Naming Ionic Compounds

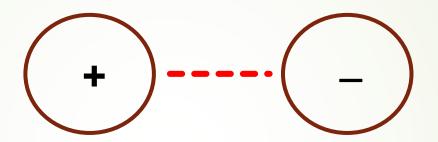
Part 1: Cations, Anions, and Ionic Bonds

By Shawn P. Shields, Ph.D.



What are Ionic Bonds?

 Ionic bonds are formed by electrostatic attractions between oppositely-charged ions



Recall:

- <u>Cations</u> are formed when an atom loses electrons to form a positively-charged ion. (Xⁿ⁺)
- Anions are formed when an atom gains electrons to form a negatively-charged ion. (Xⁿ⁻)
- Ionic bonds are generally formed between metals and nonmetals.

Recall: Identifying Metals and Nonmetals on the Periodic Table

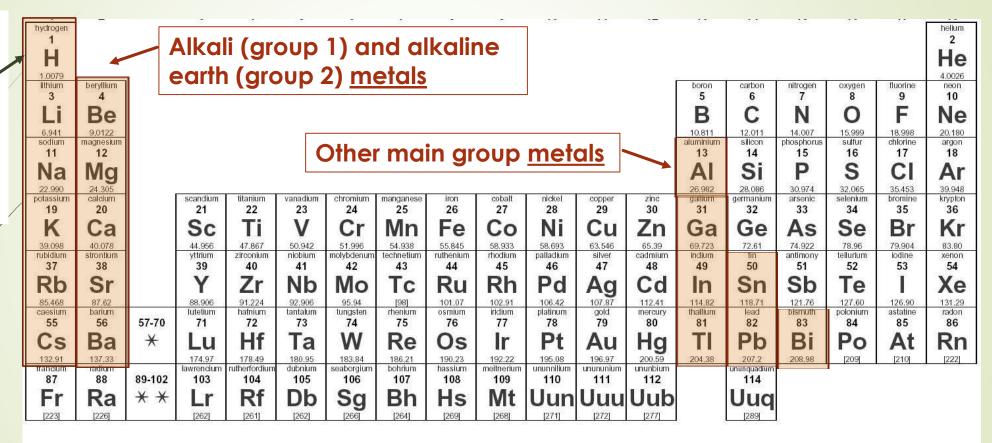
hydrogen 1) (5		253	z.	8		(**)	π	<i>5</i> 3	(2.5)	505	13.55	5.5	07.58	8E.	22.70	5.0 I	helium 2 He
1.0079 lithium	beryllium	1										Ĭ	boron	carbon	nitrogen	oxygen	fluorine	4.0026 neon
3	P =												5 D	6	7 NI	8	9	10
6.044	Be 9,0122												B 10.811	C 12.011	N 14.007	O 15.999	F	Ne
6.941 sodium	magnesium											Ì	aluminium	silicon	phosphorus	sulfur	18.998 chlorine	20.180 argon
11	12												13 A I	14	15	16	CI	18
Na 22.990	Mg 24,305												AI 26.982	Si 28.086	P 30.974	S 32.065	35,453	Ar 39.948
potassium	calcium		scandium	titanium	vanadium 23	chromium	manganese 25	iron 26	cobalt 27	nickel	copper	zinc 30	gallium	germanium 32	arsenic 33	selenium 34	bromine	krypton
19 K	20		Sc	Ti	V	24 Cr		Fe		Ni Ni	29	Zn	Ga	Ğe	A	Se	Br	Kr Kr
39.098	Ca		44.956	47,867	50.942	Cr 51.996	Mn 54.938	55.845	Co 58,933	58,693	Cu	65,39	69.723	72.61	As 74.922	78,96	79.904	83.80
rubidium 37	strontium 38		yttrium 39	zirconium 40	niobium 41	molybdenum 42	technetium 43	ruthenium 44	rhodium 45	palladium 46	silver 47	cadmium 48	indium 49	tin 50	antimony 51	tellurium 52	iodine 53	xenon 54
Rb	Sr		Ÿ	Žr	Nb	Mo	Tc	Ru	Rh	Pd	The second second	Cd	l'n	Sn	Sb	Тe	33 I	Xe
85,468	87.62		88,906	91.224	92,906	95.94	[98]	101.07	102.91	106.42	Ag	112.41	114.82	118,71	121.76	127.60	126.90	131.29
caesium 55	barium 56	57-70	lutetium 71	hafnium 72	tantalum 73	tungsten 74	rhenium 75	osmium 76	iridium 77	platinum 78	gold 79	mercury 80	thallium 81	lead 82	bismuth 83	polonium 84	astatine 85	radon 86
Cs	Ва	*	Lu	Hf	Ta	W	Re	Os	Îr	Pt	Au	Hg	ΤÏ	Pb	Bi	Po	At	Rn
132.91	137.33	Sin	174.97	178.49	180.95	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	radium 88	89-102	103	rutherfordium 104	105	seaborgium 106	107	108	109	110	unununium 111	ununbium 112		ununquadium 114			20 AND 200 AND 20	
Fr	Ra	* *	Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq				
[223]	[226]		[262]	[261]	[262]	[266]	[264]	[269]	[268]	[271]	[272]	[277]		[289]				

