

**Do not write answers here!****Fundamental Constants**Avogadro's Number  $N_A = 6.0221415 \times 10^{23} \text{ mol}^{-1}$ Gas Constant  $R = 0.08205746 \text{ L-atm / K-mol} = 8.314472 \text{ J / K-mol} = 1.9872 \text{ cal / K-mol}$ Boltzmann constant  $k_B = R/N_A = 1.3806505 \times 10^{-23} \text{ J / K}$ speed of light  $c = 2.99792458 \times 10^8 \text{ m / s}$ acceleration of gravity on the surface of earth  $g = 9.80 \text{ m / s}^2$ **Conversion Factors**Volume 1 liter (L) = 1000 cm<sup>3</sup>

Pressure 1 atmosphere (atm) = 101325 Pa = 760 mmHg (exactly)

Temperature 0 degrees Celsius (°C) = 273.15 K

Energy 1 calorie (cal) = 4.184 Joules (exactly)

101.325 Joule = 1 L-atm

1 Joule  $\equiv$  1 kg-m<sup>2</sup>/s<sup>2</sup>

RT at exactly 25°C = 2.47897 kJ/mol

Mass 1 amu = 1.66053886 x 10<sup>-27</sup> kg $\ln x = 2.302585 \log x = \ln(10) \log x$ **Average Bond Energies (kJ/mole) [from Atkins]**

	<b>H-</b>	<b>C-</b>	<b>O-</b>	<b>C=</b>	<b>O=</b>
<b>H-</b>	436	412	463		
<b>C-</b>	412	348	360		
<b>O-</b>	463	360	146		
<b>N-</b>	388	292	157		
<b>Cl-</b>	431	328	203		
<b>C=</b>				612	743
<b>O=</b>				743	497

Data at 25°C. Standard state is one atmosphere pressure.

SUBSTANCE	$\Delta_f H_m^\circ$ (kJ/mole)	$S_m^\circ$ (J/K-mole)	$\Delta_f G_m^\circ$ (kJ/mole)
H (g)	217.965	114.60	203.263
Hg (g)	61.317	174.85	31.853
C (g)	716.682	671.29	157.99
CO (g)	-110.525	197.56	-137.15
CO <sub>2</sub> (g)	-393.51	213.64	-394.36
CH <sub>4</sub> (g)	-74.81	186.15	-50.75
C <sub>2</sub> H <sub>2</sub> (g)	226.73	200.83	209.20
C <sub>2</sub> H <sub>4</sub> (g)	52.26	219.45	68.12
C <sub>2</sub> H <sub>6</sub> (g)	-84.68	229.49	-32.89
C <sub>6</sub> H <sub>6</sub> (g)	82.927	269.2	129.66
cyclopropane: c-C <sub>3</sub> H <sub>6</sub> (g)	53.30	237.55	104.45
C <sub>3</sub> H <sub>8</sub> (g)	-103.85	269.91	-23.49
CH <sub>3</sub> OH (g)	-200.66	239.70	-162.01
LiCl (s)	-408.61	59.33	-384.39
Li <sup>+</sup> (aq)	-278.49	13.4	-293.31
CH <sub>3</sub> CH <sub>2</sub> OH (l)	-277.69	160.7	-174.89
CH <sub>3</sub> COCH <sub>3</sub> (g)	-184.05	266.27	-112.67
CH <sub>3</sub> COCH <sub>3</sub> (l)	-248.1	200.4	-155.39
Cl (g)	121.68	165.09	105.71
HCl (g)	-92.307	186.80	-95.30
NaOH (s)	-425.61	64.46	-379.49
Na <sup>+</sup> (aq)	-240.12	59.0	-261.92
NH <sub>3</sub> (g)	-46.11	192.34	-16.48
NH <sub>3</sub> (aq)	-80.29	111.3	-26.50
N <sub>2</sub> H <sub>4</sub> (g)	95.40	238.47	159.35
NH <sub>4</sub> NO <sub>3</sub> (s)	-365.56	151.08	-184.02
O (g)	249.17	231.76	160.95
O <sub>3</sub> (g)	142.7	238.82	163.2
H <sub>2</sub> O (g)	-241.82	188.72	-228.59
H <sub>2</sub> O (l)	-285.83	69.91	-237.18
OH <sup>-</sup> (aq)	-229.99	-10.75	-157.24

  

ELEMENT	$S^\circ$ (J/K-mol)	ELEMENT	$S^\circ$ (J/K-mol)	ELEMENT	$S^\circ$ (J/K-mol)
Al (s)	28.33	Cl <sub>2</sub> (g)	222.96	Fe (s)	27.28
Br <sub>2</sub> (l)	152.23	F <sub>2</sub> (g)	202.67	Hg (l)	76.02
Ca (s)	41.42	H <sub>2</sub> (g)	130.57	N <sub>2</sub> (g)	191.50
C (graphite)	5.740	I <sub>2</sub> (s)	116.14	O <sub>2</sub> (g)	205.03