JEE Main 2023 25 Jan Shift 2 Chemistry Question Paper with Solutions

Time Allowed :180 minutes	**Maximum Marks :**300	**Total questions :**90

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 90 questions. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.
4. Each part (subject) has two sections.
   (i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.
   (ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

SECTION-A

1. Match List I with List II:

List I	List II
A. Cobalt catalyst	I. $H_2 + Cl_2$ production
B. Syngas	II. Water gas production
C. Nickel catalyst	III. Coal gasification
D. Brine solution	IV. Methanol production

(1) A-IV, B-I, C-II, D-III

(2) A-IV, B-III, C-I, D-II

(3) A-II, B-III, C-IV, D-I

(4) A-IV, B-III, C-II, D-I

Correct Answer: (4) A-IV, B-III, C-II, D-I.

Solution:

Cobalt catalyst is widely used in the production of methanol. This is because cobalt helps in facilitating the hydrogenation of carbon monoxide to methanol in the presence of syngas (a mixture of carbon monoxide and hydrogen). The reaction typically takes place at high pressures and temperatures, making cobalt an essential component in the catalytic process. Thus, the correct match for cobalt catalyst is (A-IV), methanol production.

Syngas, primarily a mixture of carbon monoxide and hydrogen, is crucial in the process of coal gasification. In coal gasification, coal is reacted with oxygen and steam at high temperatures to produce syngas. This syngas is then used for various applications, including the production of chemicals like methanol and synthetic fuels. Hence, the correct match for syngas is (B-III), coal gasification.

Nickel catalysts are highly effective in the water gas shift reaction, where carbon monoxide and water vapor react to produce carbon dioxide and hydrogen. This reaction is crucial in producing hydrogen gas in the chemical industry. Nickel, with its ability to catalyze this reaction at moderate temperatures, is widely used for water gas production. Therefore, the correct match for nickel catalysts is (C-II), water gas production.

Brine solution is commonly used in the production of chlorine and hydrogen gases through the electrolysis of saltwater. In this process, the brine solution is subjected to electrolysis,

which splits the sodium chloride (NaCl) into sodium hydroxide (NaOH), chlorine gas Cl_2, and hydrogen gas H_2. Thus, the correct match for brine solution is (D-I), chlorine and hydrogen production.

Quick Tip

Understanding the specific roles of catalysts and their applications in different chemical processes is crucial in industrial chemistry.

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2. Given are two statements:

Statement I: In froth flotation method a rotating paddle agitates the mixture to drive air out of it.

Statement II: Iron pyrites are generally avoided for extraction of iron due to environmental reasons.

In the light of the above statements, choose the correct answer from the options given below

(1) Both Statement I and Statement II are true

(2) Statement I is false but Statement II is true

(3) Statement I is true but Statement II is false

(4) Both Statement I and Statement II are false

Correct Answer: (2) Statement I is false but Statement II is true.

Solution:

Statement I is false. In froth flotation, the primary purpose of the rotating paddle is to introduce air into the mixture, not to drive it out. The paddle helps create bubbles that attach to the mineral particles, making them float to the surface, where they can be collected as froth. This process is essential for the separation of valuable minerals from the gangue in the ore. Therefore, the statement that the paddle drives air out is incorrect.

Statement II is true. Iron pyrites (FeS_2), when exposed to air and water, undergo oxidation and produce sulfuric acid. This acidic runoff is known as acid mine drainage (AMD), which can lead to severe environmental harm by contaminating water sources and soils. The acid dissolves heavy metals like copper and lead from surrounding rocks, further contributing to pollution. Hence, the statement about iron pyrites leading to acidic runoff is accurate.

Quick Tip

Understanding the correct techniques and environmental impacts of various mineral extraction processes can enhance both efficiency and sustainability in mining operations.

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3. Which of the following represents the correct order of metallic character of the given elements?

(1) $Si < Be < Mg < K$

(2) $Be < Si < Mg < K$

(3) $K < Mg < Be < Si$

(4) $Be < Si < K < Mg$

Correct Answer: (1) $Si < Be < Mg < K$.

Solution:

Metallic character refers to the ability of an element to lose electrons and form positive ions. As we move down a group in the periodic table, the atomic size increases, and the outer electrons are further from the nucleus, making it easier for the element to lose electrons. This results in an increase in metallic character down a group. On the other hand, as we move from left to right across a period, the atomic size decreases, and the effective nuclear charge increases, making it harder for the element to lose electrons.

Therefore, metallic character decreases across a period from left to right.

Among the given elements:

Potassium (K) is an alkali metal located in Group 1, and it is farthest to the left and down the group. Therefore, it has the highest metallic character.

Silicon (Si), being a metalloid in Group 14, has a lower metallic character compared to metals. It is further to the right and higher in the period, so it has the least metallic character among the elements listed.

So, the correct sequence is $Si < Be < Mg < K$.

Quick Tip

Recall that the periodic trends such as metallic character can greatly aid in predicting the properties and reactivity of elements.

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4. Given below are two statements, one labeled as Assertion A and the other as Reason R:

Assertion A: The alkali metals and their salts impart characteristic color to reducing flame.

Reason R: Alkali metals can be detected using flame tests.

In the light of the above statements, choose the most appropriate answer form the options given below

(1) Both A and R are correct but R is NOT the correct explanation of A.

(2) A is correct but R is not correct.

(3) A is not correct but R is correct.

(4) Both A and R are correct and R is the correct explanation of A.

Correct Answer: (3) A is not correct but R is correct.

