

PRACTICE PAPERS CHEMISTRY OLYMPIADS

STAGE – 1

Paper – 18

TIME: 1HR 30MIN

MAX MARKS: 180

- Attempt all the Questions.
- All questions carry +3 for right answer and -1 for wrong answer.
- Use of Calculator is allowed.

PERIODIC TABLE OF THE ELEMENTS

1 1A												18 8A							
1 H 1.008	2 He 4.003											3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95		
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80		
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3		
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)		
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (281)	111 Rg (272)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)		

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Name:

Correct Questions =

Wrong Questions =

Unattempt Questions =

Marks =

1. Glyoxal consists of 41.4% C, 3.5% H, and 55.1% O by mass. What is the empirical formula of glyoxal?
- (A) CHO (B) CH₂O
(C) CH₂O₂ (D) C₁₂H₁₆O₁₆
2. How many hydroxide ions are in 2.5 mol Mg(OH)₂?
- (A) 3.0×10^{23} (B) 6.0×10^{23}
(C) 1.5×10^{24} (D) 3.0×10^{24}
3. In a sample consisting of 1.00 mol NaBr and 0.300 mol KI, what is the mass percent of iodine?
- (A) 24.9% (B) 32.6% (C) 47.2% (D) 83.1%
4. What is the concentration of chloride ions in a solution formed by mixing 150. mL of a 1.50 M NaCl solution with 250. mL of a 0.750 M MgCl₂ solution?
- (A) 0.563 M (B) 1.03 M
(C) 1.50 M (D) 2.25 M
5. Barium chloride reacts with sodium sulfate according to the following equation:
- $$\text{BaCl}_2(aq) + \text{Na}_2\text{SO}_4(aq) \rightarrow \text{BaSO}_4(s) + 2 \text{NaCl}(aq)$$
- A student mixes a solution containing 10.0 g BaCl₂ ($M = 208.2$) with a solution containing 10.0 g Na₂SO₄ ($M = 142.1$) and obtains 12.0 g BaSO₄ ($M = 233.2$). What is the percent yield of this reaction?
- (A) 60.0%
(B) 73.1%
(C) 93.3%
(D) The isolated barium sulfate is most likely wet, since the yield would otherwise be greater than 100%.
6. Which aqueous solution has the highest boiling point?
- (A) 1.0 *m* acetic acid, CH₃COOH
(B) 1.0 *m* sulfuric acid, H₂SO₄
(C) 1.0 *m* phosphoric acid, H₃PO₄
(D) 1.0 *m* glucose, C₆H₁₂O₆
7. A white ionic solid is dissolved in water. Addition of a solution of sodium chloride to this solution results in a white precipitate. What was the cation in the original ionic solid?
- (A) Na⁺ (B) Fe³⁺ (C) Ag⁺ (D) Sr²⁺
8. An element is a solid at room temperature but soft enough to be cut with an ordinary knife. When placed in water, the element reacts violently. What element is it?
- (A) Na (B) Mg (C) Cu (D) Hg
9. A 0.1 M solution of which salt is the most basic?
- (A) NaNO₃ (B) NaClO₄
(C) NaHSO₄ (D) NaHCO₃
10. Addition of small amounts of which solids to 4 M HCl will result in gas evolution?
- I. Zn II. Na₂SO₃
- (A) I only (B) II only
(C) Both I and II (D) Neither I nor II
11. A student determines the acetic acid concentration of a sample of distilled vinegar by titration of 25.00 mL of the vinegar with standardized sodium hydroxide solution using phenolphthalein as an indicator. Which error will give an acetic acid content for the vinegar that is too low?
- (A) Some of the vinegar is spilled when being transferred from the volumetric flask to the titration flask.
(B) The NaOH solution is allowed to stand for a prolonged period after standardization and absorbs carbon dioxide from the air.
(C) The endpoint is recorded when the solution turns dark red instead of faint pink.
(D) The vinegar is diluted with distilled water in the titration flask before the NaOH solution is added.
12. Which piece of equipment would give the most precise delivery of 25.0 mL of a solution?
- (A) 25-mL graduated cylinder
(B) 25-mL syringe
(C) 25-mL beaker
(D) 25-mL volumetric pipet

