The General Physical Constants.

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Table *a*.

*Principal Constants and Ratios.**

Velocity of light	$c = (2{\cdot}99776 \pm 0{\cdot}00004) \times 10^{10}$ cm. sec.$^{-1}$.
Gravitation constant	$G = (6{\cdot}670 \pm 0{\cdot}005) \times 10^{-8}$ dyne cm.^{2} g.$^{-2}$.
Litre (= 1000 ml.)	$l = 1000{\cdot}028 \pm 0{\cdot}002$ cm.^{3}.
Volume of ideal gas (0° C., A_0)	$V_0 = (22{\cdot}4146 \pm 0{\cdot}0006) \times 10^3$ cm.^{3} atmos. mol.$^{-1}$.
	$V_0' = 22{\cdot}4140 \pm 0{\cdot}0006$ litre atmos. mol.$^{-1}$.
Volume of ideal gas (0° C., A_{45})	$V_{45} = (22{\cdot}4157 \pm 0{\cdot}0006) \times 10^3$ cm.^{3} atmos. mol.$^{-1}$.
	$V_{45}' = 22{\cdot}4151 \pm 0{\cdot}0006$ litre atmos. mol.$^{-1}$.
International ohm (= p abs. ohm)	$p = 1{\cdot}00048 \pm 0{\cdot}00002$.
International ampere (= q abs. amp.)	$q = 0{\cdot}99986 \pm 0{\cdot}00002$
Atomic weights (see table *a′*)	
Standard atmosphere	$A_0 = (1{\cdot}013246 \pm 0{\cdot}000004) \times 10^6$ dyne cm.$^{-2}$ atmos.$^{-1}$.
45° atmosphere	$A_{45} = (1{\cdot}013195 \pm 0{\cdot}000004) \times 10^6$ dyne cm.$^{-2}$ atmos.$^{-1}$.
Ice-point (absolute scale)	$T_0 = 273{\cdot}16 \pm 0{\cdot}01°$ K.
Joule equivalent	$J_{15} = 4{\cdot}1855 \pm 0{\cdot}0004$ abs.-joule cal.$_{15}{}^{-1}$.
Joule equivalent (electrical)	$J'_{15} = 4{\cdot}1847 \pm 0{\cdot}0003$ int.-joule cal.$_{15}{}^{-1}$.
Faraday constant	
(1) Chemical scale :	
	$F = 96501{\cdot}_2 \pm 10$ int.-coul. g.-equiv.$^{-1}$.
	$= 96487{\cdot}_7 \pm 10$ abs.-coul. g.-equiv.$^{-1}$.
	$= 9648{\cdot}7_7 \pm 1{\cdot}0$ abs.-e.m.u. g.-equiv.$^{-1}$.
	$F' = Fc = (2{\cdot}89247 \pm 0{\cdot}00030) \times 10^{14}$ abs.-e.s.u. g.-equiv.$^{-1}$.
(2) Physical scale :	
	$F = 96514{\cdot}_0 \pm 10$ abs.-coul. g.-equiv.$^{-1}$.
	$= 9651{\cdot}4_0 \pm 1{\cdot}0$ abs.-e.m.u. g.-equiv.$^{-1}$.
	$F' = Fc = (2{\cdot}89326 \pm 0{\cdot}00030) \times 10^{14}$ abs.-e.s.u. g.-equiv.$^{-1}$.
Avogadro number (chemical scale)	$N_0 = (6{\cdot}0228_3 \pm 0{\cdot}0011) \times 10^{23}$ mol.$^{-1}$.
Electronic charge	$e = F/N_0 = (1{\cdot}60203_3 \pm 0{\cdot}00034) \times 10^{-20}$ abs. e.m.u.
	$e' = ec = (4{\cdot}8025_1 \pm 0{\cdot}0010) \times 10^{-10}$ abs. e.s.u.
Specific electronic charge	$e/m = (1{\cdot}7592 \pm 0{\cdot}0005) \times 10^7$ abs.-e.m.u. g.$^{-1}$.
	$e'/m = ec/m = (5{\cdot}2736_6 \pm 0{\cdot}0015) \times 10^{17}$ abs.-e.s.u. g.$^{-1}$.
Planck constant	h (see table *c*).

