Chemistry 2740 Spring 2020 Test 3

Due: 4:00 p.m. Friday, March 20
Marks: 36
Instructions: Under no conditions are you to discuss the contents of this test with any person by any means prior to the submission deadline of 4:00 p.m. Friday, March 20.

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.**

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). The line of best fit must be shown with the data.

Any non-trivial use of a calculator or other computational device must be described. For example, if you use a calculator to solve a nonlinear equation, you need to make it clear what equation was solved, and provide any other inputs you used to the calculation.

Submission: You must submit your solutions through Crowdmark, which you access through Moodle, where you will find a link to the test. In order to facilitate submission through Crowdmark, you should start each question on a new page. You can submit multiple pages per question, if necessary. For questions with parts, you do *not* need to start a new page for each part. Do make sure to use a sufficiently dark pencil or pen so that your work will scan or photograph well.

1. In a study of binding of RNA polymerase (RNAP) to a promoter, **9 marks**

$$\mathrm{RNAP} + \mathrm{Pro} \underset{k_{\mathrm{off}}}{\overset{k_{\mathrm{on}}}{\rightleftharpoons}} \mathrm{C},$$

the following data were obtained:

$$k_{\mathrm{on}} = 8.5 \times 10^{7}\,\mathrm{L\,mol^{-1}s^{-1}},$$
$$k_{\mathrm{off}} = 1.1 \times 10^{-3}\,\mathrm{s^{-1}}.$$

(a) Write down a mass-action differential equation for the rate of change of the concentration of the complex C. [2 marks]

(b) What is the equilibrium constant for this binding process? [2 marks]

(c) The concentration of free RNA polymerase in an *Escherichia coli* cell is about $1\,\mu\mathrm{mol\,L^{-1}}$. If you sampled many cells containing the above promoter, would you expect most of them to be bound by RNA polymerase, or would you instead expect most of them to be free of polymerase? [5 marks]

2. In a study of the reduction of Ce(IV) ions catalyzed by an inorganic complex, the following data were obtained: **10 marks**

t/h	$[\mathrm{Ce^{4+}}]/10^{-4}\mathrm{mol\,L^{-1}}$
0.17	4.51
4.15	4.12
15.21	3.56
30.06	3.14
46.48	2.84
56.85	2.64
79.65	2.40

The authors make the claim that the reaction displays 4th order kinetics. Do you agree? If so, calculate the rate constant. If not, explain carefully why you don't think these data are consistent with 4th order kinetics.

3. The following data give the number of confirmed COVID-19 cases in Canada over the past week or so: **17 marks**

Date	Number
March 10	77
March 11	93
March 13	138
March 14	176
March 15	244
March 16	304
March 17	424

(a) In the media, the growth in the number of cases is often described as "exponential". However, this term is sometimes used very loosely by people without technical backgrounds to mean "growing at an increasing rate". Based on these data, is the number of COVID-19 cases really growing exponentially? [7 marks]

(b) Regardless of your answer to part a, estimate the doubling time. [4 marks]

(c) The current Canadian population is approximately 37 800 000. Low-end estimates would have 30% of the Canadian population eventually contracting COVID-19. Assuming that exponential growth continues, on roughly what date will this many Canadians have been infected? [6 marks]