13. A sample of neon gas is held at 25.0 °C and 1.0 atm in a cylinder with a movable piston. Under these conditions the gas occupies 5.0 L. What volume does the gas occupy at 12.5 °C and 1.0 atm?
 (A) 2.5 L (B) 4.8 L (C) 5.2 L (D) 10 L
14. The normal boiling points of molecular fluorine, chlorine, bromine, and iodine increase in that order. Which of the following statements accounts for this increase?
 (A) The chemical reactivity decreases in that order.
 (B) The London dispersion forces increase in that order.
 (C) The dipole-dipole forces increase in that order.
 (D) The hydrogen bonding increases in that order.
15. Quartz, SiO₂, is the most common mineral found on the surface of the earth. What is the best explanation for the fact that quartz is hard and has a high melting point?
 (A) Quartz crystals are extended structures in which each atom forms strong covalent bonds with all of its neighboring atoms.
 (B) Quartz crystals consist of positive and negative ions that are attracted to one another.
 (C) Quartz crystals are formed under extremes of temperature and pressure.
 (D) Silicon and oxygen atoms are especially hard because of their electronic structure.
16. The critical point of carbon dioxide is 304 K and 73 atm. Under which conditions is carbon dioxide a liquid?
 I. 303 K and 73 atm II. 305 K and 74 atm
 (A) I only (B) II only
 (C) Both I and II (D) Neither I nor II
17. The lattice energy (energy required to separate the ions in an ionic solid) of MgO is much larger than that of LiF. What contributes the most to this difference?
 (A) Mg²⁺ is a smaller ion than Li⁺, and O²⁻ is a smaller ion than F⁻.
 (B) F is more electronegative than O, and Li is more electropositive than Mg.
 (C) MgO contains doubly charged ions, while LiF contains singly charged ions.
 (D) MgO contains more electrons than LiF.
18. Which best describes the bonding in Cu(s)?
 (A) The copper atoms are positively charged in a sea of delocalized electrons.
 (B) The copper atoms are alternately positively and negatively charged.
 (C) The copper atoms form covalent bonds to adjacent copper atoms.
 (D) The copper atoms form hydrogen bonds to adjacent copper atoms.
19. A sample of 54.0 g of methanol is heated from 25.0 °C to 35.0 °C. How much heat is required? The specific heat capacity of methanol is 2.48 J g⁻¹ K⁻¹.
 (A) 0.00459 J (B) 0.0747 J
 (C) 1340 J (D) 4690 J
20. Given the standard enthalpy changes for the reactions:

$$\text{P}_4(\text{s}) + 3 \text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_6(\text{s}) \quad \Delta H^\circ = -1640 \text{ kJ mol}^{-1}$$

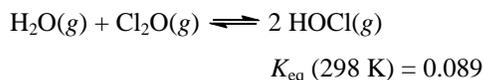
$$\text{P}_4(\text{s}) + 5 \text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s}) \quad \Delta H^\circ = -2940 \text{ kJ mol}^{-1}$$
 Calculate the standard enthalpy change ΔH° for the following reaction:

$$\text{P}_4\text{O}_6(\text{s}) + 2 \text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s})$$

 (A) $-4.58 \times 10^3 \text{ kJ mol}^{-1}$ (B) $-1.30 \times 10^3 \text{ kJ mol}^{-1}$
 (C) 1.79 kJ mol^{-1} (D) $4.82 \times 10^6 \text{ kJ mol}^{-1}$
21. At what temperature is the following reaction at equilibrium when all substances are at standard pressure? Assume that entropies and enthalpies of reaction do not vary with temperature.

