

# 1 Fundamental Constants, Elements, Units

## 1.1 Fundamental Physical Constants

**Table 1.1.** Fundamental Physical Constants

Electron mass	$m_e = 9.10939 \times 10^{-28} \text{ g}$
Proton mass	$m_p = 1.67262 \times 10^{-24} \text{ g}$
Atomic unit of mass	$m_a = \frac{1}{12}m(^{12}\text{C}) = 1.66054 \times 10^{-24} \text{ g}$
Ratio of proton and electron masses	$m_p/m_e = 1836.15$
Ratio of atomic and electron masses	$m_a/m_e = 1822.89$
Electron charge	$e = 1.602177 \times 10^{-19} \text{ C} = 4.8032 \times 10^{-10} \text{ e.s.u.}$ $e^2 = 2.3071 \times 10^{-19} \text{ erg cm}$
Planck constant	$h = 6.62619 \times 10^{-27} \text{ erg s}$ $\hbar = 1.05457 \times 10^{-27} \text{ erg s}$
Light velocity	$c = 2.99792 \times 10^{10} \text{ cm/s}$
Fine-structure constant	$\alpha = e^2/(\hbar c) = 0.07295$
Inverse fine-structure constant	$1/\alpha = \hbar c/e^2 = 137.03599$
Bohr radius	$a_0 = \hbar^2/(m_e e^2) = 0.529177 \text{ \AA}$
Rydberg constant	$R = m_e e^4/(2\hbar^2) = 13.6057 \text{ eV}$ $= 2.17987 \times 10^{-18} \text{ J}$
Bohr magneton	$\mu_B = e\hbar/(2m_e c) = 9.27402 \times 10^{-24} \text{ J/T}$ $= 9.27402 \times 10^{-21} \text{ erg/Gs}$
Avogadro number	$N_A = 6.02214 \times 10^{23} \text{ mol}^{-1}$
Stephan-Boltzmann constant	$\sigma = \pi^2/(60\hbar^3 c^2) = 5.669 \times 10^{-12} \text{ W/(cm}^2\text{K}^4)$
Molar volume	$R = 22.414 \text{ l/mol}$
Loschmidt number	$L = N_A/R = 2.6867 \times 10^{19} \text{ cm}^{-3}$
Faraday constant	$F = N_A e = 96485.3 \text{ C/mol}$

## 1.2 Elements and Isotopes

There are about 2700 stable and 2000 radioactive isotopes in nature [17]. Stable isotopes relate to elements with a nuclear charge below 83, excluding technetium  $_{43}\text{Tc}$  and promethium  $_{61}\text{Pm}$ , and also to elements with a nuclear charge in the range 90–93 (thorium, protactinium, uranium, neptunium). The diagram Pt1 contains standard atomic masses for elements, taking into account their occurrence in the Earth's crust [2, 18]. If stable isotopes of a given element are absent, the masses are given in square brackets. These masses are given in atomic mass units (amu) where the unit is taken 1/12 mass of the carbon isotope  $_{12}\text{C}$  from 1961 (see Table 1.1).

There is in diagram Pt2 the occurrence of stable isotopes in the Earth's crust, and diagram Pt3 contains the lifetimes of stable isotopes [2, 18–20]. These lifetimes are expressed in days (d) and years (y) and are given for isotopes whose lifetime exceeds 2 hours (0.08 d).

## 1.3 Physical Units and Conversion Factors

### 1.3.1 Systems of Physical Units

The unit system is a set of units through which various physical parameters are expressed. The basis of any mechanical system of units is the fact that the value of any dimensionality may be expressed through three dimensional units—length, mass and time. The CGS system, which is based on the centimeter, gram and second [3], is the oldest system of units and was introduced by British association for the Advancement of Science in 1874. The system of International Units (SI) [4] was adopted in 1960 (the conference des Poids et Mesure, Paris) and is based on the meter (m), kilogram (kg) and second (s). Other bases may be used for specific units.

In transferring from mechanics to other physics branches, additional units or assumptions are required. In particular, along with mechanical units, we deal with electric and magnetic units below. Then the base of SI units along with the above mechanical units contain the unit of an electric current ampere (A). Table 1.2 contains the SI units and their connection with the base units. Note that we express the thermodynamic temperature through energy units below.

