

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

أسئلة ميد تيرم سابقة في مادة
الكيمياء الغير عضوية 🌟



اللهم نسألك باسمك الأكرم
الذي إذا دُعيت به أجبت
اللهم أنصر أخواننا في فلسطين
اللهم وحد صفهم واجمع كلمتهم على الحق
اللهم عليك بالصهاينة المعتدين الغاصبين
اللهم أرنا بهم عجائب قدرتك واشف صدور
قوم مؤمنين يا ذا الجلال والإكرام

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1 Written:

【1】 Draw the molecular orbital energy level diagram for the helium dimer ion (He_2^+) and calculate the bond order . Would you expect this ion to be stable ?

【2】 Draw the Lewis dot structure for the methane molecule (CH_4) Using vsepr theory , predict the electronic geometry and molecular geometry of methane.

- What is the expected bond angle in methane ?
 - Is methane a polar or nonpolar molecule ?
 - What is the hybridization of the carbon atom in methane according to VBT ? Explain how this hybridization occurs ?
-

【3】 Diagram showing the energy levels of atomic orbitals of carbon and oxygen and the resulting molecular orbitals in CO and What is the Bond order ?

【4】 Explain the difference between Molecular orbital theory (M.O.T) and Valence Bond theory (V.B.T) in terms of bond formation, molecular structure, and electron distribution. Provide examples of molecules that best illustrate each theory.

【5】 Explain the difference between bonding and antibonding molecular orbitals. How do they affect the stability of a molecule?

【6】 Explain using molecular orbital theory why the diatomic helium ion (He_2^+) is stable while the diatomic beryllium molecule. (Be_2) is unstable.

【7】 BeCl_2 , BF_3 , NH_3

- Using Lewis dot , vsepr
- Certification angle and Polarity each other.

【8】 Draw the molecular orbital diagram for the diatomic lithium molecule (Li_2) and determine its bond order. Explain why only the valence electrons contribute to bonding.

【9】 Explain the concept of sp^2 hybridization, mentioning an example of a molecule that exhibits this type of hybridization. Illustrate how hybridization affects the shape of the molecule and bond angles.

【10】 Explain how s-s orbitals and s-p orbitals combine to form molecular orbitals. Draw a simple diagram illustrating the types of molecular orbitals formed in each case?

【11】 Compare the bonding in nitrogen (N_2) and oxygen (O_2) molecules using molecular orbital theory. Which molecule is more stable?

【12】 Which is more stable?

NO , NO^- , NO^+

2 Mcq:

【13】 In BF_3 electronic geometry is like molecular geometry due to.....

- A. angle in BF_3 120°
 - B. No lone pair in B 
 - C. Type of hybridization sp^2
 - D. Type of hybridization sp
-

【14】 Determine the molecular geometry of CBr_4

- | | |
|--|-----------------------|
| A. Linear | B. Trigonal planar |
| C. Tetrahedral  | D. Trigonal pyramidal |
-

【15】 Arrange according to stability.

- A. $\text{O}^{2+} > \text{O}^{2-} > \text{O}^2$
- B. $\text{O}^{2+} > \text{O}^2 > \text{O}^{2-}$ 
- C. $\text{O}^{2-} > \text{O}^2 > \text{O}^{2+}$
- D. $\text{O}^2 = \text{O}^{2+} = \text{O}^{2-}$

[16] Bond order in HCL is

A. 1 ☒

B. 2

C. 3

D. 4

[17] Bond order He_2 molecule = 0 , this means

A. He_2 molecule stable

B. He_2 molecules unstable ☒

C. He_2 molecules present

D. All of the above

[18] Which of the following has a short bond ?

A. CH_4

B. CO_2 ☒

C. NH_3

D. CO

[19] According to Valence Bond theory, which kind of orbitals overlap to form the P-Cl bonds in PCl_3 ?

A. $\text{P}(\text{sp}^3) - \text{Cl}(\text{p})$

B. $\text{P}(\text{sp}^3\text{d}) - \text{Cl}(\text{s})$

C. $\text{P}(\text{sp}^3) - \text{Cl}(\text{s})$

D. $\text{P}(\text{sp}^3\text{d}) - \text{Cl}(\text{p})$ ☒

[20] According to molecular orbital theory (M.O.T) , which molecule has an unpaired electron ?

A. O_2 ☒

B. N_2

C. H_2O

D. CO_2

[21] In molecular orbital theory (M.O.T) , a higher bond order always means a stronger and more stable bond .

A. True ☒

B. False

[22] According to Valence Bond theory (V.B.T) , hybrid orbitals explain the shape of molecules.

A. True ☒

B. False

[23] The molecular geometry of CH_4 is Trigonal planar.

A. True

B. False ☒

[24] Non - bonding orbitals do contribute to bond formation in M.O.T.

A. True

B. False ☒

[25] NH_3 This shape is Tetrahedral , angle 107° , Polarity.

A. True ☒

B. False

【 1 】 Helium Dimer Ion (He_2^+)

Molecular Orbital Energy Level Diagram: •

Helium (He) has an electronic configuration of $1s^2$. •

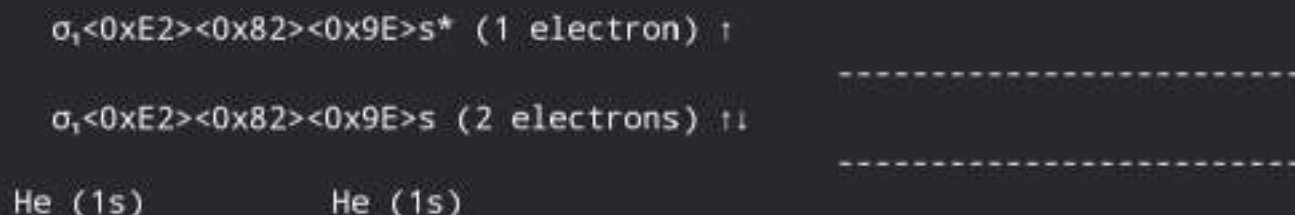
The helium dimer ion (He_2^+) has a total of $2 + 2 - 1 = 3$ electrons. •

The atomic orbitals of two He atoms ($1s$) combine to form two molecular orbitals: a bonding sigma (σ_{1s}) and an antibonding sigma star (σ_{1s}^*).

The three electrons will fill these molecular orbitals according to Hund's rule and the Aufbau principle:

σ_{1s} will be filled with 2 electrons (spin paired). •

σ_{1s}^* will be filled with the remaining 1 electron. •



Bond Order Calculation: •

Bond Order = (Number of electrons in bonding MOs - Number of electrons in antibonding MOs) / 2

$$\text{Bond Order} = (2 - 1) / 2 = 0.5$$

Stability: •

Yes, the helium dimer ion (He_2^+) is expected to be stable. A bond order greater than zero indicates that there is a net attractive force between the atoms, leading to the formation of a stable molecular entity, even though the bond order is only 0.5 (a half-bond).

【 2 】 Methane Molecule (CH₄)

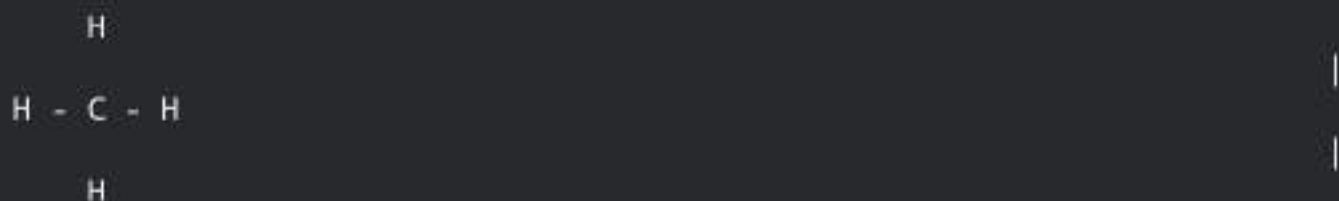
Lewis Dot Structure: •

Carbon (C) has 4 valence electrons. •

Each Hydrogen (H) has 1 valence electron. •

Total valence electrons = $4 + (4 \times 1) = 8$ electrons. •

The carbon atom is the central atom, bonded to four hydrogen atoms via single bonds. •



VSEPR Theory Predictions: •

Electronic Geometry: The central carbon atom has 4 electron groups (4 single bonds to hydrogen). According to VSEPR theory, four electron groups arrange themselves to minimize repulsion in a tetrahedral electronic geometry. •

Molecular Geometry: Since all four electron groups are bonding pairs, the molecular geometry is the same as the electronic geometry: tetrahedral. •

Expected Bond Angle: In a perfect tetrahedron, the expected bond angle is 109.5°. •

Polarity: The methane molecule (CH₄) is nonpolar. •

The C-H bonds are slightly polar due to the difference in electronegativity between carbon and hydrogen (carbon is slightly more electronegative). •

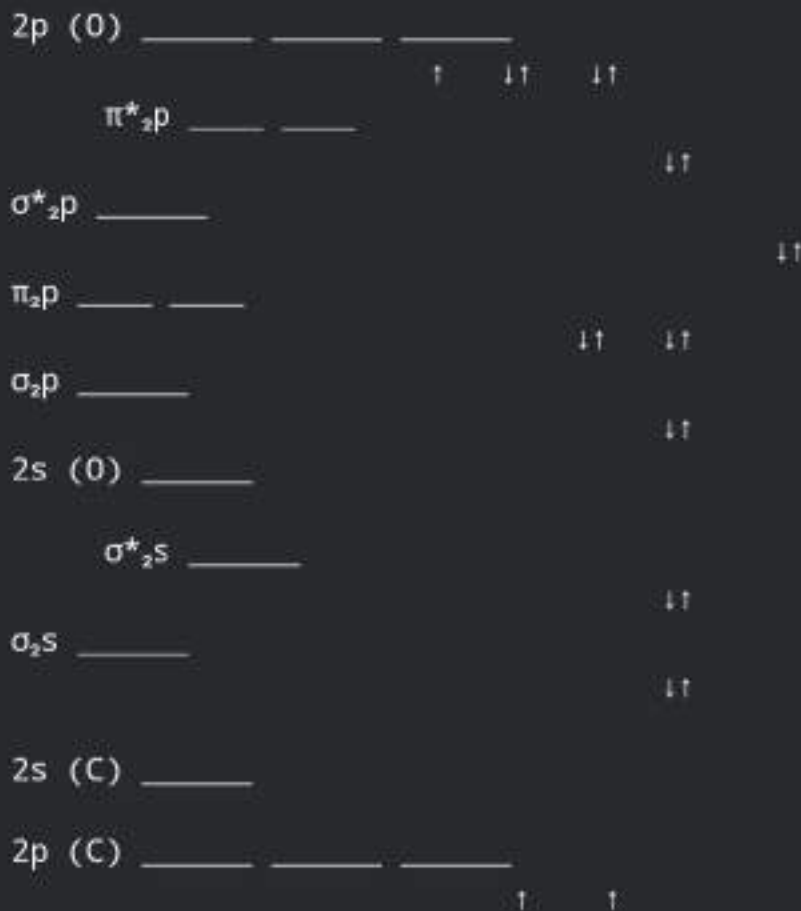
However, the tetrahedral geometry of methane results in the cancellation of these individual bond dipoles. The molecule has a symmetrical distribution of electron density, leading to a net dipole moment of zero. •

