Appendix

TABLE A.1
Conversion of Units and Constants

Conversion Factors

Acceleration	1 m/s^2	$= 4.252 \times 10^7$ ft/hr^2	$= 3.2808$ ft/s^2
Area	1 m^2	$= 1550.0$ in^2	$= 10.764$ ft^2
Density	1 kg/m^3	$= 0.06243$ lbm/ft^3	
Dynamic viscosity	1 $kg/m \cdot s$	$= 1N \cdot s/m^2$	$= 2419.1$ $lbm/ft \cdot hr$
Energy	1 kJ	$= 0.9478$ Btu	$=737.56$ $ft \cdot lbf$
Force	1 N	$= 1$ $kg \cdot m/s^2$	$= 0.22481$ lbf
Heat flux	1 W/m^2	$= 1$ kg/s^3	$= 0.3171$ $Btu/hr \cdot ft^2$
Heat transfer coefficient	1 W/m^2 K	$= 0.1761$ Btu/ft^2 hr $°F$	
Heat transfer rate	1 W	$= 3.4123$ Btu/hr	$= 1.341 \times 10^{-3}$ hp
Kinematic viscosity	1 m^2/s	$= 10.7636$ ft^2/s	$= 10^4$ $stokes$
Latent heat	1 kJ/kg	$= 0.4299$ Btu/lbm	
Length	1 m	$= 39.37$ in	$= 3.2808$ ft
Mass	1 kg	$= 2.2046$ lbm	$= 1.1023 \times 10^{-3}$ US $tons$
Mass diffusivity	1 m^2/ s	$= 10.7636$ ft^2/s	$= 3.875 \times 10^4$ ft^2/hr
Mass flow rate	1 kg/s	$= 7936.6$ lbm/hr	
Mass transfer coefficient	1 m/s	$= 1.181 \times 10^4$ ft/hr	
Pressure, stress	1 Pa	$= 1$ N/m^2	$= 1.4504 \times 10^{-4}$ lbf/in^2
Specific heat	1 kJ/kgK	$= 0.2388$ $Btu/lbm \cdot °F$	$= 0.2389$ $cal/g \cdot °C$
Temperature	K	$= °C + 273.15$	$= (5/9)(°F + 459.67)$
	R	$= °F + 459.67$	$= (9/5)$ $(°K)$
Temperature difference	1 K	$= 1°C$	$= (9/5)$ $°F$
Thermal conductivity	1 W/mK	$= 0.57782$ $Btu/hr \cdot ft \cdot °F$	
Thermal diffusivity	1 m^2/s	$= 10.7636$ ft^2/s	$= 3.875 \times 10^4$ ft^2/hr
Thermal resistance	1 K/W	$= 0.5275°$ $F/hr \cdot Btu$	
Velocity	1 m/s	$= 3.2808$ ft/s	$= 3.6$ km/hr
Volume	1 m^3	$= 264.17$ gal $(U.S.)$	$= 1000$ L
Volume flow rate	1 m^3/s	$= 1.585 \times 10^4$ gal/min	$= 2118.9$ ft^3/min

SI Unit Conversions

Prefix (Symbol)	Multiplier
Tera (T)	10^{12}
Giga (G)	10^9
Mega (M)	10^6
kilo (k)	10^3
milli (m)	10^{-3}
micro (μ)	10^{-6}
nano (n)	10^{-9}
pico (p)	10^{-12}
femto (f)	10^{-15}

Constants

Atmospheric pressure (P_{atm})	= 101,325 N/m^2	= 14.69 lbf/in^2
e	= 2.7182818	
Gravitational acceleration (g)	= 9.807 m/s^2	
1 mole	= 6.022×10^{23} *molecules*	= 10^{-3} *kmol*
π	= 3.1415927	
Universal gas constant (R)	= 8.315 $kJ/kmol \cdot K$	= 1.9872 $Btu/lbmol \cdot R$

TABLE A.2
Properties of Metals at STP[a]

