Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS / M.TECH (MBIN) / SEM-2 / MBIN-201 / 2012

2012

BIOMOLECULAR STRUCTURE & FUNCTION-II

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

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

Answer **Group-A** and any *six* questions from the other *three* **Groups-B, C and D** taking at least *one* from each Group.

GROUP – A
(Objective Type Questions)

1. Answer any *ten* questions : 10 × 1 = 10

A) Choose the correct answer :

i) The vector $G_{hkl} = ha^* + kb^* + lc^*$ is

a) parallel to the Bragg planes with Miller indices (*hkl*)

b) perpendicular to the Bragg planes with Miller indices (*hkl*)

c) $\Delta k = \frac{1}{|G_{hkl}|}$

d) $|G_{hkl}| = d_{hkl}$.

ii) The maximum point group symmetry present in the crystal is exploited in solving a crystal structure to

a) reduce the volume of the cell

b) select a primitive cell

c) reduce the number of molecules in the cell

d) reduce the volume of the asymmetric unit.

iii) Combination of a 2 fold rotation with a mirror reflection (the mirror plane being perpendicular to the 2-fold axis of rotation) gives

a) another 2-fold axis parallel to the original two fold axis of rotation

b) another mirror plane parallel to the original mirror

c) a centre of inversion at the intersection of the two fold axis and mirror

d) another mirror parallel to the original two fold axis of rotation.

B) Fill in the blanks :

iv) Noe is related to the distance (*r*) of interacting nuclei. The relation is : Noe α ..... .

v) In 2*D* NMR appearance of ..... & ..... Noe cross-peaks act as the signature of helical structure.

C) Write *True / False* for the following :

vi) For taking *CD* spectra the amount of sample required is much higher than that required for taking *NMR* spectra.

D) Answer very briefly :

vii) Why phosphorescence is a slow process compared to fluorescence ?

viii) Calculate the value of *RT* in kcal/mole at $T = 300$ K, taking $R = 2$ cal/K/mole.

ix) What is the approximate energy needed to break a hydrogen bond in kcal/mole ?

x) Define Gibbs Free Energy.

xi) Why are the peptide bonds rigid ?

xii) Does the entropy increase or decrease when a random coil protein folds ?

GROUP – B

2. a) 100 moles of a perfect monatomic gas in a cylinder expands rapidly and adiabatically against a weightless piston. As a result, the gas cools down from 1000 K to 500 K. Calculate the work done by the gas in this expansion, taking $R = 8{\cdot}3$ J/K/mole.

b) If the same amount of the perfect gas expands isothermally to 10 times its original volume, what is the change in entropy ? 5 + 5

3. a) A molecular system consists of three non-degenerate energy levels, each separated from the previous one by an energy gap of 1·2 kcal/mole. Taking R = 2 cal/K/mole, what percentage of the molecules will populate the first excited state at T = 300 K ?

   b) Assuming that there are 3 equally probable rotational isomers for each of the two torsion angles ϕ and ψ in a 'random coil' protein molecule, what is the estimated amount of nucleation energy required to initiate a α-helix at T = 300 K ? 5 + 5

4. a) Energy needed to twist a molecule about its C – C single bond by an angle 20° from the original *trans* form ($\phi = 0$) is 0·75 kcal/mole. How much energy is needed to twist the molecule by 40° ? Assume energy $U(\phi) = \left(\frac{1}{2}\right) U_0 (1 - \cos 3\phi)$, where U_0 is the maximum energy barrier for the rotation.

   b) Lennard-Jones potential $U(r) = \left[\left(\frac{A}{r^{12}}\right) - \left(\frac{B}{r^6}\right)\right]$ operates between a given pair of non-bonded neutral atoms separated by a distance r, where the parameters A and B are constants for the pair. Find the contact distance for this pair of atoms (sum of van der Waal radii) in terms of A and B. 5 + 5

GROUP – C

5. Which pulse gives the maximum signal intensity in NMR spectroscopy ? Draw the 1D NMR pulse sequence and justify the role of relaxation time in the pulse program. How do you measure longitudinal relaxation T_1 ? How do you identify whether two protons are scalar coupled or dipolar coupled in NMR spectra ? 1 + 2 + 2 + 3 + 2

6. a) NMR spectra of a short peptide sequence (AC) Ala-Gly (NH_2) is taken initially in H_2O and then in D_2O. What changes do you expect both in 1D spectrum and 2D TOCSY spectrum of the peptide sequence during this solvent shift ? [Given : Chemical shift values (δ in ppm) of Ala : NH (8·2) CαH (4·32) CH_3 (1·37) and Gly : NH (7·98) CαH (3·96)].

   b) Draw the carton representation of chemical shift index (CSI) value for CαH using 1H and 13C NMR spectra of a short seven residue peptide sequence (A-B-C-D-E-F-G) when its B-C-D-E-F segment undergoes a transition from an alpha helical conformation to beta strand conformation under thermal melting. 6 + 4

7. a) What is an intrinsic fluorophore ? Why 'Trp' shows higher fluorescence quantum yield in comparison to 'Phe' ? How protein folding can be studied using 'Trp' fluorescence ?

   b) What is Cotton effect ? How do you resolve plane polarized light into 'RCP' and 'LCP' ?

   c) A short helical peptide is treated with varying concentration of GnCl to study the unfolding process. Using CD spectroscopy how do you monitor this 'helix-coil transition' and correlate its thermodynamic parameter for transition ? 4 + 2 + 4

GROUP – D

8. Protein *X* is a tetramer which crystallizes in the space group P222 with cell parameters $a = 56{\cdot}4$, $b = 73{\cdot}2$, $c = 35{\cdot}1$ Å, $\alpha = \beta = \gamma = 90°$, with equivalent positions

   (x, y, z), $(-x, -y, z)$, $(x, -y, -z)$ and $(-x, y, -z)$.

   a) Consider a protein atom with Cartesian coordinates :

   $$20{\cdot}564i + 33{\cdot}216k + 10{\cdot}097k$$

   Generate all the equivalent positions of this atom in the cell in fractional coordinates.

   b) What is the volume of the asymmetric unit ?

   c) If there are three molecules of protein *X* in the asymmetric unit how many protein molecules are there in the cell ?

d) If there is only one subunit of the protein in the asymmetric unit, then is the protein molecule located at a special position ? What can you infer regarding the symmetry of its quaternary structure ?

e) Addition of a centre of inversion $(-x, -y, -z)$ converts point group 222 to 2/m 2/m 2/m. What are equivalent positions of 2/m 2/m 2/m ? 5 × 2

9. a) Consider a cubic crystal with cell parameters $a = b = c = 25{\cdot}67$ Å, $\alpha = \beta = \gamma = 90°$. Given $\lambda = 1{\cdot}5418$ Å. Calculate the Bragg angle of scattering for the planes with Miller indices (222).

b) What do you understand by the term 'resolution' of a crystal structure ? Why is it important in building a database of protein crystal structure ?

c) Given all the structure factors $F_{hkl}\left(\mid F_{hkl} \mid e^{i\phi hkl} \right)$. Write down the steps to solve the crystal structure and obtain the coordinates of the atoms in the cell.

5 + 2 + 3