Chemistry 2740 Spring 2022 Test 2

Total marks: 43

Submission: From the time you open the test in Crowdmark, you have a total of **75 minutes** to complete the test **and upload your answers to Crowdmark**.

General instructions: Under no conditions are you to discuss the contents of this test with, or obtain assistance from, any person by any means while the test is open. You may however email me to clear up minor issues you run into while doing the test.

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 NO credit.** If you use the equation solver of a calculator, spreadsheet or other computer program, you **must** report the following: what tool you used (calculator model or program name, e.g. TI-83, Excel, ...), the exact equation solved, and the initial guess used.

Please only use data on this test paper and in the textbook. **Do not** use data obtained from other sources as this might cause your answers to differ from mine.

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 I'm not very fussy about significant figures—that's Wayne's job—I am picky about a couple of things:

- You should give answers to a reasonable number of decimal places given the input data. Don't give me answers to eight decimal places if the data aren't that accurate, and don't round your final answer so much that I can't tell if it's right or wrong. Use reasonable judgment. Of course, you can't go wrong following the significant figure rules.
- All the digits in your final answer should be correct, which generally means that you should store intermediate results in calculator memories. Alternatively, keep a few extra digits in intermediate steps.

1. A voltaic cell can be made using aluminum and a permanganate solution. In this cell, which operates under basic conditions, an aluminum electrode reacts to form $Al(OH)^-_{4(aq)}$ ions, while permanganate ions ($MnO^-_{4(aq)}$) react at an inert (e.g. graphite) electrode to form $MnO_{2(s)}$. **11 marks**

   (a) Balance this reaction. [6 marks]

   (b) Calculate the standard emf of this cell. [5 marks]

2. The solubility product (K_{sp}) of strontium fluoride (SrF_2) at 25 °C is 2.6×10^{-9}. What is the solubility product at 100 °C? **9 marks**

3. Chloroacetic acid ($ClCH_2COOH$) has a K_a of 1.4×10^{-3} in water at 25 °C. Calculate the pH of a 5.28×10^{-3} mol L^{-1} aqueous solution of chloroacetic acid using Debye-Hückel theory. Assume that the undissociated acid has an activity coefficient of 1. Report the pH to two decimal places. **23 marks**

   Hint: Don't try to take any shortcuts. Solve the equilibrium problem using Debye-Hückel theory *before* trying to calculate a pH.

Thermodynamic data

Species	$\Delta_f H^\circ$ / kJ mol^{-1}	$\Delta_f G^\circ$ / kJ mol^{-1}	$C_{p,m}$ / J K^{-1}mol^{-1}
$Al(OH)^-_{4(aq)}$		−1301	
$F^-_{(aq)}$	−335.35	−281.52	
$H_2O_{(l)}$	−285.830	−237.140	75.40
$MnO_{2(s)}$	−520.0	−465.2	54.1
$MnO^-_{4(aq)}$	−518.4	−425.1	
$Sr^{2+}_{(aq)}$	−545.51	−557.3	
$SrF_{2(s)}$	−1217.13		