*Lanthanide series

	lanthanum 57	cerium 58	praseodymium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb
-1	138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
ĺ	actinium 89	thorium 90	protactinium 91	uranium 92	neptunium 93	plutonium 94	americium 95	curlum 96	berkelium 97	californium 98	einsteinium 99	fermium 100	mendelevium 101	nobelium 102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
Į	[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

Main Group Metals

Hydrogen (H) is considered a nonmetal, even though it is in group 1. H usually forms H+ ions.



*Lanthanide series

3	lanthanum 57	cerium 58	praseodymium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70
2	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb
	138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
	actinium 89	thorium 90	protactinium 91	uranium 92	neptunium 93	plutonium 94	americium 95	curlum 96	berkelium 97	californium 98	einsteinium 99	fermium 100	mendelevium 101	nobelium 102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
	[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

Main Group Metals

- Metals form cations (positively-charged ions).
 - **■**Examples:
 - Sodium cation (Na⁺) in Group 1
 - Magnesium cation (Mg²⁺) in Group 2
 - ► Aluminum cation (Al3+) in Group 3
- Main group metal cations have a positive charge equal to the group number.
- Hydrogen (H) is considered a nonmetal, even though it is in group 1.
- H usually forms H⁺ ions, except when bonded to metals.

Transition Metals

/_	hydrogen 1 1 1.0079	beryllium		-	• • •				•			• 1	:2E	boron	carbon	nitrogen	oxygen	fluorine	helium 2 He 4.0026 neon
	3 i	Be			sitic									B	င်	7 N	ဂိ	9 F	Ne
П	6.941	9,0122		cent	er p	orti	on a	ot th	ne b	erio	dic 1	table	2	10.811	12.011	14.007	15,999	18.998	20,180
Ī	sodium	magnesium												aluminium	silicon	phosphorus	sulfur	chlorine	argon
	11	12			(als	o co	alled	the	: "d	-blo	ck")			13	14	15	16	17	18
	Na	Mg			(_		,			AI	Si	P	S	CI	Ar
	22.990	24.305												26,982	28.086	30.974	32.065	35.453	39.948
	potassium 19	calcium 20		scandium 21	titanium 22	vanadium 23	chromium 24	manganese 25	26	cobalt 27	nickel 28	copper 29	zinc 30	gallium 31	germanium 32	arsenic 33	selenium 34	bromine 35	krypton 36
	IZ.				anger a	1/					NI:			_		-	-		
	n	Ca		Sc	11	V	Cr	Mn	Fe	Co	INI	Cu	Zn	Ga	Ge	As	Se	Br	Kr
1	39.098 rubidium	40.078 strontium		44.956 vttrium	47.867 zirconium	50.942 niobium	51.996 molybdenum	54.938 technetium	55.845 ruthenium	58,933 rhodium	58,693 palladium	63,546 silver	65.39 cadmium	69.723 indium	72.61 tin	74.922 antimony	78.96 tellurium	79.904 lodine	83.80 xenon
	37	38		39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr		Y	Zr	Nb	Мо	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
1	85,468	87.62		88.906 lutetium	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
	caesium 55	barium 56	57-70	71	hafnium 72	tantalum 73	tungsten 74	rhenium 75	osmium 76	iridium 77	platinum 78	gold 79	mercury 80	thallium 81	lead 82	bismuth 83	polonium 84	astatine 85	radon 86
	Cs	Ba	*	Lin	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	TI	Pb	Bi	Po	At	Rn
	100000000000000000000000000000000000000		^	Lu		THE RESERVE			Colores Colores At		1.40		960	1 1	1.00		1186 (1588)	1.546000 19400 44500	
ŀ	132.91 francium	137.33 radium		174.97 lawrencium	178.49 rutherfordium	180,95	183.84 seaborgium	186.21 bohrium	190.23 hassium	192.22 meitrerium	195.08 unumilium	196.97 unununium	200.59 ununbium	204.38	207.2 ununquadium	208.98	[209]	[210]	[222]
	87	88	89-102	103	104	105	106	107	108	109	110	111	112		114				
	Fr	Ra	* *	Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Umn	Ulub		Uuq				
	[223]	12261	- Jesus Amerika	[262]	[261]	12621	[266]	[264]	[269]	[268]	[271]	[272]	[277]		[289]				
ją:	220	[EEU]		[202]	[201]	[202]	[200]	[ES4]	[203]	[EOO]	[e.r.i]	[E/Z]	Let I		[203]				

