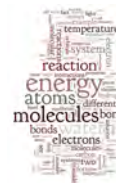


Periodic Trends

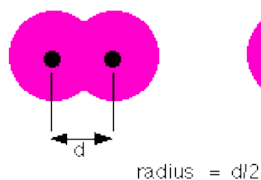
Why do we need to know about
quantized energy levels of
electrons?

What is the evidence?

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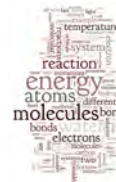


Atomic radius



- Depends on whether you are measuring the covalent interaction or the Van der Waals interaction
- But it is half the distance between the two nuclei

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Question 1

- Do you predict the atomic radius of Li is larger or smaller than that of Na?
 - A. Larger
 - B. Smaller
 - C. Same
 - D. Don't know
- What did you base your answer on (on answer sheet)?



Atomic Radius down a group

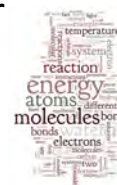
- Atomic radius **increases down a group**

Li	3 Electrons	Radius = 0.157 nm
Na	11 Electrons	Radius = 0.191 nm
K	19 Electrons	Radius = 0.235 nm
Rb	37 Electrons	Radius = 0.250 nm
Cs	55 Electrons	Radius = 0.272 nm

Question 2

- **Across a row**
- Do you predict the atomic radius of Li is larger or smaller than that of Ne?
 - A. Larger
 - B. Smaller
 - C. Same
 - D. Don't know
- What did you base your answer on (on answer sheet)?

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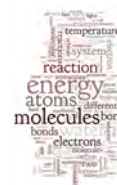


Atomic radius across a row DECREASES!!!

Atomic Radii (pm)							
1A	2A	3A	4A	5A	6A	7A	8A
Li 152	Be 112	B 85	C 77	N 75	O 73	F 72	Ne 71
Na 186	Mg 160	Al 143	Si 118	P 110	S 103	Cl 100	Ar 98
K 227	Ca 197	Ga 135	Ge 122	As 120	Se 119	Br 114	Kr 112
Rb 248	Sr 215	In 167	Sn 140	Sb 140	Te 142	I 133	Xe 131
Cs 265	Ba 222	Tl 170	Pb 146	Bi 150	Po 168	At (140)	Rn (141)

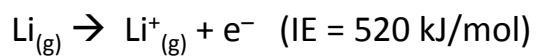
Well how can that be??
Q3 – were you surprised?

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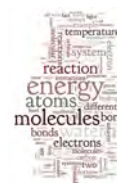


Ionization Energy

Ionization Energy: energy required to
remove an electron from an atom in the
gas phase:



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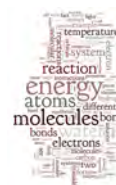
Question 4

- Do you predict the ionization energy of Li is larger or smaller than that of Na?
 - A. Larger
 - B. Smaller
 - C. Same
 - D. Don't know
- What did you base your answer on (on answer sheet)?

Question 4 Answer

- The I.E. of Lithium is 520 kJ/mol
- The I.E. of sodium (Na) is 495 kJ/mol

Why do you think this is so?



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Question 5

- Do you predict the ionization energy of Li is larger or smaller than that of Ne?
 - A. Larger
 - B. Smaller
 - C. Same
 - D. Don't know
- What did you base your answer on (on answer sheet)?

