Problem 1 – Unit Conversions

a. 18.1 mmol glucose/L whole blood to mg glucose/dL plasma, where individual's blood contains 63 vol% plasma

Molecular formula for glucose is $C_6H_{12}O_6$
Molecular weight for glucose is (6x12) + (12x1) + (6x16) = 180 g/mol

$$\frac{18.1\text{ mmol glucose}}{\text{L whole blood}}\cdot\frac{180\text{ g glucose}}{1\text{ mol glucose}}\cdot\frac{1\text{ mol}}{1000\text{ mmol}}\cdot\frac{1000\text{ mg}}{1\text{ g}}\cdot\frac{1\text{ L}}{10\text{ dL}}\cdot\frac{1\text{ dL whole blood}}{0.63\text{ dL plasma}}$$
$$= 517\text{ mg glucose/dL plasma}$$

b. 1.256 mol electrons/second to Amps

$$1.256\text{ mol electrons/second}\frac{1.602\text{ X}10^{-19}\text{ C}}{1\text{electron}}\cdot\frac{6.023X10^{23}\,electrons}{1\text{mole}}[=]<coulomb/\sec>$$
$$= 1.2110\text{ x }10^{5}\text{ Amp}$$

c. 15 grams glycerol/(ft^3.hr) to moles hydrogen peroxide/(L.min)

Molecular formula for glycerol is $C_3H_8O_3$
Molecular weight for glycerol is (3x12) + (1x8) + (3x16) = 92 g/mol

$$\frac{15.0\text{ g }C_3H_8O_3}{\text{ft}^3\text{hr}}\cdot\frac{1\text{ mol}}{92\text{ g }C_3H_8O_3}\cdot\frac{1\text{ ft}^3}{28.317\text{ L}}\cdot\frac{1\text{ hr}}{60\text{ min}}$$
$$= 9.6\text{ x }10^{-5}\text{ moles glycerol / (L}\cdot\text{min)}$$

d. 373 K to ºR

$$373\text{ K}\cdot\frac{1.8\text{R}}{1\text{ K}} = 671\ ^{\circ}\text{R}$$

e. a difference between two temperatures of 15ºF to a difference in temperature in ºC

Given (F+15) –F

Temp in C = (Temp in F – 32)(5/9)

Diff of Temp in C = [(F+15-32)-(F-32)] (5/9)

= (32*5)/9

= 8.3 ºC

Problem 2 – Units in equations

$$V_{blood}(L) = a\left(\frac{L}{cm^3}\right)\cdot H^3\left(cm^3\right) + b\left(\frac{L}{kg}\right)\cdot M(kg) + c(L)$$

a [=] L/cm^3

b [=] L/kg

c [=] L

Problem 3 – Dimensionless Numbers

In this problem we are given the heat transfer coeffient (h), length of blood vessel (L), and thermal conductivity of blood (k), and told that we can represent the Nusselt number as

$$Nu = \frac{h\,L}{k}$$

We are told that when Nu >> 1 the rate of heat transfer is limited by thermal conductivity, whereas Nu << 1 indicates that the rate is limited by fluid flow rate. **We are asked to find whether the rate of heat transfer from arterioles to tissue is limited by flow rate or thermal conductivity**.

$$h = \frac{18.7\,Btu}{ft^2\cdot hr\cdot {}^\circ F}\times\frac{252\,cal}{1\,Btu}\times\frac{1\,ft^2}{144\,in.^2}\times\frac{1\,hr}{3600\,s}\times\frac{1.8\,{}^\circ F}{K}$$
$$h = \frac{0.0163\,cal}{in.^2\cdot s\cdot K}$$

$$L = 0.10\,in.$$

$$k = \frac{584\cdot 10^{-7}\,cal}{cm\cdot s\cdot K}\times\frac{2.54\,cm}{1\,in.}$$
$$k = \frac{1.483\cdot 10^{-4}\,cal}{in.\cdot s\cdot K}$$

$$Nu = \frac{\frac{0.0163\,cal}{in.^2\cdot s\cdot K}\times 0.10\,in.}{\frac{1.483\cdot 10^{-4}\,cal}{in.\cdot s\cdot K}}$$

$$Nu = 11$$

Since Nu >> 1, the rate of heat transfer is limited by thermal conductivity.

