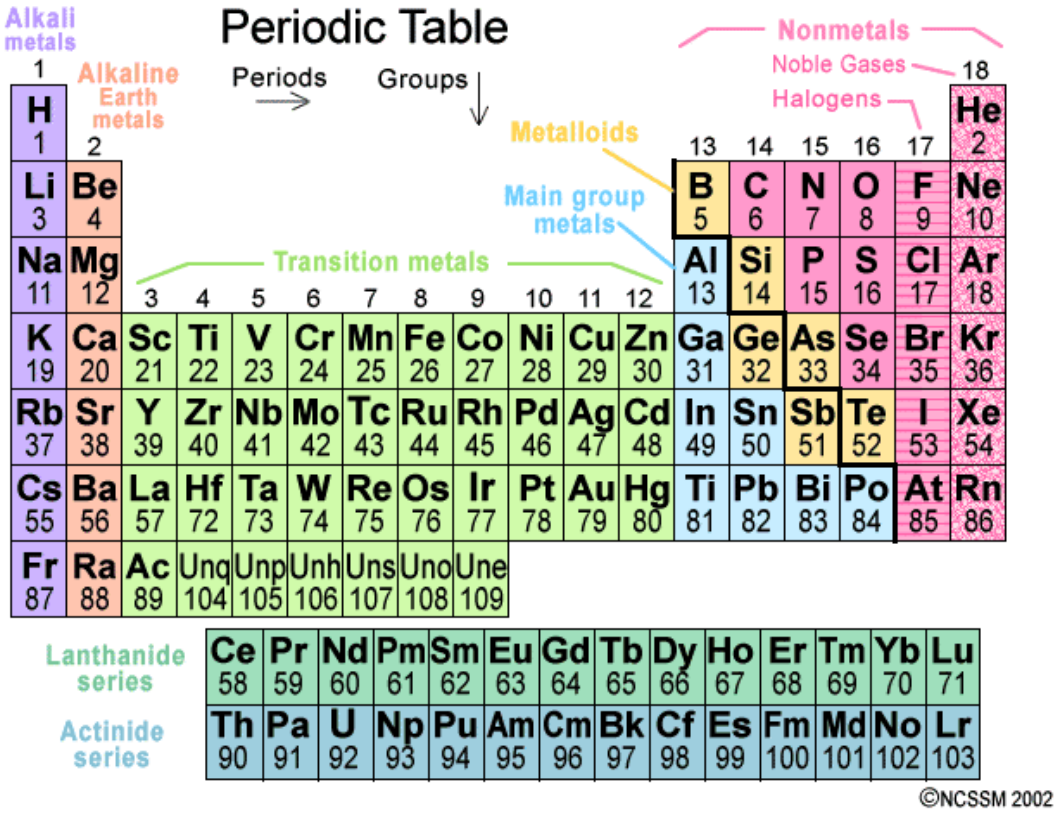
Chemical Foundations – Part 2

Reading:	Ch 4 sections 8 – 11 Ch 5 sections1 – 7	Homework:	4.8 question 44*, 46, 52 4.10 questions 66, 68, 70, 74, 76, 78 4.11 questions 80, 84*
Downloads:	Periodic table Ion Chart		5.2 questions 10*, 12, 14 5.5 questions 24, 32, 34, 36* 5.6 question 40 5.7 questions 42* 50*

* = 'important' homework question

A More Detailed Look at the Periodic Table

Fact 1: The Periodic table is arranged left – right in order of increasing atomic number (Z) (i.e. each type of atom in the p. table has one more proton in its nucleus than its predecessor).



Example: Nitrogen is element number 7, while Oxygen, the next element, is atomic number 8.


Dmitri Mendeleev

Question of historical interest: Why is the periodic table not one continuous 'line' of elements, starting with Element #1 (H) and finishing with Element ~109?

In other words, why did early chemists, such as Mendeleev, start row (period) 2 with Lithium?

Fact 2

Question: Why is the periodic table so named? Hint: Look at the above P. Table's labels and color scheme

Fact 3

Question: If the classification of the elements is periodic, would you expect their physical and chemical trends to be so also?

Examples of Physical and Chemical trends within the Periodic table

Left side (metals)	Right side (non-metals)

Making Ions

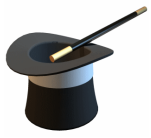
Questions: What are ions? How are they made?

