W.O.W. - Waters of the World

Kristen England ©2006

First things smirst

~95% beer is aqua
 Styles developed b/c of the water of the city

Types-O-Aqua

- Tap water
- Spring water
- RO water
- Distilled water
- 'Heavy' water
 - Deuterium isotope good for things like the Manhattan project NOT brewing

Distilled Water

- 1. Contaminated water
- 2. Heat from the heating element
- 3. Evaporation of H_2O molecules
- 4. Condenser
- 5. Cool air from fan
- 6. Distilled water
- 7. Distilled water storage



RO Water



A method of producing pure water by forcing saline or impure water through a semipermeable membrane across which salts or impurities cannot pass.

RO – Under counter



 Stage 1 - Sediment Prefiltration - 1 micron cartridge that traps dirt, rust, mud, hair

 Stage 2 - Chlorine Prefiltration - 1 micron chemical removal cartridge to ensure no chemical deterioration of membrane from residual chlorine.

Stage 3 - Membrane Process This is the primary component that can separate up to 98% of dissolved metals and minerals from ordinary tap water.

RO - Membrane pore size



Yeast 5-12u

RO – City Scale



Spring Water

Spring water is water that comes out of the ground on its own or is bottled near water that comes out of the ground on its own.

Check ion content

Tap Water – The Bad

- `Bad'
 - Non-potable
 - Chlorine and/or Chloramines
 - Sulfur
 - Nitrates ummm...poop
 - Corn chips, old feet, etc

Chlorine, borine!!!

Chlorine gas
 Used VERY little
 Boils off easily

Chloramines
 Used most often
 Need carbon filter to remove
 Sulfate and UV bs
 Boil only concentrates!!

Nitrates = POO!



Tap Water – The Good

Good

- Anything you can drink potable water
- Well water
- NOT through 'softener'
- Carbon filtered
 - Removes Cl and other nasty stuff

Activated Carbon



Figure 1. Schematic representation of formation of Water-Soluble Active Carbon from carbon black.

Uses

- Air purification
- Water purification
- Booze purification
- Hospital

Activated Carbon

- Charcoal that has been treated with oxygen
 300-2,000 m²/g (3200-21500 ft²/g)
 - A tennis court is about 260 m² (2800ft²/g)

Trap

- Carbon-based contaminants flavor and odorous stuff
- Chlorine
- Pass
 - Sodium, Nitrates
- Good at trapping other carbon-based impurities ("organic" chemicals), as well as things like <u>chlorine</u>.
- Once all of the bonding sites are filled, an activated charcoal filter stops working.

Ummm....honeycomb!



Chemistry Primer



Atoms

 Atoms are composed protons, neutrons, and electrons.



 Protons and neutrons are located in a central area called the nucleus.

 Electrons move about the nucleus. The number of electrons is equal to the number of protons.

