

PRACTICE PAPERS CHEMISTRY OLYMPIADS

STAGE – 1

Paper – 13

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	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	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. How many atoms are in 4.0×10^{-5} grams of Al?

- (A) 8.9×10^{17} (B) 2.4×10^{19}
 (C) 6.5×10^{20} (D) 2.0×10^{22}

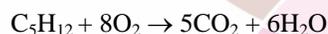
2. How many moles of sulfate ions are in 100 mL of a solution of 0.0020 M $\text{Fe}_2(\text{SO}_4)_3$?

- (A) 2.0×10^{-4} (B) 6.0×10^{-4}
 (C) 2.0×10^{-1} (D) 6.0×10^{-1}

3. The value of which concentration unit for a solution changes with temperature?

- (A) molarity (B) molality
 (C) mole fraction (D) mass percentage

4. How many moles of water are produced by the complete combustion of 14.4 g of C_5H_{12} ?



- (A) 0.200 (B) 0.600 (C) 1.20 (D) 2.40

5. A solution of $\text{Ba}(\text{OH})_2$ is standardized with potassium acid phthalate (abbreviated KHP), $\text{KHC}_8\text{H}_4\text{O}_4$ ($M = 204$). If 1.530 g of KHP is titrated with 34.50 mL of the $\text{Ba}(\text{OH})_2$ solution, what is the molarity of $\text{Ba}(\text{OH})_2$?

- (A) 0.0217 M (B) 0.0435 M
 (C) 0.109 M (D) 0.217 M

6. 30.0 mL of 0.10 M $\text{Ca}(\text{NO}_3)_2$ and 15.0 mL of 0.20 M Na_3PO_4 solutions are mixed. After the reaction is complete, which of these ions has the lowest concentration in the final solution?

- (A) Na^+ (B) NO_3^- (C) Ca^{2+} (D) PO_4^{3-}

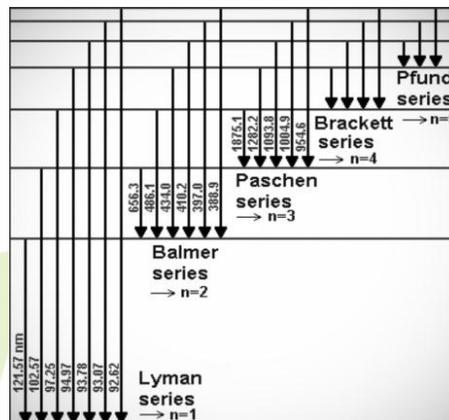
7. A dilute solution of which acid is most likely to produce a reduction product other than H_2 when it reacts with a metal?

- (A) HF (B) HCl (C) HNO_3 (D) H_2SO_4

8. Which two substances react spontaneously?

- (A) Ag and Cu (B) Ag^+ and Cu
 (C) Ag and Cu^{2+} (D) Ag^+ and Cu^{2+}

9. Which spectral series for hydrogen contains lines in the visible region of the spectrum?



- (A) Lyman series (B) Balmer series
 (C) Paschen series (D) Brackett series

10. Which piece of laboratory apparatus is not used for the purpose listed?

	Apparatus	Purpose
(A)	aspirator	measure height
(B)	buret	measure volume
(C)	calorimeter	measure thermal energy change
(D)	desiccator	store samples in dry conditions

- (A) A (B) B (C) C (D) D

11. Which transformation demonstrates that the bonds between water molecules are weaker than the bonds within a water molecule?

- (A) freezing water (B) electrolysis of water
 (C) boiling water (D) reaction of water with Na(s)

12. The molar mass of an unknown organic liquid ($M \sim 100$) is determined by placing 5 mL of the liquid in a weighed 125-mL conical flask fitted with a piece of Al foil with a pin hole in it. The flask is heated in a boiling water bath until the liquid evaporates to expel the air and fill the flask with the unknown vapor at atmospheric pressure. After cooling to room temperature the flask and its contents are reweighed. The uncertainty in which piece of apparatus causes the largest percentage error in the molar mass?

