Spring 2018 **Chemistry 2000 Midterm #2A** ____/54 marks

1) Please read over the test carefully before beginning. You should have 7 pages of questions, a blank "overflow" page and a double-sided data sheet with periodic table.
2) **DO NOT WRITE ON THE QR CODE!!!** Work on pages without a QR code will not be graded.
3) If your work is not legible, it will be given a mark of zero. Show your work for all calculations.
4) Marks will be deducted for incorrect information added to an otherwise correct answer.
5) You may use a calculator but only for calculation. No text-capable calculators are allowed.
6) You have 90 minutes to complete this test.

Confidentiality Agreement:

I agree not to discuss (or in any other way divulge) the contents of this exam until after 5:00 pm Mountain Time on Friday, March 23rd, 2018. I understand that breaking this agreement would constitute academic misconduct. The minimum punishment would be a mark of 0/54 on this exam and removal of the "overwrite midterm mark with final exam mark" option for my grade in this course; the maximum punishment would include expulsion from this university.

Signature: ______________________________ Date: ________________________________

Course: CHEM 2000 (General Chemistry II)
Semester: Spring 2018
The University of Lethbridge

Question Breakdown

Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**				**Total**
/ 7	/ 9	/ 10	/ 7	/ 7	/ 14				/ 54

1. Methanol melts at −97.9 °C with an enthalpy of fusion of 3117 J/mol. **[7 marks]**

(a) Calculate the total entropy change for 1.45 mol of methanol **freezing** at its melting point. *[5 marks]*

(b) The entropy change calculated in part (a) is negative. *(You did get a negative entropy change, did you not?)* Because of this, some people might conclude that you can never freeze methanol – that it would go against the second law of thermodynamics. Why are they wrong? *[2 marks]*

No credit will be given for answers that amount to "because they are". Explain why this is a misinterpretation of the second law of thermodynamics and what the correct interpretation is.

2. In catalytic reforming, low-octane hydrocarbons are converted to higher-octane hydrocarbons suitable for use as fuels. One reaction that occurs during catalytic reforming is the conversion of heptane (C_7H_{16}) to toluene $(C_6H_5CH_3)$ and hydrogen. During the reforming process, all reactants and products are in the gas phase.

Is this reaction thermodynamically allowed at 25 °C if the pressures of the reactants and products are as follows: **[9 marks]**

- Heptane: $5.3\ bar$
- Toluene: $1.2\ bar$
- H_2: $3.0\ bar$

Don't forget to start with a balanced reaction!

3. In the gas phase, toluene $(C_6H_5CH_3)$ can react with itself to make benzene (C_6H_6) and xylenes $(C_6H_4(CH_3)_2)$. **[10 marks]**

$$2\ C_6H_5CH_{3(g)} \rightleftharpoons C_6H_{6(g)} + C_6H_4(CH_3)_{2(g)}$$

At 25 °C, the equilibrium constant for this reaction is 0.16.

(a) Calculate the standard free energy of formation for xylenes. *[4 marks]*

(b) Calculate the equilibrium constant for this reaction at 1175 °C. *[6 marks]*

4. The following data were obtained for ammonia. **[7 marks]**

	temperature (℃)	pressure (kPa)
triple point	-77.75	6.060
critical point	132.41	11,357
normal boiling point	-33.33	
normal melting point	-77.65	

(a) Sketch a phase diagram for ammonia. On your diagram, you must label: *[5 marks]*

- both axes
- regions corresponding to the <u>four</u> states of matter discussed in class

Your sketch does not need to be to-scale; however, it must be neat and all points used to make it must be clearly labeled. Relative values must be preserved. In other words, it must be clear which pressures/temperatures are larger/smaller/approximately the same.

(b) Which is denser, liquid or solid ammonia? Explain how you determined this based on the data in this question. *[2 marks]*

5. Consider the following unbalanced redox reaction performed <u>in aqueous base</u>: **[7 marks]**

$$N_2H_{4(g)} \quad + \quad Cu(OH)_{2(s)} \quad \rightarrow \quad N_{2(g)} \quad + \quad Cu_{(s)}$$

(a) Assign oxidation numbers to all atoms in this reaction. Write them above each atom in the equation. *[3 marks]*

(b) Write a balanced equation for the oxidation half-reaction. *[1 mark]*

(c) Write a balanced equation for the reduction half-reaction. *[1 mark]*

(d) Write a balanced equation for the overall reaction. *[1 mark]*

(e) What is the stoichiometric coefficient for the electrons (ν_e)?
(Some introductory texts refer to this as n.) *[1 mark]*

6. Consider the following <u>unbalanced</u> redox reaction performed in aqueous acid: **[14 marks]**

$$C_2H_5OH_{(l)} \quad + \quad O_{2(g)} \quad \rightarrow \quad CO_{2(g)} \quad + \quad H_2O_{(l)}$$

Equations for the two relevant reduction half-reactions are shown below:

$$2\,CO_{2(g)} \;+\; 12\,H^+_{(aq)} \;+\; 12\,e^- \;\rightarrow\; C_2H_5OH_{(l)} \;+\; 3\,H_2O_{(l)} \qquad E° = ???$$

$$O_{2(g)} \;+\; 4\,H^+_{(aq)} \;+\; 4\,e^- \;\rightarrow\; 2\,H_2O_{(l)} \qquad E° = +1.24\ V$$

(a) Calculate $E°$ for this reaction. *[6 marks]*

(b) Calculate the standard reduction potential for the oxidation half-reaction. *[2 marks]*

6. *continued…*

(c) Calculate the cell potential for the combustion reaction operating with typical atmospheric pressures of oxygen and carbon dioxide at 25 °C: *[6 marks]*

- Oxygen: $0.19\ bar$
- Carbon dioxide: $4.1 \times 10^{-4}\ bar$

Overflow Page

If you use this page for any answers, please clearly indicate which question is being answered and make sure you note on the page for the question itself that the answer continues here.