

Name: _____
110 points
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Test 1
Chemistry 361
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$$\kappa_T = (\partial V / \partial p)_T / V \quad \alpha = (\partial V / \partial T)_p / V \quad C_{V,m} = 3 R / 2 \text{ (monatomic perfect gas)}$$

$$R = 8.31451 \text{ J mol}^{-1} \text{ K}^{-1} = 0.0820578 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

Answer the following multiple choice questions for 10 points each.

Must show complete work for full credit to be given:

- Which of the following is true of the critical point?
A) $(\partial V_m / \partial T)_p = 0$ B) $(\partial^2 V_m / \partial T^2)_p = 0$ C) $(\partial P / \partial T)_V = 0$
D) $(\partial P / \partial V)_T = 0$ E) $(\partial U / \partial T)_V = 0$
- Calculate the work **done** by 1.0 mol of a perfect diatomic gas expanding isothermally and reversibly from 20.0 L and 1.23 atm to 60.0 L and 0.410 atm at 300.0 K.
A) 0.00 J B) 16.4 L atm C) 27.0 L atm D) 49.2 L atm E) 81.1 L atm
- For a gas like CO_2 with $Z < 1$, will the isothermal compressibility be larger, smaller or the same as a perfect gas at a temperature above the critical temperature?
A) much larger B) slightly larger C) identical D) slightly smaller E) much smaller

Choose two of the following three exercises for 15 points:

- When 0.2715 g of fructose ($\text{C}_6\text{H}_{12}\text{O}_6$) was burned in a bomb calorimeter of calorimeter constant 437 J K^{-1} the temperature rose by 9.69 K. Calculate the heat of combustion, the internal energy change of combustion and the heat of formation for fructose. The heats of formation for CO_2 (g) and H_2O (l) are -393 kJ mol^{-1} and -285 kJ mol^{-1} respectively.
- The isothermal compressibility of copper at 293K is $2.35 \times 10^{-7} \text{ atm}^{-1}$. Calculate the pressure that must be applied to increase its density by 0.10 %.
- A sample of carbon dioxide of mass 2.45 g at 300 K is allowed to expand reversibly and adiabatically from 500.0 mL to 3.00 L. What is the work done by the gas?

Choose two of the following four problems for 25 points each:

- The equation of state of a certain gas is given by $p = R T / V_m + (a + b T) / V_m^2$ where a and b are positive constants. Find $(\partial V / \partial T)_p$.
- Show that the ΔH for the adiabatic expansion of a perfect gas may be calculated by integration of $dH = V dp$, and evaluate the integral for reversible adiabatic expansion.
- Given that $\mu C_{p,m} = T (\partial V_m / \partial T)_p - V$, derive an expression for μ for a Van der Waals gas. Evaluate μ for xenon ($a = 4.250 \text{ atm L}^2 \text{ mol}^{-2}$ and $b = 5.105 \times 10^{-2} \text{ L mol}^{-1}$) at 300.0 K and 1.0 atm, where the molar volume of the gas is 24.6 L mol^{-1} .
- The speed of sound, c_s , in a gas of molar mass M is related to the ratio of heat capacities γ by $c_s = (\gamma R T / M)^{1/2}$. Show that $c_s = (\gamma p / \rho)^{1/2}$, where ρ is the mass density of the gas. Calculate the speed of sound in argon at 25 °C and 1.0 atm (treating argon as an ideal monatomic gas).