CHEMISTRY (CODE - 043)

CHAPTER TEST - STEP-BY-STEP SOLUTIONS AND MARKING SCHEME

Class XI (2026-27) | Chapter 9: Hydrocarbons

Max. Marks: 35

SECTION A (12 × 1 = 12 marks)

Each correct answer carries 1 mark.

Q1. Ans: B. 3 [1]

C_5H_{12} has three chain isomers: pentane (continuous chain), 2-methylbutane (isopentane) and 2,2-dimethylpropane (neopentane).

Q2. Ans: D. Q is more stable than P [1]

P (back bonds almost behind the front bonds) is the eclipsed conformation and Q is the staggered conformation. The staggered form has the minimum torsional strain (electron clouds farthest apart), so it is more stable. P and Q are conformers, not structural isomers.

Q3. Ans: C. Ethane [1]

Kolbe's electrolysis: $2CH_3COO^- \rightarrow 2CH_3\bullet + 2CO_2$ (at the anode); $CH_3\bullet + \bullet CH_3 \rightarrow CH_3–CH_3$. Two acetate ions give an alkane with twice the carbon atoms of the alkyl group, i.e. ethane.

Q4. Ans: A. P is cis and has a higher dipole moment than Q [1]

In P both CH_3 groups are on the same side of C=C (cis); the bond dipoles add up (μ = 0.33 D). In Q (trans) the dipoles cancel (μ ≈ 0). Cis-but-2-ene boils at 277 K, trans at 274 K.

Q5. Ans: B. 2-Bromopropane [1]

By Markovnikov's rule the negative part (Br) goes to the carbon with fewer hydrogens (C-2): $CH_3CH{=}CH_2 + HBr \rightarrow CH_3CHBrCH_3$ (through the more stable secondary carbocation).

Q6. Ans: A. Ethanal and methanal [1]

$CH_3CH{=}CH_2 + O_3 \rightarrow$ ozonide $\rightarrow$ (Zn, H_2O) $\rightarrow CH_3CHO + HCHO$.

Q7. Ans: B. Ethyne [1]

The H atoms of ethyne are acidic (the sp carbon, 50% s character, is the most electronegative): $HC{\equiv}CH + Na \rightarrow HC{\equiv}C^-Na^+ + ½H_2$. Ethane, ethene and benzene do not react.

Q8. Ans: D. Cyclopentadienyl anion [1]

It is planar, has complete delocalisation and 6 π electrons = (4n + 2) with n = 1 (Hückel rule). Cyclooctatetraene (8π), cyclopentadiene (an sp^3 carbon, not completely conjugated) and cyclohexene are not aromatic.

Q9. Ans: C. $–NO_2$ [1]

$–NO_2$ is a strongly electron-withdrawing group (–I, –R) and is meta directing. –OH, $–CH_3$ and $–NH_2$ are ortho/para directing activators.

Q10. Ans: A. Both A and R are true, and R is the correct explanation of A. [1]

In the staggered form the C–H bond clouds are farthest apart, so repulsion (torsional strain) is minimum, energy is lowest and stability is highest.

Q11. Ans: C. A is true but R is false. [1]

In the presence of peroxide (Kharash effect) HBr adds contrary to Markovnikov's rule to give 1-bromopropane (A true). The peroxide effect is shown only by HBr, not by HCl or HI (R false).

Q12. Ans: D. A is false but R is true. [1]

Benzene is highly stable because of delocalised π electrons (resonance), so it undergoes electrophilic substitution; addition occurs only under vigorous conditions. A is false; R is true.

SECTION B (4 × 2 = 8 marks)

Q13. [2]

(i) P = **2-bromopropane**; Q = **1-bromopropane**. [½] P is formed according to **Markovnikov's rule**: the negative part of the addendum attaches to the carbon atom with fewer hydrogen atoms. [½]

(ii) Q is formed by the **peroxide effect (Kharash effect, anti-Markovnikov addition)**, which occurs only with HBr. [½] The mechanism is a **free radical chain mechanism** (Br• adds to give the more stable secondary free radical). [½]

Q14. [2]

(i) Pentane (309.1 K). [½]

(ii) Boiling point decreases with branching. A straight-chain molecule has a larger surface area and hence stronger intermolecular van der Waals forces. [½] With more branches the molecule becomes more spherical and the area of contact is smaller, so the intermolecular forces are weaker and are overcome at a lower temperature. [½] Hence b.p.: pentane (309.1 K) > 2-methylbutane (300.9 K) > 2,2-dimethylpropane (282.5 K). [½]

Q15. [2]

(i) $CH_3Br + 2Na + BrCH_3 \rightarrow$ (dry ether) $\rightarrow CH_3–CH_3 + 2NaBr$ [1]

(ii) $CH_3CH_2COONa + NaOH \rightarrow$ (CaO, Δ) $\rightarrow CH_3CH_3 + Na_2CO_3$ [1]

Q16. [2]

–OH: **ortho/para**; $–NO_2$: **meta**; –Cl: **ortho/para** (deactivating but o/p directing); $–CH_3$: **ortho/para**. [½ each]