Problem 4 – Propagation of Confidence Limits

Participant #	H (in)	H (cm)	M (lb)	M (kg)	V (liter) = aH^3 + bM + c
1	75.0	190.5000	217.0	98.4210	7.2818
2	69.5	176.5300	184.0	83.4610	6.0197
3	71.0	180.3400	210.0	95.2544	6.7022
4	69.0	175.2600	167.0	75.7499	5.6236
5	67.0	170.1800	174.0	78.9251	5.5769
6	72.0	182.8800	224.0	101.6047	7.0928
7	70.5	179.0700	190.0	86.1826	6.2427
8	71.0	180.3400	175.0	79.3787	5.9878
9	69.5	176.5300	179.0	81.1930	5.9177
10	73.0	185.4200	238.0	107.9550	7.4863

Average blood volume (L), $\bar{v} = \frac{\sum V_i}{n} = 6.39\,L$

Standard deviation (L), $s = \sqrt{\frac{\sum V_i - \bar{v}}{(n-1)}} = 0.6977\,L$

From the t-table, at 95% confidence limits, t = 2.262

$$\bar{s} = \frac{t \cdot s}{\sqrt{n}} = 0.4991$$

Thus, the average blood volume with 95% confidence limit = 6.39 ± 0.4991 L.

Problem 5 – Identifying Outliers in Data

In this problem we seek to use the Q and z tests to determine whether or not there is an outlier in the following data set.

Data point	Conc. (mM/L)
1	23.1
2	22.7
3	22.9
4	22.9
5	21.3
6	22.5

7 22.6

The most likely data points that are outliers are the ones with the maximum or minimum value. Therefore, let us focus on data point 5, with a value of 21.3 mM/L since it is the minimum value point.

Q-test
First we want to test this point using the Q-test, which takes the form

$$Q_n < \frac{|x_a - x_b|}{R} \quad ,$$

where 'x_a' is the outlier, 'x_b' is the nearest value in the data set, and 'R' is the difference between the maximum and minimum values. We have seven data points, so looking in a table we find that Q_n = 0.59. Thus,

$$0.59 < \frac{|21.3 - 22.5|}{23.1 - 21.3} = 0.667 \quad ,$$

is a true statement, and **data point 5 is an outlier**. We have shown that there is an outlier, and do not need to test any of the other values (but can for fun!).

Z-test
The Z-test takes the form

$$z = \frac{|x - \bar{x}|}{s} \quad ,$$ and note that $s = \sqrt{\frac{\sum_{i=1}^{n} |x - \bar{x}|}{n-1}}$,

where 'x' is the suspected outlier, '$\bar{x}$' is the calculated mean, 'n' is the number of data points, and 's' is the calculated standard deviation. With these three variables we calculate a z-score and then compare this result to a z-value corresponding to a 96% confidence level (which we look up in a table).

$$\bar{x} = 22.57\, mM/L$$
$$s = 0.596\, mM/L$$
$$z = \frac{|21.3 - 22.57|}{0.596} = 2.13$$
$$Z_{.96} = 2.06$$

$$z > Z_{.96}$$

By the z-test **we can say with 96% confidence that data point 5 is an outlier**. Note that had we chosen a different confidence level against which to test the calculated z-score, we might have gotten different results.

Another acceptable form of the z-test is

$$x_r = \bar{x} \pm s \cdot Z_{.96}$$

In this form, we calculate a range 'x_r.' If our point falls outside of this, then we reject it as an outlier.

A note on the z-test

The z-test is usually conducted on data sets with more than 40 samples, and here we have 7 data points. This means that in solving this problem we make certain assumptions and simplifications- mainly that our calculated mean and standard deviation are accurate representations of the actual mean and standard deviation.

Some of you performed the z-test using the form

$$z = \frac{|x - \bar{x}|}{s \cdot \sqrt{df}} \quad ,$$

where df = the degrees of freedom. Since we use the calculated the mean and standard deviation, df = 6 (number of samples minus one). However, since the z-test is historically performed when we already know the mean and standard deviation, the degrees of freedom = number of samples. Thus, in this specific problem it was acceptable if you used df = 7.