CRYOGENICS – GAS LAW CALCULATION
(REQUIRED FOR USE OF LIQUID NITROGEN IN EXPERIMENTS)

Worst-case Scenario in Oxygen depletion by liquid nitrogen spill: the entire contents of the Dewar or storage tank are lost to the room immediately after spilling (100% of the vessel contents).

Example Calculation:

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\begin{align*}
V_N & = \text{Total volume loss of Liq. } N_2 \text{ (100\%) } = 1.0 \\
V_R & = \text{Total room volume (m}^3\text{)} \\
V_D & = \text{Dewar or Vessel capacity (litres)} \\
F_G & = \text{Gas Factor for } N_2 \text{ (683 for } N_2) \\
0.21 & = \text{Normal concentration of } O_2 \text{ in air (21\%)}
\end{align*}
\]

\[
\begin{align*}
V_{OX} & = \text{Total volume of } O_2 \text{ in room (m}^3\text{)} = 0.21 \times (V_R - [(V_N \times V_D \times F_G)/1000]) \\
C_{OX} & = \text{Total concentration of } O_2 \text{ remaining in room after 100\% L. } N_2 \text{ container spill } = 100 \times V_{OX}/V_R
\end{align*}
\]

For a room size 71 m\(^3\), and a 100\% Liq. N\(_2\) spill of 41 litres:

The total vol. of O\(_2\) in room = \(V_{OX} = 0.21 \times (71 - [(1.0 \times 41 \times 683)/1000]} \) = 9.03 m\(^3\)

Total conc. of O\(_2\) remaining in room = \(C_{OX} = 100 \times 9.03/71 = 12.71\%\)

Requirements: In a worst-case scenario where all of the Liq. N\(_2\) container spills, the total concentration of O\(_2\) remaining in the room must be 20\% or more. Otherwise the following is required:

- Room equipped with O\(_2\) detector that sounds an alarm when the O\(_2\) concentration falls below 20\%
- Warning signs are displayed both on door to lab and next to L. N\(_2\) dewar or dispenser
- Proper mechanical/non-mechanical ventilation must be installed within lab

Recommended alternative action: Reduce the size/volume of the Liq. N\(_2\) dewar, to ensure that the O\(_2\) concentration exceeds the minimum, and an oxygen-deficient atmosphere is avoided.

Your Calculation:

For a room size X m\(^3\), and a 100\% Liq. N\(_2\) spill of Y litres:

The total vol. of O\(_2\) in room = \(V_{OX} = 0.21 \times (X - [(1.0 \times Y \times 683)/1000]} \) = Z m\(^3\)

Total conc. of O\(_2\) remaining in room = \(C_{OX} = 100 \times Z/X = ??? \%\)