Question

Oxygen for breathing is available as a 21 % fraction in fresh air. Which critical concentration is regarded as exhausted air?

Answer

Exhausted air doesn't have a lack of oxygen, but there is too much carbon dioxide.

Atmosphere The table on the right hand gives the composites of dry clean air at sea level (source: DIN ISO 2533, Dec. 1979).
In clean areas the volume-fraction of CO_2 is 0.035 % in summertime and 0.036 % in winter. This equals 350 ppm (parts per million) and 360 ppm respectively. These numbers raise approximately 2 ppm annually due to the green house effect.

gas	volume-fract. in %
N_2	78.084
O_2	20.9476
Ar	0.934
CO_2	0.0314
residue	0.003

Respiration Any inhaled O_2-molecule results in approximately one CO_2-molecule exhausted into the ambient air.
Breathed out air contains 17 % O_2 , which is 4 % less than in fresh air, and hence about 4 % CO_2 , which is over 100 times more than the natural concentration of CO_2 (see table).

	volume-fract. in %	
	O_2	CO_2
fresh air	21	0.036
exhalated air	17	4
ambient air (without vent.)	20.5	0.5

MAK If the MAK-value (**m**aximale **A**rbeitsplatz-**K**onzentration = maximum workplace concentration) for CO_2 (0.5 %) is reached in an unventilated room, then only 0.5 % out of the 21 % O_2 have been used for breathing. While the O_2-fraction stays almost unchanged, the CO_2-fraction has reached MAK-value, in other words it has increased to the 14-fold amount (table 2, bottom row).

History In the year 1858 the hygienist of Munich Max von Pettenkofer recommended the critical volume-fraction of 1000 ppm CO_2 to be regarded as "bad air". This figure has been termed "Pettenkofer-number".

Measurement According to Pettenkofer's definition tested air, that was taken in a flamenco studio at the end of a training and showed a CO_2-concentration of 7000 ppm should be denoted as "very bad".