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General Chemistry Review

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Subatomic Particles

(Protons - 1amu +
 n - neutrons - 1amu } nucleons
 Constat

protons = atomic number (Z)

protons + neutrons = mass number (A)

Protons - electrons = Charge

$$\begin{aligned} 4-4 &= 0 \\ 4-6 &= -2 \end{aligned}$$

$N \rightarrow Z$

2

atomiz #

Charge

2-E

N = neutrons

$$Z = \text{Protons}$$

E = electrons

$${}^9_4\text{Be}$$

Beryllium-9
Beryllium-10

$\begin{matrix} & & +2 \\ 12 & & \\ * & \subset & \\ & \text{Conv} & \end{matrix}$

Carbon - 12

hydrogen 1 H	beryllium 4 Be									boron 5 B	carbon 6 C	nitrogen 7 N	oxygen 8 O	fluorine 9 F	helium 2 He		
1.0079	9.0122									10.811	12.011	14.007	15.999	18.998	4.0026		
lithium 3 Li	magnesium 12 Mg									aluminium 13 Al	silicon 14 Si	phosphorus 15 P	sulfur 16 S	chlorine 17 Cl	argon 18 Ar		
6.941	24.305									26.982	28.086	30.974	32.065	35.453	39.948		
sodium 11 Na	calcium 20 Ca	scandium 21 Sc	titanium 22 Ti	vanadium 23 V	chromium 24 Cr	manganese 25 Mn	iron 26 Fe	cobalt 27 Co	nickel 28 Ni	copper 29 Cu	zinc 30 Zn	gallium 31 Ga	germanium 32 Ge	arsenic 33 As	selenium 34 Se	bromine 35 Br	krypton 36 Kr
22.990	40.078	44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.39	69.723	72.61	74.922	78.96	79.904	83.80
potassium 19 K	strontium 38 Sr	ytrium 39 Y	zirconium 40 Zr	niobium 41 Nb	molybdenum 42 Mo	technetium 43 Tc	ruthenium 44 Ru	rhodium 45 Rh	palladium 46 Pd	silver 47 Ag	cadmium 48 Cd	indium 49 In	tin 50 Sn	antimony 51 Sb	tellurium 52 Te	iodine 53 I	xenon 54 Xe
39.098	87.62	88.906	91.224	92.906	95.94	[98]	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.60	126.90	131.29
rubidium 37 Rb	barium 56 Ba	lanthanum 57-70 *	hafnium 72 Hf	tantalum 73 Ta	tungsten 74 W	rhenium 75 Re	osmium 76 Os	iridium 77 Ir	platinum 78 Pt	gold 79 Au	mercury 80 Hg	thallium 81 Tl	lead 82 Pb	bismuth 83 Bi	polonium 84 Po	astatine 85 At	radon 86 Rn
85.468	137.33		178.49	180.948	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.2	208.98	[209]	[210]	[222]
caesium 55 Cs	actinium 89-102 **		101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
132.905			178.49	180.948	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.2	208.98	[209]	[210]	[222]
francium 87 Fr			101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
223			101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
			101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
			101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
			101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
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			101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
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			101.07	102.906	106.42	107.87	108.91	110.48	111.90	112.41	114.82	118.71	121.76	126.90	127.60	126.90	131.29
			101.07	102.906	106.42	107.87	108.91	110.48	111.90								

Scientific Notation

$125 = 1.25 \times 100$
 $= 1.25 \times 10 \times 10$
 $125 = 1.25 \times 10^2$

$1700 = 1.7 \times 1000$
 $= 1.7 \times 10 \times 10 \times 10$
 $1700 = 1.7 \times 10^3$

Learn

prefix	symbol	10^n	(scale)
mega	M	10^6	(Million)
kilo	k	10^3	(Thousand)
deci	d	10^{-1}	(Tenth)
centi	c	10^{-2}	(Hundreth)
milli	m	10^{-3}	(Thousandth)
micro	μ	10^{-6}	(Millionth)
nano	n	10^{-9}	(Billionth)
pico	p	10^{-12}	(Trillionth)
femto	f	10^{-15}	(Quadrillionth)

93000000.
7 6 5 4 3 2 1
 9.3×10^7

67340000.
 6.734×10^7

00000003.7
 3.7×10^{-7}

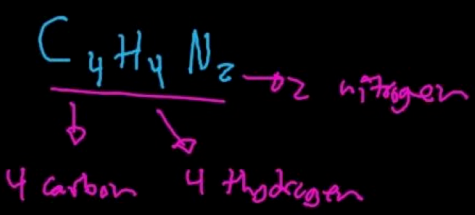
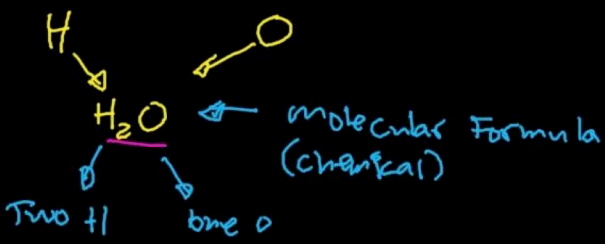
0000064
 6.4×10^{-5}

