8. CHEMICAL BONDING

LATTICE ENTHALPY, CRYSTAL STRUCTURES, FAJAN'S RULES, POLARIZINGPOWER

SOLUTIONS

TEACHING TASK

JEE MAIN LEVEL QUESTIONS

1. When does the transition from an ionic bond to a covalent bond primarily occur?

A) When the electronegativity difference between the bonded atoms is small.
B) When the electronegativity difference between the bonded atoms is large.
C) When the atoms forming the bond are of the same element.
D) When the bond length is shorter.
Answer:A

Solution:The transition occurs when the electronegativity difference between the bonded atoms decreases. For small differences, electron sharing (covalent character) increases.

2.In the transition from an ionic bond to a covalent bond, what factor contributes most significantly to the increased covalency?

A) Decrease in atomic size B) Increase in atomic size
C) Decrease in electronegativity difference
D) Increase in electronegativity difference
Answer:C

Solution:Increased covalency is primarily due to a decrease in electronegativity difference, leading to more electron sharing.

3.What happens to the degree of polarization as an ionic bond transitions to a covalent bond?

A) It decreases B) It increases C) It remains constant D) It becomes zero
Answer:B

Solution:Polarization (distortion of the electron cloud) increases as the bond becomes more covalent, especially with smaller cations and larger anions (per Fajan's rules).

4.Which of the following factors contributes to the validity of Fajan's Rules?

a) Lattice energy. b) Ionic size.
c) Ionization energy. d) Electronegativity
Answer:B

Solution:Fajan's rules relate to covalent character in ionic bonds and depend on:
Size of the cation (smaller cation has higher polarizing power)
Size of the anion (larger anion is more polarizable)
Charge on the ions (higher charge increases polarization)

5.In which of the following pairs, would the compound with more covalent character exhibit a greater deviation from the octet rule?
a) NaCl and $MgCl_2$ b) $MgCl_2$ and $AlCl_3$
c) $AlCl_3$ and $SiCl_4$ d) $SiCl_4$ and PCl_5
Answer:B
Solution:$AlCl_3$ (more covalent) deviates strongly from octet (electron-deficient) vs ionic $MgCl_2$.

6.Many ionic compounds have some covalent ability due to
a) electron polarization b) ion polarization
c) charge polarization d) proton polarization
Answer:B
Solution:Many ionic compounds have some covalent ability due to polarization of the anion by the cation, distorting the electron cloud.

7.The value of lattice energy is affected by
a) size and charge of ions b) size of ions only
c) charge of ions only d) mass of ions
Answer:A
Solution:Lattice energy depends on both charge and size of ions.

$$\text{Lattice energy} \alpha \frac{q_+ q_-}{r_1 + r_2}$$

8.Lattice energy is inversely proportional to sum of radii of
a) cation only b) anion only c) anion and cation d) ions
Answer:C
Solution:Inversely with the sum of cation + anion radi

$$\text{Lattice energy} \alpha \frac{q_+ q_-}{r_1 + r_2}$$

9.Select correct statement
a) Cations with 18 electron shells have greater polarising power than the cations with 8-electron shells.
b) Inner shell electrons have a poor shielding effect on the nucleus and thus electronegativity of the 18 electron shell is increased.
c) CuCl is covalent and NaCl is ionic
d) All are correct statements
Answer:D
Solution:a) Cations with 18-electron shells (e.g., Cu^+) have greater polarizing power than those with 8-electron shells (e.g., Na^+) due to poorer shielding.
b) Inner shell electrons (d-electrons) have poor shielding, increasing effective nuclear charge and electronegativity.
c) CuCl is covalent (due to small Cu+ with 18-electron shell) and NaCl is ionic.

All are correct.

10.The melting point of AgCl is only 455°C, while that of KCl is 776°C although crystal radii of both the cations are almost the same. Choose the best response.
1. True 2. False
3. Both compounds will have close melting point values.
4. A conclusion cannot be made.
Answer:A
Solution:AgCl has lower mp than KCl because Ag^+ (18e) gives more covalent character $\rightarrow$ lower lattice energy

12.According to Fajan's rules, the covalent nature of ionic compounds is favoured by
A) Large cation and small anion B) Large cation and large anion
C) Small cation and large anion D) Small cation and small anion
Answer:C
Solution:Covalent character increases with:
Small cation (high polarizing power)
Large anion (high polarizability)

13. The order of covalent nature for aluminium halides is $AlF_3 < AlCl_3 < AlBr_3 < AlI_3$.
The best explanation according to Fajan's rules is:
A) Al^{3+} is larger in size and hence it has greater polarizing power.
B) The polarizability of halide ions increases with increase in their size and hence the covalent nature also increases.
C) The polarizability of halide ions decreases with increase in their size and hence the covalent nature decreases.
D) Th e gi ven or d er of coval en t n at u r e i s d u e t o gr eat er p ol ar i zi n g p ow er of Al^{3+} ion.
Answer:B
Solution:The polarizability of the halide ion increases with size (F- < Cl- < Br- < I-), so larger anions are more easily polarized, leading to greater covalent character.

