EE4904
Biomedical Instrumentation
Tutorial 1

Question 1: Are the following numbers equal within the expected range of values?

(1) (3.42 ± 0.04) volts and 3.48 volts?

(2) (13.106 ± 0.014) uM and 13.206 uM?

(3) (2.95 ± 0.03) x m/s and 3.00 x m/s

Solution

(1) The 2-deviation range is 3.34 to 3.50 Volts, which means between confidence interval of −2×0.04 and 2×0.04, the true value lies with probability 0.95.

Yes the numbers are equal.

(1) The 2-deviation range is 13.078 to 13.134 uM.

No the numbers are not equal.

(1) The 2-deviation range is 2.89 x to 3.01 x m/s.

Yes the numbers are equal.

Question 2: How many significant figures are there in each of the following?

(1) 0.00042

(2) 0.14700

(3) 4.2×10^{6}

(4) -154.090×10^{-27}

Solution

Question	Number of Significant Figures
(i) 0.00042	2
(ii) 0.14700	5
(ii) 4.2×10^{6}	2
(iv) -154.090×10^{-27}	6

Question 3: A spirometer is shown in Figure below. What can it measure? Show the working principles of measurement.

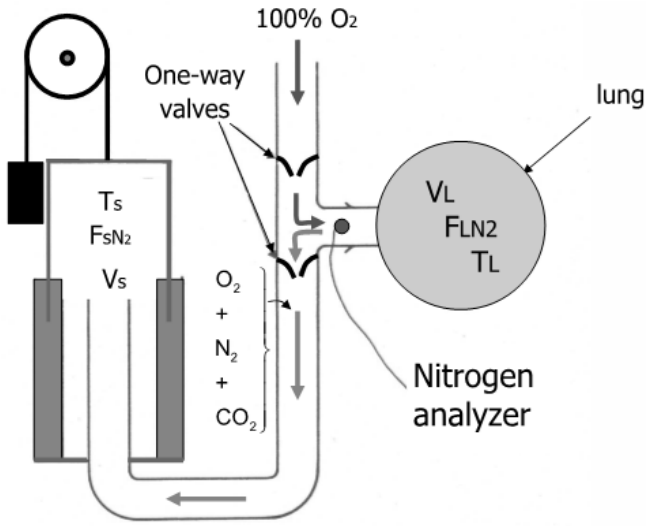

Figure. V_L lung volume; F_{LN2} nitrogen molar fraction in lung; T_L lung temperature (in K); T_S spirometer temperature (in K); V_S Spirometer volume; F_{sN2} nitrogen molar fraction in spirometer.

Solution

When the patient starts breathing through the mouthpiece, he/she can only inhale oxygen. But he/she exhales the mixed gas of oxygen, nitrogen and carbon dioxide as his lung initially contains air. As the exhaled mixed gas enters into spiromter through the one-way valve, the amont of nitrogen molecules is gradually decreasing over time in the lung. The start time t1 and end time t2 are set at the time points of functional residual volume or residual volume.

Based on mass balance, the decreased amount of N2 mole in lungs

$$F_{LN_2}(t_1)\frac{V_L(t_1)}{T_L} - F_{LN_2}(t_2)\frac{V_L(t_2)}{T_L} = F_{sN_2}(t_2)\frac{V_S(t_2)}{T_S} \qquad \textbf{Eq1}$$

Since

$$V_L(t_1)=FRC, \qquad V_L(t_1)=V_L(t_2)=FRC \qquad \textbf{Eq2}$$

Combining Eqs 1 and 2, FRC or RV can be measured as

$$FRC = \frac{T_L}{T_s}\left[\frac{F_{sN_2}(t_2)V_s(t_2)}{F_{LN_2}(t_1) - F_{LN_2}(t_2)}\right]$$

Question 4: A N_2-washout experiment is carried out

At beginning,

$V_s(t_1)=7$ liters, $F_{sN_2}(t_1)=0$

At the end

$V_s(t_2)=12$ liters, $F_{sN_2}(t_2)=0.026$ $T_s = 303$ K

and fraction of N_2 for the patient has decreased by 0.1.

What is the lung volume at which the patient is breathing ?

Solution:

At the beginning of experiment

$$T_L = 37 + 273 = 310 \text{ K}$$

where K represents absolute temperature

At the end of experiment

$$V_s(t_2) = 5 + 7 = 12 \text{ liters}$$

$$F_{sN_2}(t_2) = 0.026$$

$$F_{LN_2}(t_1) - F_{LN_2}(t_2) = 0.1, \qquad T_S = 303 \text{ K}$$

With assumption of $V_L(t_1) = V_L(t_2)=V_L$, it has from equ (3.8)

$$V_L = \frac{T_L}{T_s}\left[\frac{F_{sN_2}(t_2)V_s(t_2)}{F_{LN_2}(t_1)-F_{LN_2}(t_2)}\right]$$

$$= \frac{310}{303}\times\frac{0.026\times 12}{0.1} = 3.19 \text{ liters}$$