Chemical Reactions of Alcohols Phenols and Ethers JEE Main PYQ - 1

Total Time: 1 Hour **Total Marks:** 100

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Chemical Reactions of Alcohols Phenols and Ethers

1. **Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).** **(+4, -1)**
Assertion (A): Synthesis of ethyl phenyl ether may be achieved by Williamson synthesis.
Reason (R): Reaction of bromobenzene with sodium ethoxide yields ethyl phenyl ether.
In the light of the above statements, choose the most appropriate answer from the options given below :

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

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

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

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

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2. The number of species from the following which have square pyramidal structure is___ **(+4, -1)**
$PF_5, BrF_4^- 4-, IF_5$; $BrF_5, XeOF_4, ICl_4^-$

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3. A(g) → 2B(g) + C(g) is a first order reaction. The initial pressure of the system was found to be 800 mm Hg which increased to 1600 mm Hg after 10 min. The total pressure of the system after 30 min will be ___mm Hg. (Nearest integer) **(+4, -1)**

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4. At 298 K, the standard reduction potential for Cu^{2+}/Cu electrode is 0.34 V. **(+4, -1)**
Given: Ksp Cu(OH)2 = 1×10^{-20}
Take $\frac{2.303RT}{F}$ = 0.059V
The reduction potential at pH = 14 for the above couple is (-)x x 10^{-2} V.
The value of x is_____.

---

5. Match the List I with List II **(+4, -1)**

	List I		List II
(A)	Weak intermolecular forces of attraction	I	Hexamethylenedia mine + adipic acid
(B)	Hydrogen bonding	II	$AlEt_3 + TiCl_4$
(C)	Heavily branched polymer	III	2-chloro-1, 3-butadiene
(D)	High density polymer	III	phenol+ formaldehyde

choose the correct answer from the options given below:

a. A-II, B-III, C-I, D-IV

b. A-IV, B-I, C-III, D-II

c. A-III, B-I, C-IV, D-I

d. A-IV, B-II, C-III, D-I

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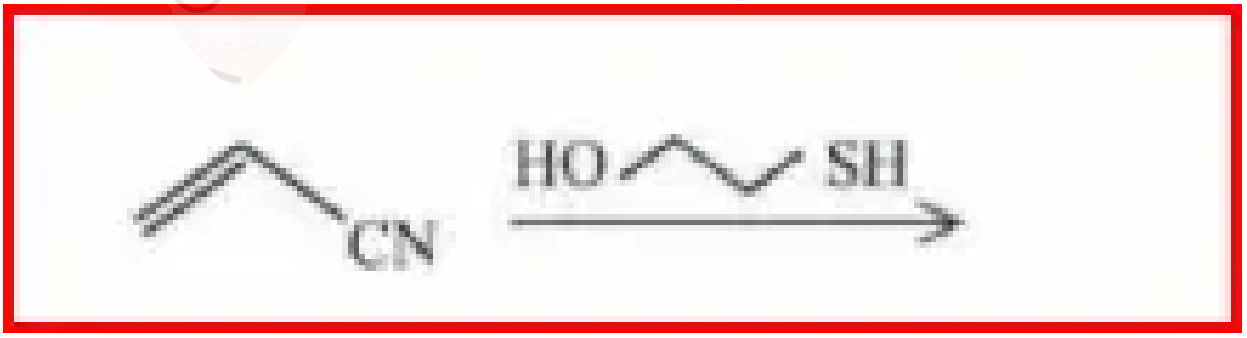
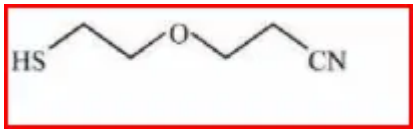
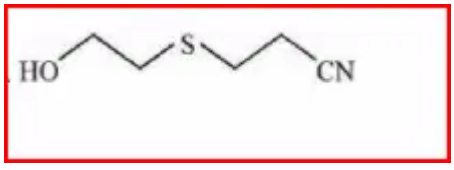
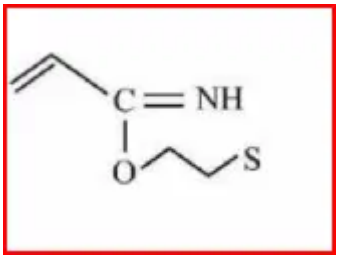
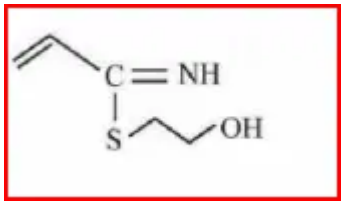
6. The major products for the following reaction is **(+4, -1)**



a. 

b. 

c. 

d. 

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7. Match the List I with List II **(+4, -1)**

1- Bromopropane is reacted with regents in List I to give products in List II

	List I-Reagent		List II-Product
(A)	KOH(alc)	I	Nitrile
(B)	KCL(alc)	II	Ester
(C)	$AgNo_2$	III	Alkene
(D)	H_3CC00A_g	III	Nitroalkane

Choose the correct answer from the options given below:

a. A-IV, B-III, C-II, D-I

b. A-III, B-I, C-IV, D-II

c. A-I, B-III, C-IV, D-II

d. A-I, B-II, C-III, D-IV

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8. Given below are two statements: **(+4, -1)**

Statement I: Tropolone is an aromatic compound and has 8л electrons.

