John Abbott College
Department of Chemistry

Chemistry 202-NYB-05 – Sample Final Exam

Please Note:
1. Available space for answers has been removed from some questions to conserve space.
2. The questions begin at number 16 because there was a set of 15 multiple choice questions that were present on this exam that have not been reproduced for this practice version. It would have taken approximately 10-30 minutes to answer the multiple choice questions.
3. There is an answer key at the end of this document.

16. (10 marks) Write the balanced molecular (formula) equation and the net ionic equation for the reactions between each of the following pairs of reactants. Be sure to include all states of reactants and products.

a) Sodium phosphate (*aq*) and calcium chloride (*aq*)

MOLECULAR (FORMULA)	
NET IONIC	

b) Nitric acid (*aq*) and sodium carbonate (*aq*)

MOLECULAR (FORMULA)	
NET IONIC	

17. (20 marks) A 0.410 g sample of sodium fluoride is dissolved in 25.00 mL of water and is then reacted with 50.00 mL of 0.500 mol/L calcium nitrate solution. After the mixture is filtered, 0.225 g of precipitate is recovered.
   a) Write the net ionic equation for the reaction which occurs.
   b) Calculate the maximum mass of precipitate that could be formed (theoretical yield).
   c) Calculate the percentage yield for this reaction.
   d) Calculate the concentrations of the three major ions in the final solution.

18. (18 marks) In an experiment similar to one you performed, samples of three different solid metals were placed in four different solutions of metal ions. The data collected is presented in the table below (NR = No Reaction):

	Al^{3+}	Co^{2+}	Cu^{2+}	Pb^{2+}
Al	NR	Reaction	Reaction	Reaction
Cu	NR	NR	NR	NR
Pb	NR	NR	Reaction	NR

a) Rank aluminum, copper and lead in terms of their strengths as reducing agents:

Weakest	
⇩	
Strongest	

b) Which species was the strongest oxidizing agent? Explain your answer.

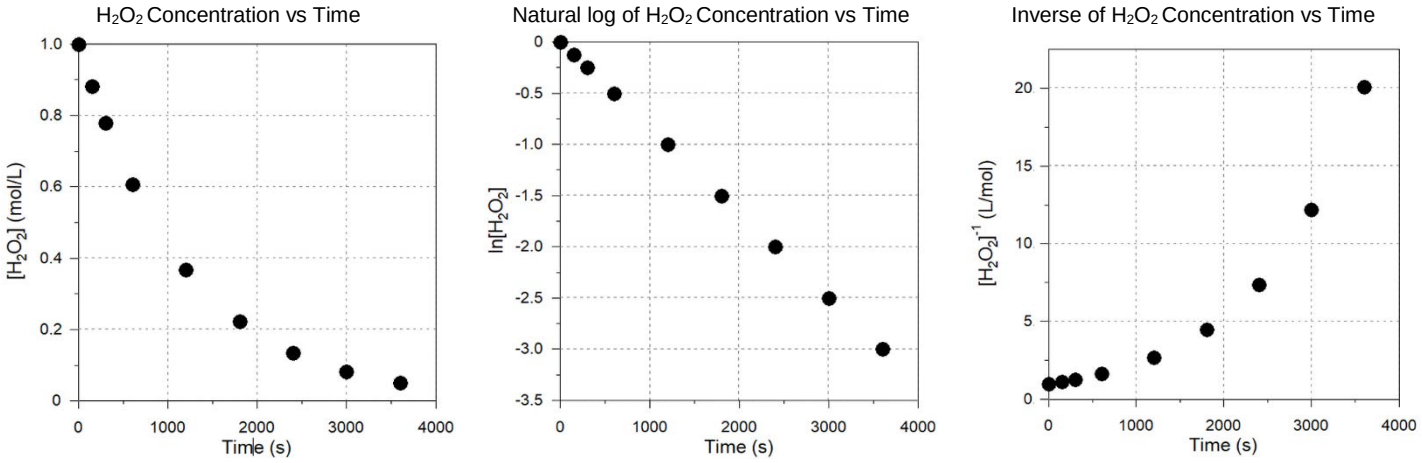
c) If metallic cobalt was tested with the four metal ion solutions, what would be the result of each combination in the following table?