14.The correct order of covalent nature of alkali metal chlorides is:
A) LiCl < NaCl < KCl < RbCl < CsCl B) CsCl < NaCl < KCl < RbCl < LiCl
C) LiCl > NaCl > KCl > RbCl > CsCl D) LiCl = NaCl = KCl = RbCl < CsCl
Answer:C
Solution:For cations: smaller cation has higher polarizing power. Li+ is smallest, so LiCl has the most covalent character. As we go down the group, size increases, so covalent character decreases.
Order: LiCl > NaCl > KCl > RbCl > CsCl

15.Polarization is the distortion of the shape of an anion by an adjacently placed cation. Which of the following statements is correct: [NCERT 1982]

A) Maximum polarization is brought about by a cation of high charge
B) A large cation is likely to bring about a large degree of polarization
C) Minimum polarization is brought about by a cation of low radius
D) A small anion is likely to undergo a large degree of polarization
Answer:A
Solution:
A) True: high charge cation has high polarizing power.
B) False: large cation has low polarizing power.
C) False: cation of low radius (small) has high polarizing power.
D) False: small anion is less polarizable.

16.The formation of a crystal lattice is
1. endothermic 2. endergonic 3. exothermic 4. exergonic
Answer:C
Solution:Formation of crystal lattice (lattice energy) is exothermic (energy is released).

17.In a Born-Haber cycle, which step represents the energy required to form gaseous ions from their elements in their standard states?
A) Ionization energy B) Electron affinity
C) Lattice energy D) Sublimation energy
Answer:A
Solution: $_{\Delta}$Hsub (Sublimation energy): Converts solid $\rightarrow$gaseous atom.
Example: Na(s) $\rightarrow$ Na(g).
Ionization energy (IE): Converts gaseous atom $\rightarrow$ gaseous cation.
Example: Na(g) $\rightarrow$ Na^{+}(g) + e^{-}.(energy required)
Electron affinity (EA): Converts gaseous atom $\rightarrow$ gaseous anion.
Example: Cl(g) + e^{-} $\rightarrow$ Cl^{-}(g).
Lattice energy: Energy released when gaseous ions combine to form ionic solid.

18. Which of the following factors affects the magnitude of lattice energy in an ionic compound?
A) Size of ions B) Charge on ions C) Both A and B D) None of the above
Answer:C
Solution:Lattice energy depends on size and charge of ions.

19. Which of the following factors primarily contributes to the magnitude of lattice energy in an ionic compound?
A) Atomic radius B) Bond length C) Ionic radius D) Electronegativity
Answer:C
Solution:Lattice energy is directly related to ionic radius (size) and charge.

20.Which of the following equations represents the correct application of Hess's Law for a Born-Haber cycle?
A)$_{\Delta}$ H_lattice = $_{\Delta}$ H_formation of ionic compound - $_{\Delta}$ H_atomization of ele

ments

B) ΔH_lattice = ΔH_sublimation of metal - Δ H_ionization of non-metal + ΔH_formation of ionic compound

C) Δ H_lattice = ΔH_sublimation of metal + Δ H_ionization of non-metal - ΔH_formation of ionic compound

D) ΔH_lattice = Δ H_atomization of elements - ΔH_formation of ionic com pound

Answer:A

Solution:

$\Delta H_{formation} = \Delta H_{sublimation} + \Delta H_{atomization} + \Delta H_{ionisation} + \Delta H_{Electron\ affinity} + \Delta H_{Lattice}$

Rearrange

$\Delta H_{Lattice} = \Delta H_{formation} - \Delta H_{atomization}$

JEE ADVANCED LEVEL QUESTIONS

MULTI CORRECT ANSWERS

1. Which of the following statements regarding polarization in covalent bonds are correct?

A) Polarization is the distortion of electron density in a covalent bond due to the electronegativity difference between bonded atoms.

B) Polarization leads to the formation of partial positive and partial negative charges on atoms within the bond.

C) Polarization is more pronounced in bonds between atoms with large elec tronegativity differences.

D) Polarization affects the bond length and bond strength.

Answer:A,B,C,D

Solution:A) Correct. This is the definition of bond polarity in covalent bonds.
B) Correct. The unequal sharing of electrons results in partial charges.
C) Correct. Greater electronegativity difference leads to greater polarity.
D) Correct. Polar bonds tend to be stronger and shorter than nonpolar bonds (due to ionic-covalent resonance).

2. Which of the following statements about Fajan's rules is/are correct?

A) Fajan's rules predict the degree of covalent character in an ionic bond.

B) Smaller cations and larger anions tend to form more polar bonds.

C) Fajan's rules apply only to ionic compounds containing halogens.

Answer:A,B

Solution:
A) Correct:Fajan's rules explain how ionic bonds can have covalent character.
B) Correct:Small cations have high polarizing power, and large anions are highly polarizable, leading to greater covalent character.
C) Incorrect: Fajan's rules apply to all ionic compounds, not just those with halogens.

