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Some Basic Principles of Organic Chemistry — 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.

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Topics covered: Hybridisation and shapes · IUPAC nomenclature · Isomerism · Fission of a covalent bond · Reaction intermediates · Electrophiles and nucleophiles · Electronic effects · Types of organic reactions

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

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

1. The hybridisation of the carbon atoms C-1, C-2 and C-3 in acrylonitrile, $CH_2=CH–C\equiv N$ (numbering from the left), are, respectively,

(1) sp^2, sp and sp

(2) sp^2, sp^2 and sp

(3) sp^3, sp^2 and sp

(4) sp^2, sp^2 and sp^2

2. The IUPAC name of $(CH_3)_3C–CH_2–CH(CH_3)–CH_2–CH_3$ is

(1) 3,5,5-trimethylhexane

(2) 2,4,4-trimethylhexane

(3) 1,1,1,3-tetramethylpentane

(4) 2,2,4-trimethylhexane

3. The correct order of decreasing priority of the following functional groups in IUPAC nomenclature is

(1) –CHO > –COOH > –OH > –COOR

(2) –COOR > –COOH > –OH > –CHO

(3) –COOH > –COOR > –CHO > –OH

(4) –COOH > –CHO > –COOR > –OH

4. The IUPAC name of $CH_2=CH–CH_2–CH(OH)–CH_3$ is

(1) pent-1-en-4-ol

(2) pent-4-en-2-ol

(3) 4-hydroxypent-1-ene

(4) pent-3-en-2-ol

5. The reaction intermediate that has an sp^2-hybridised carbon with a vacant p orbital is

(1) a carbanion

(2) a free radical

(3) a carbocation

(4) a singlet carbene

6. The correct order of stability of the following free radicals is

(1) $C_6H_5CH_2\bullet > (CH_3)_3C\bullet > (CH_3)_2CH\bullet > CH_3\bullet$

(2) $(CH_3)_3C\bullet > C_6H_5CH_2\bullet > (CH_3)_2CH\bullet > CH_3\bullet$

(3) $CH_3\bullet > (CH_3)_2CH\bullet > (CH_3)_3C\bullet > C_6H_5CH_2\bullet$

(4) $(CH_3)_3C\bullet > (CH_3)_2CH\bullet > C_6H_5CH_2\bullet > CH_3\bullet$

7. Which of the following sets contains only electrophiles?

(1) BF_3, NH_3, NO_2^+

(2) BF_3, NO_2^+, SO_3

(3) $AlCl_3$, CN^-, SO_3

(4) $(CH_3)_3C^+$, H_2O, NO_2^+

8. The correct order of acid strength of the following acids is

(1) butanoic > 4-chlorobutanoic > 3-chlorobutanoic > 2-chlorobutanoic

(2) 2-chlorobutanoic > 4-chlorobutanoic > 3-chlorobutanoic > butanoic

(3) 3-chlorobutanoic > 2-chlorobutanoic > 4-chlorobutanoic > butanoic

(4) 2-chlorobutanoic > 3-chlorobutanoic > 4-chlorobutanoic > butanoic

9. Assertion A: The tert-butyl cation is more stable than the ethyl cation.
Reason R: The tert-butyl cation has nine α-hydrogens available for hyperconjugation, whereas the ethyl cation has three.
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

10. On the basis of hyperconjugation, the most stable of the following alkenes is

(1) but-1-ene

(2) 2-methylbut-2-ene

(3) pent-2-ene

(4) 2,3-dimethylbut-2-ene

11. Which of the following alkenes shows geometrical (cis–trans) isomerism?

(1) 2-methylbut-2-ene

(2) 3-ethylpent-2-ene

(3) pent-2-ene

(4) 1,1-dichloroprop-1-ene

12. Which of the following compounds has a chiral carbon atom?

(1) 2-methylbutan-1-ol

(2) pentan-3-ol

(3) 3-methylpentane

(4) 2-methylpropan-2-ol

13. $CH_3–O–CH_2–CH_2–CH_3$ and $CH_3–CH_2–O–CH_2–CH_3$ are

(1) chain isomers

(2) functional isomers

(3) metamers

(4) position isomers

14. Which of the following groups shows a +R (+M) effect when attached to a benzene ring?

(1) $-NO_2$

(2) –CHO

(3) –CN

(4) $-OCH_3$

15. Which of the following statements about resonance is NOT correct?

(1) The contributing structures differ only in the positions of electrons, not of nuclei.

(2) The resonance hybrid is more stable than any single contributing structure.

(3) The keto and enol forms of acetone are resonance structures of each other.

(4) All contributing structures have the same number of unpaired electrons.

