MHT CET 2022 Aug 8 Shift 2 Question Paper With Solutions

Time Allowed :3 Hours	Maximum Marks :200	Total Questions :200

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 200 questions. The maximum marks are 200.
3. There are three parts in the question paper consisting of Physics, Chemistry and Biology (Botany and Zoology) having 50 questions in each part of equal weightage.

1. Use of HCl/Sn reagent

Solution:
Step 1: Identify the reagent type -
The combination of Tin (Sn) and Hydrochloric acid (HCl) is a powerful **reducing agent** used in organic chemistry.
Step 2: Primary usage -
Its most common use is the reduction of Nitro compounds ($-NO_2$) to Primary Amines ($-NH_2$). This is particularly important in the synthesis of aniline from nitrobenzene.
Step 3: Reaction Mechanism -
The reaction occurs as follows:

$$R - NO_2 + 6[H] \xrightarrow{Sn/HCl} R - NH_2 + 2H_2O$$

In the first step, Sn reacts with HCl to produce nascent hydrogen and $SnCl_2$, which reduces the nitro group.
Step 4: Other uses -
It is also used in the Stephen reduction, where nitriles ($R - CN$) are reduced to imines (using $SnCl_2/HCl$), which are then hydrolyzed to aldehydes.

Quick Tip

While Sn/HCl is effective, industrially Fe/HCl is often preferred for reducing nitro compounds because the scrap iron is cheaper and the $FeCl_2$ formed can be easily hydrolyzed to recover HCl.

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2. Structure of polyacrylonitrile

Solution:
Step 1: Identify the monomer -
The monomer for Polyacrylonitrile (PAN) is Acrylonitrile (also known as vinyl cyanide). Its formula is $CH_2 = CH - CN$.
Step 2: Polymerization process -
Acrylonitrile undergoes **addition polymerization** (specifically free-radical polymerization) in the presence of a peroxide catalyst.
Step 3: Draw the repeating unit -
During polymerization, the double bond breaks to form single bonds that link the monomers together into a long chain. The repeating unit is:

$$\begin{bmatrix} -CH_2 - CH- \\ \quad\quad | \\ \quad\quad CN \end{bmatrix}_n$$

Step 4: Properties and Uses -
PAN is a hard, high-melting, and chemically resistant polymer. It is used as a substitute for wool in making commercial fibers like Orlon or Acrilan.

> Quick Tip
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> Polyacrylonitrile is also the primary precursor used to manufacture high-quality carbon fibers through a process of controlled thermal oxidation and pyrolysis.

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3. State of Noble Gas

Solution:
Step 1: Physical state at room temperature -
All noble gases (Helium, Neon, Argon, Krypton, Xenon, and Radon) exist as colorless, odorless, and tasteless gases at standard room temperature and pressure.
Step 2: Atomic state -
Unlike many other gases (like O_2 or N_2), noble gases exist in a monoatomic state. This means they consist of single, unbonded atoms (He, Ne, Ar, etc.).
Step 3: Reason for the state -
Noble gases have a completely filled valence shell electronic configuration (ns^2np^6). This makes them exceptionally stable. Because they have very weak interatomic forces (only weak London dispersion forces), they have very low boiling points and remain in the gaseous state.
Step 4: Trends in the group -
As you go down the group from Helium to Radon:

- Atomic radius increases.
- Boiling point increases (due to stronger dispersion forces).
- Liquefaction becomes slightly easier.

Quick Tip

Helium has the lowest boiling point of any known substance (4.2 K) and is the only element that cannot be solidified by sufficient cooling at normal atmospheric pressure.

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4. Bond present in molecular

Solution:
Step 1: Define Molecular Solids -
Molecular solids consist of molecules held together by various types of intermolecular forces rather than ionic or metallic bonds.
Step 2: Types of Bonding -
The type of bond depends on the nature of the molecules:

- **Non-polar Molecular Solids:** Held by weak **London dispersion forces** (e.g., H_2, Cl_2, Ar).
- **Polar Molecular Solids:** Held by relatively stronger **dipole-dipole interactions** (e.g., HCl, SO_2).
- **Hydrogen-bonded Molecular Solids:** Held by strong **hydrogen bonds** (e.g., H_2O as ice, NH_3).

Step 3: Internal Bonding -
It is important to note that while the molecules are held together by intermolecular forces, the atoms *within* the individual molecules are held together by **covalent bonds**.
Step 4: Properties -
Due to these relatively weak intermolecular forces, molecular solids are generally soft, have low melting points, and are electrical insulators.

Quick Tip

To distinguish between them: if it's a noble gas or symmetric molecule, it's London forces; if it's asymmetric/polar, it's dipole-dipole; if H is bonded to F, O, or N, it's Hydrogen bonding.