• Electrons in cloud, not ring

Periodic Table of the Flesonnts

	1 IA	New Original		Alkali	metals		Act	inide serie	es	С	Solid							18 VIIIA	
1	1 ¹ H Hydrogen 1.00794	2 IIA		Alkali	ne earth m	etals	Poo	or metals		Br	Liquid		13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	2 ² He Helium 4.002602	к
2	3 2 Li Lithium 6.941	4 2 Be Beryllium 9.012182		Lanth	anide serie	5	Nol	ole gases		Тс	Gas Synthetic		5 23 B Boron 10.811	6 2 C Carbon 12.0107	7 25 N Nitrogen 14.00674	8 26 0 0xygen 15.9994	9 27 F Fluorine 18.9984032	10 ² ₈ Ne Ncon 20.1797	KL
3	11 28 Na Sodium 22.989770	12 8 Mg Magnesium 24.3050	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 - VIIIB	10	11 IB	12 IIB	13 28 Al 3 Aluminum 26.981538	14 28 Silicon 28.0855	15 28 P Phosphorus 30.973761	16 28 S Sulfur 32.066	17 28 7 Chlorine 35.453	18 28 Ar Argon 39.948	K L M
4	19 28 K 1 Potassium 39.0983	20 28 Ca 2 Calcium 40.078	21 8 Sc 2 Scandium 44.955910	22 28 Ti 10 2 Titanium 47.867	23 28 V 11 Vanadium 50.9415	24 28 Cr 13 Chromium 51.9961	25 28 13 28 13 28 13 28 13 28 13 28 13 28 13 28 15 15 15 15 15 15 15 15 15 15 15 15 15	26 8 Fe 14 Iron 55.8457	27 28 Co 15 Cobalt 58.933200	28 28 Ni ¹⁶ 2 Nickel 58.6934	29 28 Cu 18 Copper 63.546	30 28 Zn 18 Zinc 65.409	31 28 Ga ¹⁸ Gallium 69.723	32 28 Ge 18 Germanium 72.64	33 28 As 18 Arsenic 74.92160	34 28 Se 18 Selenium 78.96	35 28 Br 18 7 Bromine 79.904	36 28 Kr ¹⁸ Krypton 83.798	KL∭N
5	37 28 Rb 18 Rubidium 85.4678	38 Sr Strontium 87.62	39 28 18 18 92 29 20 20 20 20 20 20 20 20 20 20 20 20 20	40 28 Zr 18 21rconium 91.224	41 28 Nb 12 Niobium 92.90638	42 28 Mo Molybdenum 95.94	43 Tc ¹⁸ ¹⁸ ¹³ ² ²	44 8 Ru Ruthenium 101.07	45 28 Rh 18 Rhodium 102.90550	46 28 18 18 18 18 18 18 18 18 18 18 18 18 18	47 28 Ag 18 Silver 107.8682	48 28 Cd 18 Cadmium 112.411	49 28 In 18 Indium 114.818	50 28 Sn 18 18 18 18 18 18 18 18 18 18	51 28 Sb 18 18 18 18 18 18 18 18 18 18	52 28 Te 18 18 18 18 18 18 18 18 18 18 18 18 18 1	53 28 18 18 18 18 18 18 126.90447	54 28 Xe 18 Xenon 131.293	K J∑ZO
6	55 2 Cs 18 Cesium 1 132.90545	56 28 Ba 18 Barium 2 137.327	57 to 71	72 28 Hf 18 10 Hafnium 2 178.49	73 28 Ta 18 32 Tantalum 2 180.9479	74 28 W 18 32 Tungsten 2 183.84	75 28 Re 18 Rhenium 2 186.207	76 28 Os 18 Osmium 2 190.23	77 28 Ir 18 15 Iridium 2 192.217	78 28 Pt 18 92 Platinum 1 195.078	79 28 Au 18 Gold 1 196,96655	80 28 Hg 18 Mercury 2 200.59	81 28 TI 18 Thallium 204.3833	82 28 Pb 18 322 Lead 4 207.2	83 28 Bi 18 Bismuth 5 208.98038	84 28 Polonium 2009	85 28 At 18 Astatine 7 (210)	86 28 Rn 18 Radon 28 18 32 32 8 8 (222)	K⊔∑ZOP
7	87 2 8 Fr 32 Francium 8 (223) 1	88 28 Ra 32 Radium 8 (226) 2	89 to 103	104 28 Rf 32 Rutherfordium 10 (261) 2	105 28 Db 32 Dubnium 11 (262) 2	106 28 So 32 Seaborgium 12 (266) 2	107 2 Bh 32 Bohrium 13 (264) 2	108 28 Hs 18 Hassium 14 (269) 2	109 28 Mt 32 Meitnerium 15 (268) 2	110 2 Ds 32 Darmstadtium 17 (271) 1	111 28 Rg 32 Roentgenium 18 (272) 1	112 28 Uub 18 Ununbium 18 (285) 2	113 Uut Ununtrium (284)	114 Uuq ^{Ununguadium} (289)	115 Uup ^{Ununpentium} (288)	116 Uuh ^{Ununhexium} (292)	117 Uus Ununseptium	118 Uuo ^{Ununoctium}	KLZZORQ

Atomic masses in parentheses are those of the most stable or common isotope.