3. Identify the correct order of increasing covalent character among the following compounds based on Fajan's rules.

a) MgO < CaO < SrO < BaO b) $MgCl_2$ < $CaCl_2$ < $SrCl_2$ < $BaCl_2$

c) NaBr < KBr < RbBr < CsBr d) LiF < NaF < KF < RbF
Answer:None
Solution:
Fajan's rules: Covalent character increases with smaller cation size and larger anion size.
a) MgO < CaO < SrO < BaO
Cation size: $Mg^{2+} < Ca^{2+} < Sr^{2+} < Ba^{2+}$. Smaller cation has higher covalent character. So, MgO has the most covalent character, and BaO the least. This order is decreasing covalent character.
b) $MgCl_2 < CaCl_2 < SrCl_2 < BaCl_2$
Cation size: $Mg^{2+} < Ca^{2+} < Sr^{2+} < Ba^{2+}$. So, $MgCl_2$ has the most covalent character, and BaCl2 the least. This order is decreasing covalent character.
c) NaBr < KBr < RbBr < CsBr
Cation size: $Na^+ < K^+ < Rb^+ < Cs^+$. So, NaBr has the most covalent character, and CsBr the least. This order is decreasing covalent character. ?
d) LiF < NaF < KF < RbF
Cation size: $Li^+ < Na^+ < K^+ < Rb^+$. So, LiF has the most covalent character, and RbF the least. This order is decreasing covalent character.
None of the orders given are increasing covalent character; all are decreasing.

4. Which of the following can be calculated from the Born-Haber cycle for Al_2O_3?
a) The lattice energy of Al_2O_3 b) Electron affinity of O-atom
c) The ionization energy of Al d) Number of ions
Answer:A,B,C
Solution:The Born-Haber cycle is used to calculate lattice energy if other values are known, or it can be used to find other quantities if lattice energy is known.
a) The lattice energy of Al_2O_3 - Yes, if other enthalpies are known.
b) Electron affinity of O-atom - Yes, if other values are known, it can be determined.
c) The ionization energy of Al - Yes, it can be determined if other values are known.
d) Number of ions - No, the number of ions is fixed by the formula (Al^{3+} and O^{2-}).

5. Amongst LiCl, RbCl, $BeCl_2$ and $MgCl_2$ the compounds with the greatest and the least ionic character, respectively, are:
1. LiCl 2. RbCl 3. $BeCl_2$ 4. $MgCl_2$
Answer:2,3
Solution:Based on Fajan's rules:
$BeCl_2$: Be^{2+} is very small, high charge, so highly covalent.
LiCl: Li^+ is small, some covalent character.
$MgCl_2$: Mg^{2+} is small with high charge, covalent.
RbCl: Rb^+ is large, low charge, so ionic.
Greatest ionic character: RbCl.
Least ionic character: $BeCl_2$ (almost covalent).

6. Which of the following factors affect the lattice energy in the Born-Haber cycle?
a) Size of the ions b) Charge on the ions
c) Type of crystal structure d) Temperature of the system
Answer:A,B,C
Solution:
Lattice energy depends on:
a) Size of the ions: smaller ions have higher lattice energy.
b) Charge on the ions: higher charge has higher lattice energy.
c) Type of crystal structure: different structures have different Madelung constants, affecting lattice energy.
d) Temperature of the system: Lattice energy is calculated at 0 K, but Born-Haber cycle uses enthalpy changes at standard temperature, so temperature indirectly affects the values, but lattice energy itself is not directly affected by temperature; it is a property of the crystal.
However, in the Born-Haber cycle, we use data at room temperature, but the lattice energy is for 0 K. So, temperature is not a direct factor.

REASON AND ASSERTION TYPE

A) Both (A) and (R) are true and (R) is the correct explanation of(A)
B) Both (A) and (R) are ture and (R) is not the correct explanation of (A)
C) (A) is true but (R) is false D) (A) is false but (R) is true

7. Assertion (A): The transition from ionic to covalent bonding is favored by a decrease in the electronegativity difference between bonded atoms.
Reason (R): A decrease in electronegativity difference leads to a more even dis tribution of charge, promoting covalent character in the bond.
Answer:A
Solution:A smaller electronegativity difference means less electron transfer and more sharing (covalent character). (R) correctly explains (A).

8. Assertion (A): Transition from ionic to covalent bonding is more likely to occur in compounds with smaller cations and larger anions.
9. Reason (R): Smaller cations and larger anions have higher polarizability, facilitating the transition to covalent bonding.
Answer:C
Solution:(A) is true (per Fajan's rules). (R) is partially correct but misstated: smaller cations have higher polarizing power (not polarizability), and larger anions have higher polarizability. Polarizability is for anions, not cations. So (R) is false.

10. Assertion (A): Transition from ionic to covalent bonding is more likely to occur incompounds with similar-sized ions.
Reason (R): Similar-sized ions exhibit less polarization, making it easier for them to share electrons and form covalent bonds.
Answer:D(both statements are incorrect)

Solution:A: Transition more likely with similar-sized ions. — False. Similar sizes reduce the strong polarization asymmetry needed for covalent character.
R: Similar-sized ions exhibit less polarization, making it easier for them to share electrons and form covalent bonds. — False / self-contradictory. Less polarization does not make sharing easier; it tends to favour ionic behavior

11. Assertion: Fajan's Rules predict that smaller and highly charged ions tend toform more covalent bonds.
Reason: Smaller ions have higher charge density, leading to greater polariza tion of the electron cloud of the other ion in the bond.
Answer:A
Solution:Assertion (A): Fajan's Rules predict that smaller and highly charged ions tend to form more covalent bonds.
Reason (R): Smaller ions have higher charge density, leading to greater polarization of the electron cloud of the other ion in the bond.
Both true. (R) correctly explains (A).

