NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF SECOND SEMESTER EXAMINATIONS – MAY 2004
PHYSICAL CHEMISTRY I – SCH 2104
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES

Answer **All** questions from Section A and **ANY THREE** questions from Section B.

F = 96500 C / mol R = 8.314 J/(mol)K

Section A -40marks

1. (a) At very high temperature Kc=$1x10^{-13}$ for 2HF(g) === $H_2(g) + F_2(g)$. At a certain time the following concentrations were detected [HF] =0.500M, $[H_2]=1x10^{-3}$ and $[F_2]=4x10^{-3}$. Is the system at equilibrium? If not, what must occur in order for equilibrium to be established? (6marks)

2.A horizontal piston/cylinder arrangement is placed in a constant-temperature bath. The piston slides in the cylinder with negligible friction and an external force holds it in place against an initial gas pressure of 14bar. The initial gas volume V_1 is $0.03m^3$. The external force on the piston is reduced gradually allowing the gas to expand until its volume doubles. Experiment shows that under these conditions the volume of the gas is related to its pressure in such a way that the product PV is constant.

(a) Calculate the work done by the gas in moving the external force. (6marks)
(b) How much work would be done if the external force were suddenly reduced to half its initial value instead of being gradually reduced? (4marks)

3. Air at 1bar and 25°C enters a compressor at low velocity, discharges at 3bar and enters a nozzle in which it expands to a final velocity of $600ms^{-1}$ 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? (6marks)

4. (a) Given the following information

$PbO(s) + CO(g) \rightarrow Pb(s) + CO_2(g)$; $\Delta H°rxn = -69.96kJ$
$\Delta H°f$ for $CO_2(g) = -396.8kJ/mol$
$\Delta H°f$ for $CO(g) = -115.6kJ/mol$
Calculate $\Delta H°f$ for PbO(s). (6marks)

(b)The enthalpy change ΔH when water freezes at 273K is –6000kJ/mol. Cp for water is 76.4J/Kmol and for ice is 38.6J/Kmol. Calculate the enthalpy change when water freezes to 254K. (4marks)

5. With the aid of a diagram formulate the Lennard – Jones 12-6 potential highlighting the meaning of each term. (8marks)

Section B -60marks

6.Having a Carnot Machine that work between two fronts of heat at 300°C and 50°C respectively and remove from the hot front 1150kJ. Draw the sketch representing the machine and determine:
(a) ΔS for the hot front
(b) ΔS for the cold front
(c) ΔS for the whole process
(d) From the result in (c) how does the machine operate? (20marks)

7.(a) Calculate (i) ΔG^{o} in J/mol at 25°C from standard electrode potentials in the following reaction: $3Sn^{4+} + 2Cr \rightarrow 3Sn^{2+} + 2Cr^{3+}$ (4marks)
(ii) Calculate K relating it to ΔG^{o} (3marks)
(iii) Calculate K relating it to E^{o}cell (3marks)
(b)$Kp = 4.6x10^{-30}$ at 25°C and ΔH^{o}= 182.5kJ for the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$. Evaluate the equilibrium constant (K) for this reaction at 2500K and compare the two values. (10marks)

8. An ideal gas is one for which PV/T is a constant regardless of the changes it undergoes. Such a gas has a volume of $0.02271m^3$/mol at 0°C and 1bar. In the following problem, air may be considered an ideal gas with the constant heat capacities of: Cp=(7/2)R and Cv =(5/2)R and R=8.314J/(mol)K. The initial conditions of the air are 1bar and 25°C. It is compressed to 5bar and 25°C by two different mechanically reversible processes. Calculate the heat and work requirements and ΔU and ΔH of the air for each path.
(a) Cooling at constant pressure followed by heating at constant volume.
(b) Heating at constant volume followed by cooling at constant pressure (20marks)

9. (a) From the concept of Constant-Volume(Isochoric) Process and Constant-Pressure(Isobaric) process show that Cp =Cv +R (10marks)
(b)An electron is confined to a molecule of length 1nm(≈5atoms), what is
(i) its minimum energy (5marks)
(ii) its minimum excitation energy from that state (5marks)
Additional information:
$E_n = n^2h^2/8mL^2$, $h=6.6262x10^{-34}$J.s, $m_e = 9.10956x10^{-31}$kg

10. (a)With the aid of sketch diagrams and equations explain the three chemical equilibrium criteria. (15marks)
(b) Calculate the osmotic pressure of a certain aqueous solution at 55°C using the following formulae: $\pi V_1^{*} = -RT\ln a_1$ and using the following data all at 55°C.
Vapor pressure of solution = 5.325kPa
Vapor pressure of pure water =5.538kPa
Density of pure water $=0.9875gcm^{-3}$ (5marks)

End of question paper!!!!!