Chapter 6...Chemical-Bonding

SHORT QUESTION WITH ANSWERS

Q.1 Dipole moments of chlorobenzene is 1.70 D and of chlorobenzene is 2.5 D while that of paradichlorbenzene is zero; why?

Ans.

Benzene has zero dipole moment as it is a symmetrical planar hexagonal molecule. The substitution of benzene ring with two Cl–atoms at the para positions does not add any dipole moment to the benzene as the dipoles created being equal and opposite cancel out each other's effect. As, there is no such cancellation in monochlorobenzene. These molecules have resultant dipole moments of 1.70 D and 2.5 D respectively.

Q.2 What is covalent bond?

Ans.

A chemical bond formed by the sharing of a pair of electrons between atoms is called covalent bond.

$H + H \rightarrow H - H$

Q.3 What is meant by a coordinate covalent bond?

Ans.

A coordinate covalent bond is for a bond formed, when both electrons of the bond are denoted by one atom.

Q.4 What is the difference between a localized π bond and a delocalized one?

Ans.

In a localized π bond, the electron density is concentrated between the two atoms forming the bond. In a delocalized π bond, the electron density is spread over all the atoms that contribute p orbitals to the net work.

Q.5 How will you differentiate between a polar covalent bond and non–polar covalent bond?

Ans.

A covalent bond between two dissimilar atoms in which the shared electron pair is not attracted equally by the two atoms and the bonded atoms acquire a partial positive and negative charge is called polar covalent bond.

A covalent bond between two like atoms such as H–H, Cl–Cl, in which shared electron pair is attracted equally by both the atoms is called a non–polar covalent bond.

Q.6 Indicate the hybridization and bond angles associated with each of the following (a) linear (b) tetrahedral (c) trigonal planar.

Ans.

(a) Sp. 180o (b) Sp3. 109o (c) Sp2. 120o

Q.7 What are the similarities and differences between atomic orbitals and molecular orbitals?

Ans.

Both atomic and molecular orbitals have a characteristic energy and shape each can hold a maximum of the two electrons. Atomic orbitals are localized and their energies are the result of interactions between the subatomic particles in a single atom. Molecular orbitals can be delocalized and their energies are influenced by interactions between electrons on several atoms.

Q.8 Why is the bonding molecular orbital of H2 at lower energy than the electron in a hydrogen atom?

Ans.

There is a net lowering in energy that accompanies bond formation because the electrons in H2 are strongly attracted to both H nuclei, while in H–atom the electron is attracted by only one nucleus.

Q.9 How many electrons can be placed into each molecular orbital of a molecule?

Ans.

Two electrons can be placed into each molecular orbital of a molecule.

Q.10 What is meant by an ionic bond?

Ans.

An ionic bond is a chemical bond formed by the electzostatic attraction between positive and negative ions. The bond formed between two atoms when one or more electrons are transformed from valence shell of one atom to the valence shell of the other. The atom that loses electrons becomes cation and the atom that gains electrons becomes anion. The electronic configurations of both ions are those of noble gas atoms. All metals react with non–metals to form ionic compounds.

$Na(g) \rightarrow Na^+ + e^-$

$Cl(g) + e^- \rightarrow Cl^-(g)$

$Na^+(g) + Cl^-(g) \rightarrow NaCl$

Q.11 Can a molecule have polar bonds and not a dipole?

Ans.

Yes a molecule can have polar bonds and not a dipole, if the orientation of the polar bonds in the molecule cancel each other's effect e.g. CO2.

Q.12 Can a molecule have non–polar bonds only and have a dipole?

Ans.

No. A molecule which have non–polar bonds only cannot have a dipole.

Q.13 State the difference between a polar bond and a polar molecule.

Ans.

A polar bond is a covalent bond that exists between two atoms having an electronegativity difference greater than 0.2 a polar molecule results, if one or more polar bonds in a molecule is not balanced by other polar bonds in the

Q.14 According to molecular orbital theory, would Be2 be expected to exist? Explain.

Ans.