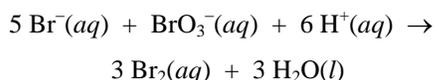
$$\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$$
- | Substance | $\Delta H^\circ_f, \text{ kJ mol}^{-1}$ | $S^\circ, \text{ J mol}^{-1} \text{ K}^{-1}$ |
|----------------------|-----------------------------------------|----------------------------------------------|
| PCl ₃ (g) | -288.7 | 311.6 |
| Cl ₂ (g) | 0 | 223.1 |
| PCl ₅ (g) | -374.9 | 364.2 |
- (A) 506 K (B) 1640 K
 (C) 1980 K (D) 4260 K
22. Given the bond dissociation enthalpies (BDE) below, what is the approximate ΔH°_f for H₂O(g)?
- | Bond | BDE, kJ mol ⁻¹ | Bond | BDE, kJ mol ⁻¹ |
|------|---------------------------|------|---------------------------|
| H-H | 432 | O-O | 146 |
| O-H | 467 | O=O | 495 |
- (A) -934 kJ mol^{-1} (B) $-510. \text{ kJ mol}^{-1}$
 (C) -429 kJ mol^{-1} (D) -255 kJ mol^{-1}
23. Which of the following are true for a spontaneous process in a system at constant temperature and pressure?
 I. $\Delta S_{\text{sys}} + \Delta S_{\text{surr}} > 0$ II. $\Delta G_{\text{sys}} < 0$
 (A) I only (B) II only
 (C) Both I and II (D) Neither I nor II

24. What is ΔG°_f of $\text{HOCl}(g)$ at 298 K?



- (A) -6.0 kJ mol^{-1}
 (B) -3.0 kJ mol^{-1}
 (C) 3.0 kJ mol^{-1}
 (D) It cannot be determined from the information given.

25. If elemental bromine is being formed according to the equation below at a rate of 0.056 M s^{-1} , at what rate is bromide ion being consumed?

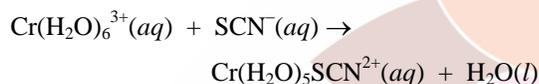


- (A) 0.019 M s^{-1} (B) 0.034 M s^{-1}
 (C) 0.056 M s^{-1} (D) 0.093 M s^{-1}

26. Thallium-201, a radioactive isotope used to image the heart, has a half-life of 3.05 d. How long would it take for a sample of thallium-201 to decay to 18% of its original activity?

- (A) 4.4 d (B) 6.1 d (C) 7.5 d (D) 17 d

27. For the reaction:



The following data were collected:

$[\text{Cr}(\text{H}_2\text{O})_6^{3+}]$, M	$[\text{SCN}^-]$, M	Rate, M hr^{-1}
0.028	0.040	8.1×10^{-6}
0.028	0.055	1.1×10^{-5}
0.037	0.055	1.5×10^{-5}

What is the rate law for the reaction?

- (A) $\text{Rate} = (9.1 \times 10^{-9} \text{ M}^{-1} \text{ hr}^{-1})[\text{Cr}(\text{H}_2\text{O})_6^{3+}][\text{SCN}^-]$
 (B) $\text{Rate} = (7.2 \times 10^{-3} \text{ M}^{-1} \text{ hr}^{-1})[\text{Cr}(\text{H}_2\text{O})_6^{3+}][\text{SCN}^-]$
 (C) $\text{Rate} = (2.9 \times 10^{-4} \text{ hr}^{-1})[\text{Cr}(\text{H}_2\text{O})_6^{3+}]$
 (D) $\text{Rate} = (3.9 \times 10^{-4} \text{ hr}^{-1})[\text{Cr}(\text{H}_2\text{O})_6^{3+}]$

28. In which of the following ways may a catalyst increase the rate of a reaction?

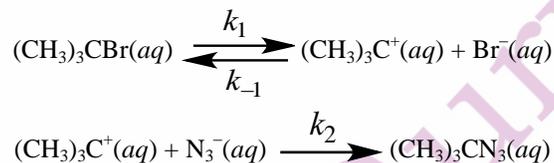
- I. It may alter the rate law.
 II. It may decrease the overall activation energy.

- (A) I only (B) II only
 (C) Both I and II (D) Neither I nor II

29. For an exothermic reaction, which of the following best describes the effect of increasing the temperature on the forward and reverse reactions?

- (A) Both the forward and reverse rates increase, but the forward rate increases more than the reverse rate.
 (B) Both the forward and reverse rates increase, but the reverse rate increases more than the forward rate.
 (C) The forward rate increases while the reverse rate decreases.
 (D) The reverse rate increases while the forward rate decreases.

30. The reaction of *tert*-butyl bromide with azide ion in aqueous solution is proposed to proceed by the following mechanism:



Assuming that $(\text{CH}_3)_3\text{C}^+(aq)$ achieves a steady-state concentration, but making no further assumptions about the relative magnitudes of the three rate constants, what is the rate law for this reaction?