Table *a′*.

Atomic Weights.

(1) Physical scale ($^{16}O = 16{\cdot}0000$).

$^1H = 1{\cdot}00813 \pm 0{\cdot}00001_7$. $^2H = 2{\cdot}01473 \pm 0{\cdot}00001_9$.
$H = 1{\cdot}00827_6 \pm 0{\cdot}00001_7$ (from $^1H/^2H$ abundance $= 6900 \pm 100$).
$^4He = 4{\cdot}00389 \pm 0{\cdot}00007$.
$^{12}C = 12{\cdot}00386 \pm 0{\cdot}00004$. $^{13}C = 13{\cdot}00761 \pm 0{\cdot}00015$.
$C = 12{\cdot}01465 \pm 0{\cdot}00023$ (from $^{12}C/^{13}C$ abundance $= 92 \pm 2$).
$^{14}N = 14{\cdot}00753 \pm 0{\cdot}00005$. $^{15}N = 15{\cdot}0049 \pm 0{\cdot}0002$.
$N = 14{\cdot}01121 \pm 0{\cdot}00009_5$ (from $^{14}N/^{15}N$ abundance $= 270 \pm 6$).
$^{16}O = 16{\cdot}0000$. $^{17}O = 17{\cdot}0045$. $^{18}O = 18{\cdot}0049$.
$O = 16{\cdot}00435_7 \pm 0{\cdot}00008_6$.
(from abundance $^{16}O : {}^{18}O : {}^{17}O = (506 \pm 10) : 1 : (0{\cdot}204 \pm 0{\cdot}008)$).

(2) Chemical scale ($O = 16{\cdot}0000$).

Ratio physical to chemical scale :
$r = (16{\cdot}004357 \pm 0{\cdot}000086)/16 = 1{\cdot}000272 \pm 0{\cdot}000005$.
$^1H = 1{\cdot}00785_6 \pm 0{\cdot}00001_8$ (from physical scale).
$^2H = 2{\cdot}01418_2 \pm 0{\cdot}00002_1$ (from physical scale).
$H = 1{\cdot}00800_2 \pm 0{\cdot}00001_8$ (from physical scale).
$^4He = 4{\cdot}00280 \pm 0{\cdot}00007$ (from physical scale).
$C = 12{\cdot}01139 \pm 0{\cdot}00024$ (from physical scale).
$N = 14{\cdot}00740 \pm 0{\cdot}00012$ (from physical scale).
$N = 14{\cdot}0086 \pm 0{\cdot}0007$ (direct observation).
$Na = 22{\cdot}994 \pm 0{\cdot}003$.
$Cl = 35{\cdot}457 \pm 0{\cdot}001$.
$Ca = 40{\cdot}080 \pm 0{\cdot}005$.
$Ag = 107{\cdot}880 \pm 0{\cdot}002$.
$I = 126{\cdot}915 \pm 0{\cdot}004$.

* Unless otherwise specified, all quantities in these tables that involve the mol. or the gram equivalent are on the chemical scale of atomic weights.

TABLE *b*.

Additional Quantities Evaluated or Used in Connection with Table a.

Ratio of e.s.u. to e.m.u. (direct).

$c' = (2{\cdot}9971_2 \pm 0{\cdot}0001) \times 10^{10}$ cm.$^{1/2}$ sec.$^{-1/2}$ int.-ohm$^{1/2}$.

$= (2{\cdot}9978_4 \pm 0{\cdot}0001_0) \times 10^{10}$ cm. sec.$^{-1}$.

Ratio of e.s.u. to e.m.u. (indirect).

