Bond Energy Chemistry Questions with Solutions

Q1: How can we determine the strength of a bond by the radius of an atom?

Answer: Any of the radius i.e. metallic radius, ionic radius or covalent radius can be used to determine the strength of bond formed by the given atoms.

For example: Boron (B) has a covalent radius of 83 pm. It makes a B-B bond of bond length 175 pm in B_2Cl_4. This indicates that the B-B bond length is even higher than the radius of an atom of B. Thus, this is a weak bond. However, in the case of Rhenium (Re), the metallic radius is 137.5 pm. The Re-Re bond length in Re_2Cl_8 is 224 pm. This indicates that the Re-Re is a very strong quadruple bond.

Q2. What is the difference between a primary and secondary bond? Give 2 examples of each.

Answer: A Primary bond is formed by the mutual sharing or complete transfer of electrons. This type of bond is stronger than the secondary bond. For example: O_2, NaCl.
A secondary bond is formed either due to permanent dipole or due to certain imbalances in the symmetrical charge distribution within the atom- creating a dipole. These dipoles induce a charge imbalance in their immediate neighbouring atoms. For example: N_2, H_2O.

Q3. How is the melting temperature of solids related to the bond energy?

Answer: The melting temperature is associated with the breaking of bonds of solid substances. The higher the melting temperature, the stronger the bond. The stronger the bond, the higher the bond energy. Hence, the melting temperature of solids has a direct relationship with the bond energy.

Q4. What is the enthalpy change for the given reaction?
$CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$
Given the enthalpies:

Bonds	Bond Enthalpy (kJ mol^{-1})
C-H	413
Cl-Cl	239
C-C	347
C-Cl	339

H-Cl	427

Answer: The total enthalpy for a reaction is calculated by the formula:
$\Delta H^o = \sum H_{bonds\ broken} - \sum H_{bonds\ formed}$
$\Delta H^o = (413 + 239)\ kJ\ mol^{-1} - (339 + 427)\ kJ\ mol^{-1}$
$\Delta H^o = -114\ kJ\ mol^{-1}$

Q5. Choose the correct statement.

a. A (-) $\Delta H_{reaction}$ indicates that energy is released.
b. A (+) $\Delta H_{reaction}$ indicates that energy is released.
c. A (-) $\Delta H_{reaction}$ indicates that energy is absorbed.
d. A (-) $\Delta H_{reaction}$ indicates that the reaction is endothermic.

Answer: (a.)

Explanation: In an exothermic reaction, the total energy change in reactants and products comes out to be negative because the products' energy is lesser than the reactants energy. Hence, (-) $\Delta H_{reaction}$ indicates the release of energy.

Q6. Pick the false statement.

a. Single bonds are more easily broken than double bonds.
b. Double bonds are more easily broken than triple bonds.
c. Triple bonds are more easily broken than double bonds.
d. The bonds formed in the endothermic reactions are weaker than the bonds broken.

Answer: (c.)

Explanation: Triple bonds are stronger than double bonds. Hence, triple bonds cannot be more easily broken than double bonds.

Q7. What is the enthalpy change in the following decomposition reaction of HCl?
$2HCl \rightarrow H_2 + Cl_2$
The average bond enthalpies (kj mol^{-1}) for the concerned bonds are:
H-Cl = 431 kj mol^{-1}
Cl-Cl = 242 kj mol^{-1}
H-H = 436 kj mol^{-1}

Answer: The total enthalpy for a reaction is calculated by the formula:
$\Delta H^o = \sum H_{Bonds\ broken} - \sum H_{Bonds\ formed}$
$\Delta H^o = 2(431)\ kj\ mol^{-1} - (242 + 436)\ kj\ mol^{-1}$

ΔH^o = +185 kJ mol^{-1}
Hence, the reaction is endothermic.

Q8. Why does $FeCl_3$ have a greater covalent character than $FeCl_2$?

Answer: This is because the charge on Fe in $FeCl_3$ is greater i.e. +3 than in $FeCl_2$ i.e. +2. Due to this reason, the size of the Fe^{+3} ion is smaller than Fe^{+2}. Hence, Fe^{+3} ion creates more polarisation and hence, more neutralization of charge takes place. Therefore, the ionic character of $FeCl_3$ decreases and the covalent character increases.

Q9. The combustion of 1 g Graphite produces 20.7 kJ heat. Calculate its molar enthalpy change.