12. Assertion: Fajan's Rules suggest that ionic compounds with large differences in electronegativity between cation and anion tend to exhibit more covalent character.
Reason: Large electronegativity differences result in stronger ionic bonds, lead ing to increased polarization and covalent character.
Answer:D(both incorrect)
Solution:Assertion: Fajan's rules suggest large EN differences $\rightarrow$more covalent character. — False.
Large EN difference increases ionic character.
Reason: Large EN differences result in stronger ionic bonds, leading to increased polarization and covalent character. — Also false/misleading.
(Large EN $\rightarrow$ ionic; polarization/covalency increase comes from small cation & large anion, not simply large EN difference.)

13. Assertion: Fajan's Rules can be applied to predict the solubility of ionic compounds in polar solvents.
Reason: Ionic compounds with higher covalent character are more likely to dissolve in polar solvents due to increased interactions with solvent molecules.
Answer:C
Solution:Fajan's rules help understand covalent character, which affects solubility.
(R) is false: ionic compounds with high covalent character are less soluble in polar solvents because they are more nonpolar. For example, AgCl is covalent and insoluble.

14. Assertion: Fajan's Rules suggest that ionic compounds with smaller cations and larger anions tend to exhibit greater covalent character.
Reason: Smaller cations have higher charge density and larger anions have

higher polarizability, leading to increased distortion of electron clouds and greater covalent character.
Answer:A
Solution:Assertion: Fajan's rules: smaller cations & larger anions $\rightarrow$ greater covalent character. — True.
Reason: Smaller cations have higher charge density; larger anions are more polarizable $\rightarrow$ increased distortion and covalent character. — True and a correct explanation

15. Assertion: The Born-Haber cycle is a theoretical method used to determine the lattice energy of an ionic compound.
Reason: The cycle involves a series of hypothetical steps, including the forma tion of gaseous ions from their elements and the combination of these ions to form the ionic compound.
Answer:A
Solution:Assertion (A): The Born-Haber cycle is a theoretical method used to determine the lattice energy of an ionic compound.
Reason (R): The cycle involves a series of hypothetical steps, including the formation of gaseous ions from their elements and the combination of these ions to form the ionic compound.
Both true. (R) correctly describes the cycle.

16. Assertion: In the Born-Haber cycle, the enthalpy change for the formation of gaseous ions from their elements is endothermic.
Reason: This step involves breaking bonds, which requires energy input, mak ing it endothermic.
Answer:A
Solution:Assertion (A): In the Born-Haber cycle, the enthalpy change for the formation of gaseous ions from their elements is endothermic.
Reason (R): This step involves breaking bonds, which requires energy input, making it endothermic.
(A) is true: forming gaseous ions from elements requires energy (sublimation, ionization, etc.). (R) is true and explains (A).

17. Assertion: The lattice energy of an ionic compound is directly proportional to the product of the charges on the ions and inversely proportional to the dis tance between them.
Reason: Lattice energy depends on the electrostatic attraction between ions, which increases with charge and decreases with distance.
Answer:A
Solution:Assertion: Lattice energy α (product of charges) / (distance between ions). — *True (Coulomb's law / Born–Landé approximations).
Reason: Lattice energy depends on electrostatic attraction — increases with charge, decreases with distance. — True and correct.

STATEMENT TYPE

1) Statement-I, Statement-II both are true
2) Statement-I, Statement-II both are false
3) Statement-I is true, Statement-II is false.
4) Statement-I is false, Statement-II is true.

18. Statement I : $MgCl_2$ is more ionic than $ZnCl_2$.
Statement II: Compounds having inert gas configuration are more ionic than compound having inert gas configuration.
Answer:1
Solution:Statement II correctly explains Statement I: $MgCl_2$ (inert gas configuration) is more ionic than $ZnCl_2$ (pseudo-inert gas configuration) due to the reason given in Statement II.

COMPREHENSION TYPE

When anions and cations approach each other, the valence shell of anions are pulled towards cation nucleus and thus, shape of anion is deformed, The phenomenon of deformation of anion by a cation is known as polarization and the ability of thecation to polarize the anion is called as polarizing power of cation. Due to polarization,sharing of electrons occurs between two ions to some extent and the bond shows some covalant character.
The magnitude of polarization depends upon a number of factors. These factors were suggested by Fajan and are known as Fajan's rules.
1) Greater is the polarization in a molecule, more is covalent character.
2) As the charge magnitude on cation increases, its tendency to polarize the anion increases.
3) As the size of the cation decreases or size of the anion increases, the polarization increases.
4) The cations with 18 electrons in the outermost shell bring greater polarization of the anion than those with inert gas configuration even both the cations have same size and same charge.