Metal	Melting Point (°C)	Boiling Point (°C)	Thermal Conductivity (W/mK)	Specific Heat, c_p (kJ/kgK)	Coefficient of Expansion ($\times 10^6/K$)	Density, ρ (kg/m^3)	Heat of Fusion (kJ/kg)
Aluminum	660	2441	237.0	0.900	25	2700	397.8
Antimony	630	1440	18.5	0.209	9		
Beryllium	1285	2475	218	1.825	12		
Bismuth	271.4	1660	8.4	0.126	13		
Cadmium	321	767	93	0.230	30		
Chromium	1860	2670	91	0.460	6	7150	330.8
Cobalt	1495	2925	69	0.419	12	8860	276.4
Copper	1084	2575	398	0.385	16.6	8960	205.2
Gold	1063	2800	315	0.130	14.2	19300	62.8
Iridium	2450	4390	147	0.130	6		
Iron	1536	2870	80.3	0.452	12	7870	272.2
Lead	327.5	1750	34.6	0.130	29	11300	23.0
Magnesium	650	1090	159	1.017	25		
Manganese	1244	2060	7.8	0.477	22		
Mercury	–38.86	356.55	8.39	0.138			
Molybdenum	2620	4651	140	0.251	5	10200	288.9
Nickel	1453	2800	89.9	0.444	13	8900	297.3
Niobium	2470	4740	52	0.268	7		
Osmium	3025	4225	61	0.130	5		
Platinum	1770	3825	73	0.134	9		
Plutonium	640	3230	8	0.134	54		
Potassium	63.3	760	99	0.753	83		
Rhodium	1965	3700	150	0.243	8		
Selenium	217	700	0.5	0.322	37		
Silicon	1411	3280	83.5	0.712	3		
Silver	961	2212	427	0.239	19	10500	111.0
Sodium	97.83	884	134	1.226	70		
Tantalum	2980	5365	54	0.142	6.5		
Thorium	1750	4800	41	0.126	12		
Tin	232	2600	64	0.226	20	7280	59.0
Titanium	1670	3290	20	0.523	8.5	4500	418.8
Tungsten	3400	5550	178	0.134	4.5		
Uranium	1132	4140	25	0.117	13.4		
Vanadium	1900	3400	60	0.486	8		
Zinc	419.5	910	115	0.389	35		

[a] Data reprinted with permission from Hewitt et al. (1997) and Weast (1970).

TABLE A.3
Properties of Nonmetals[a]

Material	Density, ρ (kg/m^3)	Thermal Conductivity, k (W/mK)	Specific Heat, c_p (kJ/kgK)
Asbestos millboard	1400	0.14	0.837
Asphalt	1100		1.67
Brick, common	1750	0.71	0.920
Brick, hard	2000	1.3	1.00
Chalk	2000	0.84	0.900
Charcoal, wood	400	0.088	1.00
Coal, anthracite	1500	0.26	1.26
Concrete, light	1400	0.42	0.962
Concrete, stone	2200	1.7	0.753
Corkboard	200	0.04	1.88
Earth, dry	1400	1.5	1.26
Fiber hardboard	1100	0.2	2.09
Fiberboard, light	240	0.058	2.51
Firebrick	2100	1.4	1.05
Glass, window	2500	0.96	0.837
Gypsum board	800	0.17	1.09
Ice (0°C)	900	2.2	2.09
Leather, dry	900	0.2	1.502
Limestone	2500	1.9	0.908
Marble	2600	2.6	0.879
Mica	2700	0.71	0.502
Mineral wool blanket	100	0.04	0.837
Paper	900	0.1	1.38
Paraffin wax	900	0.2	2.89
Plaster, light	700	0.2	1.00
Plaster, sand	1800	0.71	0.920
Plastics, foamed	200	0.03	1.26
Plastics, solid	1200	0.19	1.67
Porcelain	2500	1.5	0.920
Sandstone	2300	1.7	0.920
Sawdust	150	0.08	0.879
Silica aerogel	110	0.02	0.837
Vermiculite	130	0.058	0.837
Wood, balsa	160	0.050	2.93
Wood, oak	700	0.17	2.09
Wood, white pine	500	0.12	2.51

[a] Data reprinted with permission from Weast (1970).

