Please Note:

1. There was a set of 15 multiple choice questions that were present on this exam, but have not been reproduced for the practice version. It would have taken approximately 10-30 minutes to answer the multiple choice questions.
2. 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 0.410g sample of sodium fluoride is dissolved in 25.00mL of water and is then reacted with 50.00mL of 0.500mol/L calcium nitrate solution. After the mixture is filtered, 0.225g 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:

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

NR = No reaction

a) Rank Al, Cu and Pb in terms of their strengths as reducing agents:

Strongest ----------→ Weakest		

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

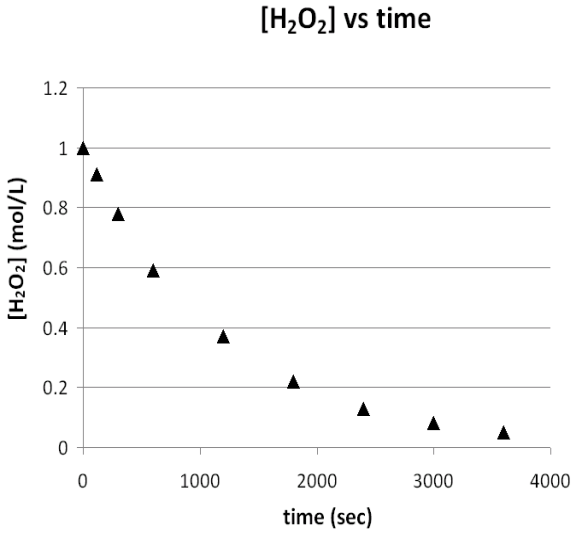
c) If metallic cobalt was tested with the four metal ion solutions, which combinations would lead to a reaction?

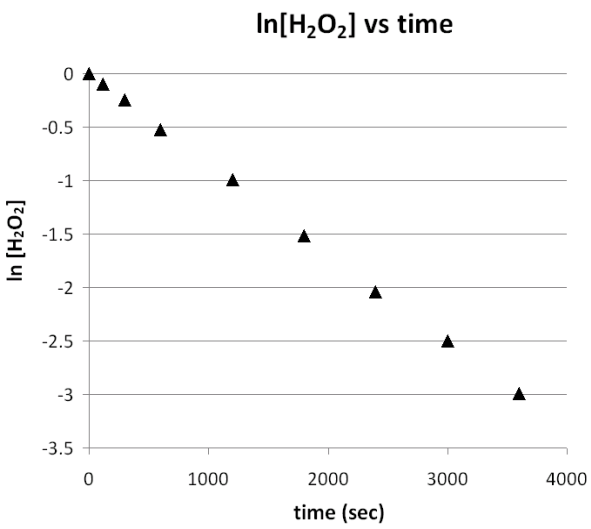
	Al^{3+}	Co^{2+}	Cu^{2+}	Pb^{2+}
Co				

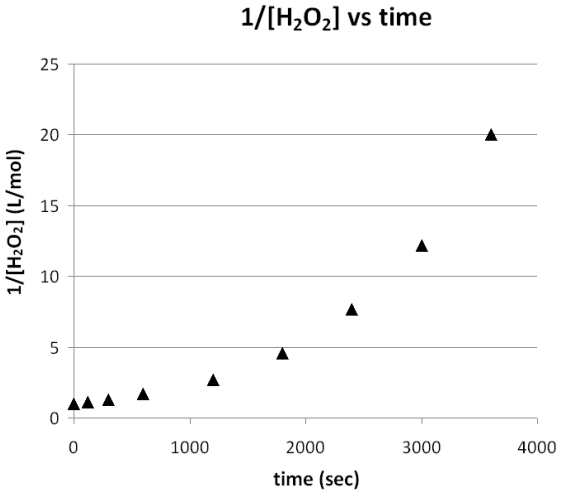
19. (15 marks) The decomposition of hydrogen peroxide (H_2O_2) was studied at 25°C. The reaction is shown below:

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

H_2O_2 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 M.

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.

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

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

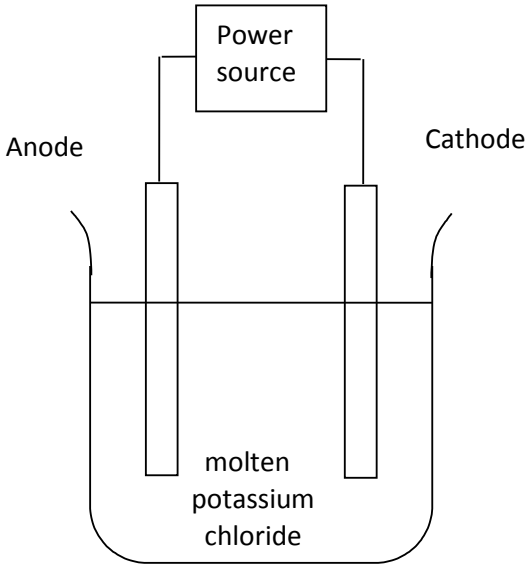
d) Some of E is removed.

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

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

A student pipetted 10.00mL of 2.50×10^{-3}mol/L iron (III) nitrate solution and then 2.00mL of 2.50×10^{-3}mol/L NaSCN solution into a 25mL 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 following diagram of an electrolytic cell:



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) List any two practical applications/real life examples of colligative properties.

i. Ii.

