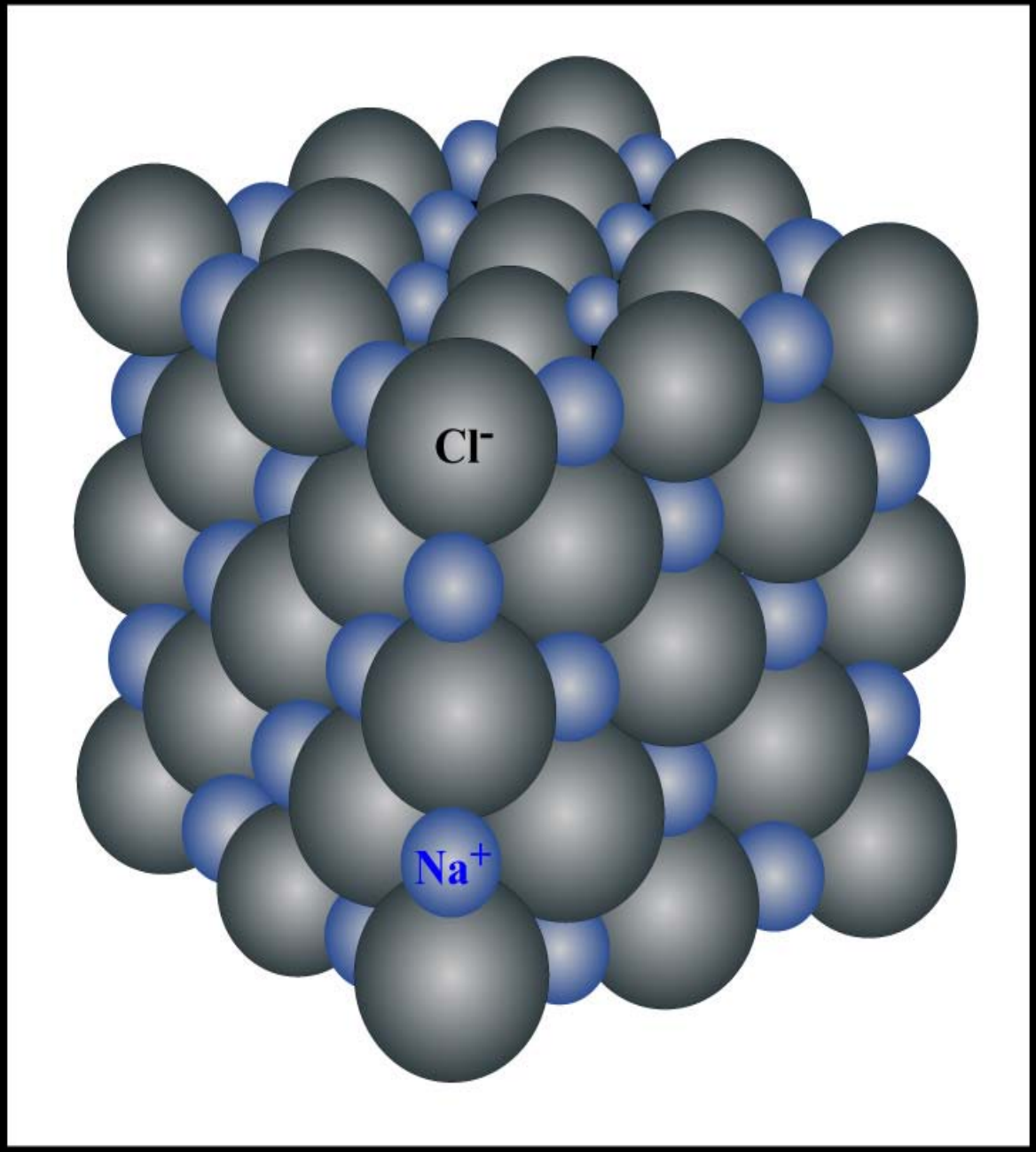
Welcome to 3.091

Lecture 8

September 25, 2009

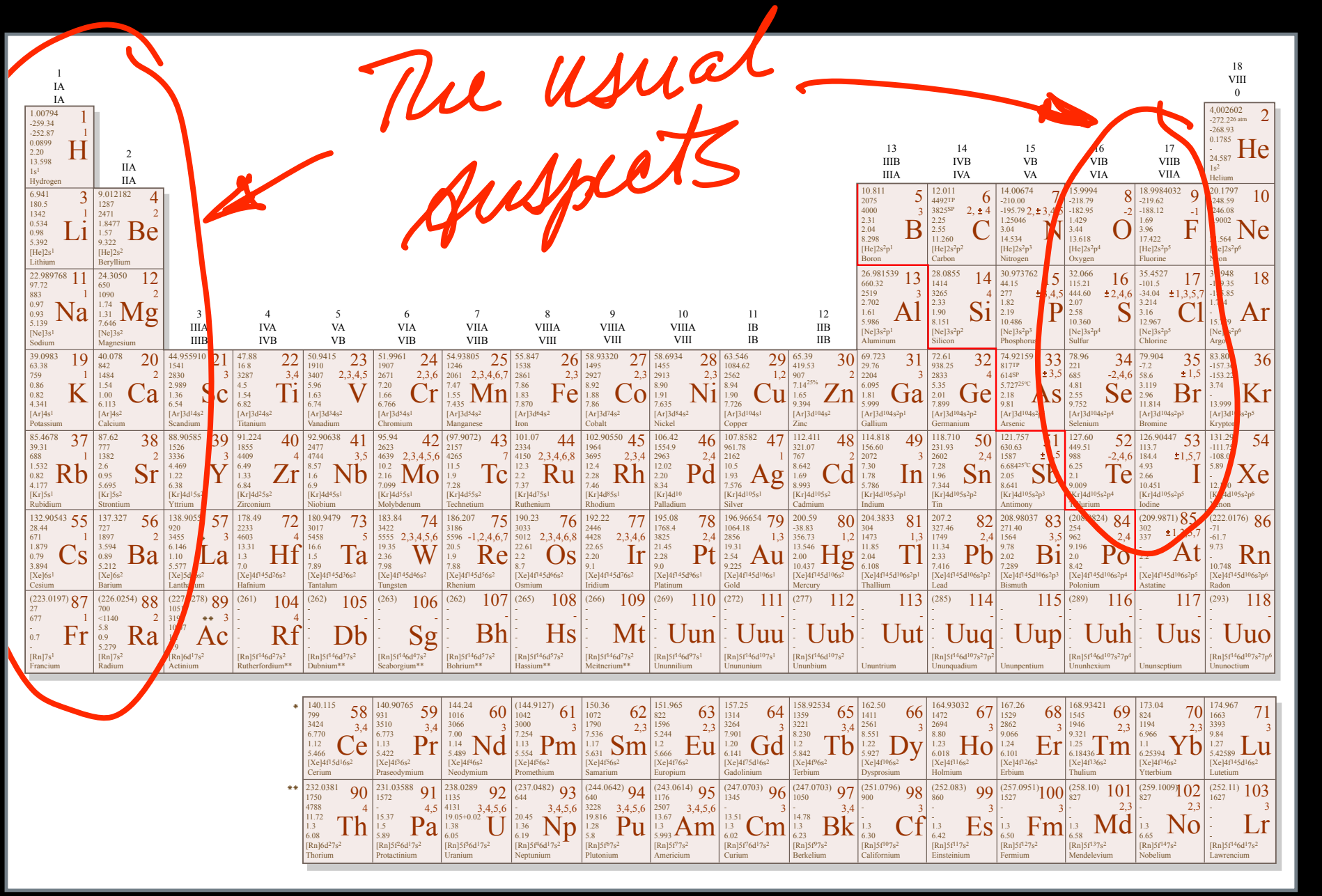
Ionic Crystals; Born-Haber Cycle

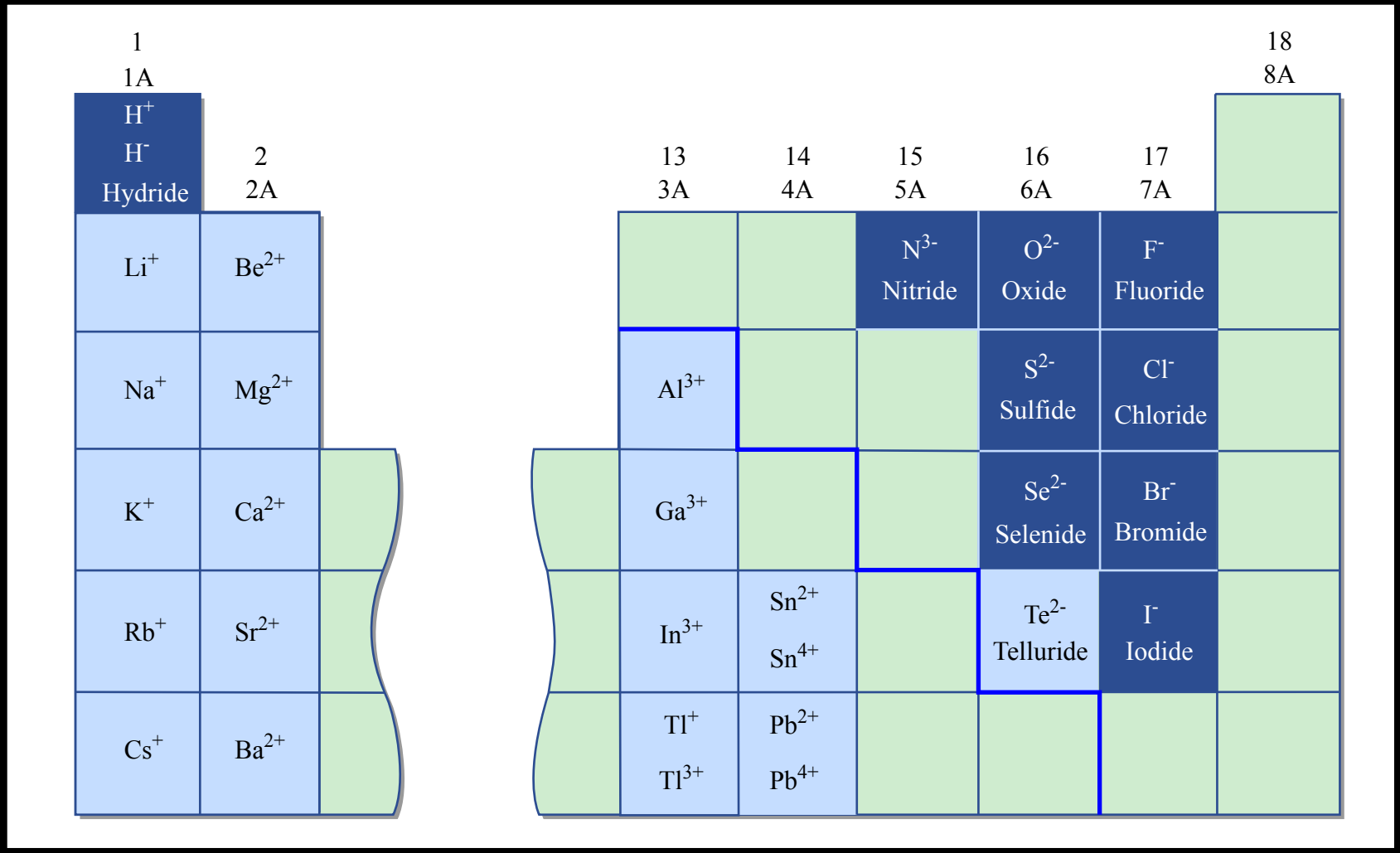


Properties of Ionic Crystals

- solid at room temperature
- high melting points & boiling points
- transparent to visible light
- electrical insulators
- hard & brittle
- soluble in water & other polar solvents
- melt to form ionic liquids (useful in electrolytic extraction of metals)

where to search for ionicity???





Max Born - Biography

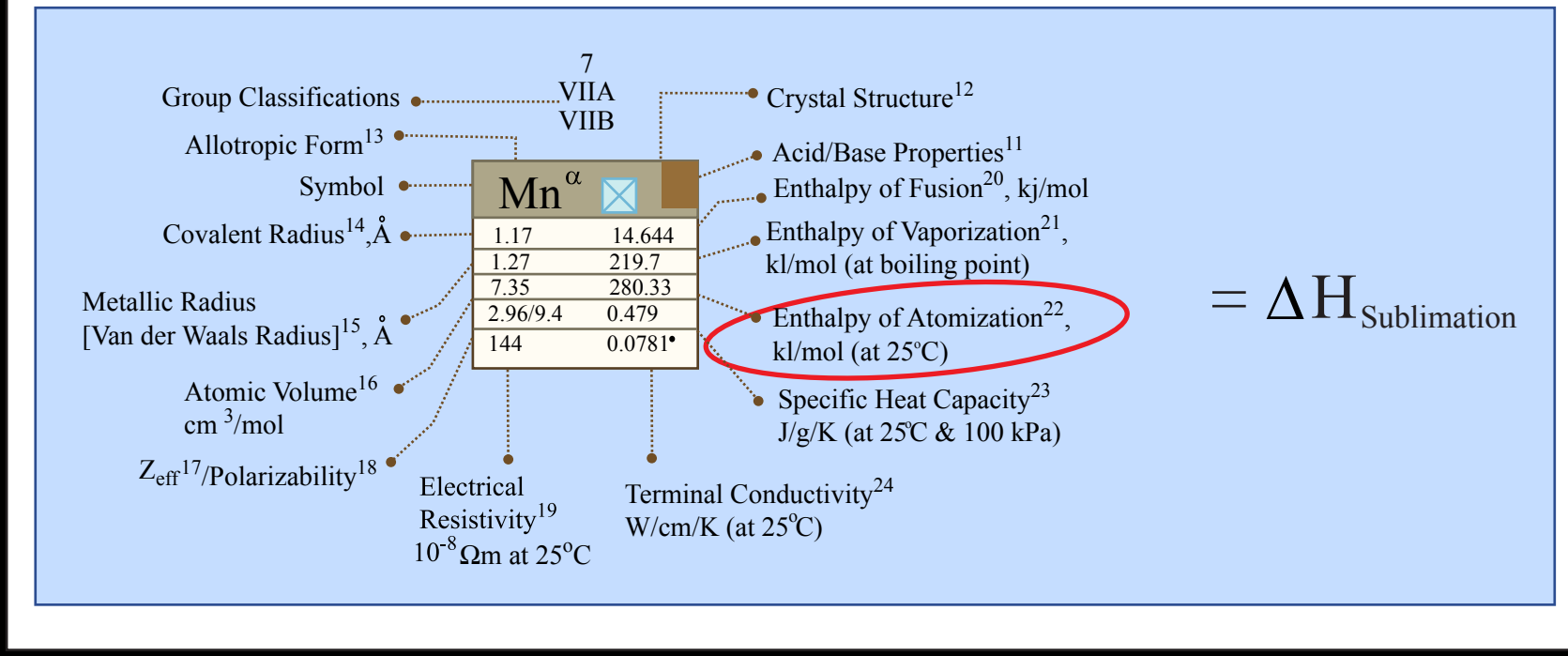
Max Born was born in Breslau on the 11th December, 1882, to Professor Gustav Born, anatomist and embryologist, and his wife Margarete, née Kauffmann, who was a member of a Silesian family of industrialists.

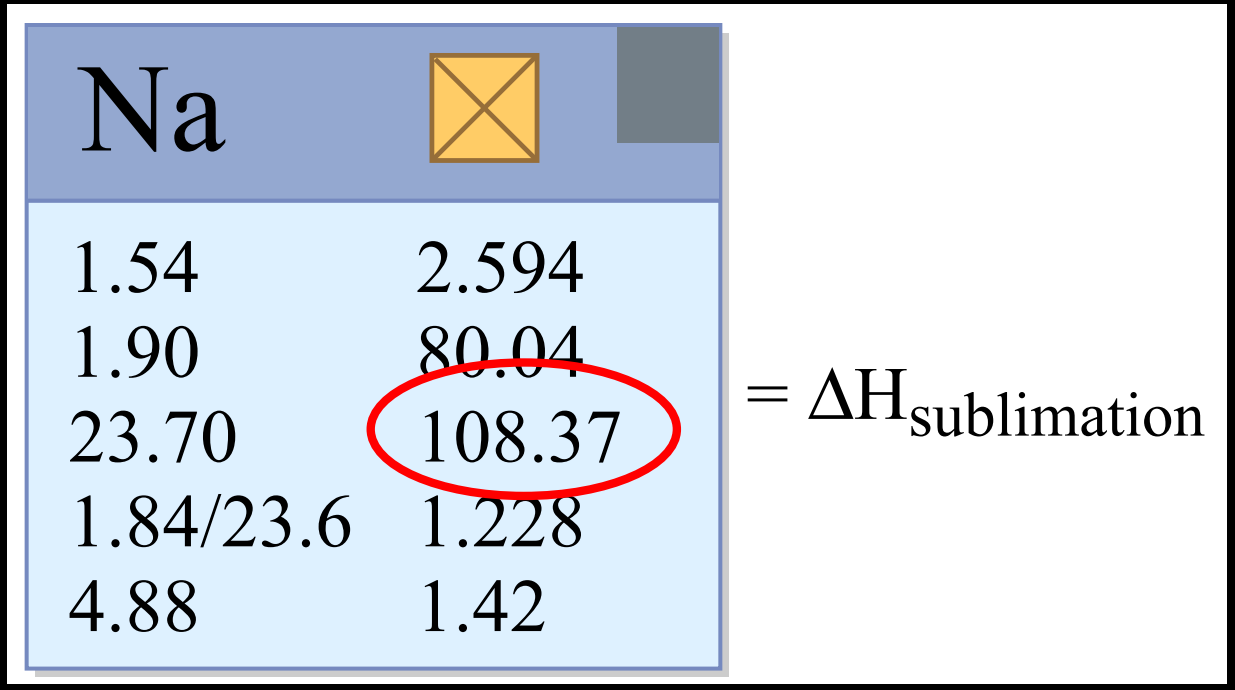
Max attended the König Wilhelm's Gymnasium in Breslau and continued his studies at the Universities of Breslau (where the well-known mathematician Rosanes introduced him to matrix calculus), Heidelber, Zurich (here he was deeply impressed by Hurwitz's lectures on higher analysis), and Göttingen. In the latter seat of learning he read mathematics chiefly, sitting under Klein, Hilbert, Minkowski, and Runge, but also studied astronomy under Schwarzschild, and physics under Voigt. He was awarded the Prize of the Philosophical Faculty of the University of Göttingen for his work on the stability of elastic wires and tapes in 1906, and graduated at this university

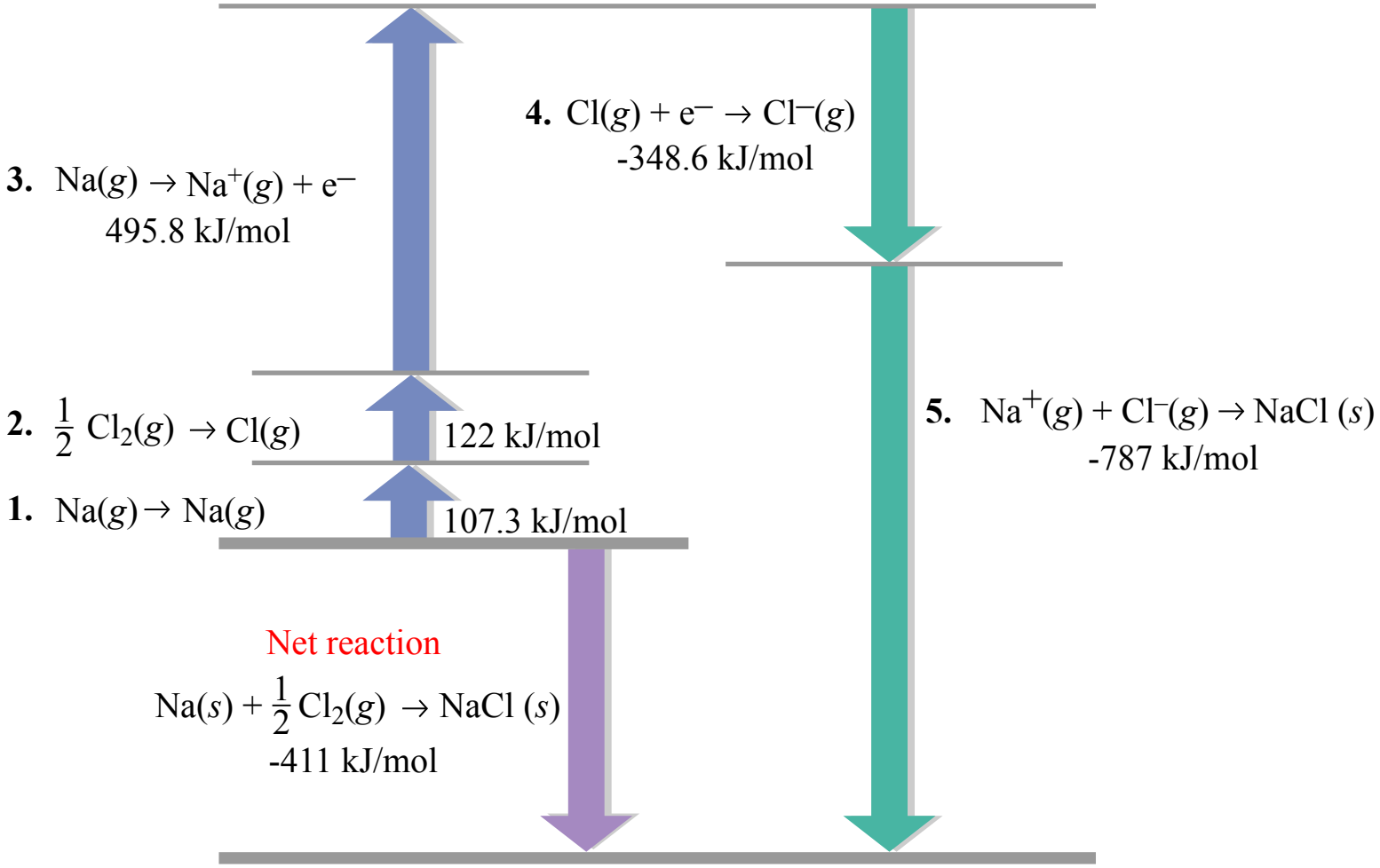
Fritz Haber - Biography

Fritz Haber was born on December 9, 1868 in Breslau, Germany, in one of the oldest families of the town, as the son of Siegfried Haber, a merchant. He went to school at the St. Elizabeth classical school at Breslau and he did, even while he was at school, many chemical experiments.

From 1886 until 1891 he studied chemistry at the *University of Heidelberg* under Bunsen, at the University of Berlin under A.W. Hoffmann, and at the Technical School at Charlottenberg under Liebermann. After completing his University studies he voluntarily worked for a time in his father's chemical business and, being interested in chemical technology, he also worked for a while under Professor Georg Lunge at the *Institute of Technology at Zurich*. He then finally





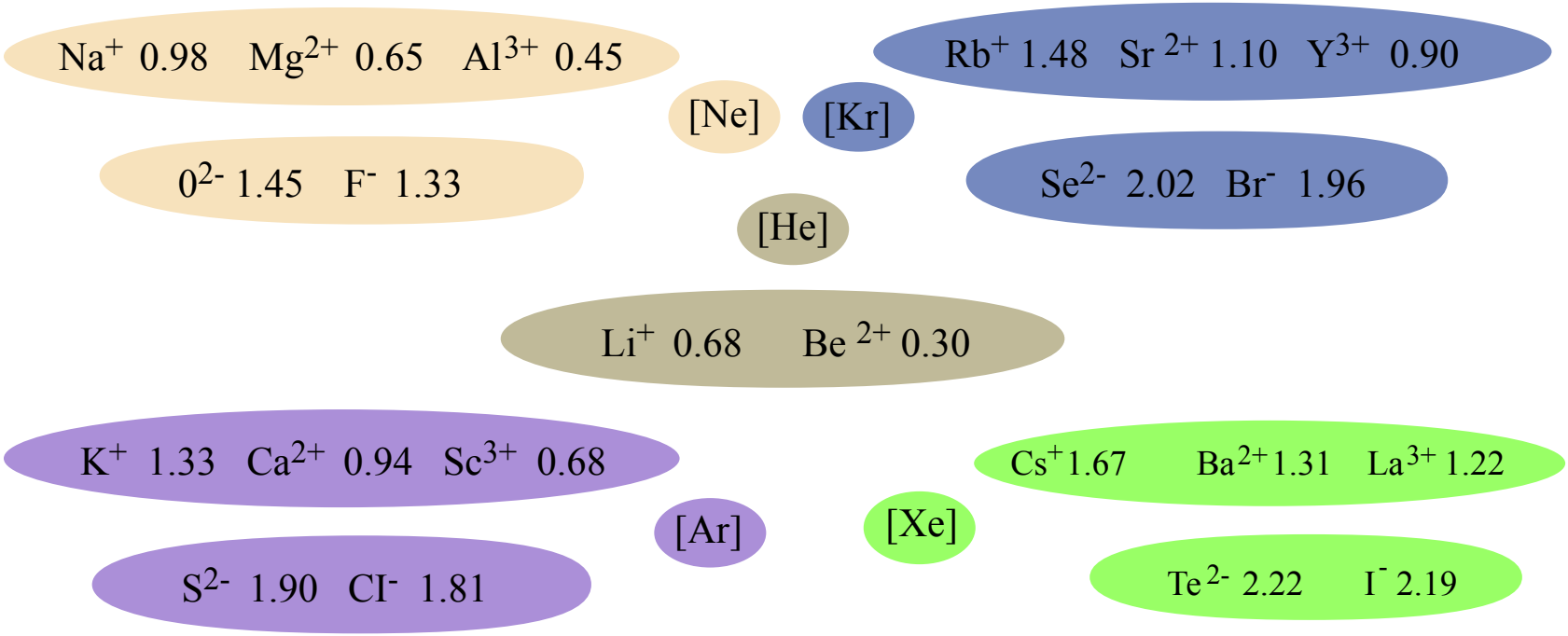


A Born – Haber Cycle for NaCl

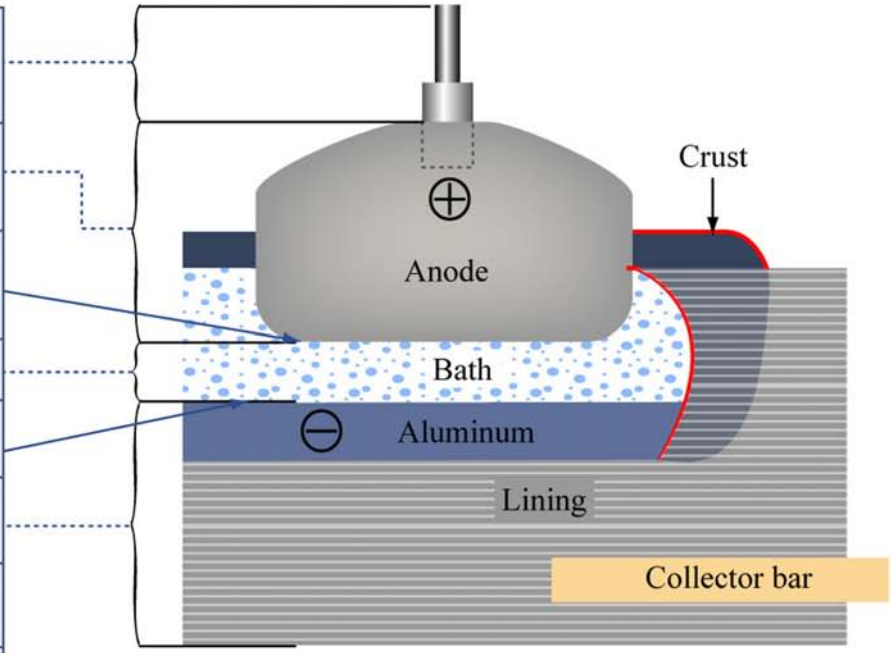
Cation	Anion				
	F^-	Cl^-	Br^-	I^-	O^{2-}
Li^+	1036	853	807	757	2925
Na^+	923	787	747	704	2695
K^+	821	715	682	649	2360
Be^{2+}	3505	3020	2914	2800	4443
Mg^{2+}	2957	2524	2440	2327	3791
Ca^{2+}	2630	2258	2176	2074	3401
Al^{3+}	5215	5492	5361	5218	15916

Lattice energies of some Ionic solids (kj/mol)

Ionic Radii (Å) for Ions with Noble-gas Electron Configurations



Voltage Component	Volts	% of Total
External	.16	3.4
Anode	.32	6.9
Polarizations	.60	12.9
Bath	1.76	38.0
Decomposition	1.20	25.9
Cathode	.47	10.1
Other	.13	2.8
Total	4.64	100.0



$$2\ Al^{3+} + 6\ e^- \Rightarrow 2\ Al$$

$$3\ O^{2-} + 1.5\ C \Rightarrow 1.5\ CO_2 + 6\ e\text{-}$$

consumable carbon anode

0.45 kg C / kg Al

aluminum produced by electrolytic reduction of Al_2O_3

world capacity: ~40 million tonnes/year

decompose Al_2O_3 dissolved in Na_3AlF_6 (T = 960°C)

- ☞ liquid Al (-) and CO_2 (+)
- ☞ find an inert anode

$2\ Al^{3+} + 6\ e^- \Rightarrow 2\ Al$

$3\ O^{2-} \Rightarrow 1.5\ O_2 + 6\ e^-$

inert anode

no CO_2; no CF_4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3.091SC Introduction to Solid State Chemistry

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