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PHYS 119A
Midterm Examination

Wednesday 28 October 2009

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Question 1: Short Answers (10 points)

a. Consider the following change in state: 1 mole of a real gas undergoes a reversible change in state in a Carnot cycle. Will ΔU be greater, smaller or equal than the ΔU for an ideal gas undergoing the same cycle. EXPLAIN (or you will not get full credit).

b. What is the constant volume heat capacity (C_v) of 1 mole of an ideal diatomic gas at room temperature? Explain. What is the heat capacity at constant pressure (C_p) for this same system? Explain.
Note: at this temperature, the vibrational modes are not excited.

c. Consider a real gas, with attractive intermolecular interactions that undergoes a **free expansion** (the external pressure is zero) in **a thermally insulated** container to twice its initial volume. In this process, will ΔU be positive, negative or zero? Explain.

Question 2: 15 points

Consider a real gas with equation of state:

$$P = \frac{RT}{\overline{V} - b} - \frac{a}{T^{1/2}} \frac{1}{\overline{V}\left(\overline{V} + b\right)}$$

and $\overline{V} = \frac{V}{n}$

Consider the reversible isothermal expansion at a temperature T of 1 mol of this gas from an initial state with volume V_1 to a final state with volume V_2. Find an expression for w and ΔU for this process. Simplify your expressions (i.e. evaluate all partial derivatives and integrals). Show all your work! Write your final answer in the table below:

	WORK	ΔU
Expression		

The following integral may be useful:

$$\int_{V_1}^{V_2} \frac{dV}{(V-b)} = \ln \frac{(V_2 - b)}{(V_1 - b)}$$

$$\int_{V_1}^{V_2} \frac{dV}{V(V+b)} = \frac{1}{b} \ln \frac{V_2(V_1 + b)}{V_1(V_2 + b)}$$

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Question 3: DERIVATIONS (10 points)

Consider a real gas with equation of state:

$$\bar{V} = \left(\frac{RT}{P}\right) + B(T)$$

where B(T) means that B is a function of T.

a) Obtain an expression for $\left(\frac{\partial H}{\partial P}\right)_T = V - T\left(\frac{\partial V}{\partial T}\right)_P$ in terms of $T, B(T)\ and\ \frac{dB(T)}{dT}$ for one mole of gas.

b) Use the properties of mixed derivatives of state functions and the result of part a) to obtain an expression for $\left(\frac{\partial C_p}{\partial P}\right)_T$ for (one mole) of this gas.
Your final expression should contain some (not necessarily all!) of the following terms: $T, B(T), \frac{dB(T)}{dT}\ and\ \frac{d^2B(T)}{dT^2}$.

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BONUS QUESTION: 2 POINTS

Show that $\left(\frac{\partial H}{\partial P}\right)_T = V - T\left(\frac{\partial V}{\partial T}\right)_P$

Hint: Use the fact that H=U+PV and that $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$

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