Uva Wellassa University, Sri Lanka
Faculty of Science and Technology
Science and Technology Degree Programme
3rd Year 2nd Semester Examination – August/September 2014

Uva Wellassa University

SCT 331-3 Materials Chemistry I

No. of Questions: Six (06)
Answer all questions
Time allocation: Three (03) hours
Total Marks Allocated: One Hundred (100)

1. a. Write down the partition function for a system with N_i number of particles in each state with energy E_i

b. How is the above equation changed, if the degeneracy of the i^{th} level is g_i?

c. Show that the vibrational partition function for molecules is given by, $q_{vib} = \frac{1}{\left(1 - e^{-h\nu/kT}\right)}$,

where h - Planck constant
ν - frequency of vibration
k- Boltzmann constant
T- Absolute temperature.

(15 marks)

2. a. Show that the rotational energy can be expressed in units of cm^{-1}.

b. The first rotational line of ^{12}CO occurs at 3.84235 cm^{-1} and that of ^{13}CO occurs at 3.67337 cm^{-1}. Calculate the mass of ^{13}C. Assume that the interatomic distances between C and O corresponding to two isotopes are equal, i.e. $r^{12}_{CO} = r^{13}_{CO}$.

(15 marks)

3. An aqueous solution of potassium permanganate ($KMnO_4$) has a deep purple colour. In acidic solution, MnO_4^- can be reduced to the pale-pink Mn^{2+}. The standard reduction potential is 1.51 V. If this half-cell is combined with a Zn^{2+}/Zn half-cell (-0.76 V) in a galvanic cell with $[MnO_4^-] = [Mn^{2+}] = [H^+] = [Zn^{2+}] = 1.0$ M;

a. Write equations for the reactions at the anode and cathode

b. Write the notation describing the galvanic cell

c. Write a balanced equation for the overall cell reaction

d. Calculate the standard cell potential.

(20 marks)

68

4. a. i. Calculate the total electron charge required to plate 10.0 g of Cu onto a metal electrode from a $CuSO_4$ solution.

ii. What current is needed to deposit 2.00 g of Cr (s) from a solution of $Cr(NO_3)_3$ in 1.00 minute?

b. i. For the Hydrogen-Oxygen Fuel Cell, write the anode, cathode and the overall reactions.

ii. The Standard Free Energy for this reaction is -228.6 kJ/mol. Calculate the standard cell potential.

(Cu= 63.5 g/mol, Cr = 52.0 g/mol, F= 96,485 C/mol)

(20 marks)

5. a. Describe 'collision cross-section' for two spherical molecules colliding with each other. Write an expression for collision cross-section in terms of the radii of two molecules being collided.

b. Describe the 'Collision Theory' and the 'Activated Complex Theory' stating assumptions made, advantages and disadvantages in each.

(15 marks)

6. a. Describe how to separate a mixture of two volatile components into its pure components by using a temperature-composition diagram.

b. Defining all the terms, write the Debye-Hückel equation used to calculate the activity coefficient of an electrolyte.

c. Describe diffusion-controlled and activation-controlled reactions, using an irreversible second order reaction, A + B → Product, which takes place via an encounter pair AB. You may clearly assign rate constants for different steps involved.

(15 marks)