

PRACTICE PAPERS CHEMISTRY OLYMPIADS

STAGE – 2

Paper – 5 Part – A

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 2A												13 3A	14 4A	15 5A	16 6A	17 7A	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. Which solution produces a black precipitate when added to an aqueous copper(II) solution?

- (A) NH_3 (B) $(\text{NH}_4)_2\text{S}$
(C) K_2SO_4 (D) NaOH

2. Which oxide is the best reducing agent?

- (A) CO_2 (B) NO_2 (C) SiO_2 (D) SO_2

3. Solutions of which ion produce a red color when vaporized in a Bunsen burner flame?

- (A) calcium (B) potassium
(C) sodium (D) zinc

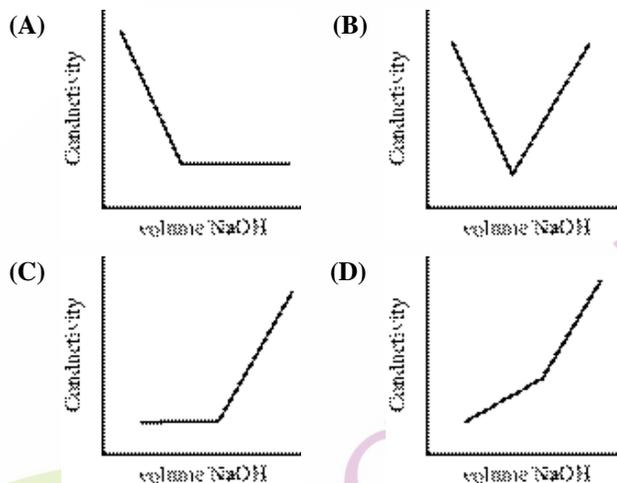
4. Which procedure for dispensing a liquid with a volumetric pipet is correct?

- (A) Draw the liquid up to the line on the pipet using a pipet bulb. Squeeze the bulb to force all the liquid in the pipet into the receiving container.
(B) Introduce the liquid into the top end of the pipet until it is filled to the line. Allow the liquid to drain into the desired container. Blow on the pipet to release the last drop.
(C) Draw the liquid above the line on the pipet using a pipet bulb. With a finger on the top of the pipet allow the curve of the meniscus to drop to the line. Place the tip of the pipet against the side of the receiving container and allow the liquid to drain.
(D) Draw the liquid above the line on the pipet by sucking on the open end of the pipet. Place a thumb on the top of the pipet and allow the curve of the meniscus to drop to the line. Allow the liquid to drain into the receiving container pipet against its side.

5. Which physical characteristic distinguishes copper from brass (an alloy of copper and zinc)?

- (A) Brass is a liquid at room temperature and copper is not.
(B) Brass is much less dense than copper.
(C) Brass is attracted to a magnet but copper is not.
(D) Brass is a much poorer electrical conductor than copper.

6. Which diagram best represents the change in electrical conductivity of a solution of acetic acid as a solution of sodium hydroxide is added?



7. Methylamine, CH_3NH_2 , reacts with O_2 to form CO_2 , N_2 , and H_2O . What amount of O_2 (in moles) is required to react completely with 1.00 mol of CH_3NH_2 ?

- (A) 2.25 (B) 2.50 (C) 3.00 (D) 4.50

8. Iodine adds to the double bonds in fatty acids (one iodine molecule per double bond). How many double bonds are in a molecule of arachidonic acid (Molar mass = 304.5 g/mol) if 0.125 g of the acid require 0.417 g of iodine?

- (A) 2 (B) 3 (C) 4 (D) 8

9. The solubility of a gas in a liquid increases when which of the following increases?

- I. pressure of the gas
II. temperature of the liquid

- (A) I only (B) II only
(C) both I and II (D) neither I nor II

10. A mineral containing only manganese and oxygen contains 69.6% Mn by mass. What is its empirical formula?

- (A) MnO (B) Mn_2O_3
(C) Mn_3O_4 (D) MnO_2

11. Toluene, C_7H_8 , is added to gasoline to increase its octane rating. What is the volume ratio of air to toluene vapor to burn completely to form CO_2 and H_2O ? (Assume air is 20% O_2 by volume.)

