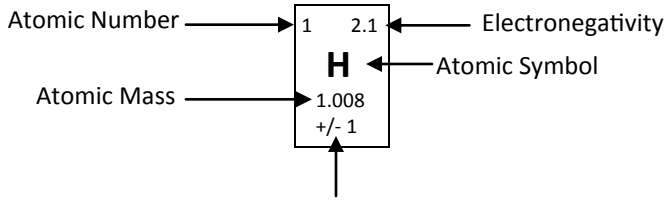
Mr. Hamm's Math & Science Information Card
Boyceville High School, Boyceville, WI
Version July 2014



Metalloids

1A												3A	4A	5A	6A	7A	8A
1 2.1 **H** 1.008 +/- 1	2A									3B	4B	5B	6B	7B	8B	8B	8B	1B	2B						2 — **He** 4.00
3 1.0 **Li** 6.941 + 1	4 1.5 **Be** 9.011 + 2																5 2.0 **B** 10.81	6 2.5 **C** 12.01 -4	7 3.0 **N** 14.01 -3	8 3.5 **O** 15.99 -2	9 4.0 **F** 19.00 -1	10 — **Ne** 20.18
11 0.9 **Na** 22.99 + 1	12 1.2 **Mg** 24.30 + 2																13 1.5 **Al** 26.98 + 3	14 1.8 **Si** 28.09	15 2.1 **P** 30.97 -3	16 2.5 **S** 32.07 -2	17 3.0 **Cl** 35.45 -1	18 — **Ar** 39.95
19 0.8 **K** 39.10 + 1	20 1.0 **Ca** 40.08 + 2	21 1.3 **Sc** 44.96 + 3	22 1.5 **Ti** 47.87 +3, +4	23 1.6 **V** 50.94	24 1.6 **Cr** 52.00 +2, +3	25 1.5 **Mn** 54.94 +3, +4	26 1.8 **Fe** 55.85 +2, +3	27 1.8 **Co** 58.93 +2, +3	28 1.8 **Ni** 58.69 +2, +3	29 1.9 **Cu** 63.55 +1, +2	30 1.6 **Zn** 65.39 +2	31 1.6 **Ga** 69.72	32 1.8 **Ge** 72.61	33 2.0 **As** 74.92	34 2.4 **Se** 78.96 -2	35 2.8 **Br** 79.90 -1	36 3.0 **Kr** 83.80
37 0.8 **Rb** 85.47 + 1	38 1.0 **Sr** 87.62 + 2	39 1.2 **Y** 88.91	40 1.4 **Zr** 91.22	41 1.6 **Nb** 92.91	42 1.8 **Mo** 95.94	43 1.9 **Tc** 98	44 2.2 **Ru** 101.1	45 2.2 **Rh** 102.9	46 2.2 **Pd** 106.4	47 1.9 **Ag** 107.9 +1	48 1.7 **Cd** 112.4 +2, +4	49 1.7 **In** 114.8	50 1.8 **Sn** 118.1 +2, +4	51 1.9 **Sb** 121.8	52 2.1 **Te** 127.6	53 2.5 **I** 126.9 -1	54 2.6 **Xe** 131.3
55 0.7 **Cs** 132.9 + 1	56 0.9 **Ba** 137.3 + 2	71 1.1 **Lu** 175.0	72 1.3 **Hf** 178.5	73 1.5 **Ta** 180.95	74 1.7 **W** 183.8	75 1.9 **Re** 186.2	76 2.2 **Os** 190.2	77 2.2 **Ir** 192.2	78 2.2 **Pt** 195.09	79 2.4 **Au** 197.0	80 1.9 **Hg** 200.6 +1, +2	81 1.8 **Tl** 204.4	82 1.8 **Pb** 207.2 +2, +4	83 1.9 **Bi** 209.0 +3, +5	84 2.0 **Po** 209	85 2.2 **At** 210	86 2.4 **Rn** 222
87 0.7 **Fr** 223 + 1	88 0.9 **Ra** 226 + 2	103 — **Lr** 260.1	104 — **Rf** 261	105 — **Db** 262	106 — **Sg** 263	107 — **Bh** 262	108 — **Hs** 265	109 — **Mt** 266	110 — **Ds** 281	111 — **Rg** 280	112 — **Cn** 285	113 — **Uut** 284	114 — **Fl** 289	115 — **Uup** 288	116 — **Lv** 293	117 — **Uus** 294	118 — **Uuo** 294