OR

Conditions: (a) planarity; (b) complete delocalisation of the π electrons in the ring; (c) presence of (4n + 2) π electrons, where n = 0, 1, 2, … (Hückel rule). [1]

Benzene is planar with six delocalised π electrons: 4n + 2 = 6 → n = 1 (an integer), so it is aromatic. [1]

SECTION C (2 × 3 = 6 marks)

Q17. [3]

(i) Initiation: homolysis of the Cl–Cl bond by light or heat: Cl–Cl → (hν) → 2Cl• (chlorine free radicals). [1]

(ii) Propagation: (a) $CH_4 + Cl• \rightarrow •CH_3 + HCl$ (b) $•CH_3 + Cl–Cl \rightarrow CH_3Cl + Cl•$ [½ each]

(iii) Termination: $•CH_3 + •CH_3 \rightarrow CH_3–CH_3$ (two methyl radicals combine, forming ethane as a by-product). [Other acceptable steps: Cl• + Cl• → Cl–Cl; $•CH_3 + Cl• \rightarrow CH_3Cl$, but the ethane-forming step is required.] [1]

Q18. [3]

(i) The two fragments $CH_3CH=$ and $=CH–CH_2CH_3$ join: A = **$CH_3CH=CHCH_2CH_3$, pent-2-ene**. [½ + ½]

(ii) $CH_3CH=CH–CH_2CH_3 + O_3 \rightarrow$ ozonide → (Zn + H_2O) → **CH_3CHO (ethanal) + CH_3CH_2CHO (propanal)**. [½ + ½]

(iii) Yes. Each doubly bonded carbon carries two different groups (CH_3/H on C-2 and C_2H_5/H on C-3) and rotation about C=C is restricted. [½] *cis*-pent-2-ene: CH_3 and C_2H_5 on the same side of C=C; *trans*-pent-2-ene: CH_3 and C_2H_5 on opposite sides. [½]

SECTION D (1 × 4 = 4 marks)

Q19. [4]

(i) P = chloroethane (C_2H_5Cl); Q = ethene ($CH_2=CH_2$); R = 1,2-dibromoethane ($BrCH_2CH_2Br$); S = ethyne (HC≡CH). [¼ each]

(ii) P → Q: dehydrohalogenation (β-elimination). Q → R: addition of bromine (electrophilic addition). [½] The reddish-orange colour of bromine in CCl_4 is decolourised – a test for unsaturation. [½]

(iii) 3HC≡CH → (red hot iron tube, 873 K) → C_6H_6 (benzene); this is **cyclic polymerisation** of ethyne. [½ + ½]

(iv) Free radical (chain) substitution (halogenation). Initiation: Cl–Cl → (hν, homolysis) → 2Cl•. [½ + ½]

SECTION E (1 × 5 = 5 marks)

Q20. [5]

(i) $C_6H_6 + CH_3Cl \rightarrow$ (anhyd. $AlCl_3$) $\rightarrow C_6H_5CH_3 + HCl$: **Friedel–Crafts alkylation**. [½] Electrophile: $CH_3Cl + AlCl_3 \rightarrow CH_3^+ + [AlCl_4]^-$ [½]

(ii) The intermediate is the **carbocation (arenium ion or σ-complex)**. The carbon bearing E and H is **sp^3** hybridised. [½] It is stabilised by resonance: the positive charge is delocalised over the ortho and para positions (structures I–III). [½]

(iii) Removal of proton: $[AlCl_4]^-$ removes H^+ from the sp^3 carbon of the σ-complex, restoring aromaticity: σ-complex + $[AlCl_4]^- \rightarrow C_6H_5CH_3 + HCl + AlCl_3$. [1]

(iv) The $–NO_2$ group withdraws electrons from the ring (strong –I and –R effects), so the overall electron density of the ring decreases and further substitution becomes difficult (deactivating group). [1] In the resonance structures of nitrobenzene the electron density at the ortho and para positions is lower than at the meta position, so the electrophile attacks the relatively electron-rich meta position. [1]

OR

(i) $C_4H_{10} + 13/2\ O_2 \rightarrow 4CO_2 + 5H_2O$ [½]; $C_nH_{2n+2} + ((3n + 1)/2)\ O_2 \rightarrow nCO_2 + (n + 1)H_2O$ [1]

(ii) Aromatisation (reforming): $C_6H_{14} \rightarrow C_6H_6 + 4H_2$ (dehydrogenation and cyclisation) [½] with catalyst Cr_2O_3 (or V_2O_5 or Mo_2O_3) [½] at 773 K, 10–20 atm. [½]

(iii) Isomerisation; products: 2-methylpentane, $CH_3CH(CH_3)CH_2CH_2CH_3$, and 3-methylpentane, $CH_3CH_2CH(CH_3)CH_2CH_3$. [½ + ½]

(iv) n-Heptane ($C_7H_{16} \rightarrow C_6H_5CH_3 + 4H_2$) – toluene is the methyl derivative of benzene. [1]

***** END OF SOLUTIONS *****