Answer to the Question#47310-Chemistry, Other

Question:

An average human adult takes about 15 breaths per min and exhales 23ml of CO_2 with each breath. If your are trapped in a cave with pressure 0.963atm and 11°C and your only source of oxygen is a breathing device containing 1kg of KO_2, how long do you have to live?

Solution:

KO_2 (potassium superoxide) can be used for rebreathers (CO_2-scrubbers). The KO_2-rebreather units work by converting the exhaled CO_2 to O_2 via the following chemical reaction:

$$4KO_2 + 2CO_2 = 2K_2CO_3 + 3O_2$$

Notice the potassium superoxide consumes CO_2, a product of respiration, and produces O_2, which can be breathed.
To solve our problem, we can describe breathing by simplified chemical equation:

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$$

1. Now calculate moles of CO_2 exhales per 1 breath using the ideal gas equation:

$$PV = nRT,$$

Convert all values to standard form:

$$0.963 \text{ atm} = (101325 \text{ Pa/atm}) \times 0.963 \text{ atm} = 97576 \text{ Pa}, 23\text{ml} = 2.3\times10^{-5}\text{m}^3, 11°\text{C} = 284 \text{ K},$$

$$R = 8.314 \text{ Pa}\times\text{m}^3/\text{mol}\times\text{K}$$

Per 1 breath: $n=PV/RT = 97576\times2.3\times10^{-5}/8.314\times284 = 9.5\times10^{-4}$ mol

2. How many moles of O_2 is needed to 1 breath?

According to simplified chemical equation of breathing 1 mole of O_2 are equals to 1 mole of CO_2. Thus 9.5×10^{-4} mol of O_2 is needed to 1 breath.

3. How many moles of O_2 can be obtained from 1 kg (1000 g) of KO_2?

KO_2 reacts with CO_2 according to the equation:

$$4KO_2 + 2CO_2 = 2K_2CO_3 + 3O_2$$

As we can see, 1 mole of O_2 is equivalent to 4/3 moles of KO_2

$$M(KO_2) = 39+16\times2 = 71 \text{ g/mol},$$

$$4/3 \text{ moles of } KO_2 = 71\times4/3 = 94.7 \text{ g/mol } O_2$$

$$1000 \text{ g}/(94.7 \text{ g/mol } O_2) = 10.6 \text{ mol } O_2$$

4. How many breaths you can do with 10.6 mol O_2?

$$10.6 \text{ mol}/9.5\times10^{-4} \text{ mol} = 11157 \text{ breaths}$$

5. How long it will be possible to breathe?

$$11157 \text{ breaths}/(15 \text{ breaths/min}) = 743 \text{ min}$$

Answer: You can to live about 743 minutes.