	Al^{3+}	Co^{2+}	Cu^{2+}	Pb^{2+}
Co				

19. (15 marks) The decomposition of hydrogen peroxide (H_2O_2) was studied at 25°C. The reaction is shown below:

$$H_2O_2(aq) \rightarrow H_2O(l) + \tfrac{1}{2}O_2(g)$$

The hydrogen peroxide concentration was monitored over time, and the following plots were made:



a) Write the rate law for this reaction.
b) Calculate the rate constant at 25°C. (Don't forget the units!)
c) Determine the half-life of H_2O_2 at 25°C. Explain or provide calculations.
d) Calculate $[H_2O_2]$ after 5.00×10^3 sec if the initial concentration of H_2O_2 is 1.0 mol/L.

20. (10 marks) Complete the following table.

AQUEOUS SOLUTION 0.1 mol/L	CHEMICAL FORMULA	ELECTROLYTE? (STRONG, WEAK, NON)	APPROXIMATE pH				
			1	2 - 6	7	8 - 12	13 - 14
Acetic acid							
Ethanol	CH_3CH_2OH						
Nitric acid							
Calcium bromide							
Sodium fluoride							
Ammonia							

21. (6 marks) Consider the following exothermic equilibrium in a closed container.

$$A(g) + 3B(s) \rightleftharpoons 5D(l) + E(g) + \text{heat}$$

How will the reaction be affected after each of the following changes? Shifts right, shifts left, or no change?

a) The temperature is raised	
b) More B is added (assume no volume change)	
c) The volume of the container is decreased	
d) Some of E is removed.	

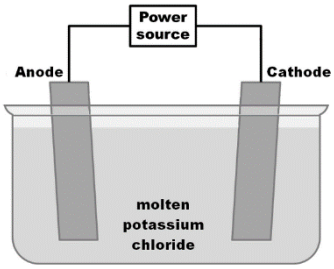
22. (15 marks) One of your laboratory experiments involved the determination of the equilibrium constant for the reaction:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons (FeSCN)^{2+}(aq)$$

A student pipetted 10.00 mL of 2.50×10^{-3} mol/L iron (III) nitrate solution and then 2.00 mL of 2.50×10^{-3} mol/L NaSCN solution into a 25-mL volumetric flask and added water up to the mark. From the absorbance of the solution, the concentration of $(FeSCN)^{2+}$ was found to be 3.46×10^{-5} mol/L. Calculate the value of the equilibrium constant for this reaction.

23. (5 marks) Consider the diagram of an electrolytic cell that is provided.

a) Indicate in the table whether the following statements are TRUE or FALSE.



STATEMENT	TRUE	FALSE
This electrolytic cell would still work using *solid* potassium chloride, but the reaction would be slower.		
Oxidation takes place at the anode.		
Electrons flow from anode to cathode.		

b) Write the half reaction that occurs at the anode.

24. (2 marks) Provide any two practical applications/real life examples of colligative properties.

i.	
ii.	

25. (8 marks) Given that $K_f = 1.86°C \cdot m^{-1}$ for water, calculate the freezing point temperature (°C) of the following aqueous solutions, assuming ideal behaviour:

    i. 0.50 *m* sucrose.

    ii. 0.50 *m* sodium sulfate.

    iii. Would 0.50 *m* sodium sulfate have a higher or lower boiling point compared to 0.50 *m* sucrose? Explain how you can quickly know without calculating the boiling point.

26. (8 marks) A volume of 0.10 mol/L sodium chloride solution is separated from an equal volume of 0.075 mol/L magnesium sulfate solution by a semi-permeable membrane as shown in Figure 1. The membrane allows the passage of the *solvent* only.

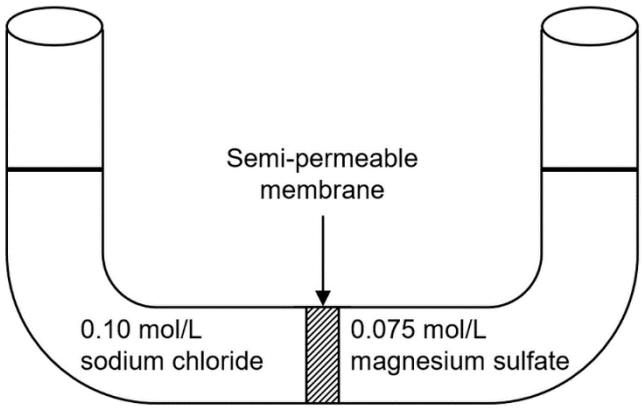


Figure 1: Initial position.

