EXAM INSTRUCTIONS/SUGGESTIONS.
READ THIS CAREFULLY!

YOU MAY OMIT TWO (2) OF THE 16 QUESTIONS ON THIS EXAM. EACH QUESTION IS WORTH 1O POINTS. IF YOU ANSWER MORE THAN 14 QUESTIONS, ONLY THE FIRST 14 ANSWERED WILL BE COUNTED.

INDICATE ON THE NEXT PAGE WHICH QUESTIONS ARE NOT TO BE GRADED BY WRITING DNG (DO NOT GRADE) NEXT TO PROBLEM NUMBER.

YOU CAN MAKE ALL REASONABLE APPROXIMATIONS IN DOING THE pH AND SOLUBILITY PROBLEMS UNLESS AN APPROXIMATION IS NOT NECESSARY.

NO PARTIAL CREDIT on any question except where indicated by the statement SHOW WORK. When work is requested, set up equations (with numbers substituted in appropriate units) in space provided, but do the calculations on scrap sheet.

IF QUESTION STATES "SHOW WORK" AND YOU GUESS CORRECTLY WITHOUT SHOWING WORK - YOU GET 1/2 CREDIT.

CHECK FRONT BLACKBOARD FOR CORRECTIONS/CHANGES.

DO THE SIMPLER QUESTIONS FIRST.

IF ANY QUESTION IS NOT CLEAR - ASK TANUJA OR ME ABOUT IT!

CONSTANTS AND CONVERSION FACTORS ARE ON THE PAGE
AT THE END OF THE EXAM. PLEASE LOOK THERE!
LAST THREE PAGES ARE FOR SCRAP WORK.
FEEL FREE TO TEAR THESE PAGES OFF.

PLEASE REMOVE THIS SHEET PRIOR TO STARTING EXAM.

CHEMISTRY S14O4 FIRST EXAM 7/15/99
PROFESSOR J. MORROW

PRINT NAME, LAST: _____

FIRST: _____

I.D.# : _____

EACH QUESTION IS WORTH 1O POINTS

1. _____	7. _____	12. _____
2. _____	8. _____	13. _____
3. _____	9. _____	14. _____
4. _____	10. _____	15. _____
5. _____	11. _____	16. _____
6. _____		

COLUMN TOTALS: (MAXIMUM)

_____(60) _____(50) _____(50)

EXAM TOTAL (14O pts) _____ _____
OUT OF 1OO

THIS INFORMATION IS FOR PROBLEMS 1 AND 2.

You are given a triprotic acid, H_3X, with $K_{a1} = 1.OOx1O^{-7}$, $K_{a2} = 1.OOx1O^{-12}$ and $K_{a3} = 1.OOx1O^{-16}$. $K_{a1} = \frac{[H^+][H_2X^-]}{[H_3X]}$, $K_{a2} = \frac{[H^+][HX^{2-}]}{[H_2X^-]}$, $K_{a3} = \frac{[H^+][X^{3-}]}{[HX^{2-}]}$

1) Calculate the ratio $\frac{[HX^{2-}]}{[H_2X^-]}$ present in a solution whose pH = 4.OO if H_3X is the only solute.

i) $1.Ox1O^{-3}$ ii) $1.Ox1O^{-12}$ iii) $1.Ox1O^{-8}$ iv) $1.Ox1O^{-1O}$

ANSWER IS: _____

2) Calculate the $[H_3X]$ in the above solution from problem 1.

i) 0.30 ii) 0.25 iii) 0.15 iv) 0.10 v) 0.050

ANSWER IS: _____

THE FOLLOWING INFORMATION IS FOR PROBLEMS 3 AND 4.

Given a sparingly soluble salt, M_3X_2 , where X is the anion from the weak triprotic acid given in problem 1. ($K_{a1} = 1.OOx1O^{-7}$, $K_{a2} = 1.OOx1O^{-12}$, and and $K_{a3} = 1.OOx1O^{-16}$) .

