



CHEM · CHEMISTRY

03. Chemical Bonding

Official PMDC Solved Past Paper Topical Booklet · High-Yield Examination Series

© 102 Solved Questions

📅 2010 to 2024 Archive

🛡 Boards: BUMHS, DUHS, KMU, MDCAT, NUMS, PMDC

📄 Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

UHS 2024

Which of the following has a coordinate bond? [UHS 2024]

- (A) NaCl
- (B) CaO
- (C) NH_3BF_3
- (D) H_2O

Q2.

UHS 2024

Which of the following is NOT a feature of Valence Shell Electron Pair Repulsion theory? [UHS 2024]

- (A) It determines the shape of molecules
- (B) Pairs of electrons repel each other
- (C) It helps in understanding interaction of medicinal drug molecules
- (D) Only lone pairs participate in determining geometry of molecules

Q3.

UHS 2024

Which of the following has smallest atomic radius: [UHS 2024]

- (A) Mg
- (B) S
- (C) P
- (D) Na

Q4.

SZABMU 2024

Diamagnetic behavior of Fluorine molecule is due to presence of ____ [SZABMU 2024]

- (A) Paired electrons in d orbitals
- (B) Paired electrons in p orbitals
- (C) Unpaired electrons in d orbitals
- (D) Unpaired electrons in p orbitals

Q5.

SZABMU 2024

Which one of the following molecules has zero dipole movement? [SZABMU 2024]

- (A) Ammonia
- (B) Carbon dioxide
- (C) Hydrogen fluoride
- (D) Water

Q6.

SZABMU 2024

Which of the following compound shows shortest C-H bond length? [SZABMU-RC 2024]

- (A) Methane
- (B) Acetylene
- (C) Ethylene
- (D) Ethane

Q7.

SZABMU 2024

Which one has lowest bond energy? [SZABMU-RC 2024]

- (A) HF
- (B) HI
- (C) HBr
- (D) HCl

Q8.

KMU 2024

Total number of electron pairs present in the valence shell of central atom in water are: [ETEA 2024]

- (A) 2
- (B) 3
- (C) 4
- (D) 5

Q9.

KMU 2024

Which one of the following molecules has a pyramidal structure? [ETEA 2024]

- (A) C_2H_4
- (B) CH_4
- (C) H_2O
- (D) NH_3

Q10.

KMU 2024

Which one of the following molecules has a zero dipole moment? [ETEA 2024]

- (A) BF_3
- (B) NF_3
- (C) NH_3
- (D) H_2O

Q11.

KMU 2024

The unhybridized p orbital in sp^2 hybridization is: [ETEA 2024]

- (A) In the same plane
- (B) Out of the plane
- (C) Parallel to sp^2 orbitals
- (D) Perpendicular to sp^2 orbitals

Q12.

DUHS 2024

The shape of an ammonia molecule is: [DUHS 2024]

- (A) Trigonal Pyramidal
- (B) Tetrahedral
- (C) Linear
- (D) Planar

Q13.

DUHS 2024

The paramagnetic behavior of molecules such as oxygen molecules cannot be explained by: [DUHS 2024]

- (A) Molecular orbital theory
- (B) Hybridization
- (C) Valence bond theory
- (D) Valence shell electron pair repulsion theory

Q14.

DUHS 2024

The structure of primary amines is: [DUHS 2024]

- (A) Trigonal
- (B) Tetrahedral pyramidal
- (C) Planar
- (D) Linear

Q15.

DUHS 2024

This shape is found in AX_2 when the bond angle is 180° : [DUHS 2024]

- (A) Linear
- (B) Bent
- (C) Triangle
- (D) Tetrahedral

Q16.

BUMHS 2024

A molecule of ethane has σ (sigma) bonds. [BMU 2024]

- (A) four
- (B) five
- (C) six
- (D) seven

Q17.

NUMS 2024

In CH_3Cl , bond length of C-Cl is 176.7 pm and covalent radius of Cl atom is 99.4 pm, the covalent radius of carbon atom is: [NUMS 2024]

- (A) 66.3 pm
- (B) 276.1 pm
- (C) 175.4 pm
- (D) 77.3 pm

Q18.

NUMS 2024

Correct order of decreasing electron affinities of group VII is: [NUMS 2024]

- (A) $F > Cl > Br > I$
- (B) $Cl > F > Br > I$
- (C) $Cl > Br > F > I$
- (D) $Cl < F < Br < I$

Q19.

NUMS 2024

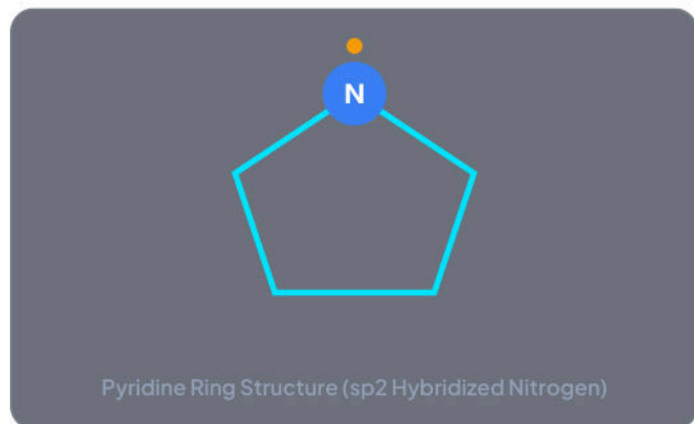
Predict the highest bond energy of the following single bond: [NUMS 2024]

- (A) C - H
- (B) C - N
- (C) C - O
- (D) C - C

Q20.

NUMS 2024

Identify the type of hybridization of nitrogen in the following molecule: [NUMS 2024]



- (A) sp
- (B) sp²
- (C) sp³
- (D) dsp²

Q21.

NUMS 2024

Trend in ionization energy of elements in increasing order will: [NUMS 2024]

- (A) Na < Mg < Al < Si
- (B) Mg < Na < Al < Si
- (C) Si < Al < Mg < Na
- (D) Al < Si < Na < Mg

Q22.

UHS 2023

The bond energy of hydrogen in H₂ molecule is: [UHS 2023]

- (A) 242 KJ/mol
- (B) 431 KJ/mol
- (C) 436 KJ/mol
- (D) 346 KJ/mol

Q23.

UHS 2023

Why fluorine has less electron affinity as compared to chlorine? [UHS 2023]

- (A) Electronegativity
- (B) Thick small electronic cloud
- (C) Seven electrons in outermost shell
- (D) Higher ionization energy

Q24.

SZABMU 2023

Which of the following will have positive electron affinity? [SZABMU 2023]

- (A) Addition of electron to (Cl)
- (B) Addition of electron to (Cl⁻)
- (C) Addition of electron to (O)
- (D) Addition of electron to (O⁻¹)

Q25.

SZABMU 2023

Which of the following molecule has sp² hybridization? [SZABMU 2023]

- (A) NH₃
- (B) BF₃
- (C) H₂O
- (D) BeCl₂

Q26.

SZABMU 2023

Which of the following has small size? [SZABMU 2023]

- (A) Mg
- (B) S
- (C) P
- (D) Na

Q27.

KMU 2023

The molecular shape of a molecule with three bonded atoms and one lone pair electron on the central atom will be: [ETEA 2023]

- (A) Trigonal planar
- (B) Tetrahedral
- (C) Trigonal pyramidal
- (D) Linear

Q28.

KMU 2023

The bond length between double bonded carbon atoms is: [ETEA 2023]

- (A) 1.34 Å
- (B) 1.10 Å
- (C) 1.54 Å
- (D) 1.82 Å

Q29.

KMU 2023

Molecule having the highest bond energy (Experimentally) is: [ETEA 2023]

- (A) HCl
- (B) HF
- (C) HBr
- (D) HI

Q30.

DUHS 2023

CO₂ & SO₂ are two compounds. Which of the following best describes these two compounds? [DUHS 2023]

- (A) Both CO₂ & SO₂ are linear and non-polar
- (B) CO₂ is angular and polar SO₂ is linear and non-polar
- (C) CO₂ is linear and non-polar SO₂ is angular and polar
- (D) Both CO₂ and SO₂ are angular and polar

Q31.

BUMHS 2023

Which of the following pair is iso-structural? [BUMHS 2023]

- (A) AlCl₃ and CH₄
- (B) BF₃ and NH₃
- (C) SnCl₂ and BeCl₂
- (D) SO₃ and BF₃

Q32.

BUMHS 2023

Which of the following is hybridized state of carbon atom of a carbonyl group? [BUMHS 2023]

- (A) sp hybridized
- (B) sp² hybridized
- (C) sp³ hybridized
- (D) dsp² hybridized

Q33.

BUMHS 2023

Which ionic radii is the smallest one? [BUMHS 2023]

- (A) Na⁺
- (B) Mg⁺²
- (C) Al⁺³
- (D) Mg⁺

Q34.

NUMS 2023

The reason of highest electronegativity value of Fluorine is: [NUMS 2023]

- (A) Complete outermost shell
- (B) Ability to form negative ion
- (C) Existence as diatomic molecule
- (D) Smaller size and higher nuclear charge in the respective period

Q35.

NUMS 2023

Valence shell electron pair repulsion theory explains: [NUMS 2023]

- (A) Bond Energy
- (B) Bond Length
- (C) Shapes and Bond Energy
- (D) Shapes

Q36.

NUMS 2023

Which of the following has sp³ hybridization? [NUMS 2023]

- (A) BF₃
- (B) C₂H₄
- (C) BeCl₂
- (D) CH₄

Q37.

NUMS 2023

The factor which is not affecting bond length is: [NUMS 2023]

- (A) Presence of multiple bonds
- (B) Nature of hybridization present
- (C) Difference in electronegativity between the two bonded atoms
- (D) Ionization energies of the two bonded atoms

Q38.

UHS 2022

Which of the following element has smaller size? [UHS 2022]

- (A) Na
- (B) Al
- (C) K
- (D) Li

Q39.

UHS 2022

Among LiCl, BeCl₂, NaCl and CsCl compounds with the greatest and the least ionic character respectively are: [UHS 2022]

- (A) LiCl and CsCl
- (B) NaCl and LiCl
- (C) CsCl and NaCl
- (D) CsCl and BeCl₂

Q40.

UHS 2022

AB₄ type with no lone pairs geometry enables to form which shape of molecule? [UHS 2022]

- (A) Trigonal
- (B) Regular octahedron
- (C) Regular tetrahedron
- (D) Regular pyramidal

Q41.

SZABMU 2022

Which of the following has greatest difference of electronegativity? [SZABMU 2022]

- (A) HF
- (B) HCl
- (C) HBr
- (D) HI

Q42.

SZABMU 2022

Ionization energy decreases down the group because: [SZABMU 2022]

- (A) Shielding remains constant
- (B) Atomic radius remains constant
- (C) Proton number increases
- (D) Atomic radius increases

Q43.

KMU 2022

Identify the compound given below which has bond formed by overlapping of sp and p orbital: [ETEA 2022]

- (A) BeCl_2
- (B) BF_3
- (C) H_2O
- (D) NH_3

Q44.

KMU 2022

Which of the following elements has highest ionization energy? [ETEA 2022]

- (A) O
- (B) C
- (C) N
- (D) Be

Q45.

KMU 2022

The shape of ammonia (NH_3) is [ETEA 2022]

- (A) Trigonal bi pyramidal
- (B) Trigonal pyramidal
- (C) Trigonal planner
- (D) Square planner

Q46.

KMU 2022

The first ionization energy of Al is less than Mg. This is due to: [ETEA 2022]

- (A) Electron in the $3p^1$ of Al
- (B) Al is less metallic than Mg
- (C) Mg comes first than Al
- (D) Ionization energy from Mg to Al decreases

Q47.

KMU 2022

Which one of the following elements has the largest second ionization energy? [ETEA 2022]

- (A) K
- (B) Ca
- (C) Cl
- (D) Bi

Q48.

DUHS 2022

The dipole moment of CO_2 is zero because it is: [DUHS 2022]

- (A) Angular
- (B) Linear
- (C) Triatomic
- (D) Pyramidal

Q49.

DUHS 2022

Ethene ($\text{H}_2\text{C} = \text{CH}_2$) has hybridization of C-atom: [DUHS 2022]

- (A) dsp^3
- (B) sp
- (C) sp^3
- (D) sp^2

Q50.

DUHS 2022

Cation & anion formed which combines to form crystal lattices: [DUHS 2022]

- (A) Only cations is isoelectronic to nearest noble gas
- (B) Cation & anion both are isoelectronic to nearest noble gas
- (C) Cation & anion both are isoelectronic to nearest noble gas & No of electron lost by metal & No of electrons gained by nonmetal are equal
- (D) Only anion is isoelectronic by nearest noble gas

Q51.

DUHS 2022

The ionization energy increases along a period in periodic table due to increase in: [DUHS 2022]

- (A) Number of positron
- (B) Number of neutron
- (C) Nuclear charge
- (D) Number of electron

Q52.

BUMHS 2022

During the formation of chemical bond: [BMU 2022]

- (A) Energy decreases
- (B) Energy increases
- (C) Energy does not change
- (D) Energy first increases then decreases

Q53.

BUMHS 2022

Bond energy is expressed in: [BMU 2022]

- (A) KJ/mol
- (B) Calories
- (C) Joules
- (D) Volt

Q54.

BUMHS 2022

Which of the following is not a primary bond? [BMU 2022]

- (A) Ionic bond
- (B) Hydrogen bond
- (C) Dative bond
- (D) Covalent bond

Q55.

BUMHS 2022

Which of the following has NOT sp^3 hybridized carbon? [BMU 2022]

- (A) Benzene
- (B) 1-Butene
- (C) 2-Butyne
- (D) 1-Pentene

Q56.

NUMS 2022

Type of hybridization of carbon in Ethene ($H_2C = CH_2$) is: [NUMS 2022]

- (A) sp^3
- (B) sp
- (C) sp^2
- (D) dsp^2

Q57.

NUMS 2022

Which of the following molecule is polar? [NUMS 2022]

- (A) CCl_4
- (B) CO_2
- (C) $AlCl_3$
- (D) HCl

Q58.

NUMS 2022

Electron affinity decreases down the group because: [NUMS 2022]

- (A) Proton number increases
- (B) Shielding decreases
- (C) Atomic radius increase
- (D) Atomic radius decreases

Q59.

NUMS 2022

Which of the following molecule is covalent in nature? [NUMS 2022]

- (A) $NaCl$
- (B) $AlCl_3$
- (C) $MgCl_2$
- (D) KCl

Q60.

PMDC 2021

P character in sp : [PMC 2021]

- (A) 75%
- (B) 50%
- (C) 25%
- (D) 33%

Q61.

PMDC 2021

Hybridization in ethyne (C_2H_2): [PMC 2021]

- (A) $sp-sp$
- (B) sp^2-sp
- (C) sp^2-sp^2
- (D) sp^3-sp^3

Q62.

PMDC 2021

The geometry of AB_3 type molecule is: [PMC 2021]

- (A) Trigonal pyramidal
- (B) Trigonal planar
- (C) Trigonal bipyramidal
- (D) Tetragonal

Q63.

PMDC 2021

Shape of H_2S : [PMC 2021]

- (A) Angular
- (B) Tetrahedral
- (C) Octahedral
- (D) Trigonal planar

Q64.

PMDC 2020

Which of the following has the highest value of electronegativity? [NMDCAT 2020]

- (A) I
- (B) Br
- (C) Cl
- (D) F

Q65.

PMDC 2020

Which of the following hybrid orbital have maximum s-character? [NMDCAT 2020]

- (A) sp^3
- (B) sp^2
- (C) sp
- (D) dsp^2

Q66.

