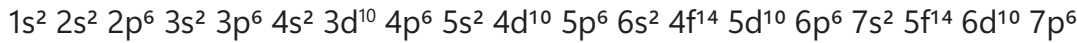


$\Delta H_{\text{vap}} = -\Delta H_{\text{cond}} = 40.67 \text{ kJ/mol}$
 $C_{\text{water}} = 4.184 \text{ J/(g} \cdot \text{K)}$
 $C_{\text{steam}} = 1.865 \text{ J/(g} \cdot \text{K)}$
 $C_{\text{ice}} = 2.11 \text{ J/(g} \cdot \text{K)}$
 $\Delta H_{\text{fus}} = -\Delta H_{\text{solid}} = 6.01 \text{ J/(g} \cdot \text{K)}$



PERIODIC TABLE OF ELEMENTS Acetic Acid $K_a = 1.8 \times 10^{-5}$

$K_a = \frac{[H_3O^+][A^-]}{[HA]}$

$K_b = \frac{[HB][OH^-]}{[B^-]}$

In a buffer solution, $\text{pH} = \text{p}K_a + \log_{10} \left(\frac{[A^-]}{[HA]} \right)$

$R_{\text{Ideal Gas}} = 62.4 \frac{\text{mmHg} \cdot \text{L}}{\text{mol} \cdot \text{K}} = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} = 8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$

$E_{\text{photon}} = hf = hc/\lambda$

$E_n = -\frac{R_H}{n^2}$

$R_H = 2.18 \times 10^{-18} \text{ J (Rydberg)}$

$\Delta E = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

$\lambda = \frac{h}{p}$

$[A] = \frac{1}{akt + \frac{1}{[A]_0}}$

Group \rightarrow

					18
					He
13	14	15	16	17	
B	C	N	O	F	Ne
2.04	2.55	3.04	3.44	3.98	
Al	Si	P	S	Cl	Ar
1.61	1.90	2.19	2.58	3.16	
Ga	Ge	As	Se	Br	Kr
1.81	2.01	2.18	2.55	2.96	3.00
In	Sn	Sb	Te	I	Xe
1.78	1.96	2.05	2.1	2.66	2.60
Tl	Pb	Bi	Po	At	Rn
1.62	1.87	2.02	2.0	2.2	2.2
Nh	Fl	Mc	Lv	Ts	Og

1	2	
H	Li	Be
1.008	6.94	9.012
Na	Mg	
22.990	24.305	
K	Ca	Sc
39.098	40.078	44.956
Rb	Sr	Y
85.468	87.62	88.906
Cs	Ba	La
132.91	137.33	138.905
Fr	Ra	Ac
(223)	(226)	(227)

$P \propto V^{-1}$ and $V \propto T$

(Ideal Gas Law) $PV = nRT$

$\left[P + \frac{an^2}{V^2} \right] [V - nb] = nRT$

Combined Gas $\frac{PV}{T} = k$ (for constant amount)

(Molarity) $M = \frac{\text{moles solute}}{\text{L solution}}$

(Molality) $m = \frac{\text{moles solute}}{\text{kg solvent}}$

(Mole Fraction) $x = \frac{\text{moles component}}{\text{moles total}}$

(Graham) $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

$\text{pH} = -\log_{10} [H^+]$

$\text{pH} + \text{pOH} = 14$

$\text{pH}_{\text{sigfig}}$ = past decimal

$K_{\text{eq}} = \frac{[\text{product}]}{[\text{reactant}]}$

$K_{\text{acid}} K_{\text{base}} = K_w = 1.0 \times 10^{-14}$

$i = 1$ (non-electrolyte) Van't Hoff Factor

$\Delta T_f = K_f m_i$

$\Delta T_b = K_b m_i$

$\Pi = iMRT$

$\Delta E = q + w = q - P\Delta V$

$\Delta H = \Delta E + P\Delta V$

$f = Ae^{-E_a/RT}$ (Boltzmann)
 $\ln k = -E_a \left(\frac{1}{RT} \right) + \ln A$

$2.54 \text{ cm} = 1 \text{ in}$

$0.946 \text{ L} = 1 \text{ qt}$

$F^\circ = \frac{9}{5} C^\circ + 32$

$C^\circ = \frac{5}{9} (F^\circ - 32)$

$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$, $\text{kg} \cdot \text{m}^2/\text{s}$

$c = 3.00 \times 10^8 \text{ m/s}$

$1 \text{ mol} = 6.022 \times 10^{23} = 22.4 \text{ L}_{\text{STP}}$

$\rho_{\text{water}} = 1 \text{ g/mL}$

$P_{\text{sea}} = 101325 \text{ Pa} = 1 \text{ atm} = 760 \text{ mmHg}$, $\text{torr} = 14.7 \text{ psi}$