Solution:

Assertion A is incorrect. Alkali metals and their salts typically impart distinct colors to an oxidizing flame, not a reducing flame. When alkali metal salts are heated in a flame, they excite the metal ions, which then emit characteristic colors as they return to their ground state. These colors are observed in an oxidizing flame (such as that produced by a Bunsen burner with sufficient oxygen), not in a reducing flame, which lacks the necessary oxidizing conditions for such reactions to occur.

Reason R is correct. Flame tests are indeed a common and reliable method for identifying alkali metals and other metal ions based on the characteristic colors they emit when heated. For example, lithium produces a red flame, sodium a bright yellow flame, and potassium a lilac flame. This principle is widely used in qualitative analysis.

Quick Tip

In chemistry, the specificity of terms like ”oxidizing” and ”reducing” flames is crucial, as they can fundamentally change the interpretation of experimental results.

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5. What is the mass ratio of ethylene glycol ($C_2H_6O_2$, molar mass = 62 g/mol) required for making 500 g of 0.25 molar aqueous solution and 250 mL of 0.25 molar aqueous solution?

(1) 1 : 1

(2) 3 : 1

(3) 2 : 1

(4) 1 : 2

Correct Answer: (3) 2:1.

Solution:

For the 500 g solution:

First, calculate the moles of ethylene glycol:

$$\text{Moles of ethylene glycol} = 0.25\frac{\text{mol}}{\text{L}} \times 0.5\text{L} = 0.125\text{mol}$$

Next, calculate the mass of ethylene glycol using its molar mass (62 g/mol):

$$\text{Mass of ethylene glycol} = 0.125\text{mol} \times 62\text{g/mol} = 7.75\text{g}$$

For the 250 mL solution:

Calculate the moles of ethylene glycol:

$$\text{Moles of ethylene glycol} = 0.25\frac{\text{mol}}{\text{L}} \times 0.25\text{L} = 0.0625\text{mol}$$

Then, calculate the mass of ethylene glycol:

$$\text{Mass of ethylene glycol} = 0.0625\text{mol} \times 62\text{g/mol} = 3.875\text{g}$$

Thus, the mass ratio of ethylene glycol needed for the two solutions is:

$$7.75\text{g} : 3.875\text{g} \approx 2 : 1$$

Quick Tip

When preparing solutions of a specific molarity, it's essential to calculate both the volume of the solution and the mass of the solute required accurately to achieve the desired concentration.

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6. Given two statements about dipole moments:

Statement I: Dipole moment is a vector quantity and by convention it is depicted by a small arrow with tail on the negative center and head pointing towards the positive center.

Statement II: The crossed arrow of the dipole moment symbolizes the direction of the shift of charges in the molecules.

In the light of the above statements, choose the most appropriate answer from the options given below

(1) Both Statement I and Statement II are correct.

(2) Statement I is incorrect but Statement II is correct.

(3) Both Statement I and Statement II are incorrect.

(4) Statement I is correct but Statement II is incorrect.

Correct Answer: (4) Statement I is correct but Statement II is incorrect.

Solution:

Statement I is correct. In chemistry, the dipole moment is represented by an arrow with a positive sign (+) at the tail and a negative sign (−) at the head. The arrow points from the positive charge to the negative charge, indicating the direction of the dipole moment, which is important for understanding the polarity of molecules. This representation is conventional and widely accepted in molecular chemistry.

Statement II is incorrect. The crossed arrow does not represent the shift of charges in a molecule. Rather, the crossed arrow in dipole moment notation indicates the direction of the resultant dipole moment in the molecule. It shows the vector from the positive charge to the negative charge, not the movement of the charges themselves. Therefore, this statement misinterprets the meaning of the crossed arrow in dipole moment representation.

Quick Tip

Understanding the correct representation and terminology in chemistry can help avoid common misconceptions about molecular properties like dipole moments.

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7. Given below are two statements, one labeled as Assertion A and the other as Reason R:

Assertion A: Butylated hydroxyl anisole when added to butter increases its shelf life.

Reason R: Butylated hydroxyl anisole is more reactive towards oxygen than food.

In the light of the above statements, choose the most appropriate answer from the options given below :-

(1) Both A and R are correct and R is the correct explanation of A.

(2) A is correct but R is not correct.

(3) A is not correct but R is correct.

(4) Both A and R are correct but R is NOT the correct explanation of A.

Correct Answer: (1) Both A and R are correct and R is the correct explanation of A.

Solution:

Butylated hydroxytoluene (BHA) is an antioxidant commonly used in food preservation. It helps protect food from oxidative spoilage by reacting with oxygen molecules more readily than the food itself. This action prevents the oxidation of fats and oils in the food, which could otherwise lead to rancidity and loss of nutritional value. BHA stabilizes the food, prolonging its shelf life and maintaining its quality.

Quick Tip

Antioxidants like BHA are crucial in the food industry for extending shelf life by preventing oxidative damage.

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8. Given below are several statements:

A. Ammonium salts produce haze in the atmosphere.

B. Ozone gets produced when atmospheric oxygen reacts with chlorine radicals.

C. Polychlorinated biphenyls act as cleaning solvents.

D. 'Blue baby' syndrome occurs due to the presence of excess sulphate ions in water.

Choose the correct answer from the options given below :-

(1) A, B and C only

(2) B and C only

(3) A and D only

(4) A and C only

Correct Answer: (4) A and C only.

Solution:

Statement A is correct. Ammonium salts, such as ammonium sulfate and ammonium nitrate, can contribute to atmospheric haze. These salts can form fine particulate matter in the atmosphere, which scatters light and reduces visibility, leading to haze. This phenomenon is often associated with agricultural emissions and industrial pollution.