In spreading the CGS system of units to electrostatics, one can use the Coulomb law for the force  $F$  between two charges  $e_1$  and  $e_2$  that are located at a distance  $r$  in a vacuum. This force is given by

$$F = \epsilon_0 \frac{e_1 e_2}{r^2}$$

where  $\epsilon_0$  is the vacuum permittivity. Defining a charge unit from this formula under the assumption  $\epsilon_0 = 1$ , we construct in this manner the CGSE system of units that describes physical parameters of mechanics and electrostatics. In the same way, in constructing of the CGSM system of units on the basis of the mechanical CGS system of units, the assumption is used that the vacuum magnetic conductivity is

## Standard Atomic Weights.

Group Period		I	II	Standard Atomic Weights.											Abundance in Earth crust, 10 <sup>-4</sup> %			
1	Hydrogen	<sup>1</sup> H 1.0079	0.0008 <sup>4</sup> He Helium												<div><div>1.5</div><div>85.84</div><div>Mo</div><div>Molybdenum</div></div>			
		20 <sup>7</sup> Li 6.941	<sup>9</sup> Be 9.012	10 <sup>5</sup> B 10.81	480 <sup>6</sup> C 12.011	25 <sup>7</sup> N 14.007	950 <sup>8</sup> O 16.998	9 Fluorine	7 <sup>10</sup> Ne 20.189	Neon								
2	Lithium	11 <sup>6</sup> Li 6.941	<sup>9</sup> Be 9.012	10 <sup>5</sup> B 10.81	480 <sup>6</sup> C 12.011	25 <sup>7</sup> N 14.007	950 <sup>8</sup> O 16.998	9 Fluorine	7 <sup>10</sup> Ne 20.189	Neon								
		23000 <sup>11</sup> Na 22.990	23000 <sup>12</sup> Mg 24.305	82000 <sup>26</sup> Al 26.982	277000 <sup>27</sup> Si 28.086	1000 <sup>30</sup> P 30.974	260 <sup>15</sup> S 32.065	130 <sup>17</sup> Cl 35.453	130 <sup>35</sup> Br 79.904	18 <sup>40</sup> Ar 39.948	Argon							
3	Sodium	23000 <sup>11</sup> Na 22.990	23000 <sup>12</sup> Mg 24.305	82000 <sup>26</sup> Al 26.982	277000 <sup>27</sup> Si 28.086	1000 <sup>30</sup> P 30.974	260 <sup>15</sup> S 32.065	130 <sup>17</sup> Cl 35.453	130 <sup>35</sup> Br 79.904	18 <sup>40</sup> Ar 39.948	Argon							
		21000 <sup>19</sup> K 39.098	41000 <sup>20</sup> Ca 40.08	16 <sup>38</sup> K 39.098	5600 <sup>47</sup> Sc 44.956	160 <sup>23</sup> V 50.942	100 <sup>51</sup> Cr 51.996	950 <sup>55</sup> Mn 54.938	20 <sup>59</sup> Co 58.933	20 <sup>60</sup> Ni 58.69	20 <sup>64</sup> Zn 65.409	20 <sup>63</sup> Cu 63.546	20 <sup>65</sup> Cu 63.546	20 <sup>64</sup> Zn 65.409				
4	Potassium	50 <sup>63</sup> K 39.098	41000 <sup>20</sup> Ca 40.08	16 <sup>38</sup> K 39.098	5600 <sup>47</sup> Sc 44.956	160 <sup>23</sup> V 50.942	100 <sup>51</sup> Cr 51.996	950 <sup>55</sup> Mn 54.938	20 <sup>59</sup> Co 58.933	20 <sup>60</sup> Ni 58.69	20 <sup>64</sup> Zn 65.409	20 <sup>63</sup> Cu 63.546	20 <sup>65</sup> Cu 63.546	20 <sup>64</sup> Zn 65.409				
