

These questions introduce the fundamental nomenclature and relationships of a planetary ionosphere.

- Hydrostatic balance
- Neutral composition
- E-region peak
- F-region peak
- Solar zenith angle
- Plasma density and critical frequency
- Wind and electric field induced plasma drifts
- Total electron content of the ionosphere
- Slab thickness

1. The composition of the thermosphere is well mixed in the lower altitude region. However above this altitude, from 110 km, the neutral species separately obey their hydrostatic balance equations. Given that the neutral composition  $N_2:O_2:O$  is 60:10:30 at 150 km and that the neutral temperature is 1000 K, calculate the neutral composition at 250 km assuming that the temperature and gravity is constant over this altitude range.

2. If in Question 1 the  $N_2$  density at 150 km is  $2 \times 10^{11} \text{ cm}^{-3}$  what is the thermospheric density at 250 km?

3. If during a geomagnetic storm the thermospheric temperature is increased to 1500 K, while at 150 km the density is unchanged, how much is the density increased at 250 km?

4. Calculate the solar zenith angle at local noon, on 23 December, for the geographic location of 29 degrees?

5. The ionospheric E-region at mid and low latitudes is mainly a balance between production by solar photons and chemistry mechanisms. Empirically the equation:

$$f_oE = 3.3 \left[ (1 + 0.008\mathfrak{R}) \cos \psi \right]^{0.25} \text{ MHz}$$

where  $f_oE$  is the peak E-region critical frequency and  $\mathfrak{R}$  and  $\psi$  are the solar Sun spot number and solar zenith angle respectively. Calculate the maximum E region density  $N_mE$  for solar minimum and for a strong solar maximum.

6. The ionospheric F-region does not have as simple a chemistry/physics scheme as that for the E-layer. However, the annual averaged noon  $\overline{f_oF_2}$  rule of thumb, empirical relationship is:

$$\overline{f_oF_2} = C(1 + 0.02\mathfrak{R})^{1/2}$$

where  $\overline{f_oF_2}$  is the critical plasma frequency at the F-layer peak, C is a constant that is location dependent, and  $\mathfrak{R}$  is the Sun spot number. Calculate the solar maximum plasma density  $N_mF_2$  given that at solar minimum  $\overline{f_oF_2}$  is 4.4 MHz.

7. A horizontal neutral wind in the upper thermosphere can drive plasma either upwards or downwards because the electrons and ions are bound to magnetic field lines even although the flowing neutral gas is colliding with the plasma. How large is the vertical induced plasma drift if an equatorward, meridional, neutral wind of 50 m/s is present at a mid-latitude location where the local magnetic dip angle is  $45^\circ$ .

8. At the same mid-latitude location an eastward electric field leads to a vertical drift. Calculate this induced drift if the eastward electric field has a magnitude of 15 mV/m.

9. The diagram shows three ionospheric electron density profiles. Determine the total electron content (TEC) for each profile. Calculate the slab thickness for each profile.

