Useful Equation Assignment 3

Osmotic pressure $p_{osm} = ck_BT$, $c = N/V$ is the number concentration (in m^{-3}) of solutes.
Useful relation for protein calculation.

Depletion Force: When two large objects come together, the change in free energy is $\Delta H = ck_BT\Delta V$, where c is the number concentration of the solute, and $\Delta V = AD$, where A is the surface area of the object, and D is the diameter of the solute. We can approximate the "depletion" force that can arise from this as, $F \sim \frac{\Delta H}{D}$.

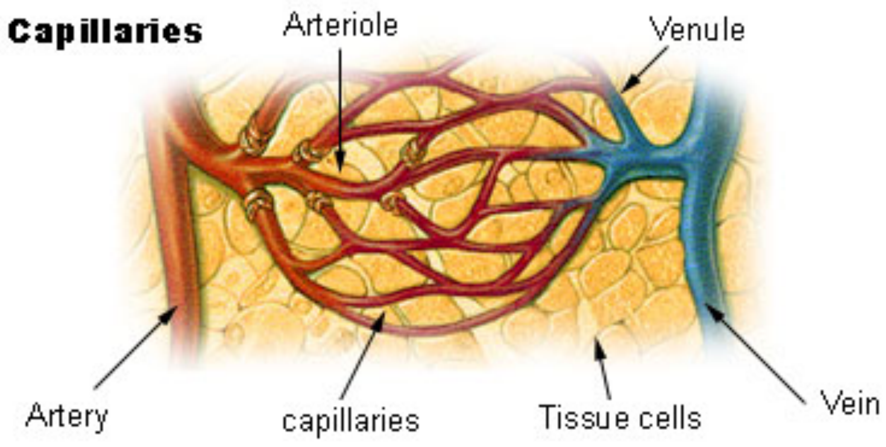
Pressure and Archimedes Principle: Atmospheric pressure $p_{atm} = 1.01 \times 10^5 Pa$; Gauge pressure $p_{gauge} = p_{absolute} - p_{atm}$; Buoyant force $F_{buoyant} = \rho_{fluid} V_{object} g$, V_{object} is volume occupied by object (such as fish or nautilus). Pascal Law, pressure under water $p = p_{atm} + \rho g d$, d is the depth.
Fluid Flow equations: Equation of continuity $\Delta V / \Delta t = A\text{v} = \text{constant}$, v is the average fluid speed; **Bernoulli's law** for an **ideal fluid** $p_1 + (1/2)\rho v_1^2 = p_2 + (1/2)\rho v_2^2 = \text{ constant}$;

Poiseuille's law for **Newtonian fluid** in a cylindrical tube $Q = \frac{\pi}{8\eta} r_{tube}^4 \frac{\Delta p}{l}$, (unit $\frac{m^3}{s}$), where $Q = \frac{\Delta V}{\Delta t}$ the volume flow rate in unit of $m^3 \bullet s^{-1}$; $\eta = 10^{-3} Pa \bullet s$ for water, and for blood $\eta = 2.5 \times 10^{-3} Pa \bullet s$. **Kirchoff's Law:** Pressure drop $\Delta p = QR$, where the "resistance" to flow (Q) is $R = \frac{8l\eta}{\pi r_{tube}^4}$; **blood vessels in series**, flow rate (Q) are the same, $\Delta p_1 = R_1 Q$, $\Delta p_2 = R_2 Q$, … gives total pressure drop $\Delta p = \Delta p_1 + \Delta p_2 + \cdots = R_{equivalent} Q$, with the equivalent "resistance", $R_{equivalent} = R_1 + R_2 + \cdots$; **blood vessels in parallel**, Pressure drop (Δp) are the same, $\Delta p = R_1 Q_1$, $\Delta p = R_2 Q_2$, … with total flow $Q = Q_1 + Q_2 + \cdots \rightarrow \Delta p = R_{equivalent} Q$, with the equivalent "resistance", $\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

DATA $e = 1.6 \times 10^{-19} C$; $1M = 1 mole / L$; $1L = 10^{-3} m^3$; Avogardo Number $N_A = 6.023 \times 10^{23} particle / mole$; pressure unit $1 atm = 1.01325 \times 10^5 pa$.

Geometrical Relations: 1) sphere, surface area $A = 4\pi r^2$ and volume $V = \frac{4}{3}\pi r^3$; 2) cylinder surface area $A = 2\pi rL$ and volume $V = \pi r^2 L$.

Data of Arteries/Veins/Capillaries



1. Gauge pressure is the pressure above or below the atmospheric pressure $1atm = 1.01325 \times 10^5 Pa, Pa = \frac{N}{m^2}$.
2. Pressure starts at 3.3 kPa at artery to 1.3 kPa at the veins.
3. Oxygenated/Deoxygenated blood flow from/to heart through arteries/veins.
4. Deoxygenated/ Oxygenated blood flow from/to heart through pulmonary arteries/pulmonary veins
5. Arteries are divided into aorta, large arteries, small arteries, and arterioles
6. Veins are divided into venae cavae, large veins, small veins, venules.
7. Capillaries are the smallest type of blood vessel in the body. Their job is to enable the exchange of substances between the blood and surrounding tissues.

	Number	Length of one	Radius of one
Aorta	1	34 cm	1.3cm
Large Arteries	40	12.5 cm	0.4 cm
Small Arteries	280	12.5 cm	0.15 cm
Arterioles	1.6×10^8	2.5×10^{-3}m	0.001 cm
Capillaries	3.2×10^9	8.5×10^{-4}m	0.00045 cm
Venules	5×10^8	0.2 cm	0.00125 cm
Small Veins	5600	1.55 cm	0.075 cm
Large Veins	1	30 cm	0.8 cm
Venae cavae	2	13.9 cm	1.6 cm