TABLE A.4
Properties of Air at Atmospheric Pressure[a]

Temperature, T (*K*)	Density, ρ (*kg/m*^{3})	Specific Heat, c_p (*kJ/kgK*)	Viscosity, ρ (*kg/ms*)	Thermal Conductivity, k (*W/mK*)	Pr
150	2.367	1.010	10.28×10^{-6}	0.014	0.758
200	1.769	1.006	13.28×10^{-6}	0.018	0.739
250	1.413	1.005	15.99×10^{-6}	0.022	0.722
260	1.359	1.005	16.50×10^{-6}	0.023	0.719
270	1.308	1.006	17.00×10^{-6}	0.024	0.716
275	1.285	1.006	17.26×10^{-6}	0.024	0.715
280	1.261	1.006	17.50×10^{-6}	0.025	0.713
290	1.218	1.006	17.98×10^{-6}	0.025	0.710
300	1.177	1.006	18.46×10^{-6}	0.026	0.708
310	1.139	1.007	18.93×10^{-6}	0.027	0.705
320	1.103	1.007	19.39×10^{-6}	0.028	0.703
330	1.070	1.008	19.85×10^{-6}	0.029	0.701
340	1.038	1.008	20.30×10^{-6}	0.029	0.699
350	1.008	1.009	20.75×10^{-6}	0.030	0.697
400	0.882	1.014	22.86×10^{-6}	0.034	0.689
450	0.784	1.021	24.85×10^{-6}	0.037	0.684
500	0.706	1.030	26.70×10^{-6}	0.040	0.680
550	0.642	1.040	28.48×10^{-6}	0.044	0.680
600	0.588	1.051	30.17×10^{-6}	0.047	0.680
700	0.504	1.075	33.32×10^{-6}	0.052	0.684
800	0.441	1.099	36.24×10^{-6}	0.058	0.689
900	0.392	1.121	38.97×10^{-6}	0.063	0.696
1000	0.353	1.142	41.53×10^{-6}	0.068	0.702

[a] Data reprinted with permission from Hewitt et al. (1997) and Weast (1970).

TABLE A.5
Properties of Other Gases (1 atm, 298 K)[a]

Gas	Density, ρ (kg/m^3)	Specific Heat, c_p (kJ/kgK)	Gas Constant (J/kg^oC)	Thermal Conductivity, k (W/mK)	Dynamic Viscosity, μ (kg/ms)
Acetylene, C_2H_2	1.075	1.674	319	0.024	1.0×10^{-5}
Ammonia, NH_3	0.699	2.175	488	0.026	1.0×10^{-5}
Argon, Ar	1.608	0.523	208	0.0172	2.0×10^{-5}
n–Butane, C_4H_{10}	2.469	1.675	143	0.017	0.7×10^{-5}
Carbon Dioxide, CO_2	1.818	0.876	189	0.017	1.4×10^{-5}
Carbon Monoxide, CO	1.144	1.046	297	0.024	1.8×10^{-5}
Chlorine, Cl_2	2.907	0.477	117	0.0087	1.4×10^{-5}
Ethane, C_2H_6	1.227	1.715	276	0.017	9.5×10^{-5}
Ethylene, C_2H_4	0.072	1.548	296	0.017	1.0×10^{-5}
Fluorine, F_2	0.097	0.828	219	0.028	2.4×10^{-5}
Helium, He	0.164	5.188	2077	0.149	2.0×10^{-5}
Hydrogen, H_2	0.083	14.310	4126	0.0182	0.9×10^{-5}
Hydrogen Sulfide, H_2S	10.753	0.962	244	0.014	1.3×10^{-5}
Methane, CH_4	0.662	2.260	518	0.035	1.1×10^{-5}
Methyl Chloride, CH_3Cl	2.165	0.837	165	0.010	1.1×10^{-5}
Nitric Oxide, NO	1.229	0.983	277	0.026	1.9×10^{-5}
Nitrogen, N_2	1.147	1.040	297	0.026	1.8×10^{-5}
Nitrous Oxide, N_2O	1.802	0.879	189	0.017	1.5×10^{-5}
Oxygen, O_2	1.309	0.920	260	0.026	2.0×10^{-5}
Ozone, O_3	1.965	0.820	173	0.033	1.3×10^{-5}
Propane, C_3H_8	1.812	1.630	188	0.017	8.0×10^{-5}
Propylene, C_3H_6	1.724	1.506	197	0.017	8.5×10^{-5}
Sulfur Dioxide, SO_2	2.622	0.460	130	0.010	1.3×10^{-5}
Xenon, Xe	5.375	0.481	63.5	0.0052	2.3×10^{-5}