Statement II: electrons of >C = O group in tropolone is involved in aromaticity.

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

a. Both Statement I and Statement II are true

b. Both Statement I and Statement II are false

c. Statement I is true but Statement II is false

d. Statement I is false but Statement II is true

---

9. The total number of stereoisomers for the complex $[Cr(ox)_2ClBr]^{3-}$ (where oxalate) is: **(+4, -1)**

a. 2

b. 4

c. 3

d. 1

---

10. Which of the following complexes will exhibit maximum attraction to an applied magnetic field? **(+4, -1)**

a. $[Co(en)_3]^{3+}$

b. $[Co(H_2O)_6]^{2+}$

c. $[Zn(H_2O)_6]^{2+}$

d. $[Ni(H_2O_6]^{2+}$

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11. The correct group of halide ions which can be oxidised by oxygen in acidic medium is **(+4, -1)**

a. Br^- and I^- only

b. Cl^- Br^- and I^- only

c. I^- only

d. Br^- only

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12. better method for preparation of bef_2 among the following is (+4, -1)

a. $Be + F_2 \xrightarrow{\triangle} BeF_2$

b. $(NH_4)_2BeF_4 \xrightarrow{\triangle} BeF_2$

c. $BeO + C + F_2 \xrightarrow{\triangle} BeF_2$

d. $BeH_2 + F_2 \xrightarrow{\triangle} BeF_2$

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13. Given below are two statements, one is labelled as Assertion: A and the other is labelled as Reason R. (+4, -1)
Assertion: A Isotopes of hydrogen have almost same chemical properties, but difference in their rates of reaction.
Reason: R Isotopes of hydrogen have different enthalpy of bond dissociation.
In the light of the above statements, choose the most appropriate answer from the options given below

a. Both A and R are correct and R is the correct explanation of A

b. Both A and R are correct but R is NOT the correct explanation of A

c. A is correct but R is not correct

d. A is not correct but R is correct

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14. Given below are two statements related to Ellingham diagram: (+4, -1)
Statement-I: Ellingham diagrams can be constructed for formation of oxides, sulfides and halides of metals.
Statement-II : It consists of plots of ΔfH^o vs T for formation of oxides of elements.
In the light of the above statements, choose the most appropriate answer from the options given below

a. Both Statement I and Statement II are correct

b. Both Statement I and Statement II are incorrect

c. Statement I is correct but Statement II is incorrect

d. Statement I is incorrect but Statement II is. correct

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15. The covalency and oxidation state respectively of boron in $[BF_4]^-$, are **(+4, -1)**

a. 4 and 4

b. 4 and 3

c. 3 and 4

d. 3 and 5

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16. Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R. **(+4, -1)**
Assertion A: The diameter of colloidal particles in solution should not be much smaller than wavelength of light to show Tyndall effect.
Reason R : The light scatters in all directions when the size of particles is large enough.
In the light of the above statements, choose the correct answer from the options given below

a. Both A and R are correct and R is the correct explanation of A

b. Both A and R are correct but R is NOT the correct explanation of A

c. A is true but R is false

d. A is false but R is true

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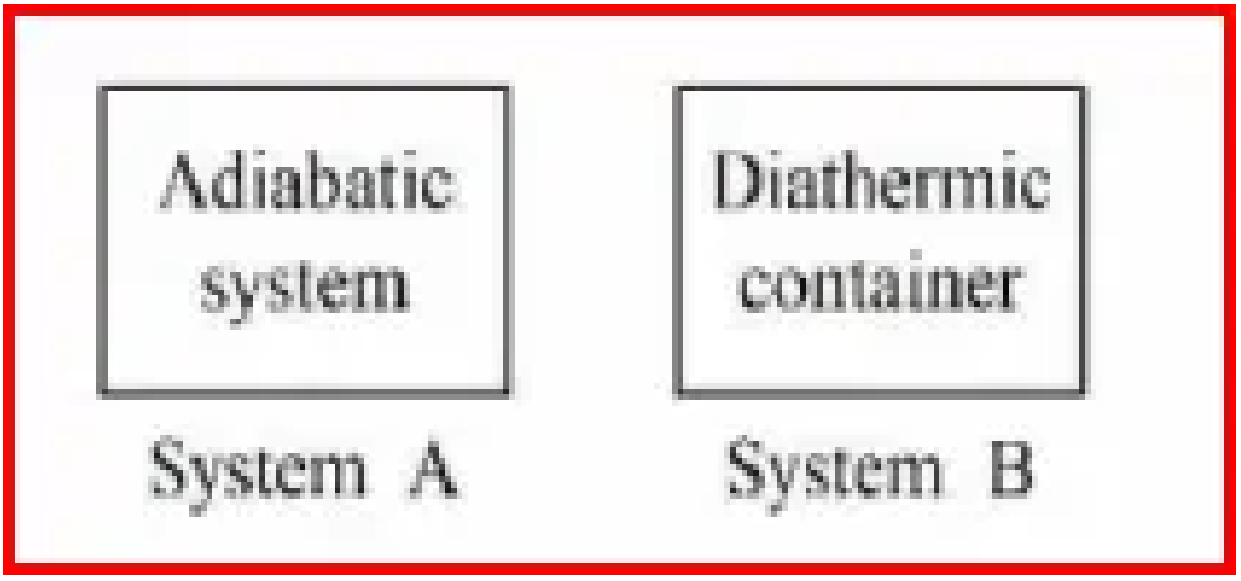
17. What happens when methane undergoes combustion in systems A and B respectively? **(+4, -1)**



a.

