Equations for Primary FRCA

**Pharmacology**

C: concentration  
t: time

**Bioavailability**

\[
\text{Bioavailability} = \frac{AUC_{ORAL}}{AUC_{IV}}
\]

AUC: area under concentration – time curve

**Exponential Function**

\[
\frac{dC}{dt} \propto C \quad \text{or} \quad \frac{dC}{dt} = K.C
\]

\[
e = 2.718 \quad \text{or} \quad \frac{1}{e} = 0.37
\]

\[
C = C_0.e^{-Kt}
\]

(for a negative exponential relationship)  
C_0 is the concentration at t = 0  
K: rate constant

**Pharmacodynamics**

D: free drug  
R: unoccupied receptors  
DR: drug occupied receptors  
K_D: dissociation constant

\[
K_D = \frac{[D][R]}{[DR]}
\]

\[
\text{affinity} = \frac{1}{K_D}
\]

**Enzyme Kinetics**
\[ V = \frac{V_{\text{max}}[S]}{K_m + [S]} \]

V: initial velocity  
\( V_{\text{max}} \): maximum initial velocity  
\( K_m \): concentration at which the initial velocity is half the maximal initial velocity  
S: substrate

**Pharmacokinetics**

Cl: clearance  
\( V_d \): volume of distribution  
\( \tau \): time constant  
K: rate constant  
D: dose

\[ V_d = \frac{D}{C_0} \]

\[ \tau = \frac{1}{K_{el}} \]

\[ \tau = \frac{V_d}{Cl} \]

\[ t_\frac{1}{2} = \tau \log_2 2 \]

*Loading dose* = \( V_d.C_p \)  
*Maintenance dose* = \( C_p.Cl \)

**Three Compartment Model**

\[ C_p = A.e^{-\alpha t} + G.e^{-\gamma t} + B.e^{-\beta t} \]

A/\( \alpha \) B/\( \beta \) G/\( \gamma \): kinetic constants

**Physics and Measurement: Pressure & Fluids**

**Pressure**
Pressure \(= \frac{force}{area}\)

Absolute pressure = gauge pressure + atmospheric pressure

**Fluids**

Q: flow  
d: tube diameter  
P: pressure  
\(\eta\): viscosity  
l: length of tube  
v: fluid velocity  
p: density

**Laminar flow. Hagen-Poiseuille Equation**

\[
Q = \frac{\pi P d^4}{128 \eta l}
\]

**Reynolds Number**

\[
Re = \frac{v p d}{\eta}
\]

**Turbulent Flow**

\[
Q \propto \sqrt{P}
\]

\[
Q \propto 1 \sqrt{l}
\]

\[
Q \propto 1 \sqrt{P}
\]

**Bernoulli’s Equation**

\[
\frac{1}{2} p v^2 + P = K
\]

P: potential energy

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**Physics and Measurement: Gas Laws**
P: pressure  V: volume  T: temperature  K: constant

Boyle’s Law: \( PV = K \)

Charles’ Law: \( \frac{V}{T} = K \)

3rd Law: \( \frac{P}{T} = K \)

\[
\frac{PV}{T} = K
\]
\[
PV = nRT
\]

n: number of moles
R: universal gas constant

**Physics and Measurement: Electricity**

V: potential difference (volts)
I: current (amps)
R: resistance (ohms)

\[ V = IR \]

**Power**

Power (watts) = \( VI = I^2 R \)

**Charge**

\[ Q = \text{amperes}(A) \times \text{seconds}(s) \]

Q: charge (coulombs)

**Capacitance**

\[ C = \frac{Q}{V} \]

C: capacitance (farads)

**Defibrillator**
\[ \text{Stored Energy} = \frac{1}{2} CV^2 = \frac{1}{2} QV \]

**Resistors**

Parallel: \[ \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \ldots \]

Series: \[ R_T = R_1 + R_2 \ldots \]

\[ \frac{R_1}{R_2} = \frac{R_3}{R_4} \]

**Physics and Measurement: Other**

**Tension**

T: tension  
R: radius  
P: pressure gradient

Tube: \[ P = \frac{T}{r} \]

Sphere: \[ P = \frac{2T}{r} \]

**Work**

Work done = force \( \times \) distance

Unit of work = Nm

**Humidity**

Relative humidity \( = \) \[ \frac{\text{actual vapour pressure}}{\text{saturated vapour pressure}} \]

**Linear Function**

\[ y = Mx + C \]

M: gradient of a straight line  
C: y axis intercept
**Light**

Lambert-Bouguer law

\[ I = I_0 e^{-ad} \]

\( I \): transmitted light  
\( I_0 \): incident light  
\( a \): extinction coefficient for the solution  
\( d \): thickness

Lambert-Beer law

\[ \text{Absorbance} = \xi cd \]

\( \xi \): molar extinction coefficient  
\( c \): molar concentration  
\( d \): thickness

**Physics and Measurement: Statistics**

\[ \text{Variance} = SD^2 = \frac{\sum (x - \bar{x})^2}{n-1} \]

\[ \text{Standard Error of the Mean} = \frac{SD}{\sqrt{n-1}} \]

SD: standard deviation

**Physiology: cellular**

**Diffusion**

\[ Q = k_p \cdot \frac{A}{T} \cdot (C_1 - C_2) \]

\( Q \): rate of diffusion  
\( k_p \): permeability constant  
\( \propto \) permeability \( \propto \frac{\text{solubility}}{\sqrt{MW}} \)  
\( A \): area of membrane  
\( T \): thickness of membrane
C₁ – C₂: concentration gradient

