NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF FIRST SEMESTER EXAMINATIONS – DECEMBER 2004
PHYSICAL CHEMISTRY I – SCH 2104
TIME: (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES

Answer FIVE questions only. Total marks – 100.

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1. (a) Air at 1 bar and 25°C enters a compressor at low velocity, discharges at 3 bar, and enters a nozzle in which it expands to a final velocity of 600m/s at the initial conditions of pressure and temperature. If the work of compression is 240kJ/kg of air, how much heat must be removed during compression? (8 marks)

   (b) At 273.16K the enthalpy change of fusion of water is 6.0kJ/mol and the corresponding volume change of -1.6×10^{-6} m^3/mol. Estimate the temperature at which ice will melt at 1000atm pressure. (take 1 atm $= 10^5 Nm^{-2}$) (7 marks)

   (c) Calculate the osmotic pressure of a sucrose solution of concentration 0.10dm^{-3} mol at 303K. The molecular weight of sucrose is 342.3g/mol (5 marks)

2. (a) Determine the vapor pressure of n-heptane at 58.7°C and 98.4°C using Clausius-Clapeyron equation. In the literature it is reported that its vapor pressure is 40mmHg at 22.3°C and that the latent heat of vaporization at 25°C is 364.94kJ/kg. The molecular weight of n-heptane is 100kg/mol and R = 8.314kJ/Kmol. (14 marks)

   (b) If the refractive index of water at 20°C is 1.330 for light of wavelength 589cm, calculate the polarizability volume of the molecule at this frequency. $N_A = 6.022 \times 10^{23}$ mol^{-1} $\rho = 0.9893 g/cm^3$ (6 marks)

3. (a). There is need to heat 1 mol of air from 200°C to 700°C at 1 atm pressure. Determine the heat required?
   Cp between 25°C and 200°C is 29.39kJ/Kmol
   Cp between 25°C and 700°C is 30.71kJ/Kmol (12 marks)

   (b). Determine the standard heat of formation for the following reactions:

   (i) $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$

   (ii) $2FeS_2(s) + 11/2O_2(g) \rightarrow Fe_2O_3(s) + 4SO_2(g)$

Component	ΔH°_f kJ/mol
HCl(g)	-92.3557
$NH_3(g)$	-46.2134
$NH_4Cl(s)$	-315.541
$FeS_2(s)$	-177.989
$O_2(g)$	0
$Fe_2O_3(s)$	-822.549
$SO_2(g)$	-297.039

(8marks)

4 A mass of 20kg has an initial internal energy of 50kJ/kg, an elevation of 150m, and a velocity of 225m/s, both measured relative to the surface of the earth. Determine the kinetic, potential and total energies of the mass relative to the surface of the earth assuming that the local acceleration of gravity is $9.8 m/s^2$
(20 marks)

5. (a) A 0.5kg block of copper initially at 80°C is cooled by immersion in an insulated tank containing 5kg liquid water at 23°C. The heat transfer process continues until the copper and the water reach thermal equilibrium. Determine the entropy change for the copper and the entropy change for the water during this process.
Cp for copper is 0.38kJ/kgK
Cp for water is 4.186kJ/kgK (12 marks)

(b) Calculate the separation between the two lowest quantised translational energy levels for oxygen molecule in a one-dimensional container of length 6 cm. (8 marks)

6. (a) What is the maximum thermal efficiency of a heat engine that operates between temperature reservoirs of 100°C and 0°C. Use a sketch diagram.
(8 marks)

(b) The emf of the cell Ag/Ag Cl(s)/HCl(aq)/Hg_2Cl_2/Hg is 0.0421V at 298K and 0.0489V at 308K.Use this information to estimate $\Delta G, \Delta S$ and ΔH for the cell reaction.
$2Ag + Hg_2Cl_2 \rightarrow 2AgCl + 2Hg$ at 298K (12 marks)

END OF QUESTION PAPER!!!!!