Chemistry 217
Problem Set 2

2.1 A mole of ethane is contained in a 200 mL cylinder at 373 K. What is the pressure according to

(a) the ideal gas law and

(b) the Van der Waals equation?

The Van der Waals constants for ethane are a = 5.562 $L^2.bar.mol^{-2}$ and b = 0.06380$L.mol^{-1}$.

2.2

(a) One mole of an ideal gas initially at 20°C and 20 bar is expanded isothermally and reversibly to a final volume of 300 L. Calculate the final pressure, the heat, and the work in the change of state.

(b) One mole of a monatomic ideal gas initially at 10°C and 20 bar is expanded adiabatically and reversibly to a final volume of 300 L. Calculate the final pressure, the heat, and the work in the change of state. (You may need $C_V = 3R/2$)

2.3 You want to heat 1 kg of water at 10°C, and you have the following four methods under consideration. The heat capacity of water is 4.184 $J.K^{-1}.g^{-1}$.

(a) You can heat it with a mechanical eggbeater that is powered by a 1-kg mass on a rope over a pulley. How far does the mass have to descend in the earth's gravitational field to supply enough work?

(b) You can send 1 A through a 100 Ω resistor. How long will it take?

(c) You can send the water through a solar collector that has an area of 1 m^2. How long will it take if the sun's intensity on the collector is 4 $J.cm^{-2}.min.^{-1}$?

(d) You can make a charcoal fire. The heat of combustion of graphite is −393 $kJ.mol^{-1}$. that is, 12 g of graphite will produce 393 kJ of heat when it is burned to $CO_2(g)$ at constant pressure. How much charcoal will have to burn?

2.4 Show the differential df is inexact.

$$df = dx - \frac{x}{y}dy$$

Thus, the integral $\int df$ depends on the path. However, we can define a new function g by

$$dg = \frac{1}{y} df$$

which has the property that dg is exact. Show that dg is exact, so that

$$\oint dg = 0$$

2.5 Show that the function f(x,y) defined by

$$df(x, y) = (x + 2y)dx - xdy$$

is inexact. Test to see whether the integrating factor $1/x^3$ makes it an exact differential.

2.6 Show that the function defined by

$$df(x, y) = (y^2 - xy)dx - x^2 dy$$

is inexact. Test the integrating factor $1/xy^2$ to see whether it produces an exact differential.

2.7 One mole of nitrogen at 25°C and 1 bar is expanded reversibly and isothermally to a pressure of 0.132 bar.

(a) What is the value of w?

(b) What is the value of w if the nitrogen is expanded against a constant pressure of 0.132 bar?

2.8

(a) Derive the equation for the work of reversible isothermal expansion of a van der Waals gas from V_1 to V_2.

(b) A mole of CH_4 expands reversibly from 1 to 50 L at 25°C. Calculate the work in joules assuming

i) the gas is ideal

ii) the gas obeys the van der Waals equation. For $CH_4(g)$, a = 2.283 L^2.bar.mol^{-2} and b = 0.04278 L.mol^{-1}.