

Time: 2 ½ hours

Chemistry 102
Final Examination

June 22, 1999

Family Name _____ First Name _____

ID Number _____ Prospective Major _____

Section: 1 8 MWF
(Circle one): 2. 11TT, 2F

Score: I / 165
II / 35

Data:

Universal Gas Constant , $R = 0.08205 \text{ L atm mol}^{-1} \cdot \text{K}^{-1}$
 $= 8.314 \text{ J mol}^{-1} \cdot \text{K}^{-1}$

Avogadro's Number = 6.02×10^{23}

K_w at 25°C = 1.00×10^{-14}

K_{sp} (AgBr) = 5.0×10^{-13}

	<u>E°(volts)</u>
$\text{Fe}^{2+} + 2e^- = \text{Fe}(s)$	-0.440
$\text{Ni}^{2+} + 2e^- = \text{Ni}(s)$	-0.250
$\text{Ag}^+ + e^- = \text{Ag}(s)$	+0.799
$2\text{H}^+ + e^- = \text{H}_2(g)$	0.00
$\text{Cu}^{2+} + 2e^- = \text{Cu}(s)$	+0.337
$\text{MnO}_4^- + 8\text{H}^+ + 5e^- = 4\text{H}_2\text{O} + \text{Mn}^{2+}$	+1.51
$\text{Br}_2 + 2e^- = 2\text{Br}^-$	+1.065
$\text{Au}^{3+} + 3e^- = \text{Au}(s)$	+1.50

I. (165 points) The following are thirty three multiple-choice type questions, five points each. CIRCLE the letter preceding the correct (best) answer. USE INK. NO PENALTY for the wrong choice.

Phenoxide ion ($\text{C}_6\text{H}_5\text{O}^-$) is a weak base, with $K_b = 7.7 \times 10^{-5}$. Calculate the pH of a 0.20 M solution of $\text{C}_6\text{H}_5\text{O}^-$.

- a. 11.6
- b. 3.9×10^{-3}
- c. 2.4
- d. 9.2
- e. 8.9

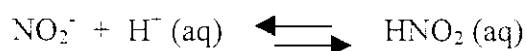
Calculate the concentrations of H^+ ion and unionized HF in a 0.50 M HF solution.

- | | [HF] | $[\text{H}^+]$ |
|----|--------|--------------------------------|
| a. | 0 | $5.0 \times 10^{-1} \text{ M}$ |
| b. | 0.50 M | $7.1 \times 10^{-4} \text{ M}$ |
| c. | 0.48 M | $1.9 \times 10^{-2} \text{ M}$ |
| d. | 0.40 M | $3.6 \times 10^{-4} \text{ M}$ |
| e. | 0.31 M | $1.9 \times 10^{-2} \text{ M}$ |

Which species listed below is present in the greatest concentration in a 0.1 M solution of CH_3COONa ?

- a. CH_3COONa
- b. CH_3COO^-
- c. Na^+
- d. CH_3COOH
- e. OH^-

For nitrous acid, HNO_2 , $K_a = 4.5 \times 10^{-4}$. Which is the equilibrium constant value for the reaction?

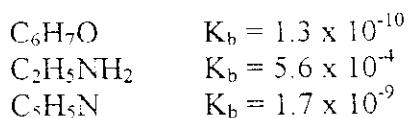


- a. 2.1×10^{-2}
- b. 4.5×10^{-4}
- c. 2.2×10^3
- d. 2.2×10^{-3}
- e. 2.2×10^{-11}

Which is a true statement with regard to a 0.10 M H_2SO_4 solution?

- a. $[\text{HSO}_4^-] > [\text{H}^+]$
- b. $[\text{SO}_4^{2-}] > [\text{H}^+]$
- c. $[\text{H}^+] > [\text{HSO}_4^-]$
- d. $[\text{H}_2\text{SO}_4] > [\text{H}^+]$
- e. $[\text{SO}_4^{2-}] > [\text{HSO}_4^-]$

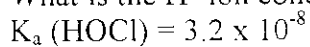
Given the weak bases below and their K_b values,



Arrange the conjugate acids of these weak bases in order of increasing acid strength.

- $C_5H_5NH^+ < C_6H_7OH < C_2H_5NH_3^+$
- $C_6H_7OH^+ < C_5H_5NH^+ < C_2H_5NH_3^+$
- $C_5H_5NH^+ < C_2H_5NH_3^+ < C_6H_7OH^+$
- $C_6H_7OH^+ < C_2H_5NH_3^+ < C_5H_5NH^+$
- $C_2H_5NH_3^+ < C_5H_5NH^+ < C_6H_7OH^+$

What is the H^+ ion concentration in a solution of 0.10 M NaOCl?