		90 <sup>37</sup> Rb 85.468	370 <sup>88</sup> Sr 87.62	30 <sup>89</sup> Y 88.906	90 <sup>90</sup> Zr 91.224	20 <sup>91</sup> Nb 92.906	20 <sup>92</sup> Mo 95.94	42 <sup>93</sup> Tc 98.907	106 <sup>101</sup> Ru 101.07	46 <sup>106</sup> Pd 106.42	6 <sup>107</sup> Ag 107.87	6 <sup>108</sup> Cd 108.90	6 <sup>109</sup> Cd 108.90	6 <sup>110</sup> Ag 107.87				
5	Rubidium	90 <sup>37</sup> Rb 85.468	370 <sup>88</sup> Sr 87.62	30 <sup>89</sup> Y 88.906	90 <sup>90</sup> Zr 91.224	20 <sup>91</sup> Nb 92.906	20 <sup>92</sup> Mo 95.94	42 <sup>93</sup> Tc 98.907	106 <sup>101</sup> Ru 101.07	46 <sup>106</sup> Pd 106.42	6 <sup>107</sup> Ag 107.87	6 <sup>108</sup> Cd 108.90	6 <sup>109</sup> Cd 108.90	6 <sup>110</sup> Ag 107.87				
		0.07 <sup>47</sup> Ag 107.87	0.11 <sup>48</sup> Cd 112.41	0.049 <sup>49</sup> In 114.82	2.2 <sup>50</sup> Sn 118.71	0.2 <sup>51</sup> Sb 121.76	0.005 <sup>52</sup> Te 127.60	0.14 <sup>53</sup> I 126.90	0.001 <sup>54</sup> Xe 131.29	0.001 <sup>55</sup> Cs 132.91	0.001 <sup>56</sup> Ba 137.33	0.001 <sup>57</sup> La 138.91	0.001 <sup>58</sup> Ce 140.12	0.001 <sup>59</sup> Pr 140.91				
6	Cesium	3.0 <sup>55</sup> Cs 132.91	0.05 <sup>56</sup> Ba 137.33	0.049 <sup>49</sup> In 114.82	2.2 <sup>50</sup> Sn 118.71	0.2 <sup>51</sup> Sb 121.76	0.005 <sup>52</sup> Te 127.60	0.14 <sup>53</sup> I 126.90	0.001 <sup>54</sup> Xe 131.29	0.001 <sup>55</sup> Cs 132.91	0.001 <sup>56</sup> Ba 137.33	0.001 <sup>57</sup> La 138.91	0.001 <sup>58</sup> Ce 140.12	0.001 <sup>59</sup> Pr 140.91				
		196.97 <sup>79</sup> Au 196.97	200.59 <sup>80</sup> Hg 200.59	0.6 <sup>81</sup> Tl 204.38	1.4 <sup>82</sup> Pb 207.2	2.2 <sup>83</sup> Bi 208.98	0.048 <sup>84</sup> Po 209	0.0001 <sup>85</sup> At 210	0.0001 <sup>86</sup> Rn 222	0.0001 <sup>87</sup> Fr 223	0.0001 <sup>88</sup> Ra 226	0.0001 <sup>89</sup> Ac 227	0.0001 <sup>90</sup> Th 232	0.0001 <sup>91</sup> Pa 231				
7	Francium	87 <sup>87</sup> Fr 223.021	88 <sup>88</sup> Ra 226.025	89 <sup>89</sup> Ac 227.033	90 <sup>90</sup> Th 232.038	91 <sup>91</sup> Pa 231.036	92 <sup>92</sup> U 238.029	93 <sup>93</sup> Np 237.048	94 <sup>94</sup> Pu 244.064	95 <sup>95</sup> Am 243.061	96 <sup>96</sup> Cm 247.070	97 <sup>97</sup> Bk 247.070	98 <sup>98</sup> Cf 251.083	99 <sup>99</sup> Es 252.083				
		255 <sup>103</sup> Lr 260.106	261 <sup>104</sup> Rf 261.106	267 <sup>105</sup> Db 268.106	273 <sup>106</sup> Sg 273.106	281 <sup>107</sup> Bh 284.106	287 <sup>108</sup> Hs 288.106	293 <sup>109</sup> Mt 293.106	297 <sup>110</sup> Ds 297.106	301 <sup>111</sup> Uut 304.106	307 <sup>112</sup> Uub 307.106	311 <sup>11</sup>	315 <sup>113</sup>	319 <sup>114</sup>				