Ion:

*Atomic Ions:

*ask me to tell you a *very* poor ion joke…

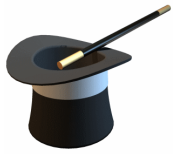
Atomic (*micro*) scale diagram of Ionization and *macro* scale crystal growth (slide)



In reality, electron(s) are EXCHANGED between atoms in order to become ionic compounds. I.E. what is lost by the metal (to become an M^{n+} cation) is gained by the non-metal (to become A^{n-} anion)

Making and Naming Ionic Formulas

List of Common atomic ions (must learn): See handout provided



Group I **Group VII**

Group II **Group VI**

Group III **Group V**

Naming atomic ions: An atomic (+ve) cation has the same name as the metal it was formed from. An atomic (-ve) anion has the *same root* as the non-metal it was formed from, **but** and *–ide ending.* Examples:

Metal atom	Metal cation	Non-metal atom	Non-metal anion
Na		Cl	
Mg		O	

Ionic formulas are made by combining ANY cation (+ve) with any anion (-ve).

The order in ANY ionic formula is cation first, anion second, in *both* formula and name. i.e. (cation)(anion)

Examples: NaCl (sodium chloride)

LiF ( )

Ionic formulas ALWAYS have a ZERO net charge – i.e. the (+) and (-) ionic charges in ANY formula cancel.

If the above rule is followed, the ionic compound must exist and is probably sitting on a shelf in the chemistry stock room!

Task: Construct and name as many ionic compounds as possible from the following ions:

Li^{+} Ca^{2+} Al^{3+} Cl^{-} O^{2-} N^{3-}

List of Common molecular ions (must learn): See attached handout.

Trick – many *molecular ions* appear on the data sheet (see handout). Just keep using (homework) and/or looking (fridge) at the rest

Naming molecular ions:

There is ONLY one molecular cation – $(NH_4)^{+}$, ammonium.

Molecular anions with NO (or very few*) oxygen atoms in their structure have the *–ide* ending. Examples: ^{-}OH (hydrox*ide*)*, CN^{-} (cyan*ide*)

Molecular anions with 'lots' of oxygen atoms in their structure have the *–ate* ending. Examples: $(SO_4)^{2-}$ (sulf*ate*), $(NO_3)^{-}$ (nitr*ate*), $(CO_3)^{2-}$ (carbon*ate*), $(PO_4)^{3-}$ (phosph*ate*)

<u>Recall</u>: Ionic formulas ALWAYS have a ZERO net charge – i.e. the ionic charges in ANY formula cancel.

This is true for molecular ions too – just treat the whole molecular ion as if it were an atomic ion when making the formula. Name the resulting compound in a similar way also.

<u>Task</u>: Construct and name as many ionic compounds as possible from the following ions:

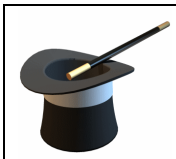
Li^{+} Mg^{2+} $(NH_4)^{+}$ $(NO_3)^{-}$ $(SO_4)^{2-}$ $(PO_4)^{3-}$

<u>Naming Ionic compounds containing a cation of variable charge</u>

Metallic elements from the center of the periodic table (the *transition series*, between groups II and III) can form atomic ions with a range of +ve charges. <u>Examples</u>: Fe^{2+} and Fe^{3+}, Cu^{+} and Cu^{2+}.

<u>Question</u>: Can you see a potential problem with regard to writing the names and formulas of ionic compounds containing such cations?

<u>Answer</u>:




Ionic formulas featuring a variable charge (oxidation state) cation include the charge of the cation (written in Roman numerals) in the formula name. E.g.: Cu_2O = Copper(I) oxide

Task: Complete the following table:

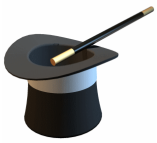
Name	Formula	Name	Formula
Iron (II) Sulfate		Copper (I) Phosphate	
	$Cu(NO_3)_2$		$FeCl_3$

Acids and Bases

Discussion: Are acids and bases typically ionic or molecular compounds (recall your recent lab)? What is 'special' about their formulas?