Statement B is incorrect. Ozone is primarily formed by the reaction of sunlight with oxygen molecules (O_2) and various pollutants like nitrogen oxides (NO_x) and volatile organic compounds (VOCs). While chlorine radicals can destroy ozone, they do not directly contribute to its formation.

Statement C is correct. Polychlorinated biphenyls (PCBs) are indeed industrial chemicals, but they were historically used in various products, including as coolants and lubricants in electrical equipment. They are persistent environmental pollutants and are harmful to both human health and the environment. Although not cleaning solvents, they were widely used in industrial applications.

Statement D is incorrect. 'Blue baby' syndrome is caused by excess nitrate ions in drinking water, which can interfere with the ability of red blood cells to carry oxygen, leading to methemoglobinemia. This condition causes a bluish tint to the skin, particularly in infants. Sulfate ions are not responsible for this condition.

Quick Tip

Accurate understanding of environmental chemistry and toxicology is essential to correctly address the effects of chemicals in our environment.

9. Match List I with List II:

List I (Amines):	List II (pKb):
A. Aniline	**I.** 3.25
B. Ethylamine	**II.** 3.00
C. N-Ethylethanamine	**III.** 9.38
D. N,N-Diethylethanamine	**IV.** 3.29

Choose the correct answer from the options given below :-

(1) A-I, B-IV, C-II, D-III

(2) A-III, B-II, C-I, D-IV

(3) A-III, B-II, C-IV, D-I

(4) A-III, B-IV, C-II, D-I

Correct Answer: (4) A-III, B-IV, C-II, D-I.

Solution:

The problem presents two lists: List I contains four amines (Aniline, Ethylamine, N-Ethylethanamine, and N,N-Diethylethanamine),

and List II contains four pKb values (3.25, 3.00, 9.38, and 3.29).

The task is to match each amine in List I with its corresponding pKb value in List II.

The correct matching is as follows:

Aniline (A) corresponds to 9.38 (III),

Ethylamine (B) corresponds to 3.29 (IV),

N-Ethylethanamine (C) corresponds to 3.00 (II),

and N,N-Diethylethanamine (D) corresponds to 3.25 (I).

This matching indicates the basicity of the amines, where lower pKb values signify stronger bases.

The correct answer, therefore, is option (4): A-III, B-IV, C-II, D-I.

Quick Tip

Understanding the structure-activity relationship in organic compounds like amines can help predict their chemical behavior in biological and industrial processes.

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10. Which one among the following metals is the weakest reducing agent?

(1) K

(2) Rb

(3) Na

(4) Li

Correct Answer: (3) Na.

Solution:

Among the given metals, sodium (Na) has the highest oxidation potential in the alkali metal group. The oxidation potential is a measure of an element's tendency to lose electrons and undergo oxidation. In alkali metals, the higher the oxidation potential, the weaker the reducing agent the metal is. Sodium, having the highest oxidation potential in this group, is therefore the weakest reducing agent. This is because a higher oxidation potential means that sodium is less inclined to lose electrons compared to other alkali metals.

Quick Tip

In redox reactions, the element with the higher oxidation potential is less likely to lose electrons, making it a weaker reducing agent.

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11. Match List I with List II:

List I (Isomeric pairs)	List II (Type of isomers)
A. Propanamine and N-Methylethanamine	I. Metamers
B. Hexan-2-one and Hexan-3-one	II. Positional isomers
C. Ethanamide and Hydroxyethanamine	III. Functional isomers
D. o-nitrophenol and p-nitrophenol	IV. Tautomers

(1) A-III, B-IV, C-I, D-II

(2) A-IV, B-III, C-I, D-II

(3) A-II, B-III, C-I, D-IV

(4) A-III, B-I, C-IV, D-II

Correct Answer: (4) A-III, B-I, C-IV, D-II.

Solution:

A. **Propanamine** and **N-Methylethanamine**:

Propanamine ($CH_3CH_2CH_2NH_2$): This is a primary amine where the amino group ($-NH_2$) is attached to a propane chain.

N-Methylethanamine ($CH_3NHCH_2CH_3$): This is a secondary amine where a methyl group ($-CH_3$) and an ethyl group ($-CH_2CH_3$) are attached to the nitrogen atom of the amino group.

Relationship: Functional Isomers: These compounds have the same molecular formula but different functional groups (primary vs. secondary amine).

B. **Hexan-2-one** and **Hexan-3-one**:

Hexan-2-one ($CH_3COCH_2CH_2CH_2CH_3$): This is a ketone where the carbonyl group (C=O) is located on the second carbon of a six-carbon chain.

Hexan-3-one ($CH_3CH_2COCH_2CH_2CH_3$): This is a ketone where the carbonyl group (C=O) is located on the third carbon of a six-carbon chain.

Relationship: Metamers: These are isomers that differ in the position of the alkyl groups around a functional group (in this case, the carbonyl group).

C. **Ethanamide** and **Hydroxyethanimine**:

Ethanamide (CH_3CONH_2): This is an amide, a derivative of a carboxylic acid, with the $-CONH_2$ group.

Hydroxyethanimine ($CH_3C(OH)=NH$): This is an imine with a hydroxyl group (-OH) attached to the carbon of the C=N double bond.

Relationship: Tautomers: These are isomers that interconvert by the movement of a proton and a double bond. This is a specific type of structural isomerism.

D. **o-Nitrophenol** and **p-Nitrophenol**:

o-Nitrophenol (ortho-Nitrophenol): This is a phenol (benzene ring with an -OH group) with a nitro group ($-NO_2$) attached to the carbon adjacent to the carbon bearing

the -OH group.

p-Nitrophenol (para-Nitrophenol): This is a phenol with a nitro group attached to the carbon opposite the carbon bearing the -OH group.