- (A) $\text{Rate} = k_1[(\text{CH}_3)_3\text{CBr}]$
 (B) $\text{Rate} = k_2[(\text{CH}_3)_3\text{CBr}][\text{N}_3^-]$
 (C) $\text{Rate} = \frac{k_1 k_2 [(\text{CH}_3)_3\text{CBr}][\text{N}_3^-]}{k_{-1}[\text{Br}^-]}$
 (D) $\text{Rate} = \frac{k_1 k_2 [(\text{CH}_3)_3\text{CBr}][\text{N}_3^-]}{k_{-1}[\text{Br}^-] + k_2[\text{N}_3^-]}$

31. Which solution has the greatest percent ionization?

- (A) 0.010 M formic acid ($K_a = 1.8 \times 10^{-4}$)
 (B) 0.10 M formic acid ($K_a = 1.8 \times 10^{-4}$)
 (C) 0.010 M acetic acid ($K_a = 1.8 \times 10^{-5}$)
 (D) 0.10 M acetic acid ($K_a = 1.8 \times 10^{-5}$)

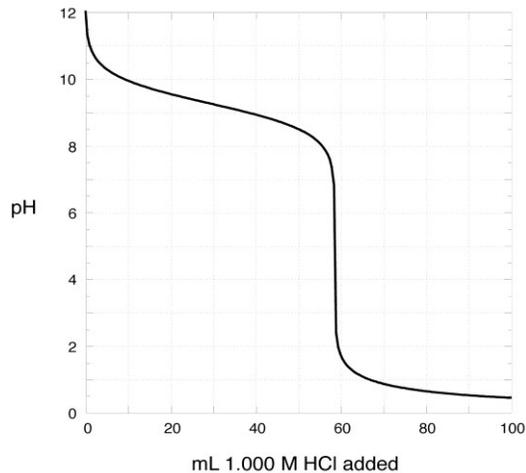
32. Calcium oxalate, CaC_2O_4 ($M = 128.1$), dissolves to the extent of 0.67 mg L^{-1} . What is its K_{sp} ?

- (A) 6.7×10^{-4} (B) 4.5×10^{-7}
 (C) 2.7×10^{-11} (D) 5.7×10^{-16}

33. What is the concentration of a solution of K_2CO_3 that has $\text{pH} = 11.90$? (For H_2CO_3 , $K_{a1} = 4.2 \times 10^{-7}$, $K_{a2} = 4.8 \times 10^{-11}$.)

- (A) $3.0 \times 10^{-1} \text{ M}$ (B) $2.6 \times 10^{-2} \text{ M}$
 (C) $7.9 \times 10^{-3} \text{ M}$ (D) $1.3 \times 10^{-12} \text{ M}$

34. 1.000 g of a weak base is titrated with 1.000 M aqueous HCl to give the data shown. What is the identity of the base?



- (A) Ammonia, NH_3 (pK_a of $\text{NH}_4^+ = 9.3$)
 (B) Aniline, $\text{C}_6\text{H}_5\text{NH}_2$ (pK_a of $\text{C}_6\text{H}_5\text{NH}_3^+ = 4.6$)
 (C) Hydroxylamine, NH_2OH (pK_a of $\text{NH}_3\text{OH}^+ = 6.0$)
 (D) Trimethylamine, $(\text{CH}_3)_3\text{N}$ (pK_a of $(\text{CH}_3)_3\text{NH}^+ = 9.8$)

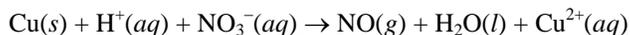
35. Sulfuryl chloride is in equilibrium with sulfur dioxide and chlorine gas:



A system with a volume of 1.00 L is in equilibrium at a certain temperature with $p(\text{SO}_2\text{Cl}_2) = 1.00$ bar and $p(\text{SO}_2) = p(\text{Cl}_2) = 0.10$ bar. By how much will the number of moles of SO_2Cl_2 at equilibrium change if the volume is reduced to 0.50 L?