For this sparingly soluble salt, M_3X_2 , $K_{sp} = 1.OOx1O^{-44}$.

EACH QUESTION IS INDEPENDENT OF THE OTHER. SHOW WORK

3) What is the solubility of M_3X_2 in pure water. Neglect the hydrolysis of X^{3-} .

i) $1.58x1O^{-10}$ ii) $6.21x1O^{-10}$ iii) $18.6x1O^{-1O}$ iv) $12.4x1O^{-10}$

ANSWER IS: _____

4) What is the solubility of M_3X_2 in a solution containing O.O1O M Na_3X ? Neglect the hydrolysis of X^{3-} .

i) $1.55x10^{-14}$ ii) $4.64x10^{-14}$ iii) $2.31x10^{-14}$ iv) $0.77x10^{-14}$

ANSWER IS: _____

5) Consider the weak acids, A, B, C, and D;

ACID	A	B	C	D
pK_a	8.3	2.7	12.9	5.6

OK

List these bases in order of increasing acidity (decreasing basicity);

LEAST ACIDIC _____ < _____ < _____ < _____ MOST ACIDIC

6) A O.1OO M solution of a salt, KX (which hydrolyzes), has a pH = 9.OO . Calculate the value of K_a for the weak acid, HX. The hydrolysis reaction is, $X^- + H_2O \rightleftharpoons HX + OH^-$

i) $1O^{-4}$ ii) $1O^{-5}$ iii) $1O^{-6}$ iv) $1O^{-7}$ v) $1O^{-8}$

ANSWER IS: _____

THE FOLLOWING INFORMATION IS FOR PROBLEMS 7, 8, AND 9.

25.OO mL of O.1OO M methylamine, CH_3NH_2 , is titrated with O.1OO M HCl.
Calculate the pH; (K_b = 4.4 x1O^{-5})

7) before any HCl is added. ($CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$)
(SHOW WORK)

pH = _____

8) halfway to the equivalence point.

pH = _____

9) at the equivalence point. (HINT: First solve for K_h) SHOW WORK

i) 2.68 ii) 6.36 iii) 5.47 iv) 10.95 v) 8.24

pH = _____

1O) How many milliliters of a O.1OO M HX (a weak acid) solution should be added to 500 mL of O.1OO M NaX solution, to produce a buffer of pH = 5.OO ? For HX , K_a = 4.OOx1O^{-5} (SHOW WORK)

i) 125 ii) 250 iii) 500 iv) 750 v) 1000

ANSWER IS: _____

11) Complete the following table. (for $M(OH)_3$, K_{sp} = 6.Ox1O^{-2O})

$[M^{3+}]$ $[OH^-]$

_____ $1.Ox1O^{-4}$ M

$6.Ox1O^{-3}$ M _____

12) Given the following K_{sp} values: for $M(OH)_3$, $K_{sp(M)} = 4.OO \times 1O^{-14}$; for $N(OH)_3$, $K_{sp(N)} = 1.OO \times 1O^{-13}$.
One mole of each of the above solids is placed in a beaker containing 1 (one) liter of pure water. These solids go into equilibrium with their ions. Calculate the pH of this solution. Do this calculation as accurately as possible. Use of the approximate method is worth 7 points. (SHOW WORK)

i) 1O.91 ii) 1O.87 iii) 1O.29 iv) 1O.8O

ANSWER IS: _____

13) Given the following reactions and their equilibrium constants:

1. $HS^- \rightleftharpoons H^+ + S^{2-}$ K_1
2. $HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$ K_2
3. $PbS \rightleftharpoons Pb^{2+} + S^{2-}$ K_{sp3}
4. $PbCO_3 \rightleftharpoons Pb^{2+} + CO_3^{2-}$ K_{sp4}
5. $H_2O \rightleftharpoons H^+ + OH^-$ K_w