LIP
Left is Positive

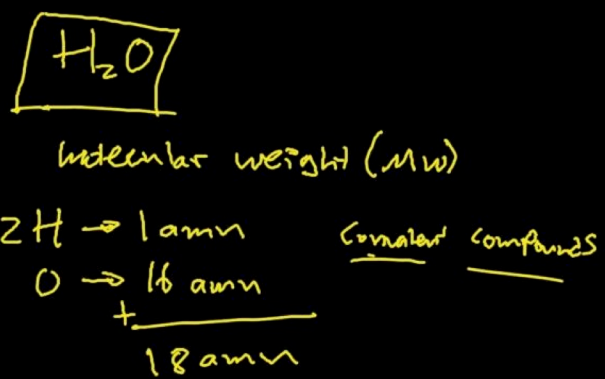
36.9×10^5
 3.69×10^6

$1 \text{ Km} = 1000 \text{ m}$
 $1 \times 10^3 \text{ m}$
 $903 \text{ cm} = 9.03 \times 10^{-2} \text{ m}$
 $= 9.03 \text{ m}$

Molecular Formulas and Molecular Weight



Atomic mass (weight) =
Amu (atomic mass unit)
Carbon = 12 → 12 amu



Formula weight
Ionic compounds
 $NaCl \rightarrow Na \quad Cl$

hydrogen 1 H 1.0079																	helium 2 He 4.0026	
lithium 3 Li 6.941	beryllium 4 Be 9.0122																	boron 5 B 10.811
sodium 11 Na 22.990	magnesium 12 Mg 24.305																	carbon 6 C 12.011
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80	
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29	
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 ★	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 ★ ★	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	unnilium 110 Uun [271]	ununium 111 Uuu [272]	unubium 112 Uub [277]	ununquadium 114 Uuq [289]					

Atomic mass in amu's

Formula weight

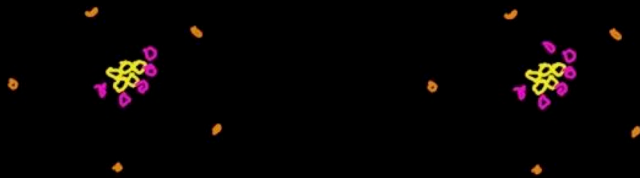
Ionic compounds

NaCl → Na Cl

18 amu

Atomic Weight

Atomic weight



Boron 10
10.013 amu
20%

Boron 11
11.009 amu
80%

$$(20\%)(10.013 \text{ amu}) + (80\%)(11.009 \text{ amu}) = 10.811 \text{ amu}$$

hydrogen 1 H 1.0079											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999		
lithium 3 Li 6.941	beryllium 4 Be 9.0122											aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	
sodium 11 Na 22.990	magnesium 12 Mg 24.305											gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39					
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 ★	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]

hydrogen 1 H 1.0079

lithium 3 Li 6.941

sodium 11 Na 22.990

potassium 19 K 39.098

rubidium 37 Rb 85.468

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strontium 38 Sr 87.62

barium 56 Ba 137.33

boron 5 B 10.811

aluminum 13 Al 26.982

gallium 31 Ga 69.723

indium 49 In 114.82

thallium 81 Tl 204.38

carbon 6 C 12.011

silicon 14 Si 28.086

germanium 32 Ge 72.61

tin 50 Sn 118.71

lead 82 Pb 207.2

nitrogen 7 N 14.007

phosphorus 15 P 30.974

arsenic 33 As 74.922

antimony 51 Sb 121.76

bismuth 83 Bi 208.98

oxygen 8 O 15.999

sulfur 16 S 32.065

selenium 34 Se 78.96

tellurium 52 Te 127.60

polonium 84 Po [209]

Doron 10 10.013 amu 20%

Doron 11 11.009 amu 80%

$(20\%)(10.013\text{ amu}) + (80\%)(11.009\text{ amu}) = 10.811\text{ amu}$

Ions: Cations and Anions

Group 9

Li^{+} Li^{+} Li^{+} Li^{+}

Li^{+} Li^{+}

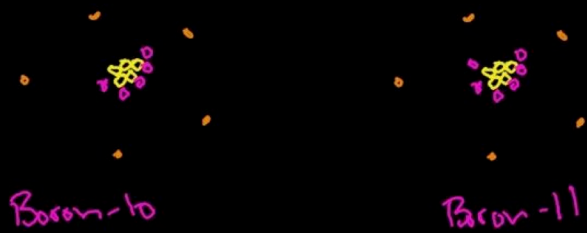
Cation Anion

negative charge

C^{+}

1 H																	5 B	6 C	7 N	8 O
3 Li	4 Be															11 Al	14 Si	15 P	16 S	
11 Na	12 Mg															21 Ga	22 Ge	23 As	24 Se	
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se					

