VITEEE 2019 Question Paper with Solutions for Chemistry

Time Allowed :90 Minutes	**Maximum Marks :**80	**Total Questions :**80

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The question paper contains a total of 80 questions divided into four parts:
   - Part I: Physics (Questions 1 to 25)
   - Part II: Chemistry (Questions 26 to 50)
   - Part III: Mathematics (Questions 51 to 75)
   - Part IV: English & Logical Reasoning (Questions 76 to 80)
2. All questions are multiple-choice with four options, and only one of them is correct.
3. For each correct answer, the candidate will earn 1 mark.
4. There is no negative marking for incorrect answers.
5. The test duration is 12 hours.

1. The set of quantum numbers not allowed in the hydrogen atom is
(A) $n = 2, l = 1, m_l = -1$
(B) $n = 3, l = 2, m_l = 2$
(C) $n = 4, l = 3, m_l = 4$
(D) $n = 8, l = 7, m_l = -6$
Correct Answer: (C) $n = 4, l = 3, m_l = 4$

Solution:
The allowed values for the magnetic quantum number (m_l) depend on the azimuthal quantum number (l).

The condition is that m_l must be an integer in the range $-l \leq m_l \leq +l$.

In option (C), the given values are $l = 3$ and $m_l = 4$.

Since $4 > 3$, the value $m_l = 4$ is not permitted for an $l = 3$ subshell.

All other options satisfy the conditions $0 \leq l < n$ and $|m_l| \leq l$.

Quick Tip

Remember the hierarchy: n defines shell, l (0 to $n-1$) defines subshell, and m_l ($-l$ to $+l$) defines orbital orientation. m_l can never exceed l.

---

2. Gibbs energy of formation of two oxides (CO and Al_2O_3) are given below as a function of temperature
$\Delta G_{\mathbf{CO}} = -0.2T - 195.4$ **and** $\Delta G_{\mathbf{Al_2O_3}} = 0.2T - 1104$**. Which one of the scenarios is possible based on Ellingham diagram at T = 2000 K?**
(A) C reducing Al_2O_3
(B) Al reducing CO
(C) No reaction between Al and CO
(D) C reducing Al_2O_3 and Al reducing CO
Correct Answer: (B) Al reducing CO

Solution:
Calculate the ΔG values at $T = 2000$ K for both oxides.

For CO: $\Delta G = -0.2(2000) - 195.4 = -400 - 195.4 = -595.4$.

For Al_2O_3: $\Delta G = 0.2(2000) - 1104 = 400 - 1104 = -704$.

In an Ellingham diagram, the metal whose oxide formation has a more negative ΔG (lower position) is more stable and can reduce the oxide of a metal with a less negative ΔG (higher position).

Since $-704 < -595.4$, Aluminium has a stronger affinity for oxygen than Carbon at this temperature.

Therefore, Al will reduce CO to form Al_2O_3 and C.

Quick Tip

In Pyrometallurgy, "lower reduces higher". The element whose ΔG_f° line is lower on the graph acts as the reducing agent for the oxide above it.

---

3. In a face centered cubic unit cell, the relation between ionic radii (r^+ and r^-) and edge length 'a' is
(A) $r^+ + r^- = \sqrt{2}a$
(B) $r^+ + r^- = \sqrt{3}a$
(C) $r^+ + r^- = a/2$

(D) $r^+ + r^- = 2a$
Correct Answer: (C) $r^+ + r^- = a/2$

Solution:
An ionic face-centered cubic (FCC) unit cell typically refers to the Rock Salt (NaCl) structure.

In this structure, anions (r^-) occupy the corners and face centers, while cations (r^+) occupy the octahedral voids at the edge centers and body center.

The ions are in contact along the edge of the unit cell.

The edge length a consists of two anion radii and two cation radii: $a = 2r^- + 2r^+$.

Dividing the equation by 2 gives the relation: $r^+ + r^- = a/2$.

Quick Tip

Visualize the edge of NaCl: $Cl^- - Na^+ - Cl^-$. The total distance is $r^- + 2r^+ + r^- = 2(r^+ + r^-) = a$.

---

4. When a catalyst is added to a system at equilibrium, a decrease occurs in the
(A) potential energy of the reactants
(B) potential energy of the products
(C) heat of reaction
(D) activation energy
Correct Answer: (D) activation energy

Solution:
A catalyst works by providing an alternative reaction pathway.

This new pathway has a lower activation energy (E_a) compared to the uncatalyzed reaction.

A catalyst does not alter the thermodynamic parameters such as the potential energy of reactants/products or the enthalpy change (ΔH) of the reaction.

Therefore, the only quantity among the options that decreases is the activation energy.

Quick Tip

Catalysts change the rate (kinetics) by lowering the energy barrier (E_a), but they never change the equilibrium position (thermodynamics).

---

5. The Nernst equation for the following electrochemical cell will be:
Ni(s) | Ni^{2+}(aq) || Ag^{+}(aq) | Ag
(A) $E_{cell} = E^{\circ}_{cell} - RT/F[\ln[Ni^{2+}]/[Ag^{+}]^2]$
(B) $E_{cell} = E^{\circ}_{cell} - RT/2F[\ln[Ni^{2+}]/[Ag^{+}]^2]$
(C) $E_{cell} = E^{\circ}_{cell} - RT/2F[\ln[Ag^{+}]^2/[Ni^{2+}]]$
(D) $E_{cell} = E^{\circ}_{cell} - RT/2F[\ln[Ni^{2+}]/[Ag^{+}]]$
Correct Answer: (B) $E_{cell} = E^{\circ}_{cell} - RT/2F[\ln[Ni^{2+}]/[Ag^{+}]^2]$

Solution:
First, write the balanced cell reaction. Oxidation: $Ni \rightarrow Ni^{2+} + 2e^{-}$. Reduction: $2Ag^{+} + 2e^{-} \rightarrow 2Ag$.

Overall reaction: $Ni(s) + 2Ag^{+}(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$.

The number of electrons transferred (n) is 2.

The reaction quotient $Q = \frac{[\text{products}]}{[\text{reactants}]} = \frac{[Ni^{2+}]}{[Ag^{+}]^2}$ (solids are omitted).

Substitute these into the Nernst equation: $E_{cell} = E^{\circ}_{cell} - \frac{RT}{nF} \ln Q$.

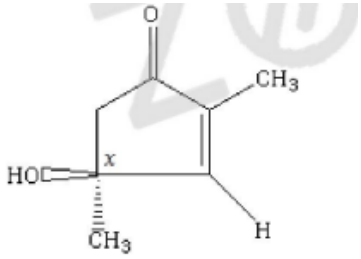
Result: $E_{cell} = E^{\circ}_{cell} - \frac{RT}{2F} \ln \frac{[Ni^{2+}]}{[Ag^{+}]^2}$.

Quick Tip

Always balance the number of electrons to determine 'n' and the exponents in the reaction quotient Q. The coefficient becomes the power in the log term.

---

6. The stereochemical description of the chiral centre (marked as 'x') and the olefin in the following compound is



(A) 4R, 2Z
(B) 4S, 2Z
(C) 4R, 2E
(D) 4S, 2E
Correct Answer: (A) 4R, 2Z

Solution:
Determine the configuration of the chiral center (C4). The priorities are: (1) -OH, (2) C3 (alkene carbon), (3) C5 (alkane carbon), (4) -CH_3.

The -OH group is on a wedge (front) and -CH_3 is on a hash (back).

Tracing the priority sequence $1 \rightarrow 2 \rightarrow 3$ (OH $\rightarrow$ Alkene $\rightarrow$ Alkane) reveals a Clockwise direction. Since the lowest priority group (4) is in the back, the configuration is R.

For the alkene (olefin) at C2-C3: In a six-membered ring, a double bond is geometrically constrained to the cis configuration to avoid ring strain.

The cis configuration corresponds to Z stereochemistry here.

Thus, the full description is 4R, 2Z.