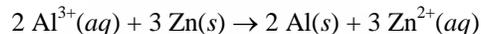
- (A) Increase 1-10% (B) Increase 11-50%
 (C) Decrease 1-10% (D) Decrease 11-50%
36. Which of the following will increase $[\text{Cl}^-]$ in a saturated solution of AgCl in contact with excess solid silver chloride?
- I. Addition of $\text{AgCl}(s)$ II. Addition of $\text{NH}_3(aq)$
- (A) I only (B) II only
 (C) Both I and II (D) Neither I nor II
37. Which is formed at the cathode during the electrolysis of aqueous AgF ?
- (A) $\text{Ag}(s)$ (B) $\text{H}_2(\text{g})$ (C) $\text{O}_2(\text{g})$ (D) $\text{F}_2(\text{g})$
38. In which of the following substances is chlorine in the lowest oxidation state?
- (A) Cl_2 (B) KCl (C) KClO (D) KClO_4

39. When the following reaction is balanced, what is the ratio of coefficients of $\text{H}^+(aq)$ to $\text{NO}(g)$?



- (A) 1 : 1 (B) 2 : 1 (C) 3 : 1 (D) 4 : 1

40. What is E° for the following reaction?



Half-Reaction	E°, V
$\text{Al}^{3+}(aq) + 3 e^- \rightarrow \text{Al}(s)$	-1.66
$\text{Zn}^{2+}(aq) + 2 e^- \rightarrow \text{Zn}(s)$	-0.76

- (A) -1.04 V (B) -0.90 V
 (C) 0.90 V (D) 1.04 V

41. Electrolysis of 1.00 g of a copper(II) salt required passage of 0.100 A of current for 123 min for complete deposition of all the copper metal. What is the copper salt?

- (A) $\text{CuCl}_2, M = 134.5$ (B) $\text{CuBr}_2, M = 223.4$
 (C) $\text{Cu}(\text{NO}_3)_2, M = 187.6$ (D) $\text{Cu}(\text{ClO}_4)_2, M = 262.5$

42. What is the K_{sp} of Hg_2Cl_2 at 298 K?

Half-Reaction	E°, V (at 298 K)
$\text{Hg}_2^{2+} + 2e^- \rightarrow 2 \text{Hg}(l)$	+0.80
$\text{Hg}_2\text{Cl}_2(s) + 2e^- \rightarrow 2 \text{Hg}(l) + 2 \text{Cl}^-(aq)$	+0.31

- (A) 2.6×10^{-17} (B) 3.3×10^{-11}
 (C) 5.1×10^{-9} (D) 5.7×10^{-6}

43. How many total orbitals are there with principal quantum number $n = 4$?

- (A) 1 (B) 4 (C) 9 (D) 16

44. Addition of an electron to a gas-phase Si atom results in the release of more energy than addition of an electron to a gas-phase P atom. What is the best explanation for their relative electron affinities?

- (A) The electron added to Si experiences less electron-electron repulsion than the electron added to P.
 (B) The electron added to Si enters a lower-energy subshell than the electron added to P.
 (C) Si is more electronegative than P.
 (D) Si is smaller than P.

45. The wavelength of one of the spectral lines of helium is 492 nm. What is the energy of a photon with this wavelength?

- (A) 3.26×10^{-40} J (B) 3.26×10^{-31} J
 (C) 4.04×10^{-28} J (D) 4.04×10^{-19} J

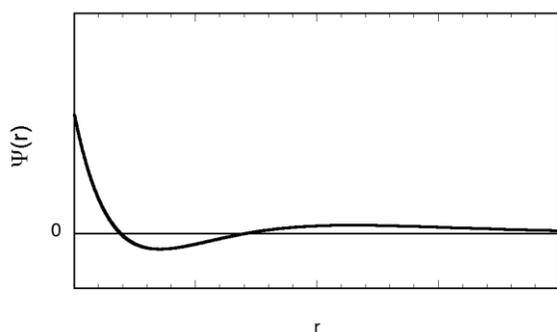
46. Which of the following gas-phase ions has the largest number of unpaired electrons in its ground state?

- (A) Cr^{3+} (B) Co^{3+} (C) Ni^{2+} (D) Cu^{2+}

47. ^{52}Mn undergoes radioactive decay to give ^{52}Cr by what decay mode?