16. Which of the following is an addition reaction?

(1) CH_3CH_2Br + alcoholic KOH $\rightarrow$ $CH_2{=}CH_2$ + KBr + H_2O

(2) C_6H_6 + Cl_2 ($FeCl_3$) $\rightarrow$ C_6H_5Cl + HCl

(3) CH_3CH_2Cl + aqueous KOH $\rightarrow$ CH_3CH_2OH + KCl

(4) $CH_2{=}CH_2$ + Br_2 $\rightarrow$ $BrCH_2{-}CH_2Br$

17. The correct order of the +I (electron-releasing inductive) effect of the alkyl groups is

(1) $CH_3- > CH_3CH_2- > (CH_3)_2CH- > (CH_3)_3C-$

(2) $(CH_3)_3C- > (CH_3)_2CH- > CH_3CH_2- > CH_3-$

(3) $(CH_3)_2CH- > (CH_3)_3C- > CH_3CH_2- > CH_3-$

(4) $CH_3CH_2- > CH_3- > (CH_3)_3C- > (CH_3)_2CH-$

18. The most stable of the following carbocations is

(1) $CH_3CH_2^+$

(2) $CH_2{=}CH{-}CH_2^+$

(3) $CH_3{-}O{-}CH_2^+$

(4) $(CH_3)_3C^+$

19. The number of structural isomers (open-chain and cyclic, stereoisomers not counted) with the molecular formula C_4H_8 is

(1) 5

(2) 4

(3) 6

(4) 3

20. Heterolytic fission of the C–Br bond in $(CH_3)_3C{-}Br$ gives

(1) $(CH_3)_3C\bullet$ and $Br\bullet$

(2) $(CH_3)_3C^-$ and Br^+

(3) $(CH_3)_3C^+$ and Br^-

(4) $(CH_3)_2C{=}CH_2$ and HBr

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. Ignoring stereoisomers, the number of saturated cyclic hydrocarbons (cycloalkanes, including alkyl-substituted rings) with the molecular formula C_6H_{12} is _____.

Answer: _____

22. The number of α-hydrogen atoms available for hyperconjugation with the double bond in 3-methylpent-2-ene, $CH_3–CH=C(CH_3)–CH_2–CH_3$, is _____.

Answer: _____

23. The number of chiral carbon atoms in $CH_3–CH(OH)–CH(Cl)–CH_2–CH(CH_3)–CH_2–CH_3$ is _____.

Answer: _____

24. The number of structural isomers of the alkane C_7H_{16} is _____.

Answer: _____

25. The number of nucleophiles among the following is _____.
H_2O, NH_3, BF_3, $AlCl_3$, CN^-, NO_2^+, CH_3O^-, $(CH_3)_3C^+$, I^-, CH_3OH

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

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

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

Q21	Q22	Q23	Q24	Q25
12	8	3	9	6

WORKED SOLUTIONS

Q1. Answer (2). A carbon with one π bond is sp^2 and one with two π bonds is sp. C-1 and C-2 share the C=C (one π each): sp^2, sp^2. C-3 is in C≡N (two π): sp.

Q2. Answer (4). The longest chain has six carbons (one CH_3 of the tert-butyl group, through to the CH_2CH_3 end). Numbering from the end nearer the branches gives locants 2,2,4 (the other direction gives 3,5,5): 2,2,4-trimethylhexane.

Q3. Answer (3). Seniority: carboxylic acid > sulfonic acid > ester > acid halide > amide > nitrile > aldehyde > ketone > alcohol > amine. So –COOH > –COOR > –CHO > –OH.

Q4. Answer (2). The –OH is the principal group (suffix -ol) and gets the lowest locant: numbering from the CH_3 end puts OH on C-2 and the double bond at C-4. Name: pent-4-en-2-ol.

Q5. Answer (3). A carbocation has three bonds and six valence electrons: the carbon is sp^2 (planar) and the unhybridised p orbital is empty. A free radical has one electron in that p orbital, and a carbanion is sp^3 with a lone pair.

Q6. Answer (1). The benzyl radical is delocalised over the ring by resonance and is the most stable. Among alkyl radicals stability follows the number of α-hydrogens for hyperconjugation: tert-butyl (9) > isopropyl (6) > methyl (0).

Q7. Answer (2). Electrophiles accept an electron pair: BF_3 and $AlCl_3$ (incomplete octet), NO_2^+ and carbocations (positive), SO_3 (electron-poor S). NH_3, H_2O and CN^- have lone pairs to donate and are nucleophiles.

Q8. Answer (4). Cl withdraws electrons by the −I effect, stabilising the carboxylate ion. The effect falls off quickly with distance, so acid strength falls as Cl moves away from –COOH: pKa 2.86 (2-Cl), 4.05 (3-Cl), 4.52 (4-Cl), 4.82 (no Cl).