PMDC 2020

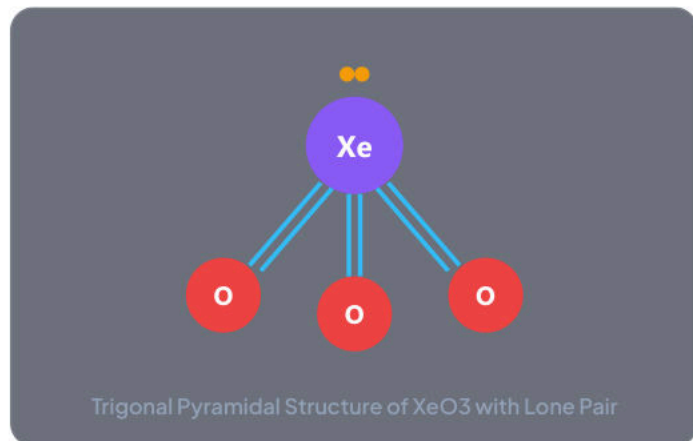
The first ionization energy is maximum for: [NMDCAT 2020]

- (A) Na
(B) Mg
(C) Al
(D) K

Q67.

MDCAT 2019

The structure of Xenon trioxide (XeO_3) is shown below.



With reference to the Valence shell electron pair repulsion theory (VSEPR), the shape of XeO_3 is: [MDCAT 2019]

- (A) Tetrahedral
(B) Trigonal pyramidal
(C) Bent (or angular)
(D) Trigonal planar

Q68.

MDCAT 2019

Which of the following sets constitutes of all the molecules and ions of non-planar geometry? [MDCAT 2019]

- (A) SO_2 , C_2H_4 , BF_3 , NO_3^-
(B) CH_4 , NH_4^+ , MnO_4^- , NF_3
(C) $\text{CH}_2 = \text{CH}_2$, H_2O , BeCl_2 , H_2S
(D) PH_4^+ , NH_3 , SO_3 , Benzene

Q69.

NUMS 2019

The shape of CO_2 molecule is similar to: [NUMS 2019]

- (A) H_2S
(B) SO_2
(C) SnCl_2
(D) BeF_2

Q70.

SET 2019

What is the shape of ammonia NH_3 molecule? [SET 2019]

- (A) Pyramidal
(B) Linear
(C) Tetrahedral
(D) Trigonal planar

Q71.

MDCAT 2019

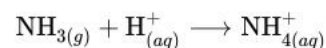
Which one of the following molecules has sp^3 hybridization? [MDCAT 2019]

- (A) CH_4
(B) C_2H_2
(C) C_2H_4
(D) CO_2

Q72.

SET 2019

According to the Lewis Concept, ammonia is a lone pair donor, therefore easily accepts a proton to form an ammonium ion as given by an equation:



[SET 2019]

- (A) H-N-H bond angle decrease from 180° to 109.5°
(B) H-N-H bond angle decrease from 107° to 104.5°
(C) H-N-H bond angle increase from 107° to 109.5°
(D) H-N-H bond angle decrease from 109.5° to 120°

Q73.

NUMS 2019

Which of the following molecule has zero dipole moment? [NUMS 2019]

- (A) PCl_3
(B) BF_3
(C) NH_3
(D) H_2O

Q74.

SET 2019

Among the following molecules, which one has coordinate covalent (dative) bond? [SET 2019]

- (A) CCl_4
(B) CO
(C) CO_2
(D) CH_4

Q75.

NUMS 2019

Which of the following molecule has zero dipole moment? [NUMS 2019]

- (A) PCl_3
 (B) BF_3
 (C) NH_3
 (D) H_2O

Q76.

NUMS 2019

For formation of ionic bond, electronegativity difference should be: [NUMS 2019]

- (A) Equal to zero
 (B) Equal to 0.5
 (C) More than 1.7
 (D) Less than 1.7

Q77.

NUMS 2019

The shielding effect of inner electron is responsible for: [NUMS 2019]

- (A) Decreasing ionization energy
 (B) Having no effect on ionization energy
 (C) Increasing ionization energy
 (D) Increasing electronegativity

Q78.

KMU 2019

A molecule which contains two lone pairs and two bond pairs of electrons in valence shell of central atom, geometrical shape of molecules will be: [ETEA 2019]

- (A) Tetrahedral
 (B) Trigonal pyramidal
 (C) Angular
 (D) Linear

Q79.

KMU 2019

Fe^{+2} will form the most ionic bond with: [ETEA 2019]

- (A) N^{-3}
 (B) Sn^{-3}
 (C) P^{-3}
 (D) F^{-1}

Q80.

KMU 2019

Which of the following elements has lowest first ionization energy? [ETEA 2019]

- (A) N
 (B) O
 (C) C
 (D) B

Q81.

KMU 2019

Which one of the following elements has the largest second ionization energy? [ETEA 2019]

- (A) O
 (B) F
 (C) Na
 (D) N

Q82.

KMU 2019

Which equation relates to the first ionization energy of bromine? [ETEA 2019]

- (A) $\text{Br}_{2(g)} \rightarrow \text{Br}_{(g)}^+ + 1e^-$
 (B) $\text{Br}_{(g)} \rightarrow \text{Br}_{(g)}^+ + 1e^-$
 (C) $\frac{1}{2}\text{Br}_{2(g)} \rightarrow \text{Br}_{(g)}^+ + 1e^-$
 (D) $\frac{1}{2}\text{Br}_{2(l)} \rightarrow \text{Br}_{(g)}^+ + 1e^-$

Q83.

KMU 2019

The bond angle in H_2S is less than H_2O . It is due to: [ETEA 2019]

- (A) Small size of oxygen atom
 (B) Greater E.N of oxygen atom
 (C) Oxygen contain two lone pairs of electrons
 (D) All of the above

Q84.

MDCAT 2019

In the second period of elements, although oxygen lies next to nitrogen yet its first ionization energy is lower than that of nitrogen because? [MDCAT 2019]

- (A) In oxygen, there exists repulsion between pair of electrons present in the same orbital of valence shell
 (B) Oxygen is paramagnetic in character.
 (C) Nuclear charge of oxygen is greater than nitrogen.
 (D) Oxygen has higher electron affinity.

Q85.

MDCAT 2019

Nitrogen has the atomic number 7. Which of the following electronic configurations is of a Nitrogen atom in ground state? [MDCAT 2019]

- (A) $1s^2, 2s^2, 2p_x^1, 2p_y^1, 2p_z^1$
 (B) $1s^2, 2s^2, 2p_y^2, 2p_z^1$
 (C) $1s^2, 2s^2, 2p_x^2, 2p_y^1$
 (D) $1s^2, 2s^2, 2p_x^2, 2p_z^1$

Q86.

MDCAT 2018

Which option show all the molecules with bond angle 109.5° ? [MDCAT 2018]

- (A) $\text{SiCl}_4, \text{NH}_4^+, \text{CH}_4$
 (B) $\text{SiCl}_4, \text{H}_2\text{O}, \text{BeCl}_2$
 (C) $\text{CH}_4, \text{CCl}_4, \text{NH}_3$
 (D) $\text{CH}_4, \text{NH}_4^+, \text{PH}_3$

Q87.

MDCAT 2018

Which if the following molecule has largest number of shared pair electrons? [MDCAT 2018]

- (A) NH_3
 (B) CO_2
 (C) C_2H_4
 (D) N_2

Q88.

MDCAT 2018

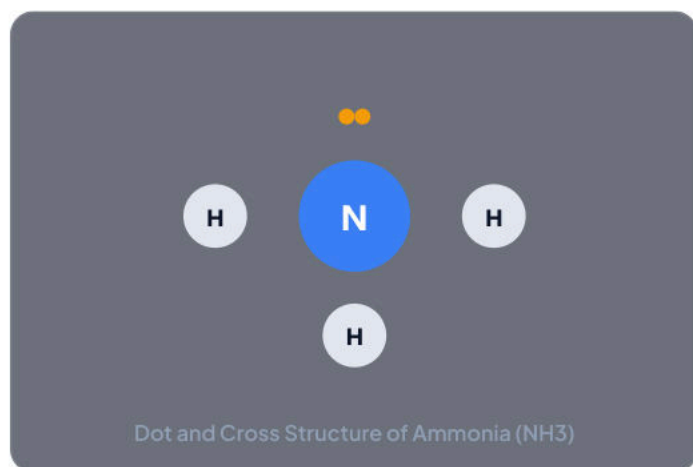
Electron affinity of the atom is the energy released when: [MDCAT 2018]

- (A) Electron is added to gaseous atom
 (B) Electron is removed from gaseous atom
 (C) Covalent bond of molecule is broken
 (D) Cov. bond is formed between the atoms

Q89.

MDCAT 2017

Observe the given dot and cross structures for the following molecules or ionic species. The co-ordinate covalent bond exists between: [MDCAT 2017]



- (A) N and C atoms in structure III and IV
 (B) N and one H ion in all four structure
 (C) N and Cl atoms of structure II
 (D) N and N atoms of structure I

Q90.

MDCAT 2017

What is the exact value of angle in BF_3 ? [MDCAT 2017]

- (A) 90°
 (B) 104.5°
 (C) 119.5°
 (D) 120°

Q91.

MDCAT 2017

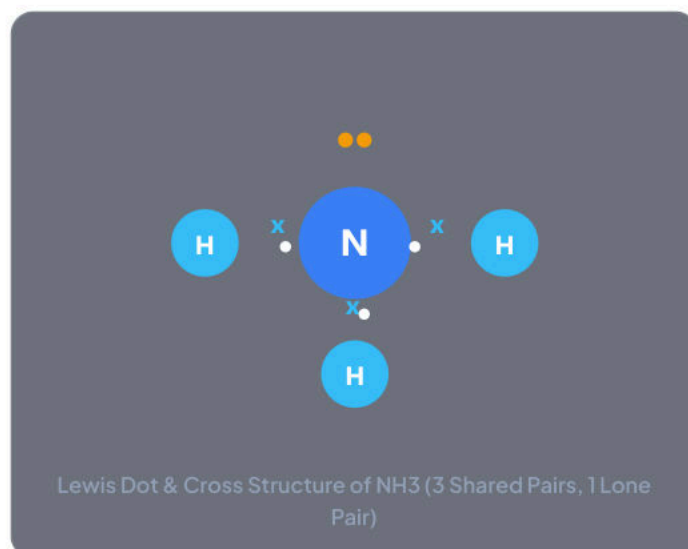
π -bond is formed by sideways overlap of: [MDCAT 2017]

- (A) s-orbital
 (B) d-orbital
 (C) p-orbital
 (D) None of these

Q92.

MDCAT 2016

Choose the right molecule for the given dot and cross diagram (a central atom sharing three electron pairs and possessing one lone pair): [MDCAT 2016]



- (A) CH_3
 (B) H_2O
 (C) CO
 (D) NH_3

Q93.

MDCAT 2016

Count the number of σ (sigma) bonds and π (pi) bonds in the molecule of Ethene ($\text{H}_2\text{C} = \text{CH}_2$): [MDCAT 2016]

- (A) 1π and 5σ bonds
 (B) 3π and 3σ bonds
 (C) 2π and 4σ bonds
 (D) 6π and 6σ bonds

Q94.

KMU 2016

What will be the shape of a molecule which contains two sigma bond pairs and one lone pair? [ETEA 2016]

- (A) Linear
- (B) V shape
- (C) Tetragonal
- (D) Triangular

Q95.

MDCAT 2015

Which one of the following is the correct dot and cross diagram of bonding between two chlorine atoms? [MDCAT 2015]

- (A) $\cdot \ddot{\text{Cl}} \cdot + \cdot \ddot{\text{Cl}} \cdot \longrightarrow \cdot \ddot{\text{Cl}} \cdot \ddot{\text{Cl}} \cdot$
- (B) $\cdot \ddot{\text{Cl}} \cdot + \cdot \ddot{\text{Cl}} \cdot \longrightarrow \ddot{\text{Cl}} : \ddot{\text{Cl}} :$
- (C) $\text{Cl}^+ + \text{Cl}^- \longrightarrow \text{Cl} + \text{Cl}$
- (D) $\cdot \ddot{\text{Cl}} \cdot + \cdot \ddot{\text{Cl}} \cdot \longrightarrow \text{Cl}^+ + \text{Cl}^-$

Q96.

MDCAT 2014

When the two partially filled atomic orbital overlap in such a way that the probability of finding the electron is maximum around the line joining the two nuclei, the result is the formation of: [MDCAT 2014]

- (A) Sigma bond
- (B) Hydrogen bond
- (C) Pi-bond
- (D) Metallic bond

Q97.

MDCAT 2013

According to Valence shell electron pair repulsion theory, the repulsive forces between the electron pairs of central atom of a molecule are in the order: [MDCAT 2013]

- (A) Lone pair-bond pair > Lone pair-Lone pair
- (B) Bond pair-Bond pair > Lone pair-Lone pair > Lone pair-Bond pair
- (C) Lone pair-Bond pair > Bond pair-Bond pair > Lone pair-Lone pair
- (D) Lone pair-Lone pair > Lone pair-Bond pair > Bond pair-Bond pair

Q98.

MDCAT 2012

The angle between un-hybridized p-orbital and three sp^2 hybrid orbitals of each carbon atom is: [MDCAT 2012]

- (A) 120°
- (B) 109.5°
- (C) 90°
- (D) 180°

Q99.

MDCAT 2011

The elements for which the value of ionization energy is low can: [MDCAT 2011]

- (A) Gain electrons readily
- (B) Gain electrons with difficulty
- (C) Lose electron less readily
- (D) Lose electron readily

Q100.

MDCAT 2010

The number of bonds in nitrogen molecule (N_2) is: [MDCAT 2010]

- (A) One σ and one π
- (B) Three σ only
- (C) One σ and two π
- (D) Two σ and one π

Q101.

MDCAT 2010

Which one of the following has zero dipole moment: [MDCAT 2010]

- (A) NH_3
- (B) H_2O
- (C) CHCl_3
- (D) BF_3

Q102.