Lantanides

## Actinides

96Cm	12.60	96Cm	12.60	96Cm	12.60	96Cm	12.60
90Th	22.04	90Th	22.04	90Th	22.04	90Th	22.04
91Pa	21.64	91Pa	21.64	91Pa	21.64	91Pa	21.64
92U	22.65	92U	22.65	92U	22.65	92U	22.65
93Np	23.65	93Np	23.65	93Np	23.65	93Np	23.65
94Pu	24.66	94Pu	24.66	94Pu	24.66	94Pu	24.66
95Am	25.67	95Am	25.67	95Am	25.67	95Am	25.67
96Cm	26.68	96Cm	26.68	96Cm	26.68	96Cm	26.68
97Bk	27.69	97Bk	27.69	97Bk	27.69	97Bk	27.69
98Cf	28.70	98Cf	28.70	98Cf	28.70	98Cf	28.70
99Es	29.71	99Es	29.71	99Es	29.71	99Es	29.71
100Fm	30.72	100Fm	30.72	100Fm	30.72	100Fm	30.72
101Md	31.73	101Md	31.73	101Md	31.73	101Md	31.73
102No	32.74	102No	32.74	102No	32.74	102No	32.74
103Lr	33.75	103Lr	33.75	103Lr	33.75	103Lr	33.75
104Rf	34.76	104Rf	34.76	104Rf	34.76	104Rf	34.76
105Db	35.77	105Db	35.77	105Db	35.77	105Db	35.77
106Sg	36.78	106Sg	36.78	106Sg	36.78	106Sg	36.78
107Bh	37.79	107Bh	37.79	107Bh	37.79	107Bh	37.79
108Hs	38.80	108Hs	38.80	108Hs	38.80	108Hs	38.80
109Mt	39.81	109Mt	39.81	109Mt	39.81	109Mt	39.81
110Ds	40.82	110Ds	40.82	110Ds	40.82	110Ds	40.82
111Rg	41.83	111Rg	41.83	111Rg	41.83	111Rg	41.83
112Nh	42.84	112Nh	42.84	112Nh	42.84	112Nh	42.84
113Fl	43.85	113Fl	43.85	113Fl	43.85	113Fl	43.85
114Mc	44.86	114Mc	44.86	114Mc	44.86	114Mc	44.86
115Lv	45.87	115Lv	45.87	115Lv	45.87	115Lv	45.87
116Ts	46.88	116Ts	46.88	116Ts	46.88	116Ts	46.88
117Og	47.89	117Og	47.89	117Og	47.89	117Og	47.89
118Uu	48.90	118Uu	48.90	118Uu	48.90	118Uu	48.90
119Uub	49.91	119Uub	49.91	119Uub	49.91	119Uub	49.91
120Uut	50.92	120Uut	50.92	120Uut	50.92	120Uut	50.92
121Uuq	51.93	121Uuq	51.93	121Uuq	51.93	121Uuq	51.93
122Uuq	52.94	122Uuq	52.94	122Uuq	52.94	122Uuq	52.94
123Uuq	53.95	123Uuq	53.95	123Uuq	53.95	123Uuq	53.95
124Uuq	54.96	124Uuq	54.96	124Uuq	54.96	124Uuq	54.96
125Uuq	55.97	125Uuq	55.97	125Uuq	55.97	125Uuq	55.97
126Uuq	56.98	126Uuq	56.98	126Uuq	56.98	126Uuq	56.98
127Uuq	57.99	127Uuq	57.99	127Uuq	57.99	127Uuq	57.99
128Uuq	58.00	128Uuq	58.00	128Uuq	58.00	128Uuq	58.00
129Uuq	59.01	129Uuq	59.01	129Uuq	59.01	129Uuq	59.01
130Uuq	60.02	130Uuq	60.02	130Uuq	60.02	130Uuq	60.02
131Uuq	61.03	131Uuq	61.03	131Uuq	61.03	131Uuq	61.03
132Uuq	62.04	132Uuq	62.04	132Uuq	62.04	132Uuq	62.04

## Lantanides

68	9.5	38	7.9	2.1	78
<sup>160</sup> Ce	<sup>140.91</sup> Pr	<sup>140.91</sup> Nd	<sup>150.36</sup> Sm	<sup>151.86</sup> Eu	<sup>157.25</sup> Gd
Cerium	Praseodymium	Niodymium	Samarium	Europium	Gadolinium
1.1	6.0	1.4	0.48	5.3	0.51
<sup>158</sup> Tb	<sup>162.50</sup> Dy	<sup>160.93</sup> Ho	<sup>168.93</sup> Tm	<sup>173.04</sup> Yb	<sup>174.97</sup> Lu
Terbium	Dysprosium	Holmium	Thulium	Ytterbium	Lutetium

**Pt1.** Standard atomic weights of elements and their natural occurrence in Earth's crust

[illegible]