Hybridization of Carbon (VBT): The carbon atom in methane is sp³ hybridized. •

Explanation: To form four equivalent C-H single bonds in methane, the valence atomic orbitals of carbon (one 2s and three 2p orbitals) undergo hybridization. These four atomic orbitals mix and rearrange to form four new, equivalent hybrid orbitals called sp³ orbitals. Each sp³ hybrid orbital has characteristics of both s and p orbitals and is directed towards the corners of a tetrahedron. •

Each sp³ hybrid orbital of carbon then overlaps with the 1s atomic orbital of a hydrogen atom to form a sigma (σ) bond, resulting in the tetrahedral methane molecule. •

Energy Level Diagram of Atomic Orbitals and Resulting Molecular Orbitals: •



The 2s and 2p atomic orbitals of carbon and oxygen interact to form sigma (σ) and pi (π) molecular orbitals. •

The order of energy levels is generally $\sigma_{2s} < \sigma_{2s}^* < \sigma_{2p} < \pi_{2p} < \pi_{2p}^* < \sigma_{2p}^*$. •

Carbon has 6 electrons ($2s^2 2p^2$) and Oxygen has 8 electrons ($2s^2 2p^4$), giving a total of 14 valence electrons in CO. •

These 14 electrons fill the molecular orbitals in increasing order of energy: $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\sigma_{2p})^2 (\pi_{2p})^4$. •

Bond Order: •

Bond Order = (Number of electrons in bonding MOs - Number of electrons in antibonding MOs) / 2

$$\text{Bond Order} = (2 (\sigma_{2s}) + 2 (\sigma_{2p}) + 4 (\pi_{2p}) - 2 (\sigma_{2s}^*)) / 2$$

$$\text{Bond Order} = (8 - 2) / 2 = 3$$

The bond order of 3 in CO indicates a triple bond (one sigma bond and two pi bonds), which is consistent with its Lewis structure ($\text{:C}\equiv\text{O:}$). •

【 4 】 Difference Between Molecular Orbital Theory (MOT) and Valence Bond Theory (VBT)

Valence Bond Theory (VBT)	Molecular Orbital Theory (MOT)
Bonds are formed by the overlap of atomic orbitals of individual atoms, and electrons are considered to be localized between the bonded atoms.	Atomic orbitals of all atoms in the molecule combine to form a set of molecular orbitals that are delocalized over the entire molecule.
Describes the molecular structure in terms of localized bonds between atoms, formed by the overlap of atomic orbitals. Resonance is introduced to explain delocalization.	Describes the electronic structure in terms of molecular orbitals, each with a specific energy level and electron distribution over the whole molecule.
Electrons are primarily localized in the overlapping region of atomic orbitals forming bonds. Lone pairs are also localized on individual atoms.	Electrons are delocalized and occupy molecular orbitals that extend over the entire molecule.
Successfully describes the bonding in many simple diatomic and polyatomic molecules like H_2 , CH_4 , and H_2O .	Effectively explains the bonding and magnetic properties of molecules like O_2 (paramagnetic), and delocalized systems like benzene.

【 5 】 Bonding and Antibonding Molecular Orbitals

Bonding Molecular Orbitals: •

Result from the constructive interference (addition) of atomic orbitals. •

Have lower energy than the original atomic orbitals. •

Increase the electron density between the nuclei, leading to attraction and stabilization of the molecule. •

Antibonding Molecular Orbitals: •

Result from the destructive interference (subtraction) of atomic orbitals. •

Have higher energy than the original atomic orbitals. •

Have a node (region of zero electron density) between the nuclei, leading to repulsion and destabilization of the molecule. •

Effect on Stability: •

Electrons occupying bonding orbitals contribute to the stability of a molecule by strengthening the bond between the atoms. •

Electrons occupying antibonding orbitals decrease the stability of a molecule by weakening the bond. •

The bond order, calculated as (number of electrons in bonding MOs - number of electrons in antibonding MOs) / 2, is a direct indicator of the net stability of a molecule based on MO theory. A higher bond order generally indicates greater stability. •

Have higher energy than the original atomic orbitals. •

Have a node (region of zero electron density) between the nuclei, leading to repulsion and destabilization of the molecule. •

Effect on Stability: •

Electrons occupying bonding orbitals contribute to the stability of a molecule by strengthening the bond between the atoms. •

Electrons occupying antibonding orbitals decrease the stability of a molecule by weakening the bond. •

The bond order, calculated as (number of electrons in bonding MOs - number of electrons in antibonding MOs) / 2, is a direct indicator of the net stability of a molecule based on MO theory. A higher bond order generally indicates greater stability. •

【 6 】 Stability of He_2^+ and Instability of Be_2 (using MOT)

Helium Dimer Ion (He_2^+): •

Electronic configuration: $(\sigma_{1s})^2 (\sigma_{1s}^*)^1$ •

Bond Order = $(2 - 1) / 2 = 0.5$ •

The positive bond order (0.5) indicates that there is a net attractive force between the two helium nuclei, resulting in a stable diatomic ion, even though it's a weak bond. •

Diatomic Beryllium Molecule (Be_2): •

Beryllium (Be) has an electronic configuration of $1s^2 2s^2$. The valence electrons are in the 2s orbitals. •

When two Be atoms combine, their 2s atomic orbitals form σ_{2s} (bonding) and σ_{2s}^* (antibonding) molecular orbitals. •

The four valence electrons (2 from each Be) fill these molecular orbitals: $(\sigma_{2s})^2 (\sigma_{2s}^*)^2$. •

Bond Order = $(2 - 2) / 2 = 0$ •

A bond order of zero indicates that there is no net attractive force between the beryllium atoms. The stabilizing effect of the bonding electrons is completely cancelled out by the destabilizing effect of the antibonding electrons. Therefore, the Be_2 molecule is unstable and does not exist under normal conditions. •

1. BeCl₂ (Beryllium Chloride)

Lewis Dot Structure: •

Beryllium (Be) has 2 valence electrons. •

Chlorine (Cl) has 7 valence electrons, and there are two chlorine atoms ($2 \times 7 = 14$ valence electrons). •

Total valence electrons = $2 + 14 = 16$ electrons. •

Beryllium is bonded to two chlorine atoms by single covalent bonds. There are no lone pairs on the beryllium atom (beryllium is an exception to the octet rule). •

Structure: Cl-Be-Cl •

VSEPR Theory: •

The central atom (Be) has two bonding pairs of electrons and no lone pairs (AX₂). •

Electronic Geometry: Linear. •

Molecular Geometry: Linear. •

Expected Angle: 180 degrees. •

Polarity: •

The electronegativity difference between Be (1.57) and Cl (3.16) is significant, making the Be-Cl bonds polar. •

However, due to the linear molecular geometry, the bond dipole moments of the two Be-Cl bonds cancel each other out (they are equal in magnitude and opposite in direction). •

Therefore, the BeCl₂ molecule is nonpolar. •

2. BF₃ (Boron Trifluoride)

Lewis Dot Structure: •

Boron (B) has 3 valence electrons. •

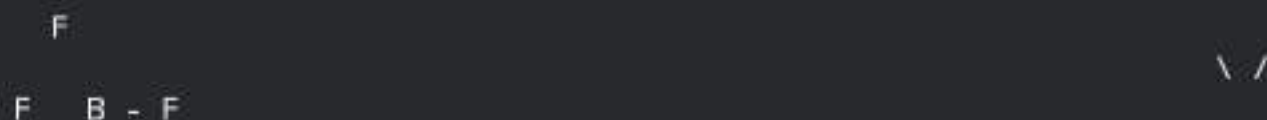
Fluorine (F) has 7 valence electrons, and there are three fluorine atoms ($3 \times 7 = 21$ valence electrons). •

Total valence electrons = $3 + 21 = 24$ electrons. •

Boron is bonded to three fluorine atoms by single covalent bonds. There are no lone pairs on the boron atom (boron is an exception to the octet rule). •

Structure: •

Structure: •



VSEPR Theory: •

The central atom (B) has three bonding pairs of electrons and no lone pairs (AX₃). •

Electronic Geometry: Trigonal planar. •

Molecular Geometry: Trigonal planar. •

Expected Angle: 120 degrees between each B-F bond. •

Polarity: •

The electronegativity difference between B (2.04) and F (3.98) is significant, making the B-F bonds polar. •

However, due to the symmetrical trigonal planar molecular geometry, the bond dipole moments of the three B-F bonds cancel each other out (the vector sum of the dipoles is zero). •

Therefore, the BF₃ molecule is nonpolar. •

3. NH₃ (Ammonia)

Lewis Dot Structure: •

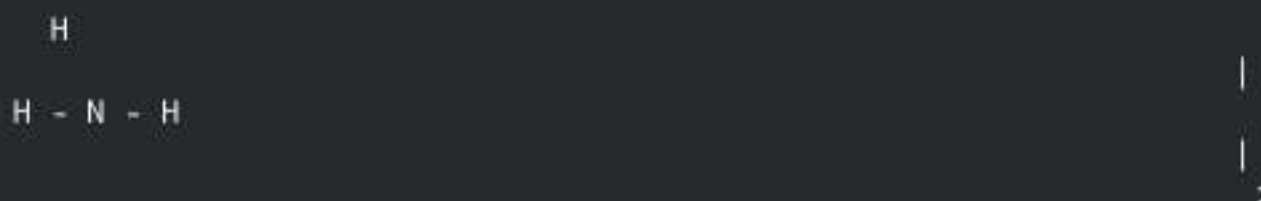
Nitrogen (N) has 5 valence electrons. •

Hydrogen (H) has 1 valence electron, and there are three hydrogen atoms (3 × 1 = 3 valence electrons). •

Total valence electrons = 5 + 3 = 8 electrons. •

Nitrogen is bonded to three hydrogen atoms by single covalent bonds, and there is one lone pair of electrons on the nitrogen atom. •

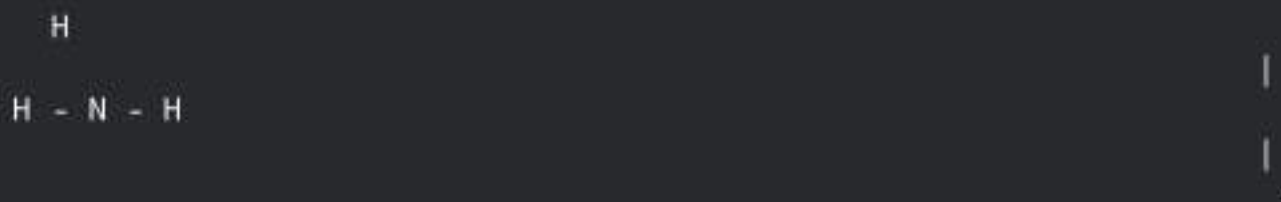
Structure: •



(The dots represent the lone pair)

Nitrogen is bonded to three hydrogen atoms by single covalent bonds, and there is one lone pair of electrons on the nitrogen atom.

Structure:



(The dots represent the lone pair)

VSEPR Theory:

The central atom (N) has three bonding pairs of electrons and one lone pair of electrons (AX₃E).

Electronic Geometry: Tetrahedral (due to four regions of electron density).

Molecular Geometry: Trigonal pyramidal (considering only the positions of the atoms).

Expected Angle: In an ideal tetrahedral electronic geometry, the angle is 109.5 degrees. However, the lone pair of electrons on nitrogen exerts a greater repulsion on the bonding pairs, compressing the H-N-H bond angles to approximately 107 degrees.

Polarity:

The electronegativity difference between N (3.04) and H (2.20) is not very large but is sufficient to make the N-H bonds polar (nitrogen is more electronegative).

Due to the asymmetrical trigonal pyramidal molecular geometry, the bond dipole moments of the three N-H bonds do not cancel out completely, and there is a net dipole moment for the molecule pointing towards the lone pair of electrons.

Therefore, the NH₃ molecule is polar.

【 8 】 ارسم مخطط المدارات الجزيئية لجزيء الليثيوم ثنائي الذرة (Li_2) وحدد رتبة الرابطة. اشرح لماذا تساهم إلكترونات التكافؤ فقط في الترابط.

الحل:

- المدارات الذرية لليثيوم: الليثيوم (Li) لديه التوزيع الإلكتروني $1s^2 2s^1$. إلكترونات التكافؤ هي تلك الموجودة في الغلاف الخارجي، أي $2s^1$.
- تكوين المدارات الجزيئية: عندما يقترب ذرتان من الليثيوم لتكوين Li_2 ، تتداخل مداراتهما الذرية $2s$ لتكوين مدارين جزيئيين:
 - مدار رابط (σ_{2s}): ذو طاقة أقل من المدارات الذرية الأصلية.
 - مدار مضاد للرابطة (σ_{2s}^*): ذو طاقة أعلى من المدارات الذرية الأصلية.
- ملء المدارات الجزيئية بالإلكترونات: يحتوي جزيء Li_2 على إجمالي 2 إلكترون تكافؤ (واحد من كل ذرة ليثيوم). يتم ملء المدار الجزيئي الرابط (σ_{2s}) بهذين الإلكترونين.
- مخطط المدارات الجزيئية:

σ_{2s}^* (مضاد للرابطة) $\uparrow \downarrow$

σ_{2s} (رابط) $\uparrow \downarrow$

5. حساب رتبة الرابطة:

رتبة الرابطة = (عدد الإلكترونات في المدارات الرابطة - عدد الإلكترونات في المدارات المضادة للرابطة) / 2

$$\text{رتبة الرابطة} = (2 - 0) / 2 = 1$$

6. لماذا تساهم إلكترونات التكافؤ فقط في الترابط؟

• الطاقة: إلكترونات التكافؤ هي الأعلى في الطاقة وبالتالي الأبعد عن النواة. هذا يجعلها الأكثر تفاعلاً وقدرة على التداخل مع مدارات التكافؤ لذرة أخرى لتكوين روابط.

• المدارات الداخلية مشغولة ومستقرة: المدارات الداخلية (مثل $1s$ في الليثيوم) مشغولة بالفعل بالكامل بالإلكترونين. لكي تشارك هذه الإلكترونات في الترابط، يجب أن ترتفع إلى مستويات طاقة أعلى، وهو أمر غير مفضل طاقياً. بالإضافة إلى ذلك، فإن تداخل المدارات الداخلية يكون أقل فعالية بسبب قربها من النواة وحجبها بواسطة الإلكترونات الأخرى. لذلك، فإن التفاعل الفعال الذي يؤدي إلى تكوين روابط جزيئية يحدث بشكل أساسي من خلال إلكترونات التكافؤ.

【 9 】 اشرح مفهوم التهجين sp^2 ، مع ذكر مثال لجزيء يظهر هذا النوع من التهجين. وضح كيف يؤثر التهجين على شكل الجزيء وزوايا الروابط.

الحل:

مفهوم التهجين sp^2 :

التهجين هو عملية خلط المدارات الذرية ذات الطاقات المتقاربة لتكوين مدارات مهجنة جديدة ذات طاقة وشكل واتجاهات فراغية متماثلة. يحدث التهجين لتفسير أشكال الجزيئات وزوايا الروابط التي لا يمكن تفسيرها بالمدارات الذرية النقية.

في تهجين sp^2 ، يتم خلط مدار ذري واحد من النوع s مع مدارين ذريين من النوع p لنفس الذرة. ينتج عن هذا الخلط ثلاثة مدارات مهجنة من النوع sp^2 ذات طاقة متساوية. يبقى المدار p الثالث غير مهجن ويكون عمودياً على مستوى المدارات المهجنة sp^2 .

مثال لجزيء يظهر تهجين sp^2 :

جزيء بوريون ثلاثي فلوريد (BF_3) هو مثال كلاسيكي للتهجين sp^2 .

1. الذرة المركزية (البوريون): التوزيع الإلكتروني لذرة البوريون (B) هو $1s^2 2s^2 2p^1$.
2. الإثارة والتهجين: لكي يرتبط البوريون بثلاث ذرات فلور، يتم إثارة أحد إلكترونات 2s إلى مدار 2p فارغ. ثم يتم خلط مدار 2s مع مدارين 2p لتكوين ثلاثة مدارات مهجنة sp^2 .
3. تكوين الروابط: تشكل كل مدار مهجن sp^2 رابطة سيجما (σ) مع مدار p لذرة فلور.

تأثير التهجين على شكل الجزيء وزوايا الروابط:

- شكل الجزيء: تتوزع المدارات المهجنة sp^2 الثلاثة في الفراغ بحيث تكون أبعد ما يمكن عن بعضها البعض لتقليل التنافر بين الإلكترونات. هذا الترتيب يؤدي إلى شكل مستوي مثلثي (Trigonal Planar) للجزيء. تكون الذرة المركزية في مركز المثلث، وتقع الذرات المرتبطة بها عند رؤوس المثلث.
- زوايا الروابط: الزاوية المثالية بين المدارات المهجنة sp^2 في الترتيب المستوي المثلثي هي 120 درجة. وبالنسبة، فإن زوايا الروابط في الجزيئات التي تظهر تهجين sp^2 (مثل BF_3) تكون حوالي 120 درجة.

【10】 اشرح كيف تتحد مدارات s-s ومدارات s-p لتكوين مدارات جزيئية. ارسم مخططًا بسيطًا يوضح أنواع المدارات الجزيئية المتكونة في كل حالة؟

الحل:

اتحاد مدارات s-s لتكوين مدارات جزيئية:

عندما تقترب ذرتان لهما مدارات ذرية من النوع s، تتداخل هذه المدارات لتكوين مدارين جزيئيين:

- مدار جزيئي رابط (σ_s): ينتج عن التداخل البناء (إضافة الموجات) بين المدارين الذريين s. يكون هذا المدار ذو كثافة إلكترونية عالية بين النواتين، مما يؤدي إلى قوة تجاذب تربط الذرتين. يكون مدار σ_s أقل طاقة من المدارات الذرية الأصلية.
- مدار جزيئي مضاد للرابطة (σ_s^*): ينتج عن التداخل الهدام (طرح الموجات) بين المدارين الذريين s. يحتوي هذا المدار على عقدة (منطقة ذات كثافة إلكترونية صفرية) بين النواتين، مما يقلل من قوة التجاذب ويزيد من التنافر. يكون مدار σ_s^* أعلى طاقة من المدارات الذرية الأصلية.

مخطط بسيط لاتحاد مدارات s-s:

(مضاد للرابطة) σ_s^*



(رابط) σ_s

اتحاد مدارات s-p لتكوين مدارات جزيئية:

عندما تقترب ذرة ذات مدار ذري s من ذرة ذات مدار ذري p على طول محور الرابطة (عادة ما يُشار إليه بالمحور z)، يحدث تداخل لتكوين مدارين جزيئيين:

- مدار جزيئي رابط (σ_{sp}): ينتج عن التداخل البناء بين مدار s وأحد فصوص مدار p. تكون الكثافة الإلكترونية عالية بين النواتين. يكون مدار σ_{sp} أقل طاقة من المدارات الذرية الأصلية.
- مدار جزيئي مضاد للرابطة (σ_{sp}^*): ينتج عن التداخل الهدام بين مدار s وأحد فصوص مدار p. يحتوي هذا المدار على عقدة بين النواتين. يكون مدار σ_{sp}^* أعلى طاقة من المدارات الذرية الأصلية.

مخطط بسيط لاتحاد مدارات s-p:

(مضاد للرابطة) σ_{sp}^*



(رابط) σ_{sp}

【 11 】 قارن الترابط في جزيئي النيتروجين (N_2) والأكسجين (O_2) باستخدام نظرية المدارات الجزيئية. أي الجزيئين أكثر استقرارًا؟

الحل:

جزيء النيتروجين (N_2):

1. المدارات الذرية: النيتروجين (N) لديه التوزيع الإلكتروني $1s^2 2s^2 2p^3$. إلكترونات التكافؤ هي $2s^2 2p^3$.
2. المدارات الجزيئية: عند تكوين N_2 ، تتحد المدارات الذرية لتكوين مدارات جزيئية بترتيب الطاقة التالي (تقريبًا): $(\sigma_2s) < (\pi_2p) < (\sigma_2p) < (\pi_2p^*) < (\sigma_2p^*)$.
3. ملء المدارات بالإلكترونات: يحتوي N_2 على إجمالي 10 إلكترونات تكافؤ (5 من كل ذرة نيتروجين). يتم ملء المدارات الجزيئية كالتالي: $(\sigma_2s)^2 (\pi_2p)^4 (\sigma_2p)^2$.
4. رتبة الرابطة: (8 إلكترونات رابطة - 2 إلكترونات مضادة للرابطة) / 2 = 3. يحتوي جزيء النيتروجين على رابطة ثلاثية قوية (σ واحدة و π اثنتين).
5. الخواص المغناطيسية: جميع الإلكترونات مزدوجة، لذا فإن N_2 غير مغناطيسي (diamagnetic).

جزيء الأكسجين (O_2):

1. المدارات الذرية: الأكسجين (O) لديه التوزيع الإلكتروني $1s^2 2s^2 2p^4$. إلكترونات التكافؤ هي $2s^2 2p^4$.
2. المدارات الجزيئية: ترتيب الطاقة للمدارات الجزيئية في O_2 يختلف قليلاً عن N_2 بسبب تفاعل أكبر بين مدارات $2s$ و $2p$. الترتيب التقريبي هو: $(\sigma_2s) < (\sigma_2s^*) < (\pi_2p) < (\pi_2p^*) < (\sigma_2p) < (\pi_2p^*) < (\sigma_2p^*)$.
3. ملء المدارات بالإلكترونات: يحتوي O_2 على إجمالي 12 إلكترون تكافؤ (6 من كل ذرة أكسجين). يتم ملء المدارات الجزيئية كالتالي: $(\sigma_2s)^2 (\sigma_2s^*)^2 (\pi_2p)^4 (\pi_2p^*)^2$.
4. رتبة الرابطة: (8 إلكترونات رابطة - 4 إلكترونات مضادة للرابطة) / 2 = 2. يحتوي جزيء الأكسجين على رابطة ثنائية (σ واحدة و π واحدة).
5. الخواص المغناطيسية: يحتوي على إلكترونين منفردين في مداري π_2p^* المتساويين في الطاقة، لذا فإن O_2 مغناطيسي بارا (paramagnetic).

مقارنة الاستقرار:

يعتبر جزيء النيتروجين (N_2) أكثر استقرارًا من جزيء الأكسجين (O_2) لعدة أسباب:

- رتبة الرابطة الأعلى: N_2 لديه رتبة رابطة 3 (رابطة ثلاثية) بينما O_2 لديه رتبة رابطة 2 (رابطة ثنائية). كلما زادت رتبة الرابطة، زادت قوة الرابطة وبالتالي زاد الاستقرار.
- غياب الإلكترونات المنفردة: جميع الإلكترونات في N_2 مزدوجة، مما يجعله أكثر استقرارًا. وجود إلكترونات منفردة في O_2 يجعله أكثر تفاعلية وأقل استقرارًا نسبيًا.
- طاقة تفكك الرابطة: طاقة تفكك الرابطة في N_2 أعلى بكثير من طاقة تفكك الرابطة في O_2 ، مما يشير إلى رابطة أقوى في N_2 .

【 12 】 أي الجزيئات أكثر استقرارًا؟ $^*\text{NO}$, NO^- , NO

الحل:

لحساب رتبة الرابطة لكل أيون/جزيء، نحتاج إلى معرفة عدد إلكترونات التكافؤ في كل منها وملء المدارات الجزيئية (بافتراض ترتيب مدارات مشابه لـ N_2 و O_2):

• (أكسيد النيتريك) NO

• عدد إلكترونات التكافؤ: $\text{N} (5) + \text{O} (6) = 11$ إلكترون.

• ملء المدارات الجزيئية (تقريب): $(\sigma_2s)^2 (\pi_2p)^4 (\sigma_2p)^3 (\sigma_2s)^2$

• رتبة الرابطة: $2.5 = (8 - 3) / 2$

• (أيون النيتروسل) NO^-

• عدد إلكترونات التكافؤ: $\text{N} (5) + \text{O} (6) + 1$ (شحنة سالبة) = 12 إلكترون.

• ملء المدارات الجزيئية (تقريب): $(\sigma_2s)^2 (\pi_2p)^4 (\sigma_2p)^4 (\sigma_2s)^2$

• رتبة الرابطة: $2 = (8 - 4) / 2$

• (أيون النيتروسونيوم) NO^+

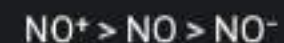
• عدد إلكترونات التكافؤ: $\text{N} (5) + \text{O} (6) - 1$ (شحنة موجبة) = 10 إلكترون.

• ملء المدارات الجزيئية (تقريب): $(\sigma_2s)^2 (\pi_2p)^4 (\sigma_2p)^2 (\sigma_2s)^2$

• رتبة الرابطة: $3 = (8 - 2) / 2$

مقارنة الاستقرار:

كلما زادت رتبة الرابطة، زاد الاستقرار. لذلك، يكون ترتيب الاستقرار كالتالي:



أيون النيتروسونيوم (NO^+) هو الأكثر استقرارًا لأنه يحتوي على أعلى رتبة رابطة (3)، مما يشير إلى رابطة ثلاثية قوية. جزيء NO لديه رتبة رابطة 2.5، وأيون النيتروسل (NO^-) لديه رتبة رابطة 2، مما يجعله الأقل استقرارًا بين الثلاثة.

بسم الرحمن الرحيم

أسئلة ميد تيرم سابقة في مادة
الكيمياء العضوية 🌟



اللهم نسألك باسمك الأكرم
الذي إذا دُعيت به أجبت
اللهم أنصر أخواننا في فلسطين
اللهم وحد صفوفهم وأجمع كلمتهم على الحق
اللهم عليك بالصهاينة المعتدين الغاصبين
اللهم أرنا بهم عجائب قدرتك واشف صدور
قوم مؤمنين يا ذا الجلال والإكرام

By : Ahmed Salah 🌟

1 Written:

【1】 What is the relationship between electronegativity and the inductive effect ? Explain how differences in electronegativity between atoms affect the direction of the inductive effect ?

【2】 Arrange the following Compounds in order of increasing acidity , explaining the reason based on the inductive effect :

(CH_3COOH)

(ClCH_2COOH)

(Cl^3CHCOOH)

(Cl^3CCOOH)

【3】 Compare between the electron - withdrawing inductive effect (-I) and the electron - donating inductive effect (+I) . Give examples of functional groups that exhibit each type of these effects.

【4】 Which is more basic , electron density , donating inductive effect (+I) :

($\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$)

($\text{CH}_3\text{CH}_2\text{NH}_2$)

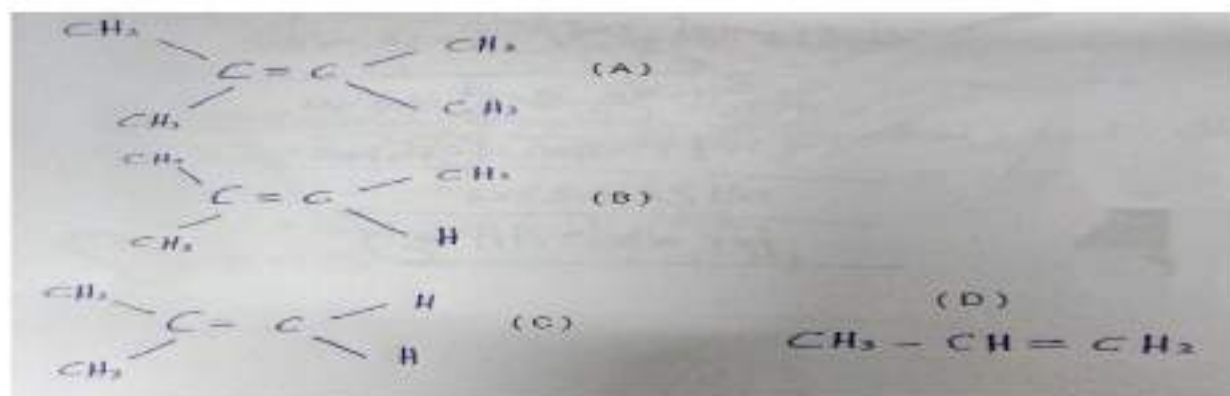
(CH_3NH_2)

(CNH_3)

ده مثل اختر ده مقالتي والله اتفضل رتبهم بقا

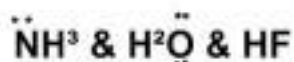
【5】 Draw the resonance structures of the ($\text{CH}_2 = \text{CH}-\text{CH}_2^+$) . Explain how resonance contributes to the stability of this ion ?

【6】 Which is more Hyper conjugation , Acidity , Stability :



【7】 Compare between homolytic fission and heterolytic fission of a covalent bond . illustrate your answer with suitable examples , mentioning the types of reactive species produced in each case ?

【8】 Arrange the following according to Nucleophilicity :-



【9】 Electrophilic substitution Reaction:

Nitration of benzene , Explain of mechanism

【10】 Explain the mechanism of free radical chlorination of methane . illustrate the initiation , propagation and termination steps ?

【11】 The addition reaction of hydrogen cyanide (HCN) to aldehydes or ketones to form cyanohydrins involves three main steps as illustrated ?

【12】 Which is more acidity , drawing effect (-I) , Stability :
(Chloroacetic acid , Dichloroacetic acid , Trichloroacetic acid)

【13】 Which is more basic , electron density :
(Primary amine , secondary amine , tertiary amine)

【14】 Compare between Electrophile & Nucleophile ?

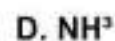
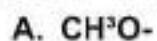
【15】 Which is more basic , electron density :
(P-nitroaniline , Aniline , P-toluidine)

【16】 Arrange the following species in order of increasing stability : primary carbocation , secondary carbocation , tertiary carbocation , methyl carbocation (CH_3^+) ?

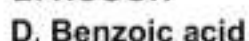
【17】 Which is more basic :
Methyl amine & ammonia & Aniline

2 Mcq:

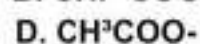
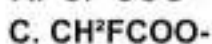
[18] Which of the following shows (-I) effect ?



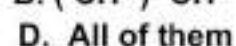
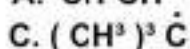
[19] Which of the following is more acidic than CH_3COOH ?



[20] Which of the following is less acidic, less stable ?



[21] Which of the following free radical is stable ?



[22] The reactivity of carbonyl group in Acetone is more reactive than carbonyl in formaldehyde.

A. True

B. False

Answer:

[18] C

[19] D

[20] D

[21] C

[22] B

By : Ahmed Salah ✨

【 1 】 Question: What is the relationship between electronegativity and the inductive effect? Explain how differences in electronegativity between atoms affect the direction of the inductive effect?

Answer:

The relationship between electronegativity and the inductive effect is that electronegativity differences between bonded atoms are the driving force behind the inductive effect. Electronegativity is a measure of an atom's ability to attract shared electrons in a covalent bond. The inductive effect is the polarization of a sigma (σ) bond due to this difference in electronegativity.

How differences in electronegativity affect the direction of the inductive effect:

When a more electronegative atom is bonded to a less electronegative atom: The more electronegative atom attracts the bonding electrons towards itself, resulting in a partial negative charge (δ^-) on it and a partial positive charge (δ^+) on the less electronegative atom. This is called the electron-withdrawing inductive effect ($-I$), and the direction of the effect is represented by an arrow pointing from the less electronegative atom to the more electronegative atom.

When a less electronegative atom or group (like an alkyl group) is considered bonded to a more electronegative system (or relative to hydrogen): In this case, the less electronegative atom or group appears to "push" electron density towards the more electronegative system or away from itself. This is called the electron-donating inductive effect ($+I$). Although the electronegativity difference might be small, groups like alkyl groups are considered electron-donating relative to hydrogen. The direction of the effect is represented by an arrow pointing from the electron-donating group towards the more electronegative part of the molecule.

In summary: Electronegativity differences create a dipole moment in the sigma bond, and the inductive effect describes the transmission of this polarity through the sigma bond network.

【 2 】 Question: Arrange the following Compounds in order of increasing acidity, explaining the reason based on the inductive effect:

(CH_3COOH) Acetic acid

(ClCH_2COOH) Chloroacetic acid

(Cl_2CHCOOH) Dichloroacetic acid

(Cl_3CCOOH) Trichloroacetic acid

Answer:

The order of increasing acidity is:

$\text{CH}_3\text{COOH} < \text{ClCH}_2\text{COOH} < \text{Cl}_2\text{CHCOOH} < \text{Cl}_3\text{CCOOH}$

Explanation based on the inductive effect:

The acidity of a carboxylic acid depends on the ease of losing a proton (H^+) from the carboxyl group ($-\text{COOH}$). After losing a proton, a carboxylate anion is formed. Any factor that stabilizes this negative charge will increase the acidity of the carboxylic acid.

Chlorine (Cl) is a highly electronegative atom and exerts an electron-withdrawing inductive effect (-I) when bonded to the carbon chain adjacent to the carboxyl group. This means it pulls electron density towards itself through the sigma bonds.

The electron-withdrawing effect of the chlorine atom(s) decreases the electron density on the oxygen atom bearing the negative charge in the carboxylate anion. This helps to disperse and stabilize the negative charge, making the loss of a proton easier and thus increasing the acidity.

As the number of chlorine atoms attached to the carbon adjacent to the carboxyl group increases, the magnitude of the electron-withdrawing inductive effect increases, leading to greater stabilization of the carboxylate ion and higher acidity.

CH_3COOH : No strong electron-withdrawing groups are present. The methyl group (CH_3) has a very weak electron-donating inductive effect (+I), which slightly destabilizes the carboxylate ion.

ClCH_2COOH : One chlorine atom exerts an electron-withdrawing effect, increasing acidity compared to acetic acid.

Cl_2CHCOOH : Two chlorine atoms provide a stronger electron-withdrawing effect, further increasing acidity.

Cl_3CCOOH : Three chlorine atoms exert the strongest electron-withdrawing effect, making this the most acidic compound in the series.

【 3 】 Question: Compare between the electron-withdrawing inductive effect (-I) and the electron-donating inductive effect (+I). Give examples of functional groups that exhibit each type of these effects.

Answer:

Electron-Donating Inductive Effect (+I)

Pushes electron density away from the group

Presence of a slightly less electronegative atom or group than the attached carbon or other effects like hyperconjugation

Increases electron density in adjacent parts of the molecule

Electron-Withdrawing Inductive Effect (-I)

Pulls electron density towards the group

Presence of a more electronegative atom or group than the attached carbon

Decreases electron density in adjacent parts of the molecule

Examples of functional groups exhibiting Electron-Withdrawing Inductive Effect (-I):

Property

Halogens: -F (strongest), -Cl, -Br, -I •

Direction of Effect

Nitro group: -NO₂ •

Main Cause

Cyano group: -CN •

Carboxyl group: -COOH •

Aldehyde group: -CHO •

Ketone group: -COR •

Ether group: -OR (oxygen is more electronegative than carbon) •

Secondary and tertiary ammonium ions: -NR₂⁺, -NR₃⁺ (positively charged nitrogen has a strong -I effect) •

Examples of functional groups exhibiting Electron-Donating Inductive Effect (+I):

Alkyl groups: -CH₃, -CH₂CH₃, -C(CH₃)₃ (the effect increases with the degree of alkyl substitution) •

Negatively charged ions: -O⁻ (very strong +I effect) •

Note: The inductive effect weakens rapidly with increasing distance from the influencing functional group.

【 4 】 Question: Which is more basic, considering the electron-donating inductive effect (+I):

($\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$) Propylamine

($\text{CH}_3\text{CH}_2\text{NH}_2$) Ethylamine

(CH_3NH_2) Methylamine

(NH_3) Ammonia

Answer:

The order of increasing basicity is:

$\text{NH}_3 < \text{CH}_3\text{NH}_2 < \text{CH}_3\text{CH}_2\text{NH}_2 < \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$

Explanation based on the electron-donating inductive effect (+I):

Basicity in amines depends on the availability of the lone pair of electrons on the nitrogen atom.

The higher the electron density on the nitrogen atom, the greater its ability to accept a proton (H^+) and form a coordinate covalent bond, thus the stronger the base.

Alkyl groups (CH_3 , CH_2CH_3 , $\text{CH}_2\text{CH}_2\text{CH}_3$) have a weak electron-donating inductive effect (+I). This means they slightly push electron density towards the carbon atom they are attached to, and consequently, they increase the electron density on the nitrogen atom in the amine to which they are ultimately connected.

NH_3 (Ammonia): No electron-donating alkyl groups are attached to the nitrogen. •

CH_3NH_2 (Methylamine): The presence of one methyl group (+I) slightly increases the electron density on the nitrogen, making it more basic than ammonia. •

$\text{CH}_3\text{CH}_2\text{NH}_2$ (Ethylamine): The presence of an ethyl group (+I) (a slightly larger +I effect than methyl due to more C-H bonds) further increases the electron density on the nitrogen, making it more basic than methylamine. •

$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ (Propylamine): The presence of a propyl group (+I) (a slightly larger +I effect than ethyl) increases the electron density on the nitrogen even more, making it the most basic in this series. •

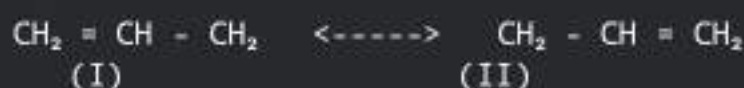
Note: While the effect of each alkyl group is small, the trend shows increasing basicity with an increasing number of carbon atoms in the alkyl chain due to the cumulative weak +I effect. However, other factors like steric hindrance and solvation can influence the basicity of amines in more complex cases.

【 5 】 Question: Draw the resonance structures of the allyl cation ($\text{CH}_2 = \text{CH} - \text{CH}_2^+$). Explain how resonance contributes to the stability of this ion?

Answer:

Resonance Structures of the Allyl Cation ($\text{CH}_2 = \text{CH} - \text{CH}_2^+$):

Two main resonance structures can be drawn for the allyl cation:



+

In structure (I), the positive charge is on the first terminal carbon, and the double bond is between the first and second carbons.

In structure (II), the positive charge has shifted to the third terminal carbon, and the double bond is now between the second and third carbons.

Explanation of how resonance contributes to the stability of the allyl cation:

Delocalization of the Positive Charge: Resonance allows the positive charge to be delocalized (spread out) over two carbon atoms instead of being concentrated on a single carbon. This delocalization of charge reduces the charge density at any one point, making the ion more stable. Concentrated charges are energetically unfavorable due to increased electrostatic repulsion.

Increased Electron Density in the Region of Positive Charge: The movement of the pi electrons in the resonance structures indicates that the electron deficiency (positive charge) is shared between the two terminal carbons. This increased electron density in the regions bearing the positive charge helps to stabilize the ion.

Resonance Hybrid: The actual structure of the allyl cation is a resonance hybrid, which is a composite of all contributing resonance structures. This hybrid has characteristics of both structures, with a partial positive charge on both terminal carbons and a partial double bond character between all three carbon atoms. This delocalization of electrons and charge leads to a lower overall energy and increased stability compared to any single resonance structure.

Resonance Energy: The stabilization gained by resonance is quantified as resonance energy. The allyl cation is more stable than a simple primary carbocation because of this resonance stabilization. The delocalization of the pi electrons creates a more extended pi system, which is energetically more favorable.

【 6 】 Question: Which of the following is more in terms of Hyperconjugation, Acidity, Stability:

- (A) 2,3,3-trimethylbut-1-ene
- (B) 2-chloro-2-methylpropane
- (C) 1-chloroethene (vinyl chloride)
- (D) Propene

Answer:

Hyperconjugation:

Hyperconjugation is the interaction between the electrons in a sigma (σ) bond (usually C-H or C-C) with an adjacent empty or partially filled p-orbital or a π orbital. It contributes to the stability of alkenes, carbocations, and radicals. The more β -hydrogen atoms (hydrogen atoms on the carbon atom adjacent to the sp^2 hybridized carbon or carbocation center), the greater the hyperconjugation.

- (A) 2,3,3-trimethylbut-1-ene: The vinylic carbons ($C=C$) have an adjacent carbon (C_2) with 3 methyl groups, each having 3 β -hydrogens. Total β -hydrogens = $3 \times 3 = 9$.
- (B) 2-chloro-2-methylpropane: No double bond or carbocation center. Hyperconjugation related to alkene or carbocation stability is not relevant here.
- (C) 1-chloroethene (vinyl chloride): The vinylic carbon ($C=C$) has an adjacent carbon (the one bonded to Cl) with 1 hydrogen atom. Total β -hydrogen = 1.
- (D) Propene: The vinylic carbons ($C=C$) have an adjacent carbon (methyl group) with 3 hydrogen atoms. Total β -hydrogens = 3.

Order of Hyperconjugation: $A > D > C > B$ (B has no relevant hyperconjugation)

Acidity:

Acidity refers to the ease of losing a proton. We need to consider the stability of the conjugate base formed after proton loss.

- (A) 2,3,3-trimethylbut-1-ene: Vinylic hydrogens are generally not very acidic.
- (B) 2-chloro-2-methylpropane: Hydrogens on the carbon bonded to chlorine will be slightly acidic due to the electron-withdrawing inductive effect of chlorine, stabilizing the negative charge of the conjugate base.
- (C) 1-chloroethene (vinyl chloride): Vinylic hydrogens are less acidic than aliphatic hydrogens due to the sp^2 hybridization of the carbon. The chlorine atom is electron-withdrawing but also has a lone pair that can donate into the π system, affecting acidity in a complex way.
- (D) Propene: Allylic hydrogens (on the carbon adjacent to the double bond) are more acidic than regular alkane hydrogens because the conjugate base (allyl anion) is stabilized by resonance.

Order of Acidity (approximate): $B > D > C > A$

Stability:

Stability of the molecule itself, considering factors like hyperconjugation, resonance (if applicable), and inductive effects.

(A) 2,3,3-trimethylbut-1-ene: Highly substituted alkene with significant hyperconjugation, making it relatively stable. •

(B) 2-chloro-2-methylpropane: No pi system for resonance or significant hyperconjugation related to unsaturation. Stability is mainly due to sigma bonds and the electronegativity of chlorine. •

(C) 1-chloroethene (vinyl chloride): Less stable than more substituted alkenes. The chlorine atom can donate electrons by resonance but is also electron-withdrawing inductively, which can destabilize the pi system to some extent. •

(D) Propene: Less substituted alkene than A, with less hyperconjugation. •

Order of Stability: $A > D > B > C$

Summary:

Hyperconjugation: $A > D > C > B$ •

Acidity: $B > D > C > A$ •

Stability: $A > D > B > C$ •

[7] Compare between homolytic fission and heterolytic fission of a covalent bond. Illustrate your answer with suitable examples, mentioning the types of reactive species produced in each case?

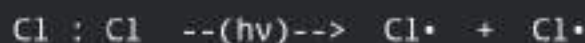
Homolytic Fission:

Description: In homolytic fission, a covalent bond breaks in such a way that each of the bonded atoms retains one of the electrons from the shared pair.

Result: This process generates uncharged reactive species called free radicals. Free radicals possess an unpaired electron, making them highly reactive.

Conditions: Homolytic fission typically occurs under conditions of high temperature or ultraviolet (UV) light.

Example: The cleavage of a chlorine molecule (Cl_2) under UV light:



Here, each chlorine atom receives one electron, forming two chlorine free radicals ($\text{Cl}^\bullet$).

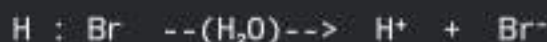
Heterolytic Fission:

Description: In heterolytic fission, a covalent bond breaks unevenly, with one of the bonded atoms receiving both electrons from the shared pair, while the other atom loses its electron contribution to the bond.

Result: This process produces charged reactive species called ions. A cation (positively charged ion) is formed from the atom that lost an electron, and an anion (negatively charged ion) is formed from the atom that gained the electron pair.

Conditions: Heterolytic fission is often favored in polar solvents or by the influence of ionic reagents.

Example: The cleavage of hydrogen bromide (HBr) in water:



In this case, bromine takes both bonding electrons, forming a bromide anion (Br^-), and hydrogen loses its electron, forming a hydrogen cation (H^+).

Summary of Reactive Species Produced:

Charge	Reactive Species Produced	Type of Fission
Neutral (with an unpaired electron)	Free Radicals	Homolytic
Charged (positive and negative)	Ions (Cation and Anion)	Heterolytic

[8] Arrange the following according to Nucleophilicity: NH_3 & H_2O & HF

Nucleophilicity: is the ability of an atom or molecule to donate a pair of electrons to form a new covalent bond with an electrophile (electron-deficient center).

When comparing nucleophiles where the attacking atom is the same (in this case, atoms with lone pairs of electrons), nucleophilicity depends on several factors, primarily charge and electronegativity.

Charge: Negatively charged nucleophiles are generally much stronger than neutral nucleophiles with the same attacking atom (not directly applicable here as all are neutral).

Electronegativity: The less electronegative the attacking atom, the greater its tendency to donate electrons, and thus the stronger the nucleophile.

In this set, the attacking atoms are nitrogen (in NH_3), oxygen (in H_2O), and fluorine (in HF). The electronegativity order of these atoms is: $\text{F} > \text{O} > \text{N}$.

Since nitrogen is the least electronegative, NH_3 is the strongest nucleophile. Oxygen is more electronegative than nitrogen, so H_2O is a weaker nucleophile than NH_3 . Fluorine is the most electronegative, making HF the weakest nucleophile.

Order of Increasing Nucleophilicity:



[9] Electrophilic substitution Reaction: Nitration of benzene, Explain the mechanism

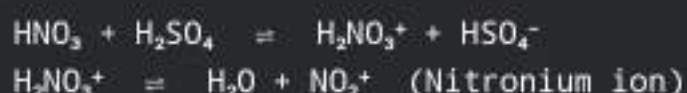
Nitration of Benzene: is an electrophilic aromatic substitution reaction in which one of the hydrogen atoms on the benzene ring is replaced by a nitro group ($-\text{NO}_2$). This reaction is typically carried out using a mixture of concentrated nitric acid and concentrated sulfuric acid (known as the nitrating mixture).

Mechanism of Nitration of Benzene: The mechanism involves three main steps:

Step 1: Generation of the Electrophile (Nitronium Ion, NO_2^+)

Sulfuric acid (H_2SO_4) acts as a catalyst and a stronger acid, protonating nitric acid (HNO_3), which acts as a base in this step.

The protonation of nitric acid followed by the loss of water generates the nitronium ion (NO_2^+), the powerful electrophile that will attack the benzene ring.



Step 2: Electrophilic Attack on the Benzene Ring and Formation of the Arenium Ion (Carbocation Intermediate)

The positively charged nitronium ion (NO_2^+) is attracted to the electron-rich π system of the benzene ring.

The nitronium ion attacks the benzene ring, forming a new sigma (σ) bond to one of the carbon atoms.

This attack disrupts the aromaticity of the benzene ring, resulting in a resonance-stabilized carbocation intermediate known as the arenium ion or sigma complex. In this intermediate, one carbon atom becomes sp^3 hybridized (instead of sp^2) and carries a formal positive charge delocalized over the remaining carbon atoms.



(Resonance structures of the arenium ion can be drawn to show the delocalization of the positive charge.)

Step 3: Loss of a Proton and Restoration of Aromaticity

The bisulfate ion (HSO_4^-) generated in the first step acts as a base and abstracts a proton (H^+) from the carbon atom in the arenium ion that is bonded to the nitro group.

The removal of this proton regenerates the π system of the benzene ring, restoring its aromaticity.

The electrons from the C-H bond move to reform the double bond, and the nitro group ($-\text{NO}_2$) remains attached to the benzene ring, forming nitrobenzene.

Sulfuric acid is regenerated as the catalyst.



Overall Product: Nitrobenzene ($\text{C}_6\text{H}_5\text{NO}_2$)

[10] Explain the mechanism of free radical chlorination of methane. Illustrate the initiation, propagation, and termination steps?

Free Radical Chlorination of Methane: is a substitution reaction in which hydrogen atoms in methane (CH_4) are successively replaced by chlorine atoms (Cl) via a free radical mechanism. This reaction typically occurs when a mixture of methane and chlorine is heated or exposed to ultraviolet (UV) light.

Mechanism of Free Radical Chlorination of Methane: The mechanism proceeds in three main

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Mechanism of Free Radical Chlorination of Methane: The mechanism proceeds in three main stages:

Step 1: Initiation

This step involves the generation of free radicals. It is initiated by the homolytic cleavage of a chlorine molecule (Cl_2) upon absorption of energy in the form of heat or UV light. The Cl-Cl bond breaks, and each chlorine atom receives one electron, forming two chlorine free radicals ($\text{Cl}\cdot$).



Step 2: Propagation

This step consists of a series of chain reactions where radicals consume reactants and produce new radicals, thus propagating the reaction. There are two key propagation steps:

Step 2a: A chlorine radical ($\text{Cl}\cdot$) attacks a methane molecule (CH_4), abstracting a hydrogen atom to form hydrogen chloride (HCl) and a methyl radical ($\text{CH}_3\cdot$).



Step 2b: The methyl radical ($\text{CH}_3\cdot$) attacks another chlorine molecule (Cl_2), abstracting a chlorine atom to form chloromethane (CH_3Cl) and a new chlorine radical ($\text{Cl}\cdot$).



These two propagation steps repeat in a cycle. The chlorine radical generated in step 2b can then react with another methane molecule (step 2a), and the methyl radical formed can react with another chlorine molecule (step 2b), leading to the continuous formation of chloromethane and the consumption of reactants.

Step 3: Termination

In this step, the chain reaction is terminated by the combination of any two free radicals to form stable, non-radical products. Several possible termination reactions can occur:

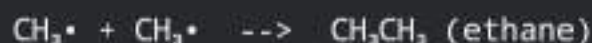
Two chlorine radicals combine:



A methyl radical and a chlorine radical combine:



Two methyl radicals combine:



These termination reactions reduce the concentration of free radicals in the reaction mixture, eventually slowing down and stopping the chain reaction.

Reaction Products:

The free radical chlorination of methane yields a mixture of chlorinated products, including chloromethane (CH_3Cl), dichloromethane (CH_2Cl_2), trichloromethane (CHCl_3 or chloroform), and tetrachloromethane (CCl_4 or carbon tetrachloride), as well as HCl . The distribution of these products depends on the relative concentrations of methane and chlorine and the reaction conditions.

[11] The addition reaction of hydrogen cyanide (HCN) to aldehydes or ketones to form cyanohydrins involves three main steps as illustrated?

(Since the question mentions that the steps are illustrated, I will describe these steps generally based on the standard mechanism for this reaction.)

Mechanism of the Addition of Hydrogen Cyanide (HCN) to Aldehydes or Ketones to Form Cyanohydrins:

This reaction is an example of nucleophilic addition to a carbonyl group ($\text{C}=\text{O}$). It typically involves the use of sodium cyanide (NaCN) or potassium cyanide (KCN) in the presence of a mild mineral acid to generate HCN *in situ*.

Step 1: Activation of the Carbonyl Group (Optional but Common)

Under slightly acidic conditions, a proton (H^+) can protonate the oxygen atom of the carbonyl group, which has lone pairs of electrons.

This protonation increases the partial positive charge on the carbonyl carbon atom, making it more susceptible to nucleophilic attack.



Step 2: Nucleophilic Attack by the Cyanide Ion (CN^-)

The cyanide ion (CN^-) is a strong nucleophile due to its negative charge and the lone pair of electrons on the carbon atom.

The cyanide ion attacks the electrophilic carbonyl carbon atom from above or below the plane of the trigonal planar carbonyl group (due to the sp^2 hybridization of the carbon).

The π electrons of the carbon-oxygen double bond shift onto the more electronegative oxygen atom, resulting in the formation of an alkoxide ion.

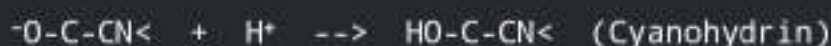


(If the carbonyl group was protonated in Step 1, the attack would be on $>\text{C}=\text{OH}^+$)

Step 3: Protonation to Form the Cyanohydrin

The alkoxide ion formed in Step 2 is a strong base and readily abstracts a proton (H^+) from the acidic medium (e.g., unreacted HCN or the protonated solvent).

This protonation of the alkoxide ion yields the cyanohydrin, which contains both a hydroxyl ($-\text{OH}$) group and a cyano ($-\text{CN}$) group attached to the same carbon atom.



Summary of the Mechanism:

Carbonyl Activation (Optional): Protonation of the carbonyl oxygen. .1

Nucleophilic Attack: Cyanide ion (CN^-) attacks the carbonyl carbon. .2

Protonation: The resulting alkoxide ion is protonated to form the cyanohydrin. .3

[12] Which is more acidity, drawing effect (-I), Stability: (Chloroacetic acid, Dichloroacetic acid, Trichloroacetic acid)

Acidity: is the ability of a compound to donate a proton (H^+). Acidity increases when the conjugate base (the anion formed after losing the proton) is more stable.

Electron-Withdrawing Effect (-I): is the ability of a group to pull electron density towards itself through a sigma bond. Atoms or groups with high electronegativity exhibit a strong electron-withdrawing inductive effect (-I).

In this case, we have three carboxylic acids that differ in the number of chlorine atoms attached to the alpha-carbon (the carbon adjacent to the carboxyl group):

- Chloroacetic acid (ClCH_2COOH): Contains one chlorine atom.
- Dichloroacetic acid (Cl_2CHCOOH): Contains two chlorine atoms.
- Trichloroacetic acid (Cl_3CCOOH): Contains three chlorine atoms.

Electron-Withdrawing Effect and Stability:

Chlorine atoms are highly electronegative and exert a strong electron-withdrawing inductive effect (-I). When these carboxylic acids lose a proton, they form their corresponding carboxylate anions. The presence of chlorine atoms helps to stabilize these carboxylate anions by pulling electron density away from the negatively charged oxygen atoms. This delocalization of the negative charge makes the carboxylate ion more stable, and therefore, the original acid is more acidic.

Trichloroacetic acid (Cl_3CCOOH) has three chlorine atoms pulling electron density strongly, leading to the greatest stabilization of the trichloroacetate anion. Therefore, it is the most acidic.

Dichloroacetic acid (Cl_2CHCOOH) has two chlorine atoms, providing less stabilization to the dichloroacetate anion compared to trichloroacetic acid, but more than chloroacetic acid. It has intermediate acidity.

Chloroacetic acid (ClCH_2COOH) has only one chlorine atom, providing the least stabilization to the chloroacetate anion among the three. Therefore, it is the least acidic.

Order of Increasing Acidity:

Chloroacetic acid < Dichloroacetic acid < Trichloroacetic acid

Order of Increasing Electron-Withdrawing Effect (-I) on the Carboxylate Anion:

Chloroacetate < Dichloroacetate < Trichloroacetate

Order of Increasing Stability of the Conjugate Base (Carboxylate Anion):

Chloroacetate < Dichloroacetate < Trichloroacetate

[13] Which is more basic, electron density: (Primary amine, secondary amine, tertiary amine)

Basicity of Amines: In the context of Brønsted-Lowry basicity (proton acceptance), the basicity of amines is related to the availability of the lone pair of electrons on the nitrogen atom to accept a proton (H^+). Factors that increase the electron density on the nitrogen atom generally increase the basicity.

Effect of Alkyl Groups (Electron-Donating): Alkyl groups are electron-donating groups through the inductive effect (+I). They push electron density towards the nitrogen atom.

Primary Amine (RNH_2): Has one alkyl group attached to the nitrogen atom. •

Secondary Amine (R_2NH): Has two alkyl groups attached to the nitrogen atom. •

Tertiary Amine (R_3N): Has three alkyl groups attached to the nitrogen atom. •

Based on the electron-donating effect of alkyl groups, one might expect the basicity to increase in the order: primary < secondary < tertiary.

However, there is a complicating factor: Solvation Effects (especially in aqueous solution).

The ammonium ion formed after an amine accepts a proton is stabilized by solvation (interaction with solvent molecules, like water, through hydrogen bonding). •

Primary ammonium ions (RNH_3^+) have three N-H bonds available for hydrogen bonding with water, leading to significant stabilization. •

Secondary ammonium ions (R_2NH_2^+) have two N-H bonds for hydrogen bonding. •

Tertiary ammonium ions (R_3NH^+) have only one N-H bond for hydrogen bonding, leading to less stabilization through solvation. •

Combined Effect:

The interplay between the electron-donating effect of alkyl groups and solvation effects leads to the following general trend for the basicity of aliphatic amines in aqueous solution:

Secondary amine > Primary amine > Tertiary amine

The secondary amine often shows the highest basicity because it benefits from a significant electron-donating effect from two alkyl groups while still having sufficient N-H bonds for solvation. Tertiary amines, although having the largest electron-donating effect on the nitrogen atom itself, suffer from poor solvation of their conjugate acid.

Electron Density on the Nitrogen Atom:

The electron density on the nitrogen atom (before protonation) generally increases with the number of electron-donating alkyl groups:

Tertiary amine > Secondary amine > Primary amine

So, while the tertiary amine has the highest electron density on the nitrogen, its conjugate acid is less stabilized in solution, leading to a lower overall basicity compared to some secondary amines.

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So, while the tertiary amine has the highest electron density on the nitrogen, its conjugate acid is less stabilized in solution, leading to a lower overall basicity compared to some secondary amines.

[14] Compare between Electrophile & Nucleophile?

Here's a comparison between electrophiles and nucleophiles:

Nucleophile	Electrophile	Feature
"Nucleus-loving"	"Electron-loving"	Name Meaning
Electron-rich; can be negative, neutral (with a lone pair or π bond)	Electron-deficient; can be positive, neutral (with a polar bond or empty orbital)	Charge
Donates an electron pair to form a new bond		
Regions of low electron density (positive charge or partial positive charge)	Accepts an electron pair to form a new bond	Role
Lewis base (electron pair donor)	Regions of high electron density (negative charge or partial negative charge)	Attracted To
OH^- , CN^- , NH_3 , H_2O , carbanions (R_3C^-), alkenes		
Undergoes nucleophilic attack (electron pair donor)	Lewis acid (electron pair acceptor)	Lewis Acid/Base
H_2O , carbanions (R_3C^-), alkenes	H^+ , NO_2^+ , carbocations (R_3C^+), SO_3 , BX_3 , RX	Examples
Undergoes nucleophilic	Undergoes electrophilic attack	Reaction

【 15 】 Which is more basic, electron density:

(P-nitroaniline, Aniline, P-toluidine)

Answer and Explanation:

Aniline: The lone pair of electrons on the nitrogen atom of the amino group ($-\text{NH}_2$) can participate in resonance with the benzene ring, making it less available for protonation and thus less basic.

P-nitroaniline: The nitro group ($-\text{NO}_2$) is an electron-withdrawing group ($-I$ and $-M$). It further withdraws electron density from the benzene ring and consequently from the nitrogen atom of the amino group. This makes the lone pair of electrons even less available for protonation, making p-nitroaniline the least basic among the three.

P-toluidine: The methyl group ($-\text{CH}_3$) is an electron-donating group ($+I$ and hyperconjugation). It pushes electron density towards the benzene ring and consequently towards the nitrogen atom of the amino group. This makes the lone pair of electrons more available for protonation, making p-toluidine the most basic among the three.

Order of Increasing Basicity:

P-nitroaniline < Aniline < P-toluidine

【 16 】 Arrange the following species in order of increasing stability: primary carbocation, secondary carbocation, tertiary carbocation, methyl carbocation (CH_3^+)?

Answer and Explanation:

The stability of carbocations is determined by the number of alkyl groups attached to the positively charged carbon. Alkyl groups are electron-donating through inductive effect ($+I$) and hyperconjugation, which helps to disperse the positive charge and stabilize the carbocation.

Methyl carbocation (CH_3^+): Has no alkyl groups attached, making it the least stable.

Primary carbocation: Has one alkyl group attached.

Secondary carbocation: Has two alkyl groups attached.

Tertiary carbocation: Has three alkyl groups attached, providing the most effective charge delocalization and making it the most stable.

Order of Increasing Stability:

Methyl carbocation < Primary carbocation < Secondary carbocation < Tertiary carbocation

【 17 】 Which is more basic:

Methyl amine & ammonia & Aniline

Answer and Explanation:

Ammonia (NH_3): Has a lone pair of electrons on the nitrogen atom that can accept a proton. •

Methyl amine (CH_3NH_2): The methyl group ($-\text{CH}_3$) is an electron-donating group (+I), which increases the electron density on the nitrogen atom, making the lone pair of electrons more available for protonation. Therefore, methyl amine is more basic than ammonia. •

Aniline ($\text{C}_6\text{H}_5\text{NH}_2$): As explained in question 15, the lone pair of electrons on the nitrogen atom is involved in resonance with the benzene ring, significantly reducing its availability for protonation. Thus, aniline is much less basic than both ammonia and methyl amine. •

Order of Increasing Basicity:

Aniline < Ammonia < Methyl amine

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

أسئلة ميد تيرم سابقة في مادة
الكيمياء الفيزيائية 🌟



اللهم نسألك بأسمك الأكرم
الذي إذا دعيت به أجبت
اللهم أنصر أخواننا في فلسطين
اللهم وحد صفوفهم وأجمع كلمتهم على الحق
اللهم عليك بالصهاينة المعتدين الغاصبين
اللهم أرنا بهم عجائب قدرتك وشف صدور
قوم مؤمنين يا ذا الجلال والإكرام

By : Ahmed Salah 🌟

The solubility of a solute is generally rises with:

- (a) increase in temperature .
- (b) decrease in temperature.
- (c) increases in volume of the solvent
- (d) none of these

In a super saturated solution, the amount of solute is ----- in comparison to saturated solution.

- (a) less (b) more (c) equal to (d) none of these



A saturated solution is defined as one which is ----- with the excess of solid at a particular temperature.

- (a) in contact (b) in equilibrium
(c) contains impurities (d) none of these

A saturated solution of KCl on heating becomes

- (a) unsaturated (b) supersaturated
(c) hydrated (d) none of these

The concentration of a solution is defined as:

- (a) The amount of solvent present in a given amount of solution
- (b) The amount of solute present in a given amount of solution
- (c) The amount of solute present in a given amount of solvent
- (d) The amount of solvent present in a given amount of solute

If n represents the number of moles of a solute and N represents the number of moles of a solvent, the mole fraction of the solvent is given by:

(a) $\frac{n}{n + N}$

(b) $\frac{N}{n + N}$

(c) $\frac{n + N}{n}$

(d) $\frac{n + N}{N}$

The molarity is defined as the number of moles of solute present in:

(a) one liter of the solvent .

(b) one liter of the solution.

(c) one kilogram of the solvent.

(d) one kilogram of the solution.

The molality of a solution is defined as the number of moles of solute present in:

(a) one liter of the solvent

(c) one kilogram of the solvent

(b) one liter of the solution

(d) one kilogram of the solution



The weight percent of a solute in a solution is given by:

$$(a) \frac{w_B}{w_A + w_A} \times 100$$

$$(b) \frac{w_B}{w_A} \times 100$$

$$(c) \frac{w_B}{w_A + w_B} \times 100$$

$$(d) \frac{w_A}{w_A + w_B} \times 100$$

Normality of a solution is the number of -----

(a) moles

(b) equivalents

(c) formula weight

(d) mole fraction

The number of moles of a solute per kilogram of the solvent is called:

(a) formality

(b) normality

(c) molarity

(d) molality



For a gas in contact with a solvent at a constant temperature, the concentration of the gas that dissolves in the solvent is directly proportional to the pressure of the gas. This law:

(a) Henry's law

(c) Dalton's law

(b) Raoult's law

(d) van't Hoff

The Henry's law is applicable if:

- (a) the temperature and pressure are moderate
- (b) the solubility of the gas in the solvent is low
- (c) the gas does not react with the solvent to form a new species
- (d) all of the above

Mathematically, Henry's law can be expressed as (C is the concentration of the gas in solution and P is the pressure of the gas)

- (a) $C \propto P$
- (b) $C = k P$
- (c) $k = C/P$
- (d) all of these

The Henry's law gives the relationship between:

- (a) the pressure and solubility of a gas in a particular solvent
- (b) the temperature and solubility of a gas in a particular solvent
- (c) the composition of the mixture and solubility of a gas in a particular solvent
- (d) none of these

When the attraction of molecules of A for B or B for A is less than for A-A or for B-B attraction. Then the molecules of A or B tend to escape from the solution relatively easier than from pure A or pure B. In this case,

- (a) The vapour pressure of the solution will be greater than that given by Raoult's Law.
- (b) The vapour pressure of the solution will be greater than that given by Henry's law .
- (c) The vapour pressure of the solution will be greater than that given by Dalton's Law.
- (d) The vapour pressure of the solution will be greater than that given by van't Hoff law.

Negative Deviation occurs :

- (a) When the attraction between A to B molecules is greater than attraction between A to A molecules or the molecules B to B .
- (b) When the attraction between A to B molecules is less than attraction between A to A molecules or the molecules B to B .
- (c) When the attraction between A to B molecules is equal to the attraction between A to A molecules or the molecules B to B .
- (d) none of these.

A chemical system is at equilibrium

- (a) when the rate of the forward reaction becomes zero.
- ☒ (b) when the rates of the forward reaction and the reverse reaction are equal.
- (c) when all of the reactants have been used up.
- (d) when the rates of the forward reaction and the reverse reaction are both zero.

Equilibrium reactions are characterized by

- (a) Going to completion.
- (b) Being non-spontaneous.
- ☒ (c) The presence of both reactants and products in a definite proportion.
- (d) none of these.



A dynamic equilibrium

- (a) is when the rate of the forward reaction is equal to the rate of the reverse reaction.
- (b) is a form of static equilibrium.
- (c) only occurs in chemical equilibrium.
- (d) involves radioactivity.

**The equilibrium mixture $2\text{NO}_{2(\text{brown})} \rightleftharpoons \text{N}_2\text{O}_{4(\text{colourless})}$;
What happens to the colour if pressure is increased?**

- (a) No change in colour intensity.
- (b) Colour intensity first increases and then decreases.
- (c) Colour intensity increases.
- (d) Colour intensity decreases.



If catalyst accelerates both the forward and backward reactions to the same extent;

- ☒ (a) The net result is to shorten the necessary time to reach the equilibrium.
- (b) The net result is to extended the necessary time to reach the equilibrium.
- (c) The net result is no effect on the necessary time to reach the equilibrium.
- (d) The net result is little time to reach the equilibrium.



The catalyst accelerates the forward reaction only, without affecting the backward reaction.

- (a) So the catalyst is said to be positive catalyst.
- (b) So the catalyst is said to be negative catalyst.
- (c) So the catalyst is said to be neutral catalyst.
- (d) So the catalyst is said to be little catalyst.

The catalyst accelerates the backward reaction only , without affecting the backward reaction.

- (a) So the catalyst is said to be positive catalyst.
- (b) So the catalyst is said to be negative catalyst.
- (c) So the catalyst is said to be neutral catalyst.
- (d) So the catalyst is said to be little catalyst.



If you have the following reaction:



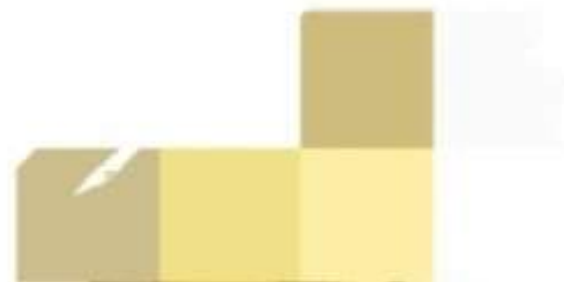
what happened when we added ammonium chloride to the reaction.

- (a) An increase in intensity of the red color.
- (b) Causes the color to become paler.
- (c) An increase in intensity of the blue color.
- (d) none of these

Which of the following will shift the reaction:

$\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$, to the right side?

- (a) Increasing volume of $\text{NH}_{3(g)}$.
- (b) Increasing pressure of the system.**
- (c) Introducing an inert gas to the system.
- (d) none of these



If the equilibrium constant for a reaction is large, what can be said about the reaction.

- (a) very little product is formed
- ☒ (b) very little reactants remains at equilibrium
- (c) the reaction goes to completion
- (d) large quantities of reactants will remain at equilibrium

What is the expression for K_{eq} or K_C for the reaction:



- (a) $\frac{[\text{N}_2][\text{O}_2]}{[\text{NO}]}$ (b) $\frac{[\text{NO}]^4}{[\text{N}_2\text{O}]^2}$ (c) $\frac{[\text{N}_2\text{O}]^2 [\text{O}_2]}{[\text{NO}]^4}$ ☒ (d) $\frac{[\text{NO}]^4}{[\text{N}_2\text{O}]^2 [\text{O}_2]}$

A reaction is at equilibrium. What happens to the value of the equilibrium constant if an additional quantity of reactant is added to the reaction mixture.

- (a) the equilibrium constant is shifted to favour production of more reactant.
- (b) the equilibrium constant is shifted to favour production of more product.
- (c) the equilibrium constant is increased.
- (d) the equilibrium constant stays the same.

In writing equilibrium constant expressions, which of the following quantities can be used to represent the amount of reactants and products.

- (a) concentrations.
- (b) partial pressures.
- (c) mole fractions .
- (d) (a) and (b) only.

Which one of the following is incorrect:

- (a) equilibrium is dynamic, as some molecules are always reacting.
- (b) the equilibrium constant is just the ratio of forward to reverse rate constants.
- (c) at equilibrium the concentrations no longer change with time.
- (d) the equilibrium constant is not affected by temperature changes.

The yield of $\text{AB}_{(g)}$ for the reaction:

$\text{A}_{(g)} + \text{B}_{(g)} \rightarrow \text{AB}_{(g)} + \text{heat}$, would be increased by:

- (a) decreasing the pressure.
- (b) adding additional AB to the reaction mixture.
- (c) decreasing the temperature.
- (d) adding a non-reactive liquid to the reaction mixture.

We can Applied the Law of Mass Action to Solutions of

- (a) Strong acid.
- (b) Strong base.
- (c) Strong acid and Strong base.
- (d) weak Electrolytes.

In Ostwald Law of Dilution, "the dissociation degree, α ,"

- (a) increases with dilution.
- (b) decreases with dilution.
- (c) unaffected with dilution.
- (d) increases with Concentration.



When a soluble salt (say A^+C^-) is added to a solution of another salt (A^+B^-) containing a common ion (A^+), the dissociation of AB is suppressed. $AB \rightleftharpoons A^+ + B^-$

- ~~(a)~~ the degree of dissociation of AB will be reduced.
- (b) the degree of dissociation of AB will be increases.
- (c) the degree of dissociation of AB will be unaffected.
- (d) the degree of dissociation of AB will be stopped.

When solid NH_4Cl is added to NH_4OH solution, the equilibrium shifts to the left:

- ~~(a)~~ the equilibrium concentration of OH^- decreases.
- (b) the equilibrium concentration of OH^- increases.
- (c) the equilibrium concentration of OH^- unaffected.
- (d) the equilibrium concentration of OH^- neutralized.

If we have a weak electrolyte such as acetic acid in equilibrium, when we added a strong electrolyte having an ion in common to this solution. The resulting equilibrium

(a) shifted to the right.

(b) shifted to the left.

(c) will be unaffected.

(d) will be stopped

In neutral solutions:

(a) $[H^+] = 10^{-7}$

(b) $[OH^-] = 10^{-7}$

(c) $pH = pOH$

(d) All of these

It is known that pH of water = 7,

- (a) If we added one ml of 0.1 N hydrochloric acid to one liter water, the pH value of water is altered to 4.
- (b) If we added one ml of 0.1 N NaOH alters the pH value to 10.0 .
- (c) the addition of slight amounts of dilute acids or dilute bases to water, its pH values greatly affected.
- (d) All of these.

It known that, acetic acid (CH_3COOH) and sodium acetate (CH_3COONa), as buffer solutions. if we added a small amounts of H^+ ions to such a solution; it will combined with;

(a) the acetate ions (from acetic acid).

(b) the acetate ions (from sodium acetate).

(c) sodium ion (from sodium acetate).

(d) OH^- (from ionization of water).



thank you



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♥ وفقكم الله إن شاء الله يا علماء المستقبل