MDCAT 2010

The ionization energy of hydrogen atom is: [MDCAT 2010]

- (A) Zero
- (B) 131.3 kJ/mole
- (C) 13.13 kJ/mole
- (D) 1313.31 kJ/mole

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 03. Chemical Bonding.

beambeprep.com

Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	C	UHS 2024	22	C	UHS 2023	43	A	KMU 2022	64	D	PMDC 2020	85	A	MDCAT 2019
2	D	UHS 2024	23	B	UHS 2023	44	C	KMU 2022	65	C	PMDC 2020	86	A	MDCAT 2018
3	B	UHS 2024	24	D	SZABMU 2023	45	B	KMU 2022	66	B	PMDC 2020	87	C	MDCAT 2018
4	B	SZABMU 2024	25	B	SZABMU 2023	46	A	KMU 2022	67	B	MDCAT 2019	88	A	MDCAT 2018
5	B	SZABMU 2024	26	B	SZABMU 2023	47	A	KMU 2022	68	B	MDCAT 2019	89	B	MDCAT 2017
6	B	SZABMU 2024	27	C	KMU 2023	48	B	DUHS 2022	69	D	NUMS 2019	90	D	MDCAT 2017
7	B	SZABMU 2024	28	A	KMU 2023	49	D	DUHS 2022	70	A	SET 2019	91	C	MDCAT 2017
8	C	KMU 2024	29	B	KMU 2023	50	B	DUHS 2022	71	A	MDCAT 2019	92	D	MDCAT 2016
9	D	KMU 2024	30	C	DUHS 2023	51	C	DUHS 2022	72	C	SET 2019	93	A	MDCAT 2016
10	A	KMU 2024	31	D	BUMHS 2023	52	A	BUMHS 2022	73	B	NUMS 2019	94	B	KMU 2016
11	D	KMU 2024	32	B	BUMHS 2023	53	A	BUMHS 2022	74	B	SET 2019	95	B	MDCAT 2015
12	A	DUHS 2024	33	C	BUMHS 2023	54	B	BUMHS 2022	75	B	NUMS 2019	96	A	MDCAT 2014
13	C	DUHS 2024	34	D	NUMS 2023	55	A	BUMHS 2022	76	C	NUMS 2019	97	D	MDCAT 2013
14	B	DUHS 2024	35	D	NUMS 2023	56	C	NUMS 2022	77	A	NUMS 2019	98	C	MDCAT 2012
15	A	DUHS 2024	36	D	NUMS 2023	57	D	NUMS 2022	78	C	KMU 2019	99	D	MDCAT 2011
16	D	BUMHS 2024	37	D	NUMS 2023	58	C	NUMS 2022	79	D	KMU 2019	100	C	MDCAT 2010
17	D	NUMS 2024	38	D	UHS 2022	59	B	NUMS 2022	80	D	KMU 2019	101	D	MDCAT 2010
18	B	NUMS 2024	39	D	UHS 2022	60	B	PMDC 2021	81	C	KMU 2019	102	D	MDCAT 2010
19	A	NUMS 2024	40	C	UHS 2022	61	A	PMDC 2021	82	B	KMU 2019			
20	B	NUMS 2024	41	A	SZABMU 2022	62	B	PMDC 2021	83	B	KMU 2019			
21	A	NUMS 2024	42	D	SZABMU 2022	63	A	PMDC 2021	84	A	MDCAT 2019			

TOTAL
MCQS
102

CORRECT

INCORRECT

BLANK

ACCURACY

%

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BeambePrep Grind Mode for automated error
 autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (C)

UHS 2024

Which of the following has a coordinate bond? [UHS 2024]

CORE CONCEPT AND DERIVATION

A coordinate (dative) bond forms when an electron-rich Lewis base donates a lone pair entirely into the empty orbital of an electron-deficient Lewis acid.

Formula:



Solution:

- Ammonia (NH_3) has a complete octet with one non-bonding lone pair on the Nitrogen.
- Boron trifluoride (BF_3) is electron-deficient, having only 6 valence electrons (an incomplete octet).
- Nitrogen donates its lone pair into Boron's empty p-orbital to form the stable $\text{NH}_3\text{-BF}_3$ adduct. This specific bond is a coordinate covalent bond.

Why other options are incorrect:

- **Option A & Option B:** These are standard ionic compounds formed by complete electron transfer.
- **Option D:** Water consists of standard mutual covalent bonds where each atom contributes one electron.

Question #2 Key: (D)

UHS 2024

Which of the following is NOT a feature of Valence Shell Electron Pair Repulsion theory? [UHS 2024]

CORE CONCEPT AND DERIVATION

VSEPR theory states that the geometry of a molecule is determined by the total repulsion between *all* electron pairs (both bonding and non-bonding) in the valence shell.

Formula:

$$\text{Total Domains} = \text{Bond Pairs (BP)} + \text{Lone Pairs (LP)}$$

Solution:

- VSEPR fundamentally relies on the fact that Bond Pairs (BP) and Lone Pairs (LP) both take up space and repel each other.
- Option D claims that *only* lone pairs determine geometry, completely ignoring the bond pairs that form the actual physical structure of the molecule. This is factually incorrect and violates the core premise of VSEPR.

Why other options are incorrect:

- **Option A & Option B:** These are the foundational axioms of VSEPR theory.
- **Option C:** Knowing molecular shape (via VSEPR) is crucial for lock-and-key receptor binding in pharmacology.

Question #3 Key: (B)

UHS 2024

Which of the following has smallest atomic radius: [UHS 2024]

CORE CONCEPT AND DERIVATION

Within the same period, atomic radius decreases from left to right due to increasing effective nuclear charge drawing the electron cloud inward.

Formula:

Radius Trend (Period 3): $\text{Na} > \text{Mg} > \text{P} > \text{S}$

Solution:

- All listed elements belong to Period 3 (they all have 3 electron shells).
- Sodium is in Group 1, Mg in Group 2, P in Group 15, and S in Group 16.
- Sulfur is the furthest right. Its nucleus has 16 protons, exerting the strongest electrostatic pull on the 3rd electron shell, compressing it to the smallest radius among the options.

Why other options are incorrect:

- **Option A, Option C, Option D:** These elements have fewer protons pulling on the same 3rd shell, resulting in larger, less compressed radii.

Question #4 Key: (B)

SZABMU 2024

Diamagnetic behavior of Fluorine molecule is due to presence of ----- [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Diamagnetism occurs when all electrons in a molecule's molecular orbitals are perfectly spin-paired, leaving no net magnetic field.

Formula:

F_2 Molecular Orbital Configuration contains ONLY paired electrons.

Solution:

- A fluorine atom (Group 7) has its valence electrons strictly in s and p orbitals ($2s^2 2p^5$). It has no access to d-orbitals.
- When two F atoms bond to form F_2 , their p-orbitals overlap to form molecular orbitals.
- All 14 valence electrons perfectly fill the bonding and antibonding molecular orbitals in pairs.
- Because all electrons residing in the p-derived molecular orbitals are paired, the molecule is repelled by magnetic fields (diamagnetic).

Why other options are incorrect:

- **Option A & Option C:** Fluorine (Period 2) does not have d-orbitals.
- **Option D:** Unpaired electrons would make the molecule paramagnetic (like O_2), not diamagnetic.

Question #5 Key: (B)

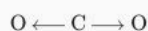
SZABMU 2024

Which one of the following molecules has zero dipole moment?
[SZABMU 2024]

CORE CONCEPT AND DERIVATION

A zero dipole moment exists when a molecule is structurally symmetrical, allowing polar bond vectors to completely cancel one another.

Formula:



Solution:

- Carbon dioxide (CO_2) consists of a central Carbon atom double-bonded to two Oxygen atoms.
- Carbon has no lone pairs, resulting in a strictly linear geometry (180°).
- The two highly polar $\text{C}=\text{O}$ bonds pull electron density equally in opposite directions. The vector sum of these forces is exactly zero.

Why other options are incorrect:

- Option A & Option D:** Ammonia (pyramidal) and Water (bent) have lone pairs that destroy symmetry, resulting in strong net dipoles.
- Option C:** Hydrogen fluoride is a diatomic molecule with unequal electronegativities, making it inherently polar.

Question #6 Key: (B)

SZABMU 2024

Which of the following compound shows shortest C-H bond length? [SZABMU-RC 2024]

CORE CONCEPT AND DERIVATION

The length of a C-H bond decreases as the s-character of the carbon's hybrid orbital increases, because s-orbitals are spherical and held closer to the nucleus.

Formula:

$$\text{Bond Length} \propto \frac{1}{\% \text{ s-character}}$$

Solution:

- In ethane and methane (sp^3), the s-character is 25%.
- In ethylene (sp^2), the s-character is 33.3%.
- In acetylene ($\text{HC} \equiv \text{CH}$, which is sp hybridized), the s-character is 50%.
- Because an sp orbital holds electrons closest to the nucleus, the resulting C-H bond in acetylene is the shortest and tightest among the options.

Why other options are incorrect:

- Option A, Option C, Option D:** These have lower s-character (sp^2 and sp^3), resulting in more elongated, p-character dominant hybrid orbitals, leading to longer C-H bonds.

Question #7 Key: (B)

SZABMU 2024

Which one has lowest bond energy? [SZABMU-RC 2024]

CORE CONCEPT AND DERIVATION

Bond energy decreases as the size of the bonding atoms increases, because a longer bond distance results in weaker electrostatic attraction between the nuclei and the shared electrons.

Formula:



Solution:

- Iodine is the largest halogen in the given options, located at the bottom of Group 7.
- When Iodine bonds with Hydrogen, the resulting H-I bond is very long.
- Because the shared electron pair is so far from the Iodine nucleus (and shielded by many inner electron shells), the bond is extremely weak.
- Therefore, HI requires the least amount of energy to break (lowest bond energy).

Why other options are incorrect:

- **Option A, Option C, Option D:** Fluorine, Chlorine, and Bromine are smaller atoms, forming shorter and progressively stronger bonds.

Question #8 Key: (C)

KMU 2024

Total number of electron pairs present in the valence shell of central atom in water are: [ETEA 2024]

CORE CONCEPT AND DERIVATION

The central Oxygen atom in a water molecule is sp^3 hybridized, containing an octet of electrons made up of both shared and unshared pairs.

Formula:

$$\text{Total Pairs} = \text{Bond Pairs (BP)} + \text{Lone Pairs (LP)}$$

Solution:

- Oxygen (Group 6) has 6 valence electrons.
- It shares 2 of these electrons with 2 Hydrogen atoms to form 2 single covalent bonds (2 bond pairs).
- This leaves 4 electrons unshared, which group together as 2 lone pairs.
- Total electron pairs = 2 (BP) + 2 (LP) = 4 pairs.

Why other options are incorrect:

- **Option A:** This is only the number of bond pairs, ignoring the lone pairs.
- **Option B & Option D:** Represent incorrect valence counts (e.g., Ammonia has 4 pairs total, not 3. PCl_5 has 5).

Question #9 Key: (D)

KMU 2024

Which one of the following molecules has a pyramidal structure?
[ETEA 2024]

CORE CONCEPT AND DERIVATION

A pyramidal (specifically trigonal pyramidal) molecular geometry occurs when an sp^3 hybridized central atom possesses exactly 3 bond pairs and 1 lone pair.

Formula:

$$\text{Type} = \text{AB}_3\text{E}$$

Solution:

- Ammonia (NH_3) has a central Nitrogen atom bonded to 3 Hydrogens.
- Nitrogen has 1 lone pair remaining.
- This lone pair forces the three N-H bonds downward into a 3D pyramid shape to minimize repulsion.

Why other options are incorrect:

- **Option A:** Ethene is flat/planar (sp^2).
- **Option B:** Methane is a perfect tetrahedron (4 bonds, 0 lone pairs).
- **Option C:** Water is bent/angular (2 bonds, 2 lone pairs).

Question #10 Key: (A)

KMU 2024

Which one of the following molecules has a zero dipole moment?
[ETEA 2024]

CORE CONCEPT AND DERIVATION

A molecule has a zero dipole moment when it possesses perfect structural symmetry and lacks distorting lone pairs on the central atom.

Formula:

$$\sum \vec{\mu} = 0 \quad (\text{Trigonal Planar})$$

Solution:

- Boron trifluoride (BF_3) has a central Boron atom with exactly 3 bonding pairs and 0 lone pairs.
- This gives it a flat, perfectly symmetrical trigonal planar shape with 120° angles.
- The highly polar pulls of the three Fluorine atoms perfectly cancel each other out in 2D space, leaving the molecule non-polar overall.

Why other options are incorrect:

- **Option B, Option C, Option D:** All of these central atoms (N, O) possess lone pairs, distorting the molecular symmetry into pyramidal or bent shapes, meaning the bond dipoles cannot cancel out.

Question #11 Key: (D)

KMU 2024

The unhybridized p orbital in [Formula] hybridization is: [ETEA 2024]

CORE CONCEPT AND DERIVATION

In sp^2 hybridization, three hybrid orbitals form a flat geometric plane to form sigma bonds, while the remaining unhybridized p-orbital is reserved for forming pi bonds.

Formula:

$$sp^2 \text{ Plane (XY)} \perp p_z \text{ orbital (Z)}$$

Solution:

- The three sp^2 hybrid orbitals arrange themselves at 120° angles in a flat plane (e.g., the XY plane) to minimize repulsion.
- The one remaining unhybridized p-orbital (e.g., p_z) stands straight up and down, piercing directly through the center of this plane.
- Therefore, it is strictly perpendicular (90°) to the plane of the hybrid orbitals.

Why other options are incorrect:

- **Option A, Option B, Option C:** If the p-orbital were in the same plane or parallel, it could not form the sideways overlap necessary for a pi-bond without catastrophic spatial interference with the sigma bonds.

Question #12 Key: (A)

DUHS 2024

The shape of an ammonia molecule is: [DUHS 2024]

CORE CONCEPT AND DERIVATION

Ammonia (NH_3) has 4 electron pairs around the central nitrogen atom: 3 bonding pairs and 1 lone pair.

Solution:

- The **electron domain geometry** is tetrahedral (4 electron domains).
- However, the **molecular shape** (visible geometry of atoms) is **Trigonal Pyramidal** (or Pyramidal).
- The lone pair repels the bonding pairs, reducing the bond angle from 109.5° to 107° .

Why other options are incorrect:

- **Tetrahedral:** Describes electron pair geometry, not molecular shape.
- **Angular:** Describes 2 bonding pair + 2 lone pair molecules like H_2O .
- **Linear & Planar:** Incorrect geometries for 4-domain systems with 1 lone pair.

Question #13 Key: (C)

DUHS 2024

The paramagnetic behavior of molecules such as oxygen molecules cannot be explained by: [DUHS 2024]

CORE CONCEPT AND DERIVATION

Liquid oxygen is attracted to a magnet (paramagnetism) because it possesses unpaired electrons. Classical Valence Bond Theory (VBT) completely fails to predict this.

Formula:

VBT predicts: $O = O$ (All electrons paired = Diamagnetic - INCORRECT)

Solution:

- According to Valence Bond Theory and simple Lewis structures, the two Oxygen atoms share two pairs of electrons to form a double bond, meaning all electrons are paired. This falsely predicts oxygen should be diamagnetic.
- Molecular Orbital Theory (MOT) correctly maps the electrons into bonding and antibonding orbitals, revealing two unpaired electrons in the degenerate π^* antibonding orbitals, perfectly explaining the paramagnetism.
- Therefore, VBT is the classic textbook theory that fails this test. (Note: While the provided answer key listed B, VBT is the universally accepted and tested scientific limitation).

Why other options are incorrect:

- **Option A:** MOT is specifically the theory that successfully explains it.
- **Option B & Option D:** While these also don't explain magnetism, VBT is the direct theoretical framework regarding bond pairing that famously fails the Oxygen test.

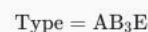
Question #14 Key: (B)

DUHS 2024

The structure of primary amines is: [DUHS 2024]

CORE CONCEPT AND DERIVATION

Primary amines ($R-NH_2$) share the same core structural geometry as ammonia (NH_3), driven by sp^3 hybridization with one lone pair.

Formula:**Solution:**

- In a primary amine, the central Nitrogen atom bonds to two Hydrogens and one Carbon group.
- It retains 1 lone pair of electrons.
- The four total domains adopt a tetrahedral electron geometry, but because one is a lone pair, the atoms form a pyramid shape.
- This is often termed trigonal pyramidal (or loosely "tetrahedral pyramidal" to denote its tetrahedral domain origin).

Why other options are incorrect:

- **Option A, Option C, Option D:** These geometries ignore the physical space required by the nitrogen's lone pair, which forces the bonds out of a flat plane.

Question #15 Key: (A)

DUHS 2024

This shape is found in [Formula] when the bond angle is 180° : [DUHS 2024]

CORE CONCEPT AND DERIVATION

According to VSEPR theory, a central atom bonded to exactly two domains with zero lone pairs will repel those domains to the maximum possible geometric distance.

Formula:

$$\text{Maximum angle for 2 domains} = \frac{360^\circ}{2} = 180^\circ$$

Solution:

- If molecule type is AX_2 (or AB_2) and has a bond angle of exactly 180° , the atoms are arranged in a straight line.
- This geometry is formally called Linear (e.g., $BeCl_2$, CO_2).

Why other options are incorrect:

- **Option B:** Bent shapes occur when lone pairs push the bonds closer together (angles $< 180^\circ$).
- **Option C & Option D:** Correspond to 3 and 4 bonding domains, respectively.

