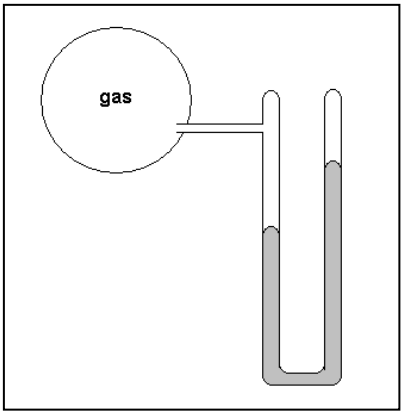
Chemistry 311 **PHYSICAL CHEMISTRY** Fall 2004
Examination 1 Extra Credit Due: October 13, 2004

All questions are worth 10 points each. Answer all questions clearly, and show all work. If you run out of space, please use the back side of the sheets. If you use the back side of the paper, please clearly indicate the number of the question you are answering. Please also remember that I can only grade what I can read. Useful mathematical relations and values of constants not given in the questions are given on a separate page.

1. Give the technical term for each of the descriptions below.

	Description	**scientific/technical term**
(a)	The temperature above which a gas cannot be liquefied by compression.	
(b)	A curve in P-V space along with the temperature is constant.	
(c)	A constant pressure process	
(d)	The heat absorbed during the melting of a solid	
(e)	A process in which the system and surroundings are always in equilibrium	

2. If the height difference of the mercury in the manometer in the picture is 230 mm, what is the pressure of the gas in the bulb in Pascal? Density of Hg = 13.595 g cm^{-3}.



3. One of the assumptions made in the kinetic molecular theory of gases (and thus in the ideal gas law) is corrected in the van der Waals equation by the term a/V_m^2 added to the pressure term. What is the assumption?

4. Boyle temperature is defined as the temperature at which the compression factor Z of a gas is exactly equal to 1. A gas obeys the following equation of state:

$$PV_m = RT\left\{1+\left(b-\frac{a}{RT}\right)\frac{1}{V_m}+\ldots\right\},$$

where a and b are constants, and we have neglected the higher powers of $(1/V_m)$. Determine the Boyle temperature T_B for the gas in terms of the constants.

5. Classify the following as exact (state-dependent) and inexact (path-dependent) differentials.

Property	Classification (exact/inexact)
(a) dT	…….
(b) dq	…….
(c) dq_P	…….
(d) dw	…….
(e) dP	……

6. Methane is heated from 298 K to 500 K at constant pressure. Find ΔH for the process. Given, $C_{P,m} = 23.64 + 47.86\times10^{-3}\ T - 1.92\times10^{5}/T^2$.

7. Find the standard enthalpy of reaction for

$$C_2H_5OH(l) + \tfrac{1}{2}O_2(g) \rightarrow CH_3CHO(l) + H_2O(l)$$

given that the enthalpies of combustion for $C_2H_5OH(l)$ and $CH_3CHO(l)$ are -1370.7 kJ mol^{-1} and -1167.3 kJ mol^{-1} respectively.

8. A gas obeys the equation of state $P(V-nb) = nRT$.

(a) Derive the expression for w_{rev} for an isothermal reversible expansion involving the gas.

(b) What is the value of w_{rev} for one mole of this gas with $b = 0.0304$ L mol^{-1} for a reversible isothermal expansion from 3.0 L to 6.0 L at 300 K?

9. Is the work calculated in Q. 8 done on the system or by the system? Why?

10. What assumption in the ideal gas law is corrected by the term subtracted from V in the equation of state given in Q. 8?

Constants, conversion factors, and Useful Mathematical Relations:

Gas constant $R = 0.083145$ L bar K^{-1} $mol^{-1} = 8.3145$ J K^{-1} mol^{-1}.

Acceleration due to gravity: $g = 9.81$ m s^{-2}.

1 bar = 10^5 Pa

1 L = 1 dm^3 = 10^3 cm^3 = 10^{-3} m^3 1 m = 100 cm 1 kg = 10^3 g

- Pressure exerted by a liquid column of height h:

$$P = \rho g h,$$

where ρ is the density of the liquid and g is the acceleration due to gravity.

- Ideal gas law for one mole of gas:

$$PV_m = RT.$$

- The van der Waals equation for one mole of gas:

$$\left(P + \frac{a}{V_m^2}\right)(V_m - b) = RT.$$

- Compression factor (for any gas):

$$Z = \frac{PV_m}{RT}.$$

- Fundamental thermodynamic definitions:

$$dH = C_{P,m}dT.$$
$$dU = C_{V,m}dT.$$

- General definition of work of expansion/compression of a gas:

$$dw = -PdV.$$

- Useful integrals:

$$\int \frac{dx}{x} = \ln x + c,$$

$$\int x^n dx = \frac{x^{n+1}}{n+1} + d,$$

where c and d are constants of integration.