Isotopes: The Atoms, Not the Baseball Team from Springfield



hydrogen 1 H 1.0079												helium 2 He 4.0026																									
lithium 3 Li 6.941		beryllium 4 Be 9.0122										boron 5 B 10.811		carbon 6 C 12.011		nitrogen 7 N 14.007		oxygen 8 O 15.999		fluorine 9 F 18.998		neon 10 Ne 20.180															
sodium 11 Na 22.990		magnesium 12 Mg 24.305										aluminium 13 Al 26.982		silicon 14 Si 28.086		phosphorus 15 P 30.974		sulfur 16 S 32.065		chlorine 17 Cl 35.453		argon 18 Ar 39.948															
potassium 19 K 39.098		calcium 20 Ca 40.078		scandium 21 Sc 44.956		titanium 22 Ti 47.867		vanadium 23 V 50.942		chromium 24 Cr 51.996		manganese 25 Mn 54.938		iron 26 Fe 55.845		cobalt 27 Co 58.933		nickel 28 Ni 58.693		copper 29 Cu 63.546		zinc 30 Zn 65.39		gallium 31 Ga 69.723		germanium 32 Ge 72.61		arsenic 33 As 74.922		selenium 34 Se 78.96		bromine 35 Br 79.904		krypton 36 Kr 83.80			
rubidium 37 Rb 85.468		strontium 38 Sr 87.62		yttrium 39 Y 88.906		zirconium 40 Zr 91.224		niobium 41 Nb 92.906		molybdenum 42 Mo 95.94		technetium 43 Tc [98]		ruthenium 44 Ru 101.07		rhodium 45 Rh 102.91		palladium 46 Pd 106.42		silver 47 Ag 107.87		cadmium 48 Cd 112.41		indium 49 In 114.82		tin 50 Sn 118.71		antimony 51 Sb 121.76		tellurium 52 Te 127.60		iodine 53 I 126.90		xenon 54 Xe 131.29			
caesium 55 Cs 132.91		barium 56 Ba 137.33		57-70 ✱		lutetium 71 Lu 174.97		hafnium 72 Hf 178.49		tantalum 73 Ta 180.95		tungsten 74 W 183.84		rhenium 75 Re 186.21		osmium 76 Os 190.23		iridium 77 Ir 192.22		platinum 78 Pt 195.08		gold 79 Au 196.97		mercury 80 Hg 200.59		thallium 81 Tl 204.38		lead 82 Pb 207.2		bismuth 83 Bi 208.98		polonium 84 Po [209]		astatine 85 At [210]		radon 86 Rn [222]	
francium 87 Fr [223]		radium 88 Ra [226]		89-102 ✱ ✱		lawrencium 103 Lr [262]		rutherfordium 104 Rf [261]		dubnium 105 Db [262]		seaborgium 106 Sg [266]		bohrium 107 Bh [264]		hassium 108 Hs [269]		meitnerium 109 Mt [268]		ununilium 110 Uun [271]		unununium 111 Uuu [272]		ununbium 112 Uub [277]		ununquadium 114 Uuq [289]											

The Mole: Avogadro's Number

The mole (n) Avogadro's number (N_A or N₀)

1 dozen = 12 units

1 mole = 602200000000000000000000 units

1 dozen donuts = 12 donuts

1 mole donuts = 602200000000000000000000 donuts

$602200000000000000000000 = 6.022 \times 10^{23}$

C = 12.01 amu

amu | Bridge | g

1 mole Carbons = 12.01 g C

log Al → n?

26.982 amu
↑ Al atom

$$\frac{26.982 \text{ g Al}}{1 \text{ mol Al}} \times \frac{1 \text{ mol Al}}{26.982 \text{ g}}$$

$$\log \text{Al} \times \frac{1 \text{ mol Al}}{26.982 \text{ g Al}} = .371 \text{ mol Al}$$

Calcium Carbonate (CaCO₃)

$$4.86 \text{ mol CaCO}_3 \times \frac{1 \text{ mol CaCO}_3}{100.09 \text{ g CaCO}_3} = 486 \text{ g CaCO}_3$$

4.86 mol CaCO₃ → ? g

$$\begin{aligned} \text{Ca} &\rightarrow 40.08 \text{ g} \\ \text{C} &\rightarrow 12.01 \text{ g} \\ \text{O}_3 &\rightarrow 16.00 \text{ g} \times 3 = 48 \text{ g} \\ \hline &= 100.09 \text{ g CaCO}_3 \\ &1 \text{ mol CaCO}_3 \end{aligned}$$

26.982 amu

hydrogen 1 H 1.0079																	helium 2 He 4.0026		
lithium 3 Li 6.941	beryllium 4 Be 9.0122																	neon 10 Ne 20.180	
sodium 11 Na 22.990	magnesium 12 Mg 24.305																	argon 18 Ar 39.948	
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80		
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29		
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *		lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *		lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnium 110 Uun [271]	ununium 111 Uuu [272]	unubium 112 Uub [277]						
													ununquadium 114 Uuq [289]						

The International System of Units (SI System)

International system of units (SI)

Base units

meter (m) → length

Kilogram (kg) → mass

second (s) → time

mole (mol) → amount of substance

Kelvin (K) → temperature

cubic meter (m³) → volume

Chemistry → 1 mL = 1 cm³ = 1 cc
volume

(liquid or gas) 1 L = 1000 cm³ 1000 L = 1 m³

Speed → $\frac{\text{distance}}{\text{time}} \rightarrow \frac{\text{m}}{\text{s}}$

mm
cm

femto → f → 10⁻¹⁵

pico → p → 10⁻¹²

Nano → n → 10⁻⁹

micro → μ → 10⁻⁶

milli → m → 10⁻³

centi → c → 10⁻²

Kilo → k → 10³

Mega → M → 10⁶

1000
10 × 10 × 10
10 × 10²
1000 g = 1 kg

Angstrom → Å → 10⁻¹⁰ m

↳ atomic radii
bond lengths

1-3 Å



Density Mini Video

Density: $\rho = \frac{\text{mass}}{\text{volume}} = \frac{\text{kg}}{\text{m}^3}$

Chem

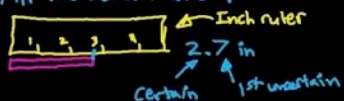
$$\frac{\text{g}}{\text{cm}^3} \xrightarrow{\times 1000} \frac{\text{kg}}{\text{m}^3}$$
$$\frac{\text{kg}}{\text{m}^3} \xrightarrow{\div 1000} \frac{\text{g}}{\text{cm}^3}$$

most
liquids $\rightarrow 1000 \text{ g/cm}^3$
solids

Significant Figures

Significant Figures

- All the certain #s + the 1st uncertain # in a measurement.



