

THE UNIVERSITY OF BRITISH COLUMBIA
CHEM 154 Midterm Examination
November 16, 2021

Time Limit: 60 minutes

Total Marks: 45

Student Number:
(one digit per dash)

Name (printed):

Signature: _____

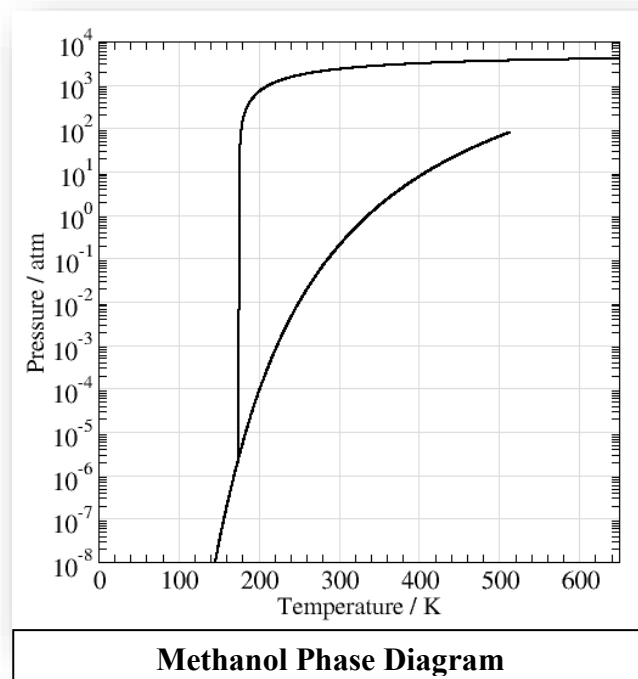
Section (circle): 111 133 177

Examination Rules and Instructions

1. **Please print your name and student number clearly, both on the first page of the exam as indicated above, and as indicated at the top of each page of the exam.** Sign the exam on the front page and circle your lecture section.
2. The exam has 6 pages. Please check that you have received correctly printed copies of each page, as well as a CHEM 154 Equation Sheet as a separate page.
3. **Please read each question carefully, and write your answers only in the spaces provided.** These exams will be scanned as part of the marking process and any answers outside the designated spaces will be omitted. You may use the equation sheet exam for rough work.
4. The invigilators will tell you when to start and stop writing the exam. Do not look at any exam questions until the start of the writing of the exam.
5. You must conduct yourself honestly, and follow any rules or directions communicated by the invigilators.
6. You are not allowed to access a computer or any other electronic device from the time you receive the printed copy of the exam until the time the exam is collected by an invigilator.
7. In addition to pens, pencils and erasers, you are allowed to have a basic scientific calculator, as well as an unassembled molecular model kit, if desired.
8. Examination candidates suspected of any of the following, or any other similar practices, may be immediately dismissed from the examination by the examiner/invigilator, and may be subject to disciplinary action:
 - i. purposely exposing written papers to the view of other examination candidates or imaging devices;
 - ii. purposely viewing the written papers of other examination candidates;
 - iii. using or having visible at the place of writing any books, papers or other memory aid devices other than those authorized by the examiner(s);
 - iv. distributing in any manner, electronic or otherwise, copies of any part of the exam.
9. If a need arises to contact the invigilator, such as the need to go to the washroom, please raise your hand and wait for an invigilator to meet you.
10. Invigilators are instructed to not provide answers to any questions about the exam content, the interpretation of exam questions, or suspected errors in questions. If you suspect a question to have an error or ambiguity, detail this on your exam paper, and all such issues will be dealt with during the marking of the exam.
11. If you finish writing the exam before the allotted time, please wait in silence at your place of writing until the allotted time has expired.

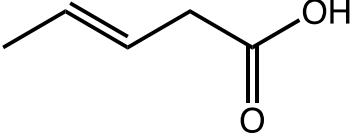
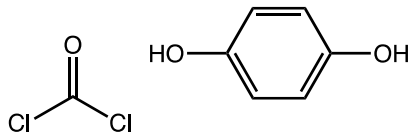
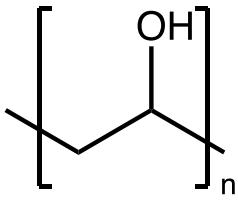
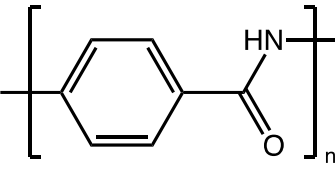
1. **[8 marks total]** Some methanol (CH_3OH) is placed in an initially evacuated, rigid, 2.00 L container and put in an oven maintained at a constant temperature. After some time, the pressure in the container becomes constant at 7.60 atm, and the container has 1.00 L of gas above 1.00 L of liquid.

a) Treating methanol as an ideal gas, calculate the number of moles of vapour in the container.