19. In which of the halides, there is maximum polarization?
1. AlF_3 2. $AlCl_3$ 3. $AlBr_3$ 4. AlI_3
Answer:4
Solution:The compounds are aluminum halides: AlF_3, $AlCl_3$, $AlBr_3$, AlI_3.
According to Fajan's rules, polarization (covalent character) increases as the size of the anion increases (since larger anions are more polarizable).
The anion size order: F^- < Cl^- < Br^-< I^- .
Therefore, AlI3 has the largest anion (I^-) and thus the maximum polarization.

20. Which is most covalent in nature?
1. NaCl 2. $MgCl_2$ 3. $AlCl_3$ 4. $CaCl_2$
Answer:3
Solution:The compounds: NaCl, $MgCl_2$, $AlCl_3$, $CaCl_2$.
Covalent character increases with:
Higher charge on the cation (Al^{3+} > Mg^{2+} > Ca^{2+}> Na^+).
Smaller cation size (Al^{3+} is small due to high charge).

$AlCl_3$ has a small and highly charged cation (Al^{3+}), which has high polarizing power, leading to significant covalent character.
In fact, $AlCl_3$ is predominantly covalent

21. Which has the minimum melting point?
1. CaF_2 2. $CaCl_2$ 3. $CaBr_2$ 4. CaI_2
Answer:4
Solution:The compounds are calcium halides: CaF_2, $CaCl_2$, $CaBr_2$, CaI_2.
Melting point decreases as covalent character increases (since covalent compounds have lower melting points than ionic compounds).
Covalent character increases with anion size (F^- < Cl^- < Br^- < I^-), as larger anions are more polarizable.
Therefore, CaI_2 has the most covalent character and thus the lowest melting point.

MATRIX MATCH TYPE

22. Column I	**Column II**
a) Ionic nature α	**1) more is covalent character**
b) size of the anion increases	**2) size of cation**
c) Greater is the polarization	**3) polarization decreases**
d) magnitude on cation decreases	**4) polarization increases**

Answer:a-2, b-4, c-1, d-3
Solution:

a) Ionic nature α	2) size of cation
b) size of the anion increases	4) polarization increases
c) Greater is the polarization	1) more is covalent character
d) magnitude on cation decreases	3) polarization decreases

INTEGER TYPE

23. If the electro negativity difference between the elements A and B is equal to 1.7then the percentage of ionic character is _____
Answer:52%
Solution:

$$\%\text{ionic character} = (1 - e^{-0.25(\Delta\chi)^2}) \times 100$$

$$\Delta\chi = 1.7$$

$$(\Delta\chi)^2 = (1.7)^2 = 2.89$$

$$e^{-0.25(\Delta\chi)^2} = e^{-0.25(1.7)^2} = 0.485$$

$$\%\text{ionic character} = (1 - 0.485) \times 100 = 51.5\% \approx 52\%$$

LEARNER'S TASK

1. The co-ordination number of the cation in the face centred cubic lattice is
1. 4 2. 8 3. 3 4. 6
Answer:4
Solution:In a face-centered cubic (FCC) lattice (e.g., NaCl), each ion is surrounded by 6 oppositely charged ions (4 in the same plane, 1 above, 1 below).

2. The number of oppositely charged nearest neighbours to a Caesium ion in Caesium Chloride lattice are

1. 8 2. 6 3. 4 4. 2

Answer:1

Solution:In the CsCl lattice, each Cs^+ ion is surrounded by 8 Cl^- ions (at the corners of a cube).

3. Which of the following is highly covalent

1. AlF_3 2. $AlCl_3$ 3. $AlBr_3$ 4.CCl_4

Answer:4

Solution:Covalent character increases with smaller cation size and larger anion size.

Al^{3+} is a small, highly charged cation, and among the halides, AlBr3 (bromide ion is larger than chloride or fluoride) has significant covalent character.

However, CCl_4 is purely covalent.

4. The compound having more covalent nature is

1. $BaCl_2$ 2.$MgCl_2$ 3. $SrCl_2$ 4. $BeCl_2$

Answer:4

Solution:Covalent character increases with smaller cation size (higher charge density).

Be^{2+} is the smallest cation among the options ($BeCl_2$ > $MgCl_2$ > $CaCl_2$ > $BaCl_2$).

5. Which of the following has a tendency to form covalent compounds

1. Ba 2. Be 3. Na 4. Ca

Answer:2

Solution:Be (Beryllium) has a small size and high charge density, leading to high polarizing power and covalent character (e.g., $BeCl_2$ is covalent).

6. Polarization introduces _____ in a molecule.

1. complexity 2. ionic character 3. covalent character 4. neutralization

Answer:3

Solution:Polarization distorts the electron cloud, leading to covalent character in ionic bonds.

7. Polarising power is directly proportional to :

A) size of cation **B) charge on cation**

C) electronegativity of cation **D) size of anion**

Answer:B

Solution:Polarising power of the cation is directly proportional to the charge on a cation and inversely proportional to the size of the cation.

8. Which of the following has a high polarising power?

A) Mg^{2+} B) Al^{3+} C) Na^{+} D) Ca^{2+}

Answer:B

Solution:Polarizing power increases with smaller size and higher charge.

Al^{3+} has the highest charge and small size.