Rules for Counting Significant Figures

1. Nonzero integers are always significant.

1 → 9 Significant

2. Zeros

- Leading zeros are zeros that come before all nonzeros.

0.00037 not significant
↑↑↑↑

- Captive zeros are zeros between two nonzeros.

120.00037 Significant
↑↑↑↑

- Trailing zeros are at the end of the #.

500 not significant (no decimal place)
↑↑
500.00 significant (decimal place)
↑↑↑↑

3. Exact numbers

#s that are counted or are defined, have ∞ sig. figs.

2 apples = 2 apples } ∞ significant figures
1 in = 2.54 cm

4. Scientific notation - shorthand for very large or small #s.

Standard notation - #s to the left of 'x10' are significant.
 $136,000,000 = 1.36 \times 10^8$
3 sig. figs.

Rules for Rounding Off

1. 1.33 → 1.3

numbers < 5 are rounded down
numbers ≥ 5 are rounded up

1.37 → 1.4

2. Round at the end of your calculations using only the digit to the right of the last sig. fig.

1.3748

Using Significant Figures in Calculations

Multiplication or division - the final answer is rounded to contain the same number of sig. figs. as the number in the problem with the smallest number of sig. figs.

$1.5 \times 4.56 = 6.84$ Rounded → 6.8
2 sig. 3 sig. < 5
 $7.06 / 301 = 2.34551...$ Rounded → 2.35
4 sig. 3 sig. 2 sig.

Addition and subtraction - the limiting term is the # with the least amount of decimal places

$12.34 + 18.0 + 1.003 = 31.343$ Rounded → 31.3
limiting term, 1 decimal < 5
 $10.6875 - 0.11 = 10.5775$ Rounded → 10.58
2 decimals 2 sig.

Examples

Solve using the correct # of sig. figs.:

A) $(10.14 + 17.372 - 18.2) / 1.41 =$
9.312 / 1.41 = 6.604255 → 6.6
2 sig. / 3 sig.

B) $(4.00 \times 10^5 - 2.34 \times 10^6) (3 + 7.5) =$ 1.29556 × 10⁴ → 1.3 × 10⁴
4 2

C) $1.789 \times (2.54 \text{ cm})^2 =$ 4.54406 cm → 4.544 cm
4 ∞

Dimensional Analysis and Unit Conversion

Dimensional Analysis and Unit Conversion

Example 1:

Convert 2.0 inches to cm. (1 in = 2.54 cm)

$$\frac{2.0 \cancel{\text{in}}}{1} \times \frac{2.54 \text{ cm}}{1 \cancel{\text{in}}} = \frac{5.08 \text{ cm}}{1} \quad \left(\frac{1 \text{ in}}{2.54 \text{ cm}} \right) \quad \left(\frac{2.54 \text{ cm}}{1 \text{ in}} \right)$$

5.08 cm

Example 2:

Convert 3 miles to yards. (1 mi = 5280 ft, 1 yd = 3 ft)

3 miles $\xrightarrow{\text{ft}}$ yards

$$3 \cancel{\text{mi}} \times \frac{5280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}} \times \frac{1 \text{ yd}}{3 \cancel{\text{ft}}} = 5280 \text{ yards}$$

Example 3:

How many milliliters are in one gallon? (1 L = 1000 mL, 1 gallon = 3.79 L)

Gallons $\xrightarrow{\text{L}}$ ~~gallons~~ mL

$$1 \cancel{\text{gallon}} \times \frac{3.79 \cancel{\text{L}}}{1 \cancel{\text{L}}} \times \frac{1000 \text{ mL}}{1 \cancel{\text{L}}} = \frac{3790 \text{ mL}}{1}$$

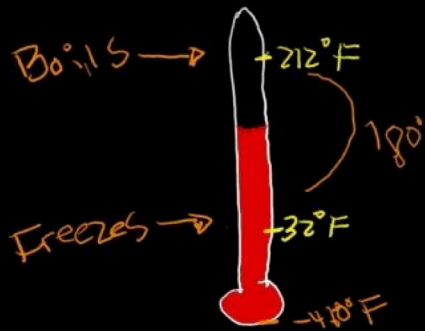
Example 4: How many moles are in a sample of Na containing 3.3×10^{20} atoms? (1 mol = 6.022×10^{23})

Atoms $\xrightarrow{\quad}$ moles

$$\frac{3.3 \times 10^{20} \cancel{\text{atoms}}}{6.022 \times 10^{23} \cancel{\text{atoms}}} \times \frac{1 \text{ mol}}{1} = \frac{3.3 \times 10^{20} \text{ mol}}{6.022 \times 10^{23}} = 5.48 \times 10^{-4} \text{ mol}$$

