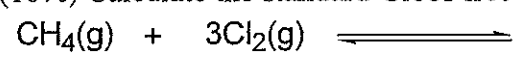
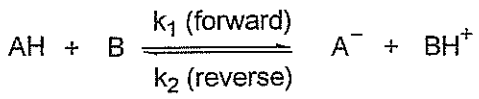
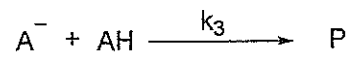
1. (10%) Calculate the standard Gibbs free energy and the equilibrium constant at 25 °C for the reaction:



	The standard Gibbs free energy of formation at 25 °C	
$CH_4(g)$	-50.72 kJ mol^{-1}	Gas constant (R) = 8.3145 J K^{-1} mol^{-1}
$Cl_2(g)$	0.00 kJ mol^{-1}	
$CHCl_3(l)$	-73.66 kJ mol^{-1}	
$HCl(g)$	-95.30 kJ mol^{-1}	

2. (10%) An acid (AH) is deprotonated by a base (B) to give A^- and BH^+. A^- then reacts with AH to furnish P. A proposed mechanism is depicted below (k is rate constant). Please use the steady-state approximation to find the concentration of A^- and estimate the rate equation for the formation of P.





3. (10%) (a) Give the gas constant (R) in L Torr K^{-1} mol^{-1}. (R = 8.3145 J K^{-1} mol^{-1}; 1 Torr = 133.322 Pa)
(b) 250 cm^3 of a gas is confined in a glass vessel. The pressure is 152 Torr and the temperature is 298 K. The mass of the gas is 33.5 mg after correcting for buoyancy effects. Please calculate the molar mass of the gas based on the above mentioned.

4. (20%) A perfect gas in a cylinder is separated by a frictionless adiabatic piston into two sections: A and B. Initially gases in the two sections have identical temperature (300 K), volume (2.00 L), and mole (2.00 mol). Heat is supplied to Section A and the piston moves reversibly unit the final volume of Section B is reduced to 1.00 L. Throughout the process, Section B is maintained at 300 K. Please calculate (a) the work done by the gas in Section A, (b) ΔU for the gas in Section B, (c) q for the gas in Section B, (d) ΔU for the gas in Section A, and (e) q for the gas in Section A. Assume $C_{V,m}$ = 20 J K^{-1} mol^{-1}.

5. (8%) Determine ΔS for 100.0 g of supercooled liquid water at -10.0 °C freezing to form ice at -10.0 °C. For water, heat of fusion ΔH_f = 6.0095 kJ mol^{-1} at 0 °C. $C_{p,m}$ = 75.3 J K^{-1} mol^{-1} for liquid water and 38.0 J K^{-1} mol^{-1} for ice.

6. (10%) Predict the ideal solubility of lead (Pb) in bismuth (Bi) at 280 °C given that the melting point of Pb is 327 °C and its enthalpy of fusion is 5.2 kJ mol^{-1}.

7. (8%) A 0.20 mm (internal radius) capillary tube and a 0.10 mm capillary tube were placed into a sample of liquid H_2O_2. The difference between the heights of the liquid in the tubes is 5.50 cm. Given that the density of H_2O_2 is 1.41 g cm^{-3}, determine the surface tension of H_2O_2.

8. (14%) Consider 1.00 mol of liquid water at 100 °C to be the warm heat reservoir for a Carnot engine. As heat is drawn from this reservoir by the engine, the temperature of the heat reservoir drops. (a) How much work can be obtained from this reservoir as it cools to the temperature of the cool heat reservoir at 0 °C? Assume $C_{p,m}$ = 75.3 J K^{-1} mol^{-1} for water in this temperature range. (b) What is the efficiency of this process?

9. (10%) For the cell Pt | $H_2(g,p^\circ)$ | HCl(aq) | AgCl(s) | Ag at 25 °C and a molality of HCl of 0.010 mol kg^{-1}, E = +0.4658 V. Assuming that the Debye-Huckel limiting law holds at this concentration, calculate E°(AgCl, Ag). Faraday's constant F = 9.6485 × 10^4 C mol^{-1} and Debye-Huckel constant A = 0.509.

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