- $5.7 \times 10^{-11} \text{ M}$
- $5.7 \times 10^{-5} \text{ M}$
- 0 M
- $1.8 \times 10^{-4} \text{ M}$
- $1.8 \times 10^{-10} \text{ M}$

Consider a buffer solution prepared from HOCl and NaOCl. Which is the net ionic equation for the reaction that occurs when NaOH is added to this buffer?

- $\text{OH}^- + \text{HOCl} \rightarrow \text{H}_2\text{O} + \text{OCl}^-$
- $\text{OH}^- + \text{OCl}^- \rightarrow \text{HOCl} + \text{O}^{2-}$
- $\text{Na}^+ + \text{HOCl} \rightarrow \text{NaCl} + \text{OH}^-$
- $\text{H}^+ + \text{HOCl} \rightarrow \text{H}_2 + \text{OCl}^-$
- $\text{NaOH} + \text{HOCl} \rightarrow \text{H}_2\text{O} + \text{NaCl}$

What is the pH at the equivalence point in the titration of 100 mL of 0.10 M HCN with 0.10 M NaOH?

- 3.0
- 6.0
- 7.0
- 11.0
- 12.0

The solubility product constant for CrF_3 is 6.6×10^{-11} . What is the solubility of CrF_3 in moles per liter of solution?

- a. 2.6×10^{-3} M
- b. 1.2×10^{-3} M
- c. 6.6×10^{-11} M
- d. 2.2×10^{-3} M
- e. 1.6×10^{-6} M

Which of the following would decrease the K_{sp} for PbI_2 ?

- a. Lower the pH of the solution
- b. Add a solution of $\text{Pb}(\text{NO}_3)_2$
- c. Add a solution of KI
- d. none of the above - the K_{sp} of a compound is constant at constant temperature.

Will a precipitate (ppt) form when 300 mL of 5.0×10^{-5} M AgNO_3 are added to 200 mL of 2.5×10^{-7} M NaBr ? Answer yes or no, and identify the precipitate if there is one.

- a. Yes, the ppt is $\text{AgNO}_3(\text{s})$.
- b. Yes, the ppt is $\text{AgBr}(\text{s})$.
- c. Yes, the ppt is $\text{NaBr}(\text{s})$.
- d. Yes, the ppt is $\text{NaNO}_3(\text{s})$.
- e. No.

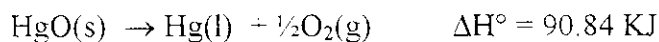
Calculate the pH of a solution that is 0.15 M CH_3COOH and 0.75 M CH_3COONa .

- a. 3.77
- b. 4.73
- c. 5.00
- d. 5.44
- e. 7.00

The entropy change on vaporization (ΔS_{vap}) of a compound or element is

- a. always negative.
- b. always positive
- c. sometimes positive and sometimes negative

The element oxygen was prepared by Joseph Priestley in 1774 by heating mercury(II) oxide.



Use the data given below to estimate the minimum temperature above which this reaction becomes spontaneous under standard state conditions.

$$S^\circ(\text{Hg}) = 76.02 \text{ J/K} \cdot \text{mol}$$

$$S^\circ(\text{O}_2) = 205.0 \text{ J/K} \cdot \text{mol}$$

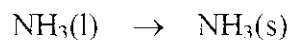
$$S^\circ(\text{HgO}) = 70.29 \text{ J/K} \cdot \text{mol}$$

- a. 298 K
- b. 430 K
- c. 620 K
- d. 775 K
- e. 840 K

A negative sign for ΔG indicates that at constant T and P

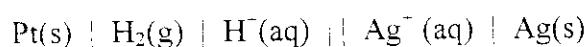
- a. the reaction is exothermic.
- b. the reaction is endothermic.
- c. the reaction is fast.
- d. the reaction is spontaneous.
- e. ΔS must be > 0 .

Given that the normal freezing point of ammonia is -78°C , predict the signs of ΔH , ΔS , and ΔG for ammonia when it freezes at -80°C and 1 atm.



- | | <u>ΔH</u> | <u>ΔS</u> | <u>ΔG</u> |
|----|------------------------------|------------------------------|------------------------------|
| a. | - | - | 0 |
| b. | - | + | - |
| c. | + | - | + |
| d. | + | + | 0 |
| e. | - | - | - |

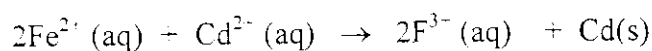
Given the following notation for an electrochemical cell



What is the balanced overall (net) cell reaction?