(*Continued*)

TABLE A.5 (CONTINUED)
Properties of Other Gases (1 atm, 298 K)[a]

Gas	Boiling Point (°C)	Latent Heat of Evaporation (kJ/kg)	Melting Point (°C)	Latent Heat of Fusion (kJ/kg)	Heat of Combustion (kJ/kg)
Acetylene, C_2H_2	–75	614.0	–82.2	53.5	50,200
Ammonia, NH_3	–33.3	1373.0	–77.7	332.3	—
Argon, *Ar*	–186	163.0			—
n–Butane, C_4H_{10}	–0.4	386.0	–138	44.7	49,700
Carbon Dioxide, CO_2	–78.5	572.0			—
Carbon Monoxide, *CO*	–191.5	216.0	–205		10,100
Chlorine, Cl_2	–34.0	288.0	–101	95.4	—
Ethane, C_2H_6	–88.3	488.0	–172.2	95.3	51,800
Ethylene, C_2H_4	–103.8	484.0	–169	120.0	47,800
Fluorine, F_2	–188.0	172.0	–220	25.6	—
Helium, *He*	4.22 K	23.3			—
Hydrogen, H_2	20.4 K	447.0	–259.1	58.0	144,000
Hydrogen Sulfide, H_2S	–60	544.0	–84	70.2	18,600
Methane, CH_4		510.0	–182.6	32.6	5327
Methyl Chloride, CH_3Cl	–23.7	428.0	–97.8	130.0	
Nitric Oxide, *NO*	–151.5		–161	76.5	—
Nitrogen, N_2	–195.8	199.0	–210	25.8	—
Nitrous Oxide, N_2O	–88.5	376.0	–90.8	149.0	—
Oxygen, O_2	–182.97	213.0	–218.4	13.7	—
Ozone, O_3	–112.0		–193	226.0	—
Propane, C_3H_8	–42.2	428.0	–189.9	44.4	50,340
Propylene, C_3H_6	–48.3	438.0	–185		50,000
Sulfur Dioxide, SO_2	–10.0	362.0	–75.5	135.0	—
Xenon, *Xe*	–108.0	96.0	–140	23.3	—

[a] Data reprinted with permission from Weast (1970).

TABLE A.6
Properties of Other Gases (Effects of Temperature)[a]

Gas	Temperature T (°C)	Density, ρ (kg/m^3)	Specific Heat, c_p (kJ/kgK)	Thermal Conductivity, k (W/mK)	Dynamic Viscosity, μ (kg/ms)
Ammonia, NH_3	0	0.956	2.176	0.022	9.18×10^{-6}
	20	0.894	2.176	0.024	9.82×10^{-6}
	50	0.811	2.176	0.027	1.09×10^{-5}
Argon, Ar	−13	1.87	0.523	0.016	2.04×10^{-5}
	−3	1.81	0.523	0.016	2.11×10^{-5}
	7	1.74	0.523	0.017	2.17×10^{-5}
	27	1.62	0.523	0.018	2.30×10^{-5}
	77	1.39	0.519	0.020	2.59×10^{-5}
	227	0.974	0.519	0.026	3.37×10^{-5}
	727	0.487	0.519	0.043	5.42×10^{-5}
	1227	0.325	0.519	0.055	7.08×10^{-5}
Butane, $C_4 H_{10}$	0	2.59	1.591	0.013	6.84×10^{-6}
	100	1.90	2.026	0.023	9.26×10^{-6}
	200	1.50	2.454	0.036	1.17×10^{-5}
	300	1.24	2.812	0.052	1.40×10^{-5}
	400	1.05	3.127	0.069	1.64×10^{-5}
	500	0.916	3.402	0.090	1.87×10^{-5}
	600	0.812	3.642	0.113	2.11×10^{-5}
Carbon Dioxide, CO_2	−13	2.08	0.813	0.014	1.31×10^{-5}
	−3	2.00	0.823	0.014	1.36×10^{-5}
	7	1.93	0.832	0.015	1.40×10^{-5}
	17	1.86	0.842	0.016	1.45×10^{-5}
	27	1.80	0.851	0.017	1.49×10^{-5}
	77	1.54	0.898	0.020	1.72×10^{-5}
	227	1.07	1.014	0.034	2.32×10^{-5}
Carbon Monoxide, CO	−13	1.31	1.041	0.022	1.59×10^{-5}
	−3	1.27	1.041	0.023	1.64×10^{-5}
	7	1.22	1.041	0.024	1.69×10^{-5}
	17	1.18	1.041	0.025	1.74×10^{-5}
	27	1.14	1.041	0.025	1.79×10^{-5}
	77	0.975	1.043	0.029	2.01×10^{-5}
	227	0.682	1.064	0.039	2.61×10^{-5}
Ethane, $C_2 H_6$	0	1.342	1.646	0.019	8.60×10^{-6}
	100	0.983	2.066	0.032	1.14×10^{-5}
	200	0.776	2.488	0.047	1.41×10^{-5}
	300	0.640	2.868	0.065	1.68×10^{-5}
	400	0.545	3.212	0.085	1.93×10^{-5}
	500	0.474	3.517	0.108	2.20×10^{-5}
	600	0.420	3.784	0.132	2.45×10^{-5}
Ethanol, C_2H_5OH	100	1.49	1.686	0.023	1.08×10^{-5}
	200	1.18	2.008	0.035	1.37×10^{-5}
	300	0.974	2.318	0.050	1.67×10^{-5}

(*Continued*)

TABLE A.6 (CONTINUED)
Properties of Other Gases (Effects of Temperature)[a]

Gas	Temperature T (°C)	Density, ρ (kg/m^3)	Specific Heat, c_p (kJ/kgK)	Thermal Conductivity, k (W/mK)	Dynamic Viscosity, μ (kg/ms)
	400	0.828	2.611	0.067	1.97×10^{-5}
	500	0.720	2.891	0.086	2.26×10^{-5}
Helium, *He*	0	0.368	5.146	0.142	1.86×10^{-5}
	20	0.167	5.188	0.149	1.94×10^{-5}
	40	0.156	5.188	0.155	2.03×10^{-5}
Hydrogen, H_2	–13	0.0944	14.133	0.162	8.14×10^{-6}
	–3	0.0910	14.175	0.167	8.35×10^{-6}
	7	0.0877	14.226	0.172	8.55×10^{-6}
	27	0.0847	14.267	0.177	8.76×10^{-6}
	77	0.0819	14.301	0.182	8.96×10^{-6}
	727	0.04912	14.506	0.272	1.26×10^{-5}
Methane, CH_4	0	0.716	2.164	0.031	1.04×10^{-5}
	100	0.525	2.447	0.046	1.32×10^{-5}
	200	0.414	2.805	0.064	1.59×10^{-5}
	300	0.342	3.173	0.082	1.83×10^{-5}
	400	0.291	3.527	0.102	2.07×10^{-5}
	500	0.253	3.853	0.122	2.29×10^{-5}
	600	0.224	4.150	0.144	2.52×10^{-5}
Nitrogen, N_2,	77	1.14	1.041	0.026	1.79×10^{-5}
	227	9.75	1.042	0.030	2.00×10^{-5}
	727	6.82	1.056	0.040	2.57×10^{-5}
Oxygen, O_2	–13	1.50	0.915	0.023	1.85×10^{-5}
	–3	1.45	0.916	0.024	1.90×10^{-5}
	7	1.39	0.918	0.025	1.96×10^{-5}
	27	1.35	0.918	0.026	2.01×10^{-5}
	77	1.30	0.920	0.027	2.06×10^{-5}
	227	1.11	0.929	0.031	2.32×10^{-5}
	727	7.80	0.972	0.042	2.99×10^{-5}
Propane, $C_3 H_8$	0	1.97	1.548	0.015	7.50×10^{-6}
	100	1.44	2.015	0.026	1.00×10^{-5}
	200	1.14	2.456	0.040	1.25×10^{-5}
	300	0.939	2.833	0.056	1.40×10^{-5}
	400	0.799	3.159	0.074	1.72×10^{-5}
	500	0.694	3.446	0.095	1.94×10^{-5}
	600	0.616	3.695	0.118	2.18×10^{-5}

[a] Data reprinted with permission from Weast (1970).

