

AP Questions: Atomic Theory

1978 D

The postulates of the Bohr model of the hydrogen atom can be stated as follows:

- (I) The electron can exist only in discrete states each with a definite energy.
 - (II) The electron can exist only in certain circular orbits.
 - (III) The angular momentum of the electron is $nh/2\pi$ where n is any positive integer.
 - (IV) Radiation is emitted by the atom only when an electron makes a transition from a state of higher energy to one of lower energy.
- (a) State whether each of these postulates is currently considered to be correct, according to the wave mechanical description of the hydrogen atom.
 - (b) Give the wave mechanical description that has replaced one of the postulates now considered to be incorrect.

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: Na_3As , AsCl_3 , and 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.

1984 C

Discuss some differences in physical and chemical properties of metals and nonmetals. What characteristic of the electronic configurations of atoms distinguishes metals from nonmetals? On the basis of this characteristic, explain why there are many more metals than nonmetals.

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.

1999 B

Answer the following questions regarding light and its interactions with molecules, atoms, and ions.

- (a) The longest wavelength of light with enough energy to break the Cl–Cl bond in $\text{Cl}_2(g)$ is 495 nm.
- Calculate the frequency, in s^{-1} , of the light.
 - Calculate the energy, in J, of a photon of the light.
 - Calculate the minimum energy, in kJ mol^{-1} , of the Cl–Cl bond.
- (b) A certain line in the spectrum of atomic hydrogen is associated with the electronic transition of the H atom from the sixth energy level ($n = 6$) to the second energy level ($n = 2$).
- Indicate whether the H atom emits energy or whether it absorbs energy during the transition. Justify your answer.
 - Calculate the wavelength, in nm, of the radiation associated with the spectral line.
 - Account for the observation that the amount of energy associated with the same electronic transition ($n = 6$ to $n = 2$) in the He^+ ion is greater than that associated with the corresponding transition in the H atom.

2000 D

Answer the following questions about the element selenium, Se (atomic number 34).

- (a) Samples of natural selenium contain six stable isotopes. In terms of atomic structure, explain what these isotopes have in common, and how they differ.
- (b) Write the complete electron configuration (*e.g.*, $1s^2 2s^2 \dots$ etc.) for a selenium atom in the ground state. Indicate the number of unpaired electrons in the ground-state atom, and explain your reasoning.
- (c) In terms of atomic structure, explain why the first ionization energy of selenium is
- less than that of bromine (atomic number 35), and
 - greater than that of tellurium (atomic number 52).
- (d) Selenium reacts with fluorine to form SeF_4 . Draw the complete Lewis electron-dot structure for SeF_4 and sketch the molecular structure. Indicate whether the molecule is polar or nonpolar, and justify your answer.