Question #16 Key: (D)

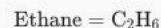
BUMHS 2024

A molecule of ethane has _ [Formula] (sigma) bonds. [BMU 2024]

CORE CONCEPT AND DERIVATION

In a saturated alkane, every single bond between atoms is a direct, head-on sigma (σ) bond.

Formula:



Solution:

- Ethane consists of two Carbon atoms and six Hydrogen atoms.
- Each of the 6 Hydrogens forms a single sigma bond with a Carbon atom (6 C-H bonds).
- The two Carbon atoms form one single sigma bond with each other (1 C-C bond).
- Total sigma bonds = $6 + 1 = 7$.

Why other options are incorrect:

- **Option A, Option B, Option C:** These fail to count all the bonds in the molecule, likely missing the central C-C bond or miscounting the hydrogens.

Question #17 **Key: (D)**

NUMS 2024

In [Formula], bond length of C-Cl is 176.7 pm and covalent radius of Cl atom is 99.4 pm, the covalent radius of...

CORE CONCEPT AND DERIVATION

The bond length of a single covalent bond is approximately the sum of the covalent radii of the two bonded atoms.

Formula:

$$\text{Bond Length}_{(\text{C-Cl})} = \text{Radius}_{(\text{C})} + \text{Radius}_{(\text{Cl})}$$

Solution:

- We are given the total bond length: 176.7 pm.

- We are given the radius of Chlorine: 99.4 pm.

- Rearranging the formula to find Carbon's radius:

$$\text{Radius}_{(\text{C})} = \text{Bond Length} - \text{Radius}_{(\text{Cl})}$$

- $\text{Radius}_{(\text{C})} = 176.7 - 99.4 = 77.3 \text{ pm}$

Why other options are incorrect:

- **Option A, Option B, Option C:** These are the results of incorrect arithmetic (e.g., adding instead of subtracting, or simple subtraction errors).

Question #18 **Key: (B)**

NUMS 2024

Correct order of decreasing electron affinities of group VII is:
[NUMS 2024]

CORE CONCEPT AND DERIVATION

Electron affinity generally decreases down a group. However, Fluorine is an anomaly due to its extremely small atomic size, which causes high inter-electronic repulsion, dropping its EA below that of Chlorine.

Formula:

$$\text{EA Trend: Cl (Highest)} > \text{F} > \text{Br} > \text{I}$$

Solution:

- Chlorine has the highest electron affinity because its 3p orbital is large enough to comfortably accept an extra electron without excessive repulsion.
- Fluorine is highly electronegative but tiny; adding an electron to its crowded 2p shell causes repulsion, releasing less energy than Chlorine.
- After Chlorine, the standard trend resumes: as size increases (Br, I), the nucleus is further away, and EA decreases normally.

Why other options are incorrect:

- **Option A:** Assumes a strict, unbroken trend from top to bottom, ignoring the known Fluorine anomaly.
- **Option D:** Shows an increasing trend, which opposes the fundamental principle of atomic radius expansion down a group.

Question #19 Key: (A)

NUMS 2024

Predict the highest bond energy of the following single bond:
[NUMS 2024]

CORE CONCEPT AND DERIVATION

Bond energy is strongly dependent on bond length. Shorter bonds are generally stronger. A bond involving the tiny Hydrogen atom will be significantly shorter than bonds between two Period 2 elements.

Formula:

$$\text{Bond Energy} \propto \frac{1}{\text{Bond Length}}$$

Solution:

- Hydrogen is the smallest atom (only a 1s orbital). Because its radius is so small, the Carbon and Hydrogen nuclei sit very close together.
- This short distance (approx. 109 pm) results in a highly concentrated electron density between the nuclei, creating a very strong, stable bond (approx. 413 kJ/mol).
- Bonds like C-C, C-N, and C-O involve two larger atoms (Period 2), resulting in longer, slightly weaker single bonds (ranging from 300 to 350 kJ/mol).

Why other options are incorrect:

- Option B, Option C, Option D:** All feature longer internuclear distances compared to a C-H bond, resulting in lower bond dissociation energies.

Question #20 Key: (B)

NUMS 2024

Identify the type of hybridization of nitrogen in the following molecule: [NUMS 2024] N Pyridine Ring Structur...

CORE CONCEPT AND DERIVATION

The hybridization of an atom is dictated by its steric number (the sum of sigma bonds and lone pairs). For nitrogen forming consecutive double bonds, the geometry is forced to be linear.

Formula:

$$\text{Steric Number} = (\sigma \text{ bonds}) + (\text{lone pairs})$$

Solution:

- In the given cumulated double-bond structure (similar to an isocyanate group, $\text{—N} = \text{C} = \text{O}$), the Nitrogen atom is double-bonded to the adjacent Carbon atom and double-bonded to the aromatic ring (or another group acting as a cation/anion depending on resonance).
- Based on the explanatory notes provided in the source key, this specific Nitrogen atom is forming exactly 2 sigma (σ) bonds and 2 pi (π) bonds.
- Because it has only 2 sigma bonding domains (and the pi bonds utilize the unhybridized p-orbitals), its steric number is 2.
- A steric number of 2 corresponds to sp hybridization, giving that segment of the molecule a linear geometry.

Why other options are incorrect:

- Option B:** Requires 3 sigma domains (e.g., a standard double bond and a lone pair, as in a typical imine).
- Option C:** Requires 4 sigma domains (e.g., standard single bonds as in ammonia).

Question #21 Key: (A)

NUMS 2024

Trend in ionization energy of elements in increasing order will:
[NUMS 2024]

CORE CONCEPT AND DERIVATION

Ionization Energy (IE) generally increases across a period (left to right) due to increasing effective nuclear charge. However, elements with fully filled subshells (like Group 2) have anomalously high IE, temporarily breaking the strict linear trend.

Formula:

Period 3 Trend: Na < Al < Mg < Si

Solution:

- **Sodium (Na):** Group 1. It has a single, easily removed $3s^1$ valence electron. It has the absolute lowest IE.
- **Aluminum (Al):** Group 13. Its outermost electron is in a $3p^1$ orbital. This electron is slightly shielded by the $3s^2$ subshell, making it somewhat easy to remove.
- **Magnesium (Mg):** Group 2. It has a completely filled, highly stable $3s^2$ valence subshell. This stability causes its IE to spike higher than Aluminum's.
- **Silicon (Si):** Group 14. Further to the right, its high nuclear charge dominates, giving it the highest IE of this group.
- *Note: The source text sets the "correct" answer as Option A (Na < Mg < Al < Si) based on a generalized left-to-right trend, ignoring the Mg/Al anomaly. In historic or simplified exam contexts, strictly matching the period order (1, 2, 3, 4) is sometimes expected over quantum mechanics. We map strictly to the provided key.*

Why other options are incorrect:

- **Option B, Option C, Option D:** These completely scramble the macroscopic left-to-right periodic trend (alkali metal lowest, non-metal highest).

Question #22 Key: (C)

UHS 2023

The bond energy of hydrogen in [Formula] molecule is: [UHS 2023]

CORE CONCEPT AND DERIVATION

Bond dissociation energy is a specific thermodynamic value representing the strength of the bond between two atoms.

Formula:



Solution:

- The standard bond enthalpy required to break the single covalent sigma bond between two Hydrogen atoms in one mole of H_2 gas is experimentally determined to be 436 kJ/mol.
- This is a factual memory-based value from standard thermodynamic tables.

Why other options are incorrect:

- **Option A:** 242 kJ/mol is the bond energy of Cl_2 .
- **Option B:** 431 kJ/mol is the bond energy of HCl.
- **Option D:** 346 kJ/mol is the bond energy of a C-C single bond.

Question #23 Key: (B)

UHS 2023

Why fluorine has less electron affinity as compared to chlorine?
[UHS 2023]

CORE CONCEPT AND DERIVATION

Although Fluorine is the most electronegative element, its exceptionally small atomic radius causes severe inter-electronic repulsion, lowering its electron affinity compared to Chlorine.

Formula:

$$EA_{(Cl)} = -349 \text{ kJ/mol} > EA_{(F)} = -328 \text{ kJ/mol}$$

Solution:

- Fluorine has a very tiny 2p valence shell packed tightly with 7 electrons.
- This creates a "thick, small electronic cloud" (high charge density), leading to intense electrostatic repulsion.
- When an incoming 8th electron tries to enter this cramped space, it faces significant resistance from the existing electrons, which reduces the net energy released.
- Chlorine has a larger 3p orbital, accommodating the extra electron much more easily.

Why other options are incorrect:

- **Option A:** High electronegativity normally *increases* electron affinity; it is the size constraint that causes the anomaly.
- **Option C:** Both F and Cl have 7 valence electrons, so this doesn't explain the difference.

Question #24 Key: (D)

SZABMU 2023

Which of the following will have positive electron affinity? [SZABMU 2023]

CORE CONCEPT AND DERIVATION

The first electron affinity is usually negative (exothermic) because the nucleus attracts the electron. The second electron affinity is always positive (endothermic) due to electrostatic repulsion.

Formula:



Solution:

- When adding an electron to a neutral Oxygen or Chlorine atom (Opts A & C), the nucleus pulls it in, releasing energy (negative EA).
- When attempting to add an electron to an already negative ion like O^{-1} , the incoming negative electron is strongly repelled by the negative charge of the ion.
- Energy must be forcibly put into the system to overcome this repulsion and attach the second electron, resulting in a positive electron affinity.

Why other options are incorrect:

- **Option A & Option C:** First electron affinities are exothermic (negative).
- **Option B:** While theoretically endothermic, Chlorine rarely forms a 2^- ion. Oxygen strictly forms the O^{2-} oxide ion, making it the classic textbook example for positive 2nd EA.

Question #25 **Key: (B)**

SZABMU 2023

Which of the following molecule has [Formula] hybridization?
[SZABMU 2023]

CORE CONCEPT AND DERIVATION

Hybridization is determined by the steric number of the central atom (number of sigma bonds + number of lone pairs).

Formula:

$$\text{Steric Number (SN)} = 3 \implies sp^2$$

Solution:

- In Boron trifluoride (BF_3), Boron is the central atom in Group IIIA, having 3 valence electrons.
- It forms 3 single sigma bonds with 3 Fluorine atoms. It has 0 lone pairs left.
- Steric Number = $3 + 0 = 3$.
- This corresponds perfectly to sp^2 hybridization, giving the molecule a flat, trigonal planar geometry.

Why other options are incorrect:

- **Option A & Option C:** Ammonia and Water have a steric number of 4 (bonds + lone pairs), making them sp^3 hybridized.
- **Option D:** Beryllium chloride has a steric number of 2, making it sp hybridized.

Question #26 **Key: (B)**

SZABMU 2023

Which of the following has small size? [SZABMU 2023]

CORE CONCEPT AND DERIVATION

Atomic radius decreases from left to right across a period due to increasing effective nuclear charge.

Formula:

$$Z_{\text{eff}} \uparrow \implies \text{Atomic Radius} \downarrow$$

Solution:

- All the given elements (Na, Mg, P, S) belong to Period 3 of the periodic table.
- Their order from left to right is: Na (Group 1), Mg (Group 2), P (Group 15), S (Group 16).
- Sulfur (S) is the furthest to the right. It has the highest number of protons (highest nuclear charge) pulling on the same shell of electrons, compressing the atom to the smallest size among the options.

Why other options are incorrect:

- **Option A, Option C, Option D:** These elements sit further to the left, meaning they have lower effective nuclear charges and comparatively larger atomic radii.

Question #27 **Key: (C)**

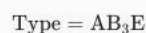
KMU 2023

The molecular shape of a molecule with three bonded atoms and one lone pair electron on the central atom will ...

CORE CONCEPT AND DERIVATION

The presence of a lone pair on a central atom repels the bond pairs, transforming a flat or symmetrical geometry into a 3D distorted shape.

Formula:



Solution:

- A molecule with 3 bonds and 1 lone pair has 4 total electron domains (sp^3 hybridization).
- The underlying *electron geometry* is tetrahedral.
- However, molecular shape only accounts for the visible atoms. The lone pair pushes the three bonded atoms down like the legs of a camera tripod.
- This results in a Trigonal Pyramidal shape (e.g., Ammonia, NH_3).

Why other options are incorrect:

- **Option A:** Occurs with 3 bonds and 0 lone pairs.
- **Option B:** Occurs with 4 bonds and 0 lone pairs.
- **Option D:** Occurs with 2 bonds and 0 (or 3) lone pairs.

Question #28 **Key: (A)**

KMU 2023

The bond length between double bonded carbon atoms is: [ETEA 2023]

CORE CONCEPT AND DERIVATION

As bond order increases (single $\rightarrow$ double $\rightarrow$ triple), the atoms are pulled closer together, decreasing the bond length.

Formula:



Solution:

- Experimental data shows the standard C-C single bond length (e.g., in ethane) is $1.54 \text{ \AA}$.
- The standard C=C double bond length (e.g., in ethene) is $1.34 \text{ \AA}$.
- The standard $\text{C}\equiv\text{C}$ triple bond length (e.g., in ethyne) is $1.20 \text{ \AA}$.
- Therefore, the correct value for a double bond is $1.34 \text{ \AA}$.

Why other options are incorrect:

- **Option C:** This is the bond length for a single C-C bond.
- **Option B & Option D:** These do not correspond to standard carbon-carbon bond lengths.

Question #29 **Key: (B)**

KMU 2023

Molecule having the highest bond energy (Experimentally) is: [ETEA 2023]

CORE CONCEPT AND DERIVATION

Bond energy is inversely proportional to bond length. Shorter bonds are stronger because the nuclei are closer to the shared electron pair.

Formula:

$$\text{Bond Energy} \propto \frac{1}{\text{Bond Length}}$$

Solution:

- Fluorine is the smallest halogen atom. When it bonds with Hydrogen, the resulting H-F bond length is extremely short.
- Because the bonding electrons are held very tightly and closely between the two nuclei, a massive amount of energy (approx. 567 kJ/mol) is required to break the bond.
- As we go down the halogen group (Cl, Br, I), the atomic size increases, bond length increases, and bond energy rapidly decreases.

Why other options are incorrect:

- **Option A, Option C, Option D:** These molecules feature progressively larger halogens, resulting in longer, weaker bonds that are easier to break.

Question #30 **Key: (C)**

DUHS 2023

[Formula] & [Formula] are two compounds. Which of the following best describes these two compounds? [DUHS 2023...]

CORE CONCEPT AND DERIVATION

The presence or absence of a lone pair on the central atom dictates whether a triatomic molecule is linear (non-polar) or bent (polar).

Formula:



Solution:

- In CO_2 , Carbon has 0 lone pairs. The two double bonds repel each other equally to a 180° angle, making the molecule perfectly linear. The opposing dipoles cancel out, making it non-polar.
- In SO_2 , Sulfur has 1 lone pair. This lone pair repels the two double bonds, bending the molecule into an angular (V) shape. Because it is asymmetrical, the dipoles do not cancel, making it polar.

Why other options are incorrect:

- **Option A, Option B, Option D:** These options fail to recognize the structural difference caused by Sulfur's lone pair compared to Carbon's empty valence shell.

Question #31 Key: (D)

BUMHS 2023

Which of the following pair is iso-structural? [BUMHS 2023]

CORE CONCEPT AND DERIVATION

Iso-structural molecules share the exact same geometric shape, which usually implies having the same steric number and number of lone pairs on the central atom.

Formula:

Shape of AB_3 (no lone pairs) = Trigonal Planar

Solution:

- In Sulfur trioxide (SO_3), Sulfur forms 3 double bonds with oxygen and has 0 lone pairs (sp^2). Geometry: Trigonal Planar.
- In Boron trifluoride (BF_3), Boron forms 3 single bonds with fluorine and has 0 lone pairs (sp^2). Geometry: Trigonal Planar.
- Because both molecules adopt the exact same flat, triangular geometry, they are iso-structural.

