2018

CHEMISTRY

(Major)

Paper : 3.1

(Structure and Bonding)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following questions : 1×7=7

(a) The second line of the Balmer series occurs at wavelength of 486·13 nm. To which transition can we attribute this line?

(b) What do you mean by ultraviolet catastrophe?

(c) What are the values of the n, l, and m_l quantum numbers that describe the $5f$ orbitals?

(d) What will be the wave functions for each of the following canonical forms?

$$\underset{(i)}{H:H} \leftrightarrow \underset{(ii)}{\overset{+1}{H}\ \ddot{H}^{(-1)}} \leftrightarrow \underset{(iii)}{\overset{(-1)}{\ddot{H}}\ \overset{(+1)}{H}}$$

(e) Write the two resonating forms of NO_2^- ion.

(f) What is meant by tunneling effect in quantum mechanics?

(g) Relate the wavelength of a photon to its mass.

2. Answer the following questions : 2×4=8

(a) State the postulates of Planck's quantum theory.

(b) Give one logical explanation to differentiate between micro- and macro-particles.

(c) Comment on the low dipole moment of CO molecule based on its three canonical forms.

(d) How do dipole moment values help us to distinguish among *ortho*-, *meta*- and *para*-isomers?

3. Answer any *three* questions : 5×3=15

(a) Discuss the wave characteristic of an electron with an experiment. What is the wavelength of an electron moving with a velocity of $8 \cdot 5 \times 10^7$ ms^{-1}?

(b) Deduce the Schrödinger wave equation on the basis of classical wave concept. What is the significance of the wave function ψ?

(c) The wave function of an electron in an atom is given by $\psi = e^{-r/a_0}$, where r is the distance of the electron from the nucleus and a_0 is the Bohr radius. Calculate the relative probability of

finding the electron inside a region of volume $0 \cdot 1\,(pm)^3$ if the electron is located—

(i) at the nucleus;

(ii) at a distance a_0 from the nucleus.

(d) Draw all the possible resonating structures of isoelectronic SCN^- and CNO^- ions and with the help of formal charges on each atom of these structures, find the most stable ones in each of them.

(e) Calculate the percent ionic character of HCl molecule if experimental value of dipole moment of this molecule is 1·03 D. Given that bond length of HCl is 1·275 Å and the charge of the electron is $4 \cdot 8 \times 10^{-10}$ e.s.u.

4. Answer any *three* questions : 10×3=30

(a) *(i)* What is the basis of Pauling's scale of electronegativity? Discuss. Calculate electronegativity of C in C—H bond if E_{C-H}, E_{H-H} and E_{C-C} are 98·8, 104 and 83 kcal/mol respectively. 4+2=6

(Continued)

(ii) Explain with the example how hybridization affects electro-negativity. 3

(iii) What do you mean by group electronegativity? 1

(b) (i) What are quantum numbers? Name different types of quantum numbers and their significance. 1+4=5

(ii) Write notes on the following : 2½+2½=5

(1) Rayleigh-Jeans radiation

(2) Bent rule

(c) Discuss the characteristics of acceptable wave function clearly explaining the conditions of acceptance.

Calculate the wavelengths of first two lines of the visible region of the hydrogen atomic spectrum. 5+5=10

(d) How will you make distinction between—

(i) photon and quantum;

(ii) continuous spectrum and line spectrum?

Calculate the uncertainty in position of a baseball thrown at 90 miles per hour if we measure its velocity to a millionth of 1%. 5+5=10

(e) Define resonance and resonance energy by taking suitable example. Is it possible to trap a resonance structure of a molecule or ion for study? How can we find the most stable canonical forms out of many? Explain with the help of proper example. 5+2+3=10

(f) (i) Calculate the kinetic energy of photoelectron ejected from a platinum surface when light of wavelength 200 nm is incident in it. The work function of platinum is 5 eV. 3

(ii) Show that $\sin nx$ is an eigenfunction of operator $\frac{d^2}{dx^2}$ but not of $\frac{d}{dx}$. Find the corresponding eigenvalues. 4

(iii) Find the de Broglie wavelength of an electron travelling at 1% of the speed of light. 3

★★★