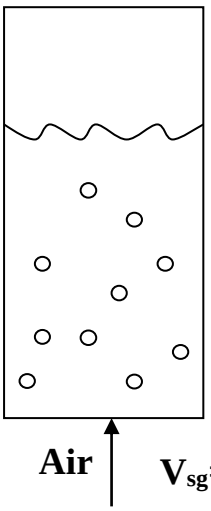
Tutorial 6: Gas Transfer - K_La coefficient

(From Sirous Ebrahimi)
Provide a MathCAD file with PDF version.



6.1. Gas liquid oxygen transfer in a bubble column (6:4+2)

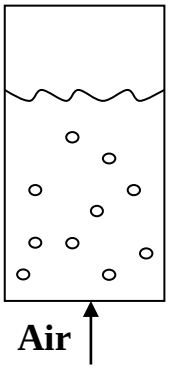
It is easy to measure gas hold up as a function of gas superficial velocity. In a bubble column filled with water and aerated at Vsg=7.5 cm/s one finds a gas hold up $\varepsilon = 0.1$.

- Estimate the maximum oxygen mass transfer rate (use gas holdup and Vsg correlation for K_La estimation)
- How does the oxygen transfer rate decrease, if O_2 concentration should be maintained to 2 mg/L?

Note: In Bubble Column, transfer is rate limited by liquid film resistant ($K_L \approx k_l$)

6.2. Scale up risk (10:2+3+2+2+1)

As an example of the scale up risks using a black box approach, let us consider the autotrophic thiosulphate ($S_2O_3^{2-}$) oxidation by Thiobacillus ferrooxidans in a bubble column reactor.

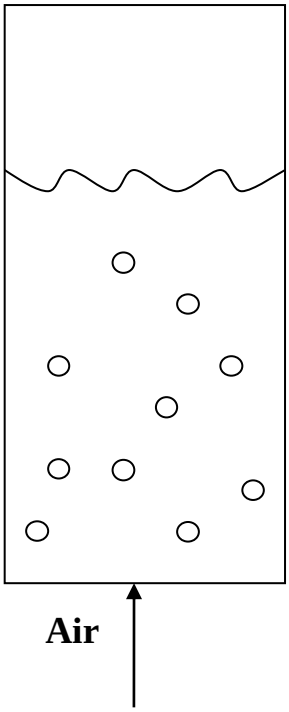


HRT=10 hr
V=100 L
A=0.1 m^2
H=1 m

V_{sg}=10 cm/s

In a pilot scale of 100L (A=0.1m^2; H= 1m) bioreactor (bubble column chemostat), the thiosulphate concentration in the influent is 0.2 mol/lit. The concentration of microorganism is measured as 1.1 g DW/L (with 7% ash). The maximal treatment capacity is obtained at a treatment time of 10hr (Hydraulic Retention Time).
Given: CO_2: 0.04% in the air,
Biomass composition $CH_{1.8}O_{0.5}N_{0.2}$

Subsequently, one does a scale up by building a bubble column of 100 m3 ($A=5m^2$; H=20m) by maintaining the superficial air velocity at 10 cm/s in order to keep the CO_2 transfer capacity equal at the two reactors.



Under these **same conditions,** observed treatment capacity was very low. Observed biomass concentration was 0.08 g/L, which is much less, than the 1.1 g/L found at pilot scale bioreactor.

To understand the problem:

a) Calculate mass and volumetric rates R_X and r_X on pilot scale reactor?
b) Calculate and compare to maximum carbon (CO_2) mass and volumetric load applied to the pilot reactor
c) Do same calculations on full scale reactor
d) Comment! What should the Vsg for full scale rector
e) What is the main difference between pilot and full-scale reactor (geometry)?

Hints: The Tutorial concerns gas transfer…

- What about the transport/supply of the C-Source?
- From mass balance, consider **mass** and **specific volumetric rates** concerning **biomass growth** and **CO_2** gas transfer (Supposing MAXIMUM CO_2 transfer (i.e. residual dissolved CO_2 liquid concentration = 0).
- Compare theses rates between pilot scale bioreactor and the full size treatment plant, even if the Vsg is equal in both bioreactors…