18 - Preparing a mission to Mars

Europe is preparing a long-term plan for the robotic and human exploration of the Solar System, with Mars, the Moon and asteroids as most likely targets. Scientists need a good knowledge of the physical features of each target to design successful missions.

Calculate the atmospheric density on the surface of Mars, assuming ideal gases. Compare with the atmospheric density on Earth.

Data:

<u>Earth</u>	
Average temperature	15 ºC
Surface Pressure	1013 mbar = 1atm
Atmospheric Composition (dry air)	78.07% N_2 21% O_2 0.9% Ar 0.03% CO_2
<u>Mars</u>	
Average temperature	-55 ºC
Surface Pressure	6.35 mbar
Atmospheric Composition (dry air)	95.49% CO_2 2.7% N_2 1.6% Ar 0.13% O_2 0.08% CO

Gas Constant: R=0.082 l·atm/mol·K

If you want to know more: http://www.esa.int

Solution "Preparing a mission to Mars"

To calculate the density:

Molecular weight $M = \frac{m}{n}$ so $m = nM$ then

Density $d = \frac{m}{V} = \frac{nM}{\left(\frac{nRT}{P}\right)} = \frac{MP}{RT}$

Earth surface density

First we have to calculate the average molecular weight for the mixture of gases

$$M_{Earth} = 0.7807 \times (28\ \text{g/mol}) + 0.21 \times (32\ \text{g/mol}) + 0.009 \times (40\ \text{g/mol}) +$$
$$+ 0.0003 \times (44\ \text{g/mol}) = 28.95\ \text{g/mol}$$

$$d = \frac{(28.97\ \text{g/mol}) \times (1\ \text{atm})}{(0.082\ \text{l} \cdot \text{atm/mol} \cdot \text{K}) \times 288\ \text{K}} = 1.22\ \text{g/l} = 1.22\ \text{kg/m}^3$$

Mars surface density

First we have to calculate the average molecular weight for the mixture of gases

$$M_{Mars} = 0.9549 \times (44\ \text{g/mol}) + 0.027 \times (28\ \text{g/mol}) + 0.016 \times (40\ \text{g/mol}) +$$
$$+ 0.0013 \times (32\ \text{g/mol}) + 0.0008 \times (28\ \text{g/mol}) = 43.47\ \text{g/mol}$$

$$P = 6.35\ \text{mbar} \times 1\ \text{atm}/1013\ \text{mbar} = 0.0062\ \text{atm}$$

$$d = \frac{(43.47\ \text{g/mol}) \times (0.0062\ \text{atm})}{(0.082\ \text{l} \cdot \text{atm/mol} \cdot \text{K}) \times 218\ \text{K}} = 0.015\ \text{g/l} = 0.015\ \text{kg/m}^3$$

The Earth's surface atmospheric density is approximately 80 times higher than that of Mars.

These values can vary on the surface of Mars due to the range of temperatures, i.e. 27 ºC in summer during the day to –133 ºC in winter at the pole.