0.000548 mol

Temperature Conversion



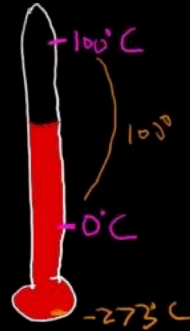
Fahrenheit

$$^{\circ}\text{F} = 1.80(^{\circ}\text{C}) + 32$$

$$^{\circ}\text{C} = \frac{^{\circ}\text{F} - 32}{1.80}$$

$$50^{\circ}\text{F} \rightarrow ^{\circ}\text{C}$$

$$^{\circ}\text{C} = \frac{50 - 32}{1.80} = \boxed{10^{\circ}\text{C}}$$



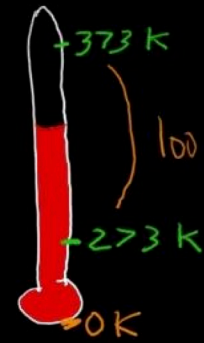
Celsius

$$\text{K} = ^{\circ}\text{C} + 273.15$$

$$^{\circ}\text{C} = \text{K} - 273$$

$$50^{\circ}\text{C} \rightarrow \text{K}$$

$$\begin{aligned} \text{K} &= 50 + 273 \\ &= \boxed{323\text{K}} \end{aligned}$$



Kelvin

Ideal Gas Law: $PV=nRT$

The Ideal Gas Law

$PV=nRT$

"Ideal" - Gas molecules bouncing off each other are not a factor.

P = Pressure (atm)

1 atm = 760.0 mmHg = 760 torr = 101,325 Pa = 14.69 psi

V = Volume (L)

1 L = 1000 cm³ = 0.001 m³

n = moles (mol)

1 mol = 6.022 x 10²³

Avogadro's Number

R = 0.08206 $\frac{L \cdot atm}{K \cdot mol}$

Universal Gas Constant

T = Temperature (K)

	Kelvin	Celsius	Fahrenheit
Boil	373 K	100°C	212°F

Freeze	273 K	0°C	32°F
	373 K - 273 K = 100	100°C - 0°C	212°F - 32°F = 180

Same Scale

°F = 1.80(°C) + 32
K = °C + 273

Standard Temperature and Pressure (STP)

1 atm

0°C or 273 K

Example - Changing Conditions

What is the volume of 1 mol of an ideal gas at STP?

$PV=nRT$

$V = \frac{nRT}{P}$

$V = \frac{(1 \text{ mol})(0.08206 \frac{L \cdot atm}{K \cdot mol})(273 \text{ K})}{1 \text{ atm}}$

$V = 0.08206 \text{ L} \cdot 273 = 22.4 \text{ L}$

Example - Changing Conditions

A cylinder with a volume of 1 L contains 2 mol of an ideal gas at 20°C and 2 atm. The gas is then heated to 30°C. Given that no change in volume has occurred what is the final pressure of the gas inside the cylinder?

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Change
 $PV=nRT$
 $\frac{P_1}{T_1} = \frac{nR}{V} = \frac{P_2}{T_2}$

20°C = 20 + 273 = 293 K
30°C = 30 + 273 = 303 K

$\frac{P_1}{T_1} = \frac{nR}{V} = \frac{P_2}{T_2}$

$P_2 = \frac{P_1}{T_1} \cdot T_2 = \frac{2 \text{ atm}}{293 \text{ K}} \cdot 303 \text{ K} = 2.07 \text{ atm}$

Not on video, good to know

$PV=Nk_B T$

P = pressure (Pa)

N = # of atoms

V = Volume (m³)

$k_B = 1.38 \times 10^{-23} \frac{J}{K}$

T = temperature in Kelvin

Ideal Gas Law: $PV=nRT$, Easier Method

The Ideal Gas Law

$$PV=nRT$$

P = Pressure (atm)

V = Volume (L)

n = moles (mol)

$R = 0.08206 \frac{\text{L atm}}{\text{K mol}}$

T = Temperature (K)

"Ideal" - molecule interaction

volume taken up by gas molecules

Any gas you work with

} not factors!

← Universal Gas Constant

Standard temperature and pressure (STP)

(atm 273 K)

Example - Changing Conditions

A cylinder with a volume of 1 L contains 2 mol of an ideal gas at 20°C and 2 atm. The gas is then heated to 30°C. Given that no change in volume has occurred what is the final pressure of the gas inside the cylinder?

change

$$PV=nRT$$

$$20^\circ\text{C} = 20 + 273 = 293\text{K}$$

$$30^\circ\text{C} = 30 + 273 = 303\text{K}$$

$$\frac{P_i}{T_i} = \frac{nR}{V} = \frac{P_f}{T_f}$$

$$\left(\frac{P_f}{T_f}\right) = \frac{P_i}{T_i} \cdot T_f = \frac{2\text{ atm}}{293\text{K}} \cdot 303\text{K}$$

