① Which of the following atomic transitions are allowed?
(allowed = electrical dipole only)

I. $3p \to 2p$
II. $4f \to 1s$
III. $4f \to 3d$
IV. $4d \to 3f$

$\Delta \ell = 1$
$m_\ell = 0, \pm 1$
$\ell = 0, \ldots, n-1$

Answer:
A. All of the above
B. I, III, and IV
C. only III
D. III and IV
E. None of the above

② Which statements are true:

I. One can never know simultaneously angular momentum coordinates L_x, L_y, L_z of an electron in atom with perfect certainty $\Delta L_x = \Delta L_y = \Delta L_z = 0$

II. Spherical potential $V(r)$ means that the following operators commute $[\hat{p}, \hat{\mathcal{H}}]$, $[\hat{L}^2, \hat{\mathcal{H}}]$, and $[\hat{L}_z, \hat{\mathcal{H}}]$
where $\hat{p}$ - momentum operator,
$\hat{\mathcal{H}} = \frac{\hat{p}^2}{2m} + V(r)$
$\hat{L}^2, \hat{L}_z$ - ang. momentum operators

Answer:
A. only I
B. only II
C. both I & II
D. neither I, nor II

(3) Energy levels in H-like atoms are degenerate w.r.t. azimuthal orbital quantum number ℓ because

Answer :

A. this is the case for any central symmetric potential energy $V = V(r)$

B. the Hamiltonian commutes with $\hat{L}^2$ operator

(C) potential energy has $\frac{1}{r^a}$ dependence where $a = 1$; and it would not be the case for any $a \neq 1$