$K_{\text{bwater}} = 0.512$

$K_{\text{fwater}} = 1.86$

IIIA	IVA	VA	VIA	VIIA	VIIIA
5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
13 Al Aluminium 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (290)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97
89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (266)

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Super 7 Strong Acids

CO₂
CO
CH₄
C₂H₆
C₃H₈
C₄H₁₀
NO
NO₂
N₂O
NH₃
SO₃
SO₂
H₂S
HCl

HI
HBr
HCl
HNO₃
H₂SO₄
HClO₃
HClO₄

Solubility Chart

Cations	Soluble with ____ (aq)	Forms Precipitates with ____ (s)
Na⁺, K⁺, and NH₄⁺	Most Anions	(NH ₄) ₂ C ₂ O ₄ forms a precipitate
Bi³⁺	Nothing	Most anions
As³⁺	I ¹⁻	Most anions
Sb³⁺	Cl ¹⁻	Most anions

Anions	Soluble with ____ (aq)	Forms Precipitates with ____ (s)
NO₃¹⁻ nitrate	Most cations	No common cations
ClO₄¹⁻ perchlorate	Most cations	No common cations
ClO₃¹⁻ chlorate	Most cations	No common cations
C₂H₃O₂¹⁻ acetate	Most cations	Ag ¹⁺ , Hg ₂ ²⁺
F¹⁻ fluoride	Most cations	Cr ³⁺
Cl¹⁻ chloride	Most cations	Ag ⁺ , Pb ^{2+,4+} , Hg ₂ ²⁺ , Tl ¹⁺
Br¹⁻ bromide	Most cations	Ag ⁺ , Pb ^{2+,4+} , Hg ₂ ²⁺ , Tl ¹⁺
I¹⁻ iodide	Most cations	Ag ⁺ , Pb ^{2+,4+} , Hg ₂ ²⁺ , Tl ¹⁺
SO₄²⁻ sulfate	Most cations	Ag ⁺ , Ba ²⁺ , Sr ²⁺ , Pb ^{2+,4+} , Ca ²⁺ , Hg ₂ ²⁺
CrO₄²⁻ chromate	Most cations	Ba ²⁺ , Sr ²⁺ , Pb ^{2+,4+} , Ca ²⁺ , Hg ₂ ²⁺
S²⁻ sulfide	Na ⁺ , K ⁺ , NH ₄ ⁺ , Li ⁺ , Sr ²⁺	Most other cations
OH¹⁻ hydroxide	Na ⁺ , K ⁺ , NH ₄ ⁺ , Li ⁺ , Sr ²⁺ , Ba ²⁺ , Ca ²⁺	Most other cations
CO₃²⁻ carbonate	Na ⁺ , K ⁺ , NH ₄ ⁺ , Li ⁺	Most other cations
PO₄³⁻ phosphate	Na ⁺ , K ⁺ , NH ₄ ⁺	Most other cations
O²⁻ oxide	No common cations	Most cations

Polyatomic Ions			
1+		2-	
(NH ₄) ⁺¹	ammonium	(CrO ₄) ⁻²	chromate
1-		(Cr ₂ O ₇) ⁻²	dichromate
(NO ₃) ⁻¹	nitrate	(CO ₃) ⁻²	carbonate
(NO ₂) ⁻¹	nitrite	(HPO ₄) ⁻²	dibasic phosphate or <u>hydrogen phosphate</u>
(OH) ⁻¹	hydroxide		
(HCO ₃) ⁻¹	<u>bicarbonate</u> or hydrogen carbonate	(MnO ₄) ⁻²	manganate
(C ₂ H ₃ O ₂) ⁻¹	acetate	(O ₂) ⁻²	peroxide
		(S ₂ O ₃) ⁻²	thiosulfate
(ClO ₄) ⁻¹	perchlorate	(SO ₄) ⁻²	sulfate
(ClO ₃) ⁻¹	chlorate	(SO ₃) ⁻²	sulfite
(ClO ₂) ⁻¹	chlorite	(C ₂ O ₄) ⁻²	oxalate
(ClO) ⁻¹	hypochlorite		
		3-	
(CN) ⁻¹	cyanide	(AsO ₄) ⁻³	arsenate
(SCN) ⁻¹	thiocyanate	(AsO ₃) ⁻³	arsenite
(HSO ₄) ⁻¹	bisulfate or hydrogen sulfate	(BO ₃) ⁻³	borate
(MnO ₄) ⁻¹	permanganate		
(H ₂ PO ₄) ⁻¹	dihydrogen phosphate	(C ₆ H ₅ O ₇) ⁻³	citrate
		(PO ₄) ⁻³	phosphate or tribasic phosphate
(IO ₄) ⁻¹	periodate	(PO ₃) ⁻³	phosphite
(IO ₃) ⁻¹	iodate		
(IO) ⁻¹	hypoiodite		
		4-	
(NH ₂) ⁻¹	amide	(SiO ₄) ⁻⁴	silicate (ortho)
(CHO ₂) ⁻¹	formate		

