West Bengal State University

B.A./B.Sc./B.Com. (Honours, Major, General) Examinations, 2010

PART – II (Honours)

CHEMISTRY

Paper – IV (A)

Duration : 2 Hours Full Marks : 50

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

Answer any *three* questions taking *one* from each Unit.

UNIT - I

1. a) State the acceptability conditions imposed on the wavefunction. Verify the acceptability of the following functions as wavefunction : 3 + 2

   i) $F(x) = e^{-x^2/2}, \{-\infty \le x \le +\infty\}$

   ii) $F(\theta) = e^{i\theta}, \{0 \le \theta \le 2\pi\}$

   b) Derive the expression for energy levels of a particle in a one-dimensional box from the de Broglie relation. 4

   c) Find the eigenfunctions and eigenvalues of the operator d/dx. If the eigenfunctions are to remain finite for $x \to \pm \infty$, find the eigenvalues. 2 + 3

   d) Sketch the probability density function for a quantum mechanical harmonic oscillator for $\upsilon = 0$ and $\upsilon = 1$ levels. 2

2. a) Consider a quantum particle of mass m confined in a zero potential energy region between impenetrable walls at $x = 0$ and $x = a$. For this system :

   i) write the time-independent Schrödinger equation.

ii) solve the equation for the wavefunction of the system.

iii) find out the expectation value of momentum, $\langle p_x \rangle$, for the system and comment on the result. 1 + 3 + 2 + 1

b) Evaluate the commutator $\left[\hat{x}, \hat{H}\right]$ for a particle in a one-dimensiional space.

The lifetime of an excited state of a molecule is 2×10^{-9} sec. What is the uncertainty in its energy in J and in cm^{-1} ? 3 + 1 + 1

c) Calculate the mean radius of a 1s orbital for the hydrogen atom.

Given : $\psi_{1s} = \left(\frac{1}{\pi a_0^3}\right)^{1/2} e^{-r/a_0}$. 4

UNIT - II

3. a) Show that the chemical potential of any ideal gas in a mixture is always less than the chemical potential of the pure ideal gas under the same total pressure.

Derive the relation, $\overline{S}_i = \overline{S}_{i(pure)} - R \ln x_i$ 2 + 2

b) For the reaction $A \rightarrow B$ at equilibrium show that $\left(\frac{\partial G}{\partial \xi}\right)_{T,p} = 0$ where ξ is the degree of advancement of the reaction.

Does the equilibrium constant of a reaction depend upon its stoichiometry ?

Under what condition does the equilibrium constant of a reaction become independent of temperature ? Explain briefly. $3 + 1\frac{1}{2} + 1\frac{1}{2}$

c) Calculate the mean ionic activity coefficient of 0·001 (M) aqueous solution of $K_3\left[Fe(CN)_6\right]$. Debye-Hückel constant is 0·51. 3

d) Show that $\frac{\partial\left(E^0/T\right)}{\partial(1/T)} = \frac{\Delta H^0}{nF}$ 3