Be2 is not expected to exist, it has bond order of zero and is not energetically favoured over isolated Be atoms.

Q.15 What is meant by bond order?

Ans.

The bond order is half the difference between the number of bonding electrons and the number of antibonding electrons.

Bond order =

(No. of bonding electrons – No. of antibonding electrons)

Q.16 What is meant by paramagnetic substance?

Ans.

A paramagnetic substance is a substance that is attracted by a magnetic field and this attraction is generally the result of unpaired electrons. The more unpaired electrons in a species (substance), the stronger the force of attraction. This type of magnetic behaviour is called paramagnetism.

Q.17 What is meant by a diamagnetic substance?

Ans.

A diamagnetic substance is a substance that is not attracted by a magnetic field. This property is called diamagnetism. This property generally means that substance has only paired electrons.

Q.18 (a) what is hybridization at carbon atom in CH4, C2H4 and C2H2.

(b) The carbon atom in CH4 cannot participate in multiple bonding, whereas that is C2H4 can. Explain.

Ans.

(a) The hybridization at the carbon atom in CH4 is Sp3, in C2H4 is sp2 and in C2H2 is sp.

(b) The C atom in CH4 is sp3 hybridized, there are no un–hybridized p orbitals, available for the π overlap required for multiple bonds. In C2H4, the C atom is sp2 hybridized with two p atomic orbitals (one on each C atom), available to form the π overlap in the C = C double bond.

Q.19 Describe briefly the VSEPR theory.

Ans.

The VSEPR theory predicts the shape of molecules and ions in which valence shell electron pairs are arranged around the central atom of a molecule or ions in

such a way that there is maximum separation so that electron repulsions are minimized and electron nucleus attractions are maximized. Some of these electron pairs are bonding and some are lone pairs. The direction in space of the bonding pairs gives the molecular geometry. A lone pair of electrons occupy more space than a bonding pair. Repulsive forces decrease sharply with increasing interpair angle. They are strong at 90o much weaker at 120o and very weak at 180o. in VSEPR model, each multiple bond is treated as though it were a single electron pair.

Q.20 A lone pair of electrons occupies more space than a bond pair?

Ans:

A lone pair of electrons occupies more space than bond pair because lone pair is attracted by only one nucleus while bond pair is attracted by two nuclei. Due to less nuclear attraction to lone pair its electronic charge is spread ot more in space than that of bond pair.

Q.21 Predict the geometry of (a) BeCl2 (b) BF3 (c) SiH4 molecules.

Ans.

(a) The two bond pairs of electrons in BeCl2 molecule arrange themselves as far apart as possible to minimize the repulsion between them. The only arrangement which can satisfy this condition is linear i.e. at angle of 180o.

: Cl —— — Cl

(b) The BF3 molecule containing three bond pairs of electrons is trigonal planar because, this structure gives maximum separation among the three bonding electron pairs.

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(c) In SiH_4 molecule, the electrostatic repulsion between four bonding electron pairs will be minimum, when they are present at corners of a regular tetrahedron making angle 109.5o with each other.

Q.22 Describe briefly the valence bond theory.

Ans.

According to valence bond theory, a covalent bond is formed by pairing of electrons by the overlap of half (partially) filled atomic orbitals of two atoms. The two overlapping orbitals must be valence orbitals, must be half filled and must retain their identities. By overlap means that the electrons of overlapping orbitals share a common region of high electron density, along the line between two nuclei called bond axis.

This theory explains the bonding in terms of overlapping of atomic orbitals and mixing of atomic orbitals called hybridization. Multiple bond occurs via the overlap of atomic orbitals to give σ bonds and π bonds.

Q.23 Why monoatomic cations smaller than their corresponding neutral atoms?

Ans.

Electrostatic repulsions are reduced by removing an electron from a neutral atom, effective neutral charge increases and therefore the cation is smaller than their corresponding neutral atoms.

Q.24 Why are monoatomic anions larger than their corresponding neutral atoms?

Ans.