Atomic Ions			
+1		-1	
Li ⁺¹	Lithium	F ⁻¹	Fluoride
Na ⁺¹	Sodium	Br ⁻¹	Bromide
K ⁺¹	Potassium	Cl ⁻¹	Chloride
Ag ⁺¹	Silver	I ⁻¹	iodide
Cu ⁺¹	Copper (I) or Cuprous	H ⁻¹	hydride
Cs ⁺¹	Cesium		
H ⁺¹	Hydrogen		
+2		-2	
Mg ⁺²	Magnesium	O ⁻²	Oxide
Ca ⁺²	Calcium	O ₂ ⁻²	Peroxide
Ba ⁺²	Barium	S ⁻²	Sulfide
Zn ⁺²	Zinc		
Cd ⁺²	Cadmium (II)		
Cr ⁺²	Chromium (II) or Chromous	+2 (cont)	
Co ⁺²	Cobalt (II) or Cobaltous	Cu ⁺²	Copper (II) or Cupric
Hg ⁺²	Mercury (II) or Mercuric	Pb ⁺²	Lead (II) or Plumbous
Hg ₂ ⁺²	Mercury (I) or Mercurous	Fe ⁺²	Iron (II) or Ferrous
Mn ⁺²	Manganese (II) or manganous	Ni ⁺²	Nickel (II)
		Sn ⁺²	Tin (II) or Stannous
		Sr ⁺²	Strontium
+3		-3	
Al ⁺³	Aluminum	N ⁻³ P ⁻³	Nitride Phosphide
Fe ⁺³	Iron (III) or Ferric		
Ni ⁺³	Nickel (III)		
Cr ⁺³	Chromium (III) or Chromic		
+4			
Pb ⁺⁴	Lead (IV)		
Si ⁺⁴	Silicon (IV)		
Sn ⁺⁴	Tin (IV) or Stannic		
Mn ⁺⁴	Manganese (IV)		

Metal Activity Series / Redox Table

Element	Metal Ion(s) Found in nature	Metal Obtained
Lithium	Li^+	$\text{Li}_{(s)}$
Potassium	K^+	$\text{K}_{(s)}$
Barium	Ba^{2+}	$\text{Ba}_{(s)}$
Calcium	Ca^{2+}	$\text{Ca}_{(s)}$
Sodium	Na^+	$\text{Na}_{(s)}$
Magnesium	Mg^{2+}	$\text{Mg}_{(s)}$
Aluminum	Al^{3+}	$\text{Al}_{(s)}$
Manganese	Mn^{2+}	$\text{Mn}_{(s)}$
Zinc	Zn^{2+}	$\text{Zn}_{(s)}$
Chromium	$\text{Cr}^{3+}, \text{Cr}^{2+}$	$\text{Cr}_{(s)}$
Iron	$\text{Fe}^{3+}, \text{Fe}^{2+}$	$\text{Fe}_{(s)}$
Cobalt	Co^{2+}	$\text{Co}_{(s)}$
Nickel	Ni^+	$\text{Ni}_{(s)}$
Tin	Sn^{2+}	$\text{Sn}_{(s)}$
Lead	Pb^{2+}	$\text{Pb}_{(s)}$
Hydrogen	2H^+	$\text{H}_{2(g)}$
Copper	$\text{Cu}^{2+}, \text{Cu}^+$	$\text{Cu}_{(s)}$
Silver	Ag^+	$\text{Ag}_{(s)}$
Mercury	Hg^{2+}	$\text{Hg}_{(l)}$
Platinum	Pt^{2+}	$\text{Pt}_{(s)}$
Gold	$\text{Au}^{3+}, \text{Au}^+$	$\text{Au}_{(s)}$

Table 20-1 Processes Leading to Oxidation and Reduction	
<u>Oxidation</u>	<u>Reduction</u>
Complete loss of electrons (ionic reactions)	Complete gain of electrons (ionic reactions)
Shift of electrons away from an atom in a covalent bond	Shift of electrons toward an atom in a covalent bond
Gain of oxygen	Loss of oxygen
Loss of hydrogen by a covalent compound	Gain of hydrogen by a covalent compound
An increase in oxidation number	A decrease in oxidation number