**Q1**. Consider a polypeptide (protein) with '$N$' sequences. Each position in the sequence has '$M$' options (amino acids).

a) Write down the number of possible sequences; call it $\Omega$

a) Define the disorder ($I$) as the natural logarithm of $\Omega$, multiplied by a constant '$K$'.

a) Define the $P_i$ as the probability that i$^{th}$ option (amino acid) is used within the sequence.

a) Use the Stirlings' approximation to arrive at SHANNON'S FORMULA for the disorder per $N$ :

$$I/N = -K \sum_{j=1}^{M} P_j \ln P_j$$

**Q2**. Show that the disorder as defined in Shannon's formula is maximum when all the probabilities ($P_i$) are the same.

**Q3**. The entropy of an ideal gas at equilibrium is given by the Sackur-Tetrode Formula:

$$S = k_{\mathrm{B}} \ln \left[ \left( \frac{2\pi^{3N/2}}{(3N/2-1)!} \right) (2mE)^{3N/2} V^N \frac{1}{N!} (2\pi\hbar)^{-3N} \frac{1}{2} \right]$$

In the above equation, $\hbar$ is the Planck's Constant whose units are Joule-second.

a) Identify the variables

b) Show that the argument within the natural logarithm is dimensionless

c) We would like to re-state the above formula as, $S = k_B ln\left[(2mE)^{3N/2}\, V^N \alpha\right]$

where '$\alpha$' represent a constant. Write down an expression for this constant.