The additional electrostatic repulsion produced by adding an electron to a neutral atom decreases the effective nuclear charge experienced by the valence electrons and increases the size of anions.

Q.25 Why does the size of ions increase as one produced down a column in the periodic table?

Ans.

Going down a column, valence electrons are further from the nucleus and they experience greater shielding by core electrons. The greater radial extent of the valence electrons outweigh the increase in atomic number. Therefore the size of ions increase as one proceeds down a column.

Q.26 What is an isoelectronic series?

Ans.

An isoelectronic series is a group of atoms or ions that have the same number of electrons, and thus the same electronic configuration.

Q.27 Why noble gases are most stable?

Ans.

Noble gases are most stable because their s and p orbitals are completely filled.

Q.28 Why O2 molecule is paramagnetic in nature?

Ans.

O2 molecule is paramagnetic in nature due to presence of unpaired electrons in its molecule.

Q.29 Why CO2 is non–polar molecule although C–O bond is polar?

Ans.

Each C–O bond in CO2 is polar. The two bond dipoles in CO2 are equal in magnitude and are exactly opposite in direction. The bond dipoles cancel each other. Therefore, the overall dipole moment of CO2 is zero. Thus CO2 is a non–polar molecule.

$O^{\delta-} = C = O^{\delta+}$

Q.30 Why H2O is a polar molecule?

Ans.

H2O is a bent molecule with two polar bonds. Both the bonds are identical, so the bond dipoles are equal in magnitude. Because the molecule is bent, however the bond dipoles do not directly oppose to each other and therefore, do not cancel each other.

Hence the H2O molecule has an overall dipole moment
($\mu = 1.85D$), because H2O has dipole moment, it is polar molecule.

Q.31 The melting and boiling points of electrovalent compounds are very high as compared with those of covalent compounds. Explain.

Ans.

The melting and boiling points of electrovalent compounds are very high, because the ions are tightly packed in the crystal lattice by strong attractive forces and high thermal energy is required to separate them from one another. The atoms of molecules in covalent compounds are held together by weak intermolecular forces and less energy is required to separate the atoms or molecules in a solid or liquid.

Q.32 (a) Why solid NaCl does not conduct electricity?

(b) What will happen if electric currents is passed through molten NaCl or its aqueous solution? Explain.

Ans.

(a) Solid NaCl does not conduct electricity because the oppositely charged ions are held together by strong electrostatic forces and the ions do not free to move.

(b) However, in the molten NaCl or its aqueous solution the ions because quite free to migrate in an electric field and conduct electricity when passed through them.

Q.33 What is molecular orbital theory?

Ans.

According to molecular orbital theory, atomic orbitals overlap to form molecular orbitals n atomic orbitals combine to form n molecular orbitals. Half of them are bonding molecular orbitals and half antibonding molecular orbitals. In this combination, the individual atomic orbital character is lost in order to form an entirely new orbital that belongs to whole molecule. The theory successfully explains bond order and paramagnetic property of O2.

Q.34 In many cases, the distinction between a coordinate covalent and a covalent bond vanishes after bond formation. Explain with the help of an example.

Ans.

A coordinate covalent bond is not essentially different from other covalent bonds, it involves the sharing of pair of electrons between two atoms. An example is formation of NH4+ ion in which all bonds are identical, so the distinction between a coordinate covalent bond and covalent bond vanishes after bond formation.

$H^+ + :NH_3 \rightarrow \quad H - \rightarrow H^+$

or

Q.35 PF3 is a polar molecule with dipole moment 1.02 D and thus the P–F bond is polar. Si, being in proximity of P in the periodic table, it is expected that Si–F bond would also be polar, but SiF4 has no dipole moment. Explain why it is so?

Ans.

PF3 has one lone pair of electrons and one P atom lies out of plane of rest of the atom and thus PF3 is pyramidal molecule and has 1.02 D dipole moment and thus the P–F bond is polar.

SiF4 molecular has tetrahedral shape and the SiF bonds are directed by Symmetrically about the central Si atom. Although Si–F bonds are polar, but all the four bond moments cancel out one another and give SiF4 molecule of zero dipole moment.

