Master Testing Agency
Practice papers, exam-standard · www.mastertestingagency.com

Hydrocarbons — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · CHEMISTRY · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Master Testing Agency is an independent test-prep publisher, not affiliated with, endorsed by or connected to the National Testing Agency (NTA), the IITs or any other exam-conducting body.

Topics covered: Conformations of alkanes · Preparation of alkanes · Alkanes: properties · Addition to alkenes · Ozonolysis · Alkynes · Benzene and aromaticity · Electrophilic substitution · Directive influence

SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

1. Which of the following statements about the conformations of ethane is correct?

(1) The eclipsed conformation is more stable than the staggered one.

(2) The two conformations can be separated at room temperature.

(3) The energy difference between them is only about 12.5 kJ/mol, so rotation about the C–C bond is almost free at room temperature.

(4) In the staggered conformation every pair of C–H bonds on adjacent carbons is at a dihedral angle of 180°.

2. A mixture of bromomethane and bromoethane is treated with sodium in dry ether. The alkanes formed are

(1) ethane, propane and butane

(2) propane only

(3) ethane and butane only

(4) methane, ethane and propane

3. Electrolysis of a concentrated aqueous solution of sodium propanoate gives, at the anode, an alkane. The alkane is

(1) ethane

(2) propane

(3) hexane

(4) butane

4. Propene reacts with HBr (i) in the dark without peroxide and (ii) in the presence of benzoyl peroxide. The main products are, respectively,

(1) 1-bromopropane and 2-bromopropane

(2) 2-bromopropane and 1-bromopropane

(3) 2-bromopropane in both

(4) 1-bromopropane in both

5. Assertion A: Propene gives anti-Markovnikov addition with HBr in the presence of peroxide, but not with HCl.
Reason R: The H–Cl bond is so strong that its homolysis by a radical in the chain step is too endothermic, so the free-radical chain does not run.
In the light of the above statements, choose the correct answer from the options given below:

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

(2) Both A and R are true but R is NOT the correct explanation of A

(3) A is true but R is false

(4) A is false but R is true

6. An alkene C_6H_{12} on ozonolysis followed by treatment with Zn/H_2O gives propanone as the only product. The alkene is

(1) hex-3-ene

(2) 2-methylpent-2-ene

(3) 2,3-dimethylbut-2-ene

(4) 3,3-dimethylbut-1-ene

7. Cold, dilute, alkaline $KMnO_4$ (Baeyer's reagent) reacts with ethene to give

(1) ethane-1,2-diol

(2) ethanal

(3) ethanoic acid

(4) two molecules of methanal

8. Which of the following gives a white precipitate with ammoniacal silver nitrate solution?

(1) but-2-yne

(2) but-1-ene

(3) but-1-yne

(4) buta-1,3-diene

9. The correct order of acidic strength of the following is

(1) $CH_3–CH_3 > CH_2=CH_2 > HC\equiv CH$

(2) $CH_2=CH_2 > HC\equiv CH > CH_3–CH_3$

(3) $HC\equiv CH > CH_2=CH_2 > CH_3–CH_3$

(4) $HC\equiv CH > CH_3–CH_3 > CH_2=CH_2$

10. Propyne is passed into dilute H_2SO_4 containing $HgSO_4$ at 333 K. The final product is

(1) propanal

(2) propan-2-ol

(3) propanoic acid

(4) propanone

11. Which of the following species is aromatic?

(1) cyclobutadiene

(2) cyclopropenyl cation

(3) cyclooctatetraene

(4) cycloheptatrienyl anion

12. The electrophiles in the nitration, sulphonation and chlorination ($Cl_2/FeCl_3$) of benzene are, respectively,

(1) NO_2^+, SO_3 and Cl^+

(2) NO_3^-, HSO_4^- and Cl^-

(3) NO_2^+, HSO_4^- and Cl_2

(4) HNO_3, SO_3 and $FeCl_4^-$

13. Which of the following groups deactivates the benzene ring towards electrophilic substitution but directs the incoming group to the ortho and para positions?

(1) $–NO_2$

(2) $–CH_3$

(3) –OH

(4) –Cl

14. The correct order of reactivity towards electrophilic nitration is

(1) $C_6H_6 > C_6H_5CH_3 > C_6H_5OH > C_6H_5NO_2$

(2) $C_6H_5OH > C_6H_5CH_3 > C_6H_6 > C_6H_5NO_2$

(3) $C_6H_5CH_3 > C_6H_5OH > C_6H_6 > C_6H_5NO_2$

(4) $C_6H_5NO_2 > C_6H_6 > C_6H_5CH_3 > C_6H_5OH$

15. Benzene is treated with 1-chloropropane in the presence of anhydrous $AlCl_3$. The main product is

(1) propylbenzene

(2) isopropylbenzene (cumene)

(3) 1,3-dipropylbenzene

(4) chlorobenzene

16. 10 mL of a gaseous hydrocarbon needs exactly 55 mL of oxygen for complete combustion and gives 40 mL of CO_2, all volumes measured at the same temperature and pressure. The formula of the hydrocarbon is