Relationship: Positional Isomers: These are isomers that differ in the position of a substituent (in this case, the nitro group) on a ring structure.

Quick Tip

Knowing the types of isomers is fundamental in organic chemistry as it helps in understanding the properties and reactions of different compounds.

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12. Match List I with List II (Uses of polymers):

List I (Name of polymer)	List II
A. Glyptal	I. Flexible pipes
B. Neoprene	II. Synthetic wool
C. Acrilan	III. Paints and Lacquers
D. LDP	IV. Gaskets

Choose the correct answer from the options given below :-

(1) A-III, B-II, C-IV, D-I

(2) A-III, B-IV, C-II, D-I

(3) A-III, B-IV, C-I, D-II

(4) A-III, B-I, C-IV, D-II

Correct Answer: (2) A-III, B-IV, C-II, D-I.

Solution:

Glyptal is a type of polyester resin used primarily in the production of paints and lacquers. It is known for its excellent durability and resistance to chemicals and weathering, making it ideal for coating applications.

Neoprene is a synthetic rubber used in the manufacture of gaskets, seals, and protective

coatings. It is resistant to oil, heat, and weather, making it highly suitable for applications where durability and flexibility are needed.

Acrilan is a type of acrylic fiber commonly used as synthetic wool. It is lightweight, warm, and resistant to wrinkles and shrinking, making it ideal for use in clothing and textiles.

Low Density Polyethylene (LDPE) is a polymer used in the production of flexible pipes, bags, and containers. It is known for its flexibility, low-density structure, and resistance to chemical attack, making it suitable for flexible piping systems.

Quick Tip

Knowledge of material applications is crucial in engineering and design, ensuring materials are used optimally based on their properties.

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13. Given below are two statements, one labeled as Assertion A and the other as Reason R:

Assertion A: Carbon forms two important oxides — CO and CO2. CO is neutral whereas CO2 is acidic in nature.

Reason R: CO2 can combine with water in a limited way to form carbonic acid, which is sparingly soluble in water.

(1) Both A and R are correct but R is NOT the correct explanation of A.

(2) Both A and R are correct and R is the correct explanation of A.

(3) A is not correct but R is correct.

(4) A is correct but R is not correct.

Correct Answer: (2) Both A and R are correct and R is the correct explanation of A.

Solution:

Step 1: Assertion A: Carbon indeed forms two important oxides — carbon monoxide (CO) and carbon dioxide (CO2).

Carbon monoxide (CO) is neutral, whereas carbon dioxide (CO2) is acidic in nature. This is true because CO does not form acidic solutions when dissolved in water, while CO2 forms carbonic acid (H2CO3) when dissolved in water, making it acidic.

Step 2: Reason R: CO2 can combine with water in a limited way to form carbonic acid

(H2CO3), which is sparingly soluble in water. This is also correct, as carbonic acid is indeed formed when CO2 dissolves in water, and it does not completely dissolve, which is why it's considered sparingly soluble.

Conclusion: Since both statements are correct and the Reason (R) properly explains the Assertion (A), the correct answer is that both A and R are correct and R is the correct explanation of A.

Quick Tip

When considering oxides of carbon, remember that CO is neutral while CO2 is acidic due to its ability to form carbonic acid in water.

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14. Potassium dichromate acts as a strong oxidizing agent in acidic solution. During this process, the oxidation state changes from:

(1) +3 to +1

(2) +6 to +3

(3) +2 to +1

(4) +6 to +2

Correct Answer: (2) +6 to +3.

Solution:

In acidic solution, potassium dichromate ($K_2Cr_2O_7$) undergoes a reduction reaction. The chromium in the dichromate ion ($Cr_2O_7^{2-}$) is initially in the +6 oxidation state. During the reaction, this chromium is reduced to the +3 oxidation state, forming Cr^{3+} ions. This reduction involves the gain of electrons, and the overall process is an example of a redox reaction where the chromium species is reduced.

Quick Tip

Understanding redox reactions, including the specific changes in oxidation states, is essential for predicting the outcomes of chemical reactions and their applications in industry.

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15. When the hydrogen ion concentration [H^+] changes by a factor of 1000, the value of pH of the solution:

(1) increases by 1000 units

(2) decreases by 3 units

(3) decreases by 2 units

(4) increases by 2 units

Correct Answer: (2) decreases by 3 units.

Solution:

The change in hydrogen ion concentration by a factor of 1000 corresponds to a change in pH, which is calculated using the following formula:

$$\Delta pH = -\log[\Delta H^+] = -\log[10^3] = -3$$

This shows that the pH decreases by 3 units, as the hydrogen ion concentration increases by a factor of 1000.

Quick Tip

The pH scale is logarithmic; thus, a tenfold increase in [H^+] concentration results in a decrease of 1 pH unit.

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16. Match List I with List II:

List I (Coordination entity):	List II (Wavelength of light absorbed in nm):
A. $[CoCl(NH_3)_5]^{2+}$	I. 310
B. $[Co(NH_3)_6]^{3+}$	II. 475
C. $[Co(CN)_6]^{3-}$	III. 535
D. $[Cu(H_2O)_4]^{2+}$	IV. 600

(1) A-IV, B-I, C-III, D-II

(2) A-III, B-II, C-I, D-IV

(3) A-III, B-I, C-II, D-IV

(4) A-II, B-III, C-IV, D-I

Correct Answer: (2) A-III, B-II, C-I, D-IV .