- $2\text{H}^+(\text{aq}) + 2\text{Ag}(\text{s}) \rightarrow \text{H}_2(\text{g}) + 2\text{Ag}^+(\text{aq})$
- $\text{H}_2(\text{g}) + 2\text{Ag}^+(\text{aq}) \rightarrow 2\text{H}^+(\text{aq}) + 2\text{Ag}(\text{s})$
- $2\text{H}^+(\text{aq}) + 2\text{Ag}(\text{s}) \rightarrow \text{H}_2(\text{g}) + 2\text{Ag}^+(\text{aq})$
- $\text{H}_2(\text{g}) + \text{Ag}^+(\text{aq}) \rightarrow \text{H}^+(\text{aq}) + \text{Ag}(\text{s})$
- $\text{H}_2(\text{g}) + 2\text{Ag}^+(\text{aq}) \rightarrow 2\text{H}^+(\text{aq}) + 2\text{Ag}(\text{s})$

Calculate E°_{cell} for the following reaction:



- 0.37 V
- 0.37 V
- 1.17 V
- 1.17 V
- none of the above.

Using standard electrode potentials, decide which of the following statements is completely correct under standard conditions:

- Cu^{2+} can oxidize H_2 , and Fe can reduce Mn^{2+} .
- Ni^{2+} can oxidize Cu^{2+} , and Fe^{2+} can reduce H^+ .
- Fe^{2+} can oxidize H_2 , and Fe^{2+} can reduce Au^{3+} .
- Br_2 can oxidize Ni, and H_2 can reduce Mn^{2+} .
- H^+ can oxidize Fe, and Ni can reduce Br_2 .

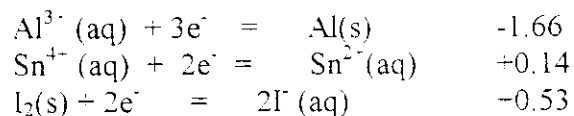
Determine the value of the equilibrium constant for the reaction



- 5.3×10^{-19}
- 18.30
- 1.7×10^{54}
- 1.9×10^{18}
- 5.7×10^{-55}

Given the following standard reduction potentials in acid solution

$E^\circ(\text{V})$



Which is the weakest oxidizing agent in this list?

- $\text{Al}^{3+}(\text{aq})$
- $\text{Al}(\text{s})$
- I^-
- $\text{I}_2(\text{s})$
- $\text{Sn}^{4+}(\text{aq})$

Arrange the following aqueous solutions in order of increasing boiling points:
0.050 m $\text{Mg}(\text{NO}_3)_2$; 0.100 m ethanol; 0.090 m NaCl .

- $\text{Mg}(\text{NO}_3)_2 < \text{NaCl} < \text{ethanol}$
- $\text{Ethanol} < \text{Mg}(\text{NO}_3)_2 < \text{NaCl}$
- $\text{Ethanol} < \text{NaCl} < \text{Mg}(\text{NO}_3)_2$
- $\text{NaCl} < \text{ethanol} < \text{Mg}(\text{NO}_3)_2$
- $\text{Mg}(\text{NO}_3)_2 < \text{ethanol} < \text{NaCl}$

A solution that contains 55.0g of ascorbic acid (Vitamin C) in 250 g of water freezes at -2.34°C . Calculate the molar mass (g/mol) of the solute. $K_f(\text{H}_2\text{O}) = 1.86^\circ\text{C}/\text{m}$

- 1.26
- 10.9
- 43.6
- 175
- 277

According to Raoult's law, which statement is false?

- The vapor pressure of a solvent over a solution decreases as its mole fraction increases.
- The solubility of a gas increases as the temperature decreases.
- The vapor pressure of a solvent over a solution is less than that of pure solvent.
- The greater the pressure of a gas over a solution the greater its solubility.
- Ionic solutes dissociate in solution causing an enhancement of all colligative properties.

The vapor pressure of water at 20°C is 17.5 mmHg. What is the vapor pressure of water over a solution prepared from 2.00×10^2 g of sucrose ($C_{12}H_{22}O_{11}$) and 3.50×10^2 g water?

- a. 0.51 mmHg
- b. 16.0 mmHg
- c. 17.0 mmHg
- d. 18.0 mmHg
- e. 19.4 mmHg

The density of a 20.3 M CH_3OH (methanol) solution is 0.858 g/ml. What is the molality of this solution? H_2O is the solvent.