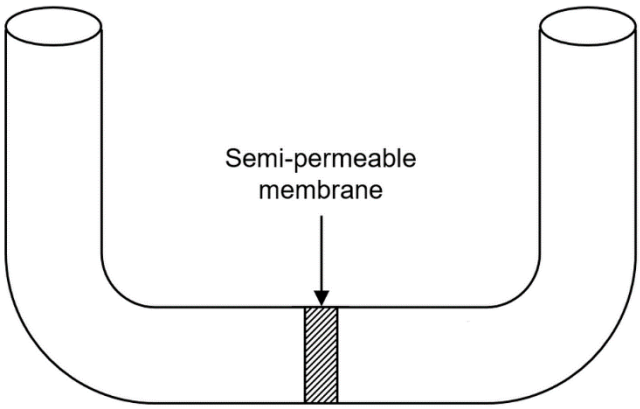
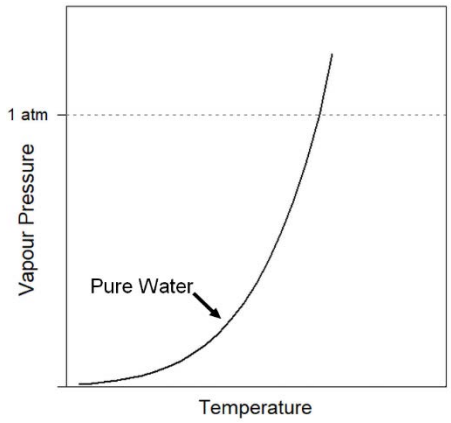


Figure 2: Equilibrium Position.

a) In Figure 2, draw the levels of the two solutions if the system is allowed to come to equilibrium.
b) Briefly explain why you placed the levels where you did.

27. (8 marks) The following graph (sometimes called a vapour pressure curve) is a plot of the vapour pressure versus temperature for pure water.



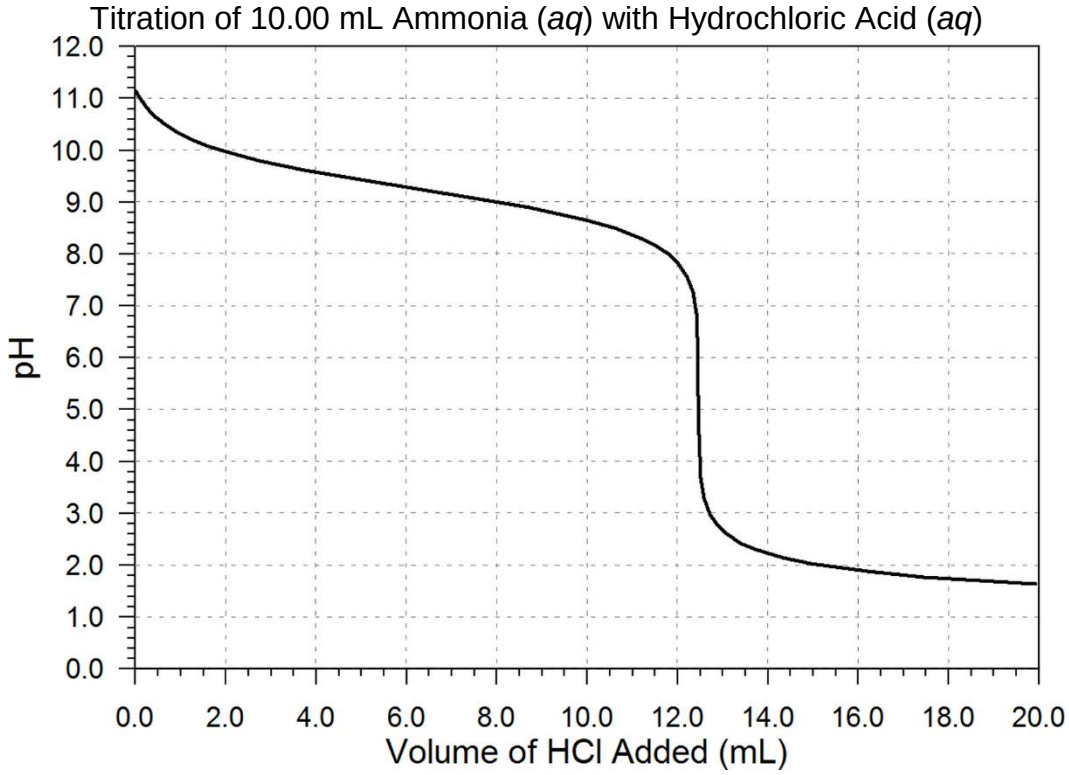
a) On the same axes, sketch the vapour pressure curve for 0.1mol/L sodium chloride.

b) On the curves, indicate clearly the normal boiling point (at 1 atm) for pure water (T_b) and for 0.1 mol/L sodium chloride (T_b').

c) Briefly explain why the two boiling points are different.

