Mise en pratique of the (new) definition of the mole

current draft:
http://www.bipm.org/cc/CCQM/Allowed/22/CCQM16-04_Mole_m_en_p_draft.pdf

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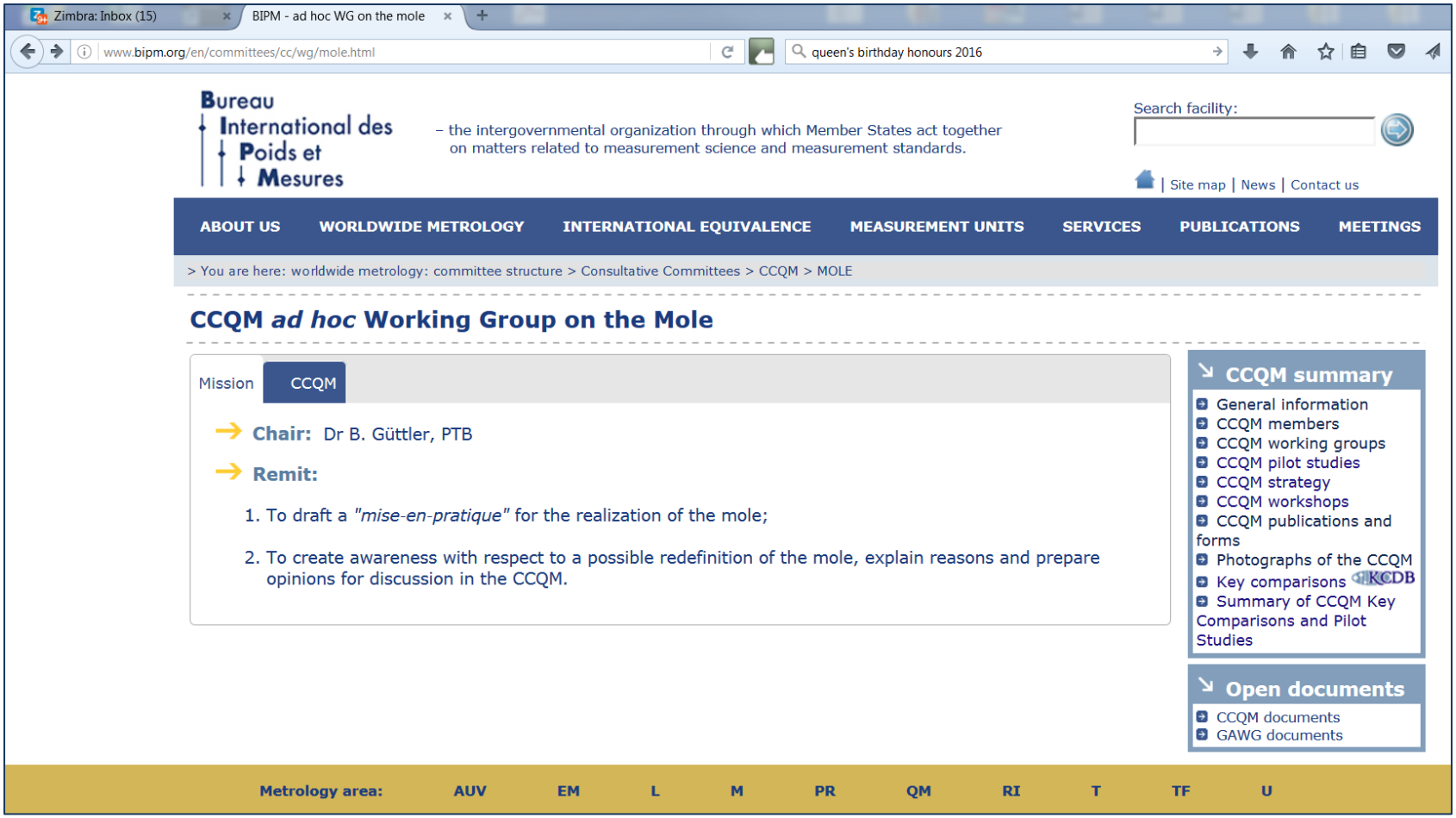
Mission statement



mise en pratique (quick review)

$$n(\mathrm{X}) = \frac{N(\mathrm{X})}{N_{\mathrm{A}}}$$

amount of X

n° of X entities

Avogadro constant

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$$n(\mathrm{X}) = \frac{N(\mathrm{X})}{N_\mathrm{A}}$$

amount of X

n° of X entities

Avogadro constant

$$N(^{28}\mathrm{Si}) = \frac{8V_\mathrm{S}}{a(^{28}\mathrm{Si})^3}$$ Si XRCD (unique)

$$N(\mathrm{X}) = \frac{w(\mathrm{X})m}{m_\mathrm{a}(\mathrm{X})}$$ gravimetry (most widely used)