Quick Tip

For cyclohexene derivatives, the endocyclic double bond is always Z (cis). For R/S, if the lowest priority group is in the back, Clockwise = R; if in front, Clockwise = S.

---

7. The reaction of but-1-ene with B_2H_6 followed by oxidation using H_2O_2/NaOH gives
(A) Butan-2-ol
(B) Butan-2-one
(C) Butyraldehyde
(D) Butan-1-ol
Correct Answer: (D) Butan-1-ol

Solution:
The reaction sequence described is Hydroboration-Oxidation.

Reagents B_2H_6 followed by H_2O_2/OH^- perform the net addition of water (H-OH) across the double bond.

This reaction follows an Anti-Markovnikov regioselectivity, where the -OH group attaches to the less substituted carbon.

Starting with but-1-ene ($CH_3CH_2CH = CH_2$), the Anti-Markovnikov addition places the -OH on the terminal carbon.

The product formed is the primary alcohol: Butan-1-ol ($CH_3CH_2CH_2CH_2OH$).

> Quick Tip
>
> Hydroboration-Oxidation = Anti-Markovnikov Hydration. (Acid catalyzed hydration = Markovnikov).

---

8. In which one of the following reactions, a new carbon-carbon bond is not formed?
(A) Cannizzaro reactions
(B) Wurtz reaction
(C) Aldol reaction
(D) Friedel-Crafts reaction
Correct Answer: (A) Cannizzaro reactions

Solution:
Analyze the bond formation in each reaction type.

Wurtz reaction couples two alkyl halides (2R-X $\rightarrow$ R-R), forming a C-C bond.

Aldol reaction connects an enolate to a carbonyl carbon, forming a C-C bond.

Friedel-Crafts reaction attaches an alkyl or acyl group to an aromatic ring, forming a C-C bond.

Cannizzaro reaction involves the disproportionation of aldehydes lacking alpha-hydrogens via hydride transfer. No new C-C bonds are created; only C-H and C-O bonds change.

Quick Tip

The Cannizzaro reaction is unique among name reactions of aldehydes as it is a redox process (disproportionation) rather than a condensation, involving no carbon chain extension.

---

9. The product formed in the following reaction is

$CH_3CHO \xrightarrow{\text{i) HCN}} \xrightarrow{\text{ii) } H_3O^+}$?

(A) CH_3CH_2CN
(B) $CH_3CH(CN)CHO$
(C) $CH_3CH(OH)CN$
(D) $CH_3CH(OH)COOH$
Correct Answer: (D) $CH_3CH(OH)COOH$

Solution:
Step i: Reaction of Acetaldehyde (CH_3CHO) with HCN involves nucleophilic addition of CN^- to the carbonyl carbon.

This forms Acetaldehyde Cyanohydrin: $CH_3CH(OH)CN$.

Step ii: Acid hydrolysis (H_3O^+) converts the nitrile group (-CN) into a carboxylic acid group (-COOH).

The final product is 2-hydroxypropanoic acid (Lactic acid): $CH_3CH(OH)COOH$.

Quick Tip

Sequence: Carbonyl + HCN $\rightarrow$ Cyanohydrin $\xrightarrow{\text{Hydrolysis}}$ α-Hydroxy Acid.

---

10. Nitrobenzene on reaction with Sn/HCl will produce
(A) 2-nitroaniline
(B) 4-nitroaniline
(C) aniline
(D) 4-chloroaniline
Correct Answer: (C) aniline

Solution:
The reagents Sn (Tin) and HCl form a strong reducing mixture.

When applied to Nitrobenzene ($C_6H_5NO_2$), this mixture reduces the nitro group (-NO_2) completely to an amino group (-NH_2).

The reaction is: Ph-$NO_2 + 6[H] \rightarrow$ Ph-$NH_2 + 2H_2O$.

The product obtained is Aniline (Benzenamine).

Quick Tip

Metals in acid (Sn/HCl, Fe/HCl) are standard reagents for reducing aromatic nitro compounds to primary aromatic amines.