System A	System B
Temperature rises	Temperature remains same

b.

System A	System B
Temperature remains same	Temperature rises

c.

System A	System B
Temperature falls	Temperature rises

d.

System A	System B
Temperature falls	Temperature remains same

---

18. The reaction 2NO + Br2 → 2NOBr **(+4, -1)**
takes places through the mechanism given below :
NO + Br2 ⇔ NOBr2 (fast)
NOBr2 + NO → 2NOBr (slow)
The overall order of the reaction is_____.

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19. 25.0 mL of 0.050 M $Ba(NO_3)_2$ is mixed with 25.0 mL of 0.020 M NaF. K_{sp} of BaF_2 is 0.5×10^{-6} at 298 K. The ratio of $[Ba2+]\,[F^-]^2$ and K_{sp} is__ (Nearest integer) **(+4, -1)**

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20. Among the following, the number of compounds which will give positive iodoform reaction is ____ . **(+4, -1)**

(a) 1-Phenylbutan-2-one
(b) 2-Methylbutan-2-ol
(c) 3-Methylbutan-2-ol
(d) 1-Phenylethanol
(e) 3,3-dimethylbutan-2-one
(f) 1-Phenylpropan-2-ol

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21. The standard reduction potential at 298 K for the following half cells are given below **(+4, -1)**

NO - 3 3 - + 4H+ + 3e- → NO(g) +2H2O E0 = 0.97V

$V^{2+}(aq) + 2e^- \rightarrow V$ E^0 = -1.19V

$Fe^{3+}(aq) + 3e^- \rightarrow Fe$ E^0 = -0.04V

$Ag^+(aq) + e^- \rightarrow Ag(s)$ E^0 = 0.80V

$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$ E^0 = 1.40V

The number of metal(s) which will be oxidized by $N0_3^-$ Oin aqueous solution is_____.

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22. Consider the following date **(+4, -1)**

Heat of combustion of $H_2(g)$ = -241.8 kJ mol^{-1}

Heat of combustion of C(s) = -393.5 kJ mol^{-1}

Heat of combustion of $C_2H_5OH(1)$ = -1234.7 kJ mol^{-1}

The heat of formation of $C_2H_5OH(1)$ is (-) ____ kJ mol^{-1} (Nearest integer)

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23. The number of species having a square planar shape from the following is __ **(+4, -1)**

$XeF_4, SF_4, SiF_4, BF_4^- BrF_4^-, [Cu(NH_3)_4]^{2+}, [FeCl_4]^{2-}, [PtCl_4]^{2-}$

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24. Number of crystal systems from the following where body centred unit cell can be found, is..... **(+4, -1)**

Cubic, tetragonal, orthorhombic, hexagonal, rhombohedral, monoclinic, triclinic.

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25. Match List I with List II **(+4, -1)**

	List I-Examples		List II-Type
A	2-Chloro-1, 3-butadiene	I	Nylon 2-nylon 6
B	Nylon 2-nylon 6	II	Synthetic Rubber
C	Polyacrylonitrile	III	Polyester
D	Dacron	IV	Addition Polymer

Choose the correct answer from the options given below:

a. A-II, B-IV, C-I, D-III

b. A-II, B-I, C-IV, D-III

c. A-IV, B-I, C-III, D-II

d. A-IV, B-III, C-I, D-II

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Answers

1. **Answer: c**

Explanation:

Step 1: Understanding the Question:
We need to evaluate the correctness of an Assertion and a Reason related to the Williamson ether synthesis.
Step 2: Key Formula or Approach:
The Williamson ether synthesis is a method for preparing ethers via an S_N2 reaction between a sodium alkoxide (or phenoxide) and an alkyl halide.

$$\text{R-O}^-\text{Na}^+ + \text{R'-X} \rightarrow \text{R-O-R'} + \text{NaX}$$

For the S_N2 mechanism to be effective, the alkyl halide (R'-X) should ideally be primary or secondary. Aryl halides and tertiary alkyl halides are unreactive under S_N2 conditions.
Step 3: Detailed Explanation:
Analysis of Assertion (A):
"Synthesis of ethyl phenyl ether may be achieved by Williamson synthesis."
Ethyl phenyl ether has the structure C_6H_5-O-CH_2CH_3. To synthesize this, we need a phenoxide part and an ethyl part. The correct strategy for Williamson synthesis is to use the phenoxide as the nucleophile and the alkyl halide as the electrophile.

$$\underbrace{\text{C}_6\text{H}_5\text{O}^-\text{Na}^+}_{\text{Sodium phenoxide}} + \underbrace{\text{CH}_3\text{CH}_2\text{Br}}_{\text{Ethyl bromide } (1^\circ)} \rightarrow \text{C}_6\text{H}_5\text{-O-CH}_2\text{CH}_3 + \text{NaBr}$$

This reaction works well because ethyl bromide is a primary alkyl halide, which is excellent for S_N2 reactions. Therefore, Assertion (A) is a correct statement.
Analysis of Reason (R):
"Reaction of bromobenzene with sodium ethoxide yields ethyl phenyl ether."
This statement describes the alternative combination of reagents:

$$\underbrace{\text{C}_6\text{H}_5\text{Br}}_{\text{Aryl halide}} + \underbrace{\text{CH}_3\text{CH}_2\text{O}^-\text{Na}^+}_{\text{Sodium ethoxide}} \rightarrow \text{No reaction}$$

This reaction does not occur. S_N2 substitution is not feasible on an aryl halide like bromobenzene. This is because:
The carbon atom of the C-Br bond is sp^2-hybridized and less susceptible to nucleophilic attack.

