

AP Questions: Periodicity

1970

Explain why in aqueous solution,

- (a) Ti^{3+} is colored but Sc^{3+} is not.
(b) Ti^{2+} is a reducing agent but Ca^{2+} is not.

1973 D

	First ionization Energy (kilocalories/mole)	Covalent Radii, Å
Li	124	1.34
Be	215	0.90
B	191	0.82
C	260	0.77
N	336	0.75
O	314	0.73
F	402	0.72

The covalent radii decrease regularly from Li to F, whereas the first ionization energies do not. For the ionization energies, show how currently accepted theoretical concepts can be used to explain the general trend and the two discontinuities.

1977 D

The electron affinities of five elements are given below.

${}_{13}\text{Al}$	12 kcal/mole
${}_{14}\text{Si}$	32 kcal/mole
${}_{15}\text{P}$	17 kcal/mole
${}_{16}\text{S}$	48 kcal/mole
${}_{17}\text{Cl}$	87 kcal/mole

Define the term “electron affinity” of an atom. For the elements listed above, explain the observed trend with the increase in atomic number. Account for the discontinuity that occurs at phosphorus.

1982 D

The values of the first three ionization energies (I_1 , I_2 , I_3) for magnesium and argon are as follows:

	I_1	I_2	I_3
	(kJ/mol)		
Mg	735	1443	7730
Ar	1525	2665	3945

- (a) Give the electronic configurations of Mg and Ar.
(b) In terms of these configurations, explain why the values of the first and second ionization energies of Mg are significantly lower than the values for Ar, whereas the third ionization energy of Mg is much larger than the third ionization energy of Ar.
(c) If a sample of Ar in one container and a sample of Mg in another container are each heated and chlorine is passed into each container, what compounds, if any, will be formed? Explain in terms of the electronic configurations given in part (a).
(d) Element Q has the following first three ionization energies:

	I_1	I_2	I_3
	(kJ/mol)		
Q	496	4568	6920

What is the formula for the most likely compound of element Q with chlorine? Explain the choice of formula on the basis of the ionization energies.

1985 D

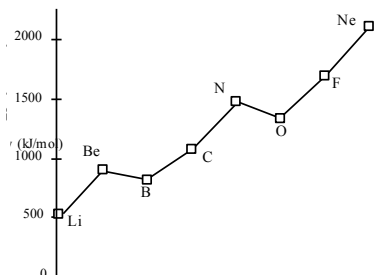
Properties of the chemical elements often show regular variation with respect to their positions in the periodic table.

- (a) Describe the general trend in acid-base character of the oxides of the elements in the third period (Na to Ar). Give examples of one acidic oxide and one basic oxide and show with equations how these oxides react with water.
(b) How does the oxidizing strength of the halogen elements vary down the group? Account for this trend.
(c) How does the reducing strength of the alkali metals vary down the group? Account for this trend.

1987 D

Use the details of modern atomic theory to explain each of the following experimental observations.

- Within a family such as the alkali metals, the ionic radius increases as the atomic number increases.
- The radius of the chlorine atom is smaller than the radius of the chloride ion, Cl^- . (Radii : Cl atom = 0.99\AA ; Cl^- ion = 1.81\AA)
- The first ionization energy of aluminum is lower than the first ionization energy of magnesium. (First ionization energies: ${}_{12}\text{Mg} = 7.6\text{ eV}$; ${}_{13}\text{Al} = 6.0\text{ eV}$)
- For magnesium, the difference between the second and third ionization energies is much larger than the difference between the first and second ionization energies. (Ionization energies for Mg: $1^{\text{st}} = 7.6\text{ eV}$; $2^{\text{nd}} = 14\text{ eV}$; $3^{\text{rd}} = 80\text{ eV}$)

1990 D

The diagram shows the first ionization energies for the elements from Li to Ne. Briefly (in one to three sentences) explain each of the following in terms of atomic structure.

- In general, there is an increase in the first ionization energy from Li to Ne.
- The first ionization energy of B is lower than that of Be.
- The first ionization energy of O is lower than that of N.
- Predict how the first ionization energy of Na compares to those of Li and of Ne. Explain.

1993 D

Account for each of the following in terms of principles of atom structure, including the number, properties, and arrangements of sub-atomic particles.

- The second ionization energy of sodium is about three times greater than the second ionization energy of magnesium.
- The difference between the atomic radii of Na and K is relatively large compared to the difference between the atomic radii of Rb and Cs.
- A sample of nickel chloride is attracted into a magnetic field, whereas a sample of solid zinc chloride is not.
- Phosphorus forms the fluorides PF_3 and PF_5 , whereas nitrogen forms only NF_3 .

1994 D

Use principles of atomic structure and/or chemical bonding to answer each of the following.

- The radius of the Ca atom is 0.197 nanometer; the radius of the Ca^{2+} ion is 0.099 nanometer. Account for this difference.
- Explain the difference between Ca and K in regard to
 - their first ionization energies,
 - their second ionization energies.
- The first ionization energy of Mg is 738 kilojoules per mole and that of Al is 578 kilojoules per mole. Account for this difference.

1997 D

Explain each of the following observations using principles of atomic structure and/or bonding.

- Potassium has a lower first-ionization energy than lithium.
- The ionic radius of N^{3-} is larger than that of O^{2-} .
- A calcium atom is larger than a zinc atom.
- Boron has a lower first-ionization energy than beryllium.