Problem 3-09 Quantum yield of a photochemical reaction

The apparatus for quantum yield determination was calibrated by the measurement of the decomposition of pure uranyl oxalate. The quantum yield of the photochemical decomposition uranyl oxalate at the wavelength of incident light λ = 300 nm is known to be ϕ_{oxalate} = 0.57. To decompose $6.2\cdot10^{-3}$ mol of oxalate took 2 hours. The apparatus was then used to determine of the quantum yield of acetone decomposition. The cell was filled with pure acetone and after 4 hours of radiation (again λ = 300 nm) the amount of the decomposed acetone was $3.7\cdot10^{-3}$ mol. What is the quantum yield of acetone decomposition?

[$\phi_A = 0.17$]

Solution:

$\lambda = 3\cdot10^{-7}$ m
$n_{\text{oxalate}} = 6.2\cdot10^{-3}$ mol of oxalate per 2 hours = $3.1\cdot10^{-3}$ mol/h

From the 1st experiment the number of light quanta per time unit is determined:

$$N_{\varepsilon 1} = \frac{N_{\text{oxalate}}}{\phi_{\text{oxalate}}} = \frac{3.1\cdot10^{-3}\cdot6.022\cdot10^{23}}{0.57} = 3.2751\cdot10^{21}\ \text{h}^{-1}$$

2nd experiment:
$N_{\varepsilon 2} = 4\ N_{\varepsilon 1} = 4 \cdot 3.275\cdot10^{21}$ of light quanta is needed to decompose $3.7\cdot10^{-3}$ mol of acetone.
Quantum yield

$$\phi_{\text{acetone}} = = \frac{N_{\text{acetone}}}{N_{\varepsilon 2}} = \frac{n_{\text{acetone}}\cdot \boldsymbol{N_A}}{N_{\varepsilon 2}} = \frac{3.7\cdot10^{-3}\cdot6.022\cdot10^{23}}{4\cdot3.2751\cdot10^{21}} = 0.17$$