**Total Blood Volume** \((V_{BL})\)

\[
\frac{V_{PL} \times 100}{(100 - Hct)}
\]

\(V_{PL}: \) volume plasma  
\(Hct: \) haematocrit

**Measurement of Fluid Compartments**

\[
\text{volume of compartment} = \frac{\text{mass of indicator}}{\text{concentration in compartment}}
\]

**Osmotic Pressure (van’t Hoff equation)**

\[
\pi = RTC
\]

\(\pi: \) osmotic pressure  
\(R: \) universal gas constant  
\(T: \) absolute temperature  
\(C: \) osmolality (mosm/kg H₂O)

**Plasma Osmolality**

\[
\text{Plasma Osmolality (mosm/kg H₂O)} = 2 \times [\text{Na}] + [\text{glucose}] + [\text{urea}]
\]

**Gibbs-Donnan**

\[
[cation]_A \times [anion]_A = [cation]_B \times [anion]_B
\]

**Nernst Equation**

For example, sodium:

\[
capillary \ wall \ potential (mV) = \frac{RT}{FZ_{Na}} \times \log_e \frac{[Na]_{int}}{[Na]_C}
\]

\(R: \) universal gas constant  
\(T: \) absolute temperature  
\(F: \) Faraday constant  
\(Z: \) valency  
\(Int: \) interstitial  
\(c: \) capillary

**Starling Forces**
Pressure Gradient = \((P_c + \pi_{\text{int}}) - (P_{\text{int}} + \pi_c)\)
Rate of Filtration = \(K \cdot (P_c + \pi_{\text{int}}) - (P_{\text{int}} + \pi_c)\)

\(\pi\): colloid osmotic pressure
\(P\): hydrostatic pressure
\(\text{Int}\): interstitial
c: capillary

**Physiology: Cardiac**

SV: stroke volume
CO: cardiac output
SVR: systemic vascular resistance (dynes.s/cm\(^5\))
BP: blood pressure (mmHg)
MAP: mean arterial blood pressure
HR: heart rate
CVP: central venous pressure (mmHg)

**Stroke Volume**

\[SV = EDV - ESV\]

\[Ejection\; Fraction = \frac{SV}{EDV}\]

EDV: end diastolic volume
ESV: end systolic volume

**Cardiac Output**

\[CO = HR \times SV\]

\[Cardiac\; Index = \frac{CO}{BSA}\]

BSA: body surface area

**Systemic Vascular Resistance**

\[SVR = \frac{MAP - CVP}{CO} \times 80\]

**Mean Arterial Blood Pressure**

\[MAP - CVP = CO \times SVR\]
**QT interval corrected** (QTc)

\[ QT_c = \frac{QT}{\sqrt{R-R}} \]

R-R: interval between two consecutive R waves

**Fick Method**

\[ CO = \frac{\dot{V}O_2}{(CaO_2 - CvO_2)} \]

VO₂: oxygen uptake  
CaO₂: oxygen content of arterial blood  
CvO₂: oxygen content of venous blood

**Physiology: Respiratory**

\[ \cdot V \]  
Vol: volume of gas per unit time  
V: volume of gas  
D: dead space  
C: content  
P: pressure or partial pressure

**Ventilation**

\[ V_T = V_A + V_D \]

\[ \cdot V_A = \frac{\dot{V}CO_2}{PACO_2} \times K \]

**Bohr equation**

\[ \frac{V_D}{V_T} = \frac{PACO_2 - PECO_2}{PACO_2} \]

(for physiological dead space)

**Alveolar Gas Equation**

\[ PAO_2 = PIO_2 - \frac{PACO_2}{R} \]
R: respiratory quotient $\Rightarrow R = \frac{\dot{V}CO_2}{\dot{V}O_2}$

**Venous to Arterial Shunt**

$$\frac{\dot{Q}_S}{\dot{Q}_T} = \frac{C_{co_2} - C_{ao_2}}{C_{co_2} - C_{vo_2}}$$

Q: volume of blood per unit time  
S: shunt  
T: total c: end capillary

**Compliance**

$$\text{compliance} = \frac{\Delta V}{\Delta P}$$

$$\frac{1}{C_R} = \frac{1}{C_L} + \frac{1}{C_W}$$

C_R: respiratory system compliance  
C_L: lung compliance  
C_W: wall compliance

**Oxygen Content**

$$\text{Content (ml O}_2/\text{g Hb)} = (1.39 \times [\text{Hb}] \times \frac{\% \text{sat}}{100}) + (0.023 \times \text{Po}_2)$$

Po_2: partial pressure in kPa

**Physiology: Other**

**Clearance**

$$C_x = \frac{U_xV}{P_x}$$

C_x: clearance of x (ml/min)  
U_x: urine concentration of x  
P_x: plasma concentration of x  
V: urine flow (ml/min)  

pK
\[ pK = -\log K \]
\[ k = \frac{[H^+][A^-]}{[HA]} \]

**Henderson-Hasselbach**

\[ \text{pH} = pK + \log \frac{\text{conjugate base}}{\text{acid}} \]
\[ \text{pH} = pK + \log \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} \]
\[ \text{pH} = pK + \log \frac{[\text{HCO}_3^-]}{0.23 \times P_{\text{CO}_2}} \]

**Cerebral Perfusion Pressure**

\[ \text{CPP} = \text{MAP} - (\text{ICP} + \text{CVP}) \]