$c' = c = (2{\cdot}99776 \pm 0{\cdot}00004) \times 10^{10}$ cm. sec.$^{-1}$.

Average density of earth	$\delta = 5{\cdot}517 \pm 0{\cdot}004$ g. cm.$^{-3}$.
Maximum density of water	$\delta_m(H_2O) = 0{\cdot}999972 \pm 0{\cdot}000002$ g. cm.$^{-3}$
Acceleration of gravity (standard)	$g_0 = 980{\cdot}665$ cm. sec.$^{-2}$.
Acceleration of gravity (45°)	$g_{45} = 980{\cdot}616$ cm. sec.$^{-2}$.
Density of oxygen gas (0° C., A_{45})	$L_1 = 1{\cdot}42897 \pm 0{\cdot}00003$ g. litre^{-1}.
Limiting density of oxygen gas (0° C., A_{45})	$L_{\text{lim}} = 1{\cdot}427609 \pm 0{\cdot}000037$ g. litre^{-1}.
Factor converting oxygen (0° C., A_{45}) to ideal gas	$1-a = 1{\cdot}000953_5 \pm 0{\cdot}0000009_4$.
International coulomb (= q abs. coul.)	$q = 0{\cdot}99986 \pm 0{\cdot}00002$.
International gauss (= q abs. gauss).	
International henry (= p abs. henry)	$p = 1{\cdot}00048 \pm 0{\cdot}00002$.
International volt (= pq abs. volt)	$pq = 1{\cdot}00034 \pm 0{\cdot}00003$.
International joule (= pq^2 abs. joule)	$pq^2 = 1{\cdot}00020 \pm 0{\cdot}00004_5$.
Specific gravity of Hg (0° C., A_0) referred to air-free water at maximum density	$\rho_0 = 13{\cdot}59542 \pm 0{\cdot}00005$.
Density of Hg (0° C., A_0)	$D_0 = 13{\cdot}59504_0 \pm 0{\cdot}00005_7$ g. cm.$^{-3}$.
Electrochemical equivalents (chemical scale) :	
Silver (apparent)	$E_{Ag}{}^* = 1{\cdot}11800 \times 10^{-3}$ g. int.-coul.$^{-1}$.
(corrected)	$E_{Ag} = (1{\cdot}11807 \pm 0{\cdot}00012) \times 10^{-3}$ g. abs.-coul.$^{-1}$.
Iodine (apparent)	$E_I{}^* = (1{\cdot}315026 \pm 0{\cdot}000025) \times 10^{-3}$ g. int.-coul.$^{-1}$.
(corrected)	$E_I = (1{\cdot}31535 \pm 0{\cdot}00014) \times 10^{-3}$ g. abs.-coul.$^{-1}$.
Effective calcite grating space (18° C.), Siegbahn system	$d''_{18} = 3{\cdot}02904 \times 10^{-8}$ cm.
True calcite grating space (20° C.), Siegbahn system	$d'_{20} = 3{\cdot}02951_2 \times 10^{-8}$ cm.
True calcite grating space (20° C.), c.g.s. system	$d_{20} = (3{\cdot}03567_4 \pm 0{\cdot}00018) \times 10^{-8}$ cm.
Ratio of grating and Siegbahn scales of wave-lengths	$\lambda_g/\lambda_s = 1{\cdot}002034 \pm 0{\cdot}000060$.
Density of calcite (20° C.)	$\rho = 2{\cdot}71029 \pm 0{\cdot}00003$ g. cm.$^{-3}$.
Structural constant of calcite (20° C.)	$\phi = 1{\cdot}09594 \pm 0{\cdot}00001$.
Molecular weight of calcite (chemical scale)	$M = 100{\cdot}091_4 \pm 0{\cdot}005$.
Rydberg constant for hydrogen (^{1}H)	$R_H = 109677{\cdot}581_2 \pm 0{\cdot}007_5$ cm.$^{-1}$ (I.A. scale).
Rydberg constant for deuterium (^{2}H)	$R_D = 109707{\cdot}419_3 \pm 0{\cdot}007_5$ cm.$^{-1}$ (I.A. scale).
Rydberg constant for helium	$R_{He} = 109722{\cdot}263 \pm 0{\cdot}012$ cm.$^{-1}$ (I.A. scale).
Rydberg constant for infinite mass	$R_\infty = 109737{\cdot}303 \pm 0{\cdot}017$ cm.$^{-1}$ (I.A. scale), or $\pm$ 0·05 cm.$^{-1}$ (c.g.s. system).

