CHAPTER 3 – SOLUTIONS

REVIEW QUESTIONS:

5. Clouds (about 17%)
6. N_2 – 78%, O_2 – 21%, Ar – 0.9%
8. Convection, Conduction, Transport of Latent Heat
9. Changing the rate of rotation of a molecule.
   Changing the rate of vibration of a molecule.
10. They are symmetric molecules.
11. **High Clouds:** Greenhouse effect is more important than the reflection of sunlight.
    Low Clouds: Reflection of sunlight is more important than greenhouse effect.
12. Two positive feedback loops: Water vapor feedback loop,
    Snow/Ice Albedo feedback loop.
    Earth's climate is stable because of the Infrared flux – $T_{surface}$ negative feedback loop.

PROBLEMS:

4. $T_{surface}$ = 288K, T_e = 255K => $\Delta T = 33K$
   Since, 1K = 1°C => 33K = 33°C
   So, $\frac{33°C}{6°C/km} = 5.5km$

5. a) Using $T_e = \sqrt[4]{\frac{S(1-A)}{4\sigma}} = \sqrt[4]{\frac{(1366W/m^2)\times 0.7\times(1-0.3)}{4\times 5.67\times 10^{-8}W/(m^2K^4)}} = 233K$

   This corresponds to -40°C (=233K-273K)

   b) $T_{surface} = T_e + \Delta T_g$ = 233K + 33K = 266K = -7°C => Mighty cold compared to today's 15°C.

6. a) $\Delta F = -6.3\ln\left(\frac{600\,ppm}{300\,ppm}\right) = -4.4W/m^2$

   b) From the planetary energy balance equation, the energy emitted would have to increase by the amount calculated in a).
   Hence:

$$4\pi R^2\times\sigma T_{e-new}^4 = 4\pi R^2\times\sigma T_e^4 + 4\pi R^2\times 4.4W/m^2$$

$$\Rightarrow \quad T_{e-new} = \sqrt[4]{T_e^4 + \frac{4.4W/m^2}{5.67\times 10^{-8}W/(m^2K^4)}}$$

$$\Rightarrow \quad T_{e-new} = 256.2K$$

$$\Rightarrow \quad \Delta T = T_{e-new} - T_e = 256.2K - 255K = 1.2K = 1.2°C$$