PHYS 340

Homework assignment #3

3-1. One mole of an ideal gas undergoes an isothermal expansion. Find the heat added to the gas in terms of the initial and final volumes and the temperature.
Answer: $RT \ln (V_f/V_i)$

3-2. Let 20.9 J of heat be added to a particular ideal gas. As a result, its volume changes from 50.0 cm^3 to 100 cm^3 while the pressure remains constant at 1.00 atm. (a) By how much did the internal energy of the gas change? If the quantity of gas present is 2.00 x 10^{-3} mol, find the molar specific heat at (b) constant pressure and (c) constant volume.
Answer: a. 15.9 J; b. 34.4 J/mol.K; c. 26.1 J/mol. K

3-3. A quantity of ideal monatomic gas consists of n moles initially at temperature T_1. The pressure and volume are then slowly doubled in such a manner as to trace out a straight line on a P- V diagram. In terms of n, R, and T_1, what are (a) W, (b) ΔU and (c) Q?

3-4. A container holds a mixture of three no reacting gases: n_1 moles of the first gas with molar specific heat at constant volume C_1 , and so on. Find the molar specific heat at constant volume of the mixture, in terms of the molar specific heats and quantities of the separate gases.
Answer: $(n_1C_1 + n_2C_2 + n_3C_3)/(n_1 + n_2 + n_3)$

3-5. One mole of an ideal diatomic gas undergoes a transition from a (5 kPa; 2 m^3) to c (2 kPa; 4 m^3) along the diagonal path. The temperature of the gas at point a is 1200 K. During the transition, (a) what is the change in internal energy of the gas, and (b) how much heat is added to the gas? (c) How much heat must be added to the gas if it goes from a to c along the indirect path abc with b(5 kPa; 4 m^3)?
Answer: a. -5 kJ; b. 2.0 kJ; c. 5.0 kJ

3-6. One mole of oxygen (O_2) is heated at constant pressure starting at 0°C. How much heat must be added to the gas to double its volume? (The molecules rotate but do not oscillate.)

3-7. Suppose 12.0 g of oxygen (O_2) is heated at constant atmospheric pressure from 25.0°C to 125°C. (a) How many moles of oxygen are present? (The molar mass for O_2 is 32 g/mol) (b) How much heat is transferred to the oxygen? (The molecules rotate but do not oscillate.) (c) What fraction of the heat is used to raise the internal energy of the oxygen?
Answer: a. 0.375 mol; b. 1090 J; c. 0.714

3-8. Suppose 4.00 mol of an ideal diatomic gas, with molecular rotation but not oscillation, experiences a temperature increase of 60.0 K under constant-pressure conditions. (a) How much heat was added to the gas? (b) How much did the internal energy of the gas increase? (c) How much work was done by the gas? (d) How much did the translational kinetic energy of the gas increase?

3-9. A mass of gas occupies a volume of 4.3 L at a pressure of 1.2 atm and a temperature of 310 K. It is compressed adiabatically to a volume of 0.76 L. Determine (a) the final pressure and (b) the final temperature, assuming the gas to be an ideal gas for which $\gamma = 1.4$.
Answer: a. 14 atm; b. 620 K

3-10. (a) One liter of gas with $\gamma = 1.3$ is at 273 K and 1.0 atm pressure. It is suddenly compressed (adiabatically) to half its original volume. Find its final pressure and temperature. (b) The gas is now cooled back to 273 K at constant pressure. What is its final volume?

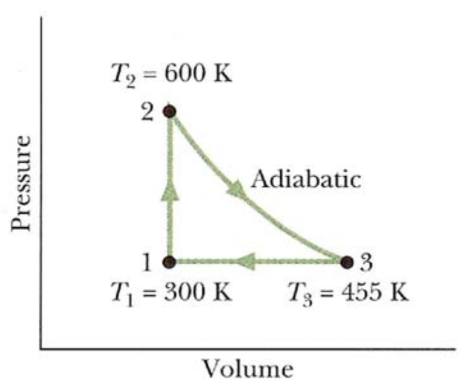
3-11. Let *n* moles of an ideal gas expand adiabatically from an initial temperature T_1 to a final temperature T_2. Prove that the work done by the gas is $n\, C_v(T_2 - T_1)$, where C_v is the molar specific heat at constant volume.

3-12. An ideal gas experiences an adiabatic compression from $P = 1.0$ atm, $V = 1.0 \times 10^6$ L, $T = 0.0°C$ to $P = 1.0 \times 10^5$ atm, $V = 1.0 \times 10^3$ L. (a) Is the gas monatomic, diatomic, or polyatomic? (b) What is its final temperature? (c) How many moles of gas are present? (d) What is the total translational kinetic energy per mole before and after the compression? (e) What is the ratio of the squares of the rms speeds before and after the compression?
Answer: a. monatomic; b. 2.7×10^4 K; c. 4.5×10^4 mol; d. 3.4 kJ; e. 0.01

3-13. A sample of ideal gas expands from an initial pressure and volume of 32 atm and 1.0 L to a final volume of 4.0 L. The initial temperature of the gas is 300 K. What are the final pressure and temperature of the gas and how much work is done by the gas during the expansion, if the expansion is (a) isothermal, (b) adiabatic and the gas is monatomic, and (c) adiabatic and the gas is diatomic?

3-14. An ideal gas, at initial temperature T_1 and initial volume 2 m^3, is expanded adiabatically to a volume of 4 m^3, then expanded isothermally to a volume of 10 m^3, and then compressed adiabatically until its temperature is again T_1. What is its final volume?
Answer: 5 m^3

3-15. One mole of an ideal monatomic gas traverses the cycle shown in figure. Process 1 → 2 takes place at constant volume, process 2 → 3 is adiabatic, and process 3 → 1 takes place at constant pressure. (a) Compute the heat *Q*, the change in internal energy ΔU and the work done *W*, for each of the three processes and for the cycle as a whole. (b) If the initial pressure at point 1 is 1.00 atm, find the pressure and the volume at points 2 and 3. Use 1.00 atm = 1.013×10^5 Pa and $R = 8.314$ J/mol.K.



Answer: a. in joules, in order Q. ΔU, W: 1→2: 3740, 3740, 0; 2→3: 0, -1810, -1810; 3→1: 3220, -1930, 1290; cycle: 520, 0, -520; b. $V_2 = 0.0246\ m^3$, $P_2 = 2.00$ atm, $V_3 = 0.0373\ m^3$, $P_3 = 1.00$ atm.

3-16. Consider a real gas at:
1. high pressure and small volume;
2. high pressure and low temperature
3. low pressure and high temperature.
For which of these sets of conditions will this real gas behave most like an ideal gas? Can this gas be

expected to deviate from the ideal gas behavior for any of the above conditions?

3-17. Express the Van der Waals equation of state in the virial form.

3-18. Using the Van der Waals equation, calculate the volume of a mole of gas at 300K and 10.1 MPa pressure. The values of a and b in the equation are 0.137 l^2 MPa mol^{-2} and 0.032 l mol^{-1}, respectively.

3-19. If the virial equation is given in the form

$$\frac{PV}{RT} = 1 + \frac{B'}{V} + \frac{C'}{V^2} + \ldots$$

find, for a Van der Waals gas, B' in terms of the Van der Waals constants.