9. Maximum covalent character is associated with the compound:
A) NaI B) MgI_2 C) $AlCl_3$ D) AlI_3
Answer:D
Solution:Covalent character increases with small cation + large anion.
Al^{3+} (small, high charge) and I^- (largest halide) make AlI3 the most covalent.

10. According to Fajan's rules, the covalent bond is favored by
A) Large cation and small anion B) Large cation and large anion
C) Small cation and large anion D) Small cation and small anion
Answer:C
Solution:Covalent character is favored by small cations (high polarizing power) and large anions (high polarizability).

JEE MAIN LEVEL QUESTIONS

1. Which of the following statements accurately describes the transition from an ionic bond to a covalent bond?
A) Ionic bonds involve sharing of electrons, while covalent bonds involve transfer of electrons.
B) The transition occurs when atoms with significantly different electronegativities bond.
C) Ionic bonds are always more polarized than covalent bonds.
D) Covalent bonds form when two atoms have identical electronegativities.
Answer:D
Solution:Covalent bonds form when atoms have similar electronegativities.
If identical, the bond is purely covalent (e.g., Cl_2, O_2).
If slightly different, the bond is polar covalent.

2. The transition from an ionic to a covalent bond is favored by:
A) High lattice energy B) Low lattice energy
C) Large difference in electronegativity D) High ionization energy
Answer:B
Solution:Low lattice energy (weaker ionic bonds) and small electronegativity difference.

3. Polarisibility of halide ions increases in the order:
A) F^-,I^-,Br^-,Cl^- B) Cl^-,Br^-,I^-,F^- C) I^-,Br^-,Cl^-,F^- D) F^-,Cl^-,Br^-,I^-
Answer:D
Solution:Larger ions are more polarizable: $F^- < Cl^- < Br^- < I^-$.

4. Polarization power of cation increases when :
A) size decrease B) size increases
C) Anion has greater polarizing power D) covalent nature increases
Answer:A
Solution:Polarizing power α charge / size. So, it increases when size decreases.

5. Calcium iodide has a lower melting point than calcium fluoride. Choose the best response.
1. True 2. False 3. Inconclusive
4. They must have similar solubilities.
Answer:1
Solution:CaI_2 has larger I^- ions (more covalent character) than CaF_2 (small F^-, ionic), so lower melting point.

6. Fajan's Rules are most applicable to:
a) Ionic compounds with high lattice energies.
b) Ionic compounds with high polarizability.
c) Covalent compounds with strong hydrogen bonding.
d) Metallic compounds with high conductivity.
Answer:B
Solution:Fajan's rules explain covalent character in ionic compounds due to polarization.

7. Fajan's Rules predict that in ionic compounds, polarization is favored when:
a) The cation is large and the anion is small.
b) The cation is small and the anion is large.
c) Both the cation and anion are small.
d) Both the cation and anion are large.
Answer:B
Solution:Small cation (high polarizing power) and large anion (high polarizability).

8. According to Fajan's Rules, which of the following compounds would exhibit the most covalent character?
a) NaCl b) $MgCl_2$ c) $AlCl_3$ d) $SiCl_4$
Answer:D
Solution:Trend $\rightarrow$ covalent nature increases with smaller, higher charged cation.$Na^+ < Mg^{2+} < Al^{3+} < Si^{4+}$

9. Which of the following is true according to the Fajan's rule?
1. Ionic nature α size of cation 2. Ionic nature α 1/size of anion
3. Ionic nature α 1/charge on cation 4. All are correct
Answer:4
Solution:Ionic nature α size of cation (larger cations are less polarizing).
Ionic nature α 1/size of anion (smaller anions are less polarizable).
Ionic nature α 1/charge on cation (lower charge reduces polarization).

10. The number of oppositely charged ions, that surround an ion at nearest possible distances in an ionic crystal is known as
1. co-ordination number 2. co-ordination state 3. Unit cell 4. Ionic compound
Answer:1
Solution:The number of oppositely charged ions surrounding an ion at nearest

distances is coordination number.

11. Which of the following statements regarding the Born-Haber cycle is true?
A) The sum of enthalpies of formation equals zero.
B) The sum of enthalpies of formation equals the lattice energy.
C) The sum of enthalpies of formation equals the enthalpy of atomization.
D) The sum of enthalpies of formation equals the enthalpy of sublimation.
Answer:B
Solution:Born-Haber: ΔHf (enthalpy of formation) = sum of (sublimation + ionization + bond dissociation + electron affinity + lattice energy)
So $\rightarrow$ enthalpy of formation equals the lattice energy only after including all intermediate steps.

12. In the Born-Haber cycle for the formation of NaCl, the enthalpy change of which step is directly measurable?
A) Formation of NaCl from its elements B) Sublimation of Na
C) Ionization of Na D) Electron affinity of Cl
Answer:A
Solution:
In the Born–Haber cycle for NaCl:
ΔHf (formation of NaCl from Na(s) + ½Cl_2(g)) $\rightarrow$ directly measurable by calorimetry.
ΔHs (sublimation of Na) $\rightarrow$ measurable too, but it's not the standard enthalpy of formation, it's a derived thermodynamic quantity.
Ionization energy of Na $\rightarrow$ obtained from spectroscopic methods, not calorimetry.
Electron affinity of Cl $\rightarrow$ indirect, not directly measurable
Calorimetry = measuring heat released or absorbed during a reaction.

