HW 2 Solutions

1) Resolution of Echelle-Littrow configuration:

$R_{max} = \frac{W}{\lambda} \times 2 \times sin\delta$ where W is the width of the configuration, λ is the reference wavelength and δ is the blaze angle. In our case,

$$R_{max} = \frac{20 \times 10^{-2}}{6000 \times 10^{-10}} \times 2 \times sin(63) = 5.9 \times 10^5$$

Resolution of Fabry-Perot Ethalon: $R_{max} = mN_r$, where m is the order and N_r is the finesse expressed by the equation $N_r = \frac{\pi R^{1/2}}{1-R}$. The order of interference is $\sim \frac{2l}{\lambda}$ for small angles (l is the length of the spacer). Hence,

$$R_{max} = \frac{2l}{\lambda} \times \frac{\pi R^{1/2}}{1-R} = \frac{2 \times 4 \times 10^{-3}}{6000 \times 10^{-10}} \times \frac{\pi\sqrt{0.8}}{1-0.8} = 1.9 \times 10^5$$

2) The diameter of acceptance cone for the Fabry-Perot: $\theta^2 = 8/R$. But there is also the telescope: $\theta^{'2} = \theta^2 \frac{d^2}{D^2}$ where d is the diameter of the Fabry-Perot plate and D is the diameter of the telescope. Hence,

$$\theta^{'} = \frac{8d}{RD} = \frac{8 \times 10}{1.9 \times 10^5 \times 250} = 1.7 \times 10^{-6} radians = 0.35''$$

3) We can assume that $\frac{S}{N} \sim \sqrt{flux}$. But this is the intensity in the instrument and we need the real intensity to calculate the flux. Therefore, we should consider the efficiencies (quantum, optics, spectrometer), and transmission of the filter at that wavelength. Or in general: $\frac{S}{N} \sim \sqrt{F_s Q t}$ were Q is the quantum efficiency and F_s is the number of photons per second arriving on the detector. Hence,

$$\frac{S}{N} \sim \sqrt{\epsilon_o \epsilon_s A B_s \delta\lambda\delta\theta Q t}$$

where $A = \pi d^2/4$ is the acceptance area of the spectrometer with diameter d and B_s is the source flux. Hence, the observed flux as a function of observation time is:

$$B_s \sim \frac{(S/N)^2}{\epsilon_o \epsilon_s A \delta\lambda\delta\theta Q t} = \frac{3.7 \times 10^{14}}{t} \quad photons \quad cm^{-2} \mathring{A}^{-1} str^{-1} s^{-1}$$