

## Periodic Table of the Elements

	IA																VIII A							
1	1 <b>H</b> 1.008																2 <b>He</b> 4.00							
2	3 <b>Li</b> 6.94	IIA	4 <b>Be</b> 9.01									IIIA	IVA	VA	VIA	VIIA	10 <b>Ne</b> 20.18							
3	11 <b>Na</b> 22.99	12 <b>Mg</b> 24.30										13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.06	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95							
4	19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	IIIB	21 <b>Sc</b> 44.96	IVB	22 <b>Ti</b> 47.88	VB	23 <b>V</b> 50.94	VIB	24 <b>Cr</b> 52.00	VIIB	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.38	VIII	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80
5	37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.9	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.9	48 <b>Cd</b> 112.4	49 <b>In</b> 114.8	50 <b>Sn</b> 118.7	51 <b>Sb</b> 121.8	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.3						
6	55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 180.9	74 <b>W</b> 183.8	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209.0	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)						
7	87 <b>Fr</b> (223)	88 <b>Ra</b> 226.0	89 <b>Ac</b> 227.0	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (262)	108 <b>Hs</b> (265)	109 <b>Mt</b> (266)															

Lanthanides	58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.2	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0
Actinides	90 <b>Th</b> 232.0	91 <b>Pa</b> 231.0	92 <b>U</b> 238.0	93 <b>Np</b> 237.0	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

### Useful Information

$$\text{pH} = -\log [\text{H}^+] \quad \text{pOH} = -\log [\text{OH}^-] \quad K_w = 1.00 \times 10^{-14}$$

$$R = 0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mole}\cdot\text{K}} = 8.314 \frac{\text{J}}{\text{mole}\cdot\text{K}}$$

$$\Delta H^\circ_{\text{rxn}} = \sum(\Delta H_f^\circ(\text{products})) - \sum(\Delta H_f^\circ(\text{reactants}))$$

$$\Delta S^\circ_{\text{rxn}} = \sum(S^\circ(\text{products})) - \sum(S^\circ(\text{reactants}))$$

$$\Delta G^\circ_{\text{rxn}} = \sum(\Delta G_f^\circ(\text{products})) - \sum(\Delta G_f^\circ(\text{reactants}))$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = -RT \ln K$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

## Solubility Table

Ion	Solubility	Exceptions
NO <sub>3</sub> <sup>-</sup>	soluble	none
ClO <sub>4</sub> <sup>-</sup>	soluble	none
Cl <sup>-</sup>	soluble	except Ag <sup>+</sup> , Hg <sub>2</sub> <sup>2+</sup> , *Pb <sup>2+</sup>
I <sup>-</sup>	soluble	except Ag <sup>+</sup> , Hg <sub>2</sub> <sup>2+</sup> , Pb <sup>2+</sup>
SO <sub>4</sub> <sup>2-</sup>	soluble	except Ca <sup>2+</sup> , Ba <sup>2+</sup> , Sr <sup>2+</sup> , Hg <sup>2+</sup> , Pb <sup>2+</sup> , Ag <sup>+</sup>
CO <sub>3</sub> <sup>2-</sup>	insoluble	except Group IA and NH <sub>4</sub> <sup>+</sup>
PO <sub>4</sub> <sup>3-</sup>	insoluble	except Group IA and NH <sub>4</sub> <sup>+</sup>
-OH	insoluble	except Group IA, *Ca <sup>2+</sup> , Ba <sup>2+</sup> , Sr <sup>2+</sup>
S <sup>2-</sup>	insoluble	except Group IA, IIA and NH <sub>4</sub> <sup>+</sup>
Na <sup>+</sup>	soluble	none
NH <sub>4</sub> <sup>+</sup>	soluble	none
K <sup>+</sup>	soluble	none

\*slightly soluble

## Activity Series of Metals

Metal	Reaction
Gold	Au <sup>3+</sup> + 3e <sup>-</sup> → Au
Platinum	Pt <sup>2+</sup> + 2e <sup>-</sup> → Pt
Mercury	Hg <sup>2+</sup> + 2e <sup>-</sup> → Hg
Silver	Ag <sup>+</sup> + e <sup>-</sup> → Ag
Copper	Cu <sup>2+</sup> + 2e <sup>-</sup> → Cu
Hydrogen	2H <sup>+</sup> + 2e <sup>-</sup> → H <sub>2</sub>
Lead	Pb <sup>2+</sup> + 2e <sup>-</sup> → Pb
Tin	Sn <sup>2+</sup> + 2e <sup>-</sup> → Sn
Nickel	Ni <sup>2+</sup> + 2e <sup>-</sup> → Ni
Cobalt	Co <sup>2+</sup> + 2e <sup>-</sup> → Co
Iron	Fe <sup>2+</sup> + 2e <sup>-</sup> → Fe
Chromium	Cr <sup>3+</sup> + 3e <sup>-</sup> → Cr
Zinc	Zn <sup>2+</sup> + 2e <sup>-</sup> → Zn
Manganese	Mn <sup>2+</sup> + 2e <sup>-</sup> → Mn
Aluminum	Al <sup>3+</sup> + 3e <sup>-</sup> → Al
Magnesium	Mg <sup>2+</sup> + 2e <sup>-</sup> → Mg
Sodium	Na <sup>+</sup> + e <sup>-</sup> → Na
Calcium	Ca <sup>2+</sup> + 2e <sup>-</sup> → Ca
Barium	Ba <sup>2+</sup> + 2e <sup>-</sup> → Ba
Potassium	K <sup>+</sup> + e <sup>-</sup> → K
Lithium	Li <sup>+</sup> + e <sup>-</sup> → Li