- (A) Alpha emission (B) Beta emission
 (C) Positron emission (D) Gamma emission

48. An orbital has the radial wavefunction shown below. What orbital is it?



- (A) 1s (B) 2s (C) 3s (D) 4s

49. Which molecule has a dipole moment of zero?

- (A) CO (B) CO_2 (C) CH_2O (D) CH_3OH

50. What is the geometry of SF_4 ?

- (A) Tetrahedral
 (B) Square planar
 (C) See-saw
 (D) Trigonal monopiramidal

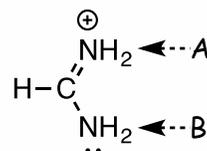
51. How many σ and π bonds are in 1,3-butadiene, $\text{H}_2\text{C}=\text{CH}-\text{CH}=\text{CH}_2$?

- (A) 7 σ and 2 π bonds (B) 2 σ and 7 π bonds
 (C) 9 σ and 2 π bonds (D) 2 σ and 9 π bonds

52. What is the formal charge on the central nitrogen in the Lewis structure of N_2O ?

- (A) 0
 (B) +1
 (C) -1
 (D) 0 in some resonance structures, -1 in other resonance structures

53. Shown below is a Lewis structure of the formamidinium ion. What geometry is exhibited by the two nitrogens in the formamidinium ion?



Geometry at A

- (A) trigonal planar
 (B) trigonal planar
 (C) trigonal pyramidal
 (D) trigonal pyramidal

Geometry at B

- trigonal planar
 trigonal pyramidal
 trigonal planar
 trigonal pyramidal

54. How many unpaired electrons are in the superoxide ion, O_2^- ?

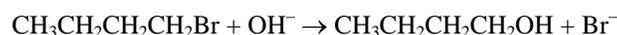
- (A) Zero (B) One (C) Two (D) Three

55. What is the relationship between the following two molecules?



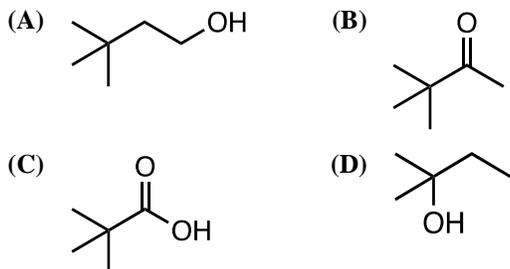
- (A) Structural isomers (B) Geometric isomers
 (C) Enantiomers (D) Identical

56. What is the role of hydroxide ion in the reaction below?

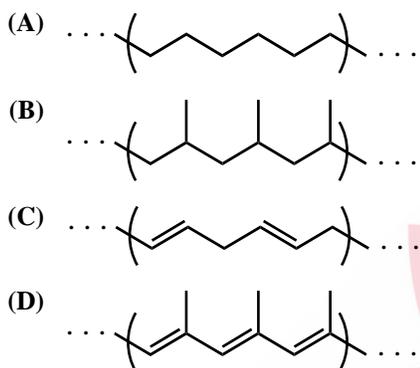


- (A) Oxidizing agent (B) Lewis acid
 (C) Catalyst (D) Nucleophile

57. Which compound reacts readily with Cr(VI) reagents?



58. What is the structure of polypropylene, formed by the polymerization of propene ($\text{CH}_2=\text{CHCH}_3$)?



59. The sequence of amino acids in a protein is known as its

- (A) primary structure. (B) secondary structure.
(C) tertiary structure. (D) quaternary structure.

60. Molecules from which class of biopolymers can react with water, in the presence of suitable enzymes, to form smaller examples of that class of biopolymers?

I. Proteins II. Polysaccharides

- (A) I only (B) II only
(C) Both I and II (D) Neither I nor II

KEY

Number	Answer	Number	Answer
1.	A	31.	A
2.	D	32.	C
3.	A	33.	A
4.	C	34.	A
5.	D	35.	A
6.	B	36.	B
7.	C	37.	A
8.	A	38.	B
9.	D	39.	D
10.	C	40.	B
11.	A	41.	D
12.	D	42.	A
13.	B	43.	D
14.	B	44.	A
15.	A	45.	D
16.	A	46.	B
17.	C	47.	C
18.	A	48.	C
19.	C	49.	B
20.	B	50.	C
21.	A	51.	C
22.	D	52.	B
23.	C	53.	A
24.	D	54.	B
25.	D	55.	D
26.	C	56.	D
27.	B	57.	A
28.	C	58.	B
29.	B	59.	A
30.	D	60.	C