Chemistry 103 Practice final
Ground Rules

In solving word problems, you must show sufficient work that the grader may follow your logic, for example, show chemical formulas and the corresponding molar masses you calculate, etc.. Many questions have multiple parts. **Clearly** indicate your answer to each part**. All questions are equally weighted .**

If you cannot complete a part of a problem due to what you see as missing information, describe what is missing and how the problem could be solved using that information and you may receive partial credit depending upon the validity of your arguments.

Finally, this exam is a reflection of *your* understanding of the material. Cheating is a serious offense that bears many penalties, outlined in the student handbook. If you do succeed in cheating, the greatest penalty will be when you are required to apply the material you were to have learned.

$R = 8.314\ J/mol{\cdot}K$ $R = 0.0821\ L{\cdot}atm/mol{\cdot}K$

$PV = nRT$ $N_o = 6.022 \times 10^{23}$ mole

760 mm Hg = 1 atm $0^\circ C = 273.15\ K$

$h = 6.626 \times 10^{-34}\ J{\cdot}s$ $F = 96{,}500C;\ C = A.s$

$c = 3.00 \times 10^{8}\ m/s$ $m_{electron} = 9.109 \times 10^{-31}\ kg$

$\lambda = \frac{h}{mv}$ $KE = \frac{1}{2}\ mv^2$

$\Delta H = \Delta E + \Delta nRT$ $\Delta S = \frac{q}{T}$

$S = k\ lnW$ $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$1\ J = 1\ kg\text{-}m^2/s^2$

$E = h\nu$ $E = mc^2$ $\Delta G = \Delta G^\circ + RTlnQ$

$E = E^\circ - (RT/nF)lnQ = E^\circ - (0.059/n)logQ$

$\Delta G^\circ = -RTln\ K$

$\Delta E = q + w$ $1\ L{\cdot}atm = 101.27\ J$

$\Delta G = -nFE$

$q = nC_p\Delta T$ $w = -P_{ext}\Delta V$ or $F{\cdot}d$

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = -RTlnK$

$q = C\Delta T$ $\Delta H = q_P$

$\Delta E_{grav} = mg\Delta h$ $(g = 9.8\ m/s^2)$ $2.2\ lb = 1\ kg$

neutron mass = 1.0086649 amu

proton mass = 1.0072765 amu

energy equivalent of 1 amu = 1.492×10^{-10} J

Significant Figures figure Significantly in your answer!

1. $H_2S\,(aq) = H^+(aq) + HS^-(aq)$ $\quad K_{a1} = 1.0 \times 10^{-7}$

$HS^-(aq) = H^+(aq) + S^{2-}(aq)$ $\quad K_{a2} = 1 \times 10^{-19}$

Aqueous solutions saturated with H_2S contain $[H_2S] = 0.1$ **M**.

K_{sp} values: CuS, 6×10^{-37} PbS, 3×10^{-28}

1.1 What is the $[S^{2-}]$ at a pH of 5.5 in a solution saturated with H_2S?

1.2 What is the molar solubility of PbS at a pH of 5.5 in a solution saturated with H_2S?

1.3 Calculate $[HS^-]$ at a pH of 5.5 in a solution saturated with H_2S ?

2. Use the data provided in Question 1.

(a) What is the $[S^{2-}]$ at a pH of 1.0 in a solution saturated with H_2S?

(b) What are the solubilities of PbS and CuS at a pH of 1.0?

(c) Using the above information can you suggest a method to separate copper sulfide from lead sulfide?

3. Lactic acid, $HC_3H_5O_3$, is a weak monoprotic acid with $K_a = 1.4 \times 10^{-4}$. 500.0 mL of solution containing 9.15 g of lactic acid in water is prepared.

(a) Calculate the pH of this solution

(b)A 50.0 mL portion of this solution is titrated with 0.200 M NaOH solution; NaOH is a strong base. Calculate the pH after 25.0 mL of the NaOH solution has been added.

(c) Calculate the pH at the equivalence point in this titration.

4. Nitrogen reacts with oxygen to form nitric oxide, NO. ($N_2 + O_2 \rightarrow NO$; not balanced). This reaction occurs in automobile engines.

4.1 calculate $\Delta G°$ for the reaction of N_2 with O_2 to form NO at 25°C and at 2000°C

4.2 calculate K for the reaction at 25°C and at 2000°C . Comment on the significance of the difference in these values.

Substance	$\Delta H_f°$(kJ)	S° (J/K)	
N_2	0	191.5	
O_2	0	205.0	
NO	33.84	210.6	

5. Carbonic acid, H_2CO_3 is diprotic. $K_{a1} = 4.3 \times 10^{-7}$; $K_{a2} = 5.6 \times 10^{-11}$. A 0.10 M solution of potassium carbonate, K_2CO_3 is prepared.

a. Calculate the pH of this solution.

b. To 500.0 mL of the 0.10 M solution of potassium carbonate, K_2CO_3 0.10 M HCl solution is added until the pH = 7.00. HCl is a strong acid. What volume of HCl is required to do this?

c. Is this solution in part b above a buffer? Explain your answer thoroughly.

6. A standard hydrogen electrode (SHE) and a silver wire are dipped into a saturated aqueous solution of silver carbonate, Ag_2CO_3 at 298K. The measured potential between the silver wire and the SHE is 0.588V with the wire being positive. Calculate K_{sp} for silver carbonate.

$Ag^+(aq) + e^- = Ag(s)$ $E^o = 0.800V$; $2H^+(aq) + 2e^- = H_2(g)$ $E^o =$

7.1 Calculate the binding energy in J/nucleon of Fe-56, of nuclear mass 55.9349 amu.

7.2 The half-life of cobalt-60, an isotope used in nuclear medicine, is 5.3 y. What mass of a 1.000 mg sample of Co-60 remains after 12 y?

7.3 Explain the principles upon which C-14 dating is based. The half life of C-14 is about 5700 y.

8.1 What is the physical basis for proton magnetic resonance spectroscopy and what kinds of information does it provide?

8.2 Explain the differences you would expect in the proton magnetic resonance spectra of the following pairs of isomers; include a sketch of the spectra you predict identifying the different chemical shifts and the spin-spin splitting patterns expected. (I DON'T EXPECT YOU TO KNOW CHEMICAL SHIFT VALUES!)

$CH_3OCH_2CH_3$ and $CH_3CH_2CH_2OH$

$HC(:O)O\ CH_2CH_3$ and $CH_3C(:O)OCH_3$

$CH_3CH_2CH{:}CH_2$ and $CH_3CH{:}CHCH_3$

9. Short answers; circle correct answer(s); no explanation required except in 10.5

9.1 In the following redox reaction which atom(s) undergo reduction?

$K_2Cr_2O_7 + KBr + HCl = CrCl_3 + KBrO_2 + H_2O$

K Cr O Br H Cl

9.2 A reaction mechanism must:

Include an equilibrium step

Predict a rate law that agrees with experiment

Include a reactive intermediate

9.3 In the following exothermic gas phase equilibrium run at a total pressure of 100 atm and 573K the addition of 50 atm of inert argon will have the following effect on the equilibrium partial pressure of SO_3:

$O_2(g) + 2\ SO_2(g) = 2SO_3(g)$

Increase it decrease it leave it unchanged

9.4 The common ion effect:

Is the usual behavior of an ion in aqueous solution

Is the interaction of positive and negative ions to neutralize each other

Is the reduction of the solubility of a salt by the presence of one of its ions in solution