TABLE *c*.

Partial List of Derived Quantities.†

Planck constant :

$$h = \left\{\frac{2\pi^2 c^3 F^5}{R_\infty N_0{}^5 (e/m)}\right\}^{1/3} = (6{\cdot}624_2 \pm 0{\cdot}002_4) \times 10^{-27} \text{ erg. sec.}$$

$$h/e = \left\{\frac{2\pi^2 c^3 F^2}{R_\infty N_0{}^2 (e/m)}\right\}^{1/3} = (4{\cdot}1349_0 \pm 0{\cdot}0007_1) \times 10^{-7} \text{ erg. sec. abs.-e.m.u.}^{-1}.$$

$$h/e' = h/ec = \left\{\frac{2\pi^2 F^2}{R_\infty N_0{}^2 (e/m)}\right\}^{1/3} = (1{\cdot}3793_3 \pm 0{\cdot}0002_3) \times 10^{-17} \text{ erg. sec. abs.-e.s.u.}^{-1}$$

Atomic weight of electron : $E = F/(e/m)$.

(physical scale) $= (5{\cdot}4862_4 \pm 0{\cdot}0017) \times 10^{-4}$.

(chemical scale) $= (5{\cdot}4847_5 \pm 0{\cdot}0017) \times 10^{-4}$.

Band spectra constant connecting wave number and moment of inertia :

$$h/8\pi^2 c = \left\{\frac{F^5}{256\pi^4 R_\infty N_0{}^5 (e/m)}\right\}^{1/3} = (27{\cdot}98_{65} \pm 0{\cdot}01_0) \times 10^{-40} \text{ g. cm.}$$

Boltzmann constant :

$$k = R_0/N_0 = V_0 A_0/T_0 N_0 = (1{\cdot}38047_4 \pm 0{\cdot}00026) \times 10^{-16} \text{ erg. deg.}^{-1}.$$

Charge in electrolysis of one gram of H :

$$F/\text{H} = 9572{\cdot}1_{73} \pm 1{\cdot}0 \text{ abs.-e.m.u. g.}^{-1}.$$

Charge in electrolysis of one gram of ^{1}H :

$$e/M_{^1H} = F/{}^1\text{H} = 9573{\cdot}5_{60} \pm 1{\cdot}0 \text{ abs.-e.m.u. g.}^{-1}.$$

† In order to be able to calculate, by propagation of errors, the probable error in a derived quantity, it is necessary to express the quantity explicitly in terms of the various fundamental quantities of Table *a* or of Table *b*, and that has been done in each case. Since in this paper **e** and **h** are treated as derived quantities, they do not therefore appear in such explicit expressions. But in calculating the *numerical* value of a derived quantity, the work can often be greatly simplified by using the values of other previously calculated derived quantities—in particular **e** and **h**. In order to show how certain derived quantities depend on quantities like **e** and **h**, such alternative expressions are given in many cases.

