**OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE**
B.Sc. (Chemistry) Degree Examination

Part II
**Harmattan Semester Examination**

**CHM 203 – BASIC PHYSICAL CHEMISTRY**

**Answer ALL questions and answer each section on separate booklet**

July, 2011 Time Allowed: $2\frac{1}{2}$ hrs

## SECTION A

1. (a) State the important postulates of kinetic theory of gases.
   (b) A quantity of dry air at 27°C is compressed slowly to one-third of its original volume. What is the percentage change in pressure?
   (c) At what temperature, pressure remaining constant will the root-mean-square velocity becomes double its value at $T_1$ = 273 K. Let $C_1$ and $C_2$ be the velocities corresponding to $T_1$ and $T_2$.
   (d) The volume of an ideal gas goes through a temperature change from 20°C to 60°C. Obtain the relation between the average molecular energy at 20°C ($E_1$) to that at 60°C ($E_2$)
2. In the presence of a metallic catalyst, nitrogen and hydrogen react to form ammonia in a process called the Haber process. The Haber reaction is:
   $$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H^\circ = -92.22 \text{ kJ at } 298.15 \text{ K}$$
   a. Compute $K_p$ for the reaction at 298.15 K
   b. Compute the equilibrium constant at 500 K. (You may assume that $\Delta H^\circ$ is a constant equal to its value at 298.15 K)
   c. At what temperature would the equilibrium constant $K_p$ = 1. Use the same assumption as (b) above
   d. Explain how change in pressure will affect the production of ammonia. (Given $\mu^\circ$ = 0.00, 0.00 and -16.46 kJ mol$^{-1}$ for $N_2$ (g), $H_2$ (g) and $NH_3$ (g) respectively.
3. a. State Kohlrausch's law and give its application(s) [Not more that 5 lines]

   b. The molar conductivities at infinite dilution (at 25°C) of NaI, $NaCH_3CO_2$ and $Mg(CH_3CO_2)_2$ are 12.69 mS m$^2$ mol$^{-1}$, 9.10 mS m$^2$ mol$^{-1}$, and 18.78 mS m$^2$ mol$^{-1}$, respectively. What is the limiting molar conductivity of $MgI_2$ at this temperature?
   c. The standard potentials at 25 °C are:
   $$Pd^{2+}(aq) + 2e^- \rightleftharpoons Pd(s) \qquad \varepsilon^0 = 0.83V$$
   $$PdCl_4^{2-}(aq) + 2e^- \rightleftharpoons Pd(s) + 4Cl^-(aq) \qquad \varepsilon^0 = 0.64V$$
   Calculate the equilibrium constant for the reaction
   $$Pd^{2+}(aq) + 4Cl^- \rightleftharpoons PdCl_4^{2-}(aq)$$
   Calculate the $\Delta G^\circ$ for this reaction

## SECTION B

4a. Define "heat of combustion of hydrocarbons"

b. The bacterium *Acetobacter suboxyams* obtains energy for growth by oxidizing ethanol in two stages as follows:

i. $C_2H_5OH\ (l) + \frac{1}{2}O_2(g) \rightarrow CH_3CHO\ (l) + H_2O\ (l)$

ii. $CH_3CHO\ (l) + \frac{1}{2}O_2(g) \rightarrow CH_3COOH\ (l)$

The enthalpy change in the complete combustion { to $CO_2(g)$ and $H_2O$ (l)} of the three compounds are:

| Compound | $\Delta H_c^{o}\ (kJ\ mol^{-1})$ |
|---|---|
| Ethanol (l) | -1171.6 |
| Acetadehyde (i) | -1168.1 |
| Acetic acid (l) | -876.7 |

Calculate $\Delta H^{o}$ values for reactions (i) and (ii)

5a. If the decomposition reaction, $2N_2O_5 \rightarrow 4NO_2 + O_2$ has the general rate law:

$$\text{Rate} = m\frac{d[N_2O_5]}{dt} = p\frac{d[NO_2]}{dt} = -q\ \frac{d[O_2]}{dt}$$

I. Write down the values of m, p and q.

ii. If oxygen gas is produced at the average rate of $9.1 \times 10^{-4}$ mol · litre$^{-1}$ · s$^{-1}$. Over the same period, what are the average rates of the production of nitrogen dioxide and the loss of nitrogen pentoxide?

b. At 27°C, a certain reaction is 50% complete in 20.0 minutes. At 57°C, the same reaction is 50% complete in 5.0 minutes. Calculate the activation energy for the reaction (Given: R =1.987cal/K/mole).

c. For the reaction $2HI \rightarrow H_2 + I_2$ at 700K, The collision frequency obtained is $10^{34}\ m^{-2}\ s^{-1}$ by collision theory. However the experimental value is $10^{20}\ m^{-2}\ s^{-1}$. Explain this observation in **just one sentence** and give 2 reasons for the observed difference. (Give two reasons why most molecular collisions do not lead to a reaction).