Group		I		II		III		IV		V		VI		VII		VIII	
Period		H		He		Li		Be		B		C		N		O	
1	Hydrogen	1		2		3		4		5		6		7		8	
2	Lithium	3		4		5		6		7		8		9		10	
3	Sodium	11		12		13		14		15		16		17		18	
4	Potassium	19		20		21		22		23		24		25		26	
5	Rubidium	37		38		39		40		41		42		43		44	
6	Barium	56		57		58		59		60		61		62		63	
7	Francium	87		88		89		90		91		92		93		94	
		101		102		103		104		105		106		107		108	
		113		114		115		116		117		118		119		120	
		127		128		129		130		131		132		133		134	
		151		152		153		154		155		156		157		158	
		171		172		173		174		175		176		177		178	
		197		198		199		200		201		202		203		204	
		223		224		225		226		227		228		229		230	
		251		252		253		254		255		256		257		258	
		287		288		289		290		291		292		293		294	
		315		316		317		318		319		320		321		322	
		349		350		351		352		353		354		355		356	
		371		372		373		374		375		376		377		378	
		395		396		397		398		399		400		401		402	
		433		434		435		436		437		438		439		440	
		475		476		477		478		479		480		481		482	
		503		504		505		506		507		508		509		510	
		521		522		523		524		525		526		527		528	
		549		550		551		552		553		554		555		556	
		583		584		585		586		587		588		589		590	
		609		610		611		612		613		614		615		616	
		637		638		639		640		641		642		643		644	
		663		664		665		666		667		668		669		670	
		695		696		697		698		699		700		701		702	
		729		730		731		732		733		734		735		736	
		759		760		761		762		763		764		765		766	
		787		788		789		790		791		792		793		794	
		815		816		817		818		819		820		821		822	
		843		844		845		846		847		848		849		850	
		871		872		873		874		875		876		877		878	
		899		900		901		902		903		904		905		906	
		927		928		929		930		931		932		933		934	
		951		952		953		954		955		956		957		958	
		979		980		981		982		983		984		985		986	
		1007		1008		1009		1010		1011		1012		1013		1014	
		1035		1036		1037		1038		1039		1040		1041		1042	
		1063		1064		1065		1066		1067		1068		1069		1070	
		1091		1092		1093		1094		1095		1096		1097		1098	
		1119		1120		1121		1122		1123		1124		1125		1126	
		1147		1148		1149		1150		1151		1152		1153		1154	
		1175		1176		1177		1178		1179		1180		1181		1182	
		1203		1204		1205		1206		1207		1208		1209		1210	
		1229		1230		1231		1232		1233		1234		1235		1236	
		1257		1258		1259		1260		1261		1262		1263		1264	
		1285		1286		1287		1288		1289		1290		1291		1292	

**Table 1.2.** Basic SI units [1, 2, 4]

Quantity	Name	Symbol	Connection with base units
Frequency	hertz	Hz	1/s
Force	newton	N	m kg/s <sup>2</sup>
Pressure	pascal	Pa	kg/(m s <sup>2</sup> )
Energy	joule	J	m <sup>2</sup> kg/s <sup>2</sup>
Power	watt	W	m <sup>2</sup> kg/s <sup>3</sup>
Charge	coulomb	C	A s
Electric potential	volt	V	W/A
Electric capacitance	farad	F	A <sup>2</sup> s <sup>4</sup> /(m <sup>2</sup> kg)
Electric resistance	ohm	$\Omega$	m <sup>2</sup> kg/(A <sup>2</sup> s <sup>3</sup> )
Conductance	siemens	S	A <sup>2</sup> s <sup>3</sup> /(m <sup>2</sup> kg)
Inductance	henry	H	m <sup>2</sup> kg/(A <sup>2</sup> s <sup>2</sup> )
Magnetic flux	weber	Wb	m <sup>2</sup> kg/(A s <sup>2</sup> )
Magnetic flux density	tesla	T	kg/(A s <sup>2</sup> )

one  $\mu_0 = 1$ . Because of units of electrostatic CGS (CGSE system of units) and electromagnetic CGS (CGSM system of units) are used, we give some conversions between these systems and SI units below.

For atomic systems, the system of atomic units (or Hartree atomic units) is of importance because parameters of atomic systems are expressed through atomic parameters. In construction the system of atomic units, the fact is used that the parameter of any dimensionality may be built on the basis of three parameters of different dimensionality. As a basis for the system of atomic units, the following three parameters are taken: the Planck constant  $\hbar = 1.05457 \times 10^{-27}$  erg s, the electron charge  $e = 1.60218 \times 10^{-19}$  C and the electron mass  $m_e = 9.10939 \times 10^{-28}$  g (we take the vacuum permittivity and the magnetic conductivity of a vacuum to be one). The system of atomic units constructed on these parameters is given below in Table 1.3.