(1) C_4H_8

(2) C_3H_8

(3) C_4H_{10}

(4) C_4H_6

17. Sodium butanoate is heated with soda lime. The hydrocarbon formed is

(1) butane

(2) propane

(3) propene

(4) hexane

18. Statement I: All six carbon–carbon bonds in benzene have the same length, 139 pm, which lies between the C–C single bond (154 pm) and the C=C double bond (134 pm).
Statement II: Benzene readily undergoes addition reactions like alkenes, decolourising bromine water.
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 true but Statement II is false

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

(4) Both Statement I and Statement II are false

19. The halogenation of methane with iodine is carried out in the presence of an oxidising agent such as HIO_3 because

(1) iodine does not react with methane at all

(2) HIO_3 makes iodine radicals

(3) the HI formed is a strong reducing agent and reverses the reaction

(4) HIO_3 is a catalyst for all halogenations

20. 2-Methylbut-2-ene reacts with HBr in the absence of peroxide. The main product is

(1) 2-bromo-2-methylbutane

(2) 2-bromo-3-methylbutane

(3) 1-bromo-2-methylbutane

(4) 1-bromo-3-methylbutane

SECTION B (Q21–25) · Numerical value · +4 / 0 / −1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

21. In the free-radical chlorination of propane at 298 K, a secondary hydrogen is replaced 3.8 times as fast as a primary hydrogen. The percentage of 2-chloropropane in the monochlorinated product (to the nearest integer) is _____.

Answer: _____

22. The volume (in L, at STP, to the nearest integer) of ethyne obtained when 32 g of calcium carbide reacts completely with water is _____. (Ca = 40, C = 12; molar volume 22.4 L)

Answer: _____

23. A mixture of bromomethane, bromoethane and 2-bromopropane is treated with sodium in dry ether (Wurtz reaction). The number of different alkanes that can be formed is _____.

Answer: _____

24. The number of structurally isomeric alkynes with the molecular formula C_5H_8 is _____.

Answer: _____

25. The number of the following substituents on a benzene ring that direct an incoming electrophile to the ortho and para positions is _____.

–OH, $–NH_2$, $–CH_3$, –Cl, –Br, $–NO_2$, –CHO, –COOH, –CN, $–OCH_3$, $–NHCOCH_3$, $–SO_3H$

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(3)	(1)	(4)	(2)	(1)	(3)	(1)	(3)	(3)	(4)

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(2)	(1)	(4)	(2)	(2)	(4)	(2)	(2)	(3)	(1)

Q21	Q22	Q23	Q24	Q25
56	11	6	3	7

WORKED SOLUTIONS

Q1. Answer (3). The staggered form is more stable (less torsional strain). The barrier is only about 12.5 kJ/mol, about 5RT at 298 K, so molecules interconvert very rapidly and cannot be separated. In the staggered form the dihedral angles are 60° and 180°, not all 180°.

Q2. Answer (1). In the Wurtz reaction any two alkyl groups can join: $CH_3 + CH_3 \rightarrow$ ethane, $CH_3 + C_2H_5 \rightarrow$ propane and $C_2H_5 + C_2H_5 \rightarrow$ butane. This is why the Wurtz reaction is not a good way to make an alkane with an odd number of carbons.

Q3. Answer (4). Kolbe's electrolysis: $2CH_3CH_2COO^- \rightarrow 2CH_3CH_2COO\bullet + 2e^- \rightarrow 2CH_3CH_2\bullet + 2CO_2$, and two ethyl radicals join to give butane, $CH_3CH_2CH_2CH_3$.

Q4. Answer (2). (i) Ionic addition: H^+ adds to C-1 to give the more stable secondary carbocation, so Br goes to C-2 (Markovnikov): 2-bromopropane. (ii) With peroxide a Br• radical adds first, to C-1, giving the more stable secondary radical; then H is taken from HBr: 1-bromopropane (anti-Markovnikov).

Q5. Answer (1). The peroxide effect is a free-radical chain. With HCl the step in which a carbon radical takes H from HCl is endothermic (H–Cl is strong), and with HI the I• radical adds to C=C too slowly; only with HBr are both steps fast. Both are true and R explains A.

Q6. Answer (3). Ozonolysis cuts the C=C and turns each end into C=O. Two molecules of $(CH_3)_2C{=}O$ come from $(CH_3)_2C{=}C(CH_3)_2$, 2,3-dimethylbut-2-ene. Hex-3-ene gives propanal; 2-methylpent-2-ene gives propanone and propanal; 3,3-dimethylbut-1-ene gives methanal and 2,2-dimethylpropanal.

Q7. Answer (1). Baeyer's reagent adds two OH groups across the double bond (syn addition), giving ethane-1,2-diol, and its pink colour disappears; this is a test for unsaturation. Hot acidic $KMnO_4$ would cleave the C=C instead.