Q9. Answer (1). Each C–H bond on a carbon next to the positive carbon can overlap with its empty p orbital (hyperconjugation), spreading the charge. $(CH_3)_3C^+$ has 3 × 3 = 9 such H, $CH_3CH_2^+$ only 3. Both are true and R explains A.

Q10. Answer (4). Count the α-hydrogens (on sp^3 carbons attached to the C=C): but-1-ene 2, pent-2-ene 5, 2-methylbut-2-ene 9, 2,3-dimethylbut-2-ene 12. The more α-H, the greater the hyperconjugative stabilisation.

Q11. Answer (3). Each carbon of the C=C must carry two different groups. Pent-2-ene: CH_3/H on one end and C_2H_5/H on the other, so cis and trans exist. In 2-methylbut-2-ene one end has two CH_3; in 3-ethylpent-2-ene one end has two C_2H_5; in $Cl_2C{=}CH{-}CH_3$ one end has two Cl.

Q12. Answer (1). In 2-methylbutan-1-ol, $HOCH_2{-}CH(CH_3){-}CH_2CH_3$, C-2 carries H, CH_3, C_2H_5 and CH_2OH: four different groups. Pentan-3-ol and 3-methylpentane have two identical ethyl groups on the central carbon, and 2-methylpropan-2-ol has three CH_3.

Q13. Answer (3). Both are ethers, $C_4H_{10}O$, with the same functional group but different alkyl groups on either side of the oxygen (methyl/propyl and ethyl/ethyl). This is metamerism.

Q14. Answer (4). The O of $–OCH_3$ has a lone pair that it can delocalise into the ring (+R). $–NO_2$, –CHO and –CN have multiple bonds to more electronegative atoms and pull π electrons out of the ring (−R).

Q15. Answer (3). Keto and enol forms differ in the position of a hydrogen atom, a nucleus, so they are tautomers (separate compounds in equilibrium), not resonance structures. The other three statements are rules of resonance.

Q16. Answer (4). In an addition the two reactants combine into one product and a multiple bond is used up: ethene + Br_2 → 1,2-dibromoethane. The others are elimination (1), and substitution (2 and 3).

Q17. Answer (2). Each alkyl group releases electrons relative to H; the more alkyl branches on the attached carbon, the stronger the +I effect: tert-butyl > isopropyl > ethyl > methyl.

Q18. Answer (3). In $CH_3–O–CH_2^+$ the oxygen lone pair forms a π bond to the cationic carbon ($CH_3–O^+=CH_2$), giving every atom an octet. This +R stabilisation outweighs the allyl resonance (charge only spread) and the hyperconjugation of the tert-butyl cation.

Q19. Answer (1). Alkenes: but-1-ene, but-2-ene, 2-methylpropene (3). Cycloalkanes: cyclobutane and methylcyclopropane (2). Total 5 (cis/trans but-2-ene counted once).

Q20. Answer (3). In heterolysis both bonding electrons go to one atom, the more electronegative one (Br, 2.8 against C, 2.5). This leaves the tertiary carbocation $(CH_3)_3C^+$ and bromide ion. Homolysis would give the two radicals.

Q21. Answer 12. Six-membered ring: cyclohexane (1). Five: methylcyclopentane (1). Four: ethylcyclobutane, 1,1-, 1,2- and 1,3-dimethylcyclobutane (4). Three: propyl- and isopropylcyclopropane, 1-ethyl-1-methyl-, 1-ethyl-2-methyl-, 1,1,2-trimethyl- and 1,2,3-trimethylcyclopropane (6). Total 12.

Q22. Answer 8. α-hydrogens are on sp^3 carbons attached to the C=C carbons: C-1 (CH_3, 3 H), the methyl on C-3 (3 H) and C-4 (CH_2, 2 H). C-5 is not attached to the double bond. Total 8.

Q23. Answer 3. C-2 (H, CH_3, OH, rest of chain), C-3 (H, Cl, $CH(OH)CH_3$, rest) and C-5 (H, CH_3, C_2H_5, CH_2–rest) each carry four different groups. C-4 and C-6 are CH_2 groups. Answer 3.

Q24. Answer 9. Heptane; 2- and 3-methylhexane; 2,2-, 2,3-, 2,4- and 3,3-dimethylpentane; 3-ethylpentane; 2,2,3-trimethylbutane. Total 9.

Q25. Answer 6. Nucleophiles donate an electron pair: H_2O, NH_3, CN^-, CH_3O^-, I^- and CH_3OH (6). BF_3, $AlCl_3$, NO_2^+ and $(CH_3)_3C^+$ are electrophiles.

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, and isomer counts, chiral centres, cis–trans isomerism, hyperconjugating hydrogens, hybridisation and alkane names were worked out from them; acid strengths from measured pKa values; and classifications against tables typed in separately from the questions.