### 1.3.2 Conversion Factors for Units

Tables 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, and 1.10 contain conversion factors between units used. The specific electric field strength  $E/p$  or  $E/N_a$  ( $E$  is the electric field strength,  $p$  is the pressure,  $N_a$  is the number density of atoms) is a spread unit in physics of ionized gases. The unit of  $E/N_a$  is 1 Townsend (Td) [21]. The connection between units of the above quantities is as follows:

$$1 \frac{\text{V}}{\text{cm} \cdot \text{Torr}} = 0.3535 \text{ Td}; \quad 1 \text{ Td} = 2.829 \frac{\text{V}}{\text{cm} \cdot \text{Torr}}; \quad 1 \text{ Td} = 1 \times 10^{-17} \text{ V cm}^2.$$

**Table 1.3.** System of atomic units

Parameter	Symbol, formula	Value
Length	$a_0 = \hbar^2/(me^2)$	$5.2918 \times 10^{-9}$ cm
Velocity	$v_0 = e^2/\hbar$	$2.1877 \times 10^8$ cm/s
Time	$\tau_0 = \hbar^3/(me^4)$	$2.4189 \times 10^{-17}$ s
Frequency	$\nu_0 = me^4/\hbar^3$	$4.1341 \times 10^{16}$ s <sup>-1</sup>
Energy	$\varepsilon_0 = me^4/\hbar^2$	27.2114 eV = $4.3598 \times 10^{-18}$ J
Power	$\varepsilon_0/\tau = m^2e^8/\hbar^5$	0.18024 W
Electric voltage	$\varphi_0 = me^3/\hbar^2$	27.2114 V
Electric field strength	$E_0 = me^5/\hbar^4$	$5.1422 \times 10^9$ V/cm
Momentum	$p_0 = me^2/\hbar$	$1.9929 \times 10^{-19}$ g cm/s
Number density	$N_0 = a_0^{-3}$	$6.7483 \times 10^{24}$ cm <sup>-3</sup>
Volume	$V_0 = a_0^3$	$1.4818 \times 10^{-25}$ cm <sup>3</sup> = 0.089240 cm <sup>3</sup> /mol
Square, cross section	$\sigma_0 = a_0^2$	$2.8003 \times 10^{-17}$ cm <sup>2</sup>
Rate constant	$k_0 = v_0a_0^2 = \hbar^3/(m^2e^2)$	$6.126 \times 10^{-9}$ cm <sup>3</sup> /s
Three body rate constant	$K_0 = v_0a_0^5 = \hbar^9/(m^5e^8)$	$9.078 \times 10^{-34}$ cm <sup>6</sup> /s
Dipole moment	$ea_0 = a_0 = \hbar^2/(me)$	$2.5418 \times 10^{-18}$ esu = 2.5418 D
Magnetic moment	$\hbar^2/(me) = 2\mu_B/\alpha$	$2.5418 \times 10^{-18}$ erg/Gs = $2.5418 \times 10^{-21}$ J/T
Electric current	$I = e/\tau = me^5/\hbar^3$	$6.6236 \times 10^{-3}$ A
Flux	$j_0 = N_0v_0 = m^3e^8/\hbar^7$	$1.476 \times 10^{33}$ cm <sup>-2</sup> s <sup>-1</sup>
Electric current density	$i_0 = eN_0v_0 = m^3e^9/\hbar^7$	$2.3653 \times 10^{14}$ A/cm <sup>2</sup>
Energy flux	$J = \varepsilon_0N_0v_0 = m^4e^{12}/\hbar^9$	$6.436 \times 10^{15}$ W/cm <sup>2</sup>

Table 1.4. Conversion factors for units of energy

	1 J	1 erg	1 eV	1 K	1 cm <sup>-1</sup>	1 MHz	1 kcal/mol	1 kJ/mol
1 J	1	10 <sup>7</sup>	6.2415 × 10 <sup>18</sup>	7.2429 × 10 <sup>22</sup>	5.0341 × 10 <sup>22</sup>	1.5092 × 10 <sup>27</sup>	1.4393 × 10 <sup>20</sup>	6.0221 × 10 <sup>20</sup>
1 erg	10 <sup>-7</sup>	1	6.2415 × 10 <sup>11</sup>	7.2429 × 10 <sup>15</sup>	5.0341 × 10 <sup>15</sup>	1.5092 × 10 <sup>20</sup>	1.4393 × 10 <sup>13</sup>	6.0221 × 10 <sup>13</sup>
1 eV	1.6022 × 10 <sup>-19</sup>	1.6022 × 10 <sup>-12</sup>	1	11604	8065.5	2.4180 × 10 <sup>8</sup>	23.045	96.485
1 K	1.3807 × 10 <sup>-23</sup>	1.3807 × 10 <sup>-16</sup>	8.6174 × 10 <sup>-5</sup>	1	0.69504	2.0837 × 10 <sup>4</sup>	1.9872 × 10 <sup>-3</sup>	8.3145 × 10 <sup>-3</sup>
1 cm <sup>-1</sup>	1.9864 × 10 <sup>-23</sup>	1.9864 × 10 <sup>-16</sup>	1.2398 × 10 <sup>-4</sup>	1.4388	1	2.9979 × 10 <sup>4</sup>	2.8591 × 10 <sup>-3</sup>	1.1963 × 10 <sup>-2</sup>
1 MHz	6.6261 × 10 <sup>-28</sup>	6.6261 × 10 <sup>-21</sup>	4.1357 × 10 <sup>-9</sup>	4.7992 × 10 <sup>-5</sup>	3.3356 × 10 <sup>-5</sup>	1	9.5371 × 10 <sup>-9</sup>	3.9903 × 10 <sup>-7</sup>
1 kcal/mol	6.9477 × 10 <sup>-21</sup>	6.9477 × 10 <sup>-28</sup>	4.3364 × 10 <sup>-2</sup>	503.22	349.76	1.0485 × 10 <sup>7</sup>	1	4.184
1 kJ/mol	1.6605 × 10 <sup>-21</sup>	1.6605 × 10 <sup>-28</sup>	1.0364 × 10 <sup>-2</sup>	120.27	83.594	2.5061 × 10 <sup>6</sup>	0.23901	1