Q.36 NaCl is a harder substance at room temperature than glucose explain.

Ans.

The hardness of substance depends on the strength of the forces between the particles forming a substance. NaCl is an ionic compound and consists of Na+ and

Cl– ions which are held together by strong electrostatic forces of attraction while glucose consists of molecules which are held together by weak intermolecular forces. Therefore, NaCl is a harder substance at room temperature than glucose.

Q.37 The linear of $BeCl_2$ suggests that central Be atom is sp–hybridized. What type of hybridization a central atom undergoes when the atoms bonded to it are located at the corners of (a) an equilateral triangle and (b) a regular tetrahedron.

Ans.

(a) The central atom undergoes Sp^2 hybridization when the atoms bonded to it are located at the corners of an equilateral triangle.

(b) The central atom undergoes Sp^3 hybridization when the atoms bounded to it are located at the corners of a regular tetrahedron.

Q.38 A double bond is shorter and stronger than a single bond.

Ans.

The greater the number of electron pairs in the bond, the shorter and stronger will be the bond because of greater nuclei–electron attractions. A double bond has two shared electron pairs, while a single bond has only one shared electron pair. Thus a double bond has a greater nuclei electron attraction, than a single bond. Therefore, a double bond is shorter and stronger than a single bond.

Q.39 NH_3 and H_2O can form coordinate covalent bond with H^+ but CH_4 cannot do so.

Ans.

NH_3 and H_2O both have lone pair of electrons on N and O atoms which can donate to a H^+ (electron deficient) to from a coordinate covalent bond. In CH_4 there is no lone pair of electrons to donate H^+ for the formation of coordinate covalent bond. Therefore, NH_3 and H_2O can form coordinate covalent bond with H^+ but CH_4 cannot do so.

$$H_3N: + H^+ \rightarrow [H_3N \rightarrow H]^+$$

$$H_2O + H^+ \rightarrow H_3O \rightarrow [H_2O^+ \rightarrow H]^+$$

Q.40 Covalent bond may be non–polar but coordinate covalent bond is always polar.

Ans.

A covalent bond between two like atoms is always non–polar, whereas between two unlike atoms, it is a polar. In coordinate covalent bond the shared electron pair is denoted by only one of the two bonded atoms. The atom which denotes the electron pair acquires partial positive charge and the atom which accepts the electron pair acquires partial negative charge. Therefore, coordinate covalent bond is always polar. Hence a covalent bond may be non–polar, but coordinate covalent bond is always polar.

Q.41 Molecule of O2 is paramagnetic in nature. Explain.

Ans.

A substance is paramagnetic, when it has unpaired electrons.

According to molecular orbital theory, O2 has two unpaired electrons in the degenerate orbitals π2 py and π*2 px. Due to the presence of these two unpaired electrons O2 molecule is paramagnetic.

Q.42 Dipole moment of CO2 is zero but that of CO is o.12 Debye.Why?

Ans:

CO_2 is a linear molecule and the tow diploes cancel the effect of each other. In CO there is a single dipole directed from carbon to oxygen and it not cancelled.

Q.43 Why dipole moment of benzene is zero?

Ans:

Benzene is symmetrical planar molecule. It has six C – H there are six dipole moments. All the dipole moments cancel the effect of each other and net value is zero.

Q.44 I.E is index of metallic character why?

Ans:

Metals have loosely held electrons which are delocalized and are responsible for the properties of metals. So, metals have low ionization energies.

Q.45 The abnormality of the bond length and bond strength in HI is less prominent than that of HCl, give reason?

Ans:

Chlorine has higher electronegative than iodine. So, the polarities of HCI and HI bonds are unequal. Therefore, abnormality of bond length and bond strength of HCI is more prominent than HI.

Q.46 How does electro negativity difference decide the nature of ionic bond?

Ans:

When the electro negativity difference between two bonded atoms is 1.7 or move than that, then the bond is said to be ionic, otherwise, covalent. The % age of ionic character is more the 51% when the electro negativity difference is 1.7.