Answer: Molar enthalpy change is calculated as:
Molar enthalpy change for combustion of 1 g Graphite = Enthalpy of Combustion of 1 g Graphite x Molar Mass
Enthalpy of Combustion of 1 g Graphite = -20.7 kJ g^{-1} (energy is released)
Since graphite (C) is made from carbon, its molar mass is 12 g mol^{-1}
$\Delta H_{combustion}$ = -20.7 kJ g^{-1} x 12 g mol^{-1}
$\Delta H_{combustion}$ =-2.48 x 10^2 kJ mol^{-1}
This reaction is exothermic in nature.

Q10. Predict the spontaneity of the reaction:
N_2O_4 (g) $\rightleftharpoons$ $2NO_2$ (g); Given K_P = 0.98 and T = 298 K.

Answer: From the relationship between standard free energy change and the equilibrium constant, we have:
$\Delta_r G^o = -RT \ln K_P$
Since K_P = 0.98, $\Delta_r G^o$ comes out to be negative. This indicates that the reaction is spontaneous.

Q11. Why is the molar enthalpy of vaporisation of acetone less than that of water?

Answer: In this, the inter-molecular forces come into play. Since the water molecules have strong H-bonding, water has higher molar enthalpy of vaporisation.

Q12. Comment on the bond energies of 4 C-H bonds in CH_4.

Answer: Bond energy is the amount of energy required to break 1 mole of bonds present in between the gaseous molecules. Since the bond energies of 1^{st}, 2^{nd}, 3^{rd} and 4^{th} C-H bonds in CH_4 are not equal. An average value of the bond energies are taken.

Q13. Predict the enthalpy change for the isomerization of acetonitrile into methyl isocyanide.

Answer: The isomerization of acetonitrile into methyl isocyanide can be written into equation as:
$H_3C\text{-}CN \rightarrow H_3C\text{-}NC$
In this, a C-C bond is broken and a new C-N bond is formed.
Bond dissociation energy for C-C = 347 kJ mol^{-1}
Bond dissociation energy for C-N = 305 kJ mol^{-1}
$\Delta H^o = \sum H_{Bonds\ broken} - \sum H_{Bonds\ formed}$
ΔH^o = (347 -305) kJ mol^{-1}
ΔH^o = 42 kJ mol^{-1}
The reaction is endothermic.

Q14. Name 3 ions that are isoelectronic to Neon.

Answer: Neon has 10 electrons. The ions isoelectronic to Neon are Na^+, Mg^{2+}, and F^-.

Q15. Out of NaCl and KCl, which will have more exothermic lattice energy?

Answer: The anions in both salts are the same. Both the cations have the same charge but differ in size. Since, Na^+ is smaller than K^+, NaCl has more exothermic lattice energy.

Practise Questions on Bond Energy

Q1. Which of the following alkali metals has the least melting point?

a. Na
b. K
c. Cs
d. Rb

Answer: (c.)

Explanation: Cs has the highest size among the alkali metals and the weakest metallic bond strength. Hence, Cs has the lowest melting point among the alkali metals.

Q2. Why does Calcium have an abnormally higher boiling point than magnesium?

Answer: The electronic configuration of Calcium is [Ar] $4s^2$; while that of Mg is [Ne] $3s^2$. Ca has vacant 3d orbitals due to which it forms strong metallic bonds. Hence, Ca has abnormally higher b.pt.

Q3. Name the energy associated when 1 mole of an ionic compound is formed from gaseous ions.

Answer: Lattice energy is the overall energy change that takes place along the conversion of gaseous ions into a crystal lattice. Hence, the energy associated when 1 mole of an ionic compound is formed from gaseous ions is Lattice energy.

Q4. In Spite of the large electronegativity gap between Be and O in the BeO molecule, BeO is covalent. Why?

Answer: The electronegativity gap between Be and O is 1.87; even then BeO is covalent. This is because Be^{2+} has a very small size. Due to its very small size, Be^{2+} creates large polarisation in O^{2-} ion. Hence, a large neutralisation of charges takes place and the ionic character of the Be-O bond decreases. This is why BeO is covalent.

Q5. What are the decomposition products of Group II nitrates?

Answer: Decomposition of nitrate salts yields a mixture of products. The products involve O_2, NO_2, and oxides of the broken salt.