(1) Goodbye to Mars, (2) Why planets have atmospheres

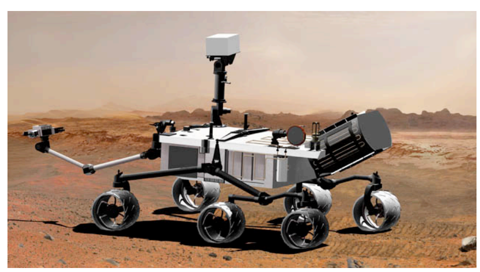
What have we learned from the MERs and "Mars Phoenix"

- It now seems clear that there were standing bodies of water for long periods of time early in Martian history
- Evidence is presence of hematite, jarosite, and other minerals that form in lakes or oceans
- Relative absence of carbonate rocks is due to alternative chemistry in acidic water
- **But,** apparently oldest rock strata do contain carbonate rocks and clay (montmorillonite)

The launch, interplanetary journey, and arrival at Mars of an MER spacecraft

The journey to Mars of "Spirit"

In the future…Mars Science Laboratory



Launch in fall, 2011, arrival fall 2012. Will make tests for organic chemicals, biological molecules

The El Dorado of future missions: Mars Sample Return

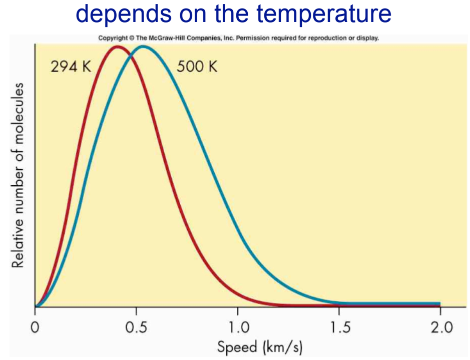
Stay tuned!

Atmospheres: some planets have them, some don't

Whether a planet has an atmosphere or not depends on the relative magnitude of two speeds

- The speed at which molecules move around in the gas (thermal speed)
- The speed of escape from the planet (escape speed, depends on mass and radius of a planet)

The distribution of molecular speeds depends on the temperature



the gravitational escape speed from a planet

Result from Newton's theory of gravity. The escape speed is the speed necessary for a projectile to move an infinite distance from a planet. If the planet has mass M (kilograms) and radius R (meters), then the escape speed is

$$v_{esc} = \sqrt{\frac{2GM}{R}} \tag{1}$$

where $G = 6.673 \times 10^{-11}$ (SI) units.
Work out the case for the Earth: $M = 5.97 \times 10^{24}$ kg, $R = 6378$ km $= 6.378 \times 10^6$ m, $v_{esc} = 11.2 \times 10^3$ m/sec $= 11.2$ km/sec.

the mean molecular speed in a gas

The average speed v_{av} of molecules in a gas is

$$v_{av} = \sqrt{\frac{8k_BT}{\pi m}} \tag{2}$$

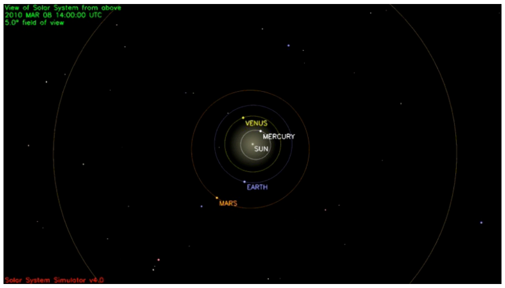
where k_B is a, the *Boltzmann constant*, $k_B = 1.38 \times 10^{-23}$ in SI units, T is the temperature in degrees Kelvin, and m is the mass of the molecule which makes up the gas.
The average temperature at the surface of the Earth is around 290K. The mass of molecule of oxygen (O_2) is 5.31×10^{-26} kg. Substituting these numbers into the equation for the average speed gives a value of 438 meters/sec, which is *much less* than the escape speed from the Earth. This explains why the Earth has been able to hold on to its oxygen atmosphere for 2 billion years.

The criterion for hanging onto an atmosphere

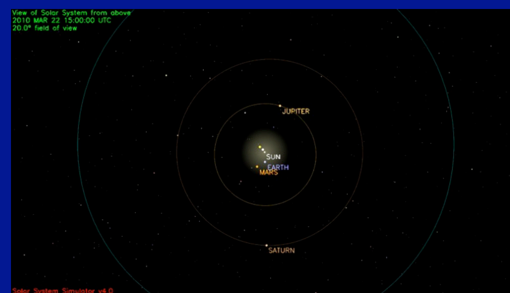
- Depends on relative magnitude of escape speed and average molecular speed
- If molecular speed > about 1/6 of escape speed, atmosphere will "leak out" over a period of billions of years
- If molecular speed << 1/6 of escape speed, the planet should retain the atmosphere.

Above rule of thumb seems to roughly work (see Table 7.3), but there are some mysteries. Example: Mars and Titan

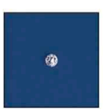
Where we have been so far…the inner solar system and the **terrestrial planets**

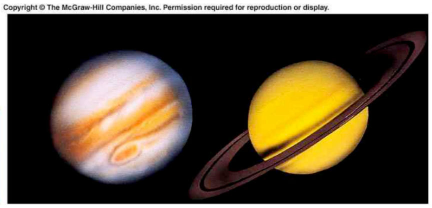


Now let's move out further in space…the outer solar system and the **Jovian planets**

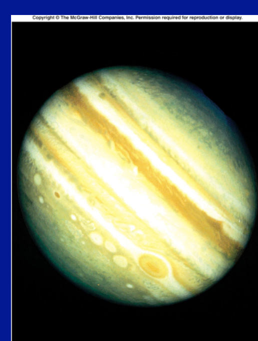


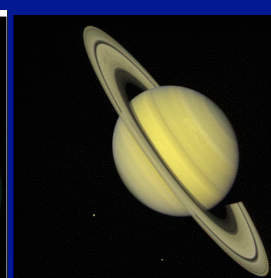
Jupiter and Saturn are giants



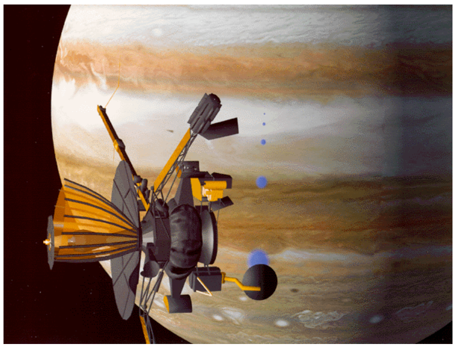


Our first look at Jupiter and Saturn

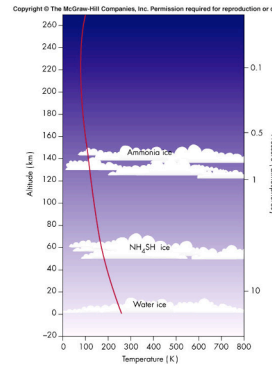




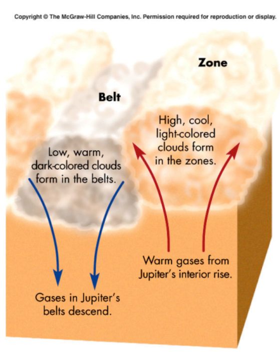
Exploration of Jupiter



The atmospheric structure of Jupiter



The cloud bands of Jupiter



The Galileo Probe

The interior structure of Jupiter (and Saturn)