Table 1.5. Conversion factors for units of pressure

	1 Pa = 1 N/m <sup>2</sup>	1 dyn/cm <sup>2</sup>	1 Torr	1 atm <sup>a</sup>	1 at <sup>b</sup>	1 bar
1 Pa = 1 N/m <sup>2</sup>	1	10	7.5001 × 10 <sup>-3</sup>	9.8693 × 10 <sup>-6</sup>	1.0197 × 10 <sup>-5</sup>	10 <sup>-5</sup>
1 dyn/cm <sup>2</sup>	0.1	1	7.5001 × 10 <sup>-4</sup>	9.8693 × 10 <sup>-7</sup>	1.0197 × 10 <sup>-6</sup>	10 <sup>-6</sup>
1 Torr	133.332	1333.32	1	1.3158 × 10 <sup>-3</sup>	1.3595 × 10 <sup>-3</sup>	1.33332 × 10 <sup>-3</sup>
1 atm <sup>a</sup>	1.01325 × 10 <sup>5</sup>	1.01325 × 10 <sup>6</sup>	760	1	1.01332	1.01325
1 at <sup>b</sup>	9.80665 × 10 <sup>4</sup>	9.80665 × 10 <sup>5</sup>	735.56	0.96785	1	0.980665
1 bar	10 <sup>5</sup>	10 <sup>6</sup>	750.01	0.98693	1.0197	1

<sup>a</sup> atm—physical atmosphere  
<sup>b</sup> at = kg/cm<sup>2</sup>—technical atmosphere



**Table 1.6.** Conversion factors for units of electric voltage

	1 V	1 CGSE	1 CGSM
1 V	1	$3.33564 \times 10^{-3}$	$10^8$
1 CGSE	299.792	1	$2.99792 \times 10^{10}$
1 CGSM	$10^{-8}$	$3.33564 \times 10^{-11}$	1

**Table 1.7.** Conversion factors for units of electric field strength

	1 V/cm	1 CGSE	1 CGSM
1 V/cm	1	$3.33564 \times 10^{-3}$	$10^8$
1 CGSE	299.792	1	$2.99792 \times 10^{10}$
1 CGSM	$10^{-8}$	$3.33564 \times 10^{-11}$	1

**Table 1.8.** Conversion factors for units of electric resistance

	1 $\Omega$	1 CGSE	1 CGSM
1 $\Omega$	1	$1.11265 \times 10^{-12}$	$10^9$
1 CGSE	$8.98755 \times 10^{11}$	1	$8.98755 \times 10^{20}$
1 CGSM	$10^{-9}$	$1.11265 \times 10^{-21}$	1

**Table 1.9.** Conversion factors for units of magnetic field strength

	1 Oe	1 CGSE	1 A/m
1 Oe	1	$2.99792 \times 10^{10}$	79.5775
1 CGSE	$3.33564 \times 10^{-11}$	1	$2.65442 \times 10^{-9}$
1 A/m	0.012566	$1.11265 \times 10^{-21}$	1

**Table 1.10.** Conversion factors for units of magnetic induction

	1 CGSE	1 T = 1 Wb/m <sup>2</sup>	1 Gs
1 CGSE	1	$2.99792 \times 10^6$	$2.99792 \times 10^{10}$
1 T = 1 Wb/m <sup>2</sup>	$3.33564 \times 10^{-7}$	1	$10^4$
1 Gs	$3.33564 \times 10^{-11}$	$10^{-4}$	1

