Exercise – Series 1 – Dissolved gas in liquids

Exercise 1:

Consider a vessel filled with $1\ L$ of water in CO_2 atmosphere at $2.5\ atm$. Calculate the mass of dissolved CO_2 when the temperature of the system is $25°C$. Henry's constant for carbon dioxide in water at $25°C$ is $3.36 \times 10^{-2}\ mol/(L.atm)$. The molar mass of CO_2 is $44.009\ g/mol$.

Exercise 2:

Knowing that the mass concentration $c_{m,1}$ of a generic gas in solution at partial pressure $p_1^* = 150\ mmHg$ is $4.4\ g/L$, compute its mass concentration $c_{m,2}$ in the same solution when its partial pressure $p_2^* = 56\ mmHg$. The temperature is the same in both cases.

Exercise 3:

Table 1- Constants of equation 1 for different gases

Name	Formula	A	B	C	D	T range, K
Acetylene	C_2H_2	−156.51	8,160.2	21.403	0	274–343
Carbon dioxide	CO_2	−159.854	8,741.68	21.6694	−1.10261E-03	273–353
Carbon monoxide	CO	−171.764	8,296.9	23.3376	0	273–353
Ethane	C_2H_6	−250.812	12,695.6	34.7413	0	275–323
Ethylene	C_2H_4	−153.027	7,965.2	20.5248	0	287–346
Helium	He	−105.9768	4,259.62	14.0094	0	273–348
Hydrogen	H_2	−125.939	5,528.45	16.8893	0	273–345
Methane	CH_4	−338.217	13,282.1	51.9144	−0.0425831	273–523
Nitrogen	N_2	−181.587	8,632.13	24.7981	0	273–350
Oxygen	O_2	−171.2542	8,391.24	23.24323	0	273–333

Table 2: Henry's constant for air [H]=[atm^{-1}]

T [°C]	0	5	10	15	20	25	30	35	40	45	50	60	70	80	90	100
10^{-4} x H	0.23	0.20	0.18	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.11	0.10	0.10	0.09	0.09	0.09

1. Using Table 1 and equation 1 provided below, plot the evolution of the molar fraction of the gases listed in the table, when dissolved in water as a function of temperature.

$$\ln(x) = A + \frac{B}{T} + C \cdot ln(T) + D \cdot T \quad (1)$$

where T is expressed in Kelvin and x is the molar fraction of the solute dissolved in water when its partial pressure is $1\ atm$.

2. Compute the Henry's constant for all listed gases at $25°C$.

3. Calculate the mass concentration (in g/L) of oxygen and nitrogen dissolved in water from air (assume air is made by 21% in volume of oxygen and 79% in volume of nitrogen) at $25°C$ and atmospheric pressure. The molar masses of oxygen, nitrogen, and water are $31.998\ g/mol$, $28.013\ g/mol$, and $18.02\ g/mol$, respectively.

4. Calculate the mass concentration of dissolved air in water at $25°C$ exploiting the Henry's constant for air mixtures provided in Table 2, where H is given in atm^{-1}. The molar mass of gas mixtures is computed as follow:

$$\bar{M} = \sum_i X_i M_i$$

Where X_i is the molar fraction of the $i-th$ gas within the mixture, and M_i its molar mass. Compare the result with the mass concentration deduced from question 3.

5. Does the O_2/N_2 ratio is conserved when air is dissolved in water?