Chemistry 2740 Spring 2021 Test 2

Total marks: 37

Submission: From the time you open the test in Crowdmark, you have a total of **2 hours** to complete the test **and upload your answers to Crowdmark**.

Data: Much of the data you will need is contained in the appendices of the textbook. Some additional data is given at the end of the test. Please use data from the textbook and from this test paper and **not** from other sources.

Instructions: Under no conditions are you to discuss the contents of this test with, or obtain assistance from, any person by any means prior to the submission deadline of **7:00 p.m. Friday, March 5th**. You may however email me to clear up minor issues you run into while doing the test. Note that I can't watch my email every minute of the day, so last-minute questions may not receive timely answers.

You can use any resources you like (textbook, web resources, etc.), and any computational tools (calculator, spreadsheet, etc.). However, the point of this test is to evaluate your understanding of the material so you must give full details of any work or reasoning. **Answers without detailed work will receive <u>NO</u> credit.**

Make sure to use a sufficiently dark pencil or pen so that your work will scan or photograph well. Also, verify the quality of your images before uploading them. If I can't read it, I can't mark it. Color is permitted if you think it would be useful. While the test is intended to be hand-written—neatly please!—I don't mind computer (word processor, spreadsheet) output if you think it's helpful for some problems.

Keep in mind the **firm** deadlines: **two hours, ending before 7:00 p.m.**

If you need a graph to answer a question, you must show your graph. Given the nature of this test, you can (a) hand-sketch your graph, or (b) generate an image of your graph from (e.g.) a spreadsheet. However, an acceptable graph will have fully labeled axes (so don't just take a picture of your calculator screen). Additionally, the line of best fit must be shown with the data.

1. If you wanted to calculate an emf for a cell operating at a temperature other than $25\,°C$, what calculations would we need to do? What data would we need? Your answer should focus on the temperature dependence. Assume that you have the usual set of thermodynamic tables at $25\,°C$. **5 marks**

2. The solubility of lead(II) azide $(Pb(N_3)_2)$ in water and the permittivity of water vary with temperature as follows:[1] **32 marks**

$T/°C$	25	35	45
$s/\mathrm{mol\,L^{-1}}$	7.5×10^{-4}	1.2×10^{-3}	1.6×10^{-3}
$\varepsilon/10^{-10}\mathrm{C^2J^{-1}m^{-1}}$	6.939	6.633	6.338

   (a) Using Debye-Hückel theory, calculate the solubility product at each temperature. [13 marks]

   Note: The calculations are somewhat repetitive. Show a sample calculation, and then feel free to use a spreadsheet or programmable calculator to do the rest. Present your final results in tabular form.

   (b) Calculate the enthalpy change for dissolving lead azide in water. [9 marks]

   (c) Calculate the standard enthalpy of formation of solid lead azide. [2 marks]

   (d) Calculate the standard free energy change for dissolving lead azide in water. [2 marks]

   (e) Calculate the standard free energy of formation of solid lead azide. [2 marks]

   (f) Calculate the standard entropy of solid lead azide. [4 marks]

Note: The following table is in a different format than the one in the textbook.

Species	$\dfrac{\Delta_f H°}{\mathrm{kJ\,mol^{-1}}}$	$\dfrac{\Delta_f G°}{\mathrm{kJ\,mol^{-1}}}$	$\dfrac{S_m°}{\mathrm{J\,K^{-1}mol^{-1}}}$
$N_{3(aq)}^-$	274.2	348.4	96.76
$Pb_{(aq)}^{2+}$	0.92	-24.24	21

[1]Solubilities calculated from data given by Lieber et al., *J. Chem. Eng. Data* **11**, 105 (1966)