### 1.3.3 Conversion Factors in Formulas of General Physics with Atomic Particles

Explanations to Table 1.11:

1. The particle velocity is  $v = \sqrt{2\varepsilon/m}$ , where  $\varepsilon$  is the energy,  $m$  is the particle mass

**Table 1.11.** Conversion factors for formulas involving atomic particles

Number	Formula <sup>a</sup>	Factor $C$	Units used
1	$v = C\sqrt{\varepsilon/m}$	$5.931 \times 10^7$ cm/s	$\varepsilon$ in eV, $m$ in e.m.u. <sup>a</sup>
		$1.389 \times 10^6$ cm/s	$\varepsilon$ in eV, $m$ in a.m.u. <sup>a</sup>
		$5.506 \times 10^5$ cm/s	$\varepsilon$ in K, $m$ in e.m.u.
		$1.289 \times 10^4$ cm/s	$\varepsilon$ in K, $m$ in a.m.u.
2	$v = C\sqrt{T/m}$	$1.567 \times 10^6$ cm/s	$T$ in eV, $m$ in a.m.u.
		$1.455 \times 10^4$ cm/s	$\varepsilon$ in K, $m$ in a.m.u.
3	$\varepsilon = Cv^2$	$3.299 \times 10^{-12}$ K	$v$ in cm/s, $m$ in e.m.u.
		$6.014 \times 10^{-9}$ K	$v$ in cm/s, $m$ in a.m.u.
		$2.843 \times 10^{-16}$ eV	$v$ in cm/s, $m$ in e.m.u.
		$5.182 \times 10^{-13}$ eV	$v$ in cm/s, $m$ in a.m.u.
4	$\omega = C\varepsilon$	$1.519 \times 10^{15}$ s <sup>-1</sup>	$\varepsilon$ in eV
		$1.309 \times 10^{11}$ s <sup>-1</sup>	$\varepsilon$ in K
5	$\omega = C/\lambda$	$1.884 \times 10^{15}$ s <sup>-1</sup>	$\lambda$ in $\mu$ m
6	$\varepsilon = C/\lambda$	1.2398 eV	$\lambda$ in $\mu$ m
7	$\omega_H = CH/m$	$1.759 \times 10^7$ s <sup>-1</sup>	$H$ in Gs, $m$ in e.m.u.
		9655 s <sup>-1</sup>	$H$ in Gs, $m$ in a.m.u.
8	$r_H = C\sqrt{\varepsilon m}/H$	3.372 cm	$\varepsilon$ in eV, $m$ in e.m.u., $H$ in Gs
		143.9 cm	$\varepsilon$ in eV, $m$ in a.m.u., $H$ in Gs
		$3.128 \times 10^{-2}$ cm	$\varepsilon$ in K, $m$ in e.m.u., $H$ in Gs
		1.336 cm	$\varepsilon$ in K, $m$ in a.m.u., $H$ in Gs
9	$p = CH^2$	$4.000 \times 10^{-3}$ Pa	$H$ in Gs
		$= 0.04$ erg/cm <sup>3</sup>	

<sup>a</sup> e.m.u. is the electron mass unit ( $m_e = 9.108 \times 10^{-28}$  g), a.m.u. is the atomic mass unit ( $m_a = 1.6605 \times 10^{-24}$  g)

2. The average particle velocity is  $v = \sqrt{8T/(\pi m)}$  with the Maxwell distribution function of particles on velocities;  $T$  is the temperature expressed in energetic units,  $m$  is the particle mass
3. The particle energy is  $\varepsilon = mv^2/2$ , where  $m$  is the particle mass,  $v$  is the particle velocity
4. The photon frequency is  $\omega = \varepsilon/\hbar$ , where  $\varepsilon$  is the photon energy
5. The photon frequency is  $\omega = 2\pi c/\lambda$ , where  $\lambda$  is the wavelength
6. The photon energy is  $\varepsilon = 2\pi\hbar c/\lambda$
7. The Larmor frequency is  $\omega_H = eH/(mc)$  for a charged particle of a mass  $m$  in a magnetic field of strength  $H$
8. The Larmor radius of a charged particle is  $r_H = \sqrt{2\varepsilon/m}/\omega_H$ , where  $\varepsilon$  is the energy of a charged particle,  $m$  is its mass,  $\omega_H$  is the Larmor frequency
9. The magnetic pressure is  $p_m = H^2/(8\pi)$

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