TABLE A.7
Properties of Liquids (300 K, 1 atm)[a]

Liquid	Latent Heat of Fusion (*kJ/kgK*)	Boiling Point (*K*)	Latent Heat of Evaporation (*kJ/kgK*)	Coefficient of Expansion (1/*K*)
Acetic acid	181	391	402	0.0011
Acetone	98.3	329	518	0.0015
Alcohol, ethyl	108	351.46	846	0.0011
Alcohol, methyl	98.8	337.8	1100	0.0014
Alcohol, propyl	86.5	371	779	
Benzene	126	353.3	390	0.0013
Bromine	66.7	331.6	193	0.0012
Carbon disulfide	57.6	319.40	351	0.0013
Carbon tetrachloride	174	349.6	194	0.0013
Chloroform	77.0	334.4	247	0.0013
Decane	201	447.2	263	
Dodecane	216	489.4	256	
Ether	96.2	307.7	372	0.0016
Ethylene glycol	181	470	800	
Fluorine, R-11		297.0	180.0	
Fluorine, R-12	34.4	243.4	165	
Fluorine, R-22	183	232.4	232	
Glycerine	200	563.4	974	0.00054
Heptane	140	371.5	318	
Hexane	152	341.86	365	
Iodine	62.2	457.5	164	
Kerosene			251	
Linseed oil		560		
Mercury	11.6	630	295	0.00018
Octane	181	398	298	0.00072
Phenol	121	455		0.00090
Propane	79.9	231.08	428	
Propylene	71.4	225.45	342	
Propylene glycol		460	914	
Toluene	71.8	383.6	363	
Turpentine		433	293	0.00099
Water	333	373	2260	0.00020

[a] Data reprinted with permission from Weast (1970).

TABLE A.8
Properties of Saturated Water[a]

T (°C)	P (kPa)	ρ_f (kg/m^3)	ρ_v (kg/m^3)	h_{fg} (kJ/kg)	$c_{p,f}$ (kJ/kgK)	$\mu_f \cdot 10^6$ (kg/ms)	k_f (W/mK)	Pr_f	σ_f (N/m)
0.01	0.612	999.8	0.005	2501	4229	1791	0.561	13.50	0.0757
10	1.228	999.7	0.009	2477	4188	1308	0.580	9.444	0.742
20	2.339	998.2	0.017	2453	4182	1003	0.598	7.010	0.0727
30	4.246	995.6	0.030	2430	4182	798	0.615	5.423	0.0712
40	7.381	992.2	0.051	2406	4183	653	0.631	4.332	0.0696
50	12.34	988.0	0.083	2382	4181	547.1	0.644	3.555	0.0680
60	19.93	983.2	0.130	2358	4183	466.8	0.654	2.984	0.0662
70	31.18	977.8	0.198	2333	4187	404.5	0.663	2.554	0.0645
80	47.37	971.8	0.293	2308	4196	355.0	0.670	2.223	0.0627
90	70.12	965.3	0.423	2283	4205	315.1	0.675	1.962	0.0608
100	101.3	958.4	0.597	2257	4217	282.3	0.679	1.753	0.0589
110	143.2	951.0	0.826	2230	4233	255.1	0.682	1.584	0.0570
120	198.5	943.2	1.121	2202	4249	232.2	0.683	1.444	0.0550
130	270.0	934.9	1.495	2174	4267	212.8	0.684	1.328	0.0529
140	361.2	926.2	1.965	2145	4288	196.3	0.683	1.232	0.0509
150	475.7	917.1	2.545	2114	4314	182.0	0.682	1.151	0.0488
160	617.7	907.5	3.256	2082	4338	169.6	0.680	1.082	0.0466
170	791.5	897.5	4.118	2049	4368	158.9	0.677	1.025	0.0444
180	1001.9	887.1	5.154	2015	4404	149.4	0.673	0.977	0.0422
190	1254.2	876.2	6.390	1978	4444	141.0	0.669	0.937	0.0400
200	1553.7	864.7	7.854	1940	4489	133.6	0.663	0.904	0.0377
220	2317.8	840.3	11.61	1858	4602	121.0	0.650	0.857	0.0331
240	3344.7	813.5	16.74	1766	4759	110.5	0.632	0.832	0.0284
260	4689.5	783.8	23.70	1662	4971	101.5	0.609	0.828	0.0237
280	6413.2	750.5	33.15	1543	5279	93.4	0.581	0.848	0.0190
300	8583.8	712.4	46.15	1405	5751	85.8	0.548	0.901	0.0144
320	11279	667.4	64.6	1239	6536	78.4	0.509	1.006	0.0099
340	14594	610.8	92.7	1028	8241	70.3	0.469	1.236	0.0056
360	18655	528.1	143.7	721	14686	60.2	0.428	2.068	0.0019
373	21799	402.4	242.7	276	21828	46.7	0.545	18.69	0.0001

