1. (8%) The mean solar flux at the Earth's surface is about 2.0 J/cm^2/min. Using a solar collector, the temperature of the device can reach 85.0 °C. A heat engine is operated using the collector as the hot reservoir and a cold reservoir at 25 °C. What area of the collector is needed to produce 746 W? Assume the engine operates at the maximum Carnot efficiency.

2. (9%) An automobile tire contains air at 2.25 × 10^5 Pa pressure and temperature of 25 °C. The stem valve is removed and air flows out adiabatically against a constant external pressure of 1 bar. The final pressure of the air is 1 bar. What is the final temperature? For air, the molar constant volume heat capacity is 2.5R where R is the ideal gas constant.

3. (8%) Calculate ΔG and ΔS for mixing 1 mole of He (gas), 3.0 mole of Ne (gas), 2.0 mole of Ar (gas), and 2.5 mole of Xe (gas) at T = 25 °C and P = 1 bar.

4. For the reaction, FeO(s) + CO(g) ⇄ Fe(s) + CO$_2$(g), the equilibrium constants (expressed in species partial pressures) at two temperatures have been determined to be 0.688 at 700 °C and 0.310 at 1200 °C.
   (a) (9%) Calculate ΔG^0, ΔH^0, ΔS^0 of the reaction at 700 °C. The standard pressure P^0 is 1 bar.
   (b) (8%) Calculate the mole fraction of CO$_2$ gas in the gas phase at 700 °C.

5. (8%) The vapor pressure over ice has been measured at different temperatures. At -53 °C, it is 2.732 torr and at -43 °C, it is 9.195 torr. Determine the enthalpy of sublimation of ice in this region of temperature.

6. (8%) A 2-cm diameter spherical ball made of stainless steel (density = 7.90 g/cm^3) is dropped at 25 °C through glycerol (viscosity = 10690 millipoise, density = 1.2613 g/cm^3). What is the expected terminal velocity of the ball?

7. Co and Ni have very similar standard reduction potentials at 25 °C:
   Ni^{2+}(aq) + 2e^- → Ni(s)　E_{red}^0 = -0.250 V
   Co^{2+}(aq) + 2e^- → Co(s)　E_{red}^0 = -0.277 V
   (a) (8%) What is the equilibrium constant for Ni^{2+} + Co ⇄ Ni + Co^{2+}?
   (b) (8%) For the cell Co(s) | Co^{2+}(aq, a = 1) || Ni^{2+}(aq, a = 0.01) | Ni(s) with ion activities as shown, what is the spontaneous net reaction that would occur if current was allowed to flow between the metal electrodes?

8. (10%) The reaction that transforms ozone into dioxygen, O$_3$ + O → 2O$_2$, is catalyzed by chlorinated species. The mechanism is

   $$Cl + O_3 \xrightarrow{k_1} ClO + O_2$$

   $$ClO + O \xrightarrow{k_2} Cl + O_2$$

   Solve for the rate law at steady state in terms of the reactants ([O$_3$] and [O]) and the total concentration of chlorine [Cl]$_{tot}$ which is defined as [Cl]$_{tot}$ = [ClO] + [Cl].

9. (8%) The adsorptions of two gases, A and B, are described well by the Langmuir isotherm with the Langmuir constant b_A = 0.85 and b_B = 1.75 kPa^{-1} at 25 °C. Calculate the total pressure of a 50:50 mixture of these gases at which the fractional coverage of gas A is 0.15.

10. (8%) The self-diffusion coefficient of pure water at 25 °C is determined to be 2.25 × 10^{-9} m^2/s. Under these conditions, determine the diameter of a water molecule, assuming it is a sphere.

試題隨卷繳回