- (A) 9/1 (B) 11/1 (C) 28/1 (D) 45/1

12. Acidified solutions of dichromate ion, $Cr_2O_7^{2-}$, oxidize Fe^{2+} to Fe^{3+} , forming Cr^{3+} in the process. What volume of 0.175 M $K_2Cr_2O_7$ in mL is required to oxidize 60.0 mL of 0.250 M $FeSO_4$?

- (A) 14.3 (B) 28.6 (C) 42.9 (D) 85.7

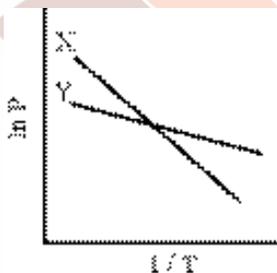
13. Which property is the same for 1.0 g samples of H_2 and CH_4 in separate 1.0 L containers at $25^\circ C$?

- (A) pressure
(B) number of molecules
(C) average molecular velocity
(D) average molecular kinetic energy

14. When CsI , SiO_2 , CH_3OH and C_3H_8 are listed in order of increasing melting point, which is the correct order?

- (A) CsI , SiO_2 , CH_3OH , C_3H_8
(B) CH_3OH , C_3H_8 , CsI , SiO_2
(C) CH_3OH , C_3H_8 , SiO_2 , CsI
(D) C_3H_8 , CH_3OH , CsI , SiO_2

15. According to the graph (ln vapor pressure vs $1/T$) what can be concluded about the enthalpies of vaporization (ΔH_{vap}) of liquids X and Y?



- (A) $\Delta H_{vap} X > \Delta H_{vap} Y$
(B) $\Delta H_{vap} X = \Delta H_{vap} Y$
(C) $\Delta H_{vap} X < \Delta H_{vap} Y$
(D) No conclusions can be drawn about the relative ΔH_{vap} values from this diagram.

16. An unknown gas effuses through a pin-hole in a container at a rate of 7.2 mmol/s. Under the same conditions gaseous oxygen effuses at a rate of 5.1 mmol/s. What is the molar mass (in g/mol) of the unknown gas?

- (A) 16 (B) 23 (C) 45 (D) 64

17. When NaF , MgO , KCl and CaS are listed in order of increasing lattice energy, which order is correct?

- (A) MgO , NaF , KCl , CaS (B) CaS , MgO , KCl , NaF
(C) KCl , CaS , NaF , MgO (D) KCl , NaF , CaS , MgO

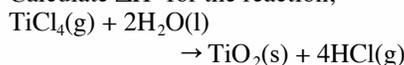
18. When compared to most other substances of similar molar mass the values of

- I. boiling point
II. specific heat capacity
III. surface tension

which properties of liquid H_2O are unusually large?

- (A) I only (B) I and II only
(C) II and III only (D) I, II and III

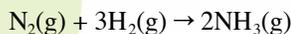
19. Calculate ΔH° for the reaction;



	ΔH_f° kJ/mol
$TiCl_4(g)$	-763
$H_2O(l)$	-286
$TiO_2(s)$	-945
$HCl(g)$	-92

- (A) -264 kJ (B) 12 kJ
(C) 22 kJ (D) 298 kJ

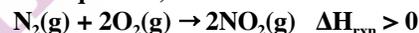
20. Use bond energies to estimate the value of ΔH° for the reaction;



	Bond Energies kJ/mol
H-H	436
H-N	386
N-N	193
N=N	418
N≡N	941

- (A) -995 kJ (B) -590 kJ
(C) -67 kJ (D) 815 kJ

Questions 21. and 22. should be answered using this thermochemical equation;



21. Which relationship is correct for this reaction at a pressure of 1 atm?

- (A) $\Delta E_{rxn} > \Delta H_{rxn}$ (B) $\Delta E_{rxn} < \Delta H_{rxn}$
(C) $\Delta E_{rxn} = \Delta H_{rxn} + \Delta S_{rxn}$ (D) $\Delta E_{rxn} = \Delta H_{rxn} - \Delta S_{rxn}$

22. Under what temperature conditions is this reaction spontaneous at standard pressure?

- (A) at low temperatures only
(B) at high temperatures only
(C) at all temperatures
(D) at no temperature

23. Diethyl ether has a normal boiling point of 35.0 °C and has an entropy of vaporization of 84.4 J/mol·K. What is its enthalpy of vaporization?

