI_{2\,(s)}$

new volume = 0.1 L

$Q_{sp} = \frac{\text{Products}}{\text{reactants}}$

V	0.02 L	0.08 L
c	1.1×10^{-4}	4.45×10^{-2} mol/L
n	0.0000022	0.00356

0.0000022

0.000022 M 0.0356 M 0.000022 0.000022 M

1:2? $Q_{sp} = \frac{0.000022}{0.000022(0.0356)}$ ^2?

$= 28.089$

∴ $Q_{sp} > K_{sp}$

$Pb + I_2 = PbI_2$

0.000022 0.00356 0.000022

-2

Not Gas

$Pb + 2I$

∴ yes a precipitate will form

Knowledge/Understanding – *Multiple Choice. Choose the most appropriate answer and transfer your selection onto the Scantron provided.* **(12 marks)**

1. For the equilibrium that exists in an aqueous solution of nitrous acid (HNO_2), the equilibrium constant expression is:

a) $K = \frac{[H^+][NO_2^-]}{[HNO_2]}$ b) $K = \frac{[H^+][N][O]^2}{[HNO_2]}$ c) $K = [H^+][NO_2^-]$ d) $K = \frac{[H^+]^2[NO_2^-]}{[HNO_2]}$

2. Which of the following is a conjugate acid/base pair?

a) HCl/OCl^- b) H_2SO_4/SO_4^{2-} c) NH_4^+/NH_3 d) H_3O^+/OH^-

3. Which of the following equilibrium expressions can be simplified by assuming a negligible value for one or more instances of '*x*'?

a) $K_{eq} = \frac{(3.5-x)(x)}{1.5x^2}$ $K_{eq} = 1.4$ b) $K_{eq} = (0.001 + x)(2x)$ $K_{eq} = 0.002$

c) $K_{eq} = \frac{(3x)(2x)}{(2-2x)}$ $K_{eq} = 0.001$ d) $K_{eq} = (3x)(2x)$ $K_{eq} = 0.002$

4. If you know K_b for ammonia, NH_3, you can calculate the equilibrium constant, K_a, for the following reaction:

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

a) $K_a = K_w K_b$ b) $K_a = K_w/K_b$ c) $K_a = 1/K_b$ d) $K_a = K_b/K_w$

5. Which equilibrium shows an increase in [products] when the volume decreases?

I. $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)}$ *II.* $Cl_{2(g)} + PCl_{3(g)} \rightleftharpoons PCl_{5(g)}$

III. $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ *IV.* $2NH_{3(g)} \rightleftharpoons N_2 + 3H_{2(g)}$

a) I b) I and II c) IV d) III and IV e) II

6. Consider the following system at equilibrium: $C_2H_{2(g)} + Br_{2(g)} + 44\ kJ \rightleftharpoons C_2HBr_{2(g)}$

Which of the following actions would cause the value of K_{eq} to increase?

I. *increasing the volume at constant pressure and temperature*
II. *decreasing the volume at constant pressure and temperature*
III. *increasing the temperature*
IV. *adding bromine gas at constant temperature and pressure*
V. *removing ethyne gas at constant temperature and pressure*
VI. *decreasing the temperature*

a) I and II b) III and VI c) IV and V d) III e) VI

7. If the K_{sp} of zinc hydroxide is 3.0×10^{-16} the [Zn] in this solution in mol/L is which of the following?

a) 8.4×10^{-6} b) 4.2×10^{-6} c) 1.2×10^{-8} d) 2.4×10^{-8}

8. What do Bronsted-Lowry acids do?

a) They accept electrons.
b) They donate electrons.
c) They accept protons.
d) They donate protons.

9. Which of the following salts could be combined with CH_3COOH to form a buffer?

a) Potassium oxalate
b) Iron (iii) carbonate
c) Sodium acetate
d) Magnesium sulphate

10. What is true about the association between the strength of an acid and the strength of its conjugate base?
    a) the strength of the acid does not matter
    b) the weaker the acid, the weaker the conjugate base
    c) the stronger the acid, the stronger the conjugate base
    d) the stronger the acid, the weaker the conjugate base

11. Methanol is a useful substrate for the production of esters, aldehydes, and other industrial chemicals. Carbon dioxide is reacted with hydrogen to produce methanol.
    $\Delta H = -238.7$ kJ/mol. Raising the temperature will
    a) have no effect on the equilibrium
    b) favour the production of carbon dioxide and hydrogen
    c) prevent the reaction from occurring
    d) favour the production of methanol

12. Which of these is **not** an example of heterogeneous equilibrium?
    a. $H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$
    b. $C_{(s)} + CO_{2(g)} \rightleftharpoons O_{2(g)}$
    c. $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$
    d. $C_2H_5OH_{(l)} \rightleftharpoons C_2H_5OH_{(g)}$
    e. $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

PART 1

SUBJECTIVE SCORE INSTRUCTOR USE ONLY

100	90	80	70	60
50	40	30	20	10
9	8	7	6	5
4	3	2	1	0

	(T) %	(F) 2	3		KEY 5
1	●	B	C	D	E
2	A	B	●	D	E
3	A	B	●	D	E
4	A	●	C	D	E
5	A	●	C	D	E
6	A	B	C	●	E
7	A	B	●	D	E
8	A	B	●	D	E
9	A	B	●	D	E
10	A	B	C	●	E
11	A	B	●	D	E
12	A	●	C	D	E
13	A	B	C	D	E
14	A	B	C	D	E
15	A	B	C	D	E
16	A	B	C	D	E
17	A	B	C	D	E
18	A	B	C	D	E
19	A	B	C	D	E
20	A	B	C	D	E
21	A	B	C	D	E
22	A	B	C	D	E
23	A	B	C	D	E
24	A	B	C	D	E
25	A	B	C	D	E

B
D
B
C
08

IMPORTANT

- USE NO. 2 PENCIL ONLY
- MAKE DARK MARKS
- ERASE COMPLETELY TO CHANGE
- EXAMPLE: A B ● D E

TO USE SUBJECTIVE SCORE FEATURE:
- Mark total possible subjective points
- Only one mark per line on key
- 163 points maximum

EXAMPLE OF STUDENT SCORE:

SCANTRON

NAME	Uni Lee
SUBJECT	Chemistry
DATE	Oct 28 2014
TEST NO.	2
PERIOD	2

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PART 1	
PART 2	
TOTAL	

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