Compton shift at 90°:

$$h/mc = \left\{\frac{2\pi^2 F^2 (e/m)^2}{R_\infty N_0^2}\right\}^{1/3} = (0{\cdot}024265_{14} \pm 0{\cdot}000005_7) \times 10^{-8} \text{ cm.}$$

Energy in ergs of one abs.-volt-electron:

$$E_0 = 10^8 e = 10^8 F/N_0 = (1{\cdot}60203_3 \pm 0{\cdot}00034) \times 10^{-12} \text{ erg}$$

Energy in calories per mol. for one abs.-volt-electron per molecule:

$$\frac{F \text{ (abs. coul. per gram-equiv.)}}{J_{15} \text{ (abs. joules per cal.)}} = 23052{\cdot}_{85} \pm 3{\cdot}_2 \text{ cal.}_{15} \text{ mol.}^{-1}.$$

Fine structure constant:

$$\alpha = 2\pi(e')^2/hc = \left\{\frac{4\pi R_\infty F(e/m)}{N_0}\right\}^{1/3} = (7{\cdot}2976_6 \pm 0{\cdot}0008_6) \times 10^{-3}.$$

$$1/\alpha = 137{\cdot}030_2 \pm 0{\cdot}016.$$

$$\alpha^2 = (5{\cdot}3256 \pm 0{\cdot}0013) \times 10^{-5}.$$

Gas constant per mol.:

$$R_0 = V_0 A_0/T_0 = (8{\cdot}31436 \pm 0{\cdot}00038) \times 10^7 \text{ erg. deg.}^{-1} \text{ mol.}^{-1}.$$

$$R_0' = R_0 \,.\, 10^{-7}/J_{15} = 1{\cdot}98646_7 \pm 0{\cdot}00021 \text{ cal.}_{15} \text{ deg.}^{-1} \text{ mol.}^{-1}.$$

$$R_0'' = V_0'/T_0 = (8{\cdot}20544_7 \pm 0{\cdot}00037) \times 10^{-2} \text{ litre atmos. deg.}^{-1} \text{ mol.}^{-1}.$$

$$R_0''' = R_0/A_0 = V_0/T_0 = 82{\cdot}0566_7 \pm 0{\cdot}0037 \text{ cm.}^3 \text{ atmos. deg.}^{-1} \text{ mol.}^{-1};$$

also

$$R_0 T_0 = V_0 A_0 = (2{\cdot}27115_0 \pm 0{\cdot}00006) \times 10^{19} \text{ erg. mol.}^{-1}.$$

Loschmidt number (0° C., A_0):

$$n_0 = N_0/V_0 = (2{\cdot}6870_{12} \pm 0{\cdot}0005_0) \times 10^{19} \text{ atmos.}^{-1} \text{ cm.}^{-3}.$$

Magnetic moment of one Bohr magneton:

$$\mu_1 = (h/4\pi)(e/m) = \frac{1}{4\pi}\left\{\frac{2\pi^2 c^3 F^5 (e/m)^2}{R_\infty N_0^5}\right\}^{1/3}.$$

$$= (0{\cdot}9273_{45} \pm 0{\cdot}0003_7) \times 10^{-20} \text{ erg. gauss}^{-1}.$$

Magnetic moment per mol. for one Bohr magneton per molecule:

$$\mu_1 N_0 = \frac{1}{4\pi}\left\{\frac{2\pi^2 c^3 F^5 (e/m)^2}{R_\infty N_0^2}\right\}^{1/3} = 5585{\cdot}2_4 \pm 1{\cdot}6 \text{ erg. gauss.}^{-1} \text{ mol.}^{-1}.$$

Mass of α-particle:

$$M_\alpha = (\text{He} - 2\text{E})/N_0 = (6{\cdot}6442_2 \pm 0{\cdot}0012) \times 10^{-24} \text{ g.}$$

Mass of atom of unit atomic weight:

$$M_0 = 1/N_0 = (1{\cdot}66035 \pm 0{\cdot}00031) \times 10^{-24} \text{ g.}$$

Mass of electron:

$$m = e/(e/m) = (F/N_0)/(e/m) = (9{\cdot}1066_0 \pm 0{\cdot}0032) \times 10^{-28} \text{ g.}$$

