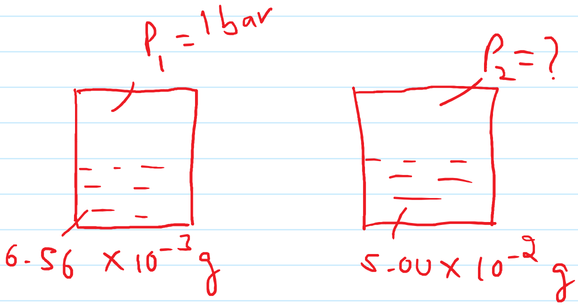
Question

The partial pressure of ethane over a solution containing 6.56×10^{-3} g ethane is 1 bar. If the solution contains 5.00×10^{-2} g of ethane, then what shall be the partial pressure of the gas?



Answer

By Henry's law

$P \propto$ solubility

$$\frac{P_2}{(\text{solubility})_2} = \frac{P_1}{(\text{solubility})_1}$$

$$\frac{P_2}{5 \times 10^{-2}} = \frac{1}{6.56 \times 10^{-3}}$$

$P_2 = 7.62$ bar.

Question

Henry's law constant for the solubility of methane in benzene at 298 K is 4.27×10^5 mm Hg. Calculate solubility of methane in benzene at 298 K under 760 mm Hg.

Answer

By Henry's law

$P = k_H x$

$760 = 4.27 \times 10^5 x$

$x = 1.78 \times 10^{-3}$

Mole fraction of methane in benzene $= 1.78 \times 10^{-3}$

Question

The air is a mixture of a number of gases. The major components are oxygen and nitrogen with approximate proportion of 20% is to 79% by volume at 298 K. The water is in equilibrium with air at a pressure of 10 atm.

At 298 K, if the Henry's Law constants for oxygen and nitrogen are 3.30×10^7 mm and 6.51×10^7 mm respectively, calculate the composition of these gases in water.

Answer

P_{O_2} = 20% of total pressure $= 0.2 \times 10 = 2$ atm

$= 2 \times 760$ mm

P_{N_2} = 79% of total pressure $= 0.79 \times 10 = 7.9$ atm

$= 7.9 \times 760$ mm

By Henry's law

$$x_{O_2} = \frac{P_{O_2}}{K_H(O_2)} = \frac{2 \times 760}{3.3 \times 10^7} = 4.6 \times 10^{-5}$$

$$x_{N_2} = \frac{P_{N_2}}{K_H(N_2)} = \frac{7.9 \times 760}{6.51 \times 10^7} = 9.22 \times 10^{-5}$$

Question

H_2S, a toxic gas with rotten egg like smell, is used for the qualitative analysis. If the solubility of H_2S in water at STP is 0.195 m, calculate Henry's law constant.

Answer

$$P = K_H \text{(solubility)}$$

P ↓ 1 atm; solubility ↓ 0.195 m

$$m = \frac{n_{solute} \times 1000}{w_{solvent}} = \frac{n_{solute} \times 1000}{n_{solvent} \times M_{solvent}} = \frac{x_{solute} \times 1000}{x_{solvent} \times M_{solvent}}$$

$$m = \frac{x_{solute} \times 1000}{x_{solvent} \times M_{solvent}}$$

$$0.195 = \frac{x_{H_2S} \times 1000}{x_{water} \times 18}$$

$$\frac{x_{H_2S}}{x_{water}} = \frac{0.195 \times 18}{1000} = \frac{3.51}{1000}$$

$X = 3.51 \sim 3.51 = 0.0035$

$$X_{H_2S} = \frac{3.51}{3.51 + 1000} \simeq 3.51 = 0.0035$$

at STP, P = 1 atm

By Henry's law

$$P_{H_2S} = K_H(H_2S)\, X_{H_2S}$$

$$1 = K_H(H_2S) \times 0.0035$$

$$K_H(H_2S) = 285.7 \text{ atm}$$

Question

Henry's law constant for CO_2 in water is 1.67×10^8 Pa at 298 K. Calculate the quantity of CO_2 in 500ml of soda water, when packed under 2.5 atm CO_2 pressure at 298 K.

Answer:

By Henry's law

$$P_{CO_2} = K_H(CO_2)\, X_{CO_2}$$

$$2.5 \times 1.01325 \times 10^5 \text{ Pa} = 1.67 \times 10^8 \text{ Pa} \; X_{CO_2}$$

$$X_{CO_2} = 0.00152$$

$$\frac{n_{CO_2}}{n_{CO_2} + n_{H_2O}} = 0.00152$$

$$\frac{n_{CO_2}}{n_{H_2O}} = 0.00152$$ $[n_{CO_2} << n_{H_2O},\ n_{H_2O} + n_{CO_2} = n_{H_2O}]$

$$\frac{n_{CO_2} \times M_{H_2O}}{W_{H_2O}} = 0.00152$$

$$\frac{n_{CO_2} \times 18}{500} = 0.00152$$ [500ml soda water = 500 gm soda water]

$$n_{CO_2} = \frac{0.00152 \times 500}{18}$$

$$w_{CO_2} = n_{CO_2} \times M_{CO_2} = \frac{0.0015\ 2 \times 500}{18} \times 44 = 1.86\ gm.$$

Question

If N_2 gas is bubbled through water at 293K, how many millimoles of N_2 gas would dissolve in 1L of water? Assume that N_2 exerts a partial pressure of 0.987 bar. Given that Henry's law constant for N_2 at 293 K is 76.48 kbar.

Answer:

By Henry's law

$$p_{N_2} = K_H(N_2)\ x_{N_2}$$

$$0.987 = 76.48 \times 1000\ x_{N_2}$$

$$x_{N_2} = 1.29 \times 10^{-5}$$

$$\frac{n_{N_2}}{n_{N_2} + n_{H_2O}} = 1.29 \times 10^{-5}$$

As $n_{N_2} << n_{H_2O}$, take $n_{N_2} + n_{H_2O} \simeq n_{H_2O}$

$$\frac{n_{N_2}}{n_{H_2O}} = 1.29 \times 10^{-5}$$

$$\frac{n_{N_2}}{55.55} = 1.29 \times 10^{-5}$$

$$n_{N_2} = 0.000717 \text{ moles}$$

$$= 0.717 \text{ millimoles}$$

1 L water = 1 kg water

= 1000 gm water

$\simeq \frac{1000}{18}$ moles

= 55.55 moles