

Ri Christmas Lectures® 2012: The Modern Alchemist

Teaching Resource - The Composition of Air

Overview:

This resource contains ideas and materials to aid teachers/group leaders in the teaching and exploration of Chemistry topics based around the composition of the mixture known as Air. Included are potential questions, ideas for discussion, links to video clips from the 2012 Christmas Lectures®, general information, and suggestions of other resources which may prove useful.

Composition of the Air:

How many components do we think are in the air?

Can anyone name a gas that's found in the air?

- The aim of these questions is not to receive the correct answers, simply to generate discussion. These questions can be answered by viewing the video clip provided below.

Video Clip: Mixing Air

A video clip from the 2012 Christmas Lectures®, during which Dr Peter Wothers and a volunteer mix up a sample of air from its constituent gases.

[Mixing Air](#)

Running Time - 4 min 49 secs

Current Vs. Historic Composition of the Air:

Included below are figures for the composition of the air in recent times (2010), and in historic times (1750 - 1800, pre-industrial). Also included is a general description of how the atmosphere is believed to have changed over the history of the Earth, along with links to resources containing further information.

Recent (Year 2010):

- Nitrogen 78 %, Oxygen 20 %, Argon ~ 1 %, Carbon Dioxide 0.037 % (370 ppm), Trace Gases (Neon 18 ppm, Helium 5.24 ppm, Methane 1.79 ppm, Krypton 1.14 ppm, Hydrogen 0.55 ppm, Nitrous oxide 0.33 ppm, Carbon monoxide 0.10 ppm, Xenon 0.09 ppm, Ozone 0.0 - 0.07 ppm, Nitrogen dioxide 0.02 ppm, Iodine 0.01 ppm, Ammonia).

Historic (1750 - 1800, pre-industrial)

- Nitrogen 78 %, Oxygen 20 %, Argon ~ 1 %, Carbon Dioxide 0.028 % (280 ppm), Trace Gases (Neon 18 ppm, Helium 5.24 ppm, Methane 0.80 ppm, Krypton 1.14 ppm, Hydrogen 0.55 ppm, Nitrous oxide 0.28 ppm, Carbon monoxide 0.10 ppm, Xenon 0.09 ppm, Ozone 0.0 - 0.07 ppm, Nitrogen dioxide 0.02 ppm, Iodine 0.01 ppm, Ammonia).

Comparison of the Changes in the Composition of Pre-Industrial and Modern Air:

Gas	Percentage Composition at Pre-Industrial Levels	Percentage Composition at Modern Levels	Percentage Change
Nitrogen	78	78	N/A
Oxygen	20	20	N/A
Argon	1	1	N/A
Carbon Dioxide	0.028	0.037	32 % increase
Methane	0.00008	0.000179	123 % increase
Nitrous Oxide	0.000028	0.000033	18 % increase

Notes:

- Water vapour has not been included in these lists, as traditionally the composition is taken in dry air - typically, water vapour accounts for 1 - 4 % of the atmosphere in uncontrolled air.
- The percentages provided do not add to 100 %, this is due to rounding and uncertainty effects in the raw data.
- Trace gases are quoted in terms of ppm, or parts per million (e.g. 140 ppm is equivalent to 0.0014 %)

Development of the atmosphere: - 'First, Second, and Third Atmospheres'

- First Atmosphere
 - The first atmosphere was present early after formation of the Earth
 - Likely to have consisted primarily of hydrogen and Helium, and possibly simple molecular gases such as water vapour, methane, and ammonia
 - The high temperatures present, and exposure to the solar winds, caused the first atmosphere to be lost to space
- Second Atmosphere
 - Formed from the gases released by volcanoes

- Likely to have consisted of mainly nitrogen, carbon dioxide, and water vapour
- This atmosphere can be classified as a 'reducing' atmosphere due to the likely presence of hydrogen, and the lack of oxygen
- Third Atmosphere (Today)
 - High levels of carbon dioxide allowed the evolution of photosynthesising algae
 - These began to reduce the amount of carbon dioxide within the atmosphere, and allow for the oxidation of iron within the atmosphere, forming oxides
 - Once the easily oxidised materials were consumed, free oxygen began to accumulate, eventually building to the levels we see today
 - There is evidence for higher oxygen levels within the atmosphere than those we encounter today
 - Today, the atmosphere is in this stage, and is now an 'oxidising' atmosphere

Links to resources containing further information regarding the composition of Earth's atmosphere:

- NASA - [Atmospheric Composition](http://science.nasa.gov/earth-science/)¹
- ESA - [IR Spectrum of Earth's Atmosphere](http://spaceinimages.esa.int)²
- Encyclopaedia Britannica³ - [Evolution of the Atmosphere](http://www.britannica.com)

These figures and the information from the external resources can be used as a starting point for discussion on how the Earth's atmosphere has changed over time, and why. Interesting points to discuss could include:

- How the chemistry of the Earth would be different under reducing and oxidising conditions (i.e. the presence of many more metals in native form)
- How Oceans would have been affected with higher concentrations of CO₂ in the atmosphere (Ocean acidification, and buffers)
- How human activity could have altered the atmosphere, and may affect it in years to come (also, see Teaching Resource - Climate Change)

Effects of Altering the Composition of Air:

Besides Climate Change (covered in Teaching Resource - Climate Change), outlined below are two potentially interesting examples of the effects of altering the

¹ NASA Science, Earth, <http://science.nasa.gov/earth-science/>

² ESA, Space in Images, <http://spaceinimages.esa.int>

³ Encyclopaedia Britannica, <http://www.britannica.com>

composition of the Air. Both of which are focussed upon altering the amount of Oxygen present.

Video Clip: Altering the Composition of the Air; Increased and Decreased Oxygen Levels

A video clip from the 2012 Christmas Lectures[®], during which Dr Peter Wothers explains one of the potential effects of altered oxygen levels; including examples of both increased, and decreased oxygen levels.

[Altering the Composition of the Air](#)

Running Time: 5 min 14 secs

Points for discussion:

- What is needed for combustion to take place?
- Would combustion take place in a hydrogen atmosphere?
- Other uses of altered atmospheres/altered air

View the full 2012 Ri Christmas Lectures[®] - The Modern Alchemist, along with behind the scenes footage, and related content, at the [Ri Channel](#)⁴.

⁴ RI Channel, www.richannel.org