$$= \underline{\underline{2.07\text{ atm}}}$$

$$\frac{P_i V_i = n R T_i}{P_f V_f = n R T_f}$$

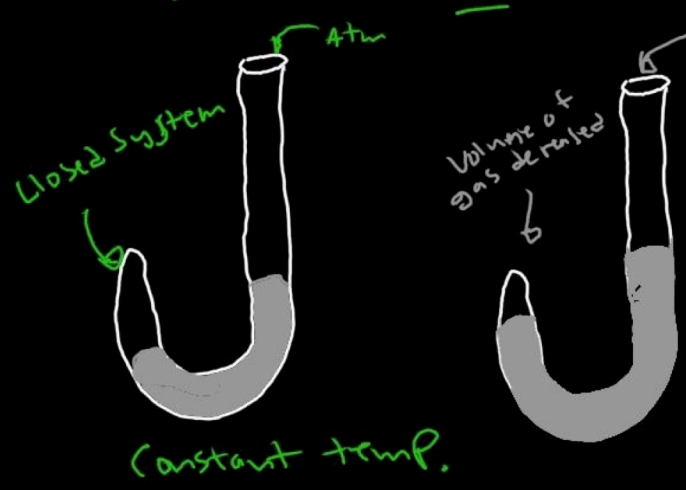
$$\frac{P_i}{P_f} = \frac{T_i}{T_f} \Leftrightarrow P_i T_f = T_i P_f$$
$$\frac{P_i}{T_i} = \frac{P_f}{T_f}$$

$$P_f = \frac{T_f P_i}{T_i} = \frac{303\text{K} \cdot 2\text{ atm}}{293\text{K}} = \frac{606\text{ atm}}{293} = \underline{\underline{2.07\text{ atm}}}$$

Boyles Law: $PV = PV$

Boyle's Law: pressure and volume

Robert Boyle → 1691



Trial	Pressure	Volume
1	29.1	48.0
2	58.2	24.0
3	117.5	12.0

$\uparrow \downarrow$
 $P \downarrow$
 $V \uparrow$

1.40×10^3

$$PV = 1.40 \times 10^3$$

$$PV = nRT$$

$$PV = k$$

$$P_i V_i = k = P_f V_f$$

$P_i V_i = P_f V_f$ Boyle's Law

In an automobile engine the gaseous fuel-air mixture enters the cylinder and is compressed by a moving piston before it is ignited by a spark. In a certain engine the initial cylinder volume is 0.725 L. After the piston moves up, the volume is 0.075 L. The initial pressure of the cylinder is 1.00 atm. Find the pressure of the compressed fuel-air mixture, assuming that both the temperature and the amount of gas remain constant.



$$P_i V_i = P_f V_f$$

$$\frac{P_i V_i = nRT}{P_f V_f = nRT}$$

$$\frac{P_i V_i}{P_f V_f} = 1$$

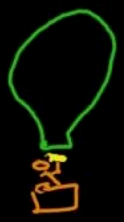
$$P_f = \frac{P_i V_i}{V_f} = \frac{0.725 \text{ L}}{0.075 \text{ L}} = 9.7 \text{ atm}$$

$P_i V_i = P_f V_f$

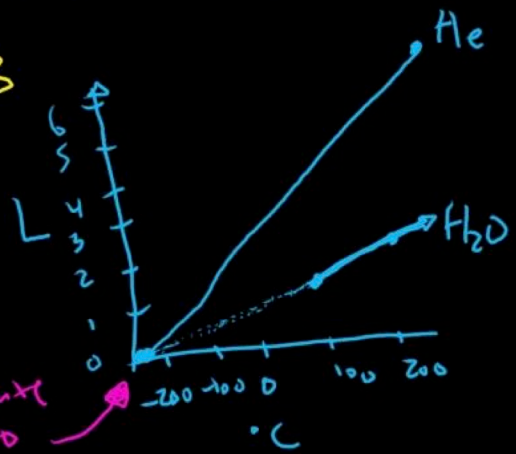
Charles's Law: $V/T = V/T$

Charles's Law: Volume and Temperature

Jacque Charles 1746 - 1823



Temp ↑ Volume ↑
300 K 1 L
600 K 2 L



$$\frac{V}{T} = b$$
$$\frac{V_i}{T_i} = \frac{V_f}{T_f}$$

$$\frac{1}{1} = \frac{2}{2}$$

$$PV = nRT$$

$$\frac{V_i}{T_i} = \frac{nR}{P} = \frac{V_f}{T_f}$$

A 2.0 L sample of air is collected at 298 K and then cooled to 278 K. The pressure is constant at 1.0 atm. Does the volume of the air increase or decrease? Calculate the volume of the air at 278 K.

T ↓ V ↓

$$\frac{V_i}{T_i} = \frac{V_f}{T_f}$$

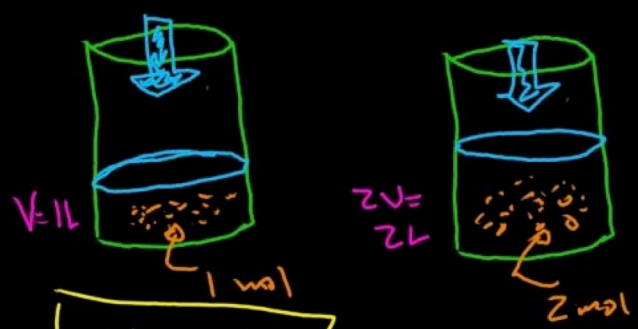
$$\frac{2.0 \text{ L}}{298 \text{ K}} = \frac{V_f}{278 \text{ K}}$$

$$V_f = \frac{2.0 \text{ L}}{298 \text{ K}} \cdot 278 \text{ K} = 1.9 \text{ L}$$