57 1.1 **La** 138.9	58 1.1 **Ce** 140.1	59 1.1 **Pr** 140.9	60 1.1 **Nd** 144.2	61 1.1 **Pm** 144.9	62 1.2 **Sm** 150.4	63 1.1 **Eu** 152.0	64 1.2 **Gd** 157.2	65 1.1 **Tb** 158.9	66 1.2 **Dy** 162.5	67 1.2 **Ho** 164.9	68 1.2 **Er** 167.3	69 1.3 **Tm** 168.9	70 1.1 **Yb** 173.0
89 1.1 **Ac** 227	90 1.3 **Th** 232.0	91 1.5 **Pa** 231	92 1.3 **U** 238.0	93 1.4 **Np** 237	94 1.3 **Pu** 244	95 1.3 **Am** 243	96 1.3 **Cm** 247	97 1.3 **Bk** 247	98 1.3 **Cf** 242.1	99 1.3 **Es** 254	100 1.3 **Fm** 257.1	101 1.3 **Md** 258.1	102 1.3 **No** 259.1

Newtonian Mechanics

$v_f = v_o + at$

$d_f = d_o + v_o t + \frac{1}{2}at^2$

$v_f^2 = v_o + 2ad$

$F = ma$

$F_{fric} \leq \mu F_N$

$a_c = \frac{v^2}{r}$

$\tau = rF\sin\theta$

$p = mv$

$J = F\Delta t = \Delta p$

$K = \frac{1}{2}mv^2$

$U_g = mgh$

$W = F\Delta d\cos\theta$

$P_{avg} = \frac{w}{\Delta t}$

$P = Fv\cos\theta$

$F_s = -kx$

$U_x = \frac{1}{2}kx^2$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{l}{g}}$

$T = \frac{1}{f}$

$F_G = \frac{Gm_1m_2}{r^2}$

$U_G = -\frac{Gm_1m_2}{r}$

a = acceleration
d = distance
F = force
f = frequency
h = height
J = impulse
K = kinetic energy
k = spring constant
l = length
m = mass
Fn = Normal Force
P = power
p = momentum
r = radius
T = period
t = time
U = potential energy
v = velocity or speed
W = work done on system
μ = coefficient of friction
θ = angle
τ = torque

Metric Prefixes

Giga	G	10^9	Centi	c	10^{-2}
Mega	M	10^6	Milli	m	10^{-3}
Kilo	k	10^3	Micro	μ	10^{-6}
Hecto	h	10^2	Nano	n	10^{-9}
Deca	da	10^1	Ang.	A	10^{-10}
Base Unit		1	Pico	p	10^{-12}
Deci	d	10^{-1}			

7 Fundamental SI Units

Meter	Ampere	Mole
Kilogram	Kelvin	
Second	Candela	

Electricity & Magnetism

$F = \frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r^2}$

$E = \frac{F}{q}$

$U_E = qV = \frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r}$

$E_{avg} = -\frac{V}{d}$

$V = \frac{1}{4\pi\varepsilon_o}\sum_i \frac{q_i}{r_i}$

$C = \frac{Q}{V}$

$C = \frac{\varepsilon_o A}{d}$

$U_C = \frac{1}{2}QV = \frac{1}{2}CV^2$

$I_{avg} = \frac{\Delta Q}{\Delta t}$

$R = \frac{\rho l}{A}$

$V = IR$

$P = IV$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

A = area
B = magnetic field
C = capacitance
d = distance
E = electric field
ε = emf
F = force
I = current
l = length
P = power
Q = charge
q = point charge
R = resistance
r = distance
t = time
U = potential energy
V = electric potential or potential difference
v = velocity or speed
ρ = resistivity
θ = angle
ϕ = magnetic flux

$F_B = qvB\sin\theta$

$F_B = BIl\sin\theta$

$B = \frac{\mu_o}{2\pi}\frac{I}{r}$

$\phi_m = BA\cos\theta$

$\varepsilon_{avg} = -\frac{\Delta\phi_m}{\Delta t}$

$\varepsilon = Blv$

Atomic & Nuclear Physics

$E = hf = pc$

$K_{\max} = hf - \phi$

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

$\Delta E = (\Delta m)c^2$

E = energy
f = frequency
K = kinetic energy
m = mass
p = momentum
λ = wavelength
ϕ = wave function

