Engineering Daily 29 [Set 04] EV - Answer Sheet

Organic Chemistry [Nomenclature + Isomerism + Alkenes, Alkynes + Aromatic Compounds + Polymers]

Total Marks: 50 **Negative Marks:** 0.25 **Time:** 1 Hour

MCQ 50 marks

1. **A. Every carbon is sp^3 hybridized**
Explanation: In an alkane, every carbon forms four σ bonds
So each carbon is sp^3 hybridized, with a tetrahedral bond angle of about 109.5°

2. **B.** CH_3CO^+
Explanation: $CH_3COCl + AlCl_3 \rightarrow CH_3C^+ = O + AlCl_4^-$
The acylium ion (CH_3CO^+) formed attacks the benzene ring to give acetophenone

3. **A. Their σ bonds are strong and nearly non-polar**
Explanation: Alkanes contain only strong σ bonds, with no π bonds or lone pairs
Carbon and hydrogen have nearly equal electronegativity, so the C − H bond is nearly non-polar
So there is no reactive site for attack by an electrophile or a nucleophile
This is why alkanes are called paraffins (little affinity)

4. **C. Propanoic acid and** CO_2
Explanation: Strong oxidation cleaves the triple bond
The $CH_3CH_2 - C \equiv$ part gives CH_3CH_2COOH
The terminal ≡ CH part gives HCOOH, which is further oxidized to $CO_2 + H_2O$

5. **C. Butanone and methanal**
Explanation: The double bond of $CH_2 = C(CH_3) - CH_2CH_3$ is cleaved
The $CH_2 =$ part gives HCHO (methanal)
The $= C(CH_3)C_2H_5$ part gives $CH_3COC_2H_5$ (butanone)

6. **A.** 1000–1200 atm
Explanation: The high-pressure process uses 1000–1200 atm, 200°C and a trace of O_2 as catalyst
$n\,CH_2 = CH_2 \rightarrow -[CH_2 - CH_2]_n-$

7. **D. Propan-2-ol**
Explanation: H_2SO_4 adds by Markovnikov's rule to give $CH_3CH(OSO_3H)CH_3$
Hydrolysis with water gives $CH_3CH(OH)CH_3$, i.e. propan-2-ol

8. **A. 4**
Explanation: 2-Methylbutane:
$(CH_3)_2CH - CH_2 - CH_3$
It has 4 kinds of distinct H: the two equivalent CH_3, the CH, the CH_2 and the terminal CH_3
Products: 1-chloro-2-methylbutane, 2-chloro-2-methylbutane, 2-chloro-3-methylbutane and 1-chloro-3-methylbutane
Therefore, 4 in total

9. **A. 2-Methyl-4-oxopentanal**
Explanation: Priority: aldehyde > ketone, so −CHO is the principal group and its carbon is C1
C1 (CHO), C2 (bearing CH_3), C3, C4 (C = O), C5
The ketone group is named with the prefix 'oxo'
Therefore, the name is 2-methyl-4-oxopentanal

10. **C.** 6.72 L
Explanation: $Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3C$
Molar mass of $Al_4C_3 = 4 \times 27 + 3 \times 12 = 144$
Moles = $\frac{14.4}{144} = 0.1$ mol
$CH_4 = 0.1 \times 3 = 0.3$ mol
Therefore, volume = $0.3 \times 22.4 = 6.72$ L

11. **B. 70%**
Explanation: Let the fraction of A in the mixture be x
Given, $45x + (-45)(1 - x) = 18$
or, $90x - 45 = 18$
or, $90x = 63$
Therefore, $x = 0.70$, i.e. A = 70%

12. **D. Methylglyoxal**
Explanation: In the presence of Zn, ozonolysis of an alkyne converts both triple-bond carbons into carbonyl groups that stay bonded together (a 1,2-dicarbonyl compound)
$CH_3 - C \equiv CH \rightarrow CH_3 - CO - CHO$
Product: methylglyoxal

13. **B. 2-Methylpropan-2-ol**
Explanation: Ease of dehydration: 3° > 2° > 1° alcohol, because the 3° carbocation is the most stable
2-Methylpropan-2-ol is a 3° alcohol
It dehydrates with only about 20% H_2SO_4 at 85°C to give 2-methylpropene

14. **B. Cyclopentadiene**

Explanation: Cyclopentadiene has an sp^3-hybridized CH_2 carbon in its ring
So the ring lacks a fully conjugated cyclic π system
Therefore, it is not aromatic

15. **A. Hexachlorobenzene (C_6Cl_6)**
Explanation: With a Lewis acid, electrophilic substitution occurs and the aromatic ring remains intact
With excess Cl_2, all ring H atoms are replaced step by step
$C_6H_6 + 6Cl_2 \xrightarrow{AlCl_3} C_6Cl_6 + 6HCl$

16. **B.** $HC \equiv CH$
Explanation: The higher the bond order, the shorter the bond
$HC \equiv CH$ has a carbon–carbon triple bond (bond order 3)
Therefore, its $C \equiv C$ bond is the shortest (about 1.20 Å)