Naming acids and bases: There are two ways of naming acids, and one way for bases:

1. Just use the standard approach for naming ionic compounds:



Remember:

H^+ = 'hydrogen' ion, ^-OH = 'hydroxide' ion.

Task: Name the following acids and bases using standard ionic compound nomenclature:

HCl NaOH

H_2SO_4 $Ca(OH)_2$

HNO_3 $Al(OH)_3$

2. Using common nomenclature (chemical 'nicknames', must learn)

Rules: Acids with *–ide* anions (e.g. Chloride, Cl^-) have a '*hydro*' prefix and an '*–ic'* ending, followed by 'acid'.

Example: HCl = *Hydro*chlor*ic* acid

Task: name the following acids:

HBr HI

HCN H_2S

Acids with molecular *'–ate'* anions, such as nitrate, $(NO_3)^-$, and sulfate, $(SO_4)^{2-}$, simply become *'–ic* acids':

Example: $H(NO_3)$ = nitr*ic* acid

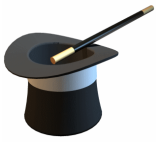
Task: name the following acids:

H_2SO_4 H_3PO_4

H_2CO_3

Question of the week - Group work

Understanding ionic formulas is 'all about' practicing writing and naming ionic formulas.



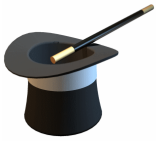
Recall:

Ionic formulas ALWAYS have a ZERO net charge – i.e. the ionic charges in ANY formula cancel.

Ionic compounds are named (cation name) (anion name)

The group work outlined below will cement your knowledge of ionic compounds…

Task: Complete tables 5.A (write formulas) and 5.B (write formulas) – both on (p 140). Work in groups for two or three, write you answers in the blank tables provided:



Tip: *This may take a while, but it is worth it*. If you can do this task the exam questions will seem easy…….

Table 5A: Make ionic formulas from ion formula pairs

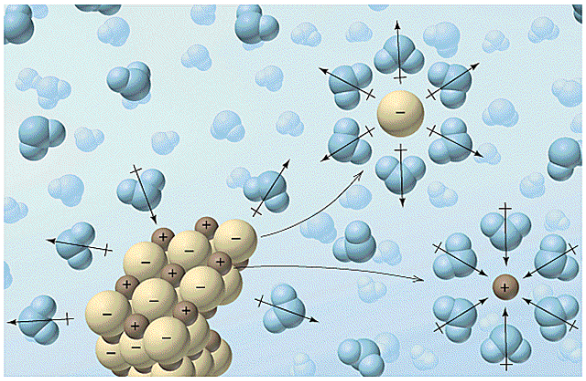
Ions	Fe^{2+}	Al^{3+}	Na^{+}	Ca^{2+}	NH_4^{+}	Fe^{3+}	Ni^{2+}	Hg_2^{2+}	Hg^{2+}
CO_3^{2-}	$FeCO_3$								
BrO_3^{-}									
$C_2H_3O_2^{-}$									
OH^{-}									
HCO_3^{-}									
PO_4^{3-}									
SO_3^{2-}									
ClO_4^{-}									
SO_4^{2-}									
O^{2-}									
Cl^{-}									

Table 5B: Make ionic formulas from ion name pairs

Ions	nitrate	sulfate	hydrogen sulfate	dihydrogen phosphate	oxide	chloride
calcium	$Ca(NO_3)_2$					
strontium						
ammonium						
aluminum						
iron(III)						
nickel(II)						
silver(I)						
gold(III)						
potassium						
mercury(II)						
barium						

Electrolytes

Recall your lab: What is an electrolyte? Why do sports drinks contain electrolytes?



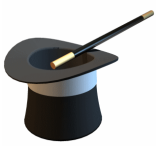
Task: Using the slides and figure to help you, write a description of how solutions containing *strong electrolytes* are formed:

Most ionic compounds dissolve in water ⇒ they MUST dissociate ('break apart) to form an *electrolytic solution*. The dissolved ions are called *electrolytes*. See slide and figure.