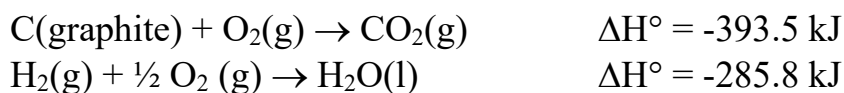
- b) If part a) was repeated treating methanol as a real gas, would the expected number of moles of vapour be less than, equal to, or greater than the value calculated in part a)? Please give qualitative arguments to explain your answer. (Do not try to calculate this number.)
- c) The temperature of the oven is slowly increased to 600 K. Describe what happens in the container, that is the number phases present, any pressure changes, etc.. If desired, please draw on the phase diagram to help explain your answer.

2. **[8 marks total]** Complete the table below by drawing the missing polymer or monomer(s), selecting the type of polymerization reaction, and indicating **all** intermolecular forces (IMF) governing the mechanical properties of the polymer.

Monomer(s)	Polymer	Reaction? (fill in circle)	IMFs? (fill in circle(s))
		<input type="radio"/> Condensation <input type="radio"/> Addition	<input type="radio"/> London Dispersion Forces <input type="radio"/> Dipole-dipole <input type="radio"/> H-bonding
		<input type="radio"/> Condensation <input type="radio"/> Addition	<input type="radio"/> London Dispersion Forces <input type="radio"/> Dipole-dipole <input type="radio"/> H-bonding
		<input type="radio"/> Condensation <input type="radio"/> Addition	<input type="radio"/> London Dispersion Forces <input type="radio"/> Dipole-dipole <input type="radio"/> H-bonding
		<input type="radio"/> Condensation <input type="radio"/> Addition	<input type="radio"/> London Dispersion Forces <input type="radio"/> Dipole-dipole <input type="radio"/> H-bonding

3. **[2 marks total]** Draw all the Lewis structures for NO_2 having zero formal charge on every atom and only one unpaired electron.

4. **[5 marks total]** All quantities are at 298 K. Combusting 1 mole of ethanol ($\text{CH}_3\text{CH}_2\text{OH(l)}$) to $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{g})$ releases 1235 kJ. Using this information, and the equations below, as well as knowing $\Delta H^\circ(\text{vap}) = 44.00 \text{ kJ mol}^{-1}$ for liquid water, determine the enthalpy of formation of liquid ethanol, in kJ mol^{-1} . Please show your work, and write your final answer on the line indicated below.



$\Delta H^\circ_f(\text{CH}_3\text{CH}_2\text{OH(l)}) = \underline{\hspace{2cm}}$

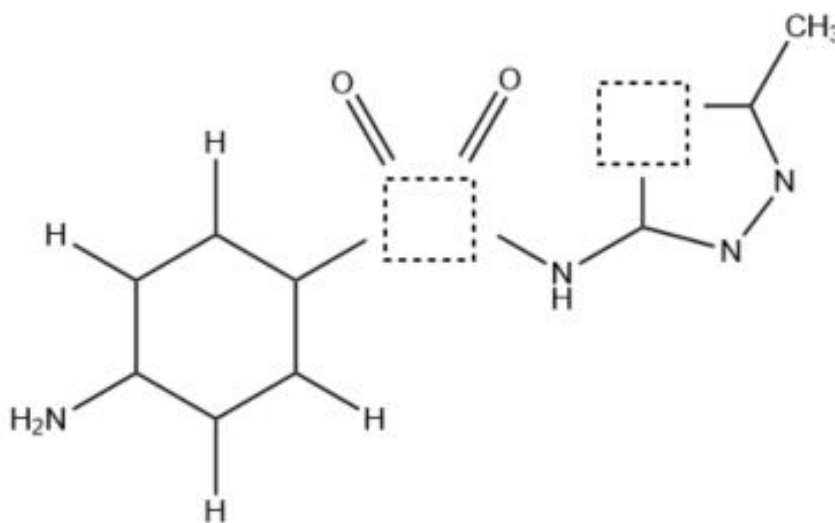
5. [7 marks total] Complete the table by drawing for each molecule the best Lewis structure and a perspective diagram, as well as indicating whether it is polar. For the Lewis structure, show all bonds as lines and lone pairs as dots. Write the parent and molecular shapes for each molecule.

Molecule	Best Lewis Structure	Shape	Perspective Diagram	Polar?
				Yes/No
PCl_3		Parent: Molecular:		
PCl_5		Parent: Molecular:		

6. [6 marks total] The skeletal structure (showing atom connectivity) of an antibiotic is shown below. The formal charge on all atoms of the best Lewis structure is zero, and the boxes represent a missing element with an atomic number less than 20.

- a) Produce the best Lewis structure by drawing multiple bonds or lone pairs, as necessary, on the skeletal structure diagram. Write the name of element in the boxes (both boxes contain the same element).

- b) Circle all the atoms with a trigonal pyramidal molecular shape.



7. **[3 marks total]** Write two balanced equations showing the first and second ionization of helium. For each equation, indicate whether ΔH is positive, negative or zero.
8. **[6 marks total]** Limestone is a sedimentary rock used extensively in building construction and is composed mostly of calcium carbonate (CaCO_3). Draw all valid Lewis structures contributing to the resonance hybrid of the carbonate anion (CO_3^{2-}). Show all bonds as lines and lone pairs as dots; indicate formal charges and overall charges where applicable.

Estimate the bond order of the C—O bond in CO_3^{2-} (please show your work).