CHEM 1032
PRACTICE
UNIT ASSESSMENT 3

SECTION: _____

NAME: Key

TUID: | | | | | | | | | |

Before the Unit Assessment begins, read the rest of this page, and follow the instructions.

!!! Do not turn this page until given the signal to begin !!!

Put away everything besides pencil(s) and a scientific calculator.

- Non-programmable (scientific) calculators are permitted. Graphing calculators **are not permitted** (such as these models: TI-83, TI-84, TI-89, Casio FX-9750).
- Any other electronic devices - including cell phones, smart phones, and smart watches - **are not permitted**. If you are not sure what is permitted, ask *before* the exam begins.

When you are told to begin work, open the booklet and read the directions.

A periodic table and other useful information can be found on the next page.

Grading. Each question is graded by your instructor using the scale below.

1 - Excellent
- The student demonstrates a deep understanding of concepts and problem-solving techniques.
- Calculations are clear and legibly written.
- Any mistakes are minor or careless errors that do not indicate a major conceptual misunderstanding.

0.5 - Fair
- The student demonstrates a partial understanding of concepts and techniques.
- Calculations are clear and legibly written but contain errors.
  - The student may have started out correctly but gone on a tangent or not finished the problem.
  - The student may have used pattern matching to answer a different, more familiar question instead.

0 - Unsatisfactory/Incomplete
- The student did not demonstrate an understanding of the problem or has minimal understanding.
- Calculations are unclear, missing, or incomplete.
  - The student may have written some appropriate formulas or diagrams, but nothing further.
  - The student may have done something entirely wrong.
  - The student may have written almost nothing or nothing at all.

Unit Assessment Time: 50 minutes.
It is to your advantage to answer every question.

!!! Do not turn this page until given the signal to begin !!!

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																		2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122												5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305												13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078(4)		21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845(2)	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546(3)	30 **Zn** 65.38(2)	31 **Ga** 69.723	32 **Ge** 72.630(8)	33 **As** 74.922	34 **Se** 78.971(8)	35 **Br** 79.904	36 **Kr** 83.798(2)
37 **Rb** 85.468	38 **Sr** 87.62		39 **Y** 88.906	40 **Zr** 91.224(2)	41 **Nb** 92.906(2)	42 **Mo** 95.95	43 **Tc**	44 **Ru** 101.07(2)	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60(3)	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-70 *	71 **Lu** 174.97	72 **Hf** 178.49(2)	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23(2)	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	89-102 **	103 **Lr**	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Ds**	111 **Rg**	112 **Cn**	113 **Nh**	114 **Fl**	115 **Mc**	116 **Lv**	117 **Ts**	118 **Og**

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [144.91]	62 **Sm** 150.36(2)	63 **Eu** 151.96	64 **Gd** 157.25(3)	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05
89 **Ac** [227.03]	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**

Units:

amu	*atomic mass unit*
atm	*atmosphere*
g	*gram*
h	*hour*
J	*joule*
K	*kelvin*
mmHg	*unit of pressure*
M	*molarity*
K	*kelvin*
L	*liter*
mol	*mole*
s	*second*

Symbols:

H	*enthalpy*
ν	*frequency*
M	*molar mass*
mol	*mole*
P	*pressure*
t	*time*
T	*temperature*
V	*volume*

Constants:

N_A	*Avogadro's number*
R	*ideal gas constant*

SI (Metric) Prefixes:

c	*centi-*
d	*deci-*
k	*kilo-*
m	*milli-*

!!!! FOR CREDIT, BE CLEAR AND WRITE LEGIBLY !!!!

Solid ammonium hydrogen sulfide (NH_4SH) is hypothesized to be the solid ice component of clouds on Jupiter and Saturn. However, on Earth the compound readily decomposes according to the reaction below which has a K_c of 1.8×10^{-4} . The two products of the decomposition have acid base properties if dissolved in water.

$$NH_4SH_{(s)} \rightleftharpoons NH_{3\,(g)} + H_2S_{(g)}$$

Part I – Multiple Choice Questions (1 pt each)

Excellent Answer = 1 pt *Fair Answer = 0.5 pts* *Unsatisfactory Answer = 0 pts*

D B 1. NH_3 is dissolved in water. The K_b expression is:

$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_{4\,(aq)}^+ + OH^-_{(aq)}$

$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$ prod / react

A. NH_3 is a Strong Acid

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

C. $K_b = \frac{[NH_3]}{[H_3O^+][NH_4^+]}$

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

D 2. NH_3 has a $pK_b = 4.74$. A researcher isolates NH_3 from the reaction and dissolves it in 500 mL of water. What is the pH of the solution when it is half neutralized with HCl?

Half neutralized means $\frac{1}{2}$ $NH_3 \rightarrow NH_4^+$

$[NH_3] = [NH_4^+]$

$pH = pK_a + \log\left(\frac{NH_3}{NH_4^+}\right)$

$pH = pK_a =$

$14 = 4.74 + pK_a = 9.26$

A. 4.74
B. 5.04
C. 8.96
D. 9.26

A 3. H_2S can be converted to H_2SO_4 by oxidizing bacteria. In equal volume solutions of 0.500 M H_2S and 0.500 M H_2SO_4, which of the following is true?

strong weak

A. H_2S solution will have a higher pH because it has an equilibrium while H_2SO_4 does not. True
B. H_2S solution will have a lower pH because HSO_4^- is a stronger base than HS^-.
C. H_2S solution will have a higher pOH because the HS^- concentration is higher than $H_2SO_4^-$.
D. The solutions will have the same pH since both are diprotic acids.