Example: 'pasta water'

$$NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$$

(aq) is a state symbol which means 'dissolved' or 'with water'



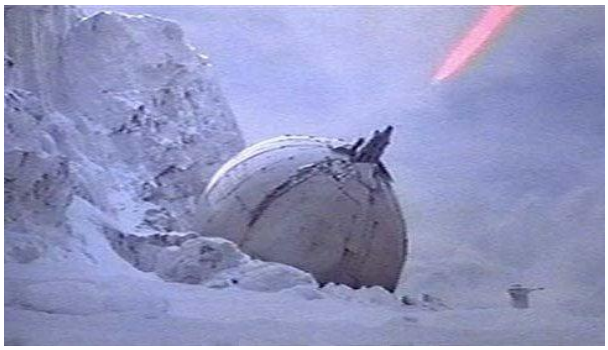
***Mobile* (aq) ions conduct electricity** ⇒ *all* electrolytic solutions conduct electricity.

The 'stronger' the electrolytic solution is, the more ions there are in solution and more electricity can be conducted

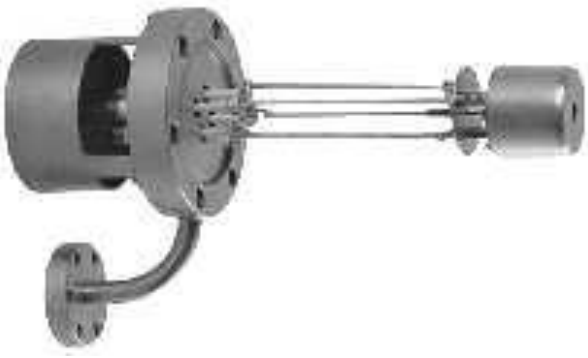
Ions in the Movies – Science fact or Science fiction?

Discussion: What makes for a good sci-fi movie? Why was *Star Wars* 'good' and *Battlestar Galactic* (released at the same time) 'bad'??

'Bad Guy' Brian Cox



An ion cannon, as seen in *The Empire Strikes Back* has a lot in common with a computer technician's static-guard wrist strap – electrical discharges can 'fry' sensitive electronics



Actual ion guns, used in surface science research and microchip manufacture.

Discussion: Would a commercially available ion gun be any use for 'home defense'??

"Ionic"

The following question was taken from your 2nd practice midterm:

Question 2a (18 points): Write the formulas and names of nine ionic compounds that may be formed through combining the anions and cations ions listed immediately below.

H^+ Cu^{2+} Al^{3+} Cl^- SO_4^{2-} PO_4^{3-}

Ionic Formula	Name of Ionic Compound

Chart of the Common Ions (Learn)

+1 ions	**+2 ions**	**+3 ions**	**-3 ions**	**-2 ions**	**-1 ions**
H^+	Mg^{2+}	Al^{3+}	N^{3-}	O^{2-}	F^-
Li^+	Ca^{2+}	Fe^{3+}		S^{2-}	Cl^-
Na^+	Sr^{2+}	Cr^{3+}	PO_4^{3-}		Br^-
K^+	Ba^{2+}		(phosph*ate*)	SO_4^{2-}	I^-
Au^+	Cu^{2+}			(sulf*ate*)	
Ag^+	Zn^{2+}			CO_3^{2-}	^-OH (hydrox*ide*)
Cu^+	Fe^{2+}			(carbon*ate*)	NO_3^- (nitr*ate*)
NH_4^+	Pb^{2+}				CN^- (cyan*ide*)
(ammonium)					

Solubility rules (will be covered in later handouts):

Soluble Compounds		Exceptions
Compounds containing	NO_3^-	None
	Cl^-	Ag^+, Hg^{2+},Pb^{2+}
	Br^-	Ag^+, Hg^{2+},Pb^{2+}
	I^-	Ag^+, Hg^{2+},Pb^{2+}
	SO_4^{2-}	Ba^{2+}, Hg^{2+},Pb^{2+}

Insoluble Compounds		Exceptions
Compounds containing	CO_3^{2-}	NH_4^+ & group IA cations
	PO_4^{3-}	NH_4^+ & group IA cations
	OH^-	group IA cations Ca^{2+},Sr^{2+}, Ba^{2+} & NH_4^+

Tricks:

Group # = ion charge for metal ions, e.g. Li (group 1) = +1

-(8 –group #) = ion charge for atomic non-metal ions, e.g. O = -(8-6) = -2

Formulas for most molecular ions appear on the solubility chart (supplied in data sheet).