Calculate the value of K (in terms of any or all of the above K values) for the following reaction;

$$PbCO_3 + HS^- \rightleftharpoons PbS + HCO_3^- \qquad K = ?$$

i) $\frac{K_{sp4}K_2}{K_{sp3}K_1}$ ii) $\frac{K_{sp3}K_2}{K_{sp4}K_1}$ iii) $\frac{K_{sp3}K_1}{K_{sp4}K_2}$ iv) $\frac{K_{sp4}K_1}{K_{sp3}K_2}$ v) $\frac{K_{sp4}K_2K_w}{K_{sp3}K_1}$

ANSWER IS: _____

14) A certain metal has a work function, Φ , of 1.5O eV (= $2.4O3_{x}1O^{-19}$ J). When monochromatic light of wavelength, λ , falls on this metal, photoelectrons are expelled. The kinetic energy of these photoelectrons is 2.64 eV ? What is the wavelength, λ (in nm), of this light ? SHOW WORK

i) 255 ii) 3OO iii) 334 iv) 319

ANSWER IS: _____

15) An atom has a velocity of 5O.O $\frac{m}{sec}$ and a deBroglie wavelength of 1.991 Å. Which of the following is the element? (Hint:The atomic weights in the Periodic Table are averages over the weights of isotopes. To answer this question, just round off the numbers in the Periodic Table to the nearest integer.) BE CAREFUL WITH UNITS! (SHOW WORK)

i) H ii) C iii) Mg iv) Ti v) Ca

ANSWER IS: _____

16) The linear velocity, v, of an electron in the hydrogen atom (according to the Bohr Theory) is,

$$v = \frac{2\pi e^2}{nh}$$

where: n = principle quantum number, h = Plancks constant

m_e = electron mass, e = q = electron charge, $\pi = 3.14$

What is the de Broglie wavelength, λ (in Å), of an electron in the first shell of the H atom? (HINT: Use the cgs system) SHOW WORK

i) O.O332 ii) 384 iii) 3.32 iv) 6.64 v) 332

ANSWER IS: _____

CONVERSION FACTORS and POTENTIALLY (BUT NOT NECESSARILY) USEFUL EQUATIONS

$C = 3.00 \times 10^{8}$ m/sec $= 3.00 \times 10^{10}$ cm/sec

$h = 6.626 \times 10^{-34}$ J·sec $= 6.626 \times 10^{-27}$ erg·sec

$m_e = 9.108 \times 10^{-28}$ g $= 9.108 \times 10^{-31}$ kg

$\varepsilon = h\nu$

$N_A = 6.022 \times 10^{23}$

$R = 0.0821 \ \frac{L \cdot atm}{mol \cdot degK} = 82.1 \ \frac{cm^3 \cdot atm}{mol \cdot degK}$

$\lambda\nu = c$

1 Å $= 0.1$ nm $= 10^{-8}$ cm $= 10^{-10}$ m

$\lambda = \frac{h}{p}$ (deBroglie equation) where $p = mv$

Heisenberg Uncertainty principle: $P \quad X = \frac{h}{4\delta}$ where $p = mv$

kinetic energy: $\varepsilon = \frac{1}{2} mv^2 = \frac{p^2}{2m}$ where $p = mv$

$q = e = 1.6022 \times 10^{-19}$ coulombs $= 4.806 \times 10^{-10}$ esu

1 eV $= 1.6022 \times 10^{-19}$ J

$\varepsilon_n = - \frac{2.179 \times 10^{-18}}{n^2}$ J

$\varepsilon = qV = h\nu - \Phi$

UNIT RELATIONSHIPS

1 amp $= 1 \ \frac{\text{coulomb}}{\text{sec}}$ 1 volt·coulomb $= 1$ Joule

1 esu$^2 = 1$ erg·cm 1 Watt $= 1 \ \frac{\text{joule}}{\text{sec}}$

1 Joule $= 1 \times 10^{7}$ erg 1 Joule $= 1 \ \frac{kg \cdot m^2}{sec^2}$ 1 erg $= 1 \ \frac{g \cdot cm^2}{sec^2}$

SCRAP WORK SHEET

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