

Problem Set 3 Solutions

Problem 1: D

Dense molecular clouds are too cold for hydrogen to be excited high enough for $H\alpha$, but supernova remnants and young massive stars are not.

Problem 2: E

Star formation can happen when a cloud is massive enough for gravity to overcome pressure support, which typically happens in cold molecular clouds.

Problem 3: F

Dust extincts optical light at all wavelengths but preferentially bluer wavelengths.

Problem 4: A

As the light travels through the Earth's atmosphere, blue light is scattered in all directions while red light is better able to pass straight through. Therefore the light that hits the Moon is reddened, giving the Moon a redder color during lunar eclipses.

Problem 5: A

At 6 PM the Sun will be setting; if the Moon is rising at the same time, it must be on the opposite side of the Earth.

Problem 6: B

Problem 7: C

Pluto is massive enough to become spherical but has not cleared its orbit, so A is not true. There are other Kuiper belts that are similar to Pluto, and this is one reason it was

re-classified, but the only completely correct answer here is C.

Problem 8: C

Problem 9: A

Problem 10: E

Both clouds must be at their respective Jeans lengths in order to just barely be able to collapse. The Jeans length goes as $\lambda_J \propto \sqrt{T/\rho}$, so if they are the same temperature, then the cloud with the shorter Jeans length has a higher density. This cloud also has a shorter free-fall time $t_{ff} \sim 1/\sqrt{G\rho}$.

Problem 11 (4 points)

The potential energy that is released is roughly

$$\Delta U \sim GM^2 \left(\frac{1}{R_f} - \frac{1}{R_i} \right) \approx \frac{GM^2}{R_f}, \quad (1)$$

where R_i is the initial mass of the cloud, R_f is the radius of the Sun, and $R_i \gg R_f$.

About half this energy is radiated away and contributes to the luminosity, but let's not worry about factors of order unity since we're already making lots of approximations. The luminosity is then

$$L \sim \frac{\Delta U}{t} \approx 3 \times 10^{33} \text{ erg s}^{-1}, \quad (2)$$

which is comparable to the luminosity of the Sun today.