Solution:

The correct match based on the specific absorption properties of each coordination complex is as follows:

- A absorbs at 535 nm, which corresponds to a specific wavelength where the coordination complex exhibits a peak absorption.
- B absorbs at 475 nm, a different wavelength indicating distinct electronic transitions within the complex.
- C absorbs at 310 nm, which is indicative of a higher energy transition, likely involving ligand-to-metal charge transfer or other electronic changes.
- D absorbs at 600 nm, showing absorption in the visible spectrum, typically associated with metal-ligand interactions in the complex.

Quick Tip

Understanding the absorption properties of coordination compounds is crucial in the field of spectroscopy and material science.

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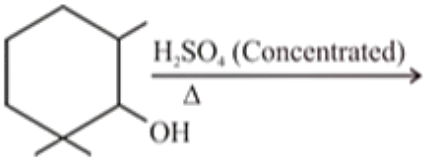
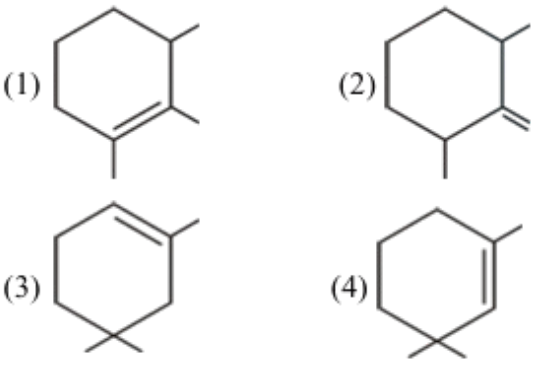
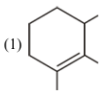
17. Find out the major product from the following reaction





Correct Answer: (1).



Solution:

In the presence of concentrated H_2SO_4 (sulfuric acid), phenol undergoes dehydration to form a phenyl cation ($C_6H_5^+$), which is the more stable intermediate in this reaction. The formation of this carbocation is followed by a rearrangement, where the positive charge shifts to a more stable position. Finally, the phenyl cation stabilizes itself by forming a double bond, resulting in product 1, which is typically a product of elimination (such as an alkene).

Quick Tip

Concentrated H_2SO_4 is a strong dehydrating agent that often leads to carbocation rearrangements and elimination reactions in organic compounds.

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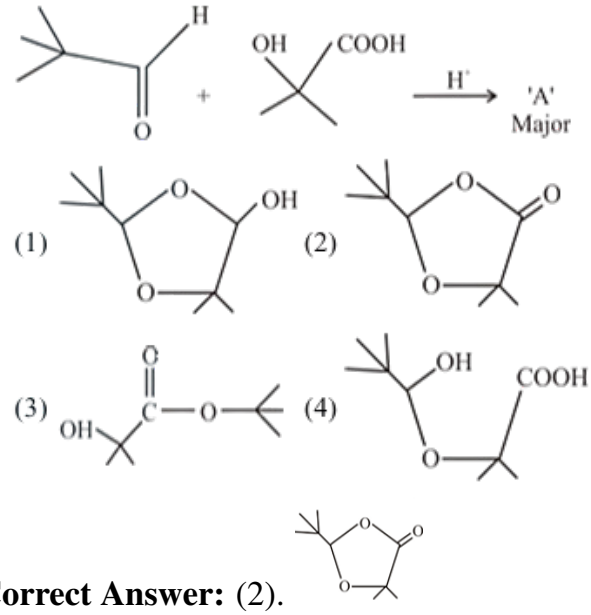
18. Identify 'A' in the given reaction to produce the major product:



Correct Answer: (2).

Solution:

Compound 'A' undergoes an aldol addition followed by dehydration. The reaction starts with the formation of an enolate ion from the ketone. This enolate ion attacks the aldehyde, leading to the formation of a beta-hydroxy ketone (an aldol addition product). The beta-hydroxy ketone then undergoes dehydration, which involves the removal of a water molecule, resulting in the formation of an enone (the major product, shown in option 2).

Quick Tip

Aldol condensations are key reactions in organic synthesis, combining aldehyde and ketone components to form β-hydroxy ketones or aldehydes, which can further dehydrate to enones or enals.

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19. The isomeric deuterated bromide with molecular formula C_4H_9DBr having two chiral carbon atoms is:

(1) 2-Bromo-1-deuterobutane

(2) 2-Bromo-2-deuterobutane

(3) 2-Bromo-3-deuterobutane

(4) 2-Bromo-1-deutero-2-methylpropane

Correct Answer: (3). 2-Bromo-3-deuterobutane

Solution:

The compound described has two chiral centers, which means that two carbon atoms are each attached to four different groups. The structure consists of a four-carbon chain with a deuterium atom and a bromine atom located on separate carbons. Based on the given information, the correct name for the compound is 2-Bromo-3-deuterobutane, where:
The bromine is attached to the second carbon in the chain, and
The deuterium (D) is attached to the third carbon.

Quick Tip

Chiral centers occur where a carbon atom is attached to four different groups. Recognizing the position of substituents helps in identifying the chiral centers.