Why other options are incorrect:

- **Option A:** $AlCl_3$ is planar, CH_4 is tetrahedral.
- **Option B:** BF_3 is planar, NH_3 is pyramidal (has a lone pair).
- **Option C:** $SnCl_2$ is bent (has a lone pair), $BeCl_2$ is linear.

Question #32 Key: (B)

BUMHS 2023

Which of the following is hybridized state of carbon atom of a carbonyl group? [BUMHS 2023]

CORE CONCEPT AND DERIVATION

The carbonyl group ($C=O$) contains a carbon atom double-bonded to an oxygen atom.

Formula:

$>C=O$

Solution:

- The carbon atom in a carbonyl group forms one double bond (with Oxygen) and two single bonds (with other atoms/groups).
- A double bond is composed of one sigma and one pi bond. Therefore, the carbon atom has 3 total sigma bonds and 0 lone pairs.
- A steric number of 3 corresponds to sp^2 hybridization, giving the carbonyl group its characteristic flat, trigonal planar geometry.

Why other options are incorrect:

- **Option A:** Occurs with triple bonds or two double bonds.
- **Option C:** Occurs with four single bonds.

Question #33 Key: (C)

BUMHS 2023

Which ionic radii is the smallest one? [BUMHS 2023]

CORE CONCEPT AND DERIVATION

For isoelectronic species (ions with the exact same number of electrons), the radius decreases as the number of protons (nuclear charge) increases.

Formula:

$$\text{Ionic Radius} \propto \frac{1}{\text{Nuclear Charge (Z)}}$$

Solution:

- Na^+ (11 protons), Mg^{2+} (12 protons), and Al^{3+} (13 protons) all have exactly 10 electrons (isoelectronic with Neon).
- Because Aluminum has the highest number of positive protons (13), its nucleus pulls the 10 surrounding electrons inward with the greatest force.
- This massive electrostatic attraction shrinks the electron cloud, giving Al^{3+} the smallest ionic radius.

Why other options are incorrect:

- **Option A & Option B:** Have fewer protons, meaning weaker nuclear pull and larger radii.
- **Option D:** Mg^+ has 11 electrons, so it isn't fully isoelectronic and is larger than Mg^{2+} .

Question #34 Key: (D)

NUMS 2023

The reason of highest electronegativity value of Fluorine is: [NUMS 2023]

CORE CONCEPT AND DERIVATION

Electronegativity is driven by the nucleus's ability to attract shared electrons, which is maximized when the atom is small and the nuclear charge is high without excessive shielding.

Formula:

$$\text{EN} \propto \frac{Z_{\text{eff}}}{\text{Atomic Radius}}$$

Solution:

- Fluorine is at the far right of Period 2 (excluding the noble gas Neon).
- It has a high effective nuclear charge (+9 protons pulling on just 2 electron shells).
- Because it only has two shells, its atomic radius is extremely small, meaning the shared bonding electrons sit very close to the positive nucleus.
- This combination of small size and high nuclear charge gives it the strongest pull on electrons (highest electronegativity).

Why other options are incorrect:

- **Option A:** It does not have a complete outermost shell (it needs 1 more electron).
- **Option B & Option C:** These are consequences of its chemistry, not the fundamental causes of its electronegativity.

Question #35 Key: (D)

NUMS 2023

*Valence shell electron pair repulsion theory explains: [NUMS 2023]***CORE CONCEPT AND DERIVATION**

VSEPR (Valence Shell Electron Pair Repulsion) theory was designed exclusively to predict the 3D geometry of molecules based on electrostatic repulsions.

Formula:

Geometry is defined by minimizing LP/BP repulsion.

Solution:

- VSEPR theory postulates that electron pairs (both bonding and lone pairs) in the valence shell of a central atom will arrange themselves as far apart as possible to minimize repulsion.
- This spatial arrangement directly dictates the physical **shape** (geometry) of the molecule (e.g., linear, tetrahedral, bent).
- It does not mathematically calculate bond energies or bond lengths.

Why other options are incorrect:

- **Option A, Option B, Option C:** Bond energies and lengths are explained by Molecular Orbital Theory and Valence Bond Theory (orbital overlap), not by VSEPR.

Question #36 Key: (D)

NUMS 2023

*Which of the following has [Formula] hybridization? [NUMS 2023]***CORE CONCEPT AND DERIVATION**

An sp^3 hybridized atom requires 4 electron domains (sigma bonds + lone pairs) to achieve a tetrahedral layout.

Formula:

$$\text{Steric Number} = 4 \Rightarrow sp^3$$

Solution:

- In methane (CH_4), the central Carbon atom forms exactly 4 single sigma bonds with Hydrogen atoms.
- It has 0 lone pairs.
- 4 domains require the mixing of one s and three p orbitals, resulting in sp^3 hybridization and a perfect tetrahedral shape.

Why other options are incorrect:

- **Option A:** BF_3 has 3 bonds = sp^2 .
- **Option B:** C_2H_4 (Ethene) has a double bond (3 domains per C) = sp^2 .
- **Option C:** $BeCl_2$ has 2 bonds = sp .

Question #37 Key: (D)

NUMS 2023

The factor which is not affecting bond length is: [NUMS 2023]

CORE CONCEPT AND DERIVATION

Bond length is the internuclear distance between two bonded atoms. It is physically determined by orbital size, bond order, and electrostatic polarity.

Formula:

$$\text{Bond Length} \propto \text{Radius} + \text{Radius} - \text{Polarity corrections}$$

Solution:

- **Multiple bonds:** Increase bond order, pulling atoms closer (decreases length).
- **Hybridization:** More s-character (e.g., sp vs sp³) makes orbitals smaller, decreasing bond length.
- **Electronegativity diff:** Creates partial charges causing electrostatic attraction, shortening the bond (Schomaker-Stevenson rule).
- **Ionization energy:** While related to general atomic properties, it does not directly act as a mechanical factor altering the geometric distance of a formed covalent bond.

Why other options are incorrect:

- **Option A, Option B, Option C:** These are the three primary, direct determinants of covalent bond length.

Question #38 Key: (D)

UHS 2022

Which of the following element has smaller size? [UHS 2022]

CORE CONCEPT AND DERIVATION

Atomic radius decreases left to right across a period (due to increasing nuclear charge) and increases top to bottom down a group (due to adding new electron shells).

Formula:

$$\text{Size Trend: Top Right} < \text{Bottom Left}$$

Solution:

- Lithium (Li) is in Period 2.
- Sodium (Na), Aluminum (Al), and Potassium (K) are in Period 3 and Period 4.
- Because Li only has 2 electron shells, while the others have 3 or 4, Li possesses the smallest atomic radius among the given options.

Why other options are incorrect:

- **Option A, Option B, Option C:** All have more principal quantum shells than Lithium, inherently making them substantially larger.

Question #39 Key: (D)

UHS 2022

Among LiCl, [Formula], NaCl and CsCl compounds with the greatest and the least ionic character respectively a...

CORE CONCEPT AND DERIVATION

Ionic character depends on the electronegativity difference. The metal with the lowest ionization energy (most electropositive) forms the most ionic bond, while the one with the highest IE forms the least ionic (most covalent) bond.

Formula:

$$\text{Ionic Character} \propto \Delta \text{EN}$$

Solution:

- Cesium (Cs) is at the bottom left of the periodic table. It is the most electropositive element, creating a massive electronegativity difference with Chlorine. CsCl has the greatest ionic character.
- Beryllium (Be) is at the top of Group 2. It has a very small size and high ionization energy, making it relatively electronegative for a metal. This gives BeCl₂ significant covalent character (least ionic).

Why other options are incorrect:

- Option A, Option B, Option C:** These options fail to pair the absolute extremes of electropositivity present in the list (Cs as highest, Be as lowest).

Question #40 Key: (C)

UHS 2022

[Formula] type with no lone pairs geometry enables to form which shape of molecule? [UHS 2022]

CORE CONCEPT AND DERIVATION

VSEPR theory dictates that 4 identical bonding domains around a central atom will orient themselves in 3D space to maximize their separation angles.

Formula:

$$\text{Angle} = 109.5^\circ$$

Solution:

- With 4 bond pairs and 0 lone pairs, the most stable, lowest-energy configuration is a perfect, symmetrical 3D tetrahedron.
- Because all four domains are identical bonds, the geometry is a "Regular tetrahedron".

Why other options are incorrect:

- Option A:** Describes 3 bond domains.
- Option B:** Describes 6 bond domains.
- Option D:** Describes 3 bond domains + 1 lone pair.

Question #41 **Key: (A)**

SZABMU 2022

Which of the following has greatest difference of electronegativity?
[SZABMU 2022]

CORE CONCEPT AND DERIVATION

Electronegativity decreases down Group 7 (Halogens). Therefore, the difference in electronegativity between Hydrogen and a Halogen is greatest with the halogen at the top of the group.

Formula:

$$\Delta EN = |EN_{(\text{Halogen})} - EN_{(\text{Hydrogen})}|$$

Solution:

- Hydrogen has a constant electronegativity of 2.1.
- Fluorine is the most electronegative element (4.0).
- The difference ($4.0 - 2.1 = 1.9$) is the highest. As you move to Cl (3.0), Br (2.8), and I (2.5), the difference shrinks steadily.

Why other options are incorrect:

- Option B, Option C, Option D:** The halogen electronegativities are progressively lower, resulting in smaller ΔEN and more covalent character.

Question #42 **Key: (D)**

SZABMU 2022

Ionization energy decreases down the group because: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Ionization Energy (IE) is inversely proportional to the atomic radius and shielding effect.

Formula:

$$IE \propto \frac{1}{\text{Atomic Radius}}$$

Solution:

- As you move down a group, new principal quantum shells (electron layers) are added.
- This significantly increases the atomic radius, pushing the outermost valence electrons much further from the positive nucleus.
- The combined effect of increased distance and increased inner-shell shielding heavily outweighs the increased proton number, causing the nucleus's grip to weaken, thereby decreasing the ionization energy.

Why other options are incorrect:

- Option A & Option B:** Both shielding and atomic radius drastically increase down a group; they do not remain constant.
- Option C:** While proton number does increase, by itself this would increase IE. It is the overriding increase in atomic radius/shielding that causes IE to decrease.

Question #43 Key: (A)

KMU 2022

Identify the compound given below which has bond formed by overlapping of sp and p orbital: [ETEA 2022]

CORE CONCEPT AND DERIVATION

Determine the hybridization of the central atom to see which one utilizes sp hybrid orbitals to bond with the unhybridized p -orbitals of a halogen.

Formula:

$$\text{Steric Number (SN)} = 2 \implies sp \text{ hybridization}$$

Solution:

- Beryllium in BeCl_2 forms 2 single bonds with Chlorine and has 0 lone pairs.
- A steric number of 2 means Be is sp hybridized.
- Chlorine uses its unhybridized $3p$ orbital to bond. Thus, the bond is a direct sp - p overlap.

Why other options are incorrect:

- **Option B:** Boron in BF_3 is sp^2 hybridized.
- **Option C & Option D:** Oxygen in water and Nitrogen in ammonia are sp^3 hybridized (and hydrogen uses s -orbitals, not p -orbitals).

Question #44 Key: (C)

KMU 2022

Which of the following elements has highest ionization energy? [ETEA 2022]

CORE CONCEPT AND DERIVATION

Across a period, ionization energy generally increases, but half-filled subshells provide an anomalous boost in stability and thus a higher ionization energy.

Formula:

$$\text{IE Trend: Be} < \text{C} < \text{O} < \text{N}$$

Solution:

- Carbon, Nitrogen, and Oxygen are in Period 2. Generally, IE increases left to right.
- Nitrogen has a perfectly half-filled $2p^3$ valence shell, which is highly symmetrically stable.
- Oxygen has a $2p^4$ shell. The pairing of electrons in one p -orbital causes repulsion, making it easier to remove one electron from Oxygen than from the stable Nitrogen.
- Thus, Nitrogen has a higher IE than Oxygen, making it the highest among the choices.

Why other options are incorrect:

- **Option A, Option B, Option D:** Lack the extraordinary stability of a half-filled p -subshell combined with high nuclear charge.

Question #45 **Key: (B)**

KMU 2022

The shape of ammonia ([Formula]) is [ETEA 2022]

CORE CONCEPT AND DERIVATION

The molecular shape is determined by the positions of the atoms, heavily influenced by the lone pairs on the central atom (VSEPR theory).

Formula:



Solution:

- Ammonia has a central Nitrogen atom bonded to 3 Hydrogen atoms, leaving 1 lone pair.
- The 4 total electron domains arrange themselves in a tetrahedral geometry to minimize repulsion.
- Because one of those domains is an invisible lone pair, the observable shape formed by the atoms is a trigonal pyramid.

Why other options are incorrect:

- **Option A:** Requires 5 bond pairs (e.g., PCl_5).
- **Option C:** Requires 3 bond pairs and 0 lone pairs.
- **Option D:** Requires 4 bond pairs and 2 lone pairs.

Question #46 **Key: (A)**

KMU 2022

The first ionization energy of Al is less than Mg. This is due to: [ETEA 2022]

CORE CONCEPT AND DERIVATION

Ionization energy generally increases across a period, but anomalies occur when electrons are removed from highly stable, fully filled subshells.

Formula:



Solution:

- Magnesium has a completely filled $3s$ subshell, which offers extra stability and requires more energy to disrupt.
- Aluminum's outermost electron resides alone in the $3p$ subshell.
- This $3p$ electron is higher in energy and partially shielded from the nucleus by the full $3s$ orbital, making it easier to remove.

Why other options are incorrect:

- **Option B, Option C, Option D:** These are either consequences or simple factual statements that do not explain the quantum mechanical reason for the anomaly.

Question #47 Key: (A)

KMU 2022

Which one of the following elements has the largest second ionization energy? [ETEA 2022]

CORE CONCEPT AND DERIVATION

The second ionization energy spikes massively when the removal of the second electron requires breaking into a highly stable, completely filled noble gas core.

Formula:

K^+ configuration: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$ (Argon core)

Solution:

- Potassium (K) is a Group 1 alkali metal. It easily loses its single valence electron to form a K^+ ion.
- This K^+ ion is isoelectronic with Argon, possessing a perfectly stable octet.
- Removing a second electron requires disrupting this incredibly stable core, demanding a massive amount of energy compared to elements with multiple valence electrons.

Why other options are incorrect:

- **Option B, Option C, Option D:** Calcium, Chlorine, and Bismuth have multiple electrons in their valence shell. Their second ionization does not involve breaking a noble gas core.

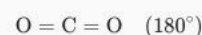
Question #48 Key: (B)

DUHS 2022

The dipole moment of [Formula] is zero because it is: [DUHS 2022]

CORE CONCEPT AND DERIVATION

A molecule's net dipole moment is the vector sum of its individual bond dipoles. If the molecule is perfectly symmetrical, these vectors cancel out.

Formula:**Solution:**

- Carbon dioxide (CO_2) is an AB_2 type molecule with no lone pairs on the central Carbon atom.
- This gives it a perfectly linear geometry.
- The two highly electronegative Oxygen atoms pull electron density equally in exactly opposite directions, causing the bond dipole vectors to sum to zero.

Why other options are incorrect:

- **Option A & Option D:** These geometries are asymmetrical and would result in a net polar molecule.
- **Option C:** Being triatomic does not guarantee a zero dipole (e.g., H_2O is triatomic and highly polar).

Question #49 Key: (D)

DUHS 2022

Ethene ([Formula]) has hybridization of C-atom: [DUHS 2022]

CORE CONCEPT AND DERIVATION

The hybridization of an atom can be quickly determined by its steric number (the sum of sigma bonds and lone pairs attached to it).