The C-Br bond has partial double-bond character due to resonance with the benzene ring, making it stronger and harder to break.
The bulky and electron-rich benzene ring sterically hinders and electrostatically repels the incoming nucleophile.
Therefore, Reason (R) is an incorrect statement.
Step 4: Final Answer:
The Assertion (A) is correct, but the Reason (R) is incorrect. This corresponds to option (C).

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2. **Answer: 3 - 3**

Explanation:

The determination of molecular geometry is based on the **VSEPR (Valence Shell Electron Pair Repulsion)** theory. A square pyramidal structure corresponds to the AX_5E type, where:

- A = Central atom
- X = Bonded atoms
- E = Lone pairs of electrons

Analysis of Each Species:

1. **PF_5:** Trigonal bipyramidal structure (AX_5), not square pyramidal.
2. **BrF_4^-:** Square planar structure (AX_4E_2), not square pyramidal.
3. **IF_5:** Square pyramidal structure (AX_5E), as it has 5 bonded atoms and 1 lone pair.
4. **BrF_5:** Square pyramidal structure (AX_5E), as it has 5 bonded atoms and 1 lone pair.
5. **$XeOF_4$:** Square pyramidal structure (AX_5E), as it has 5 bonded groups (4 F and 1 O) and 1 lone pair.
6. **ICl_4^-:** Square planar structure (AX_4E_2), not square pyramidal.

Conclusion:

Species with square pyramidal structures are:

- IF_5

- BrF_5
- $XeOF_4$

Answer: The number of species with a square pyramidal structure is **3**.

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3. Answer: 2200 - 2200

Explanation:

1. Initial Condition: At $t = 0$:

$$P_A = 800\,\text{mm Hg}, \quad P_B = 0, \quad P_C = 0.$$

2. First-order Kinetics Relation: For a first-order reaction:

$$(P_A)_t = (P_A)_0 \left(\frac{1}{2}\right)^{t/t_{1/2}}.$$

Here: $(P_A)_0 = 800\,\text{mm Hg}$, At $t = 10\,\text{min}$, $(P_A)_t = 1600\,\text{mm Hg}$. Half-life $(t_{1/2})$ of the reaction is $10\,\text{min}$. 3. Pressure after 30 minutes: At $t = 30\,\text{min}$:

$$t = 3 \cdot t_{1/2}.$$

The pressure of P_A will be:

$$(P_A)_t = 800 \cdot \left(\frac{1}{2}\right)^3 = 800 \cdot \frac{1}{8} = 100\,\text{mm Hg}.$$

4. Total Pressure Contribution: The pressure due to products $2B + C$: For $2B$: $P_B = 2 \cdot (800 - 100) = 1400\,\text{mm Hg}$, For C: $P_C = 800 - 100 = 700\,\text{mm Hg}$. Total pressure:

$$P_{\text{total}} = (P_A) + (P_B) + (P_C).$$

Substituting values:

$$P_{\text{total}} = 100 + 1400 + 700 = 2200\,\text{mm Hg}.$$

% Final Answer **Final Answer:** $\boxed{2200}\,\text{mm Hg}$

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4. Answer: 25 - 25

Explanation:

1. Dissociation of $Cu(OH)_2$:

$$\mathrm{Cu(OH)_2(s)} \rightleftharpoons \mathrm{Cu^{2+}(aq)} + 2\mathrm{OH^-(aq)}.$$

$$K_{\mathrm{sp}} = [\mathrm{Cu^{2+}}][\mathrm{OH^-}]^2.$$

2. At pH = 14:

$$\mathrm{pH} = 14 \implies \mathrm{pOH} = 0 \implies [\mathrm{OH^-}] = 1\,\mathrm{M}.$$

Substituting in the solubility product expression:

$$[\mathrm{Cu^{2+}}] = \frac{K_{\mathrm{sp}}}{[\mathrm{OH^-}]^2} = \frac{1 \times 10^{-20}}{1^2} = 1 \times 10^{-20}\,\mathrm{M}.$$

3. Reduction Half Reaction:

$$\mathrm{Cu^{2+}(aq)} + 2\mathrm{e^-} \rightarrow \mathrm{Cu(s)}.$$

Using the Nernst equation:

$$E = E^\circ - \frac{0.059}{n} \log_{10}\left(\frac{1}{[\mathrm{Cu^{2+}}]}\right).$$

Here: - $E^\circ = 0.034\,\mathrm{V}$, - $n = 2$, - $[\mathrm{Cu^{2+}}] = 1 \times 10^{-20}$. 4. Substitute Values in Nernst Equation:

$$E = 0.034 - \frac{0.059}{2} \log_{10}\left(\frac{1}{1 \times 10^{-20}}\right).$$

Simplify the logarithmic term:

$$\log_{10}\left(\frac{1}{1 \times 10^{-20}}\right) = \log_{10}(10^{20}) = 20.$$

Substituting back:

$$E = 0.034 - \frac{0.059}{2} \times 20.$$

$$E = 0.034 - 0.59.$$

$$E = -0.25\,\mathrm{V}.$$

5. Express in Required Format: The reduction potential is $-x \times 10^{-2}$, where $x = 25$. % Final Answer **Final Answer:** $\boxed{25}$

5. **Answer: c**

Explanation:

1. A. Weak intermolecular forces of attraction: 2–chloro–1,3–butadiene (chloroprene) is the monomer of neoprene, which has weak intermolecular forces of attraction, being an elastomer. Correct match: III. 2–chloro–1,3–butadiene.

