# AST 102 ANSWERS TO ASSIGNMENT 3N

## CHAPTER 7 "Atoms" to end of chapter

### Questions

4. A neutral atom contains an equal number of positively charged protons within the nucleus and negatively charged electrons in the surrounding shell, resulting in an overall cancelled out, or neutral electric charge.

An ion is an atom with an imbalance in its number of protons and electrons. If electrons are lacking, the ion is positively charged. If an excess of electrons are contained, the ion is negative. For the most part in the universe, we are dealing with positive ions.

An excited atom is one in which one or more of its electrons reside in an orbit higher than the lowest available orbit (an orbit with one or more vacancies).

5. The light emitted or absorbed by atoms arises from the electrons within the atoms when they (the electrons) change orbits. There are only certain particular energy levels (orbits) allowable by the laws of quantum mechanics.

7. The temperature of a star's atmosphere, where the absorptions lines are formed, determines the relative proportions of excited atoms. In regard to the Balmer Series, which is formed by hydrogen atoms with electrons jumping up from the first excited state to higher levels, the temperature will determine the number of such atoms to the total number of hydrogen atoms in the atmosphere. The more atoms doing this, the more absorption at the Balmer series wavelengths takes place. At temperatures too high this ratio is low because the hydrogen atoms within the atmosphere are generally too excited and the ratio of those with the electrons jumping up from the first excited state is low. At temperatures too low this ratio is again low, this time because the atoms are generally not excited enough to get a significant number to the first excited state from where they can then absorb light to get more excited and result in the Balmer series of absorption lines in the observed spectrum of the star.

8. The deeper layers are hotter and so thoroughly ionized as to become a plasma. Light rays do not travel directly through a plasma; in other words plasma tends to be opaque. The atmosphere is both less ionized and less dense. Here the light reaching the surface can travel relatively easily into space for us to eventually observe.

10. TiO is a molecule (one atom of titanium with one atom of oxygen). The violence of particle collisions in the atmospheres of stars hotter than cool K type breaks molecular bonds.

11. No, we are not safe in that conclusion because temperature is also a determining factor in the appearance of a spectrum. The source may be too hot or too cool to enable the element to create its spectral lines. (See response to question 7.)

### Problems

6. Since light's wavelength ($\lambda$) varies inversely with energy (E), and since transition B involves twice as much E as transition A, which shows up at $\lambda$ = 500 nm, then the $\lambda$ of B is half (½) that of

transition A, or 250 nm.

7. a. ~20,000 K
   b. ~7,500 K
   c. ~3,000 K
   d. ~4,500 K

8. a. B-type
   b. F-type
   c. M-type
   d. K-type

9. In a non-relativistic situation, which is the norm for dealing with star velocities, the equation is a simple proportion (two ratios that are equal). The radial velocity, *v*, is to the speed of light, *c*, as the doppler shift of the light in the spectrum, $\Delta\lambda$, is to the original (or "rest") wavelength, $\lambda_o$, or:

$$v/c = \Delta\lambda/\lambda_o, \text{ where } \Delta\lambda \text{ is } (\lambda - \lambda_o) \text{ and } c \text{ is } 3 \times 10^8 \text{ m/s}$$

To solve for v, you must get rid of the inverse c by multiplying by *c*. Of course, you must do this to both sides of the equation to maintain its equal nature. Substitute your numbers and solve for v in km/s:

$$v = (\Delta\lambda/\lambda_o)\, c = [(486.3 - 486.1) / 486.1] \times 3 \times 10^8$$

$$v = 0.0012343134 \times 3 \times 10^8$$

$$v = 3.70 \times 10^5 \text{ m/s or, better to use km, so 370 km/s}$$

The positive result of the subtraction means red shift, going away (observed $\lambda$ longer, see?)

## <u>Chapter 6.2</u> "Astronomical Telescopes" to end

## Questions

1. Light collection varies directly (and linearly) with aperture area. Bigger pupils means more light let in, an important factor for nighttime situations where the ambient light is low. Improved resolution may be a secondary factor.

2. Larger lenses get very heavy (mass varies directly and linearly with volume). This greater mass has several negative consequences. 1) The telescope must be built like a tank to withstand structural distortions as it is reoriented to different directions. 2) Larger lenses get harder to hold, as they can only be supported at their edge — mirrors can also be supported there, but are also supported over their entire back surface. 3) Though a solid, glass does flow slowly. Gravity will thus distort a lens' shape, thereby degrading its focussing ability.

4. I would stress the aperture of the telescope, which determines both how much magnification power the telescope is capable of *and* its light gathering ability. I would also advertise what the mount is and whether it has a computer and diurnal drive.

8. It would be exactly like observing in space, wherein, lacking an atmosphere, <u>all wavelengths</u> reach the moon unimpeded.