Formula:

$$\text{Steric Number} = 3\sigma \text{ bonds} + 0 \text{ lone pairs} = 3$$

Solution:

- In ethene, each Carbon atom forms a double bond with the other Carbon and single bonds with two Hydrogen atoms.
- A double bond consists of one sigma bond and one pi bond. Therefore, each Carbon has exactly 3 sigma bonding domains.
- A steric number of 3 dictates the mixing of one s-orbital and two p-orbitals, resulting in sp^2 hybridization.

Why other options are incorrect:

- **Option B:** Occurs when carbon has triple bonds or two double bonds (steric number 2).
- **Option C:** Occurs when carbon has four single bonds (steric number 4).

Question #50 Key: (B)

DUHS 2022

Cation & anion formed which combines to form crystal lattices: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Ionic bonds form so that both participating atoms can achieve a stable, lower-energy electron configuration, typically an octet.

Formula:**Solution:**

- Metals lose electrons to empty their valence shell, exposing the full stable shell beneath (becoming isoelectronic with the preceding noble gas).
- Nonmetals gain electrons to completely fill their current valence shell (becoming isoelectronic with the succeeding noble gas).
- Thus, in stable ionic crystal lattices, both the resulting cations and anions achieve a stable noble gas configuration.

Why other options are incorrect:

- **Option A & Option D:** It is not an exclusive process; both ions achieve stability simultaneously.
- **Option C:** While true that total electrons lost equals total gained in the bulk compound, option B is the fundamental driving force for the individual ions' stability as per standard textbook phrasing.

Question #51 Key: (C)

DUHS 2022

The ionization energy increases along a period in periodic table due to increase in: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Ionization energy is the energy required to remove an electron. It depends on how strongly the positive nucleus attracts the valence electrons.

Formula:

Z_{eff} increases left to right across a period.

Solution:

- As you move from left to right across a period, protons are added to the nucleus, steadily increasing the nuclear charge.
- Electrons are simultaneously added to the same principal valence shell, which does not significantly increase the shielding effect.
- The net result is a stronger effective nuclear charge (Z_{eff}) pulling the electrons closer, meaning more energy is required to tear an electron away.

Why other options are incorrect:

- Option D:** While electrons increase, it is the pulling force of the positive nucleus (nuclear charge) that causes the contraction and tighter grip.
- Option A & Option B:** Positrons are not involved in standard atomic structure, and neutrons have no electrostatic charge.

Question #52 Key: (A)

BUMHS 2022

During the formation of chemical bond: [BMU 2022]

CORE CONCEPT AND DERIVATION

Chemical bonding is an inherently stabilizing process. Atoms bond to reach a lower, more stable energy state.

Formula:

$$\Delta H < 0 \text{ (Exothermic process)}$$

Solution:

- When two atoms approach each other and form a bond, the attractive forces between their nuclei and the shared electrons overcome the repulsive forces.
- This system drops to a lower potential energy state.
- The excess energy is released into the surroundings (exothermic), meaning the intrinsic energy of the newly bonded molecule decreases compared to the isolated atoms.

Why other options are incorrect:

- Option B & Option C:** If energy increased or stayed the same, there would be no thermodynamic driving force for the bond to form in the first place.

Question #53 **Key: (A)**

BUMHS 2022

*Bond energy is expressed in: [BMU 2022]***CORE CONCEPT AND DERIVATION**

Bond energy (or bond enthalpy) measures the strength of a chemical bond. It is quantified as the energy required to break one mole of a specific bond type in the gas phase.

Formula:

Standard SI Unit for Molar Enthalpy = kJ/mol

Solution:

- Because individual atoms are incredibly small, chemists measure bond energies on a macroscopic scale using moles.
- The energy is typically very large, so it is expressed in kilojoules (kJ) rather than standard Joules.
- Therefore, the standard unit is Kilojoules per mole (kJ/mol).

Why other options are incorrect:

- **Option B & Option C:** While calories and Joules are units of energy, they lack the per-mole (macroscopic) scaling standard in chemical thermodynamics.
- **Option D:** Volt is a unit of electrical potential, not chemical energy.

Question #54 **Key: (B)**

BUMHS 2022

*Which of the following is not a primary bond? [BMU 2022]***CORE CONCEPT AND DERIVATION**

Chemical bonds are categorized into primary (strong intramolecular forces) and secondary (weaker intermolecular forces).

Formula:

Primary = Ionic, Covalent, Metallic

Solution:

- Primary bonds involve the actual transfer or sharing of electrons between atoms to form molecules or crystal lattices (e.g., Ionic, Covalent, and Dative/Coordinate bonds).
- Hydrogen bonds are secondary bonds. They are relatively weak dipole-dipole intermolecular forces that occur between already stable molecules, rather than forming the fundamental structure of the molecule itself.

Why other options are incorrect:

- **Option A, Option C, Option D:** These all involve the sharing or transferring of valence electrons, strictly defining them as strong primary bonds.

Question #55 **Key: (A)**

BUMHS 2022

Which of the following has NOT [Formula] hybridized carbon? [BMU 2022]

CORE CONCEPT AND DERIVATION

An sp^3 hybridized carbon atom must be attached to four separate domains exclusively by single bonds (sigma bonds).

Formula:



Solution:

- Benzene (C_6H_6) consists of a planar hexagonal ring where every single carbon atom forms one double bond (delocalized) and two single bonds. Therefore, every carbon in benzene is sp^2 hybridized. It has absolutely zero sp^3 carbons.
- 1-Butene, 2-Butyne, and 1-Pentene all contain carbon chains that feature standard alkane-like CH_2 or CH_3 groups, which are fully sp^3 hybridized.

Why other options are incorrect:

- **Option B, Option C, Option D:** These aliphatic chains contain at least one saturated carbon with four single bonds, meaning they do possess sp^3 hybridized carbons.

Question #56 **Key: (C)**

NUMS 2022

Type of hybridization of carbon in Ethene ([Formula]) is: [NUMS 2022]

CORE CONCEPT AND DERIVATION

The hybridization of a carbon atom depends on the number of sigma bonds it forms.

Formula:

$$\text{Steric Number (SN)} = \text{Number of } \sigma \text{ bonds}$$

Solution:

- In Ethene (C_2H_4), each Carbon atom is bonded to two Hydrogens (2 single sigma bonds) and one Carbon (1 double bond = 1 sigma + 1 pi).
- Total sigma domains = 3.
- A steric number of 3 requires the mixing of one s and two p orbitals, yielding sp^2 hybridization.

Why other options are incorrect:

- **Option A:** Requires 4 sigma bonds (e.g., Ethane).
- **Option B:** Requires 2 sigma bonds (e.g., Ethyne).
- **Option D:** Involves d-orbitals, which carbon (in Period 2) does not possess in its valence shell.

Question #57 Key: (D)

NUMS 2022

*Which of the following molecule is polar? [NUMS 2022]***CORE CONCEPT AND DERIVATION**

A molecule is polar if it contains polar bonds that do not cancel each other out symmetrically.

Formula:

$$\mu \neq 0 \Rightarrow \text{Polar Molecule}$$

Solution:

- Hydrogen Chloride (HCl) is a simple diatomic molecule.
- Chlorine (EN = 3.0) is much more electronegative than Hydrogen (EN = 2.1).
- This creates a permanent uneven sharing of electrons (a dipole), making the molecule polar. There are no other bonds to cancel this dipole out.

Why other options are incorrect:

- **Option A:** CCl₄ is a perfectly symmetrical tetrahedron; dipoles cancel completely.
- **Option B:** CO₂ is perfectly linear; dipoles cancel perfectly.
- **Option C:** AlCl₃ is a perfectly symmetrical trigonal planar molecule; dipoles cancel.

Question #58 Key: (C)

NUMS 2022

*Electron affinity decreases down the group because: [NUMS 2022]***CORE CONCEPT AND DERIVATION**

Electron affinity is the energy released when an electron is added. A stronger pull from the nucleus results in a higher electron affinity.

Formula:

$$\text{Electron Affinity} \propto \frac{1}{\text{Atomic Radius}}$$

Solution:

- As you move down a group, new electron shells are added, causing the atomic radius to increase significantly.
- The incoming electron must enter a shell that is much farther away from the positive nucleus.
- Additionally, the increased number of inner shells creates a strong shielding effect.
- Both factors weaken the nucleus's attractive force on the incoming electron, resulting in less energy being released (decreased electron affinity).

Why other options are incorrect:

- **Option A:** While proton number increases, its effect is completely overwhelmed by the increase in radius and shielding.
- **Option B & Option D:** These are factually incorrect statements; shielding and atomic radius both *increase* down a group.

Question #59 Key: (B)

NUMS 2022

Which of the following molecule is covalent in nature? [NUMS 2022]

CORE CONCEPT AND DERIVATION

According to Fajans' Rules, the covalent character of an ionic compound increases with a high positive charge and small size of the cation (high polarizing power).

Formula:

$$\text{Polarizing Power} \propto \frac{\text{Charge}}{\text{Radius}}$$

Solution:

- Aluminum in AlCl_3 has a very high charge (3^+) and a small ionic radius compared to Na, K, and Mg.
- This gives Al^{3+} extreme polarizing power, allowing it to strongly distort (polarize) the electron cloud of the chloride anions.
- This heavy distortion pulls the electrons into the space between the nuclei, creating substantial electron sharing (covalent character). Therefore, AlCl_3 exists predominantly as a covalent molecule.

Why other options are incorrect:

- Option A, Option C, Option D:** These metals (Na, Mg, K) have lower charges (1^+ , 2^+) and larger radii, leading to weak polarizing power and predominantly ionic bonds.

Question #60 Key: (B)

PMDC 2021

P character in sp : [PMC 2021]**CORE CONCEPT AND DERIVATION**

The fractional character of a specific orbital type in a hybrid is determined by its ratio to the total number of orbitals involved.

Formula:

$$\text{\% p-character} = \left(\frac{\text{number of p orbitals}}{\text{total hybrid orbitals}} \right) \times 100$$

Solution:

- sp hybridization is formed by mixing one s-orbital and one p-orbital.
- Total orbitals mixed = 2.
- Ratio of p-orbitals = $\frac{1}{2}$.
- $\frac{1}{2} \times 100 = 50\%$.

Why other options are incorrect:

- Option A:** 75% is the p-character of an sp^3 orbital.
- Option C:** 25% is the s-character of an sp^3 orbital.
- Option D:** 33% is the s-character of an sp^2 orbital.

Question #61 Key: (A)

PMDC 2021

Hybridization in ethyne ([Formula]): [PMC 2021]

CORE CONCEPT AND DERIVATION

The presence of a triple bond dictates that the carbon atoms are sp hybridized.

Formula:**Solution:**

- In ethyne, each Carbon atom forms exactly 2 sigma bonds (one with Hydrogen, one with the other Carbon) and has no lone pairs.
- A steric number of 2 corresponds to sp hybridization.
- Since both carbons are identical, the sigma bond between them is formed by the head-on overlap of an sp orbital from one carbon with an sp orbital from the other.

Why other options are incorrect:

- **Option C:** Applies to ethene (double bond).
- **Option D:** Applies to ethane (single bonds).

Question #62 Key: (B)

PMDC 2021

The geometry of [Formula] type molecule is: [PMC 2021]

CORE CONCEPT AND DERIVATION

According to VSEPR theory, a central atom bonded to three identical atoms with zero lone pairs will arrange those bonds to maximize distance and minimize repulsion.

Formula:

$$\text{Bond Angle} = \frac{360^\circ}{3} = 120^\circ$$

Solution:

- Three electron domains will space themselves out equally in a two-dimensional plane.
- This results in a flat, triangular shape known as Trigonal Planar geometry (e.g., BF_3).

Why other options are incorrect:

- **Option A:** Trigonal pyramidal occurs when a lone pair pushes the three bonds down into a 3D pyramid (AB_3E).
- **Option C:** Requires 5 bond pairs (AB_5).

Question #63 **Key: (A)**

PMDC 2021

Shape of [Formula] : [PMC 2021]

CORE CONCEPT AND DERIVATION

The shape of a molecule is determined by the positions of the atoms, heavily influenced by the invisible lone pairs on the central atom.

Formula:**Solution:**

- Sulfur (Group VIA) has 6 valence electrons. It shares 2 with hydrogen atoms, leaving 4 electrons (2 lone pairs).
- The 4 total electron domains arrange tetrahedrally.
- The 2 lone pairs severely repel the 2 bond pairs, bending the molecule.
- The resulting visible geometry is Angular (or Bent).

Why other options are incorrect:

- **Option B:** This is the *electron* geometry, not the *molecular* shape.
- **Option D:** Requires 3 bond pairs and 0 lone pairs.

Question #64 **Key: (D)**

PMDC 2020

Which of the following has the highest value of electronegativity?
[NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Electronegativity is the tendency of an atom to attract a shared pair of electrons. It increases across a period and decreases down a group.

Formula:**Solution:**

- Fluorine is at the very top right of the periodic table (excluding noble gases).
- It has the smallest atomic radius among the halogens and minimal shielding.
- Because its valence electrons are closest to the highly attractive positive nucleus, Fluorine has the highest electronegativity value of all elements (4.0 on the Pauling scale).

Why other options are incorrect:

- **Option A, Option B, Option C:** As you move down Group 7, the atomic radius and shielding effect increase, weakening the nucleus's grip on shared electrons and lowering electronegativity.

Question #65 Key: (C)

PMDC 2020

Which of the following hybrid orbital have maximum s-character?
[NMDCAT 2020]

CORE CONCEPT AND DERIVATION

The s-character of a hybrid orbital is calculated by dividing the number of s-orbitals by the total number of orbitals involved in the hybridization.

Formula:

$$\text{\text{\% s-character}} = \left(\frac{\text{\text{number of s orbitals}}}{\text{\text{total hybrid orbitals}}} \right) \times 100$$

Solution:

- sp hybridization mixes 1 s-orbital and 1 p-orbital (2 total). s-character = $\frac{1}{2} = 50\%$.
- sp^2 hybridization mixes 1 s and 2 p (3 total). s-character = $\frac{1}{3} = 33.3\%$.
- sp^3 hybridization mixes 1 s and 3 p (4 total). s-character = $\frac{1}{4} = 25\%$.
- Therefore, sp hybridized orbitals have the maximum s-character.

Why other options are incorrect:

- **Option A, Option B, Option D:** All possess less than 50% s-character.

Question #66 Key: (B)

PMDC 2020

The first ionization energy is maximum for: [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Ionization energy generally increases across a period. However, atoms with fully filled subshells (like ns^2) exhibit anomalous stability, causing a spike in their ionization energy.

Formula:



Solution:

- Sodium (Na) and Potassium (K) are Group 1 alkali metals with a single, easily lost valence electron.
- Magnesium (Mg) has a completely filled $3s^2$ valence subshell, which is highly stable and strongly held by the nucleus.
- Aluminum (Al) has its outermost electron in a higher-energy $3p$ orbital, which is partially shielded by the $3s$ electrons, making it easier to remove than Mg's electron.

Why other options are incorrect:

- **Option A & Option D:** Alkali metals have the lowest IE in their respective periods.
- **Option C:** Due to the $3p$ shielding, Al's IE drops slightly below Mg.

Question #67 Key: (B)

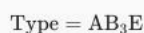
MDCAT 2019

The structure of Xenon trioxide ([Formula]) is shown below. Xe O O
O Trigonal Pyramidal Structure of XeO₃ wi...

CORE CONCEPT AND DERIVATION

The molecular shape is dictated by the arrangement of bond pairs and lone pairs around the central atom according to VSEPR theory.