2. B. Hydrogen bonding: Hexamethylenediamine reacts with adipic acid to form Nylon-6,6. The presence of the amide group allows hydrogen bonding between polymer chains. Correct match: I. Hexamethylenediamine + adipic acid.

3. C. Heavily branched polymer: - Phenol reacts with formaldehyde to form Bakelite, which is a heavily branched (cross-linked) polymer. Correct match: IV. Phenol + formaldehyde.

4. D. High density polymer: - High-density polyethylene is prepared using the Ziegler-Natta catalyst ($\mathrm{AlEt_3 + TiCl_4}$). Correct match: II. $\mathrm{AlEt_3 + TiCl_4}$. ### Final Matching:

$$\mathrm{A–III, B–I, C–IV, D–II.}$$

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6. **Answer: b**

Explanation:

The reaction involves the interaction of a nucleophile (HS-) with an electrophilic site on the given substrate. - SH is a better nucleophile than OH due to the softness of sulfur compared to oxygen. - Soft nucleophiles prefer to attack soft electrophilic centers, following the principle of hard-soft acid-base (HSAB) theory. The mechanism proceeds as follows: 1. The sulfur atom in SH attacks the electrophilic carbon of the $\mathrm{C{=}N}$ group. 2. This leads to the formation of a new bond between sulfur and carbon. 3. The OH group remains intact as sulfur is the more reactive nucleophile in this scenario. The major product of the reaction is:

$$\mathrm{HO\text{-}CH(SH)\text{-}CN.}$$

Thus, the correct product matches option (2).

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7. **Answer: b**

Explanation:

The reactions of bromopropane with the given reagents are as follows: 1. A. Reaction with KOH (alc): Bromopropane reacts with alcoholic KOH to undergo dehydrohalogenation, forming an alkene.

$$\mathrm{CH_3-CH_2-CH_2Br+KOH(alc)\rightarrow CH_3-CH=CH_2\,(Alkene)}.$$

2. B. Reaction with KCN (alc): Bromopropane reacts with alcoholic KCN to undergo a nucleophilic substitution reaction, forming a nitrile.

$$\mathrm{CH_3-CH_2-CH_2Br+KCN\rightarrow CH_3-CH_2-CH_2CN\,(Nitrile)}.$$

3. C. Reaction with $AgNO_2$: Bromopropane reacts with silver nitrite ($AgNO_2$) to form a nitroalkane via substitution.

$$\mathrm{CH_3-CH_2-CH_2Br+AgNO_2\rightarrow CH_3-CH_2-CH_2NO_2+AgBr\,(Nitroalkane)}.$$

4. D. Reaction with $H_3CCOOAg$: Bromopropane reacts with silver acetate ($H_3CCOOAg$) to form an ester via substitution.

$$\mathrm{CH_3-CH_2-CH_2Br+CH_3COOAg\rightarrow CH_3-CH_2-CH_2COOCH_3+AgBr\,(Ester)}.$$

Thus, the correct matching is:

$$\mathrm{A–III,\ B–I,\ C–IV,\ D–II}.$$

---

8. **Answer: c**

Explanation:

1. Statement I: Tropolone is an aromatic compound with a conjugated ring system containing 8 π electrons: - 6 π electrons are endocyclic (within the ring). - 2 π electrons from the $>\mathrm{C=O}$ group are exocyclic (outside the ring). Hence, tropolone satisfies the conditions of aromaticity. Therefore, Statement I is correct.

2. Statement II: The π electrons of the $>\mathrm{C=O}$ group are not involved in the aromaticity of the compound, as they are exocyclic and do not contribute to the

conjugated system of the ring. Therefore, Statement II is incorrect. ### Diagram:

$$\text{Tropolone: Aromatic compound with 6 } \pi \text{ endocyclic electrons}$$

$$\text{Structure:}$$

$$\text{OH} \quad \text{C} = \text{O}$$

Conclusion: Statement I is true, but Statement II is false.

---

9. **Answer: c**

Explanation:

The given complex is $[\text{Cr(ox)}_2\text{ClBr}]^{3-}$, where: - ox (oxalate) is a bidentate ligand, forming chelate rings with the central metal atom. - Cl and Br are monodentate ligands. ### Types of Isomerism: 1. Geometrical Isomerism: - The Cl and Br ligands can be arranged either cis (adjacent) or trans (opposite) to each other. - This results in two geometrical isomers: cis and trans. 2. Optical Isomerism: - Among the geometrical isomers, only the cis-isomer can exhibit optical isomerism. - The cis-isomer does not have a plane of symmetry, so it can exist as two enantiomers: d-form and l-form. Thus, the total number of stereoisomers for this complex is:

$$1 \text{ trans-isomer (no optical isomerism)} + 2 \text{ cis-enantiomers (d and l forms)} = 3 \text{ isomers.}$$

Explanation with Diagrams: 1. Trans-isomer: This structure has a plane of symmetry, so no optical isomerism is observed.

$$\text{Cl and Br are opposite to each other.}$$

2. Cis-isomer: This structure does not contain a plane of symmetry, so it exhibits optical isomerism.

$$\text{Cl and Br are adjacent to each other. Two forms (d and l) are possible.}$$

Conclusion: The total number of stereoisomers is $\boxed{3}$.

---

10. **Answer: b**

Explanation:

The attraction of a complex to a magnetic field depends on the number of unpaired electrons in the complex. Let us analyze each given complex:

1.$[Zn(H_2O)_6]^{2+}$: The electronic configuration of Zn^{2+} is $3d^{10}$. It has no unpaired electrons, so it is diamagnetic.

2. $[Ni(H_2O)_6]^{2+}$: The electronic configuration of Ni^{2+} is $3d^8$. In an octahedral field, this gives a $t_{2g}^6 e_g^2$ configuration, with 2 unpaired electrons.

3. $[Co(en)_3]^{3+}$: The electronic configuration of Co^{3+} is $3d^6$. Due to strong-field ligands (en), it undergoes pairing, resulting in a $t_{2g}^6 e_g^0$ configuration with no unpaired electrons. It is diamagnetic.

4. $[Co(H_2O)_6]^{2+}$: The electronic configuration of Co^{2+} is $3d^7$. In an octahedral field with weak-field ligands like water, it gives a $t_{2g}^5 e_g^2$ configuration with 3 unpaired electrons. Hence, $[Co(H_2O)_6]^{2+}$ has the maximum number of unpaired electrons and will exhibit the maximum attraction to an applied magnetic field.

---

11. Answer: c

Explanation:

In acidic medium, only iodide ions (I^-) can be oxidized by oxygen to form iodine (I_2). The reaction is as follows:

$$4I^- + 4H^+ + O_2 \rightarrow 2I_2(s) + 2H_2O(l).$$

Chloride (Cl^-) and bromide (Br^-) ions are not oxidized by oxygen in acidic medium because their reduction potentials are not favorable for such oxidation under standard conditions.

---

12. Answer: b

Explanation:

The better method for preparing BeF_2 involves the decomposition of ammonium beryllium fluoride, $(NH_4)_2BeF_4$, by heating it to produce BeF_2 and ammonia fluoride (NH_3F) as by-product. This method is efficient and widely used for preparing

beryllium fluoride in laboratory conditions. The reaction is as follows:

$$(NH_4)_2BeF_4 \xrightarrow{\Delta} BeF_2 + 2NH_3F.$$

Thus, the correct answer is $\boxed{(2)}$.

---

13. **Answer: a**

Explanation:

Isotopes of hydrogen, such as protium, deuterium, and tritium, have the same electronic configuration, so they exhibit almost identical chemical properties. However, due to their differences in mass, the rates of reactions differ significantly, primarily because of differences in the enthalpy of bond dissociation.

The enthalpy of bond dissociation is higher for heavier isotopes (such as deuterium and tritium) compared to protium, leading to slower reaction rates for the heavier isotopes. Hence, both the assertion (A) and reason (R) are correct, and the reason (R) correctly explains the assertion (A).

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14. **Answer: c**

Explanation:

Statement I: The Ellingham diagram can indeed be constructed for the formation of oxides, sulfides, and halides of metals. This statement is correct.
Statement II: The Ellingham diagram does not consist of plots of ΔH° vs T. Instead, it represents plots of ΔG° (Gibbs free energy change) vs T (temperature) for the formation of oxides of elements. This statement is incorrect.

The Ellingham diagram is primarily used to determine the feasibility of reduction reactions of metal oxides and to compare the relative stability of oxides at different temperatures. Thus, the correct answer is $\boxed{(3)}$.

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15. **Answer: b**

Explanation:

The structure of the $[BF_4]^-$ ion is as follows:

Covalency of Boron: The covalency of boron is the number of covalent bonds it forms. In the $[BF_4]^-$ ion, boron is surrounded by four fluorine atoms, forming four covalent bonds. Thus, the covalency of boron is 4.

Oxidation State of Boron: The oxidation state of boron can be calculated as follows: - Each fluorine atom has an oxidation state of -1. - Let the oxidation state of boron be x. The total charge on the $[BF_4]^-$ ion is -1, so:

$$x + 4(-1) = -1.$$

Simplify:

$$x - 4 = -1 \implies x = +3.$$

Thus, the oxidation state of boron is $+3$. ### Final Answer: The covalency and oxidation state of boron are 4 and $+3$, respectively.

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16. **Answer: a**

Explanation:

The Tyndall effect is observed only when the following two conditions are satisfied:

1. The diameter of the dispersed particles is not much smaller than the wavelength of the light used. If the particles are much smaller than the wavelength of light, scattering is negligible, and the Tyndall effect is not observed.

2. The refractive indices of the dispersed phase and the dispersion medium differ greatly in magnitude. Explanation of Statements: Assertion A: This is correct because the particle size needs to be comparable to the wavelength of light to scatter light effectively and show the Tyndall effect. Reason R: This is correct because light scatters in all directions when the particle size is large enough to cause significant scattering. Furthermore, the reason directly explains why the assertion is true.

Conclusion: Both Assertion A and Reason R are correct, and Reason R is the correct explanation of Assertion A.

17. **Answer: a**

Explanation:

1. System A (Adiabatic System): In an adiabatic system, there is no heat exchange with the surroundings. During the combustion of methane, the heat generated cannot escape. This results in an increase in temperature within the system.

2. System B (Diathermic Container): In a diathermic container, heat can flow in and out of the system. During the combustion of methane, the heat generated escapes to maintain constant temperature.

Thus, in System A, the temperature rises, while in System B, the temperature remains the same.

18. **Answer: 3 - 3**

Explanation:

Solution:

1. Identify the rate-determining step: The slow step is the rate-determining step, as it dictates the overall rate of the reaction. The slow step is: $NOBr_2 + NO \rightarrow 2NOBr$

2. Write the rate law based on the slow step: Rate = $k[NOBr_2][NO]$

3. Express the concentration of the intermediate ($NOBr_2$) in terms of reactants: Since the first step is a fast equilibrium, we can write its equilibrium constant (K): $K = [NOBr_2] / ([NO][Br_2])$ $[NOBr_2] = K[NO][Br_2]$

4. Substitute the expression for $[NOBr_2]$ into the rate law: Rate = $k(K[NO][Br_2])[NO]$ Rate = $kK[NO]^2[Br_2]$

5. Determine the overall order of the reaction: The overall order is the sum of the exponents in the rate law. Order = 2 (for NO) + 1 (for Br_2) = 3 Therefore, the overall order of the reaction is 3.

19. **Answer: 5 - 5**

Explanation:

We are given the following data:

Volume of $Ba(NO_3)_2$ = 25.0 mL,

Concentration of $Ba(NO_3)_2$ = 0.050 M,

Volume of NaF = 25.0 mL,

Concentration of NaF = 0.020 M,

K_{sp} of BaF_2 = 0.5×10^{-6}.

First, calculate the concentrations of Ba^{2+} and F^- after mixing. The total volume after mixing is:

$$V_{\text{total}} = 25.0\,\text{mL} + 25.0\,\text{mL} = 50.0\,\text{mL}.$$

Now, the concentration of Ba^{2+} after mixing:

$$[\text{Ba}^{2+}] = \frac{0.050 \times 25.0}{50.0} = 0.025\,\text{M}.$$

The concentration of F^- after mixing:

$$[\text{F}^-] = \frac{0.020 \times 25.0}{50.0} = 0.010\,\text{M}.$$

The solubility product for BaF_2 is:

$$K_{sp} = [\text{Ba}^{2+}][\text{F}^-]^2.$$

Substitute the values:

$$K_{sp} = (0.025) \times (0.010)^2 = 0.5 \times 10^{-6}.$$

We are asked for the ratio of $[\text{Ba}^{2+}]$ to K_{sp}. This is given by:

$$\frac{[\text{Ba}^{2+}]}{K_{sp}} = \frac{0.025}{0.5 \times 10^{-6}} = 5 \times 10^4.$$

Thus, the ratio is 5×10^4.

20. **Answer: 4 - 4**

Explanation:

Iodoform Test Analysis

The iodoform test is a qualitative test for the presence of methyl ketones (R-CO-CH3) and certain secondary alcohols (R-CH(OH)-CH3). A positive iodoform test results in the formation of a yellow precipitate of iodoform (CHI3).

The necessary structural feature for a positive iodoform test is the presence of a methyl ketone group (CH3C=O) or a methyl carbinol group (CH3CH(OH)-).

Let's examine each compound:

- **(a) 1-Phenylbutan-2-one:** This is a methyl ketone (Ph-CH2-CO-CH3) and will give a positive iodoform test.
- **(b) 2-Methylbutan-2-ol:** This is a tertiary alcohol and will not give a positive iodoform test.
- **(c) 3-Methylbutan-2-ol:** This is a secondary alcohol with the required CH3CH(OH)- group, so it will give a positive iodoform test.
- **(d) 1-Phenylethanol:** This is a secondary alcohol with the required CH3CH(OH)- group (Ph-CH(OH)-CH3), so it will give a positive iodoform test.
- **(e) 3,3-dimethylbutan-2-one:** This is a methyl ketone (CH3-CO-C(CH3)3), so it will give a positive iodoform test.
- **(f) 1-Phenylpropan-2-ol:** This is a secondary alcohol with the required CH3CH(OH)- group (Ph-CH2-CH(OH)-CH3) and will give a positive iodoform test.

Conclusion:

Therefore, **four** compounds (a, c, d, and f) will give a positive iodoform reaction.

21. **Answer: 3 - 3**

Explanation:

Nitrate Ion Oxidation Analysis

For NO_3^- to oxidize a metal, NO_3^- must itself be reduced. The given reduction half-reaction is:

$$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O \qquad E^0 = 0.97\ V$$

For a metal to be oxidized by NO_3^-, the overall cell potential (E^0_{cell}) for the redox reaction must be positive. The cell potential is calculated as:

$$E^0_{cell} = E^0_{reduction} - E^0_{oxidation}$$

In our case, $E^0_{reduction}$ is 0.97 V (for the NO_3^- reduction). For the cell potential to be positive, $E^0_{oxidation}$ must be less than 0.97 V.