17. **C. 6**
Explanation: Pent-1-ene: 1
Pent-2-ene (cis and trans): 2
2-Methylbut-1-ene: 1
3-Methylbut-1-ene: 1
2-Methylbut-2-ene: 1
Therefore, total = 1 + 2 + 1 + 1 + 1 = 6

18. **C. 7 σ, 3 π**
Explanation: There are 4 C − H bonds, each a σ bond
There are 3 carbon–carbon bonds, each containing 1 σ bond
Total σ = 4 + 3 = 7
π bonds: 1 in C = C and 2 in $C \equiv C$, 3 in total

19. **D. 2-Methylpropane**
Explanation: The R^- part of the Grignard reagent takes H^+ from water to form an alkane
$(CH_3)_3CMgBr + H_2O \rightarrow (CH_3)_3CH + Mg(OH)Br$
Product: 2-methylpropane (isobutane)

20. **D. Butane**
Explanation: $2R - X + Zn \rightarrow R - R + ZnX_2$
$2CH_3CH_2Cl + Zn \rightarrow CH_3CH_2 - CH_2CH_3 + ZnCl_2$
Product: butane

21. **A. The $-NO_2$ group strongly deactivates the ring**
Explanation: The strong −M and −I effects of $-NO_2$ make the ring electron-deficient
The weak electrophile R^+ cannot attack such a ring
For this reason, nitrobenzene is often used as a solvent for Friedel–Crafts reactions

22. **D. Hex-1-en-5-yne**
Explanation: From either end, the multiple-bond locant set is {1,5}, i.e. equal
In such a case, the double bond (ene) gets the lower number
Numbering from the CH_2 = end gives ene = 1, yne = 5
Therefore, the name is hex-1-en-5-yne

23. **D. 2-Methylbuta-1,3-diene**
Explanation: Natural rubber is a polymer of isoprene (cis-polyisoprene)
Isoprene: $CH_2 = C(CH_3) - CH = CH_2$
Therefore, the IUPAC name of the monomer is 2-methylbuta-1,3-diene

24. **B. Neopentane**
Explanation: Melting point depends on how closely the molecules pack in the crystal
Neopentane ($C(CH_3)_4$) is nearly spherical and highly symmetric, so it packs best in the crystal
Therefore, neopentane has the highest melting point (about −17°C)

25. **A. The sp carbon is more electronegative**
Explanation: An sp hybrid orbital has 50% s-character, so its electrons stay closer to the nucleus
So an sp carbon is more electronegative than sp^2 and sp^3 carbons
The C − H bond electrons are pulled towards carbon, so H^+ is released easily

26. **C.** CH_3COOCH_3 **and** CH_3CH_2COOH
Explanation: Both CH_3COOCH_3 and CH_3CH_2COOH have the molecular formula $C_3H_6O_2$
But one is an ester and the other a carboxylic acid, i.e. their functional groups differ
Therefore, they are functional group isomers

27. **B. Nylon-6,6**
Explanation: When nylon-6,6 forms, H_2O molecules are eliminated as hexamethylenediamine and adipic acid join
Therefore, nylon-6,6 is a condensation polymer

28. **A. 14**

Explanation: Anthracene ($C_{14}H_{10}$) has 7 C = C, i.e. 7 π bonds
π electrons = $7 \times 2 = 14$
$4n + 2 = 14 \Rightarrow n = 3$, so it is aromatic

29. C. Ethylbenzene
Explanation: In the Wurtz–Fittig reaction, an aryl and an alkyl group couple to give an alkylbenzene
$C_6H_5Br + 2Na + BrC_2H_5 \rightarrow C_6H_5 - C_2H_5 + 2NaBr$
Product: ethylbenzene

30. B. Propyne
Explanation: Two molecules of HBr are removed in two steps
$CH_3CH_2CHBr_2 \xrightarrow{KOH} CH_3CH = CHBr \xrightarrow{NaNH_2} CH_3C \equiv CH$
Removal of the second HBr needs the strong base $NaNH_2$
Product: propyne

31. B. H_3PO_2
Explanation: Hypophosphorous acid (H_3PO_2) replaces the diazonium group with H
$C_6H_5N_2Cl + H_3PO_2 + H_2O \rightarrow C_6H_6 + N_2 + H_3PO_3 + HCl$

32. C. Benzophenone
Explanation: This is a Friedel–Crafts acylation
$C_6H_6 + C_6H_5COCl \xrightarrow{AlCl_3}$
$C_6H_5 - CO - C_6H_5 + HCl$
$C_6H_5COC_6H_5$ is diphenyl ketone, i.e. benzophenone

33. C. 3-Ethyl-2-methylpentane
Explanation: The compound has more than one longest chain of 5 carbons
Among equal-length chains, the one with more substituents is the parent; that chain carries two substituents (methyl and ethyl)
Numbering puts methyl on C2 and ethyl on C3; ethyl comes first alphabetically
Therefore, the name is 3-ethyl-2-methylpentane

