IDEAL GAS LAW

$$p\,V = n\,R\,T$$

Depends on Units

Absolute Units
[Pa, bara, psia]

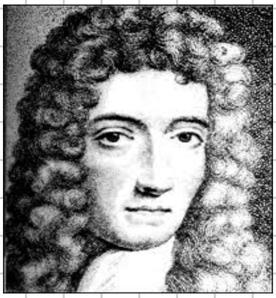
Always associated with a mass unit
[g-mole, kg-mole, lb-mole]
"mol"

Absolute Units
[K, °R]

Assumption:
"Low Pressure"
"High Temperature"

ANY
Compound or Mixture

Boyle : $pV = \text{constant}$ @ "Low" pressures



Charles Law : $V \propto T$

Other Quantities used in this equation

v = molar volume
$\equiv V/n$

"Equation of State"
(EOS)

$$\boxed{p-V-T-n}$$

Z = deviation factor
↑
from ideal gas behavior

$$Z \equiv \frac{pv}{RT} = \frac{pV}{nRT} = 1$$

$pV = nRT$

Ideal Gas Molar Volume

$$v_g \text{ @ } p_{sc}, T_{sc} \equiv \boxed{v_{\bar{g}} = \frac{V_{\bar{g}}}{n} = \frac{RT_{sc}}{p_{sc}}} \quad V_{\bar{g}} \leftrightarrow n$$

1 atm
14.696 psia
1.0135 bara

60°F + 459.67 = 520°R
15.56°C + 273.15 = 520/1.8 = K

s.c. STC

$\bar{g}$, $\bar{o}$, $\bar{w}$: bar implies @ p_{sc}, T_{sc}

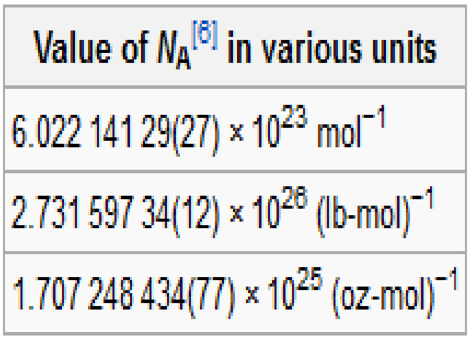
SI : $v_{\bar{g}}$ = 23.6x Sm³/kg-mole std m³/kg-mole

Field : v_g = 379.1x scf/lb-mole

Avogadro's Law:

Ideal Gases:

$$\frac{V}{n} = \text{constant}$$



Value of N_A[6] in various units
$6.022\,141\,29(27) \times 10^{23}$ mol^{-1}
$2.731\,597\,34(12) \times 10^{26}$ (lb-mol)$^{-1}$
$1.707\,248\,434(77) \times 10^{25}$ (oz-mol)$^{-1}$

Avogadro's Number $N_A = \frac{N}{n}$

gmol

6.022×10^{26} kg-mol^{-1}

CLASS EXERCISES:

1. Calculate Ideal Gas Molar Volumes $v_{\bar{g}}$ for

(a) SI : m^3 , kg-mole

(b) Field : scf , lb-mole
(standard condition ft^3)

$$v_{\bar{g}} = \frac{R T_{sc}}{p_{sc}}$$

	SI	Field
p_{sc}	1.0135 bara ✓	14.696 psia ✓
T_{sc}	15.56 °C → K +273.15 = 288.71 K ✓	60 °F → °R +459.67 = 519.67 °R ✓
R	✓ 8314.3	10.7315 ✓
$v_{\bar{g}}$	23.68 $\frac{\text{std } m^3}{\text{kg-mole}}$	379.5 $\frac{\text{scf}}{\text{lb-mole}}$

2. TROLL GAS RESERVOIR

$$V_{\bar{g}i} = \underset{\uparrow \text{ sc gas}}{IGIP} = OGIP \quad \overset{\swarrow \text{SPE symbol}}{(G)} = 45 \text{ Tcf}$$

$$= \underline{45 \cdot 10^{12} \text{ scf}}$$

(a) → n_g [lb-mole] $= 45.10^{12} \cancel{\text{scf}} \times \frac{\text{lb-mole}}{379 \cancel{\text{scf}}} = 11.87 \cdot 10^{10}$ lb-mole

(b) → n_g [Kg-mole] $= 11.87 \cdot 10^{10} \cancel{\text{lb-moles}} \cdot \frac{\text{kg-mole}}{2.204 \cancel{\text{lb-mole}}} = 5.39 \cdot 10^{10}$

(c) → $V_{\bar{g}i}$ (G) [std m3] $= 5.39 \cdot 10^{10} \cancel{\text{kg-mole}} \cdot 23.68 \text{ Sm}^3/\cancel{\text{Kg-mole}}$

$= 127.\underline{\underline{6}} \cdot 10^{10}$ Sm^3

NOK/Sm^3

(d) Check (c) using 35.31 scf/Sm^3

$$= 45.10^{12} \text{ scf} \times \frac{Sm^3}{35.31 \text{ scf}} = 127.\underline{\underline{4}} \cdot 10^{10} \text{ Sm}^3$$

$$\cancel{\$}5/\cancel{\text{Mscf}} \times 6 \underbrace{\frac{\text{NOK}}{\cancel{\$}}}_{1} \times \underbrace{\frac{\cancel{\text{M}}\text{scf}}{1000 \cancel{\text{scf}}}}_{1} \times \underbrace{\frac{35.31 \cancel{\text{scf}}}{Sm^3}}_{1} = 1.05 \quad \frac{\text{NOK}}{Sm^3}$$

6 NOK/USD

$$0.2 \cdot 10^{10} \text{ Sm}^3 \times 1 \frac{\text{NOK}}{\text{Sm}^3} = 2 \cdot 10^9 \text{ NOK}$$

$\sim$ 100 Life-Salaries

Life-Salary Unit $\sim$ $700{,}000 \text{ NOK/yr} \times 30 \text{ yr} = 21 \cdot 10^6 \text{ NOK}$