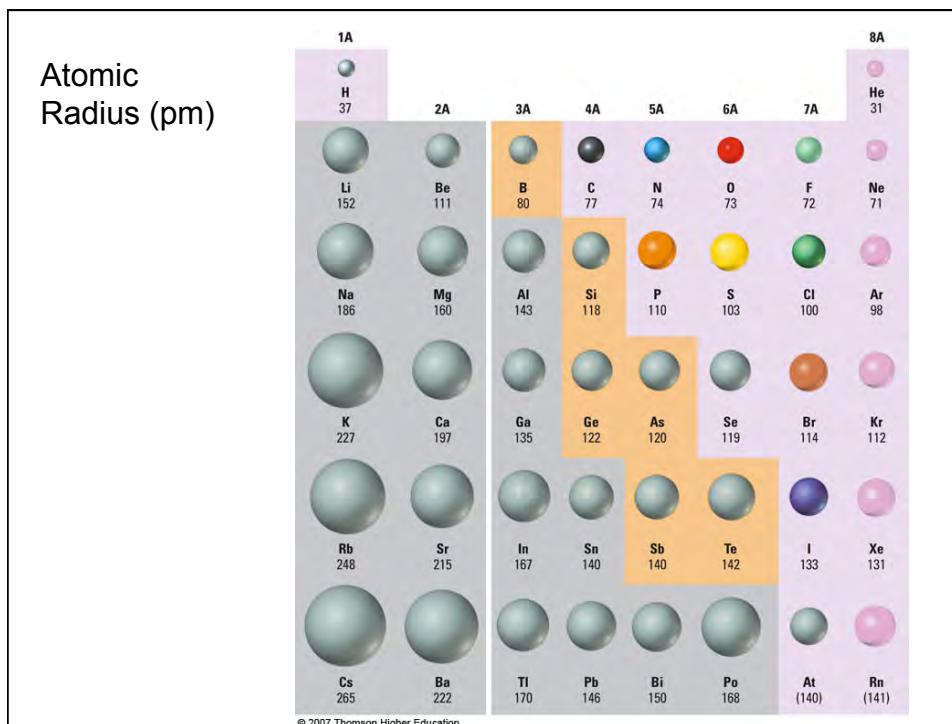
Question 5 Answer

- The I.E. of Lithium is 520 kJ/mol
- The I.E. of Neon (Ne) is 2080.6 kJ/mol

Why do you think this is so?

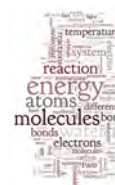
What factors affect the ionization energy?

Is there a relationship between atomic radius and ionization energy?



Size of Atom

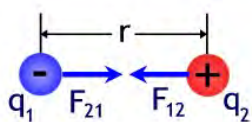
- Depends on the balance between the:
 - attractions of the protons and electrons, and
 - Repulsions between the electrons in the atom.



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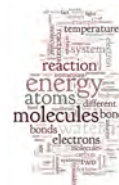
Coulomb's Law

Unlike charges attract



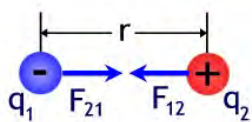
$$F = k \frac{q_1 q_2}{r^2}$$

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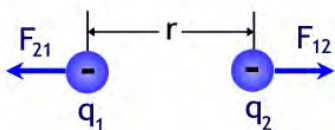


Coulomb's Law

Unlike charges attract

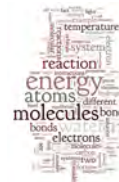


$$F = k \frac{q_1 q_2}{r^2}$$



Like charges repel

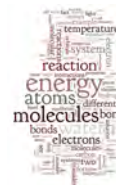
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Coulomb's Law

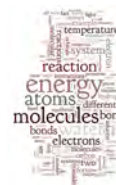
- a) Coulomb's Law: $F = \text{Constant } (q_1 \cdot q_2) / r^2$ can be applied to isolated atoms.
- b) What do q_1 and q_2 and r represent?
- c) What happens to the force (F) as $q_1 \cdot q_2$ increases?
A) Increase, B) decrease, C) same, D) DK
- d) What happens as r increases?
A) Increase, B) decrease, C) same, D) DK

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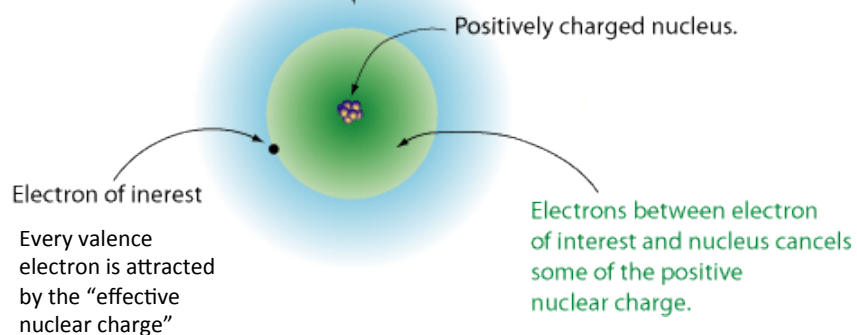
Coulomb's law explains both attractions between the protons and electrons, and the repulsions between the electrons.

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Effective Nuclear Charge

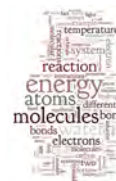
Electrons outside
have no effect on
effective nuclear charge
for electron of interest.

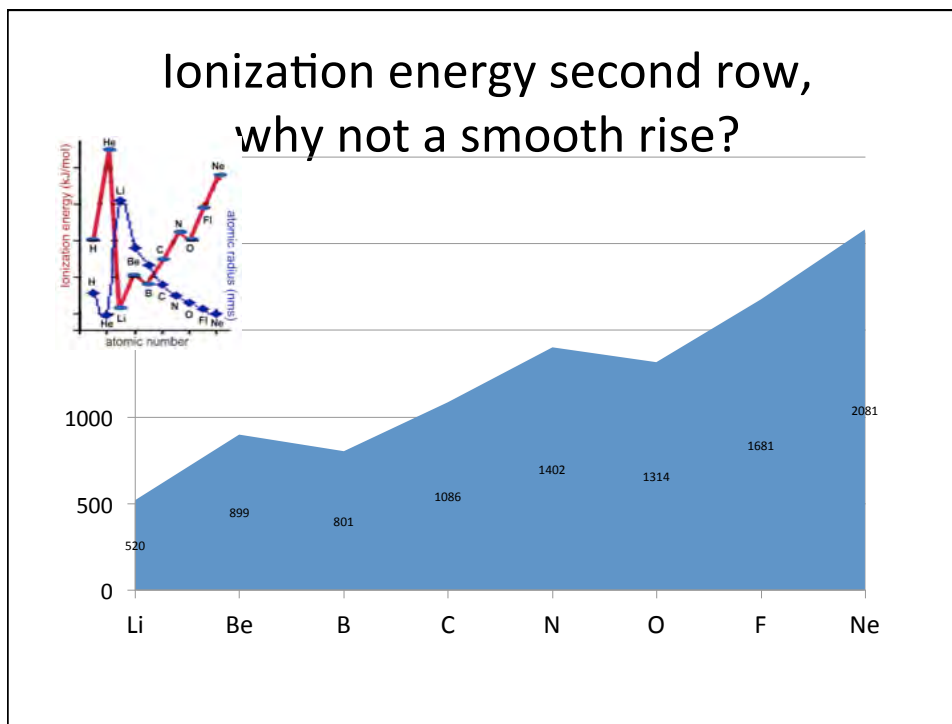


What is the effective nuclear charge of:

- Be, C, F
- A. +1
- B. +2
- C. +4
- D. +7

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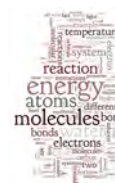


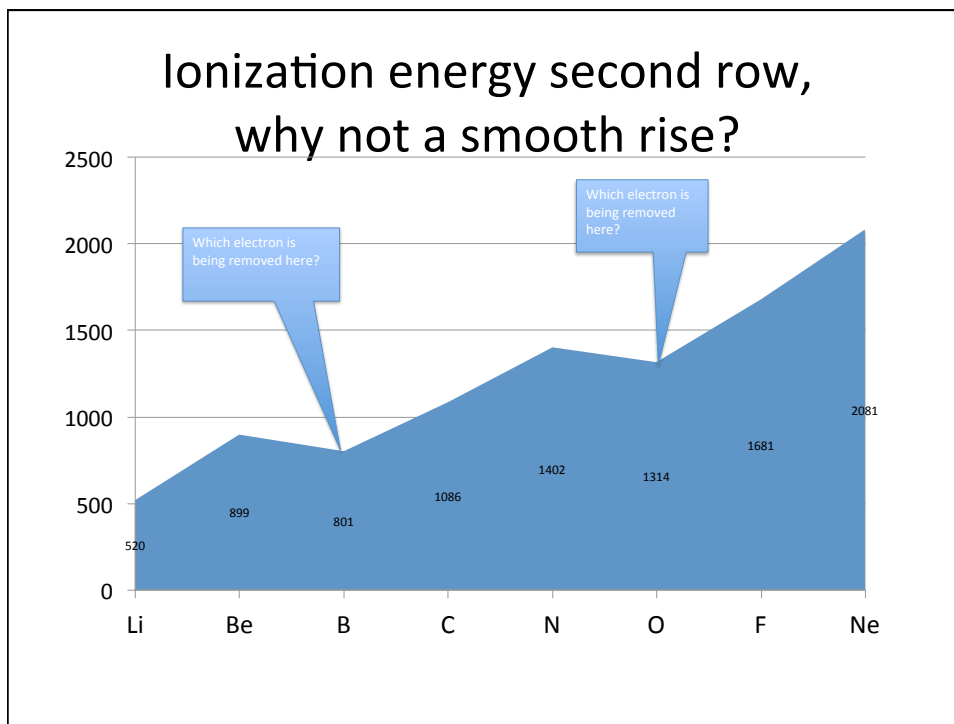


What is the core/valence electron configuration of B? of O?

- [He] $2s^2 2p^4$
- [Ne] $2s^2 2p^4$
- [Ne] $2s^2 2p^1$
- [He] $2s^2 2p^1$

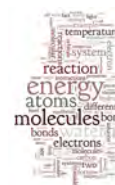
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2nd Ionization Energy

- $M^+(g) \rightarrow M^{2+}(g) + e^-$
- Third IE
- $M^{2+}(g) \rightarrow M^{3+}(g) + e^-$

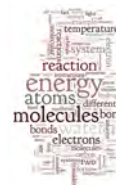


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Which ionization energy is larger?

- A. First IE: $\text{Mg}_{(g)} \rightarrow \text{Mg}_{(g)}^{+} + e^{-}$
B. Second IE: $\text{Mg}_{(g)}^{+} \rightarrow \text{Mg}_{(g)}^{2+} + e^{-}$
C. Third IE: $\text{Mg}_{(g)}^{2+} \rightarrow \text{Mg}_{(g)}^{3+} + e^{-}$

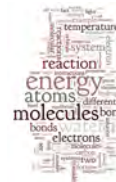
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Which ionization energy is larger?

- A. First IE: $\text{Mg}_{(g)} \rightarrow \text{Mg}_{(g)}^{+} + e^{-}$
• 738 kJ/mol
B. Second IE: $\text{Mg}_{(g)}^{+} \rightarrow \text{Mg}_{(g)}^{2+} + e^{-}$
• 1450 kJ/mol
C. Third IE: $\text{Mg}_{(g)}^{2+} \rightarrow \text{Mg}_{(g)}^{3+} + e^{-}$
• 7730 kJ/mol

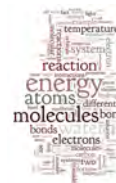
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Note that huge jump for the 3rd
ionization energy of Mg
Why?

Because that electron is being
removed from the “core”

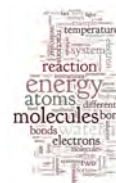
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Ionization energies are affected by

- Size of atom/ion (smaller size – higher IE)
- Size of charges (larger charge larger IE)
- The shell that the electron is removed from

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Consider the following successive ionization energies (kJ/mol):

IE_1	IE_2	IE_3	IE_4	IE_5	IE_6	IE_7
1012	1900	2910	4960	6270	22,200	26,345

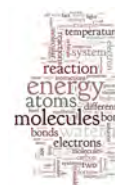
Which element in period three would most likely show this trend in ionization energies?

A. Mg
B. Al
C. Si
D. P
E. S

1A 1	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	8A 18		
1 H	2 He											3 B	4 C	5 N	6 O	7 F	8 Ne		
3 Li	4 Be	3B 5	4B 6	5B 7	6B 8	7B 9	8B 10	1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar				
11 Na	12 Mg	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	35 Br	36 Kr		
19 K	20 Ca	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe		
37 Rb	38 Sr	55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112	114	116						

Why?

- What factors affect removing the electron?
- Charge (q_1 , q_2)
- r
- What happens to the radius of the atom (ion) when an electron is removed?



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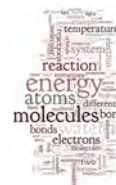
Formation of cations

- Which has a larger radius? (why)

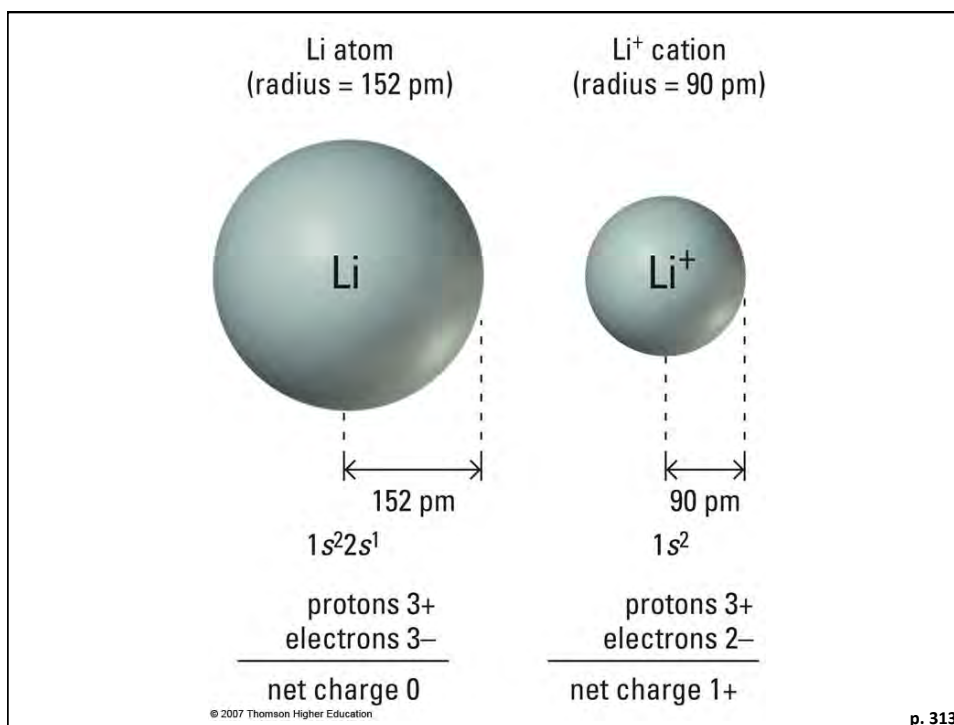
A.Li

B.Li⁺

C.same



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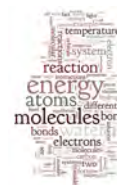
Formation of anions

- Which has the largest radius? Why?

A.F

B.F⁻

C.same



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