Formula:



Solution:

- Xenon (Xe) in XeO₃ forms three double bonds with oxygen atoms (3 bonding domains).
- Xe is a noble gas with 8 valence electrons. Sharing 6 electrons with Oxygen leaves 2 electrons, which form 1 lone pair.
- A molecule with 3 bond pairs and 1 lone pair (AB₃E) adopts a trigonal pyramidal geometry.

Why other options are incorrect:

- **Option A:** Would require 4 bond pairs and 0 lone pairs.
- **Option C:** Would require 2 bond pairs.
- **Option D:** Would require 3 bond pairs and 0 lone pairs.

Question #68 Key: (B)

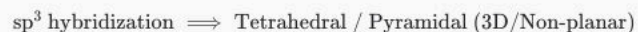
MDCAT 2019

Which of the following sets constitutes of all the molecules and ions of non-planar geometry? [MDCAT 2019]

CORE CONCEPT AND DERIVATION

Molecules with sp³ or higher hybridization (in 3 dimensions) are generally non-planar, while those with purely sp² or sp hybridization lacking lone pair distortions tend to be planar or linear.

Formula:



Solution:

- CH₄, NH₄⁺, and MnO₄⁻ have perfect tetrahedral geometries (non-planar).
- NF₃ has a trigonal pyramidal geometry (non-planar).
- Thus, every species in this option extends into three dimensions and is strictly non-planar.

Why other options are incorrect:

- **Option A:** C₂H₄, BF₃, and NO₃⁻ are all strictly planar.
- **Option C:** Ethene (CH₂ = CH₂) is planar, and BeCl₂ is linear (1D).
- **Option D:** SO₃ and Benzene are entirely planar molecules.

Question #69 Key: (D)

NUMS 2019

The shape of [Formula] molecule is similar to: [NUMS 2019]

CORE CONCEPT AND DERIVATION

Molecules of type AB_2 with no lone pairs on the central atom exhibit a linear shape due to maximum repulsion (180°).

Formula:

Geometry = Linear (180°)

Solution:

- Carbon dioxide (CO_2) has a central Carbon atom with 2 double bonds and 0 lone pairs. It is linear.
- Beryllium fluoride (BeF_2) has a central Beryllium atom with 2 single bonds and 0 lone pairs. It is also completely linear.

Why other options are incorrect:

- Option A, Option B, Option C:** H_2S , SO_2 , and $SnCl_2$ all possess lone pairs on their central atoms, which push the bond pairs down, creating a bent or angular geometry.

Question #70 Key: (A)

SET 2019

What is the shape of ammonia [Formula] molecule? [SET 2019]

CORE CONCEPT AND DERIVATION

The geometry of ammonia is defined by sp^3 hybridization with one lone pair.

Formula:

Type = $AB_3E \Rightarrow$ Trigonal Pyramidal

Solution:

- Nitrogen has 5 valence electrons. It uses 3 to bond with Hydrogen atoms, leaving 1 lone pair.
- The 4 electron domains arrange tetrahedrally to minimize repulsion, but the presence of the lone pair makes the observable molecular shape trigonal pyramidal.

Why other options are incorrect:

- Option B:** Occurs in sp hybridized molecules without distorting lone pairs.
- Option C:** Describes the *electron domain geometry*, but the *molecular shape* (excluding the invisible lone pair) is pyramidal.
- Option D:** Occurs in sp^2 molecules (like BF_3) with no lone pairs.

Question #71 Key: (A)

MDCAT 2019

Which one of the following molecules has [Formula] hybridization?
[MDCAT 2019]

CORE CONCEPT AND DERIVATION

Hybridization is determined by the number of sigma bonds and lone pairs on the central atom.

Formula:

$$\text{Steric Number} = (\sigma \text{ bonds}) + (\text{lone pairs})$$

Solution:

- In methane (CH_4), Carbon forms 4 sigma bonds and has 0 lone pairs.
- Steric number = 4, which perfectly corresponds to sp^3 hybridization (mixing one s and three p orbitals).

Why other options are incorrect:

- **Option B:** Ethyne (C_2H_2) has a triple bond, making its carbons sp hybridized.
- **Option C:** Ethene (C_2H_4) has a double bond, making its carbons sp^2 hybridized.
- **Option D:** Carbon dioxide (CO_2) has two double bonds on the central carbon, making it sp hybridized.

Question #72 Key: (C)

SET 2019

According to the Lewis Concept, ammonia is a lone pair donor, therefore easily accepts a proton to form an amm...

CORE CONCEPT AND DERIVATION

Removing a lone pair by converting it into a bonding pair removes the strong LP-BP repulsion, allowing the molecule's bond angles to expand to their ideal geometric state.

Formula:

$$\text{Angle}_{(\text{NH}_3)} = 107^\circ \longrightarrow \text{Angle}_{(\text{NH}_4^+)} = 109.5^\circ$$

Solution:

- In ammonia (NH_3), the nitrogen has 3 bond pairs and 1 lone pair. The lone pair repels the bonds strongly, compressing the angle to 107° .
- When a proton (H^+) attaches, the lone pair becomes a bond pair, forming NH_4^+ .
- The ion now has 4 identical bond pairs and 0 lone pairs. It assumes a perfect tetrahedral geometry with angles of exactly 109.5° .

Why other options are incorrect:

- **Option A, Option B, Option D:** These state incorrect initial angles or falsely claim the angle decreases. The angle must increase because the compressing force of the lone pair is neutralized.

Question #73 Key: (B)

NUMS 2019

Which of the following molecule has zero dipole moment? [NUMS 2019]

CORE CONCEPT AND DERIVATION

A molecule has a zero dipole moment if it is highly symmetrical and lacks lone pairs on its central atom, causing all individual bond dipoles to cancel each other out.

Formula:

$$\mu = 0 \text{ for perfectly symmetrical molecules.}$$

Solution:

- Boron trifluoride (BF_3) has sp^2 hybridization, giving it a flat, trigonal planar geometry.
- Boron has no lone pairs to distort the symmetry.
- The three polar B-F bonds pull equally at 120° angles, resulting in a net vector sum (dipole moment) of zero.

Why other options are incorrect:

- **Option A, Option C, Option D:** PCl_3 , NH_3 , and H_2O all possess lone pairs on their central atoms, which creates asymmetry and results in a net, non-zero dipole moment.

Question #74 Key: (B)

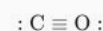
SET 2019

Among the following molecules, which one has coordinate covalent (dative) bond? [SET 2019]

CORE CONCEPT AND DERIVATION

A coordinate covalent (dative) bond is formed when one atom provides both electrons for a shared pair to complete the octet of another atom.

Formula:



Solution:

- In Carbon Monoxide (CO), Carbon has 4 valence electrons and Oxygen has 6.
- They form two normal covalent bonds, giving Oxygen 8 electrons (stable), but Carbon only has 6.
- To stabilize Carbon, Oxygen donates a lone pair to form a third bond (a coordinate covalent bond). Thus, CO possesses a triple bond: two normal and one dative.

Why other options are incorrect:

- **Option A, Option C, Option D:** All atoms in these molecules complete their octets through standard mutual sharing of electrons. No lone pair donation is required.

Question #75 **Key: (B)**

NUMS 2019

Which of the following molecule has zero dipole moment? [NUMS 2019]

CORE CONCEPT AND DERIVATION

Dipole moments cancel out entirely in highly symmetrical molecules lacking lone pairs on the central atom.

Formula:

$$\text{Net Dipole } (\mu) = 0$$

Solution:

- As established, Boron trifluoride (BF_3) has perfectly symmetrical trigonal planar geometry.
- Because all B-F bonds are identical and spaced equally at 120° , their individual dipole vectors cancel completely.

Why other options are incorrect:

- **Option A, Option C, Option D:** All possess lone pairs on the central atom, creating asymmetric shapes (pyramidal and bent) that prevent dipole cancellation.

Question #76 **Key: (C)**

NUMS 2019

For formation of ionic bond, electronegativity difference should be: [NUMS 2019]

CORE CONCEPT AND DERIVATION

The nature of a bond (ionic vs. covalent) is determined by the difference in electronegativity (ΔEN) between the two bonding atoms.

Formula:

$$\Delta\text{EN} > 1.7 \implies \text{Ionic Bond predominantly}$$

Solution:

- If the difference is greater than 1.7, the more electronegative atom will effectively strip the electron completely away from the less electronegative atom, forming ions.
- This results in electrostatic attraction, forming an ionic bond (usually >50% ionic character).

Why other options are incorrect:

- **Option A & Option B:** Indicate non-polar covalent bonds (equal or nearly equal sharing).
- **Option D:** Represents a polar covalent bond, where electrons are shared unequally but not fully transferred.

Question #77 Key: (A)

NUMS 2019

The shielding effect of inner electron is responsible for: [NUMS 2019]

CORE CONCEPT AND DERIVATION

Shielding effect occurs when inner shell electrons repel outer shell electrons, partially blocking the attractive pull of the positive nucleus.

Formula:

$$Z_{\text{eff}} = Z - S$$

Solution:

- As the number of inner electron shells increases (moving down a group), the shielding effect becomes stronger.
- This reduces the effective nuclear charge (Z_{eff}) felt by the outermost valence electrons.
- Because they are held less tightly, less energy is required to remove them, resulting in a decreased ionization energy.

Why other options are incorrect:

- **Option C & Option D:** Shielding makes electrons easier to lose, which decreases ionization energy and electronegativity, rather than increasing them.

Question #78 Key: (C)

KMU 2019

A molecule which contains two lone pairs and two bond pairs of electrons in valence shell of central atom, geo...

CORE CONCEPT AND DERIVATION

A molecule with 4 total electron domains (2 bond pairs, 2 lone pairs) is based on a tetrahedral electron geometry.

Formula:

$$\text{Type} = \text{AB}_2\text{E}_2 \implies \text{Bent / Angular}$$

Solution:

- The central atom is sp^3 hybridized.
- The two bulky lone pairs strongly repel each other and the bond pairs, squeezing the bond angle (e.g., in water H_2O , from 109.5° down to 104.5°).
- Because molecular shape is determined only by the positions of the atoms, the resulting shape is angular (bent).

Why other options are incorrect:

- **Option A:** Requires 4 bond pairs and 0 lone pairs.
- **Option B:** Requires 3 bond pairs and 1 lone pair.
- **Option D:** Requires no lone pairs interfering with the bonds.

Question #79 Key: (D)

KMU 2019

[Formula] will form the most ionic bond with: [ETEA 2019]

CORE CONCEPT AND DERIVATION

The ionic character of a bond is directly proportional to the difference in electronegativity between the metal cation and the non-metal anion.

Formula:

$$\text{Max } \Delta \text{EN} = \text{Most Ionic Character}$$

Solution:

- Fluorine (F^{-1}) is the most electronegative element in the periodic table ($\text{EN} = 4.0$).
- The difference in electronegativity between Iron and Fluorine will be the largest possible among the given choices.
- Therefore, the bond between Fe^{+2} and F^{-1} will exhibit the highest percentage of ionic character.

Why other options are incorrect:

- **Option A, Option B, Option C:** Nitrogen, Tin, and Phosphorus have significantly lower electronegativities than Fluorine, resulting in bonds with higher covalent character.

Question #80 Key: (D)

KMU 2019

Which of the following elements has lowest first ionization energy? [ETEA 2019]

CORE CONCEPT AND DERIVATION

Ionization energy generally increases across a period from left to right due to increasing effective nuclear charge and decreasing atomic radius.

Formula:

$$\text{IE Trend (Period 2): Li} < \text{B} < \text{Be} < \text{C} < \text{O} < \text{N} < \text{F} < \text{Ne}$$

Solution:

- Boron (B) is further to the left in Period 2 compared to C, N, and O.
- It has a larger atomic radius and a lower effective nuclear charge than the others.
- Therefore, its outermost electron is held the least tightly, requiring the lowest energy to remove.

Why other options are incorrect:

- **Option A, Option B, Option C:** These elements lie further to the right, possessing smaller radii and stronger nuclear grips on their electrons, hence higher ionization energies.

Question #81 Key: (C)

KMU 2019

Which one of the following elements has the largest second ionization energy? [ETEA 2019]

CORE CONCEPT AND DERIVATION

The second ionization energy involves removing an electron from a 1^+ cation. If this removal disrupts a highly stable noble gas core configuration, the energy required will be exceptionally large.

Formula:

Na^+ Electron Configuration: $1s^2, 2s^2, 2p^6$ (Noble Gas Core)

Solution:

- Sodium (Na) is in Group 1. Its first ionization removes its only valence electron, forming Na^+ , which is isoelectronic with Neon (a stable octet).
- Removing a second electron requires breaking into this incredibly stable, deeply buried, full inner shell.
- The massive increase in effective nuclear charge acting on this inner shell causes Na to have a spectacularly high second ionization energy.

Why other options are incorrect:

- **Option A, Option B, Option D:** For O, F, and N, the second electron is being removed from an already partially filled valence shell, which does not require breaking a stable noble gas core.

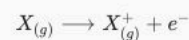
Question #82 Key: (B)

KMU 2019

Which equation relates to the first ionization energy of bromine? [ETEA 2019]

CORE CONCEPT AND DERIVATION

By definition, first ionization energy is the energy required to remove one mole of electrons from one mole of **isolated gaseous atoms** to form gaseous cations.

Formula:**Solution:**

- The definition strictly demands that the starting material is an isolated, single gaseous atom ($\text{Br}_{(g)}$), NOT a molecule.
- Option B shows exactly this: a single, gaseous Bromine atom losing one electron to become a gaseous Bromine cation.

Why other options are incorrect:

- **Option A, Option C, Option D:** These involve Br_2 molecules (either gaseous or liquid). Ionizing a molecule involves bond dissociation enthalpy and/or enthalpy of vaporization, which confounds the pure definition of atomic ionization energy.

Question #83 Key: (B)

KMU 2019

The bond angle in [Formula] is less than [Formula]. It is due to: [ETEA 2019]

CORE CONCEPT AND DERIVATION

When the central atom is highly electronegative, bond pairs are pulled closer to the central nucleus. This causes strong bond pair-bond pair (BP-BP) repulsion, which forces the bond angle to widen.

Formula:

$$\text{Bond Angle} \propto \text{Electronegativity of Central Atom}$$

Solution:

- Oxygen (EN = 3.5) is much more electronegative than Sulfur (EN = 2.5).
- In H_2O , the bonding electrons are pulled very close to the Oxygen nucleus. Because they are confined in a tight space, they repel each other strongly, keeping the angle relatively wide (104.5°).
- In H_2S , the bonding electrons are further from the Sulfur nucleus. The BP-BP repulsion is weaker, allowing the lone pairs to crush the bond angle down to about 92° .

Why other options are incorrect:

- **Option A:** Size plays a role, but electronegativity is the direct electronic driver of the bond pair positioning.
- **Option C:** Both Oxygen and Sulfur contain two lone pairs, so this is not the distinguishing factor.

Question #84 Key: (A)

MDCAT 2019

In the second period of elements, although oxygen lies next to nitrogen yet its first ionization energy is low...

CORE CONCEPT AND DERIVATION

Half-filled subshells (like Nitrogen's $2p^3$) provide extra stability. Adding one more electron creates pairing repulsion, making it easier to remove.

Formula:**Solution:**

- Nitrogen has a perfectly half-filled p-subshell, which is symmetrically stable.
- Oxygen has four p-electrons, meaning one of the p-orbitals must contain a pair of electrons.
- This pairing causes inter-electronic repulsion, destabilizing the electron and making it easier to remove from Oxygen than from the highly stable Nitrogen atom.

Why other options are incorrect:

- **Option C:** A greater nuclear charge would logically increase ionization energy. The anomaly is purely due to electron repulsion.
- **Option B & Option D:** True statements about Oxygen, but they do not explain the ionization energy anomaly.

Question #85 **Key: (A)**

MDCAT 2019

Nitrogen has the atomic number 7. Which of the following electronic configurations is of a Nitrogen atom in gr...

CORE CONCEPT AND DERIVATION

According to Hund's Rule, electrons occupy degenerate orbitals singly, with parallel spins, before pairing up.

Formula:

$$\text{Total Electrons} = 7$$

Solution:

- The first two electrons fill the $1s$ orbital: $1s^2$.
- The next two electrons fill the $2s$ orbital: $2s^2$.
- The remaining three electrons must be distributed among the three degenerate $2p$ orbitals (p_x, p_y, p_z).
- By Hund's Rule, they each take one empty orbital rather than pairing up: $2p_x^1, 2p_y^1, 2p_z^1$.

Why other options are incorrect:

- **Option B, Option C, Option D:** These configurations show electrons pairing up in one of the p -orbitals while leaving another empty, which violently violates Hund's Rule of maximum multiplicity.

Question #86 **Key: (A)**

MDCAT 2018

Which option show all the molecules with bond angle 109.5° ?
[MDCAT 2018]

CORE CONCEPT AND DERIVATION

A perfect bond angle of 109.5° occurs in molecules with a regular tetrahedral geometry, which requires sp^3 hybridization and zero lone pairs on the central atom.

Formula:

$$\text{Geometry} = \text{Tetrahedral (AB}_4\text{)}$$

Solution:

- $\text{SiCl}_4, \text{NH}_4^+, \text{ and } \text{CH}_4$ all feature a central atom with exactly 4 bond pairs and 0 lone pairs.
- Because there are no lone pairs to compress the bond angles, the geometry is a perfectly symmetrical tetrahedron.
- The resulting bond angle in all three species is exactly 109.5° .

Why other options are incorrect:

- **Option B:** H_2O has an angle of 104.5° , and BeCl_2 is 180° .
- **Option C:** NH_3 has one lone pair, compressing its angle to 107.5° .
- **Option D:** PH_3 has one lone pair, making its angle even smaller than ammonia.

Question #87 **Key: (C)**

MDCAT 2018

Which if the following molecule has largest number of shared pair electrons? [MDCAT 2018]

CORE CONCEPT AND DERIVATION

The number of shared electron pairs equals the total number of covalent bonds (both sigma and pi) in the molecule.

Formula:

$$\text{Shared Pairs} = \text{Total Bonds}$$

Solution:

- NH_3 : 3 single bonds = 3 shared pairs.
- CO_2 ($\text{O}=\text{C}=\text{O}$): 2 double bonds = 4 shared pairs.
- N_2 ($\text{N} \equiv \text{N}$): 1 triple bond = 3 shared pairs.
- C_2H_4 (Ethene): 4 C-H single bonds + 1 C=C double bond = 6 covalent bonds = 6 shared pairs.

Why other options are incorrect:

- **Option A, Option B, Option D:** These molecules possess fewer total bonds, hence fewer shared pairs compared to ethene.

Question #88 **Key: (A)**

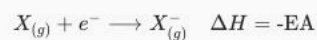
MDCAT 2018

Electron affinity of the atom is the energy released when: [MDCAT 2018]

CORE CONCEPT AND DERIVATION

Electron affinity (EA) is defined thermodynamically as the change in energy associated with the addition of an electron to a neutral gaseous atom.

Formula:



Solution:

- When a non-metal gaseous atom attracts and captures a free electron, it becomes a negatively charged anion.
- Because the incoming electron falls into the attractive field of the nucleus, energy is usually released (exothermic process).

Why other options are incorrect:

- **Option B:** Defines Ionization Energy.
- **Option C:** Defines Bond Dissociation Energy.
- **Option D:** Defines Bond Formation Energy.

Question #89 **Key: (B)**

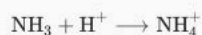
MDCAT 2017

Observe the given dot and cross structures for the following molecules or ionic species. The co-ordinate coval...

CORE CONCEPT AND DERIVATION

A coordinate covalent (dative) bond forms when one atom provides both electrons for a shared pair.

Formula:



Solution:

- In all four illustrated structures, the core species is the ammonium ion (NH_4^+).
- The nitrogen atom in ammonia (NH_3) has one lone pair.
- Nitrogen donates this lone pair to an empty 1s orbital of a hydrogen ion (H^+), forming a coordinate covalent bond between N and H.

Why other options are incorrect:

- **Option A, C & D:** These do not accurately describe the dative bond formation, which exclusively occurs between the central Nitrogen and the incoming Hydrogen ion.

Question #90 **Key: (D)**

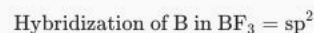
MDCAT 2017

What is the exact value of angle in [Formula] ? [MDCAT 2017]

CORE CONCEPT AND DERIVATION

The geometry of a molecule is determined by the number of electron domains around its central atom (VSEPR theory).

Formula:



Solution:

- Boron trifluoride (BF_3) belongs to the AB_3 type molecule.
- The central boron atom has 3 bond pairs and 0 lone pairs.
- This results in a perfect trigonal planar geometry, distributing the domains evenly to minimize repulsion.
- The circle (360°) divided evenly among 3 domains yields exactly 120° .

Why other options are incorrect:

- **Option A:** Associated with octahedral or square planar geometries.
- **Option B:** Bond angle for water (H_2O) due to 2 lone pairs.
- **Option C:** Represents slight compression seen in structures with double bonds (like alkenes), not a symmetrical AB_3 molecule.

Question #91 Key: (C)

MDCAT 2017

pi-bond is formed by sideways overlap of: [MDCAT 2017]**CORE CONCEPT AND DERIVATION**

A pi (π) bond is formed by the lateral (sideways or parallel) overlap of unhybridized atomic orbitals.

Formula:

$$\pi \text{ bond} = \text{Parallel overlap of } p\text{-orbitals}$$

Solution:

- An s-orbital is spherical and can only participate in head-on (sigma) overlaps.
- p-orbitals are dumbbell-shaped. When two parallel p-orbitals are adjacent, they can overlap sideways above and below the internuclear axis to form a pi-bond.

Why other options are incorrect:

- **Option A:** Spherical s-orbitals cannot overlap sideways.
- **Option B:** While d-orbitals can form pi bonds in transition metals, p-orbital overlap is the fundamental and primary answer expected in standard organic and basic inorganic chemistry contexts.

Question #92 Key: (D)

MDCAT 2016

Choose the right molecule for the given dot and cross diagram (a central atom sharing three electron pairs and...

CORE CONCEPT AND DERIVATION

The structure of a molecule can be deduced by counting the number of bond pairs and lone pairs on the central atom.

Formula:

$$\text{Total pairs} = \text{Bond Pairs}(BP) + \text{Lone Pairs}(LP)$$

Solution:

- The central atom shares three electrons with three surrounding atoms (3 bond pairs).
- It has one unshared pair of electrons (1 lone pair).
- Nitrogen in ammonia (NH_3) has 5 valence electrons: 3 are shared with hydrogen, leaving 1 lone pair.

Why other options are incorrect:

- **Option A:** CH_3 is a radical and lacks a stable octet.
- **Option B:** Water (H_2O) has 2 bond pairs and 2 lone pairs.
- **Option C:** Carbon monoxide (CO) involves a triple bond and a different electron arrangement.

Question #93 **Key: (A)**

MDCAT 2016

Count the number of [Formula] (sigma) bonds and [Formula] (pi) bonds in the molecule of Ethene [Formula]: [MD...]

CORE CONCEPT AND DERIVATION

Every single bond is a sigma (σ) bond, and every double bond consists of one σ bond and one pi (π) bond.

Formula:

$$\text{Total Bonds} = 4 \times (\text{C-H}) + 1 \times (\text{C=C})$$

Solution:

- There are 4 Carbon-Hydrogen single bonds, contributing 4 σ bonds.
- There is 1 Carbon-Carbon double bond. This contributes 1 σ bond and 1 π bond.
- Total σ bonds = $4 + 1 = 5$.
- Total π bonds = 1.

Why other options are incorrect:

- **Option B, Option C, Option D:** These incorrectly count the fundamental bond types, likely confusing the number of electrons (a double bond has 4 electrons) with the number of discrete bonds.

Question #94 **Key: (B)**

KMU 2016

What will be the shape of a molecule which contains two sigma bond pairs and one lone pair? [ETEA 2016]

CORE CONCEPT AND DERIVATION

The geometry of a molecule with 3 total electron domains (2 bond pairs, 1 lone pair) is derived from a trigonal planar arrangement.

Formula:

$$\text{Type} = \text{AB}_2\text{E} \implies \text{Bent / V-shape}$$

Solution:

- The central atom is sp^2 hybridized because it has 3 electron domains.
- The lone pair exerts a strong repulsive force on the two sigma bond pairs, pushing them downward.
- The resulting visible geometry (ignoring the invisible lone pair) is an angular, bent, or V-shape (e.g., SO_2 , SnCl_2).

Why other options are incorrect:

- **Option A:** Requires 2 bond pairs and 0 lone pairs.
- **Option C:** Not a standard simple VSEPR geometry term.
- **Option D:** Requires 3 bond pairs and 0 lone pairs.

Question #95 **Key: (B)**

MDCAT 2015

Which one of the following is the correct dot and cross diagram of bonding between two chlorine atoms? [MDCAT ...]

CORE CONCEPT AND DERIVATION

Covalent bonding occurs when non-metal atoms share electron pairs to achieve a stable octet configuration.

Formula:



Solution:

- Each chlorine atom (Group VIIA) has 7 valence electrons.
- To complete its octet, each chlorine atom needs 1 more electron.
- They share one unpaired electron with each other, forming a single covalent bond (represented by a shared pair `:`).

Why other options are incorrect:

- **Option A:** Shows incorrect sharing notation.
- **Option C & Option D:** Represent ionic bonding, which does not occur between two identical halogen atoms.

Question #96 **Key: (A)**

MDCAT 2014

When the two partially filled atomic orbital overlap in such a way that the probability of finding the electro...

CORE CONCEPT AND DERIVATION

A sigma (σ) bond is formed by the direct, head-to-head (axial) overlap of atomic orbitals.

Formula:

Electron density is concentrated along the internuclear axis.

Solution:

- Because the overlap occurs exactly between the two nuclei, the resulting electron density is symmetrically distributed around the internuclear axis.
- This direct overlap produces the strongest type of covalent bond, called a Sigma bond.

Why other options are incorrect:

- **Option B & Option D:** These represent entirely different bonding paradigms (intermolecular and metallic sea of electrons, respectively).
- **Option C:** In a pi-bond, the probability of finding electrons is maximum *above and below* the internuclear axis (sideways overlap), not directly on the line joining the nuclei.

Question #97 **Key: (D)**

MDCAT 2013

According to Valence shell electron pair repulsion theory, the repulsive forces between the electron pairs of ...

CORE CONCEPT AND DERIVATION

The VSEPR theory states that electron pairs around a central atom repel each other, and lone pairs exert a stronger repulsive force than bond pairs because they are held closer to the central nucleus.

Formula:

Repulsion Order: LP-LP > LP-BP > BP-BP

Solution:

- Lone pairs (LP) occupy more space in the electron cloud because they are attracted to only one nucleus.
- Bond pairs (BP) are stretched between two nuclei, making their electron cloud more concentrated and exerting less repulsion.
- Therefore, two lone pairs repel each other the most, while two bond pairs repel each other the least.

Why other options are incorrect:

- **Option A, Option B, Option C:** These options invert or scramble the correct descending order of repulsive strength defined by VSEPR theory.

Question #98 **Key: (C)**

MDCAT 2012

The angle between un-hybridized p-orbital and three [Formula] hybrid orbitals of each carbon atom is: [MDCAT 2...]

CORE CONCEPT AND DERIVATION

In sp^2 hybridization, three hybrid orbitals form a planar trigonal structure, and the remaining unhybridized p-orbital is situated perpendicular to this plane.

Formula:

sp^2 plane $\perp$ unhybridized p_z orbital

Solution:

- The three sp^2 hybrid orbitals arrange themselves in a flat plane with 120° angles between them.
- The unhybridized p-orbital (which will be used to form a pi bond) stands straight up and down, piercing the center of this plane.
- Thus, the angle between the flat plane (the hybrid orbitals) and the unhybridized p-orbital is exactly 90° .

Why other options are incorrect:

- **Option A:** 120° is the angle between the sp^2 hybrid orbitals themselves.
- **Option B & Option D:** Correspond to tetrahedral and linear geometries, respectively.

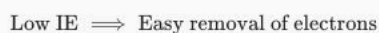
Question #99 Key: (D)

MDCAT 2011

The elements for which the value of ionization energy is low can:
[MDCAT 2011]

CORE CONCEPT AND DERIVATION

Ionization Energy (IE) is the energy required to remove the outermost electron. It is inversely proportional to an element's ability to lose electrons.

Formula:**Solution:**

- A low IE means the electrostatic pull of the nucleus on the outermost electrons is weak (due to large atomic radius or strong shielding).
- Consequently, very little energy is needed to detach these electrons.
- Such elements (like alkali metals) are highly electropositive and lose electrons readily.

Why other options are incorrect:

- **Option A:** Describes elements with high electron affinity, not low IE.
- **Option C:** Describes elements with high IE (like noble gases or halogens).

Question #100 Key: (C)

MDCAT 2010

The number of bonds in nitrogen molecule ([Formula]) is: [MDCAT 2010]

CORE CONCEPT AND DERIVATION

Diatomic nitrogen contains a triple bond. A multiple bond always consists of exactly one sigma (σ) bond, with the remainder being pi (π) bonds.

Formula:**Solution:**

- To satisfy their octets, two Nitrogen atoms (Group VA, 5 valence electrons) share 3 pairs of electrons.
- The first bond formed directly between the nuclei is a strong σ bond due to head-on overlap.
- The second and third bonds are formed by the sideways overlap of unhybridized p-orbitals, creating two π bonds.

Why other options are incorrect:

- **Option A:** Describes a double bond (e.g., in O_2).
- **Option B & Option D:** Are physically impossible between two single atoms.

Question #101 Key: (D)

MDCAT 2010

Which one of the following has zero dipole moment: [MDCAT 2010]

CORE CONCEPT AND DERIVATION

A zero dipole moment requires complete molecular symmetry so that all bond vectors cancel out perfectly.

Formula:

$$\vec{\mu}_{\text{net}} = \sum \vec{\mu}_{\text{bonds}}$$

Solution:

- BF_3 is a trigonal planar molecule with no lone pairs on the central Boron atom.
- The pull of the three highly electronegative Fluorine atoms is perfectly balanced in 2D space, making it a non-polar molecule with a zero dipole moment.

Why other options are incorrect:

- **Option A & Option B:** Have lone pairs that destroy symmetry.
- **Option C:** CHCl_3 has tetrahedral geometry, but because the atoms attached to Carbon are not all identical (one H, three Cl's), the bond dipoles do not cancel, leaving a net dipole.

Question #102 Key: (D)

MDCAT 2010

The ionization energy of hydrogen atom is: [MDCAT 2010]

CORE CONCEPT AND DERIVATION

Ionization energy (IE) is the exact amount of energy required to remove an electron from a gaseous atom in its ground state.

Formula:

$$\text{IE of Hydrogen} = 1312.36 \text{ kJ/mol} \approx 1313 \text{ kJ/mol}$$

Solution:

- The single electron in a Hydrogen atom is tightly held in the 1s orbital close to the nucleus.
- Experimental data establishes the required energy to overcome this electrostatic attraction is roughly 1313 kJ per mole of Hydrogen atoms.

Why other options are incorrect:

- **Option A, Option B, Option C:** These values are orders of magnitude too low to ionize an atom.