733.

Problem 50.23 (RHK)

A nucleus in an excited state will return to its ground state, emitting a gamma ray in the process. If its mean lifetime is 8.7 ps *in a particular excited state of energy* 1.32 MeV, *we have to find the uncertainty in the energy of the corresponding emitted gamma ray photon*.

Solution:

The Heisenberg's uncertainty principle states that the product in the uncertainty in energy ΔE and the time period over which the energy is observed Δt is of the order of $h/2\pi$. That is

$$\Delta E \Delta t \approx \frac{h}{2\pi}.$$

As the mean lifetime of the given excited state of the nucleus is 8.7 ps, we have

$$\Delta t = 8.7 \text{ ps} = 8.7 \times 10^{-12} \text{ s}.$$

The uncertainty in the energy state of the nucleus will therefore be

$$\Delta E = \frac{h}{2\pi\,\Delta t} = \frac{6.63\times10^{-34}\ \text{J s}}{2\pi\times8.7\times10^{-12}\ \text{s}} = 1.21\times10^{-23}\ \text{J}$$

$$= \frac{1.21\times10^{-23}}{1.6\times10^{-19}}\ \text{eV}$$

$$= 7.6\times10^{-5}\,\text{eV}.$$

As the nucleus makes a transition to the ground state, and the energy of this state may be known to a desired accuracy, we neglect the uncertainty in the energy of the second state in calculating the energy of the emitted gamma ray photon. Therefore, the uncertainty in the energy of the emitted gamma ray photon will be $7.6\times10^{-5}\,\text{eV}$.