

Total Marks: 20, All questions compulsory

1. What group is obtained by adding to or deleting from each of the following groups the indicated symmetry operation? (4)
  - (a)  $C_3$  plus  $i$
  - (b)  $S_4$  plus  $i$
  - (c)  $C_3$  plus  $S_6$
  - (d)  $S_6$  minus  $i$
2. Write down all the operations of a  $D_{nh}$  group. What is the order of a  $D_{nh}$  group? (2)
3. Which of the following pair of operations always commute? (2)
  - (a) Two proper rotations about different axes
  - (b) Two  $C_2$  rotations about perpendicular axes
  - (c) Reflection through planes perpendicular to each other
4. If we start with the multiplication table for the group  $G_3$  (A, B, E) and add another element C, what will be the order of the new group? Write the multiplication table of the new group assuming C commutes with A and B. (1+2)
5. Prove that for a cyclic group  $G_n$ , each element is a class in itself. (2)
6. Argue that absence of  $S_n$  is a necessary and sufficient condition for dissymmetry. (2)
7. Show that the expectation value of dipole moment for a superposition state,  $\psi(t) = a_0\psi_0(t) + a_1\psi_1(t)$  is time-dependent, where  $\psi_0$  and  $\psi_1$  are solutions of the time-dependent Schrodinger equation. (3)
8. Calculate the time it takes for a 2-level system ( $M_{10} = 3.313 \times 10^{-14}$  C m) to be completely inverted, when interacting with an intense radiation ( $E_0 = 10^{-10}$  kg m C<sup>-1</sup> s<sup>-2</sup>) at resonance; Planck's constant,  $h = 6.626 \times 10^{-34}$  m<sup>2</sup> kg s<sup>-1</sup>. (2)