- (A) 0.274 J/mol (B) 2.41 J/mol
(C) 3.65 J/mol (D) 26.0 kJ/mol

24. A 9.40 g sample of KBr is dissolved in 105 g of H₂O at 23.6 °C in a coffee cup. Find the

Solution Properties	
Molar mass KBr	119 g/mol
ΔH_{soln} KBr	19.9 kJ/mol
C_p solution	4.184 J/g°C

final temperature of this system. Assume that no heat is transferred to the cup or the surroundings.

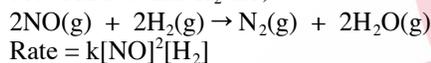
- (A) 20.0 °C (B) 20.3 °C
(C) 26.9 °C (D) 27.2 °C

25. For the reaction $A \rightarrow B$ which is first order in A, which of the following change as the concentration of A changes?

I.	rate
II.	rate constant
III.	Half-life

- (A) I only (B) III only
(C) II and III only (D) I, II and III

26. The equation and rate law for the gas phase reaction between NO and H₂ are;



What are the units of k if time is in seconds and the concentration is in moles per liter?

- (A) L·s·mol⁻¹ (B) L²·mol⁻²·s⁻¹
(C) mol·L⁻¹·s⁻¹ (D) mol²·L⁻²·s⁻¹

27. At a given temperature a first-order reaction has a rate constant of $3.33 \times 10^{-3} \text{ s}^{-1}$. How much time is required for the reaction to be 75% complete?

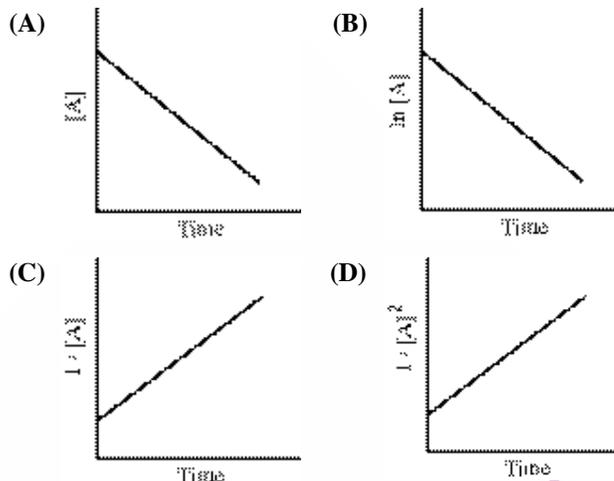
- (A) 100 s (B) 210 s (C) 420 s (D) 630 s

28. Most reactions occur more rapidly at high temperatures than at low temperatures. This is consistent with an increase in which property at higher temperatures?

I.	activation energy
II.	collision energy
III.	rate constant

- (A) I only (B) II only
(C) I and III only (D) II and III only

29. Which graph is diagnostic of an irreversible second order reaction $A \rightarrow B$?



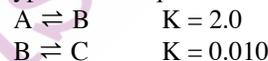
30. The reaction; $2\text{NO}(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) + \text{N}_2(\text{g})$ obeys the rate equation $\text{Rate} = k[\text{NO}]^2[\text{H}_2]$. This mechanism has been proposed:

1. $2\text{NO}(\text{g}) \rightarrow \text{N}_2\text{O}_2(\text{g})$
2. $\text{N}_2\text{O}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow 2\text{HON}(\text{g})$
3. $\text{HON}(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + \text{HN}(\text{g})$
4. $\text{HN}(\text{g}) + \text{HON}(\text{g}) \rightarrow \text{N}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$

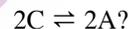
Which step of the mechanism is the rate-determining step?