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5. Formula for zero order reaction

Solution:
Step 1: Define Zero Order Reaction -
A reaction is zero order when the rate of the reaction is independent of the concentration of the reactants. Rate $= k[A]^0 = k$.
Step 2: Integrated Rate Equation -
For a reaction $A \rightarrow$ Products, the change in concentration over time is:

$$-\frac{d[A]}{dt} = k$$

Integrating both sides from $t = 0$ to $t = t$:

$$[A]_t = -kt + [A]_0$$

Where:

- $[A]_t$ = Concentration at time t.
- $[A]_0$ = Initial concentration.
- k = Rate constant.

Step 3: Half-life Formula ($t_{1/2}$) -
The half-life is the time when $[A]_t = [A]_0/2$. Substituting this into the integrated equation:

$$t_{1/2} = \frac{[A]_0}{2k}$$

Step 4: Units of k -
For a zero-order reaction, the units of the rate constant k are **mol L^{-1} s^{-1}**.

Quick Tip

In a zero-order reaction, the half-life is directly proportional to the initial concentration of the reactant, unlike a first-order reaction where it is constant.

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6. IUPAC name of mesityl oxide

Solution:
Step 1: Identify the common name -
Mesityl oxide is a common name for an α, β-unsaturated ketone formed by the aldol condensation of acetone.
Step 2: Determine the Chemical Structure -
The structure consists of a 5-carbon chain with a double bond and a carbonyl group.

$$(CH_3)_2C = CH - C(= O) - CH_3$$

Step 3: Apply IUPAC Rules -

- **Longest Chain:** 5 carbons (Pentane).
- **Principal Functional Group:** Ketone at position 2 (suffix: -2-one).
- **Unsaturation:** Double bond at position 3 (infix: -3-en).
- **Substituent:** Methyl group at position 4.

Step 4: Combine into the final name -
Combining these parts, we get: **4-Methylpent-3-en-2-one**.

> Quick Tip
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> Mesityl oxide is an important industrial solvent and is a key intermediate in the synthesis of methyl isobutyl ketone (MIBK).

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7. Chiral structures

Solution:
Step 1: Define Chirality -
A molecule is considered chiral if it is not superimposable on its mirror image. This property is similar to our left and right hands, which are mirror images but cannot be perfectly aligned one on top of the other.
Step 2: The Chiral Center -
The most common cause of chirality in organic chemistry is the presence of an asymmetric carbon atom (chiral center). This is a carbon atom bonded to four different groups or atoms.

$$\text{Example: } C(A)(B)(D)(E) \text{ where } A \neq B \neq D \neq E$$

Step 3: Symmetry elements -
A structure is chiral only if it lacks a plane of symmetry (σ), a center of inversion (i), or an improper rotation axis (S_n). If a molecule has a plane of symmetry, it is "achiral" (not chiral).
Step 4: Enantiomers -
The two non-superimposable mirror image forms of a chiral molecule are called enantiomers. They often rotate plane-polarized light in opposite directions (levorotatory and dextrorotatory).

> Quick Tip
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> To quickly identify a chiral center, look for a carbon with four single bonds. If any two groups are the same (e.g., two hydrogens), the center is not chiral.

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8. Highest Negativity

Solution:
Step 1: Define Electronegativity -
Electronegativity is the tendency of an atom to attract a shared pair of electrons towards itself in a covalent bond.
Step 2: Identify the element with the highest value -
On the Pauling scale, **Fluorine (F)** is the most electronegative element with a value of approximately 3.98 (commonly rounded to 4.0).
Step 3: Periodic Trends -

- **Across a Period:** Electronegativity increases from left to right because the nuclear charge increases, pulling electrons more strongly.

- **Down a Group:** Electronegativity decreases because the atomic radius increases and the effective nuclear charge on the valence electrons decreases.

Step 4: Top 3 Electronegative Elements -
1. Fluorine (F) ≈ 4.0
2. Oxygen (O) ≈ 3.5
3. Nitrogen (N) / Chlorine (Cl) ≈ 3.0

> Quick Tip
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> The "FON" rule (Fluorine, Oxygen, Nitrogen) helps remember the most electronegative elements, which are also the elements capable of forming Hydrogen bonds.

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9. Probability of getting odd numbers in first 100 numbers

Solution:
Step 1: Identify the Sample Space (S) -
The "first 100 numbers" usually refers to the natural numbers from 1 to 100. The total number of outcomes is:

$$n(S) = 100$$

Step 2: Identify the Event (E) -
The event E is getting an odd number. Odd numbers are those not divisible by 2. The set of odd numbers in this range is $\{1, 3, 5, \ldots, 99\}$.
Step 3: Count the number of favorable outcomes ($n(E)$) -
In any sequence of consecutive natural numbers starting from 1, half are even and half are odd.

$$n(E) = \frac{100}{2} = 50$$

Step 4: Calculate the Probability ($P(E)$) -
The formula for probability is:

$$P(E) = \frac{n(E)}{n(S)}$$

$$P(E) = \frac{50}{100} = \frac{1}{2} \text{ or } 0.5$$

Step 5: Express as percentage -
The probability is 50%.

> Quick Tip
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> For any range of numbers 1 to $2n$, there will always be exactly n even and n odd numbers. The probability of picking either will always be 1/2.