34. D. 2,3-Dimethylbutane
Explanation: In Kolbe electrolysis, $R - COO^-$ loses CO_2 at the anode to form the radical R·
Two R· radicals combine to give R − R
Here, R = $(CH_3)_2CH-$, so the product is $(CH_3)_2CH - CH(CH_3)_2$
Therefore, the product is 2,3-dimethylbutane

35. B. 2-Methylbut-2-ene
Explanation: Alcoholic KOH brings about elimination (dehydrohalogenation)
Saytzeff's rule: H is removed from the β-carbon (C3) bearing fewer H atoms
Therefore, the product is $(CH_3)_2C = CH - CH_3$, i.e. 2-methylbut-2-ene

36. B. 6
Explanation: $DU = C + 1 + \frac{N}{2} - \frac{H}{2}$
Here, C = 7, H = 5, N = 1
Therefore, $DU = 7 + 1 + \frac{1}{2} - \frac{5}{2} = 6$

37. A. C_4H_8
Explanation: Moles of $Br_2 = \frac{2.0}{160} = 0.0125$ mol
Alkene and Br_2 react in a 1 : 1 mole ratio, so moles of alkene = 0.0125 mol
$M = \frac{0.70}{0.0125} = 56$
For C_nH_{2n}, $14n = 56 \Rightarrow n = 4$
Therefore, the alkene is C_4H_8

38. B. −Cl
Explanation: For halogens, the −I effect outweighs the +M effect, so the ring is deactivated
However, the +M effect keeps the relative electron density higher at the ortho and para positions, so −Cl is ortho-para directing

39. A. E-isomer
Explanation: At C2: Br and CH_3; Br has priority (higher atomic number)
At C3: Cl and C_2H_5; Cl has priority
If Br and ethyl are on the same side, Br and Cl are on opposite sides
Therefore, it is the E-isomer

40. D. 2,4-Dinitrophenol
Explanation: −OH is the principal group, so the parent name is phenol and the carbon bearing −OH is C1
The two $-NO_2$ groups get the lowest locants, 2 and 4
Therefore, the name is 2,4-dinitrophenol

41. D. Glyoxal, methylglyoxal and dimethylglyoxal
Explanation: o-Xylene has two Kekulé structures
One gives: 2 methylglyoxal + 1 glyoxal
The other gives: 1 dimethylglyoxal + 2 glyoxal
So all three products are obtained, which is evidence for the Kekulé structures (resonance)

42. A. 2,3-Dimethylbut-2-ene

Explanation: A single product means the alkene is symmetric about its double bond
Joining the carbonyl carbons of two $(CH_3)_2C = O$ molecules with a double bond gives $(CH_3)_2C = C(CH_3)_2$
Therefore, the alkene is 2,3-dimethylbut-2-ene

43. **A. Propylbenzene**
Explanation: In Clemmensen reduction, the $C = O$ group becomes CH_2 and the carbon chain is unchanged
$C_6H_5COCH_2CH_3 + 4[H] \rightarrow C_6H_5CH_2CH_2CH_3 + H_2O$
Product: propylbenzene

44. **C.** $FeSO_4$ **and** H_2O_2
Explanation: Tetrafluoroethylene is polymerized using $FeSO_4$ and H_2O_2 as catalyst
$n\,CF_2 = CF_2 \xrightarrow{FeSO_4,\ H_2O_2} -[CF_2 - CF_2]_n-$ (Teflon)

45. **C. 8**
Explanation: Chiral carbons: C2, C3, C4, i.e. $n = 3$
The molecule is unsymmetrical, so optical isomers $= 2^n$
$= 2^3 = 8$

46. **C.** $HOOC - CH(Br) - CH(Br) - COOH$
Explanation: A meso compound needs two or more chiral carbons and an internal plane of symmetry
$HOOC - CH(Br) - CH(Br) - COOH$ (2,3-dibromobutanedioic acid) has two chiral carbons and two identical halves
Therefore, it can exist in a meso form

47. **D. 13**
Explanation: $nCO + (2n + 1)H_2 \rightarrow C_nH_{2n+2} + nH_2O$
For hexane, $n = 6$
$H_2 = 2 \times 6 + 1 = 13$ mol
$6CO + 13H_2 \rightarrow C_6H_{14} + 6H_2O$

48. **C. o- and p-Nitrotoluene**
Explanation: The $-CH_3$ group raises the electron density at the ortho and para positions through its +I effect and hyperconjugation
So NO_2^+ attacks mainly at the ortho and para positions, giving o- and p-nitrotoluene

49. **D. The trans isomer has the higher melting point**
Explanation: The trans isomer is more symmetric
So its molecules pack more closely in the crystal
Therefore, the trans isomer has the higher melting point

50. **D. But-2-ene**
Explanation: When two halogens are on adjacent carbons (vic-dihalide), Zn removes both Br atoms to form a double bond
$CH_3CHBr - CHBrCH_3 + Zn \rightarrow CH_3CH = CHCH_3 + ZnBr_2$
Product: but-2-ene