Analytical Instruments

Quick reference for instrumentation and control engineers

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pH

Definition	**$pH = -\log_{10} a_{H+}$**
Nernst slope	**$S = 0.198416 \times T(K)$ mV/pH**
pH from mV	**$pH = 7 - E \div S$**
Slope %	**$S_{meas} \div S \times 100$ (often 90 to 105 %)**
Offset	**mV at pH 7 (often within ± 30 mV)**

Nernst slope vs temperature

°C	mV/pH
0	54.20
25	59.16
50	64.12
75	69.08

Standard buffers (25 °C)

- pH 4.01, 7.00, 10.01 (10 drifts fastest, absorbs CO_2).
- Calibrate with pH 7 plus one buffer near the process value.

Conductivity

Conductivity	**$\kappa = G \times K$ (cell constant)**
To 25 °C	**$\kappa_{25} = \kappa_T \div [1 + \alpha (T - 25)]$, $\alpha \approx 0.02$**
TDS	**TDS ≈ 0.5 to 0.7 × κ_{25} (mg/L per µS/cm)**
Ultrapure water	**0.055 µS/cm at 25 °C**

DO saturation (fresh water, sea level)

°C	mg/L
0	14.62
10	11.29
20	9.09
25	8.26
30	7.56

Gas units

ppm to mg/m³	**$mg/m^3 = ppm \times M \div V_m$**
V_m	**24.45 L/mol at 25 °C, 22.41 at 0 °C**
% vol	**1 % = 10,000 ppm**
Hardness	**2.497 Ca + 4.118 Mg (mg/L as $CaCO_3$)**

LEL (IEC 60079-20-1, % vol)

Gas	LEL
Methane	4.4
Propane	1.7
Hydrogen	4.0

Mixture: $LEL = 100 \div \Sigma(C_i \div LEL_i)$.

20 % LEL methane = 0.88 % vol.

Combustion

Excess air	**$EA\ \% \approx O_2 \div (20.9 - O_2) \times 100$**
O_2 correction	**$C_{ref} = C \times (20.9 - O_{2ref}) \div (20.9 - O_2)$**
Zirconia cell	**$E = 0.0496\ T \log_{10}(20.95 \div O_2)$ mV**

Sample systems

Lag time	**$t = V \div Q = \pi d^2 L \div 4Q$**
Example	**4 mm ID × 30 m at 1 L/min ≈ 23 s**