25. (8 marks) Given that $K_f = 1.86^oC/m$ for water, calculate the freezing point temperature (^oC) of the following aqueous solutions, assuming ideal behaviour:

i. 0.50m sucrose
ii. 0.50m sodium sulfate
iii. Would 0.50m sodium sulphate have a higher or lower ***boiling*** point compared to 0.50m 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 sulphate solution by a semi-permeable membrane as shown in Figure 1. The membrane is permeable to the passage of water only.

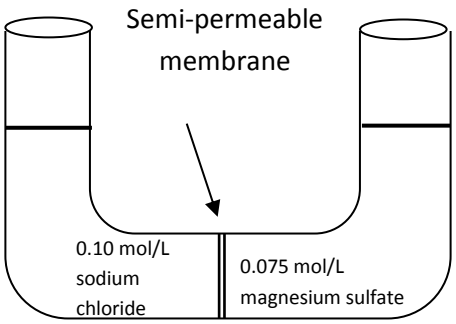


Figure 1: Initial position

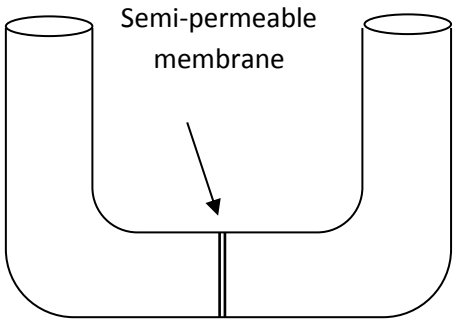
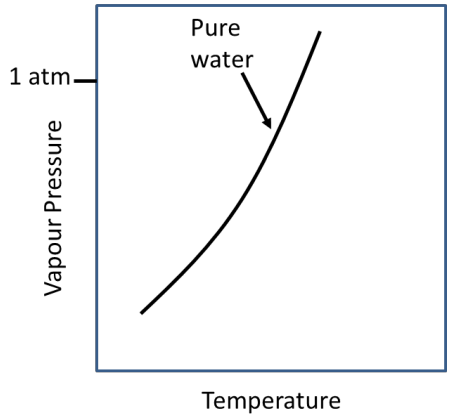


Figure 2: Equilibrium position

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.



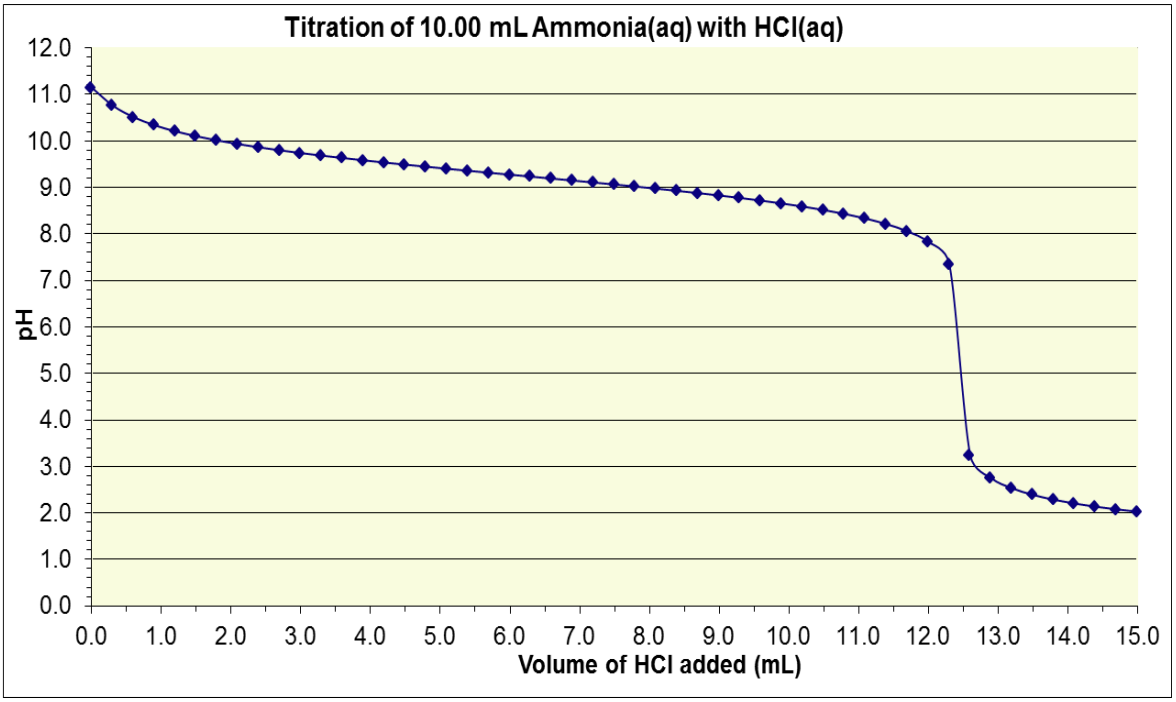
a) On the same axes, sketch the vapour pressure curve for 0.1mol/L sodium chloride.

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

b) 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 new 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 375.0mL buffer solution of 0.1000 mol/L acetic acid (K_a = 1.8×10^{-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+}, for it oxidises both Al and Pb. c) Reaction with Cu^{2+} and Pb^{2+} only

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
Ammonia, 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) The second one, 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 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. a) The second curve should be identical, parallel and below/to the right of the original one.
b) Select the points on the two curves where P = 1 atm.
c) Too long to give here. May somewhat vary depending on instructor.

28. 11.1-11.4 depending on rounding throughout the calculation
29. a) $NH_3(aq) + H_3O^+ \rightarrow NH_4^+(aq) + H_2O(l)$ Can also use H^+ or give molecular equation.
b) 0.115 mol/L 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