B 4. Another way to generate NH_3 in solution is by adding $NH_4Cl_{(s)}$ to water. What phrase would complete the sentence correctly: The pH of an NH_4Cl solution would be _____ the pH of an NH_3 solution.

$NH_4^+ \rightarrow H_3O^+$ lower pH

$NH_3 \rightarrow OH^-$

A. greater than
B. less than
C. equal to
D. More information is needed.

A 5. A 10.0 g sample NH_4SH of is placed in a closed vessel. What is the concentration of NH_3?

$NH_4SH_{(s)} \rightleftharpoons NH_{3\,(g)} + H_2S_{(g)}$

$K_c = 1.8 \times 10^{-4} = x^2$

$0.013\ M = x$

A. 0.013 M
B. 1.8×10^{-4} M
C. 9.0×10^{-5} M
D. 3.0×10^{-8} M

Part II – Open Answer Questions – *See Page 1 for full grading details*

Excellent Answer = 1 pt *Fair Answer = 0.5 pts* *Unsatisfactory Answer = 0 pts*

6. After the decomposition, the products are separated and dissolved in water. In one container, H_2S dissolves. Write the equilibrium reactions for H_2S with water. Assign the two K values, 1.1×10^{-19} and 9.3×10^{-8}.

Show your work in this box.

K

(1) $H_2S_{(aq)} + H_2O_{(l)} \rightleftharpoons HS^-_{(aq)} + H_3O^+_{(aq)}$ 9.3×10^{-8}

(2) $HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons S^{2-}_{(aq)} + H_3O^+_{(aq)}$ 1.1×10^{-19}

Each subsequent deprotonation is less favorable, so fewer products will form. The smaller a K value is the more reactants are favored. Putting these two ideas together, the 1st proton loss will occur more so its K is larger than 2nd proton loss.

7. In the other container, 0.250 M NH_3 is present in 250.0 mL of water. What is the pH of the solution? K_b of NH_3 is 1.8×10^{-5}.

Show your work in this box.

$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$

	NH_3		NH_4^+	OH^-
I	0.250		0	0
C	$-x$		$+x$	$+x$
E	$0.250-x$		x	x

$1.8\times10^{-5} = \frac{x^2}{0.250-x}$ ← ignore

$x = 0.00212\ M = [OH^-]$

$pOH = -\log(0.00212\ M) = 2.67$

$14 = pH + 2.67$ $pH = 11.33$

ANSWER IN THIS BOX → *Write the pH here.* 11.33

8. You want to make a buffer of the **highest** buffering capacity by adding 250 mL of one of the solutions below to 250 mL of 0.250 M NH_3. Clearly **circle** one solution and calculate the pH of the buffer.

Circle ONE.				
	SA	~~SA~~ different compound	SA	~~SB~~
	0.500 M HBr	~~0.500 M CH_3NH_4Br~~	0.125 M HCl	~~0.125 M NaOH~~

Justify your choice here…

0.250 M NH_3

→ need either equal NH_4^+
→ or ½ conc SA
↳ 0.125 M HCl

0.250 M NH_3 = $\frac{x}{0.250\,L}$

x = 0.0625 moles NH_3

0.125 M HCl = $\frac{x}{0.250\,L}$

x = 0.0312 moles H_3O^+ (from HCl)

0.0625 moles NH_3
− 0.0312 moles H_3O^+
0.0313 moles NH_3

0.0 moles NH_4^+
+ 0.0312 moles H_3O^+
0.0312 moles NH_4^+

K_b NH_3 1.8×10^{-5}

$-\log(1.8\times10^{-5}) = 4.74 = pK_b$

$14 = pK_a + 4.74$

$pK_a = 9.26$

$pH = 9.26 + \log\left(\frac{0.313}{0.312}\right)$

$pH = 9.26$

9. Which is the stronger acid, H_2S or H_2O? Justify your answer qualitatively.

Justify your choice here…

H_2S and H_2O are binary acids.
↳ only made of H and one other element.

Thus the strength of the acid is based on bond strength. Since O & S are in the same group we can infer bond strength from atom size, the smaller an atom the closer it can get to another, so bond strength increases. O is smaller than S, thus H-O bond stronger than H-S bond. If H-S bond weaker, it's easier to lose H, so it is a stronger acid.

CIRCLE THE STRONGER ACID

(H_2S) or H_2O

10. Consider instead of separating the gases, that they were allowed to dissolve in the same container of water, resulting in a mixture of 0.250 M H_2S and 0.250 M NH_3. Hypothesize and justify whether the solution would be acidic, basic, or neutral.

Show your work in this box.

K_{a_1} of H_2S 9.3×10^{-8}

K_b of NH_3 1.8×10^{-5}

$K_b > K_a$ so the solution would be expected to be basic.

CIRCLE pH CHARACTER→ *ACIDIC* or *NEUTRAL* or *BASIC*

END OF EXAM
!!! DON'T FORGET TO CHECK YOUR WORK !!!!

Useful information:

1 atm = 760 mmHg 1 mmHg = 1 torr 0 °C = 273 K

R = 8.314 J/(mol K) = 0.08206 (L atm)/(mol K)

$K_P = K_C(RT)^{\Delta n}$

$K_aK_b = K_w$ $pH = -\log[H_3O^+]$ $pOH = -\log[OH^-]$

At 25 °C: $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$ $pH + pOH = 14.00$ $pK_a + pK_b = 14.00$

$$pH = pK_a + \log\left(\frac{[base]}{[acid]}\right)$$

USE THIS PAGE FOR SCRAP. IT WILL NOT BE GRADED.

USE THIS PAGE FOR SCRAP. IT WILL NOT BE GRADED.