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:

V_N = Total volume loss of Liq. N_2 (100%) = 1.0

V_R = Total room volume (m^3)

V_D = Dewar or Vessel capacity (litres)

F_G = Gas Factor for N_2 (683 for N_2)

0.21 = Normal concentration of O_2 in air (21%)

V_{OX} = Total volume of O_2 in room (m^3) = $0.21 \times \{V_R - [(V_N \times V_D \times F_G)/1000]\}$

C_{OX} = Total concentration of O_2 remaining in room after 100% L. N_2 container spill = $100 \times V_{OX}/V_R$

For a room size 71m³, 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 = $V_{OX} = 0.21 \times \{\mathbf{X} - [(1.0 \times \mathbf{Y} \times 683)/1000]\} = \mathbf{Z}\ m^3$

Total conc. of O_2 remaining in room = $C_{OX} = 100 \times \mathbf{Z}/\mathbf{X}$ = **????** %