JEE ADVANCED LEVEL QUESTIONS

MULTI CORRECT ANSWERS

1. The extent of polarization in a covalent bond depends on which of the following factors?
A) Electronegativity difference between atoms B) Size of the atoms involved
C) Hybridization of the orbitals D) Geometry of the molecule
Answer:A,B,C,D
Solution:A) Electronegativity difference between atoms: Greater difference leads to more polarization.
B) Size of the atoms involved: Larger atoms are more polarizable.
C) Hybridization of the orbitals: Affects bond length and strength (e.g., sp hybrids are shorter and less polarizable).
D) Geometry of the molecule: Symmetry can cancel out dipole moments (e.g., CO_2 is nonpolar despite polar bonds).

2. Born Haber cycle involves
1. Sublimation energy 2. Ionization energy
3. Electron affinity 4. Lattice energy
Answer:1,2,3,4

Solution:The Born-Haber cycle includes:
Sublimation energy (solid to gas for metal).
Ionization energy (to form cation).
Electron affinity (to form anion).
Lattice energy (formation of crystal from ions).

3. Which of the following statements are true about fajan's rules
1. Greater is the polarization in a molecule, more is covalent character.
2. As the charge magnitude on cation increases, its tendency to polarize the anion increases.
3. As the size of the cation decreases or size of the anion increases, the polar ization increases.
4. cations with 18 electrons in the outermost shell bring greater polarization of the anion.
Answer:1,2,3,4
Solution:1.True (polarization leads to covalent character).
2. True (higher charge = higher polarizing power).
3.True (small cation + large anion = high polarization).
4.True (due to poor shielding, high effective nuclear charge).

REASON AND ASSERTION TYPE
A) Both (A) and (R) are true and (R) is the correct explanation of(A)
B) Both (A) and (R) are ture and (R) is not the correct explanation of (A)
C) (A) is true but (R) is false D) (A) is false but (R) is true

4. Assertion (A): A decrease in the size of the ions involved in bonding promotes the transition from ionic to covalent bonding.
Reason (R): Smaller ions have higher polarizability, facilitating the formation of covalent bonds through electron sharing.
Answer:Both incorect
Solution:Why A is false: A smaller cation (not "smaller ions" in general) tends to increase covalency because it has high polarising power. But a smaller anion reduces polarizability and therefore does not favour covalency. The blanket statement "decrease in the size of the ions" is misleading.
Why R is false: Smaller ions are less polarizable (their electron clouds are held tightly); they have higher polarising power but lower polarizability. So R is incorrect

5. Assertion (A): In the transition from ionic to covalent bonding, the electrostatic attraction between ions decreases.
6. Reason (R): Covalent bonds involve the sharing of electrons, resulting in a reduction of electrostatic attraction compared to purely ionic bonding.
Answer:A
Solution:(A) is true: Covalent bonds have weaker electrostatic attraction than ionic bonds.
(R) is true and correctly explains (A): Electron sharing reduces full charge separation, lowering electrostatic attraction.

7. Assertion: Fajan's Rules predict that ionic compounds containing ions with higher charges exhibit greater covalent character.
Reason: Higher charge ions have greater ability to distort the electron cloud of neighboring ions, leading to increased covalent character.
Answer:A
Solution:(A) is true: Higher charge increases polarizing power (e.g., Al^{3+} > Mg^{2+} > Na^{+}).
(R) is true and correctly explains (A): Higher charge density distorts the anion more.

8. Assertion: Fajan's Rules predict that the covalent character of an ionic bond increases with increasing polarizability of the anion.
Reason: More polarizable anions can be more easily distorted by the cation, leading to increased sharing of electron density and greater covalent character.
Answer:A
Solution:(A) is true: Larger anions (e.g., I^{-}) are more polarizable and form more covalent bonds.
(R) is true and correctly explains (A): Easy distortion promotes electron sharing.

9. Assertion: Born-Haber cycles cannot be used to determine the lattice energy of covalent compounds.
Reason: Covalent compounds do not have distinct ions with fixed charges, making it impossible to apply the Born-Haber cycle.
Answer:A
Solution:(A) is true: Born-Haber cycles are for ionic compounds.
(R) is true and correctly explains (A): Covalent compounds lack ions.

10. Assertion: In the Born-Haber cycle for the formation of an ionic compound, the sublimation energy of the metal is always greater than the electron affinity of the non-metal.
Reason: Sublimation energy represents the energy required to convert a solid metal into gaseous atoms, which is typically higher than the energy released when a non-metal accepts an electron.
Answer:Both incorrect
Solution:This is not universally true: electron affinities (magnitude of energy released when an atom accepts an electron) can be larger than sublimation energies for many element pairs (e.g., Cl's EA magnitude is large). So the blanket "always greater" is false; the given reason is likewise a false generalization.

11. Assertion: The magnitude of lattice energy increases as the size of the ions decreases.
Reason: Smaller ions can pack more closely together, increasing the strength of the electrostatic attractions between them.
Answer:A
Solution:Closer packing strengthens Coulombic attraction.