Avogadro's Law: $V/n = V/n$

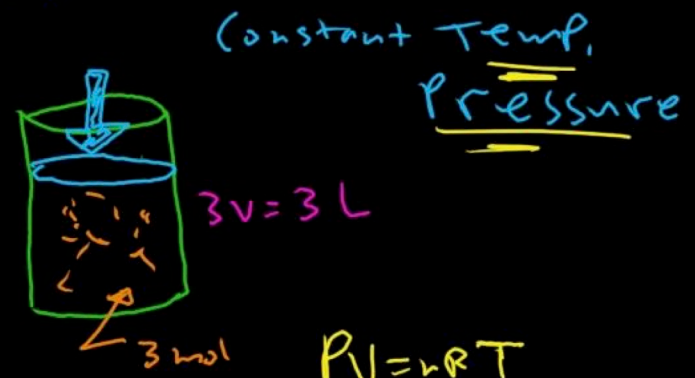
Avogadro's Law: Volume and moles

Amedeo Avogadro → 1811



$$\frac{V_i}{n_i} = \frac{V_f}{n_f}$$

$V = \text{volume}$
 $n = \text{moles}$



Constant Temp,
Pressure

$$PV = nRT$$
$$\frac{V}{n} = \frac{RT}{P}$$

Dalton's Law of Partial Pressures: $P = P_1 + P_2 + P_3$

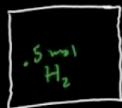
Dalton's Law of Partial Pressure

John Dalton 1803

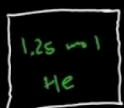
$P_{total} = P_1 + P_2 + P_3$

"For a mixture of gases in a container, the total pressure exerted is the sum of the partial pressures of the gases present. The partial pressure of a gas is the pressure that the gas would exert if it were alone in the container."

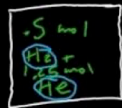
John Dalton At constant temp and Volume.



5.0 L tank
 $P_{H_2} = 2.4 \text{ atm}$
 $P = \text{pressure}$



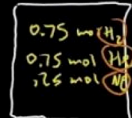
5.0 L tank
 $P_{He} = 6.0 \text{ atm}$



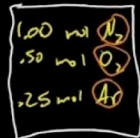
5.0 L tank
 $P_{total} = P_{H_2} + P_{He} = 2.4 + 6 = 8.4 \text{ atm}$



5.0 L tank
 8.4 atm



5.0 L tank
 8.4 atm



5.0 L tank
 8.4 atm

Total # of moles is what is important!
not the identity of the gas!

- 1) Volume the gases take up is not important
- 2) The forces between gases is not important.



$P = \frac{nRT}{V}$
 $P_2 = \frac{0.49 \text{ mol} \cdot 0.08206 \frac{\text{L atm}}{\text{mol K}} \cdot 298 \text{ K}}{5.0 \text{ L}} = 2.4 \text{ atm}$

Scuba divers use mixtures of helium and oxygen for deep dives. For one particular dive, 12 L of O_2 at 25°C and 1.0 atm and 46 L of He at 25°C and 1.0 atm were pumped into a 5.0 L Tank. Calculate the partial pressure of each gas and the total pressure in the tank at 25°C.

$PV = nRT$
 $n = \frac{PV}{RT}$

$25^\circ\text{C} + 273 = 298 \text{ K}$
 $n_{O_2} = \frac{1.0 \text{ atm} \cdot 12 \text{ L}}{0.08206 \frac{\text{L atm}}{\text{mol K}} \cdot 298 \text{ K}} = 0.49 \text{ mol } O_2$
 $n_{He} = \frac{1.0 \text{ atm} \cdot 46 \text{ L}}{0.08206 \frac{\text{L atm}}{\text{mol K}} \cdot 298 \text{ K}} = 1.9 \text{ mol He}$

Answers not in video:

He Partial Pressure:

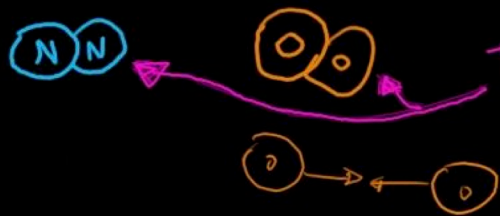
$P_{He} = \frac{1.9 \text{ mol} \cdot 0.08206 \frac{\text{L atm}}{\text{mol K}} \cdot 298 \text{ K}}{5.0 \text{ L}} = 9.3 \text{ atm}$

Total Tank Pressure:

$P_{total} = P_{O_2} + P_{He} = 2.4 \text{ atm} + 9.3 \text{ atm} = 11.7 \text{ atm}$

Diatomic Molecules

Diatomic Molecules



Two atoms per molecule

25C
or
50

- Bromine (liquid)
- Iodine (solid)
- Nitrogen (gas)
- Chlorine
- Hydrogen
- Oxygen
- Fluorine

Br I N Cl H O F

Molarity vs. Molality

Fundamentals of Solutions

1. Solution - a mixture in which the components are uniformly mixed (salt water)
2. Solvent - the component present in the largest amount (water)
3. Solute - the other component or components present (salt)

$$\text{Molarity (M)} \\ M = \frac{\text{amount (mol) of solute}}{\text{volume (L) of solution}} \\ M = \frac{\text{mol}}{\text{L}}$$

$$\text{vs. Molality (m)} \\ m = \frac{\text{amount (mol) of solute}}{\text{mass (kg) of solvent}} \\ m = \frac{\text{mol}}{\text{kg}}$$

***NOT ON VIDEO, GOOD TO KNOW: Molality is the more precise of the two because molality depends on mass rather than volume. Volume will change with regard to temperature, which can have an impact on measure of molarity when dealing with very precise measures. We also do not always know how two mixed solutions will interact. 0.5 mL + 0.5 mL is not always equal to 1 mL when mixing chemicals. That is why Molality is more precise.