## Thermodynamic Values (25 °C)

Substance and State	$\Delta H_f^\circ$ ( $\frac{\text{kJ}}{\text{mol}}$ )	$\Delta G_f^\circ$ ( $\frac{\text{kJ}}{\text{mol}}$ )	$S^\circ$ ( $\frac{\text{J}}{\text{K}\cdot\text{mol}}$ )	Substance and State	$\Delta H_f^\circ$ ( $\frac{\text{kJ}}{\text{mol}}$ )	$\Delta G_f^\circ$ ( $\frac{\text{kJ}}{\text{mol}}$ )	$S^\circ$ ( $\frac{\text{J}}{\text{K}\cdot\text{mol}}$ )
<b>Carbon</b>				<b>Nitrogen</b>			
C(s) (graphite)	0	0	6	N <sub>2</sub> (g)	0	0	192
C(s) (diamond)	2	3	2	NCl <sub>3</sub> (g)	230	271	-137
CO(g)	-110.5	-137	198	NF <sub>3</sub> (g)	-125	-83.6	-139
CO <sub>2</sub> (g)	-393.5	-394	214	NH <sub>3</sub> (g)	?	-17	193
CH <sub>4</sub> (g)	?	-51	186	NH <sub>3</sub> (aq)	?	-27	111
CH <sub>3</sub> OH(g)	-201	-163	240	NH <sub>2</sub> CONH <sub>2</sub> (aq)	?	?	174
CH <sub>3</sub> OH(l)	-239	-166	127	NO(g)	90	87	211
H <sub>2</sub> CO(g)	-116	-110	219	NO <sub>2</sub> (g)	32	52	240
HCOOH(g)	-363	-351	249	N <sub>2</sub> O(g)	82	104	220
HCN(g)	135.1	125	202	N <sub>2</sub> O <sub>4</sub> (g)	10	98	304
C <sub>2</sub> H <sub>2</sub> (g)	227	209	201	N <sub>2</sub> O <sub>5</sub> (g)	-42	134	178
C <sub>2</sub> H <sub>4</sub> (g)	52	68	219	N <sub>2</sub> H <sub>3</sub> CH <sub>3</sub> (l)	54	180	166
CH <sub>3</sub> CHO(g)	-166	-129	250	HNO <sub>3</sub> (aq)	-207	-111	146
C <sub>2</sub> H <sub>5</sub> OH(l)	-278	-175	161	HNO <sub>3</sub> (l)	-174	-81	156
C <sub>2</sub> H <sub>6</sub> (g)	-84.7	-32.9	229.5	NH <sub>4</sub> Cl(s)	-314	-201	95
C <sub>3</sub> H <sub>6</sub> (g)	20.9	62.7	266.9	NH <sub>4</sub> ClO <sub>4</sub> (s)	-295	-89	186
C <sub>3</sub> H <sub>8</sub> (g)	-104	-24	270	<b>Silver</b>			
<b>Bromine</b>				Ag(s)	0	0	42.6
Br <sub>2</sub> (l)	0	0	152.	Ag <sup>+</sup> (aq)	105.6	77.1	72.7
BrCl(g)	14.64	-0.96	240	Ag(S <sub>2</sub> O <sub>3</sub> ) <sup>3-</sup> (aq)	-1285.7	--	--
<b>Chlorine</b>				AgBr(s)	-100.4	-96.9	107.1
Cl <sub>2</sub> (g)	0	0	223	AgCl(s)	-127.1	-109.8	96.2
Cl <sub>2</sub> (aq)	-23	7	121	<b>Titanium</b>			
Cl <sup>-</sup> (aq)	-167	-131	57	TiCl <sub>4</sub> (g)	-763	-727	355
HCl(g)	-92	-95	187	TiO <sub>2</sub> (s)	-945	-890	50
<b>Fluorine</b>				<b>Aluminum</b>			
F <sub>2</sub> (g)	0	0	203	AlCl <sub>3</sub> (s)	-526	-505	184
F(aq)	-333	-279	-14	<b>Barium</b>			
HF(g)	-271	-273	174	BaCl <sub>2</sub> (aq)	-872	-823	123
<b>Hydrogen</b>				Ba(OH) <sub>2</sub> ·8H <sub>2</sub> O(s)	-3342	-2793	427
H <sub>2</sub> (g)	0	0	131	<b>Iodine</b>			
H(g) 217	203	115		I <sub>2</sub> (s)	0	0	116.7
H <sup>+</sup> (aq)	0	0	0	HI(g)	25.94	1.30	206.3
OH <sup>-</sup> (aq)	-230	-157	-11				
H <sub>2</sub> O(l)	-286	-237	70				
H <sub>2</sub> O(g)	-242	-229	189				
<b>Magnesium</b>							
Mg(s)	0	0	33				
Mg(aq)	-492	-456	-118				
MgO(s)	-601	-569	26.9				
<b>Oxygen</b>							
O <sub>2</sub> (g)	0	0	205				
O(g) 249	232	161					
O <sub>3</sub> (g)	143	163	239				