# CYL501 2011-2011

Homework 1

August 5, 2011

1. A cylinder fitted with a sliding piston contains a volume $V$ of a gas which exerts a pressure $P$ on the piston. The gas expands slowly, pushing the piston outward. The following data are taken:

| $P$/bar | 15 | 12 | 9 | 6 | 4 | 2 |
|---|---|---|---|---|---|---|
| $V/\mathrm{m}^3$ | 0.0300 | 0.0361 | 0459 | 0644 | 0.0903 | 0.1608 |

   Calculate the work done by the gas on the piston.

2. The numerical $P - V$ data in the problem no. 1 can be very closely fit by the equation $PV^{1.2} = 0.2232$. Make use of this expression for the evaluation of the work integral.

3. The differential equation relating hydrostatic pressure to fluid depth is $dP = -\rho g dz$, where $\rho$ is the local density, $g$ is the local acceleration due to gravity, and $z$ is the elevation above the fluid. Apply this equation to develop an expression for the atmospheric pressure as a function of elevation above the surface of the earth.

4. A perfectly insulated rigid container of total volume $V^t$ is divided into two parts by a partition of negligible volume. One side of the partition contains $n$ mole of an ideal gas with constant heat capacities at a temperature $T_i$, and the other side is evacuated. If the partition is broker, calculate $q$, $w$, and $\Delta U$ for the ensuing process, and the final temperature and pressure, $T_f$ and $P_f$, of the gas.

5. (a) A small Dewar vessel, containing a 10-ohm resistor and a sensitive thermometer, is used as a calorimeter. When 0.01 mole of metallic zinc is added to excess dilute aqueous HCl in this calorimeter, a temperature rise of 2.429 K is swiftly produce by the reaction: Zn(s) + $2H^+$ (aq = $Zn^{2+}$ (aq) + $H_2$(g). The calorimeter and its contents are then permitted to cool slowly back to their original temperature. At this point a 12-volt difference of potential is applied for 2.00 minutes to the 10.00-ohm resistor, and the total temperature rise so produced is found to be 2.757 K. Indicating any special assumptions used in obtaining your answer, calculate $\Delta H$, per mole of Zn, for the reaction written above.

   (b) In a similar determination, the addition of 0.01 mole of ZnO to the same volume of equally dilute aqueous HCl yields $\Delta H = -21.5$ kcal per mole of ZnO for the reaction ZnO(s) + $2H^+$ (aq) = $Zn^{2+}$ (aq) + $H_2O$(l). Given that for liquid $H_2O$, $\Delta H_f = -68.3$ kcal/mole, calculate the heat of formation of ZnO.

   (c) The calculation is part 5b involves a major implicit assumption – well justified in the present case by good agreement of the calculated value with that measured directly. What is that assumption?

6. The vernier rockets used to maneuver space vehicles may be fueled with an aqueous solution that is 73 % by weight $H_2O_2$. When the rocket is to be actuated, this solution is forced through a catalyst that brings about rapid completion of the reaction

$$H_2O_2(l) = H_2O(l) + \frac{1}{2}O_2(g), \quad \Delta H_{298} = -23.4 \text{ kcal}.$$

   If the solution enters the catalyst chamber at 298 K, at what temperature will the reaction products leave that chamber? What auxiliary simplifying assumptions have you made?

   As values of $C_P$ use for $H_2O$(l), 18 cal/mole-K; for $H_2O$(g), 9 cal/mole-K; for $O_2$(g), 7 cal/mole-K. As the molar heat of vaporization of liquid water use $\Delta H_{\text{vap}} = 9.7$ kcal/mole.