Q.47 Why NH_3 and PH_3 give coordinate covalent bond?

Ans:

NH_3 and PH_3 have lone pairs of electrons, which can be donated to H+ to make a coordinate covalent bond. In this way, NH_4^+ and PH_4^+ are produced which have perfect tetrahedral structure and all the four bonds have perfectly equal status.

Q.48 Most of the elements of the periodic table attain the electronic configuration of inert gases during bond formation. Justify it

Ans:
Inert gases are not reactive due to complete octet except He, Most of the S- and P-block elements may attain eight electrons in the outermost orbitals they do so either by losing gaining or sharing the electrons.

Q.49 Define octet rule?
Ans:
The tendency of the atoms to attain a maximum of eight electrons in the valence shell is called octet rule.

Q.50 What is an ionic radius?
Ans:
The ionic radius of an ion is the radius of the ion while considering it to be spherical in shape.

Q.51 What is a covalent radius?
The covalent radius of an element is defined as half of the single bond length between tow similar atoms covalently bonded in a molecule.

Q.52 What is difference between sigma & pi bond?
Ans:

SIGMA BOND:
The bond which is formed by the head to head overlapping called sigma bond. The electron density is present between two nuclei.

Pi BOND:
The bond which is formed by the sideways overlapping of two half filled orbitals. The electron density is present above and below the line joining the two nuclei.

Q.53 Why the size of an atom can not be measured directly?
Ans:
The size of an atom can not be measured directly due following reasons:
(i)There is no sharp boundary of an atom. The probability of finding an electron never becomes zero even at larger distances from the nucleus.
(ii) The electronic probability distribution is affected by neighbouring atoms. For this reason the size of an atom may change from one compound to another.

Q.54 Why E.A of Flourine is less than the expected value?
Ans
Since the size of fluorine is very small when electron is added in the fluorine it is strongly repelled by the already existing electrons. An extra amount of energy is

provided to add an electron therefore its electron affinity is less than the expected value.

Q.55 Why sigma bond is stronger than pi bond? Or Why pi bond is more diffused than sigma bond?

Ans:

Sigma bond is more diffused than pi bond due to the linear overlapping of orbitals. Moreover electron density is present between two nuclei which is strongly attracted by two nuclei. While in pi bond electron density is not strongly attracted by two nuclei therefore it is weak than pi bond

Q.56 Define bond length.

Ans.

The distance between the nuclei of two atoms forming a covalent bond is called bond length. In general it is the sum of the covalent radii of the combined atoms.

Q.57 What is dipole moment? What are its units?

Ans.

The dipole moment may be defined as the product of electric charge (q) and distance (r) between the two oppositely charged centres. It is vector quantity as it has magnitude and direction. It plays a major role in determining the % age ionic character of a covalent bond and the shapes of molecules.

The dipole moment is measured in Debye units (D). It is denoted by symbol μ.

Q.58 Define bond energy Give its units.

Ans.

The bond energy is defined as the average amount of energy required to break all bonds of particular type in one mole of substance. It is determined by measuring the heat involved in a chemical reaction.

It is also defined as the energy required to break Avogadro's number (6.02 x 1023) of bonds or the energy released when an Avagadro number of bonds are formed. It is a measure of strength of bonds. The bond energy is measured in KJ mol–1.

Q.59 Define the following terms.

(a) Ionization energy

(b) Electron affinity

(c) electronegativity

Ans.

(a) Ionization energy:

The minimum amount of energy required to remove an electron from an atom is called ionization energy.

It depends upon the atomic size, nuclear charge and shielding effect of electrons.

(b) Electron Affinity:

The minimum amount of energy released when an electron is added to an isolated neutral gaseous atom in the lowest energy state to produce an anion is called electron affinity. It is measured in kJ mol–1.

(c) Electronegativity:

The tendency of an atom to attract shared pair of electron towards itself is called electronegativity. It is measured in electron volts.