Waves and Optics

$v = f\lambda$

$f = \frac{R}{2}$

$n = \frac{c}{v}$

$d\sin\theta = m\lambda$

$n_1\sin\theta_1 = n_2\sin\theta_2$

$\sin\theta_c = \frac{n_2}{n_1}$

$x_m \approx \frac{m\lambda L}{d}$

$\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f}$

$M = \frac{h_i}{h_o} = -\frac{s_i}{s_o}$

d = separation
f = frequency
f = focal length
h = height
L = distance
M = magnification
m = an integer
n = index of refraction
R = radius of curvature
s = distance
v = speed
x = position
λ = wavelength
θ = angle

Fluid Mechanics & Thermodynamics

$$P = P_o + \rho g h$$

$$F_{buoy} = \rho V g$$

$$A_1 V_1 = A_2 V_2$$

$$P + \rho g y + \frac{1}{2}\rho v^2 = cons$$

$$\Delta l = \alpha l_o \Delta T$$

$$H = \frac{kA\Delta T}{L}$$

$$P = \frac{F}{A}$$

$$PV = nRT = Nk_BT$$

$$K_{avg} = \frac{3}{2}k_BT$$

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

$$W = P\Delta V$$

$$\Delta U = Q + W$$

$$e = \left|\frac{W}{Q_H}\right| \quad e_c = \frac{T_H - T_C}{T_H} \quad \rho = \frac{mass}{V} \quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

A = area
e = efficiency
F = force
h = depth
H = rate of heat transfer
k = thermal conductivity
K_{avg} = average molecular KE
I = length
L = thickness
M = molar mass
n = number of moles
N = number of molecules
P = pressure
Q = heat transferred to a system
T= temperature
U = internal energy
V = volume
v = velocity or speed
v_{rms} = root-mean-square velocity
W = work done on a system
y = height
α = coeff. of linear expansion
μ = mass of molecule

Conversion Factors

Mass
1 lb = 454 g
1 lb = 16 oz
1 kg = 2.2 lb

Length
1 in = 2.54 cm
1 yd = 3 ft
1 mile = 5280 ft
1 m = 1.09 yd

Energy
1 calorie = 4.184 J
1 eV = 1.602 x 10^{-19} J
1 BTU = 1054 J
1 food calorie = 1000 calories

Area
1 sq mile = 640 acres

Temperature
K = °C + 273
°C = (°F—32) x 0.56
°F = (1.8 x °C) + 32

Volume
1 cm^3 = 1 mL
2 cups = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
1 quart = 946 mL
1 L = 1.057 quarts

Pressure
1 atm = 760 mm Hg
1 atm = 760 Torr
1 atm = 101300 Pa
1 atm = 14.9 psi

Specific Heat, Latent Heats of Selected Substances

	Specific Heat (J/ kg K)	L_f (J/kg)	L_v (J/kg)
Water	4184	33400	2260000
Ice	2058	33400	2260000
Copper	385	20900	4730000
Iron	452	24700	6090000
Mercury	237	11400	2950000

Geometry and Trigonometry

Rectangle
$$A = bh$$

Triangle
$$A = \frac{1}{2}bh$$

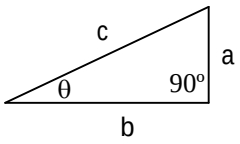
Circle
$$A = \pi r^2$$
$$C = 2\pi r$$

Cylinder
$$V = \pi r^2 h$$
$$S = 2\pi r l + 2\pi r^2$$

Sphere
$$V = \frac{4}{3}\pi r^3$$
$$S = 4\pi r^2$$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
r = radius

Right Triangle
$$a^2 + b^2 = c^2$$
$$\sin\theta = \frac{a}{c}$$
$$\cos\theta = \frac{b}{c}$$
$$\tan\theta = \frac{a}{b}$$



Calculus

Differentiation

$$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$$
$$\frac{d}{dx}(x^n) = nx^{n-1}$$
$$\frac{d}{dx}(e^x) = e^x$$
$$\frac{d}{dx}(\ln x) = \frac{1}{x}$$
$$\frac{d}{dx}(\sin x) = \cos x$$
$$\frac{d}{dx}(\cos x) = -\sin x$$

Integration

$$\int x^n dx = \frac{1}{n+1}x^{n+1}, n \neq 1$$
$$\int e^x dx = e^x$$
$$\int \frac{dx}{x} = \ln|x|$$
$$\int \cos x dx = \sin x$$
$$\int \sin x dx = -\cos x$$

Constants

Proton mass: 1.67 x 10^{-27} kg
Neutron mass: 1.67 x 10^{-27} kg
Electron mass: 9.11 x 10^{-31} kg
Avogadro's Number: 6.02 x 10^{23} /mol
Univ gas const: R = 8.31 J/mol K
Boltzmann's const: k_b = 1.38 x 10^{-23} J/K
Electron charge: 1.60 x 10^{-19} C
Speed of Light: c = 3.00 x 10^8 m/s
Univ. grav. const.:
G = 6.67 x 10^{-11} m^3/kg s^2
Accel. due to gravity near Earth:
g = 9.8 m/s^2

Planck's Const: h = 6.63 x 10^{-34} J s
Vacuum permittivity:
ε_o = 8.85 x 10^{-12} C^2 / N m^2
Vacuum permeability:
$\mu_o = 4\pi$ x 10^{-7} (T m) / A
One atmosphere pressure:
1 atm = 101300 Pa
Standard Temp & Press (STP):
T = 273 K, P = 1.00 atm
molar volume = 22.4 L

Common Polyatomic Ions

Acetate = $C_2H_3O_2^-$
Ammonium = NH_4^+
Carbonate = CO_3^{2-}
Chlorate = ClO_3^-
Chlorite = ClO_2^-
Cyanide = CN^-
Dichromate = $Cr_2O_7^{2-}$
Dihydrogen Phosphate = $H_2PO_4^-$
Hydrogen Carbonate = HCO_3^-
Hydrogen Phosphate = HPO_4^{2-}
Hydrogen Sulfate = HSO_4^-
Hydrogen Sulfite = HSO_3^-
Hypochlorite = ClO^-
Hydroxide = OH^-
Nitrate = NO_3^-
Nitrite = NO_2^-
Oxalate = $C_2O_4^{2-}$
Perchlorate = ClO_4^-
Permanganate = MnO_4^-
Peroxide = O_2^-
Phosphate = PO_4^{3-}
Sulfate = SO_4^{2-}
Sulfite = SO_3^{2-}
Thiocynate = SCN^-
Thiosulfate = $S_2O_3^{2-}$

Activity Series

Displaces H^+ from water and steam: Li, K, Ca, Na
Displaces H^+ from steam: Mg, Al, Zn, Cr, Fe, Cd
Displaces H^+ from acids: Co, Ni, Sn, Pb, H, Cu, Hg, Ag, Pt

Decreasing Activity ↓

F, Cl, Br, I

Decreasing Activity ↓

Solubility of Common Ionic Compounds

Soluble Salts

Acetates and Nitrates
Ammonium, Potassium, Lithium, & Sodium
Bromidides **EXCEPT** $PbBr_2$, HgBr, & AgBr.
Chlorides, **EXCEPT** $PbCl_2$, HgCl, and AgCl.
Iodides, **EXCEPT** PbI_2, HgI, and AgI.
Sulfates, **EXCEPT** $BaSO_4$, $CaSO_4$, $SrSO_4$, & $PbSO_4$.

Insoluble Salts

Carbonates, **EXCEPT** Li_2CO_3, K_2CO_3, Na_2CO_3, & $(NH_4)_2CO_3$
Chromates, **EXCEPT** Li_2CrO_4, Na_2CrO_4, K_2CrO_4, & $(NH_4)_2CrO_4$
Hydroxides, **EXCEPT** LiOH, KOH, NaOH, NH_4OH, $Ba(OH)_2$, $Ca(OH)_2$, & $Sr(OH)_2$.
Phosphates, **EXCEPT** Li_3PO_4, K_3PO_4, $(NH_4)_3PO_4$, & Na_3PO_4.
Sulfides, **EXCEPT** BaS, CaS, Li_2S, K_2S, Na_2S, $(NH_4)_2S$, & SrS.

Stoichiometry

$$n = \frac{m}{M}$$

$$\%_{yield} = \frac{AY}{TY} \times 100$$

$$\%_{comp} = \frac{m_{element}}{m_{compound}}$$

n = number of moles
m= mass
M = molar mass
AY = actual yield
TY = theoretical yield

Order of Filling Orbitals

1s -> 2s -> 2p -> 3s -> 3p -> 4s -> 3d -> 4p -> 5s -> 4d -> 5p -> 6s -> 4f -> 5d -> 6p -> 7s ...

Diatomic Molecules ... "Dirty Seven"

H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

Double-Replacement Reactions

Requirements to complete a double-replacement reaction. Only one of these need to be satisfied:

1. Water is a product
2. A gas is a product
3. A precipitate is formed

Solution Chemistry

$$M_1V_1 = M_2V_2$$

$$ppm_A = \frac{m_A}{m_{solution}} \times 10^6$$

$$M = \frac{n_{solute}}{V_{solvent(L)}}$$

$$m_m = \frac{n_{solute}}{m_{solvent(kg)}}$$

M = molarity
V = volume
m = mass
n = number of moles
BP = boiling point
FP = freezing point
i = Van't Hoff constant
k_b = BP elevation const.
k_f = FP depression const.
m_m = molality

$$\Delta T_B = BP_{solution} - BP_{solvent} = k_b m i$$

$$\Delta T_f = FP_{solvent} - FP_{solution} = k_f m i$$

Values of k_B & k_f

Solvent	BP, °C	k_B(°C/m)
Acetic Acid	118.5	3.08
Benzene	80.2	2.61
Carbon Disulfide	46.3	2.40
Cyclohexane	80.74	2.79
Ethanol	78.3	1.07
Water	100.0	0.52

Solvent	FP, °C	k_f(°C/m)
Acetic Acid	16.60	3.59
Benzene	5.455	5.065
Cyclohexane	6.55	20.0
Water	0.000	1.86

Matrix Arithmetic

$$\begin{bmatrix} 3 & 2 & -1 \\ 4 & 5 & 6 \\ 5 & 0 & 2 \end{bmatrix}$$

columns ↓ rows →

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \quad A \times A^{-1} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

det(A) = ad - bc

$$A^{-1} = \frac{1}{\det(A)} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

$$\begin{bmatrix} 2 & 1 & 0 \\ 3 & 2 & 5 \end{bmatrix} \times \begin{bmatrix} -1 & 2 \\ 0 & 0 \\ 6 & 3 \end{bmatrix} = \begin{bmatrix} -2 & 4 \\ 27 & 21 \end{bmatrix}$$

2 x 3 × 3 x 2 = 2 x 2

must be equal

row dimension of answer

column dimension of answer

Row matrix = only one row in matrix
Column matrix = only one column in matrix
Identity matrix = all zeros except ones along main diagonal only

Chemical Equilibrium

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$$K_p = \frac{P_C P_D}{P_A P_B}$$

$$K_P = K_c(RT)^{\Delta n}$$

a & b = coefficients of reactants A & B
c & d = coefficients of products C & D
Kc = Equilibrium constant in terms of conc.
Kp = Equilibrium constant in terms of partial press.
Δn = moles of gaseous products—moles of gaseous reactants
P = partial pressure
[ ] = concentration in Molarity

Trigonometric Identities

$$\sin(2a) = 2\sin a \cos a$$

$$\cos(2a) = 2\cos^2 a - 1$$

$$\tan(2a) = \frac{2\tan a}{1 - \tan^2 a}$$

$$\sec a = \frac{1}{\cos a} \quad \cot a = \frac{1}{\tan a}$$

$$\csc a = \frac{1}{\sin a} \quad \tan a = \frac{\sin a}{\cos a}$$

$$\tan(a + b) = \frac{\tan a + \tan b}{1 - \tan a \tan b}$$

$$\tan(a - b) = \frac{\tan a - \tan b}{1 + \tan a \tan b}$$

Law of Sines & Cosines for ΔABC

$$c^2 = a^2 + b^2 - 2ab\cos\theta$$

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\cos(a \pm b) = \cos a \cos b \mp \sin a \sin b$$

$$\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b$$

Pythagorean Relationships in Trigonometry

$$\sin^2\theta + \cos^2\theta = 1$$

$$1 + \tan^2\theta = \sec^2\theta$$

$$1 + \cot^2\theta = \csc^2\theta$$