7. From your physics courses, you know that a molecule's thermal energy is given by E=(3/2) kT, where k is the Boltzmann constant and T is the temperature in Kelvin.

- What is the energy in a mole of gas at 273 K?

$R^* = k N_{Avagadro} = 8.3$ J deg^{-1} mole^{-1} $\quad E = \frac{3}{2}(8.3)(273) = 3.4\times10^3$ J/mole

- How many moles of gas are in a m^3 of space if T = 273 K and p = 1013 hPa?

$\rho_{STP} \approx 1.28$ kg m^{-3}. Each mole has a mass of 0.029 kg/mole

#moles = (1.28 kg m^{-3})/(0.029 kg/mole) = 44.6 moles m^{-3}

- What is the thermal energy of a m^3 of air at STP (T= 273K and p = 1013 hPa)?

$E = 44.6 \frac{moles}{m^3} \cdot 3.4\times10^3 \frac{J}{mole} = 1.5\times10^5$ J $\quad$ (1 Watt = 1 J/s ∴ 1.5×10^5 J runs a computer for 8 min.)

- Assuming an average temperature for the atmosphere of 250 K, what is the thermal energy in the atmosphere?

Atmosphere has 1.7×10^{20} moles. $E_{atm} = (1.7\times10^{20})\frac{3}{2}(8.3)(250) = 5.3\times10^{23}$ J

- A stiff wind at Earth's surface is 30 m s^{-1}. What is the energy associated with one m^3 of air that is traveling at this speed?

$E = \frac{1}{2}mv^2 = \frac{1}{2}\rho V v^2 = \frac{1}{2}(1.28 \text{ kg m}^{-3})(1 \text{ m}^3)(30 \text{ m s}^{-1})^2 = 580$ J

- How does this compare to your answer for the amount of thermal energy in 1 m^3 of air?

It is $(1.5\times10^5)/(1150) = 130$ times less.

8. Consider a small fair-weather cumulus cloud (like those you see on a nice summer's day). If the liquid water content (LWC) is 0.3 g m^{-3}, what is the total liquid water mass in the cloud? State your estimate of the cloud's size.

A good size fair weather cumulus cloud is about equivalent to a 100 m radius sphere.

Total liquid water = $\frac{4}{3}\pi(r)^3 \cdot LWC = \frac{4}{3}\pi(100)^3 \cdot 0.3 = 1.2\times10^3$ kg

~ 1.2 ton

9. Satellites often fly a few hundred kilometers above Earth's surface. Why don't they burn up during an active sun period?

During an active sun, T ~ 2000 K! But what is the total energy encountered during 1 orbit?

$E = \frac{3}{2}(\#molecules) kT = \frac{3}{2}\left(10^{15} \frac{molecules}{m^3} \cdot 1 m^2 \cdot 2\pi(6.800\times10^6 m)\right) \times$

↑ from Fig 1.5 ↑ satellite size ↑ orbit path

1.4×10^{-23} J deg^{-1} molecule^{-1} · 2000 ≈ 2000 J. An orbit takes about 1 hour, so the Watts of heating is .5 W from this effect.