

All of the planets in our solar system, and some of its smaller bodies too, have an outer layer of gas we call the atmosphere. The atmosphere usually sits atop a denser, rocky crust or planetary core. Atmospheres can extend thousands of kilometers into space.

The table below gives the name of the kind of gas found in each object's atmosphere, and the total mass of the atmosphere in kilograms. The table also gives the percentage of the atmosphere composed of the gas.

| Object  | Mass (kilograms)     | Carbon Dioxide | Nitrogen | Oxygen | Argon | Methane | Sodium | Hydrogen | Helium | Other |
|---------|----------------------|----------------|----------|--------|-------|---------|--------|----------|--------|-------|
| Sun     | $3.0 \times 10^{30}$ |                |          |        |       |         |        | 71%      | 26%    | 3%    |
| Mercury | 1000                 |                |          | 42%    |       |         | 22%    | 22%      | 6%     | 8%    |
| Venus   | $4.8 \times 10^{20}$ | 96%            | 4%       |        |       |         |        |          |        |       |
| Earth   | $1.4 \times 10^{21}$ |                | 78%      | 21%    | 1%    |         |        |          |        | <1%   |
| Moon    | 100,000              |                |          |        | 70%   |         | 1%     |          | 29%    |       |
| Mars    | $2.5 \times 10^{16}$ | 95%            | 2.7%     |        | 1.6%  |         |        |          |        | 0.7%  |
| Jupiter | $1.9 \times 10^{27}$ |                |          |        |       |         |        | 89.8%    | 10.2%  |       |
| Saturn  | $5.4 \times 10^{26}$ |                |          |        |       |         |        | 96.3%    | 3.2%   | 0.5%  |
| Titan   | $9.1 \times 10^{18}$ |                | 97%      |        |       | 2%      |        |          |        | 1%    |
| Uranus  | $8.6 \times 10^{25}$ |                |          |        |       | 2.3%    |        | 82.5%    | 15.2%  |       |
| Neptune | $1.0 \times 10^{26}$ |                |          |        |       | 1.0%    |        | 80%      | 19%    |       |
| Pluto   | $1.3 \times 10^{14}$ | 8%             | 90%      |        |       | 2%      |        |          |        |       |

**Problem 1** – Draw a pie graph (circle graph) that shows the atmosphere constituents for Mars and Earth.

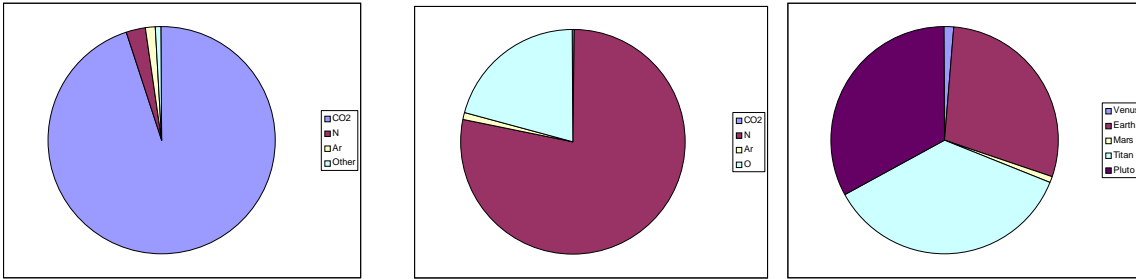
**Problem 2** – Draw a pie graph that shows the percentage of Nitrogen for Venus, Earth, Mars, Titan and Pluto.

**Problem 3** – Which planet has the atmosphere with the greatest percentage of Oxygen?

**Problem 4** – Which planet has the atmosphere with the greatest number of kilograms of oxygen?

**Problem 5** – Compare and contrast the objects with the greatest percentage of hydrogen, and the least percentage of hydrogen.

**Problem 1** – Draw a pie graph (circle graph) that shows the atmosphere constituents for Mars and Earth. Answer: Mars (left), Earth (middle)



**Problem 2** – Draw a pie graph that shows the percentage of Nitrogen for Venus, Earth, Mars, Titan and Pluto. Answer: First add up all the percentages for Nitrogen in the column to get 271.7%. Now divide each of the percentages in the column by 271.7% to get the percentage of nitrogen in the planetary atmospheres that is taken up by each of the planets: Venus =  $(4/271) = 1.5\%$ ; Earth =  $(78/271) = 28.8\%$ , Mars =  $(2.7/271) = 1.0\%$ , Titan =  $(97/271) = 35.8\%$ , Pluto =  $(90/271) = 33.2\%$ . Plot these new percentages in a pie graph (see above right). This pie graph shows that across our solar system, Earth, Titan and Pluto have the largest percentage of nitrogen. In each case, the source of the nitrogen is from similar physical processes involving the chemistry of the gas methane (Titan and Earth) or methane ice (Pluto).

**Problem 3** – Which planet has the atmosphere with the greatest percentage of Oxygen? Answer: From the table we see that **Mercury** has the greatest percentage of oxygen in its atmosphere.

**Problem 4** – Which planet has the atmosphere with the greatest number of kilograms of oxygen? Answer: Only two planets have detectable oxygen: Earth and Mercury. Though mercury has the highest percentage of oxygen making up its atmosphere, the number of kilograms of oxygen is only  $1000 \text{ kg} \times 0.42 = 420$  kilograms. By comparison, **Earth** has a smaller percentage of oxygen (21%) but a vastly higher quantity:  $1.4 \times 10^{21} \text{ kg} \times 0.21 = 2.9 \times 10^{20}$  kilograms. (That's 290,000,000,000,000,000,000 kg)

**Problem 5** – Compare and contrast the objects with the greatest percentage of hydrogen, and the least percentage of hydrogen.

Answer: The objects with the highest percentage of hydrogen are the sun, Mercury, Jupiter, Saturn, Uranus and Neptune. The objects with the least percentage are Venus, Earth, Moon, Mars, Titan, Pluto. With the exception of Mercury, which has a very thin atmosphere, the high-percentage objects are the largest bodies in the solar system. The planet Jupiter, Saturn, Uranus and Neptune are sometimes called the Gas Giants because so much of the mass of these planets consists of a gaseous atmosphere. These bodies generally lie far from the sun. The low-percentage objects are among the smallest bodies in the solar system. They are called the 'Rocky Planets' to emphasize their similarity in structure, where a rocky core and mantle are surrounded by a thin atmosphere. Most of these bodies lie close to the sun.