12. Assertion: The Born-Haber cycle involves Hess's law, which states that the total enthalpy change for a reaction is independent of the pathway taken.
Reason: The cycle allows for the calculation of lattice energy by considering a series of enthalpy changes, which can be manipulated using Hess's law.
Answer:A
Solution:(A) is true: The cycle applies Hess's law.
(R) is true and correctly explains (A): Hess's law is the basis for the cycle

STATEMENT TYPE

1) Statement-I, Statement-II both are true
2) Statement-I, Statement-II both are false
3) Statement-I is true, Statement-II is false.
4) Statement-I is false, Statement-II is true.
13. Statement-I: Cations with inert gas configurations form ionic compounds whilethose cations with psuedo inert gas configurations favour covalent bond formation
Statement-II: The cations with 18 electrons in the outermost shell bring greater polarization of the anion
Answer:A
Solution: Cations with true noble-gas configurations (e.g., Na^+, K^+) are typically low in polarising power and form ionic compounds, whereas cations with pseudo-noble (18-electron, d^{10}) configurations (e.g., Cu^+, Zn^{2+}, Ag^+) tend to polarize anions more and therefore promote covalent character. Statement II correctly explains why the pseudo-noble (18-electron) cations favour covalency.

COMPREHENSION TYPE

The Chemical bond formed due to electron transfer is called ionic bond or electro valent bond. Ionic bond will be formed more easily between the elements with low ionization potential and high electron affinity. Energy changes involved during the formation of ionic compound can be calculated by Born – Haber cycle. Lattice enthalpy changes are directly proportional to the stability of ionic compound.
13. Born- Haber cycle is based on
1. Faradays law 2. Gay-Lumar's law 3. Emetons law 4. Hess's law
Answer:4
Solution:The Born-Haber cycle applies Hess's Law, which states that the total enthalpy change for a reaction is independent of the pathway taken.

14. The Born Haber cycle below represents the energy changes occurring at 298K when KH is formed from its elements
v : ΔHatomisation K = 90 kJ/mol
w : Δ Hionisation K = 418 kJ/mol
x : Δ Hdissociation H = 436 kJ/mol
y : Δ Helectronaffinity H = 78 kJ/mol
z : Δ Hlattice KH = 710 kJ/mol
the correct value of ΔH is

Answer:-62
Solution:

$$\Delta H_f = v + w + \frac{x}{2} + y + z$$
$$\Delta H_f = 90 + 418 + 218 + (-78) + (-71)$$
$$\Delta H_f = -62$$

MATRIX MATCH TYPE

11. Column I Column II

a) Co-ordiantion number in NaCl	**1) radius ratio of the ionic crystal**
b) Co-ordiantion number in CsCl	**2) unit cell**
c) lattice arrangement	**3) 6**
d) co-ordination number	**4) 8**

Answer:a-3,b-4,c-2,d-1
Solution:

a) Co-ordiantion number in NaCl	3) 6
b) Co-ordiantion number in CsCl	4) 8
c) lattice arrangement	2) unit cell
d) co-ordination number	1) radius ratio of the ionic crystal

INTEGER TYPE

12. For covalent compound the electronegativity difference is less than ____
Answer:1.7
Solution:Covalent bonds typically occur when the electronegativity difference ($_{\Delta}$EN) is less than 1.7.

13. Application of Hess law of heat summation to the formation of solid ionic compounds involve enthalpy of all processes that are necessary for the formation of the solid ionic compound, in this cycle total energy on summation is _____
Answer:0
Solution:Hess's Law states that the total enthalpy change for a reaction is independent of path. In the Born-Haber cycle, the sum of all steps equals the formation enthalpy:

$$\Delta H_f = \Delta H_{\text{sub}} + \Delta H_{ionisation} + \frac{1}{2}\Delta H_{dissociation} + \Delta H_{\text{E.A}} + \Delta H_{lattice}$$

$$\Delta H_f - (\Delta H_{\text{sub}} + \Delta H_{ionisation} + \frac{1}{2}\Delta H_{dissociation} + \Delta H_{\text{E.A}} + \Delta H_{lattice}) = 0$$

Therefore, the total energy on summation is zero (because the cycle is closed).

KEY

				TEACHING TASK					
			JEE MAIN LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	10
A	C	B	B	B	B	A	C	D	A
11	12	13	14	15	16	17	18	19	20
	C	B	C	A	C	A	C	C	A
			JEE ADVANCED LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	10
A,B,C,D	A,B	NONE	A,B,C	2,3	A,B,C	A	C		D
11	12	13	14	15	16	17	18	19	20
A	D	C	A	A	A	A	1	4	3
21	22		23						
4	a-2, b-4, c-1, d-3		52%						
				LEARNER'S TASK					
1	2	3	4	5	6	7	8	9	10
4	1	4	4	2	3	B	B	D	C
			JEE MAIN LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	10
D	B	D	A	1	B	B	D	4	1
11	12								
B	A								
			JEE ADVANCED LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	10
A,B,C,D	1,2,3,4	1,2,3,4	D	A		A	A	A	D
11	12	13		13	14	11		12	13
A	A	A		4	-62	a-3,b-4,c-2,d-1		1.7	0