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

31. For the hypothetical equilibrium reactions;



What is the value of K for the reaction;



- (A) 2500 (B) 50 (C) 25 (D) 4.0×10^{-4}

32. For which reaction is $K_p = K_c$?

- | | |
|------|---|
| I. | $2\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{N}_2\text{O}(\text{g})$ |
| II. | $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g})$ |
| III. | $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ |

- (A) II only (B) III only
(C) I and III only (D) II and III only

33. What is the pH of a 0.010 M solution of a weak acid HA that is 4.0% ionized?

- (A) 0.60 (B) 0.80 (C) 2.80 (D) 3.40

34. Given the acid ionization constants, when the conjugate bases are arranged in order of increasing base strength, which order is correct?
- | Acid Ionization Constant, K_a | |
|---|-----------------------|
| HClO | 3.5×10^{-8} |
| HClO ₂ | 1.2×10^{-2} |
| HCN | 6.2×10^{-10} |
| H ₂ PO ₄ ⁻ | 6.2×10^{-8} |

- (A) ClO₂⁻, ClO⁻, HPO₄²⁻, CN⁻
 (B) ClO₂⁻, HPO₄²⁻, ClO⁻, CN⁻
 (C) CN⁻, HPO₄²⁻, ClO⁻, ClO₂⁻
 (D) CN⁻, ClO⁻, HPO₄²⁻, ClO₂⁻

35. Calculate the concentration of hydrogen ion in mol/L of a 0.010 M solution of NH₄Cl.
- | Base Ionization Constant, K_b | |
|---------------------------------|----------------------|
| NH ₃ | 1.8×10^{-5} |

- (A) 4.2×10^{-4} (B) 2.4×10^{-6}
 (C) 1.8×10^{-7} (D) 5.6×10^{-12}

36. For the reaction;
 $\text{PbI}_2(\text{s}) \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + 2\text{I}^{-}(\text{aq}) \quad K_{sp} = 8.4 \times 10^{-9}$
 What is the concentration of Pb²⁺ in mol/L in a saturated solution of PbI₂ in which [I⁻] = 0.01 M?

- (A) 8.4×10^{-7} (B) 8.4×10^{-5}
 (C) 1.3×10^{-3} (D) 2.0×10^{-3}

37. Which statement is correct about the electrochemical cell represented here? Ag | Ag⁺ || NO₃⁻, NO | Pt

- (A) NO undergoes oxidation at the anode.
 (B) The major purpose of the Pt is to act as a catalyst.
 (C) The Ag electrode decreases in mass as the cell operates.
 (D) The voltage of the cell can be increased by doubling the size of the Ag electrode.

38. The overall reaction for the lead storage battery when it discharges is;
 $\text{Pb}(\text{s}) + \text{PbO}_2(\text{s}) + 4\text{H}^{+}(\text{aq}) + 2\text{SO}_4^{2-}(\text{aq}) \rightarrow 2\text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$

- | |
|---|
| I. PbSO ₄ is formed only at the cathode. |
| II. The density of the solution decreases. |

Which statement(s) correctly describe(s) the battery as it discharges?

- (A) I only (B) II only
 (C) both I and II (D) neither I nor II

39. The standard reduction potential for H⁺(aq) is 0.00 V. What is the reduction potential for a 1×10^{-3} M HCl solution?