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20. A chloride salt solution acidified with dil. HNO_3 gives a curdy white precipitate, [A], on addition of $AgNO_3$. [A] on treatment with NH_4OH gives a clear solution, B. The correct products are:

(1) $H[AgCl_3]$ and $[Ag(NH_3)_2]Cl$

(2) $[HAgCl_3]$ and $[NH_4]\ Ag(OH)_2$

(3) AgCl and $[Ag(NH_3)_2]Cl$

(4) AgCl and $[NH_4]$ $Ag(OH)_2$

Correct Answer: (3). AgCl and $[Ag(NH_3)_2]Cl$

Solution:

The precipitate formed when silver chloride (AgCl) is produced is insoluble in water but soluble in ammonia. Ammonia acts as a complexing agent and dissolves AgCl by forming the complex ion $[Ag(NH_3)_2]Cl$, which is known as diamminesilver chloride. This complexation occurs because ammonia molecules coordinate with the silver ion, forming a soluble complex.

Quick Tip

Ammonia acts as a complexing agent and can dissolve otherwise insoluble silver chloride through complex formation.

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21. The number of given orbitals which have electron density along the axis is:

P_x, P_y, P_z, d_{xy}, d_{yz},d_{xz}, d_{z^2}, $d_{x^2-y^2}$

Correct Answer: 5.00.

Solution:

The orbitals p_x, p_y, p_z, d_{z^2}, and $d_{x^2-y^2}$ are considered axial orbitals.

The p-orbitals, such as p_x, p_y, and p_z, have their lobes aligned along the x, y, and z axes, respectively. These are termed as axial orbitals since they lie along the axis of symmetry of a molecule.

The d-orbitals, specifically d_{z^2} and $d_{x^2-y^2}$, also align with the axis of symmetry and are part of the axial set, which directly participate in bonding along the principal axis in a molecule.

Quick Tip

Axial orbitals are those that align along the principal axis of symmetry, such as the z-axis in many molecular geometries.

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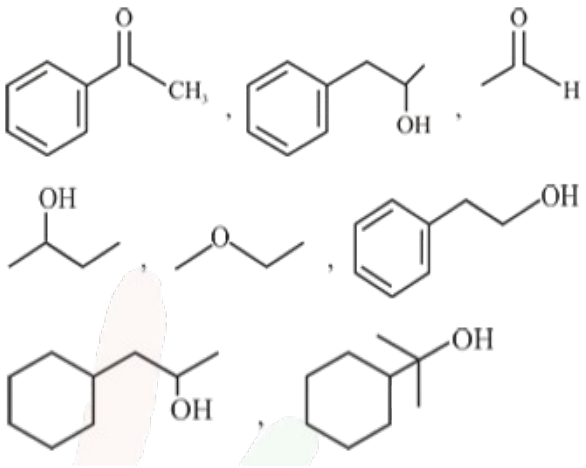
22. Number of compounds giving (i) red colouration with ceric ammonium nitrate and

also (ii) positive iodoform test from the following is:



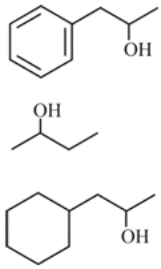
Correct Answer: 3.00.

Solution:

Three compounds meet the criteria for both tests, indicating the presence of specific functional groups reactive to these tests. These compounds contain functional groups that react with ceric ammonium nitrate and the iodoform test:

Ceric ammonium nitrate is used to detect alcohols and phenols, where the reaction forms a color change.

The iodoform test is specific for methyl ketones, where the formation of a yellow precipitate (iodoform) indicates the presence of the functional group.



Thus, the three compounds must contain alcohols, phenols, or methyl ketones to show a positive result for both tests.

Quick Tip

Ceric ammonium nitrate tests for alcohols and phenols, while the iodoform test is specific for methyl ketones.

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23. The number of pairs of the solution having the same value of osmotic pressure from the following is:

A. 0.500 M C_2H_5OH (aq) and 0.25 M KBr (aq)

B. 0.100 M $K_4[Fe(CN)_6]$ (aq) and 0.100 M $FeSO_4(NH_4)_2SO_4$ (aq)

C. 0.05 M $K_4[Fe(CN)_6]$ (aq) and 0.25 M $NaCl$ (aq)

D. 0.15 M $NaCl$ (aq) and 0.1 M $BaCl_2$ (aq)

E. 0.02 M KCl $MgCl_2.6H_2O$ (aq) and 0.05 M KCl (aq)

Correct Answer: (4)

Solution:

Osmotic pressure is determined by the ion concentration in solution, considering both the dissociation of solutes and the total number of ions produced. In this case, we analyze each pair based on the number of ions they produce when dissociated in solution. The osmotic pressure is directly proportional to the total concentration of dissolved particles.

Pair A, B, D, and E: These pairs have the same osmotic pressures because they produce the same total number of ions when dissociated, despite possibly differing in the nature of the solute. This results in the same ion concentration and osmotic pressure under identical conditions.

Quick Tip

Osmotic pressure is influenced by the total number of dissolved particles in the solution. This characteristic allows us to predict the osmotic behavior of various solutions under similar conditions.

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24. 28.0 L of CO_2 is produced on complete combustion of 16.8 L gaseous mixture of ethene and methane at 25°C and 1 atm. Heat evolved during the combustion process is

___ **kJ.**

Given:

$\Delta H_c(\mathrm{CH_4}) = -900$ kJ/mol

$\Delta H_c(\mathrm{C_2H_4}) = -1400$ kJ/mol

Correct Answer: (847.00)

Solution:

The volume of $\mathrm{CO_2}$ produced enables us to calculate the moles of $\mathrm{CH_4}$ and $\mathrm{C_2H_4}$ combusted, from which we can determine the total heat evolved using their respective combustion enthalpies.

