

1997 D

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

- (a) Potassium has a lower first-ionization energy than lithium.
- (b) The ionic radius of  $\text{N}^{3-}$  is larger than that of  $\text{O}^{2-}$ .
- (c) A calcium atom is larger than a zinc atom.
- (d) Boron has a lower first-ionization energy than beryllium.

1994 D

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

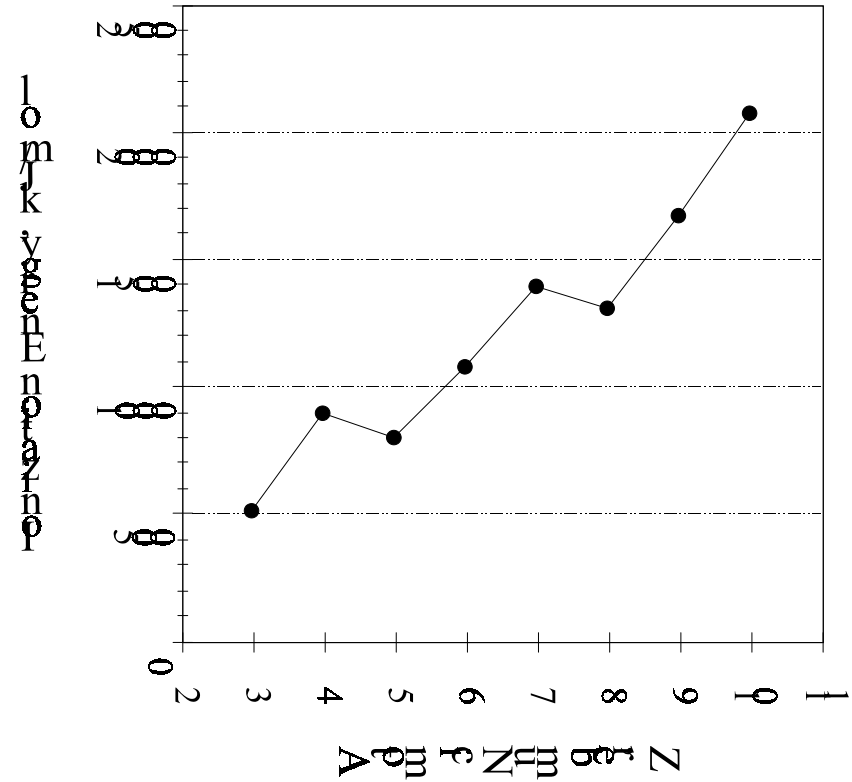
- (a) The radius of the Ca atom is 0.197 nanometer; the radius of the  $\text{Ca}^{2+}$  ion is 0.099 nanometer. Account for this difference.
- (b) The lattice energy of  $\text{CaO}(s)$  is -3,460 kilojoules per mole; the lattice energy for  $\text{K}_2\text{O}(s)$  is -2,240 kilojoules per mole. Account for this difference.

Ionization Energy	First	Second
K	419 kJ/mol	3,050 kJ/mol
Ca	590 kJ/mol	1,140 kJ/mol

- (c) Explain the difference between Ca and K in regard to
- their first ionization energies,
  - their second ionization energies.
- (d) The first ionization energy of Mg is 738 kilojoules per mole and that of Al is 578 kilojoules per mole. Account for this difference.

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.

1987 D

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

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

1987 D

Two important concepts that relate to the behavior of electrons in atom systems are the Heisenberg uncertainty principle and the wave–particle duality of matter.

- (a) State the Heisenberg uncertainty principle as it related to the determining the position and momentum of an object.
- (b) What aspect of the Bohr theory of the atom is considered unsatisfactory as a result of the Heisenberg uncertainty principle?
- (c) Explain why the uncertainty principle or the wave nature of particles is not significant when describing the behavior of macroscopic objects, but it is very significant when describing

the behavior of electrons.

1980 D

- (a) Write the ground state electron configuration for an arsenic atom, showing the number of electrons in each subshell.
- (b) Give one permissible set of four quantum numbers for each of the outermost electrons in a single As atom when it is in its ground state.
- (c) Is an isolated arsenic atom in the ground state paramagnetic or diamagnetic? Explain briefly.
- (d) Explain how the electron configuration of the arsenic atom in the ground state is consistent with the existence of the following known compounds:  $\text{Na}_3\text{As}$ ,  $\text{AsCl}_3$ , and  $\text{AsF}_5$ .

1981 D

The emission spectrum of hydrogen consists of several series of sharp emission lines in the ultraviolet (Lyman series) in the visible (Balmer series) and in the infrared (Paschen series, Brackett series, etc.) regions of the spectrum.

- (a) What feature of the electronic energies of the hydrogen atom explains why the emission spectrum consists of discrete wavelength rather than a continuum wavelength?
- (b) Account for the existence of several series of lines in the spectrum. What quantity distinguishes one series of lines from another?
- (c) Draw an electronic energy level diagram for the hydrogen atom and indicate on it the transition corresponding to the line of lowest frequency in the Balmer series.
- (d) What is the difference between an emission spectrum and an absorption spectrum? Explain why the absorption spectrum of atomic hydrogen at room temperature has only the lines of the Lyman series.