Note: The subgroup numbers 1-18 were adopted in 1984 by the International Union of Pure and Applied Chemistry. The names of elements 112-118 are the Latin equivalents of those numbers.

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57 28 La 18 Lanthanum 2 138.9055	58 Ceriu 140.1	2 8 19 9 9 16	59 Pi Pras 140	2 8 8 21 21 eodymium 2 .90765	60 Nd Neodymium 144.24	2 8 18 22 8 2	61 28 Pm 23 Promethium 2 (145)	62 Sm ¹² Samarium 150.36	2 8 18 24 2	63 Eu Europium 151.964	2 8 18 25 8 2	64 28 Gd 18 Gadolinium 2 157.25	65 28 Tb 18 77 Terbium 2 158.92534		66 28 Dy 182 Dysprosium 2 162.500	67 28 Ho Holmium 164.93032	68 Er 30 Erbium 167.259	69 28 Tm 18 7hulium 2 168.93421	70 28 Yb 18 Ytterbium 2 173.04	71 2 Lu 32 Lutetium 2 174.967
89 28 Ac 18 Actinium 9 (227) 2	90 Th Thori 232.0	2 8 18 32 18 18 18 381 2	91 Prot 231	a 18 32 20 actinium 9 .03588 2	92 U Uranium 238.02891	2 8 18 32 21 9	93 2 Np 18 Neptunium 9 (237) 2	94 Pu Plutonium (244)	2 8 18 32 24 2	95 Am Americium (243)	2 8 18 32 25 8 2	96 28 Cm 18 32 Curium 9 (247) 2	97 28 Bk 18 Berkelium 82 (247) 2		98 28 Cf 32 Californium 8 (251) 2	99 8 Es 18 29 Einsteinium 8 (252) 2	100 Fm 33 Fermium (257)	101 28 Md 18 Mendelevium 8 (258) 2	102 28 No 188 32 Nobelium 232 (259) 2	103 2 Lr 32 Lawrencium 9 (262) 2



 Elements cannot be broken down into substances with different properties.

 Substances that are composed of two or more elements are called *compounds*.

 For example, water (H2O) is not an element because it can be broken down into hydrogen (H) and oxygen (O).

Ionic Compound



 Ionic bonding is the transfer of electrons from one atom to another.



- Atoms that have lost or gained electrons are called *ions*.
 - + = Cations
 - - = Anions

Ionization



H-Deuce-O



 Polar
 Covalent

 Shares electrons, doesnt lose or gain

 Molecule





Meniscus

Solvent

High surface tension

'Water bugs'

Action is independent of volume

Sorry, Its not that simple...

Review
Water types
Water properties
Solutes – bits in the water

Cations – Positive

Most widely occurring cations in water
 Ca >> Mg > Na >> K >> Mn

- Ca
 - Principle mineral hardness
 - ↓ mash pH, enzyme activity, protein digestion, lauter runoff
 - Neutralizes toxic substances in yeast: Peptone & Lecithin
 - inverts malt phosphate to pp alkaline phosphate
- Mg
 - 2ndary mineral in hardness
 - accentuates bitterness
- ■\Na
 - Accentuates beer flavor

Anions - Negative

Strong vs Weak Buffers CO₃²⁻ - Carbonate $CO_3 >> SO_4 >> CI$ • Contributes most of alkalinity • $CO_3^{2-} + H_2O \rightarrow HCO_3^{-} + OH^{-}$ • Pulls H^+ from $H_20 = OH^-$ • STRONG alkaline buffer = neutralizes acids Resists ↓ mash pH • $\downarrow \alpha$ -amylase activity, cold break, >200ppm = NEEDED dark roast grains to buffer SO₄²⁻ - Sulfate Weak buffer • >150ppm = cleaner, more pleasant bitter Cl⁻ - Chloride • Very weak buffer

Complicated?? • Ca – ↓ mash pH

CO3 – buffers mash pH
resists changes in mash pH
neutralizes acid

Hard vs Soft: The other definition

 Old Skizool nomenclature: Ability to form a lather with a bar of soap??
 Hard: Buncha stuff
 Soft: notta so much stuff

Water Softener



Exchanges Na for Ca and Mg

- Ca/ Mg precipitate out in pipes
- 'Scale' or 'Beer Stone'
- Bypass!!!

hAHdness

Ca & Mg in water

- Inhibit lather of soap = `hard'
- Slightly acidic = weak bonds
- Combine with CO₃²⁻, SO₄²⁻
 PP as insoluble mineral salts
- Temporary vs. Permanent
 - Temp = carbonate hardness
 - part of hardness that will pp after boiling
 - Permanent
 - Ca/Mg w/ non-carbonate ions

 $\frac{\text{CaCO}_3 \text{ Hardness}}{\text{Soft 50ppm} \rightarrow \text{Hard 300ppm}}$

Alkalinity

Alkalinity

buffering capacity of dissolved anions

 HCO₃⁻ (bicarbonate) ~ CO₃²⁻ → <u>ONLY</u> significant factor

Accepted standard – CaCO3??

- expresses hardness and alkalinity together
- Ca primary mineral of hardness
- CO3 principle cause of alkalinity

MEHHHH!!??

 ■ Alkalinity > hardness → hardness is <u>TEMPORARY</u>

 Hardness > alkalinity → <u>PERMANENT</u> SO4 hardness

Rho to the H!!



 PH
 Measure of acid (H+)
 BEER!!! to alkaline (OH-) ratios of a solution

> pH values run from 1 to 14

- negative log10 of [H+]
- 0 (highly acidic) to14 (highly basic), 7 neutral

Das pH boot camp

- Log scale
 - pH = -log₁₀ [H+]
 - By 10's
 - Calculation
 - Change pH from 7 to 5
 - $10^{-7} \rightarrow 10^{-6} \rightarrow 10^{-5}$
 - $10^2 = 10 \times 10 = \text{ increase } [\text{H+}] = 100 \text{ fold}$
- HCI(aq) [H+] = 0.01 = pH2
- Distilled H2O(I) [H+] = 0.0000001 = pH 7
- NaOH(aq) [H+] = 0.000000000001 = pH 14
- The more acidic the solution, the lower the pH value;
- Conversely: the pH value rises as the solution becomes more alkaline.

pH in Brewing

pH in Brewing

- prerequisite of brewing cycle!!
 - Enzyme activity, kettle break, yeast performance, hop extraction, clarification (flocculation)

Target pH

- pH 5.2 5.5 saccrification
- pH 5.0 = protein degradation
- pH 5.5 = amylase
- pH 6.0 = reduce enzymatic activities, *extracts tannins*

Malt pH

Distilled H2O = NO ions
100% base = pH 5.7 - 5.8
Caramel/crystal = pH 4.5 - 4.8
Chocolate = pH 4.3 - 4.5
Black/RB = pH 4.0 - 4.2

Water Treatment

↓ pH = MOST common ↓ HCO3??

- Boil
 - PP out organic salts in boil
 - $\bullet CO_2 + H_2O \Rightarrow H_2CO_3$
 - $\mathbf{H}_{\mathbf{2}}\mathbf{CO}_{\mathbf{3}} = \mathrm{HCO}_{\mathbf{3}}^{-} + \mathbf{H}^{+}$
- Roast malts
 - Acid is created over high kiln temperatures
 - Dublin
- Add acid
 - Phosphoric acid
 - $H_3PO_4 + CaCO_3 \rightarrow H_2CO_3 + CaHPO_4 pp$
 - Lactic acid
 - $2C_3H_6O_3 + CaCO_3 \rightarrow H_2CO_3 + Ca(C_3H_5O_3)_2 pp$

Summarizationizzal

IMPORTANTE!!!!
Types aqua
Chemstry
Ions
pH
Adjustments

Transmogrification

Brewing centers

Specific water

Salt Additions

Recreations!!







Brewing Capitals



How much do you know???