Since we are given standard reduction potentials, we need to reverse the sign to obtain the oxidation potentials for each metal:

- V: $E^0_{oxidation} = -(-1.19\ V) = 1.19\ V$
- Fe: $E^0_{oxidation} = -(-0.04\ V) = 0.04\ V$
- Ag: $E^0_{oxidation} = -(0.80\ V) = -0.80\ V$
- Au: $E^0_{oxidation} = -(1.40\ V) = -1.40\ V$

Comparing these values to 0.97 V, we find that Fe, Ag, and Au have oxidation potentials less than 0.97 V. Therefore, these three metals can be oxidized by NO_3^- in aqueous solution.

Conclusion:

Vanadium (V) has an oxidation potential greater than 0.97 V, so it will not be oxidized by NO_3^-. So, the number of metal(s) which will be oxidized by NO_3^- in aqueous solution is 3.

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22. **Answer: 278 - 278**

Explanation:

Hess's Law Enthalpy Calculation

Given Reactions and Enthalpy Changes:

$$2C(s) + O_2 \rightarrow 2CO_2 \qquad \Delta H = -393.5 \times 2 = -787\ \text{kJ} \qquad (1)$$

$$3H_2 + \tfrac{3}{2}O_2 \rightarrow 3H_2O \qquad \Delta H = -241.5 \times 3 = -725.4\ \text{kJ} \qquad (2)$$

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O \qquad \Delta H = -1234.7\ \text{kJ} \qquad (3)$$

$$3H_2O + 2CO_2 \rightarrow C_2H_5OH + 3O_2 \qquad \Delta H = +1234.7\ \text{kJ} \qquad (4)$$

Target Reaction:

$$2C(s) + 3H_2(g) + \tfrac{1}{2}O_2 \rightarrow C_2H_5OH \qquad (5)$$

Calculation:

Equation (5) is derived as:

$$(5) = (1) + (2) + (4)$$

$$\Delta H = (-787) + (-725.4) + (1234.7)$$

$$\Delta H = -277.7\ \text{kJ} \implies \Delta H \approx -278\ \text{kJ}$$

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23. **Answer: 4 - 4**

Explanation:

Square Planar Molecular Geometry Analysis

To determine the shapes of these species, we need to consider their electron domain geometry and the effect of lone pairs. Square planar geometry arises from an octahedral electron domain geometry with two lone pairs occupying axial positions. It can also arise from dsp2 hybridisation when the central atom has a d8 configuration in a complex ion.

Let's analyze each species:

- XeF_4: Xe has 8 valence electrons, and 4 are used for bonding with F. This leaves 4 electrons (2 lone pairs). XeF_4 has 6 electron domains (4 bonding, 2 lone pairs) adopting an octahedral electron domain geometry. The lone pairs occupy axial positions, resulting in a square planar molecular geometry.
- SF_4: S has 6 valence electrons, 4 used for bonding. This leaves 2 electrons (1 lone pair). SF_4 has 5 electron domains (4 bonding and 1 lone pair) with a trigonal bipyramidal electron domain geometry. The lone pair occupies an equatorial position leading to a see-saw shape.
- SiF_4: Si has 4 valence electrons, all used for bonding. SiF_4 has 4 electron domains (4 bonding, 0 lone pairs) and is tetrahedral.
- BrF_4^-: Br has 7 valence electrons + 1 (from the negative charge) = 8 electrons. 4 are used for bonding. This leaves 4 electrons (2 lone pairs). BrF_4^- has 6 electron domains (4 bonding, 2 non-bonding), adopting an octahedral electron geometry. The two lone pairs are in the axial positions, leading to a square planar molecular geometry.
- $[Cu(NH_3)_4]^{2+}$: Cu^{2+} is a d9 system. Due to Jahn Teller distortion, this complex prefers to be a distorted square planar structure rather than a perfect square planar shape. For this type of question, it's usually counted as a square planar complex.
- $[FeCl_4]^{2-}$: Fe^{2+} is a d6 system, which is generally tetrahedral when dealing with weak field ligands.
- $[PtCl_4]^{2-}$: Pt^{2+} is a d8 system. These often form square planar complexes due to dsp2 hybridization.

Conclusion:

Therefore, XeF_4, BrF_4^-, $[Cu(NH_3)_4]^{2+}$, and $[PtCl_4]^{2-}$ are square planar. The answer is **4**.

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24. **Answer: 3 - 3**

Explanation:

Body-Centered Cubic (BCC) Crystal Systems

A body-centered cubic (BCC) unit cell is a type of unit cell where an atom is located at each corner of the cube and one atom is located at the center of the cube. BCC arrangements are found in the following crystal systems:

- **Cubic:** This is the classic body-centered cubic structure.
- **Tetragonal:** A body-centered tetragonal structure exists where the cell is elongated along one axis.
- **Orthorhombic:** A body-centered orthorhombic structure exists where the cell has unequal sides but all angles are 90 degrees.

Body-centered unit cells are not found in the hexagonal, rhombohedral, monoclinic, or triclinic crystal systems.

Conclusion:

Therefore, the number of crystal systems where BCC unit cells can be found is **3**.

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25. **Answer: c**

Explanation:

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

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