- (A) 0.355 V (B) 0.178 V
 (C) -0.178 V (D) -0.355 V

40. What is the approximate value of the equilibrium constant, K_{eq} , at 25 °C for the reaction;
 $3\text{Ag}^{+}(\text{aq}) + \text{Cr}(\text{s}) \rightarrow \text{Cr}^{3+}(\text{aq}) + 3\text{Ag}(\text{s})$
- | Standard Reduction Potential, V | |
|---|-------|
| $\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$ | +0.80 |
| $\text{Cr}^{3+}(\text{aq}) + 3\text{e}^{-} \rightarrow \text{Cr}(\text{s})$ | -0.74 |

- (A) 10^{22} (B) 10^{26} (C) 10^{33} (D) 10^{78}

41. Which products are formed by the electrolysis of an aqueous solution of AlCl₃?

- | | | | |
|----------|-------------------------|-------------------------|------------------------|
| I. Al(s) | II. Cl ₂ (g) | III. H ₂ (g) | IV. O ₂ (g) |
|----------|-------------------------|-------------------------|------------------------|

- (A) I and III only (B) I and IV only
 (C) II and III only (D) II and IV only

42. A current of 0.20 amps is passed through an aqueous solution of nickel(II) nitrate for 45.0 minutes. What mass of Ni metal (in grams) will be deposited?

- (A) 0.16 (B) 0.22 (C) 0.33 (D) 0.66

43. How many orbitals are in an atomic sublevel with $l = 3$?

- (A) 3 (B) 5 (C) 7 (D) 9

44. A ground state gaseous atom of which element has the greatest number of unpaired electrons?

- (A) As (B) Br (C) Ge (D) Se

45. An atom of which element has the highest second ionization energy?

- (A) Na (B) Mg (C) Al (D) K

46. Which of these properties increase across the period from Na to Cl?

- | |
|------------------------|
| I. atomic radius |
| II. density |
| III. electronegativity |

- (A) I only (B) III only
 (C) I and II only (D) II and III only

47. For the elements in group 14 (C to Pb), which property increases with increasing atomic number?

- (A) melting points
 (B) covalent radius
 (C) magnitude of stable oxidation state
 (D) ability to form chains of atoms with themselves

48. What mode of radioactive decay is most likely for the isotope $^{20}_{11}\text{Na}$?

- (A) alpha (B) beta
 (C) gamma (D) electron capture

49. Oxygen gas is paramagnetic. This observation is best explained by
 (A) resonance.
 (B) the Lewis structure of O₂.
 (C) the molecular orbital description of O₂.
 (D) the hybridization of atomic orbitals in O₂.
50. What is the geometry of the iodine atoms in the I₃⁻ ion?
 (A) bent (B) linear
 (C) T-shaped (D) triangular
51. Which species has a dipole moment other than zero?
 (A) BrF₃ (B) CF₄ (C) SbF₅ (D) SF₆
52. In the Lewis structure what are the formal charges on the sulfur and oxygen atoms, respectively?
-
- (A) 0, 0 (B) -2, 0 (C) +2, -1 (D) +6, -2
53. How many different isomers exist for the octahedral complex [Co(NH₃)₄Cl₂]⁺?
 (A) 1 (B) 2 (C) 3 (D) 4
54. Which order is correct when the species are arranged in order of increasing average N-O bond length?
 (A) NO₃⁻, NO₂⁻, NO⁺ (B) NO⁺, NO₃⁻, NO₂⁻
 (C) NO₂⁻, NO₃⁻, NO⁺ (D) NO⁺, NO₂⁻, NO₃⁻
55. All of the classes of compounds contain at least one oxygen atom EXCEPT
 (A) esters (B) aldehydes
 (C) ethers (D) alkynes
56. What is the most characteristic reaction of benzene?
 (A) addition (B) polymerization
 (C) reduction (D) substitution
57. Which organic acid is the strongest?
 (A) HCOOH (B) CH₃COOH
 (C) ClCH₂COOH (D) ClCH₂CH₂COOH
58. How many structurally isomeric alcohols have the formula C₄H₉OH?
 (A) one (B) two (C) three (D) four
59. Which compound can exist as two optical isomers?
 (A) ClHC = CHCl (B) meta-C₆H₄Cl₂
 (C) CH₂ClBr (D) CH₃CH(Cl)CH₂CH₃
60. Which type of dietary fat is currently considered the least harmful?
 (A) monounsaturated fat (B) polyunsaturated fat
 (C) saturated fat (D) trans fat

KEY

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