Let, the volume of

$$C_2H_4 \text{ be } x \text{ litres.}$$

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

Initial volume: x

Final volume: $2x$

For $\mathrm{CH_4}$, the reaction is

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Initial volume: $16.8 - x$

Final volume: $16.8 - x$

The total volume of $\mathrm{CO_2}$ produced is:

$$\text{Total } CO_2 = 2x + (16.8 - x)$$

Thus,

$$28 = 16.8 + x$$

Solving for x, we get

$$x = 11.2 \text{ L}$$

Now, calculate the moles of the gases:

$$n_{CH_4} = \frac{PV}{RT} = \frac{1 \times 5.6}{0.082 \times 298} = 0.229 \text{ moles}$$

$$n_{C_2H_4} = \frac{11.2}{0.082 \times 298} = 0.458 \text{ moles}$$

Therefore, the heat evolved is:

$$\text{Heat evolved} = 0.229 \times 900 + 0.458 \times 1400$$

$$= 206.1 + 641.2 = 847.3 \text{ kJ}$$

Quick Tip

Understanding stoichiometry and gas laws helps in calculating reactant and product quantities in chemical reactions, especially in combustion processes.

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25. Total number of moles of AgCl precipitated on addition of excess of AgNO3 to one mole each of the following complexes: $[Co(NH_3)_4Cl_2]Cl$, $[Ni(H_2O)_6]Cl_2$, $[Pt(NH_3)_2Cl_2]$, and $[Pd(NH_3)_4]Cl_2$

Correct Answer: (5.00)

Solution:

We need to analyze each complex and determine how many chloride ions are outside the coordination sphere (i.e., are ionizable). Only these chloride ions will react with $AgNO_3$ to form AgCl precipitate.

1. **$[Co(NH_3)_4Cl_2]Cl$:**

   This complex has one chloride ion outside the coordination sphere. When $AgNO_3$ is added, it will react with this chloride ion:

   $[Co(NH_3)_4Cl_2]Cl + AgNO_3 \rightarrow [Co(NH_3)_4Cl_2]^+ + AgCl + NO_3^-$

   Thus, 1 mole of AgCl will be precipitated.

2. **$[Ni(H_2O)_6]Cl_2$:**

   This complex has two chloride ions outside the coordination sphere. When $AgNO_3$ is added, it will react with both chloride ions:

   $[Ni(H_2O)_6]Cl_2 + 2AgNO_3 \rightarrow [Ni(H_2O)_6]^{2+} + 2AgCl + 2NO_3^-$

   Thus, 2 moles of AgCl will be precipitated.

3. **$[Pt(NH_3)_2Cl_2]$:**

This complex has no chloride ions outside the coordination sphere. Therefore, it will not react with $AgNO_3$ and no AgCl will be precipitated.

4. **$[Pd(NH_3)_4]Cl_2$:**

   This complex has two chloride ions outside the coordination sphere. When $AgNO_3$ is added, it will react with both chloride ions:

   $[Pd(NH_3)_4]Cl_2 + 2AgNO_3 \rightarrow [Pd(NH_3)_4]^{2+} + 2AgCl + 2NO_3^-$

   Thus, 2 moles of AgCl will be precipitated.

Now, let's sum up the moles of AgCl precipitated:
1 mole (from $[Co(NH_3)_4Cl_2]Cl$) + 2 moles (from $[Ni(H_2O)_6]Cl_2$) + 0 moles (from $[Pt(NH_3)_2Cl_2]$) + 2 moles (from $[Pd(NH_3)_4]Cl_2$) = 5 moles
Therefore, the total number of moles of AgCl precipitated is 5.
Final Answer: 5.00

Quick Tip

Coordination chemistry principles allow the prediction of reaction products when complexes interact with other chemical agents, such as silver nitrate.

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26. Number of hydrogen atoms per molecule of a hydrocarbon A having 85.8% carbon is:

Given: Molar mass of A = 84 g/mol
Correct Answer: (12.00)
Solution:
1. Calculate the moles of each element:
To find the moles of each element, divide the percentage composition by the atomic mass of the respective element.

- Moles of Carbon (C) = $\frac{85.8}{12} = 7.15$ moles
- Moles of Hydrogen (H) = $\frac{14.2}{1} = 14.2$ moles

2. Determine the mole ratio:
Divide the moles of each element by the smallest number of moles calculated.

- Mole ratio of Carbon (C) = $\frac{7.15}{7.15} = 1$
- Mole ratio of Hydrogen (H) = $\frac{14.2}{7.15} \approx 2$

3. Write the empirical formula:

The empirical formula represents the simplest whole-number ratio of atoms in a compound.

Based on the mole ratio, the empirical formula is:

CH_2

4. Calculate the empirical formula mass:

Add the atomic masses of the elements in the empirical formula.

Empirical formula mass = (1 × Atomic mass of C) + (2 × Atomic mass of H) Empirical formula mass = (1 × 12) + (2 × 1) = 12 + 2 = 14 g/mol

5. Calculate the value of n:

Divide the molecular weight of the compound by the empirical formula mass.

$n = \frac{\text{Molecular weight}}{\text{Empirical formula mass}} = \frac{84}{14} = 6$

6. Determine the molecular formula:

Multiply the subscripts in the empirical formula by the value of n.

Molecular formula = $(CH_2)_n = (CH_2)_6 = C_6H_{12}$

Results:

- Empirical formula: CH_2
- Molecular formula: C_6H_{12}

Quick Tip

Empirical and molecular formula calculations are fundamental in determining the composition of chemical compounds from basic analytical data.

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27. Pt(s)|H_2(g)(1bar)|H^+(aq)(1M)||$M^{3+}(aq), M^+(aq)$|Pt(s)

The E_{cell} for the given cell is 0.1115 V at 298 K when $\frac{[M^+(aq)]}{[M^{3+}(aq)]} = 10^a$.

