

[TP] Which is the correct order of first ionization energy of the atoms barium, beryllium, chlorine, and iodine.

7%	1.	Ba < Be < Cl < I
4%	2.	I < Cl < Be < Ba
7%	3.	I < Ba < Cl < Be
3%	4.	Be < Cl < Ba < I
12%	5.	Ba < I < Cl < Be
66%	6.	Ba < Be < I < Cl
1%	7.	Something else

Try to answer using periodic table only — without looking up values.

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Lecture 6 CH131 Fall 2020

Thursday, September 24, 2020

- Complete IE_1 → electron cloud expansion
- Electron affinity: $X^-(g) \rightarrow X(g) + e^-$
- Electronegativity: $EN \sim IE_1 + EA$
- Dipole moment and ionic character: $\sim \Delta EN$

Next lecture: Lewis diagrams; Shapes and polarity of molecules; Begin ch9.1−9.6. The gaseous state

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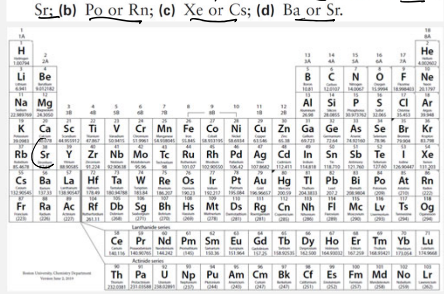
Problem 3.9

Sr > Rb
Rn > Po
Xe > Cs
Sr > Ba

9. For each of the following pairs of atoms, state which you expect to have the higher first ionization energy: (a) Rb or Sr; (b) Po or Rn; (c) Xe or Cs; (d) Ba or Sr.



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[TP] Which is the correct order of first ionization energy of the atoms barium, beryllium, chlorine, and iodine.

2%	1.	Ba < Be < Cl < I
2%	2.	I < Cl < Be < Ba
1%	3.	I < Ba < Cl < Be
1%	4.	Be < Cl < Ba < I
12%	5.	Ba < I < Cl < Be
80%	6.	Ba < Be < I < Cl
1%	7.	Something else

$X(g) \rightarrow X^+(g) + e^-(g)$

Be

Ba

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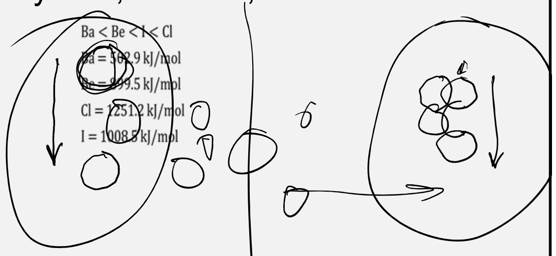
IE_1 of barium, beryllium, chlorine, and iodine

Ba < Be < I < Cl
Ba = 502.9 kJ/mol
Be = 899.5 kJ/mol
Cl = 1251.2 kJ/mol
I = 1008.5 kJ/mol



Be and Ba < Cl and I
Ba < Be < I < Cl

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Electron affinity, EA: $X^-(g) \rightarrow X(g) + e^-$

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~~Electronegativity, EN~~
~~Ionic character~~
~~$X^-(g) \rightarrow X(g) + e^-$~~

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Electron affinity, EA: $X^-(g) \rightarrow X(g) + e^-$

TABLE 3.2

Electron Affinity of Selected Atoms (in kJ mol^{-1})

H							**He**
73							*
Li	**Be**	**B**	**C**	**N**	**O**	**F**	**Ne**
60	*	27	122	*	141	328	*
Na	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
53	*	42	134	72	200	349	*
K	**Ca**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
48	2	41	119	79	195	325	*
Rb	**Sr**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
47	5	29	107	101	190	295	*
Cs	**Ba**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
46	14	19	35	91	183	270	*

*No stable anion A^- exists for this element in the gas phase.

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Problem 3.23a

$IE_1(\mathrm{K}) = 4.34$ eV/atom
$IE_1(\mathrm{Cl}) = 12.97$ eV/atom
$EA(\mathrm{K}) = 48$ kJ/mol
$EA(\mathrm{Cl}) = 349$ kJ/mol

23. Use the data in Figure 3.7 and Table 3.2 to calculate the energy changes (ΔE) for the following pairs of reactions:

(a) $K(g) + Cl(g) \longrightarrow K^+(g) + Cl^-(g)$
$K(g) + Cl(g) \longrightarrow K^-(g) + Cl^+(g)$

(b) $Na(g) + Cl(g) \longrightarrow Na^+(g) + Cl^-(g)$
$Na(g) + Cl(g) \longrightarrow Na^-(g) + Cl^+(g)$

Explain why K^+Cl^- and Na^+Cl^- form in preference to K^-Cl^+ and Na^-Cl^+.

$Cl \rightarrow Cl^+ + e^-$ 12.97 eV
$Cl^- \rightarrow Cl + e^-$ 349 kJ

Chlorine holds its electrons tightly

Chlorine holds onto an additional electron tightly

IE + EA is a measure of how strongly an atom "wants" electrons.

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Electronegativity: $EN \sim IE_1 + EA$

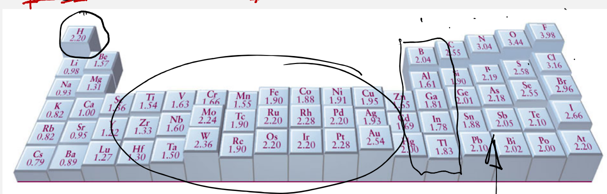

Fig. 3-10, p. 90

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Dipole moment and ionic character: ~ ΔEN

μ = charge × separation

Dipole moment of charges e⁺ and e⁻ separated by 0.2082×10^{-10} m is defined as one Debye,

$1\text{ D} = 3.336 \times 10^{-30}\text{ C m}$

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Dipole moment

Typically, only a fraction, δ, of an electron charge is displaced

$\pm q = \pm\delta|e|$

Where δ is the fractional ionic character.

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Ionic character

The internuclear distance of HF is $R_e = 0.917 \times 10^{-10}$ m and its dipole moment is 1.82 D.

Calculate dipole moment, assuming displacement of one full unit of charge, |e| .

Answer: $1.602 \times 10^{-19}\text{C} \times 0.917 \times 10^{-10}\text{m} \times \frac{\text{D}}{3.336\times10^{-30}\text{C m}} = 4.40\text{ D}$

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Ionic character

The internuclear distance of HF is $R_e = 0.917 \times 10^{-10}$ m and its dipole moment is 1.82 D.

Calculate what fraction of an electron charge is displaced, that is, the fractional ionic character of HF.

Answer: $\delta = \frac{1.82\ \text{D}}{4.40\ \text{D}} = 0.41$

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Ionic character

The internuclear distance of HF is $R_e = 0.917 \times 10^{-10}$ m and its dipole moment is 1.82 D. The fractional ionic character of HF is 0.41.

Percent ionic character is $\delta \times 100\ \% = 41\ \%$

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Ionic character

If the ionic character were 100 %, the molecule would be

$$H^{1.0+}F^{1.0-} \text{ with } \mu = \mu_{\max} = e^- \times R_e \times \frac{\text{D}}{3.336\times10^{-30}\,\text{C m}} = 4.40\ D$$

with one full unit of electron charge transferred.

Since the ionic character is 41 %, the molecule actually is

$$H^{0.41+}F^{0.41-} \text{ with } \mu = \mu_{\text{observed}} = 0.41e^- \times R_e \times \frac{\text{D}}{3.336\times10^{-30}\,\text{C m}} = 1.82\ \text{D}$$

That is, only 0.41 of an electron charge is transferred. So the fractional charge transferred is $\delta = 0.41$.

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Percent ionic character

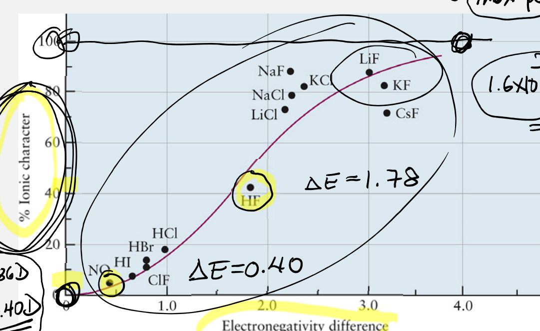

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Fig. 3-16, p. 107

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