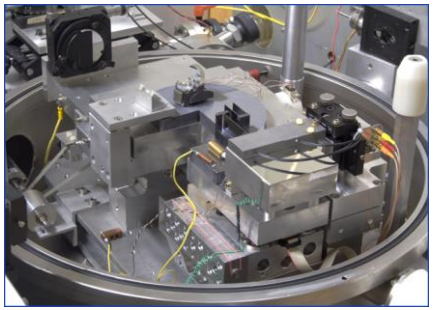
$$N = \frac{pV}{kT}$$ gas analysis

$$N = \frac{Q}{ze}$$ electrolyis

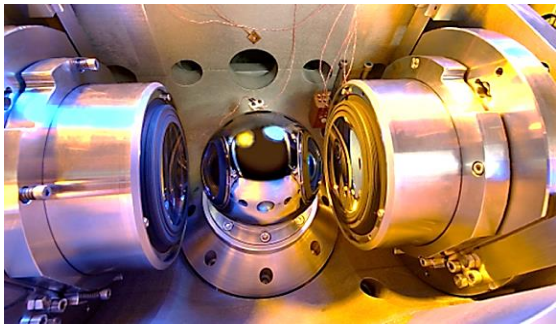
2. Realization of the definition of the mole with the smallest uncertainty

- Silicon XRCD

$$N\left(^{28}\mathrm{Si}\right) = \frac{8V_\mathrm{S}}{a\left(^{28}\mathrm{Si}\right)^3}$$



determine a



determine V_S

$$n = \frac{8V_\mathrm{S}}{a\left(^{28}\mathrm{Si}\right)^3 N_\mathrm{A}}$$

n equals volume, $\boldsymbol{V_\mathrm{S}}$, divided by molar volume, $\boldsymbol{N_\mathrm{A}a(^{28}\mathrm{Si})^3/8}$.

$u_\mathrm{r} \sim 2 \times 10^{-8}$

3. Common methods for the realization and dissemination of the mole

- Gravimetric preparation

$$N(\mathrm{X}) = \frac{w(\mathrm{X})m}{m_{\mathrm{a}}(\mathrm{X})} = \frac{w(\mathrm{X})m}{A_{\mathrm{r}}(\mathrm{X})m_{\mathrm{u}}}$$

$$n = \frac{w(\mathrm{X})m}{A_{\mathrm{r}}(\mathrm{X})N_{\mathrm{A}}m_{\mathrm{u}}} = \frac{w(\mathrm{X})m}{A_{\mathrm{r}}(\mathrm{X})M_{\mathrm{u}}}$$

n equals total mass of X, $\boldsymbol{w(\mathrm{X})m}$, divided by molar mass of X, $\boldsymbol{A_{\mathrm{r}}(\mathrm{X})M_{\mathrm{u}}}$.

$u_{\mathrm{r}} > 10^{-6}$ is usual

3. Common methods for the realization and dissemination of the mole

- Use of the gas law

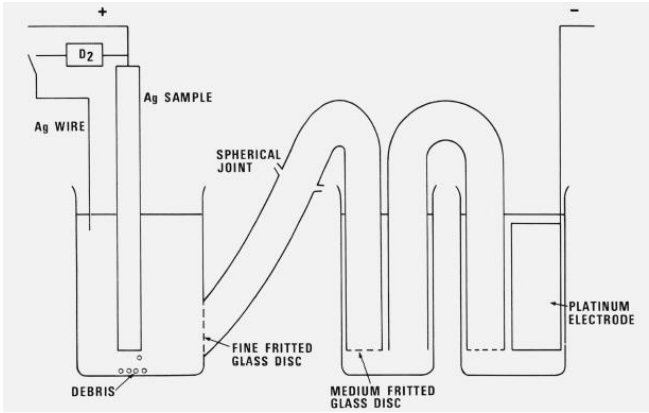
NOAA. relative mole fraction of CO_2 in air; 1997-present

$$pV = nRT\left[1 + B(T)\left(\frac{n}{V}\right) + \ldots\right]$$

R ($=N_A k$) has a fixed value

3. Common methods for the realization and dissemination of the mole

- Electrolysis



Bower&Davis 1980; last electro-chemical measurement of F

$$N = \frac{Q}{ze}$$

$$n = \frac{Q}{zN_A e} = \frac{Q}{zF}$$

$F\ (=N_A e)$ has a fixed value

5. Continuity with previous definition

- The molar mass constant M_u no longer has a fixed value, but this has negligible consequences
- Recall slide 6:

$$n = \frac{w(\mathrm{X})m}{m_a(\mathrm{X})N_A} = \frac{w(\mathrm{X})m}{A_r(\mathrm{X})m_u N_A} = \frac{w(\mathrm{X})m}{A_r(\mathrm{X})M_u}$$

5. Continuity with previous definition

- The molar mass constant M_u no longer has a fixed value, but this has negligible consequences.
- Recall slide 6:

$$n = \frac{w(\mathrm{X})m}{m_a(\mathrm{X})N_A} = \frac{w(\mathrm{X})m}{A_r(\mathrm{X})m_u N_A} = \frac{w(\mathrm{X})m}{A_r(\mathrm{X})M_u} \neq \frac{w(\mathrm{X})m}{A_r(\mathrm{X})\frac{\mathrm{g}}{\mathrm{mol}}}$$

- The *mise en pratique* shows the quantity relation

$$M_u = \frac{2N_A h}{c}\frac{R_\infty}{\alpha^2 A_r(\mathrm{e})}$$

and states that M_u = **1.000 000 000 ·10^{-3} kg mol^{-1}**
with $u_r < 10^{-9}$ (based on CODATA 2010; to be updated).

Next meeting of AHWG on the mole:
TBD when needed.

(Next meeting of CCQM & WGs:
April 2017.)