Test 1

CHEM 2011: Introduction to Thermodynamics

February 27, 2022

First name (please write as legibly as possible within the boxes)

Last name

Student ID

Question:	1	2	3	4	Total
Points:	12	13	13	12	50
Score:					

Instructions:

1. Answer all questions. Write your answers on the space provided. No other paper is allowed.
2. All work must be clearly shown.
3. No credit will be given to any answer without adequate justification.
4. All solutions should be articulate and complete.
5. Do not ask any questions during the test.
6. The definitions and notations in the textbook are used.
7. Use your own judgement to decide when you can quote a result to support your reasoning.
8. No aids of any kind are permitted.

GOOD LUCK!!!

1. (12 points) (a) Briefly answer the following questions.

   i. (2) Does Charles' Law hold during a reversible adiabatic expansion or compression of an ideal gas? Briefly explain your answer.

   ii. (1) Dalton's Law of partial pressure states that for reactive gases, behaving ideally, the pressure exerted by one gas is independent of the other gases in the mixture. Circle ONE.

   TRUE FALSE

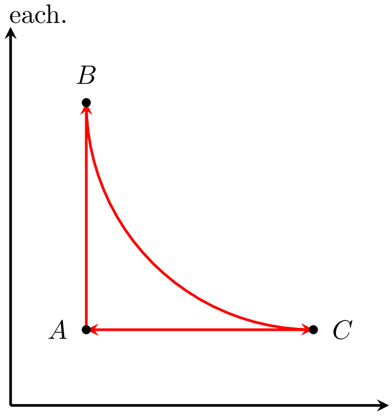
   iii. (1) For real gases, the ratio PV/RT can be greater or smaller than one. A positive deviation (meaning $PV/RT > 1$) is due to the molecules having intermolecular forces and is quantified by the a factor. Circle ONE.

   TRUE FALSE

   iv. (1) Non-ideal behavior in gases is more important at high temperature and low-pressures. Circle ONE.

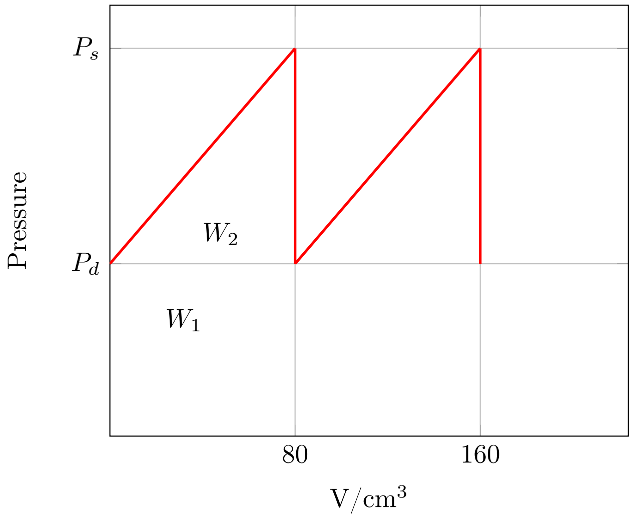
   TRUE FALSE

   v. (3) An ideal gas is taken around the cycle $A \to B \to C \to A$ shown in the PV-diagram. Process $B \to C$ is isothermal. For the complete cycle, what are the signs of q, W, and ΔU. Circle ONE for each.



ΔU	POSITIVE	NEGATIVE	ZERO
q	POSITIVE	NEGATIVE	ZERO
W	POSITIVE	NEGATIVE	ZERO

(b) (4) The PV-diagram below can be used to represent the pressure dependence in a ventricle of the human heart as a function of the volume of blood pumped. The systolic pressure, P_s is 137 mm Hg and the diastolic pressure P_d is 81 mm Hg. If the volume of blood pumped in one heartbeat is 80 cm^3, calculate the work done in one heartbeat.



2. (13 points) (a) (6) A 243.0 g sample of Silicon (Si) in the crystalline form solid form is heated from 300 K to 425 K at constant pressure. Over this temperature range, $C_{p,m}$ is given by the expression:

$$\frac{C_{P,m}}{\mathrm{J/mol\ K}} = -6.25 + 0.1681\frac{T}{\mathrm{K}} - 3.437 \times 10^{-4}\frac{T^2}{\mathrm{K}^2}$$

Calculate ΔH and q_p.

(b) (5) How large is the relative error in ΔH if we assume that $C_{P,m}$ is a constant at 300 K and that $C_{P,m}$ remains constant for temperature interval considered in (a)?

(c) (2) For the process described in (a), calculate ΔU.

3. (13 points) A sample of two moles of an ideal diatomic gas is initially at $T = 290$ K and at a pressure of 10.0 bar.

   (a) (6) The gas then undergoes a reversible adiabatic expansion to a final pressure of 1.50 bar. Calculate the final temperature, q, W, ΔU, and ΔH.

   (b) (4) In a second experiment, the gas sample is found at the same initial conditions, but it expands to a final pressure of 1.50 bar during an irreversible adiabatic expansion against a constant pressure of 1.50 bar, calculate the final temperature and the work done in that process.

(c) (3) On the same PV-diagram, sketch the work that was done in (a) and in (b). Clearly label the area that corresponds to each of the processes. Who did the work in (a) and (b) – the system or the surroundings?

4. (12 points) (a) (2) Enthalpy H is a state function and dH is an exact differential. Write an expression for the full differential expansion of dH illustrating the dependence of enthalpy on P and T.

(b) (2) Write the cyclic rule expression for $H(T, P)$.

(c) (4) Using the equation given below, demonstrate that for an ideal gas, $\frac{\partial H}{\partial P} = 0$.

$$\frac{\partial H}{\partial P} = T\frac{\partial P}{\partial T}\frac{\partial V}{\partial P} + V$$

(d) (4) The potential of interaction of two molecules or atoms is shown in the figure below (as a function of their separation r). On the diagram, indicate where there is (i) no interaction, (ii) attraction, (iii) repulsion between the gas molecules. (iv) For real gases $\frac{\partial H}{\partial P} = -C_P \mu_{J-T}$. In which region is $\frac{\partial H}{\partial P} > 0$ for real gases? Circle ONE:

ATTRACTIVE REPULSIVE