Question 1  [20 points, 5 each]

Consider the following cell:

\[ \text{Pt} \* \text{H}_2(g) \* \text{HCl(aq)} \* \text{AgCl(s)} \* \text{Ag(s)} \]

(a) Give a rough sketch of how the cell would be constructed

(b) Give anode, cathode and overall cell reactions
(a) Give the Nernst equation for this cell assuming fugacity of hydrogen is unity.

(a) Prove that for the electrolyte used in this cell, \( \ln \left( \frac{\%b}{b} \right)^{1/2} \), where \( b \) is the molality of the electrolyte.

Question 2  
[30 points; 10 points each]
(a) Using the following cell:
\[ \text{Ag(s)}^* \text{Ag}^{+}(\text{aq})^* \text{AgCl(s)}^* \text{Ag(s)} \]

How would you determine the solubility product of AgCl? Using the standard tables, determine this value.
(a) Prove that the potential of a standard hydrogen electrode changes by 59.2 mV for every unit change in pH
(a) The zero-current potential of the cell: Pt|H₂(g)|HCl(aq)|AgCl(s)|Ag is 0.277 V at 25 °C. What is the pH of the electrolyte solution?
Question 3  

[30 points; 5 points each except (d) which is weighted at 10 points]

50.0 mL of 0.10 M acetic acid are titrated against 50.0 mL of 0.10 M sodium hydroxide. The acid dissociation constant for acetic acid is $1.75 \times 10^{-5}$ M.

(a) Give a rough plot of the change in pH as base is continuously added to the acid.

(b) Calculate the pH of the acid solution before addition of base commences.

©) Calculate the pH of the solution after exactly half of the required base has been added to the reaction solution.
(d) Calculate the pH of the solution at the equivalence point. What indicator might be most suitable to follow this titration?

(e) Finally, evaluate the pH of the reaction mixture after 40 mL of base have been added.
Question 4  [20 points; 10 points each]
(a) Using the thermodynamics tables given to you, evaluate equilibrium constant for the reaction:

\[
\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})
\]

at 298.15 K.

(b) Calculate its equilibrium constant at 100 °C. Does this variation conform to Le Chatelier’s principle?
Bonus Questions. [Need not be attempted for full credit to this exam; 5 points each]
(a) Fuel cells have gained prominence in the past 5 years because of their non-polluting nature. Give a brief report on how fuel cells work.

(b) There are several types of fuel cells that are presently being used. Briefly describe the construction of the Proton Exchange Membrane types of fuel cells.