[a] Data reprinted with permission from Hewitt et al. (1997).

TABLE A.9
Atomic Weights of Elements[a]

Element	kg/kmol	Element	kg/kmol	Element	kg/kmol
Hydrogen, H	1.01	Bromine, Br	79.90	Thulium, Tm	168.93
Helium, He	4.00	Krypton, Kr	83.80	Ytterbium, Yb	173.04
Lithium, Li	6.94	Rubidium, Rb	85.47	Lutetium, Lu	174.97
Beryllium, Be	9.01	Strontium, Sr	87.62	Hafnium, Hf	178.49
Boron, B	10.81	Yttrium, Y	88.91	Tantalum, Ta	180.95
Carbon, C	12.01	Zirconium, Zr	91.22	Tungsten, W	183.84
Nitrogen, N	14.01	Niobium, Nb	92.91	Rhenium, Re	186.21
Oxygen, O	16.00	Molybdenum, Mo	95.94	Osmium, Os	190.23
Fluorine, F	19.00	Technetium, Tc	97.91	Iridium, Ir	192.22
Neon, Ne	20.18	Ruthenium, Ru	101.07	Platinum, Pt	195.08
Sodium, Na	22.99	Rhodium, Rh	102.91	Gold, Au	196.97
Magnesium, Mg	24.31	Palladium, Pd	106.42	Mercury, Hg	200.59
Aluminum, Al	26.98	Silver, Ag	107.87	Thallium, Tl	204.38
Silicon, Si	28.09	Cadmium, Cd	112.41	Lead, Pb	207.2
Phosphorus, P	30.97	Indium, In	114.82	Bismuth, Bi	208.98
Sulfur, S	32.07	Tin, Sn	118.71	Polonium, Po	208.98
Chlorine, Cl	35.45	Antimony, Sb	121.76	Astatine, At	209.99
Argon, Ar	39.95	Tellerium, Te	127.60	Radon, Rn	222.02
Potassium, K	39.10	Iodine, I	126.90	Francium, Fr	223.02
Calcium, Ca	40.08	Xenon, Xe	131.29	Radium, Ra	226.03
Scandium, Sc	44.96	Caesium, Cs	132.91	Actinium, Ac	227.03
Titanium, Ti	47.87	Barium, Ba	137.33	Thorium, Th	232.04
Vanadium, V	50.94	Lanthanum, La	138.91	Protactinium, Pa	231.04
Chromium, Cr	52.00	Cerium, Ce	140.12	Uranium, U	238.03
Manganese, Mn	54.94	Praseodymium, Pr	140.91	Neptunium, Np	237.05
Iron, Fe	55.85	Neodymium, Nd	144.24	Plutonium, Pu	239.05
Cobalt, Co	58.93	Promethium, Pm	144.91	Americium, Am	243.06
Nickel, Ni	58.69	Samarium, Sm	150.36	Curium, Cm	247.07
Copper, Cu	63.55	Europium, Eu	151.97	Berkelium, Bk	249.07
Zinc, Zn	65.39	Gadolinium, Gd	157.25	Californium, Cf	251.08
Gallium, Ga	69.72	Terbium, Tb	158.93	Einsteinium, Es	252.08
Germanium, Ge	72.61	Dysprosium, Dy	162.50	Fermium, Fm	257.10
Arsenic, As	74.92	Holmium, Ho	164.93	Mendelevium, Md	258.10
Selenium, Se	78.96	Erbium, Er	167.26	Nobelium, No	259.10

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