- a. 17.4 m
- b. 20.8 m
- c. 23.7 m
- d. 70.0 m
- e. 97.5 m

Solid iodine has a vapor pressure of 1.0 mmHg at 39°C. How many moles of iodine will sublime into a 500 ml flask at this temperature? If the volume of the flask is doubled at constant temperature, what will happen to the equilibrium vapor pressure of I_2 ? Assume some solid I_2 is always present in the container.

- a. 2.1×10^{-4} mol; VP increases
- b. 2.0×10^{-2} mol; VP increases
- c. 2.6×10^{-5} mol; no change in VP
- d. 2.1×10^{-4} mol; no change in VP
- e. 2.6×10^{-5} mol; VP decreases

Acetic acid has a heat of fusion of 10.8 kJ/mol and a heat of vaporization of 24.3 kJ/mol. What is the expected value for the heat of sublimation of acetic acid?

- a. 35.1 kJ/mol
- b. -13.5 kJ/mol
- c. +13.5 kJ/mol
- d. -35.1 kJ/mol
- e. cannot tell from the data

Each of the following substances is a gas at 25°C and 1 atmosphere pressure. Which one will liquefy most easily when compressed at a constant temperature?

- a. F₂
- b. H₂
- c. HF
- d. SiH₄
- e. Ar

Which one of the following substances would exhibit hydrogen bonding in the liquid state?

- a. SiH₄
- b. H₂
- c. H₂S
- d. CH₄
- e. CH₃NH₂

Given the following liquids and their boiling points, which has the highest vapor pressure at its normal boiling point?

- a. ethanol bp= 78°C
- b. methanol bp= 65°C
- c. water bp= 100°C
- d. benzene bp= 80°C
- e. All the same

II. (35 points). SHORT ANSWER QUESTIONS: Put your numerical answer in the space provided or give a brief explanation as is appropriate:

At 10°C one volume of water dissolves 3.10 volumes of chlorine gas, Cl_2 at 1 atm pressure. What is Henry's law constant in mol/L • atm?

Answer: _____

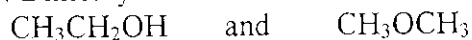
How many liters of ethylene glycol antifreeze ($\text{C}_2\text{H}_6\text{O}_2$) would you add to your car radiator containing 15.0 L of water if you needed to protect your engine to -17.8°C . The density of ethylene glycol is 1.1 g/mL. For water, $K_f = 1.86^\circ\text{C}/\text{m}$.

Answer: _____

Boron nitride, BN_3 , melts at approximately at $3,000^\circ\text{C}$ under high pressure. This material is almost as hard as diamond. What kind of crystal is this?

Answer: _____

Ethanol and dimethyl ether have the molecular formula, $\text{C}_2\text{H}_6\text{O}$. Ethanol boils at 78.4°C . Dimethyl ether boils at -23.7°C . Their structural formulas are



Explain why the boiling point of the ether is so much lower than the boiling point of ethanol.

Answer: _____

Consider an electrochemical cell constructed from the following half cells, linked by a KCL salt bridge.

- a Fe electrode in 1.0 M FeCl₂ solution.
- a Ni electrode in 1.0 M Ni(NO₃)₂ solution.

Give the cell diagram for the galvanic cell with the anode on the left and the cathode on the right:

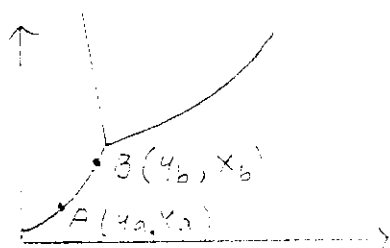
Answer: _____

Given that: $\text{H}_2\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + \frac{1}{2} \text{O}_2(\text{g})$ $\Delta H^\circ_{298} = -106 \text{ kJ}$ $\Delta S^\circ_{298} = +58 \text{ J/k}$

Calculate ΔG° for the reaction above in kJ. Is H₂O₂(g) stable?

Answer: _____

The following is a sketch of the phase diagram of a pure substance Z.



a. Label the axes:

y-axis is _____

x-axis is _____

b. Which of the following inequalities is correct? (Circle one)

(density)_{solid Z} > (density)_{liquid Z}

(density)_{solid Z} < (density)_{liquid Z}

c. Give the clausius-Clapeyron equation that relates points A and B in terms of the coordinates y_b , x_b , y_a , x_a , and constants: