

Chapter 8

Periodic Relationship Among the Elements

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Which of the following make an *isoelectronic* pair:



Isoelectronic are species have the same number of electrons

Species	Number of electrons
Cl^-	$17 + 1 = 18 \text{ e}$
O^{2-}	$8 + 2 = 10 \text{ e}$
F	9 e
Ca^{2+}	$20 - 2 = 18 \text{ e}$
Fe^{3+}	23 e

Cl^- and Ca^{2+} is isoelectronic pair

Which one of the following is **NOT** *isoelectronic* with the others:

Br^- , Rb^+ , Se^{2-} , Sr^{2+} , Te^{2-} ?

Species	Number of electrons
Br^-	$35 + 1 = 36 \text{ e}$
Rb^+	$37 - 1 = 36 \text{ e}$
Se^{2-}	$34 + 2 = 36 \text{ e}$
Sr^{2+}	$38 - 2 = 36 \text{ e}$
Te^{2-}	$52 + 2 = 54 \text{ e}$

Answer: Te^{2-}

Which of the atoms listed below has the smallest radius?

- A) Al **B) P** C) As D) Te E) Na

1 1A																		18 8A
1 H	2 2A												13 3A	14 4A	15 5A	16 6A	17 7A	2 He
3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
19 K	20 Ca	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	
37 Rb	38 Sr	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	

Which of the atoms listed below has the largest (greatest) radius?

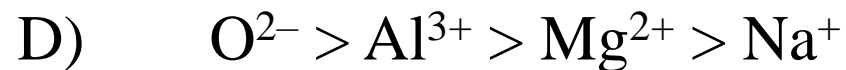
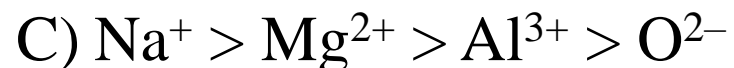
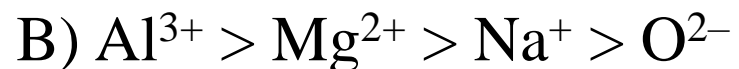
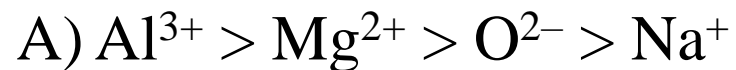
- A) Cl B) I C) P **D) Sb** E) Se

1 1A																		18 8A
1 H	2 2A												13 3A	14 4A	15 5A	16 6A	17 7A	2 He
3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
19 K	20 Ca	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	
37 Rb	38 Sr	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	

Arrange the following ions in order of decreasing ionic radius:



decreasing radius \rightarrow



Anion is always **larger** than atom from which it is formed.

Cation is always **smaller** than atom from which it is formed.

Cations < Anions

Cation < neutral < anion

For cations: the larger the charge the smaller the radius

For anions: the smaller the charge the smaller the radius

Which one in the following pairs has larger atomic/ionic radius:

$\text{Al}^{+3}, \text{F}^-$	F^- is larger
$\text{Al}^{+3}, \text{Ga}^{+3}$	Ga^{+3} is larger
$\text{Cu}^{+2}, \text{Cu}^{+3}$	Cu^{+2} is larger
$\text{P}^{-3}, \text{Cl}^-$	P^{-3} is larger
Ar, P^{-3}	P^{-3} is larger

Which of the atoms listed below has the smallest Z_{eff} ?

- A) Si B) Cl C) Mg **D) Na**

Periodic Table of the Elements

1																	18
1															2		
H															He		
Hydrogen															Helium		
1.008															4.003		
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
Lithium	Beryllium											Boron	Carbon	Nitrogen	Oxygen	Fluorine	Neon
6.941	9.012											10.811	12.011	14.007	15.999	18.998	20.180
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
Sodium	Magnesium											Aluminum	Silicon	Phosphorus	Sulfur	Chlorine	Argon
22.990	24.305											26.982	28.086	30.974	32.066	35.453	39.948
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton
39.098	40.078	44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.38	69.723	72.631	74.922	78.971	79.904	84.798
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	I	Xe
Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon
85.468	87.62	88.906	91.224	92.906	95.94	98.906	101.07	102.905	106.42	107.868	112.411	114.818	118.710	121.757	127.603	126.905	131.29

Which of the atoms listed below has the largest Z_{eff} ?

- A) Na B) Be **C) F** D) Si

Periodic Table of the Elements

1																	18
1															2		
H															He		
Hydrogen															Helium		
1.008															4.003		
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
Lithium	Beryllium											Boron	Carbon	Nitrogen	Oxygen	Fluorine	Neon
6.941	9.012											10.811	12.011	14.007	15.999	18.998	20.180
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
Sodium	Magnesium											Aluminum	Silicon	Phosphorus	Sulfur	Chlorine	Argon
22.990	24.305											26.982	28.086	30.974	32.066	35.453	39.948
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton
39.098	40.078	44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.38	69.723	72.631	74.922	78.971	79.904	84.798
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	I	Xe
Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon
85.468	87.62	88.906	91.224	92.906	95.94	98.906	101.07	102.905	106.42	107.868	112.411	114.818	118.710	121.757	127.603	126.905	131.29

Which one in the following sets has higher ionization energy:

Na, Mg, Al

Answer:

same period (exception) → **Mg**

Periodic Table of the Elements

1																	18	
1				5	6	7	8	9	10									2
H Hydrogen 1.008				B Boron 10.811	C Carbon 12.011	N Nitrogen 14.007	O Oxygen 15.999	F Fluorine 18.998	Ne Neon 20.180									He Helium 4.003
3	4												13	14	15	16	17	18
Li Lithium 6.941	Be Beryllium 9.012												Al Aluminum 26.982	Si Silicon 28.086	P Phosphorus 30.974	S Sulfur 32.066	Cl Chlorine 35.453	Ar Argon 39.948
11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Na Sodium 22.990	Mg Magnesium 24.305	Sc Scandium 44.956	Ti Titanium 47.867	V Vanadium 50.942	Cr Chromium 51.996	Mn Manganese 54.938	Fe Iron 55.845	Co Cobalt 58.933	Ni Nickel 58.693	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.631	As Arsenic 74.922	Se Selenium 78.971	Br Bromine 79.904	Kr Krypton 84.738	
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K Potassium 39.098	Ca Calcium 40.078	Sc Scandium 44.956	Ti Titanium 47.867	V Vanadium 50.942	Cr Chromium 51.996	Mn Manganese 54.938	Fe Iron 55.845	Co Cobalt 58.933	Ni Nickel 58.693	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.631	As Arsenic 74.922	Se Selenium 78.971	Br Bromine 79.904	Kr Krypton 84.738	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb Rubidium 85.468	Sr Strontium 87.62	Y Yttrium 88.906	Zr Zirconium 91.224	Nb Niobium 92.906	Mo Molybdenum 95.94	Tc Technetium 98	Ru Ruthenium 101.07	Rh Rhodium 102.91	Pd Palladium 106.42	Ag Silver 107.87	Cd Cadmium 112.41	In Indium 114.82	Sn Tin 118.71	Sb Antimony 121.76	Te Tellurium 127.6	I Iodine 126.91	Xe Xenon 131.29	

Which of the elements listed below has the smallest first ionization energy?

A) C **B) Ge** C) P D) O E) Se

Periodic Table of the Elements

1																	18	
1				5	6	7	8	9	10									2
H Hydrogen 1.008				B Boron 10.811	C Carbon 12.011	N Nitrogen 14.007	O Oxygen 15.999	F Fluorine 18.998	Ne Neon 20.180									He Helium 4.003
3	4												13	14	15	16	17	18
Li Lithium 6.941	Be Beryllium 9.012												Al Aluminum 26.982	Si Silicon 28.086	P Phosphorus 30.974	S Sulfur 32.066	Cl Chlorine 35.453	Ar Argon 39.948
11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Na Sodium 22.990	Mg Magnesium 24.305	Sc Scandium 44.956	Ti Titanium 47.867	V Vanadium 50.942	Cr Chromium 51.996	Mn Manganese 54.938	Fe Iron 55.845	Co Cobalt 58.933	Ni Nickel 58.693	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.631	As Arsenic 74.922	Se Selenium 78.971	Br Bromine 79.904	Kr Krypton 84.738	
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K Potassium 39.098	Ca Calcium 40.078	Sc Scandium 44.956	Ti Titanium 47.867	V Vanadium 50.942	Cr Chromium 51.996	Mn Manganese 54.938	Fe Iron 55.845	Co Cobalt 58.933	Ni Nickel 58.693	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.631	As Arsenic 74.922	Se Selenium 78.971	Br Bromine 79.904	Kr Krypton 84.738	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb Rubidium 85.468	Sr Strontium 87.62	Y Yttrium 88.906	Zr Zirconium 91.224	Nb Niobium 92.906	Mo Molybdenum 95.94	Tc Technetium 98	Ru Ruthenium 101.07	Rh Rhodium 102.91	Pd Palladium 106.42	Ag Silver 107.87	Cd Cadmium 112.41	In Indium 114.82	Sn Tin 118.71	Sb Antimony 121.76	Te Tellurium 127.6	I Iodine 126.91	Xe Xenon 131.29	

Arrange the following elements in order of increasing ionization energy:

Mg, Al, Si, P, S, Ar

Same period → IE increases from left to the right with exception

1A < 3A < 2A < 4A < 6A < 5A < 7A < 8A

Al < Mg < Si < S < P < Ar

Ionization energy increases (with exceptions)

Ionization energy decreases

Periodic Table of the Elements

1 H Hydrogen 1.008	2 He Helium 4.003																
3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180										
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948										
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon

Circle the right answer for each:

Largest electron affinity: P S Cl

Smallest electron affinity: Kr, Br

Periodic Table of the Elements

1																	18
1																	2
3	4											13	14	15	16	17	18
11	12											13	14	15	16	17	18
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54

Order the following elements from smallest to largest in terms of electron affinity:

Cl, Si, Ca, P

A. Si < Ca < Cl < P

B. Ca < P < Si < Cl

C. P < Ca < Si < Cl

D. Ca < Si < P < Cl

EA increases from left to the right with exception

8A < 2A < 1A < 3A < 5A < 4A < 6A < 7A

Periodic Table of the Elements

1																	18
1																	2
3	4											13	14	15	16	17	18
11	12											13	14	15	16	17	18
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54


Arrange the following elements in order of increasing electronegativity:

Al, Si, P, S, F

electronegativity increases from left to the right

$\text{Al} < \text{Si} < \text{P} < \text{S} < \text{F}$

Electronegativity increases



Periodic Table of the Elements

1 H Hydrogen 1.008	2 He Helium 4.003																
3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180										
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948										
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon

Which one of the following has the smallest radius?

- A. P
- B. Na
- C. Br
- D. Cl

Order the following elements from largest to smallest in terms of ionization Energy:

Al, P, Ar, Na

- A. $\text{Ar} > \text{Na} > \text{P} > \text{Al}$
- B. $\text{Ar} > \text{P} > \text{Al} > \text{Na}$
- C. $\text{Ge} > \text{Ar} > \text{P} > \text{Al}$
- D. $\text{Ar} > \text{P} > \text{Na} > \text{Al}$

Which one of the following atoms has the largest radius?

- A. Sr
- B. I
- C. Ca
- D. Ba

The first ionization energies of the elements _____ as you go from left to right across a period of the periodic table, and _____ as you go from the bottom to the top of a group in the table.

- A. increase, increase
- B. increase, decrease
- C. decrease, increase
- D. decrease, decrease

Which of the following statements is false?

- A. A sodium atom has a smaller radius than a potassium atom.
- B. A neon atom has a smaller radius than an oxygen atom.
- C. A fluorine atom has a smaller first ionization energy than an oxygen atom.
- D. A cesium atom has a smaller first ionization energy than a lithium atom.

Which of the following atoms has the largest ionization energy?

- A. O
- B. Li
- C. Ne
- D. Be

Periodic Table of the Elements

1																	18
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
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19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon