

CUET Chemistry Solution 2024 (SET A)

Ques 1. Ions from $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$

- The complex ion, $[\text{Cr}(\text{NH}_3)_6]^{3+}$, remains intact in solution.
- Three Cl^- ions dissociate from the chloride salt.
- Total ions: 1 (complex cation) + 3 (chloride anions) = 4 ions

Therefore, the correct answer is (3) 4.

Ques 2. Number of Molecules

- Avogadro's constant (N_A) = 6.022×10^{23} molecules/mol

Calculations:

- Molecules in 16 g of O_2 : $(16 \text{ g}) / (32 \text{ g/mol O}_2) * N_A = 3.01 \times 10^{22}$ molecules
- Molecules in 16 g of CO_2 : $(16 \text{ g}) / (44 \text{ g/mol CO}_2) * N_A = 2.27 \times 10^{22}$ molecules
- Molecules in 16 g of CO : $(16 \text{ g}) / (28 \text{ g/mol CO}) * N_A = 3.57 \times 10^{22}$ molecules
- Molecules in 16 g of H_2 : $(16 \text{ g}) / (2 \text{ g/mol H}_2) * N_A = 1.20 \times 10^{24}$ molecules

Ordering:

- Most molecules: H_2 (D)
- Less molecules: CO (C)
- Even less molecules: CO_2 (B)
- Least molecules: O_2 (A)

Therefore, the correct order is (2) (D), (C), (A), (B).

Ques 3. Van't Hoff Factor and Association

Given:

- Van't Hoff factor (i) = 0.80
- Fraction of associated molecules = 0.3

Understanding:

- Van't Hoff factor indicates the number of particles (ions or molecules) a solute dissociates or associates into in solution compared to its non-associated state.
- In this case, $i = 0.80$ suggests the associated molecule X forms less than 1 particle (itself) upon dissociation.
- The fraction of associated molecules (0.3) implies that 70% of X molecules are not associated (exist as monomers).

Deriving the formula for i :

Let X be the monomer and X_n be the associated molecule (n monomers).

$i = (\text{number of particles after dissociation}) / (\text{number of particles before dissociation})$

Since only 1 monomer dissociates from X_n , and 0.3 of X molecules are associated (forming X_n), we can write:

$$i = (1 + 0.3 * n) / (1 + 0.7)$$

Solving for n :

Substitute $i = 0.80$ and solve for n :

$$0.80 = (1 + 0.3 * n) / (1.7) \quad 1.36 = 1 + 0.3 * n \quad 0.36 = 0.3 * n \quad n = 1.2$$

(non-integer value, not possible)

Explanation:

The calculated value of n (1.2) is not an integer, which is unusual for the degree of association in equilibrium situations like this. There might be a slight error in the problem statement or the interpretation of the given data. However, considering the closest integer value that makes sense in this context, $n = 1$ would be a reasonable approximation. This suggests that X associates to form a dimer (X_2).

Therefore, the most likely answer is (1) 2.

Important Note:

If the problem statement intended a different interpretation of the data, or if there's a correction to the van't Hoff factor or fraction of associated molecules, the solution might need to be adjusted accordingly.

Ques 4.

1. Sulfate Charge: 3 SO_4^{2-} ions contribute -6 charge (-2 each).
2. Ligand Charge: $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ is neutral (H = +1, N = -3, but they cancel out).
3. Complex Ion Charge (assumed): +3 (balances sulfate charge).

Balancing Charges:

Let x be Co's oxidation number. We need x to balance the overall charge:

$$x + (\text{neutral ligands}) = +3 (\text{complex ion}) - (-6) (\text{sulfates})$$

$$x = +3 + 6 \quad x = 9$$

Divide by the number of complex ions (3):

$$x/3 = 3$$

Therefore, the oxidation number of Co is 3.

Ques 5. The correct structure of the dipeptide Gly-Ala (glycyl alanine) is:

(4) $\text{H}_2\text{N}-\text{CH}(\text{CH}_3) - \text{CO} - \text{NH}-\text{CH}_2-\text{COOH}$

Here's why:

- Glycine (Gly) has a hydrogen (H_2N) at one end and a carboxylic acid group (COOH) at the other.
- Alanine (Ala) has a methyl group (CH_3) attached to the central carbon atom, along with an amino group (NH_2) and a carboxylic acid group.
- In a dipeptide, the carboxylic acid group of one amino acid (Gly in this case) forms a peptide bond with the amino group of the other amino acid (Ala).
- A peptide bond is formed by the condensation reaction between the carboxyl group (losing an OH) and the amino group (losing an H), resulting in a new amide bond ($\text{CO}-\text{NH}$).

Therefore, the structure starts with the H_2N group of glycine, followed by the $\text{CO}-\text{NH}$ peptide bond linking it to the $\text{CH}(\text{CH}_3)-\text{CH}_2-\text{COOH}$ chain of alanine.

Ques 6. Copper Crystal Radius (FCC Lattice)

(1) 127 pm is the correct answer.**

In an FCC lattice, the face diagonal of the unit cell is equal to 4 times the radius of the atom. We can use the given unit cell edge length (a) to find the face diagonal (d) and then calculate the radius (r).

$$d = \sqrt{2} * a = \sqrt{2} * 361 \text{ pm} \quad r = d / 4 = (\sqrt{2} * 361 \text{ pm}) / 4 \approx 127 \text{ pm}$$

Ques 7. First-Order Reaction Time

We can use the integrated rate law for a first-order reaction:

$$\ln([A]_0 / [A]) = kt$$

where:

- $[A]_0$ is the initial concentration
- $[A]$ is the concentration at time t
- k is the rate constant
- t is time

We know 75% of the reaction is complete in 32 minutes, which means $[A]$ is 25% of $[A]_0$.

$$\ln(4) = k * 32 \text{ min}$$

For 50% completion, $[A]$ is 50% of $[A]_0$. Solving for the time (t') to reach 50% completion:

$$\ln(2) = k * t'$$

Since k remains constant, we can set up a proportion:

$$(\ln(4) / 32 \text{ min}) = (\ln(2) / t')$$

Solving for t' :

$$t' = (\ln(2) * 32 \text{ min}) / \ln(4) \approx 16 \text{ minutes}$$

Therefore, the answer is (1) 16 minutes.

Ques 8. Magnetic Field Repulsion

Compounds with unpaired electrons are attracted to a magnetic field.

Here's the analysis:

- $\text{Na}_2[\text{CuCl}_4]$: Cu^{2+} has no unpaired electrons (d^{10} configuration). Repelled. (Answer: (1))
- $\text{Na}_2[\text{CdCl}_4]$: Cd^{2+} has no unpaired electrons (d^{10} configuration). Repelled.

- $K_4[Fe(CN)_6]$: Fe^{2+} has 4 unpaired electrons (d^6 configuration).
Attracted.
- $K_3[Fe(CN)_6]$: Fe^{3+} has 3 unpaired electrons (d^5 configuration).
Attracted.

Ques 9. Spin-Only Magnetic Moment (Mn^{2+})

Mn^{2+} has 5 unpaired electrons (d^5 configuration). The spin-only magnetic moment (μ) can be calculated using:

$$\mu = \sqrt{n(n + 2)} \text{ BM}$$

where n is the number of unpaired electrons.

$$\mu = \sqrt{5(5 + 2)} \text{ BM} \approx 5.90 \text{ BM}$$

Therefore, the answer is (1) 5.90 BM.

Ques 10. Boiling Point Order

Boiling point depends on several factors:

- Hydrogen bonding: Compounds with hydrogen bonding have higher boiling points.
- Molecular weight: Heavier molecules generally have higher boiling points.
- Dipole-dipole interactions: Molecules with stronger dipole-dipole interactions have higher boiling points.

Analysis:

- n-Butane ($CH_3CH_2CH_2CH_3$): No hydrogen bonding, low molecular weight, weak dipole-dipole interactions (lowest boiling point).
- Ethoxyethane ($CH_3CH_2OCH_2CH_3$): Hydrogen bonding between ether oxygen and hydrogen, slightly higher boiling point than n-butane.
- Pentanal ($CH_3CH_2CH_2CH_2CHO$): Hydrogen bonding between aldehyde carbonyl group and hydrogen, higher boiling point than ethoxyethane.
- Pentan-1-ol ($CH_3CH_2CH_2CH_2CH_2OH$): Strongest hydrogen bonding between alcohol hydroxyl group and hydrogen, highest boiling point.

Therefore, the correct order is:

(1) n-Butane, Ethoxyethane, Pentanal, Pentan-1-ol

Ques 12. Colloid Protection (Question 12)

Correct Answer: (1) A

Gold number refers to the minimum amount of a lyophilic colloid (protective colloid) required to prevent the coagulation of a lyophobic colloid (protected colloid) when an electrolyte is added. A lower gold number indicates a more effective protective colloid.

Here's the analysis:

- A: 0.005-0.01 (lowest gold number range)
- B: 0.15-0.25
- C: 0.04-1.0
- D: 15-25 (highest gold number range)

Since option A has the lowest gold number range, it requires the least amount of the protective colloid to achieve stability, making it the most effective protective colloid.

Ques 13. Nitration of Aniline

Correct Answer: (4) 2,4-Dinitroaniline

Aniline reacts with a mixture of concentrated nitric acid (HNO_3) and concentrated sulfuric acid (H_2SO_4) at high temperatures (not 298 K, which is room temperature) to undergo nitration. The major product is typically a mixture of ortho (o-) and para (p-) nitroanilines, with a higher yield of the para isomer due to its increased stability. However, under specific conditions or with stronger nitrating agents, further nitration can occur, leading to the formation of di- or even tri-nitroanilines.

In this case, the information about 47% yield suggests it's not the typical o/p mixture. The most likely product with a significant yield under these conditions is 2,4-dinitroaniline, where both the ortho and para positions are substituted with nitro groups.

Ques 14. Basic Strength Order

Correct Answer: (3) $(\text{C}_2\text{H}_5)_3\text{N} < (\text{C}_2\text{H}_5)_2\text{NH} < \text{C}_6\text{H}_5\text{NH}_2 < \text{C}_2\text{H}_5\text{NH}_2$

Here's the increasing order of basic strength based on the concept of inductive effect:

1. Tertiary amine $((\text{C}_2\text{H}_5)_3\text{N})$: Three electron-donating ethyl groups attached to the nitrogen significantly increase its ability to donate a lone pair of electrons, making it the strongest base.
2. Secondary amine $((\text{C}_2\text{H}_5)_2\text{NH})$: Two ethyl groups still contribute electron-donating effects, but to a lesser extent compared to the tertiary amine.
3. Aniline $(\text{C}_6\text{H}_5\text{NH}_2)$: The lone pair on the nitrogen is slightly deactivated due to the weakly electron-withdrawing effect of the phenyl ring.
4. Primary amine $(\text{C}_2\text{H}_5\text{NH}_2)$: The ethyl group has a negligible inductive effect, and the basic strength is primarily due to the lone pair on nitrogen (weakest base).

Hell-Volhard-Zelinsky Reaction

Ques 15. Correct Answer: (1) $\text{R-CH}_2\text{-COOH}$

The Hell-Volhard-Zelinsky reaction is used for the α -halogenation of carboxylic acids. It involves converting a carboxylic acid (R-COOH) into an α -halo carboxylic acid (R-CHX-COOH) through a series of steps including the formation of an acyl halide intermediate.

Here's why the other options won't work:

- (2) R_2CO (ketones): Don't have the necessary carboxylic acid group for the reaction.
- (3) $\text{R}_3\text{C-CHO}$ (aldehydes): Similar to ketones, they lack the carboxylic acid functionality.
- (4) H-COOH (formic acid): While technically a carboxylic acid, it doesn't have an α -carbon for halogenation.

Ques 16. Approach to arranging these carboxylic acids by increasing acidity! Here's the breakdown:

Factors Affecting Acidity:

The acidity of a carboxylic acid depends on the stability of its conjugate base (the anion formed after losing a proton).

- Electron-withdrawing groups (EWGs): These groups tend to pull electron density away from the oxygen atom holding the negative charge in the conjugate base, stabilizing it and making the acid more likely to donate a proton (increasing acidity).
- Inductive effect vs. resonance effect: EWGs can exert their electron-withdrawing effect through two main mechanisms:
 - Inductive effect: A direct "pull" of electrons along the covalent bonds.
 - Resonance effect: Electrons are delocalized across multiple contributing structures.

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Analysis of the Acids:

1. HCOOH (formic acid): Small size and the presence of a hydrogen atom (weak electron-withdrawing) contribute to its high acidity.
2. FCH₂COOH (fluoroacetic acid): Fluorine is a weak EWG due to its small size. The inductive effect is weak, and there's minimal resonance stabilization.
3. ClCH₂COOH (chloroacetic acid): Chlorine is a moderate EWG with a stronger inductive effect compared to fluorine. It can also participate in some resonance stabilization.
4. NO₂CH₂COOH (nitric acid): The nitro group (NO₂) is a strong EWG due to its ability to withdraw electrons through both inductive and resonance effects.

Ordering the Acids:

Based on the above analysis, the electron-withdrawing strengths increase in the order F < Cl < NO₂. Therefore, the increasing order of acidity is:

(1) HCOOH < FCH₂COOH < ClCH₂COOH < NO₂CH₂COOH

Ques 17.

- Steric hindrance: Bulky groups (methyl in acetophenone) block nucleophiles, decreasing reactivity. Acetophenone is least reactive due to this.
- Electron-withdrawing groups (EWGs): EWGs (nitro group in p-nitrobenzaldehyde) make the carbonyl carbon more positive, attracting nucleophiles and increasing reactivity. p-Nitrobenzaldehyde is most reactive.
- Other factors: Between benzaldehyde and p-tolualdehyde, the delocalization effect in benzaldehyde might slightly decrease its reactivity compared to p-tolualdehyde.

Therefore, the order is:

(2) Acetophenone < Benzaldehyde < p-Tolualdehyde < p-Nitrobenzaldehyde

Ques 18. In the Gatterman-Koch reaction that makes benzaldehyde, the key ingredient that attacks the benzene ring is like a positively charged fragment (electrophile) with a carbon and oxygen atom bonded together (HCO^+). Imagine a tiny, electron-hungry carbon monoxide (CO) molecule getting a positive charge and ready to react with benzene. That's the HCO^+ in action!

Ques 19. Formaldehyde and Cannizzaro Reaction:

- Formaldehyde can undergo the Cannizzaro reaction because:
 - It lacks an alpha-hydrogen atom (needed for a different reaction).
 - It undergoes self-oxidation and reduction (one molecule becomes an alcohol, another an acid).

Ques 20. Reaction Mechanism and Products:

- The reaction between tert-butyl methyl ether and HI forms methanol and tert-butyl chloride.

- This happens because:
 - The reaction likely follows an S_N1 mechanism (carbocation formation is key).
 - The reaction favors formation of a more stable carbocation (tert-butyl over methyl).

Ques 21. Why Aniline Doesn't Like Friedel-Crafts:

Aniline skips the Friedel-Crafts party because:

- It gets stuck with the aluminum chloride (used to start the reaction), making it unavailable.
- The reaction puts a positive charge on the nitrogen atom in aniline, like a tiny roadblock.
- This positive charge makes the benzene ring less reactive (like a "Do Not Enter" sign).

Ques 22. Chlorine's Two Faces in Aromatic Rings:

Chlorine acts like a selfish friend in aromatic rings:

- It pulls electrons towards itself (electron-withdrawing).
- It can also share some electrons with the ring in certain spots (ortho and para positions), making them more attractive for reactions.

This combined behavior makes chlorine a friend who directs reactions to specific spots on the ring.