*Lanthanide series

lanthanum 57	cerium 58	praseodymium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb
138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
actinium 89	thorium 90	protactinium 91	uranium 92	neptunium 93	plutonium 94	americium 95	curium 96	berkelium 97	californium 98	einsteinium 99	fermium 100	mendelevium 101	nobelium 102
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

Transition Metals

- Transition metals form cations (positively-charged ions).
- Most have more than one possible charge for the cation.
 - **Examples**:
 - ■Iron: Fe²⁺ and Fe³⁺
 - Copper: Cu⁺ and Cu²⁺
 - ■Gold: Au⁺ and Au³⁺

Nonmetals

ê	hydrogen 1	/ 3 22 -		75.	2	Æ.	3	2	æ		.348.	fo	und	on t	s are he ri tabl	ght h		•	helium 2 He
	1.0079 lithium	beryllium	ž											boron	carbon	nitrogen	oxygen	fluorine	4.0026 neon
	3	_4												5	6	7	8	9	10
	Li	Be												В	C	N	0	F	Ne
	6.941 sodium	9.0122 magnesium												10.811 aluminium	12.011 silicon	14.007 phosphorus	15,999 sulfur	18,998 chlorine	20.180 argon
	11	12												13	14	15	16	17	18
	Na	Mg												Al	Si	Р	S	CI	Ar
	22.990	24.305												26,982	28,086	30.974	32.065	35.453	39.948
	potassium 19	calcium 20		scandium 21	titanium 22	vanadium 23	chromium 24	manganese 25	1ron 26	cobalt 27	nickel 28	copper 29	zinc 30	gallium 31	germanium*	arsenic 33	selenium 34	bromine 35	krypton 36
	19					1/							-						
	n	Ca		Sc		V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
3	39.098 rubidium	40.078 strontium		44.956 yttrium	47.867 zirconium	50.942 niobium	51.996 molybdenum	54.938 technetium	55.845 ruthenium	58,933 rhodium	58.693 palladium	63,546 silver	65,39 cadmium	69,723 indium	72.61 tin	74.922 antimony	78,96 tellurium	79.904 lodine	83.80 xenon
	37	38		39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr		Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te		Xe
8	85,468	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
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	Cs	Ba	*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	TI	Pb	Bi	Po	At	Rn
	132.91	137,33	^	174.97	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200,59	204.38	207.2	208.98	[209]	[210]	[222]
	francium	radium	92/2012/92/98	lawrencium	rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium	ununnilium	unununium	ununbium	204.30	ununquadium	200,30	[203]	[210]	[222]
	87	88	89-102	103	104	105	106	107	108	109	110	111	112		114				
	Fr	Ra	* *	Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq				
	[223]	[226]		[262]	[261]	[262]	[266]	[264]	[269]	[268]	[271]	[272]	[277]		[289]				

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2	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb
	138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
Ī	actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium
- 1	89	90	91	92	93	94	95	96	97	98	99	100	101	102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
Į	[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

Nonmetals in Ionic Compounds

- Nonmetals generally form anions (negativelycharged ions) when in ionic compounds.
 - **Examples**:
 - Chloride anion (Cl⁻)
 - \blacksquare Oxide anion (O^{2-})
 - \blacksquare Sulfide anion (S²⁻)
- Nonmetals form covalent, as opposed to ionic, bonds when bonded to other nonmetals.
- Noble gases (group 8) do not form ions.

Identifying Metals and Nonmetals on the Periodic Table

1,0079 1,0079 1,0071 1,007 1		hydrogen 1	v dita		125	15		ē	-T -T	Æ		(5.2)	8.5		6.5	17374	6.3		6.0	helium 2
The content of the												Me	allo	ids						Не
10811 12.011 14.007 15.999 18.998 20.188 20			beryllium 4												242444232	2004 St. 2004	nitrogen 7	oxygen 8	100000000000000000000000000000000000000	neon
Sodium S		Li												7	2500000000	С	N	0	1.00	Ne
22.990 24.305 24.305 24.305 24.305 24.305 25.26 27 28 29 30 31 32 33 34 35 36 36 36 36 36 36 36		sodium	magnesium												aluminium	silicon	phosphorus	sulfur	chlorine	argon
Polassium Calcium 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 36 36 36 39 39 30 31 32 33 34 35 36 36 39 39 30 31 32 33 34 35 36 36 36 36 36 36 36			1900 4 (2000)												(A) A A	10 0 A 10 A 10 A	Г	300 N T T T T T T T T T T T T T T T T T T		Ar
Sc		potassium	calcium		and the second s	144(0)(0)(0)(0)		Makes Street Statement							gallium	germanium	arsenic	selenium	bromine	krypton
Tubidium 37 38 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54			(ASSESSED		No. 25 (1) (5) (5)	11	and the same	A STATE OF THE A	\$7500 BERNELLEN	MA				VA. 200200		ST. 10.157		\$5.500 Sept.	(A	Kr
85,468 87,62 88,906 91,224 92,906 95,94 [98] 101,07 102,91 106,42 107,87 112,41 114,82 118,71 121,76 127,60 126,90 131,25 126,90 126,90 131,25 126,90 126,9		rubidium	strontium		yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	ün	antimony	tellurium	iodine	xenon
C Ba X Lu Hf Ta W Re Os Ir Pt Au Hg Ti Pb Bi 201.					T														1	Xe
132.91 137.33 174.97 178.49 180.95 183.84 196.21 190.23 192.22 195.08 196.97 200.59 204.38 207.2 208.98 [209] [210] [222] 195.08 196.97 200.59 204.38 207.2 208.98 209]		caesium	barium	57-70	lutetium	hafnium	tantalum	tungsten	rhenium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon
Fr Ra $\star\star$ Lr Rf Db Sg Bh Hs Mt Uun Uuu Uub Uuq				*							1.00.00	10.000				11000 110000011		11.000 11.00000000	15	Rn
Fr Ra * Lr Rf Db Sg Bh Hs Mt Uun Uuu Uub Uuq	١	francium	radium	89-102	lawiencium	rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium	ununnilium	unununium	ununbium	204.38	ununquadium	208.98	[209]	[210]	[222]
		230			\$3855E	(6)(9)(1)		0.000												
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L	[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

Metalloids

Metalloids (generally) form covalent as opposed to ionic bonds in compounds.

In particular, compounds composed from a nonmetal and a metalloid contain covalent bonds.

Summary

- Metals form cations in ionic compounds.
 - **■** Cations are positively-charged ions.
 - → When a cation is formed, the atom loses electrons.
- Nonmetals form anions in ionic compounds.
 - ► Anions are negatively-charged ions.
 - When an anion is formed, the atom gains electrons.
- Ionic compounds form between metals and nonmetals.
 - ► An ionic bond is an electrostatic attraction between oppositely-charged particles (ions).