Mass of ^{1}H atom:

$$M_{^1\text{H}} = {}^1\text{H}/N_0 = (1{\cdot}67339_3 \pm 0{\cdot}00031) \times 10^{-24} \text{ g.}$$

Mass of proton:

$$M_\text{P} = ({}^1\text{H} - \text{E})/N_0 = (1{\cdot}67248_2 \pm 0{\cdot}00031) \times 10^{-24} \text{ g.}$$

Radiation density constant:

$$a = 8\pi^5 k^4/15c^3h^3 = \left(\frac{V_0 A_0}{T_0}\right)^4 \frac{4\pi N_0^3 R_\infty (e/m)}{15c^6 F^5} = (7{\cdot}569_{42} \pm 0{\cdot}004_9) \times 10^{-15} \text{ erg. cm.}^{-3} \text{ deg.}^{-4}.$$

Ratio mass ^{1}H atom to mass electron:

$$M_{^1\text{H}}/m = (e/m)({}^1\text{H}/F) = 1837{\cdot}5_{61} \pm 0{\cdot}5_6.$$

Ratio mass proton to mass electron:

$$M_\text{P}/m = (e/m)\left(\frac{{}^1\text{H} - \text{E}}{F}\right) = 1836{\cdot}5_{61} \pm 0{\cdot}5_6.$$

Second radiation constant:

$$c_2 = hc/k = \frac{T_0 c^2}{V_0 A_0}\left\{\frac{2\pi^2 F^5}{R_\infty N_0^2 (e/m)}\right\}^{1/3} = 1{\cdot}4384_8 \pm 0{\cdot}0003_4 \text{ cm. deg.}$$

Specific charge of α-particle:

$$2e/M_\alpha = \frac{2F}{\text{He} - 2\text{E}} = 4822{\cdot}3_3 \pm 0{\cdot}5_1 \text{ abs.-e.m.u. g.}^{-1}.$$

Specific charge of proton:

$$e/M_\text{P} = \frac{F}{{}^1\text{H} - \text{E}} = 9578{\cdot}7_7 \pm 1{\cdot}0 \text{ abs.-e.m.u. g.}^{-1}.$$

Stefan-Boltzmann constant:

$$\sigma = ac/4 = 2\pi^5 k^4/15c^2h^3 = \left(\frac{V_0 A_0}{T_0}\right)^4 \frac{\pi^3 N_0 R_\infty (e/m)}{15(Fc)^5}$$

$$= (5{\cdot}672_{83} \pm 0{\cdot}003_7) \times 10^{-5} \text{ erg. cm.}^{-2} \text{ deg.}^{-4} \text{ sec.}^{-1}.$$

Wave-length associated with one abs. volt :

$$\lambda_0 = 10^{-8}c^2(h/e') = \frac{c^2}{10^8}\left\{\frac{2\pi^2F^2}{R_\infty N_0^2(e/m)}\right\}^{1/3} = (12395\cdot_4 \pm 2\cdot_1) \times 10^{-8} \text{ cm. abs.-volt.}$$

Wave number associated with one abs. volt :

$$s_0 = 1/\lambda_0 = \frac{10^8}{c^2}\left\{\frac{R_\infty N_0^2(e/m)}{2\pi^2F^2}\right\}^{1/3} = 8067\cdot4_9 \pm 1\cdot4 \text{ cm.}^{-1} \text{ abs.-volt}^{-1}.$$

Wien's displacement-law constant : *

$$A = c_2/4\cdot965114 = 0\cdot28971_8 \pm 0\cdot00007 \text{ cm. deg.}$$

Zeeman displacement per gauss :

$$(e/m)/4\pi c = (4\cdot6699_1 \pm 0\cdot0013) \times 10^{-5} \text{ cm.}^{-1} \text{ gauss.}^{-1}.$$

* The factor 4·965114 is the root of $e^{-\beta} + (\beta/5) - 1 = 0$.