ASTR100 HW#3 Solutions

4.6 C Hydrogen and helium made up 98% of the solar nebula. After the Big Bang, very nearly all of the universe consisted of hydrogen and helium, however after 9 billion years through nuclear fusion in stars and supernovae some, ~2%, of the hydrogen and helium had been converted to heavier elements. Thus 98% of the solar nebula consisted of hydrogen and helium, while the other 2% are heavier elements and molecules.

5.5 C If a planet has few impact craters we conclude the other geological processes have erased many craters. During the period of heavy bombardment, all of the planets and moons were hit with many asteroids and comets while after this period, impacts became less frequent. Therefore the only the way to remove the craters from these collisions is through geological activity such as erosion and and volcanic eruptions.

5.8 B Water vapor is a strong greenhouse gas. A strong greenhouse gas is one that is composed of more than one element rather than the same element such as N_2(nitrogen) and O_2(oxygen). Water is composed of both hydrogen and oxygen. Strong greenhouse gases also absorb and emit infrared light which water does.

6.20

$$n_{asteroids} = number\,of\,asteroids = 10^6 asteroids$$

$$r = radius\,of\,asteroids = .5\,km$$

$$V_{asteroid} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi\,(.5\,km)^3 = .524\,km^3$$

$$Total\,Volume = n_{asteroids} \times V_{asteroid} = \left(10^6\,asteroids\right)\left(.524\,km^3/asteroid\right) = \mathbf{5.24 \times 10^5 km^3}$$

$$V_{earth} = \frac{4}{3}\pi r_{earth}^3 = \frac{4}{3}\pi\,(6378\,km)^3 = 1.09 \times 10^{12}\,km^3$$

The total volume of all the asteroids in the asteroid belt is smaller by about a factor of $10^7$when compared to the size of the Earth.

6.21 Using Newton's version of Kepler's third law, $M_1 + M_2 = M_{Jupiter} + M_{Io} \approx M_{Jupiter}$ since the mass of Jupiter is so much larger than that of Io.

$$P_{Io}^2 = \frac{4\pi^2}{GM_{Jupiter}} a_{Io}^3$$

Rearranging the equation:

$$M_{Jupiter} = \frac{4\pi^2}{GP_{Io}^2} a_{io}^3$$

$$P_{Io} = 1.77\, days = 1.77\, days \left(86400 \frac{sec}{day}\right) = 152928\, s$$

$$a_{Io} = 421,600\, km = 421,600\, km \left(1000 \frac{m}{km}\right) = 4.216 \times 10^8\, m$$

Plugging in these values as well as $G = 6.67 \times 10^{-11} m^3/kg\, s^2$we calculate for the mass of Jupiter:

$$M_{Jupiter} = \frac{4\pi^2}{(6.67 \times 10^{-11} m^3/kg\, s^2)\,(152928\, s)^2} \left(4.216 \times 10^8\, m\right)^3 = \mathbf{1.9 \times 10^{27}\, kg}$$

Extra Credit: 4.21

$$speed = \frac{distance}{time}$$

In this case the distance is the distance between Earth and Pluto which will be the difference between their semimajor axes.

$$distance = a_{pluto} - a_{earth} = 39.5\, AU - 1\, AU = 38.5\, AU$$

So the speed will be:

$$v = \frac{38.5\, AU}{9\, yrs} = \mathbf{4.28\, AU/yr}$$

and in kilometers per hour:

$$v = 4.28\, \mathrm{AU/yr} \left(\frac{150 \times 10^6 km}{1AU}\right) \left(\frac{1yr}{8760hr}\right) = \mathbf{7.33 \times 10^4\, km/hr}$$