What is the molarity of a solution prepared by dissolving 5 moles of NaCl in 2 liters of water?

- a) 0.4 M
- b) 0.4 m
- ☒ c) 2.5 M
- d) 2.5 m

$$M = \frac{5 \text{ mol}}{2 \text{ L}} = 2.5 \text{ M}$$

A .5 molal solution of could be prepared by dissolving .5 mol of NaOH in

- a) 0.3 liter of water
- b) 1 liter of water
- c) 0.3 kg of water
- ☒ d) 1 kg of water

$$.5 \text{ m} = \frac{\text{mol}}{\text{kg}} = \frac{.5 \text{ NaOH}}{\text{kg}} \\ \text{kg} = \frac{.5 \text{ NaOH}}{.5 \text{ m}} = 1 \text{ kg}$$

The Bohr Model of the Atom

The Bohr Model of the Atom

1913 Niels Bohr



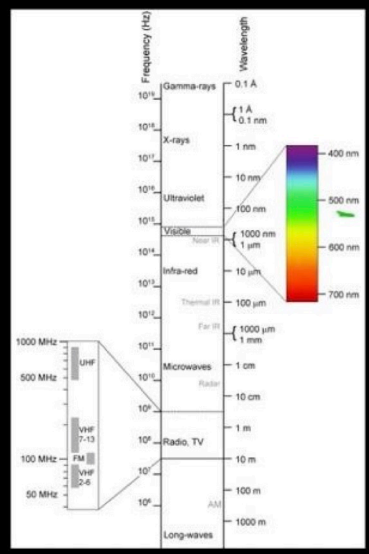
$$\Delta E = h \frac{c}{\lambda}$$

Energy = Joules

h = Planck's constant = 6.63×10^{-34} J·s

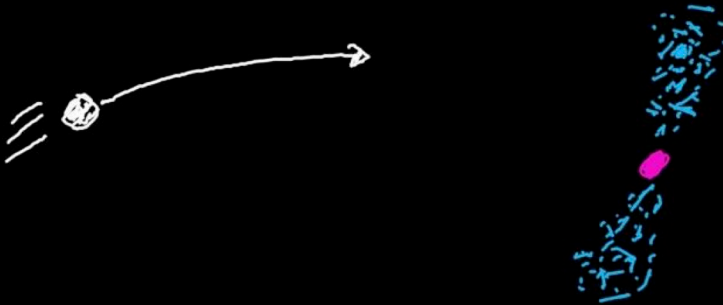
c = speed of light = 3.00×10^8 m/s

λ = wavelength (m)

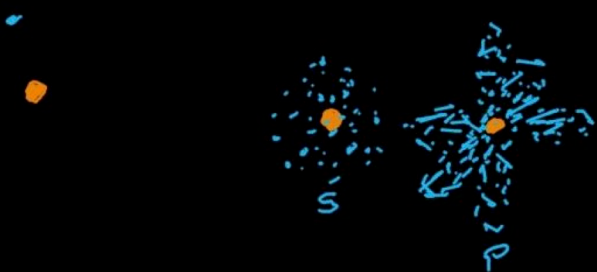


The Heisenberg Uncertainty Principle

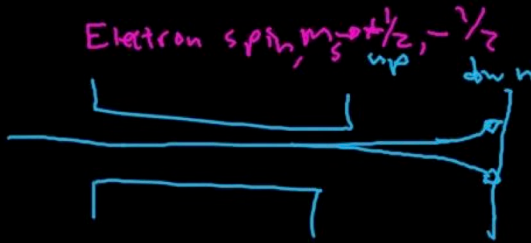
Heisenberg uncertainty principle: It is impossible to know an electron's position and momentum (mass $\times$ speed) at the same time.

[illegible]

Electron Quantum Numbers and Modern Atomic Theory



Shell number, $n \rightarrow$ energy, size
subshell number, $l \rightarrow$ shape
 $l=0 \rightarrow s$ $l=2 \rightarrow d$
 $l=1 \rightarrow p$ $l=3 \rightarrow f$
orbital number, $m_l \rightarrow$ orientation
 $m_l = -l$
 $l=2 \quad m_l = -2, -1, 0, 1, 2$



	s ($l=0$)			p ($l=1$)					d ($l=2$)					f ($l=3$)						
	$m=0$	$m=0$	$m=\pm 1$	$m=0$	$m=\pm 1$	$m=\pm 2$	$m=0$	$m=\pm 1$	$m=\pm 2$	$m=0$	$m=\pm 1$	$m=\pm 2$	$m=\pm 3$	$m=0$	$m=\pm 1$	$m=\pm 2$	$m=\pm 3$	$m=0$	$m=\pm 1$	$m=\pm 2$
	s	p_z	p_x	p_y	d_{z^2}	d_{xz}	d_{yz}	d_{xy}	$d_{x^2-y^2}$	f_{z^3}	f_{xz^2}	f_{yz^2}	f_{xyz}	$f_{z(x^2-y^2)}$	$f_{x(x^2-3y^2)}$	$f_{y(3x^2-y^2)}$				
n=1																				
n=2																				
n=3																				
n=4																				
n=5										...	...	...	...	...	...	...				
n=6					...	...	...	...	...	...	...	...	...	...	...	...				
n=7		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...				