28. (10 marks) A 50.0 mL aqueous solution of sodium hydroxide has a pH of 12.50. If 36.00 ml of 0.0200 mol/L sulfuric acid is added to this sodium hydroxide solution, what will be the final pH of the resulting solution? Assume that the temperature stays constant at 25°C, and that the volumes are perfectly additive.

29. (20 marks) The following titration curve was collected for the titration of 10.00 mL ammonia(*aq*) with hydrochloric acid(*aq*).



a) Write the chemical equation for this neutralization reaction.
b) What is the original concentration of the ammonia solution if 10.00 mL of the solution was titrated with 0.0923 mol/L hydrochloric acid?
c) At what point on the titration curve is pH = pK_a? Briefly explain your answer.
d) Calculate the pH at the equivalence point of this titration.

30. (15 marks) Consider a 375.0 mL buffer solution of 0.1000 mol/L acetic acid ($K_a = 1.8\times10^{-5}$) and 0.1550 mol/L barium acetate.
a) What is the pH of this buffer solution?
b) What would be the pH if 7.5×10^{-3} moles of hydrochloric acid is added to the buffer? Assume no volume change due to this addition.

Answers

16. a) Molecular eq: $2Na_3PO_4(aq) + 3CaCl_2(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaCl(aq)$
    Net ionic eq: $3Ca^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$
    b) Molecular eq: $2HNO_3(aq) + Na_2CO_3(aq) \rightarrow 2NaNO_3(aq) + CO_2(g) + H_2O(l)$
    Net ionic eq: $2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$

17. a) $Ca^{2+}(aq) + 2F^-(aq) \rightarrow CaF_2(s)$ b) 0.381 g c) 59.0%
    d) 0.268 mol/L Ca^{2+}, 0.130 mol/L Na^+ and 0.667 mol/L NO_3^-

18. a) Al > Pb > Cu b) Cu^{2+}, because it oxidizes both Al and Pb. c) NR: Al^{3+} & Co^{2+}, Reaction: Pb^{2+} & Cu^{2+}.

19. a) rate = $k[H_2O_2]$ b) 8.3×10^{-4} s^{-1} c) 830 s d) 0.016 mol/L

20.

CH_3COOH,	weak electrolyte,	pH 2–6
CH_3CH_2OH,	nonelectrolyte,	pH 7
HNO_3,	strong electrolyte,	pH 1
$CaBr_2$,	strong electrolyte,	pH 7
NaF,	strong electrolyte,	pH 8–12
NH_3,	weak electrolyte,	pH 8–12

21. a) Shifts left b) No effect c) No effect d) Shifts right

22. 220

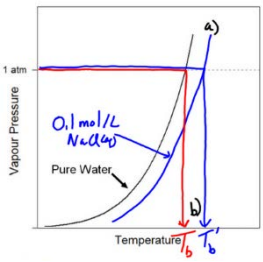
23. a) false, true, true. b) $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

24. Putting salt on roads, preserving food with salt or sugar, rise of sap in trees, etc.

25. i) -0.93°C ii) -2.8°C iii) 0.50 *m* sodium sulfate, because of its higher concentration of solute particles.

26. a) The level in the left arm should go up. The level in the right arm should go down by approximately the same amount.
    b) Water flows from the side that is less concentrated in solute to the one that is more concentrated in solute.

27.



c) An acceptable answer would be based on recognizing that the 0.1 mol/L NaCl(*aq*) solution would require a greater input of (thermal or kinetic) energy than pure water to have its vapour pressure match the external pressure (given that its vapour pressure is lower than that of pure water at all temperatures - part a).

28. 11.1-11.4 depending on rounding throughout the calculation.

29. a) $NH_3(aq) + H_3O^+(aq) \rightleftharpoons NH_4^+(aq) + H_2O(l)$ b) 0.115 mol/L (using an estimated V_{eq} of 12.50 ml)
    c) At half-equivalence, because $[NH_3] = [NH_4^+]$ d) 5.27 (depends on pK_a value obtained from graph)

30. a) 5.23 b) 5.12