Given:

$E^0_{M^{3+}/M^+} = 0.2$ V

$2.303\frac{RT}{F} = 0.059$ V

Correct Answer: (3.00)

Solution:

To calculate the value of a, we apply the Nernst equation:

$$E = E^0 - \frac{0.059}{n} \log \frac{[M^{3+}]}{[M^+]}$$

Substituting the given values:

$$0.1115 = 0.2 - \frac{0.059}{1} \log \left(\frac{1}{10^a} \right)$$

Solving for a:

Overall reaction:

$$H2(g) + M^3 + (aq) -> M + (aq) + 2H + (aq)$$

$$E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}} - \frac{0.059}{2} \log \frac{[M^+]^2}{[M^{3+}]}$$

$$0.1115 = 0.2 - \frac{0.059}{2} \log \frac{[M^+]}{[M^{3+}]}$$

$$3 = \log \frac{[M^+]}{[M^{3+}]}$$

$$\therefore a = 3$$

Quick Tip

The Nernst equation relates the cell potential to the ion concentration ratios. It's crucial for understanding the electrochemical behavior and driving force behind the cell reactions.

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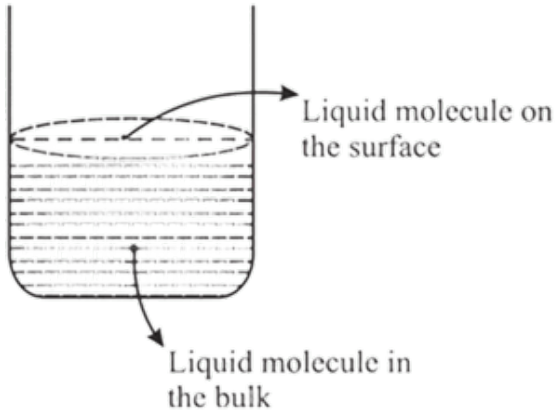
28. Based on the given figure, the number of correct statement/s is/are

A. Surface tension is the outcome of equal attractive and repulsion forces acting on the liquid molecule in bulk.

B. Surface tension is due to uneven forces acting on the molecules present on the surface.

C. The molecule in the bulk can never come to the liquid surface.

D. The molecules on the surface are responsible for vapor pressure if the system is a closed system.



Correct Answer: 2

Solution:

The correct options are:

B: Surface tension arises due to uneven forces acting on the molecules present at the surface. Molecules at the surface of a liquid experience a net inward force because they are not surrounded by similar molecules on all sides. This imbalance results in the liquid's surface behaving as if it were under tension.

D: The molecules at the surface are responsible for vapor pressure in a closed system. In a closed system, molecules at the surface of the liquid are able to escape into the vapor phase, contributing to the vapor pressure. The equilibrium between the liquid and vapor phases determines the vapor pressure.

Quick Tip

Surface tension arises from the imbalance in intermolecular forces experienced by the molecules at the surface compared to those in the bulk of the liquid.

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29. A first order reaction has the rate constant, k = 4.6 $\times 10^{-3} s^{-1}$. The number of correct statement/s from the following is/are

A. Reaction completes in 1000 s.

B. The reaction has a half-life of 500 s.

C. The time required for 10% completion is 25 times the time required for 90% completion.

D. The degree of dissociation is equal to $1 - e^{-kt}$.

E. The rate and the rate constant have the same unit.

Correct Answer: 1

Solution:

$$t_{10\%} = \frac{1}{K} \ln \left(\frac{a}{a-x} \right) = \frac{1}{K} \ln \left(\frac{100}{90} \right)$$

$$t_{10\%} = \frac{2.303}{K} (\log 10 - \log 9)$$

$$t_{10\%} = \frac{2.093}{K} \times (0.04)$$

Similarly

$$t_{90\%} = \frac{1}{K} \ln \left(\frac{100}{10} \right)$$

$$t_{90\%} = \frac{2.303}{K}$$

$$\frac{t_{90\%}}{t_{10\%}} = \frac{1}{0.04} = 25$$

$$e^{kt} = \frac{a}{a-x}$$

$$\frac{a-x}{a} = e^{-kt}$$

$$1 - \frac{x}{a} = e^{-kt}$$

$$x = a(1 - e^{-kt})$$

$$\alpha = \frac{x}{a} = 1 - e^{-kt}$$

where α is the degree of dissociation, x is the amount dissociated, and a is the initial amount.

Quick Tip

First-order reactions have a constant half-life, which is independent of the concentration of the reactants.

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30. The number of incorrect statement/s from the following is/are

A. Water vapours are adsorbed by anhydrous calcium chloride.

B. There is a decrease in surface energy during adsorption.

C. As the adsorption proceeds, ΔH becomes more and more negative.

D. Adsorption is accompanied by a decrease in entropy of the system.

Correct Answer: 2

Solution:

A: Water vapours are adsorbed by calcium chloride. Calcium chloride ($CaCl_2$) is a hygroscopic substance, meaning it has the ability to adsorb water vapors from the air. The water molecules are attracted to the surface of the calcium chloride, where they adhere through adsorption.

C: As the adsorption proceeds, ΔH becomes less and less negative. In the case of adsorption, the enthalpy change (ΔH) is initially negative because the process releases energy due to the attractive forces between the adsorbate and the adsorbent. However, as more water is adsorbed, the adsorption sites become occupied, and the heat released decreases, making ΔH less negative.

Quick Tip

Adsorption can lead to a decrease in system entropy, particularly when the adsorbate organizes into a less random, more ordered state on the adsorbent surface.