Q8. Answer (3). Only a terminal alkyne has an acidic H on an sp carbon (≡C–H), which is replaced by Ag to give the alkynide $CH_3CH_2C{\equiv}CAg$. But-2-yne has no ≡C–H, and alkenes have no acidic H.

Q9. Answer (3). The more s character in the C–H carbon's orbital (sp 50%, sp^2 33%, sp^3 25%), the closer the electron pair of the conjugate base is held to the nucleus and the more stable the carbanion. So $HC{\equiv}CH > CH_2{=}CH_2 > CH_3{-}CH_3$.

Q10. Answer (4). Water adds by Markovnikov's rule: OH goes to the more substituted carbon C-2, giving the enol $CH_3{-}C(OH){=}CH_2$, which tautomerises to the ketone CH_3COCH_3 (propanone).

Q11. Answer (2). Aromatic: planar, cyclic, fully conjugated, with $(4n + 2)$ π electrons. Cyclopropenyl cation has 2 π electrons ($n = 0$). Cyclobutadiene (4) and the cycloheptatrienyl anion (8) have 4n electrons; cyclooctatetraene (8) is also tub-shaped, not planar.

Q12. Answer (1). $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ (nitronium ion); in fuming sulfuric acid the electrophile is SO_3; $Cl_2 + FeCl_3 \rightarrow Cl^+ + FeCl_4^-$.

Q13. Answer (4). Halogens withdraw electrons by the −I effect (deactivating) but donate a lone pair by the +R effect, which stabilises the ortho and para intermediates (o/p directing). $–NO_2$ deactivates and directs meta; $–CH_3$ and –OH activate and direct o/p.

Q14. Answer (2). Electron donation raises the ring's electron density: –OH (+R, strong) > $–CH_3$ (+I, hyperconjugation) > H. $–NO_2$ withdraws strongly. So phenol > toluene > benzene > nitrobenzene.

Q15. Answer (2). $AlCl_3$ gives a primary propyl carbocation (or a polarised complex), which rearranges by a 1,2-hydride shift to the more stable secondary isopropyl cation before attacking the ring. The main product is isopropylbenzene.

Q16. Answer (4). $C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O$. From CO_2: x = 40/10 = 4. From O_2: x + y/4 = 55/10 = 5.5, so y = 6: C_4H_6.

Q17. Answer (2). Decarboxylation: $CH_3CH_2CH_2COONa + NaOH\ (CaO) \rightarrow CH_3CH_2CH_3 + Na_2CO_3$. The alkane has one carbon fewer than the acid salt: propane.

Q18. Answer (2). Delocalisation of the six π electrons makes all C–C bonds equal (139 pm): I is true. The same delocalisation (resonance energy) makes benzene resist addition; it prefers substitution, which keeps the aromatic ring, and does not decolourise bromine water: II is false.

Q19. Answer (3). $CH_4 + I_2 \rightleftharpoons CH_3I + HI$ is reversible because HI reduces CH_3I back to CH_4. An oxidising agent (HIO_3 or HNO_3) removes HI: $5HI + HIO_3 \rightarrow 3I_2 + 3H_2O$, driving the reaction forward.

Q20. Answer (1). H^+ adds to C-3 to give the tertiary carbocation at C-2 (rather than a secondary one at C-3); Br^- then attaches there: $(CH_3)_2CBr–CH_2–CH_3$, 2-bromo-2-methylbutane.

Q21. Answer 56. Propane has 6 primary H and 2 secondary H. Relative amounts: 1-chloro ∝ 6 × 1 = 6; 2-chloro ∝ 2 × 3.8 = 7.6. Percentage of 2-chloropropane = 7.6/13.6 × 100 = 55.9, i.e. 56.

Q22. Answer 11. $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$. 32 g CaC_2 = 32/64 = 0.5 mol, giving 0.5 mol C_2H_2 = 11.2 L, i.e. 11.

Q23. Answer 6. Each pair of alkyl groups can join: $CH_3–CH_3$ (ethane), $CH_3–C_2H_5$ (propane), $CH_3–CH(CH_3)_2$ (2-methylpropane), $C_2H_5–C_2H_5$ (butane), $C_2H_5–CH(CH_3)_2$ (2-methylbutane) and $(CH_3)_2CH–CH(CH_3)_2$ (2,3-dimethylbutane). All six are different.

Q24. Answer 3. Pent-1-yne, pent-2-yne and 3-methylbut-1-yne. (A triple bond cannot sit next to a carbon with four bonds already, so 2-methyl- and 3-methylbut-2-yne do not exist.) Answer 3.

Q25. Answer 7. o/p directing: –OH, $–NH_2$, $–CH_3$, –Cl, –Br, $–OCH_3$ and $–NHCOCH_3$ (each has a lone pair next to the ring or donates electrons). Meta directing: $–NO_2$, –CHO, –COOH, –CN and $–SO_3H$. Answer 7.

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: structures were built as graphs; ozonolysis, Wurtz and Kolbe products were worked out on the graphs, the direction of addition from the stability of the intermediate formed, isomer counts by enumeration, and combustion and yields by stoichiometry; directive effects come from a separate table.