Space Weather PHYS 501 Homework 6

NAME:_____ Due:

6 points

1. Energetic solar flare particles (SEPs) come from the Sun at nearly the speed of light. How long does that take? (use 1.5 x 10^8 km as the distance). Energetic solar particles can cause ionospheric absorption at high latitudes (and therefore radio blackouts).

2. The solar wind has a nominal speed of 300-400 km/s but can be as slow as 200 km/s and as fast, in CME's as 1600 km/s. What would be the minimum and maximum travel time (hours) for the solar wind from the Sun to the Earth?

   minimum=

   maximum=

3. The maximum useable frequency (MUF) is related to the peak density of the ionosphere. A radio signal will reflect when its frequency matches the local plasma frequency. The plasma frequency is given by 9 kHz (sqrt (n / 1 cm^{-3})). The maximum density ionospheric density generally ranges from 10^3 to 10^6 cm^{-3}. What range in plasma frequency is that?

   From _____ to _____

4. A GPS uses triangulation of time delays from several orbiting spacecraft to determine your location on the earth. If the ionosphere is very disturbed, radio wave propagation can be disrupted and an extra delay can be introduced. This extra time delay can amount to an error in location of 30-50 m. Name two businesses or occupations that depend on GPS accuracy that could be harmed with this size error.

5. Draw a sketch of daytime ionospheric layers and nighttime ionospheric layers (label the density and height axes). Which layer does not exist at night? Which layer is absorbing as opposed to reflecting? What frequencies would be absorbed?

6. The atmosphere has an exponential decay with height, with $N = N_0 \exp -(mGh/kT) = N_0 \exp -(h/H)$. The ratio kT/mG is sometimes called the **scale height**, H, (the height at which the density falls by "e" or 2.7…). If the surface atmospheric density is 7.2 E 23 (particles/cubic foot), what is the density in particles per cubic cm? (http://www.aerospaceweb.org/design/scripts/atmosphere/). If the scale height is 8km, what will be the number density at 800 km height? _____

That gives you the number density for N_2 which is TINY at that height.
Now, the real atmosphere at that height is atomic O (not N_2) so the weight is 16 not 28. And the temperature is 2000K instead of 300, so the scale height for Oxygen is not 8 km but 93 km!

So, if Oxygen is 16% of the density at the surface, then what is its density at 800 km? _____

If the ionospheric density at 800 km is 10 E 6 /cm3, what fraction of the atmosphere is ionized at that altitude? _____

Useful links:
https://www.swpc.noaa.gov/sites/default/files/images/u33/Space%20Weather%20101_20140219.pdf
https://spaceplace.nasa.gov/spaceweather/en/
https://www.windows2universe.org/space_weather/space_weather.html