Beer central

1. Pilsen 2. Munich 3.London 4. Dublin 5. Edinburgh 6. Köln

1.	Softest brewing water –
	pale and clean beers
2.	High Carbonates – low
	hops, high color and malt
3.	High Carbonates –
	smooth dark ales
4.	VERY VERY high
	Carbonate levels – acidic
	dark malts needed for
	masn pH
5.	similar to London's, more
	bicarbonate and sulfate,
	lends neavier mait body
6.	Soft, low levels of
	calcium, magnesium,
	bicarbonates. Lends
	delicate impression.

Rock Formations

Non-reactive
 Granite, Sandstone
 ~90% Silica (SiO₂)

Reactive
 Lime Stone (CaCO₃)
 Dolomite (CaMg(CO₃)₂
 Gypsum (CaSO₄)

Specific locations



Blessed waters

Brewing city, check! ...specific water???

Water Salts: Stick the what in the where now??

	Pilsen	Munich	London	Vienna	Dublin	Dortmund	Burton
Calcium	<mark>7</mark>	75	52	<mark>200</mark>	118	<mark>225</mark>	<mark>268</mark>
Magnesium	<mark>2</mark>	18	16	60	4	40	62
Sodium	<mark>2</mark>	7	99	8	12	60	54
Chloride	<mark>5</mark>	10	60	12	19	60	36
Sulfate	<mark>5</mark>	10	77	125	54	<mark>120</mark>	<mark>638</mark>
Alkalinity	<mark>14</mark>	<mark>152</mark>	<mark>156</mark>	<mark>120</mark>	<mark>319</mark>	180	200

10gal Salts

T.

M



Only worry is solubility!

Don't have to be exactly accurate

Mother Nature
 Not same stuff we have

Stick the what in the where now??

Key ideas

- WEIGH, WEIGH, WEIGHT DON'T use volumes e.g. NO tsp
- Add to water then to mash, NOT directly
- CaCO3 Calcium carbonate (chalk)
 - Buffers mash acidity
 - Partly pp in kettle
- CaSO4 Gypsum
 - ↓ pH = pp CaPO4
- MgSO4 Epsom salts
 - ↑ Mg & SO4
- Ca(OH)2 Slaked lime
 - ↑ pH = pp CaCO3

Tasting!!!

Taste the water • Get a 'feel' for it Slosh it around Sip distilled water for rinse Taste the beer Think about the 'flavor', mouthfeel Repeat Compare the water with the beer

Order

- 1. Edinburgh
 - 1. Balhaven Scottish
- 2. Köln
 - 1. Reissdorf kölsch
- 3. Munich
 - 1. Hacker-Pschorr Ofest
- 4. London
 - 1. Fullers London Pride
- 5. Plzeň
 - 1. Pilsner Urquel
- 6. Dublin
 - 1. Guinness

Water Analysis

SOURCE	Са	Mg	Na	CO3	SO4	CI
Antwerp [DeKonick]	90	11	37	76	84	57
Beerse region [Westmalle]	41	8	16	91	62	26
Brugse [Brugs Tarwebier]	132	13	20	326	99	38
Brussels region	100	11	18	250	70	41
Burton-upon-Trent 1	268	62	-	280	638	36
Burton-upon-Trent 2	270	60	30	200	640	40
Burton-upon-Trent 3	295	45	55	300	725	25
Burton-upon-Trent 4	268	62	54	200	638	36
Dortmund 1	225	40	60	180	120	60
Dortmund 2	250	25	70	550	280	100
Dublin 1	119	4	12	156	53	19
Dublin 2	118	4	12	319	54	19
Düsseldorf	40	-	25	-	80	45
Edinburgh 1	140	60	80	140	96	34
Edinburgh 2	120	25	55	225	140	20
Edinburgh 3	100	18	20	160	105	45
Köln (Cologne)	104	15	52	152	86	109
London Well 1	52	32	86	104	32	34
London Well 2	50	20	100	160	80	60
Munich 1	75	18	2	150	10	2
Munich 2	109	21	2	171	79	36
Munich 3	75	18	-	152	10	2
Pilsen	7	2	2	15	5	5
San Francisco [Anchor]	24	15	28	104	39	39
Vienna 1	200	60	8	120	125	12
Willebroek/Rumst [Duvel]	68	8	33	143	70	60