- (A) balance (+0.01 g) (B) barometer (+0.2 mm Hg)
 (C) flask (+1.0 mL) (D) thermometer (+0.2 °C)

13. At the molecular level, the factor that determines whether a substance will be a solid, liquid, or gas is the balance between the

- (A) kinetic energies of the molecules and their intermolecular forces.
- (B) potential energies of the molecules and their intermolecular forces.
- (C) kinetic energies of the molecules and their intramolecular forces.
- (D) potential energies of the molecules and their intramolecular forces.

14. A gas sample in a flexible container is maintained at constant pressure while its temperature is increased from 25 °C to 75 °C. If the initial volume of the gas is 4.2 L, what is the change in volume due to the temperature increase?

- (A) 0.7 L (B) 4.9 L (C) 8.4 L (D) 12.6 L

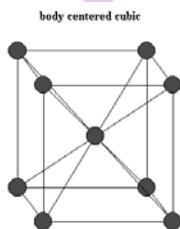
15. The critical temperature of carbon dioxide is 304.3 K. Which statement is true about the behavior of carbon dioxide above this temperature?

- (A) Solid, liquid and gaseous carbon dioxide are in equilibrium above this temperature.
- (B) Liquid and gaseous carbon dioxide are in equilibrium above this temperature.
- (C) Liquid carbon dioxide does not exist above this temperature.
- (D) Carbon dioxide molecules do not exist above this temperature.

16. Which substance is matched incorrectly with the type of solid it forms?

- (A) ammonium sulfate-ionic solid
- (B) lead-metallic solid
- (C) potassium chloride-ionic solid
- (D) silicon dioxide-molecular solid

17. Metallic sodium has a body-centered cubic unit cell. How many atoms are contained in one unit cell?



- (A) 1 (B) 2 (C) 5 (D) 9

18. Which substance has the lowest boiling point?

- (A) H₂O (B) H₂S (C) H₂Se (D) H₂Te

19. The combustion of 1.00 mole of methane, CH₄, produces carbon dioxide and water and releases 802 kJ•mol⁻¹. When 3.00 mol of oxygen react with a stoichiometric quantity of methane, what is ΔH for the reaction?

- (A) -1.20 × 10³ kJ (B) -8.02 × 10² kJ
(C) 8.02 × 10² kJ (D) 1.20 × 10³ kJ

20. What is the final temperature when 20.0 g of water (specific heat capacity 4.184 J•g⁻¹•K⁻¹) at 80.0 °C is mixed with 30.0 g of water at 20.0 °C in an insulated container?

- (A) 32 °C (B) 44 °C (C) 50 °C (D) 56 °C

21. PCl₅(s) reacts with H₂O(l) according to the equation:



What is ΔH° for this reaction in kJ•mol⁻¹?

Substance	PCl ₅ (s)	H ₂ O(l)	H ₃ PO ₄ (aq)	HCl(aq)
ΔH _f °, kJ/mol	-443.5	-285.8	-1284.4	-167.1

- (A) -722.2 (B) -533.2 (C) 533.2 (D) 722.2

22. Which is a statement of the Second Law of Thermodynamics?

- (A) The energy of the universe is conserved.
- (B) The energy of the universe is decreasing.
- (C) The entropy of the universe is conserved.
- (D) The entropy of the universe is increasing.

23. For which signs of ΔH and ΔS will a reaction always be spontaneous?

- (A) ΔH +, ΔS + (B) ΔH +, ΔS -
(C) ΔH -, ΔS - (D) ΔH -, ΔS +

24. What is correct about the signs and magnitudes of the free energy, ΔG°, and the equilibrium constant, K, for a thermodynamically spontaneous reaction under standard conditions?

- (A) ΔG° < 0, K < 0 (B) ΔG° = 0, K > 0
(C) ΔG° < 0, K = 0 (D) ΔG° < 0, K > 0

25. The rate of a stoichiometric reaction between a solid and a gas in a container may be increased by increasing all of the following factors EXCEPT the

- (A) pressure of the gas.
- (B) temperature of the gas.
- (C) volume of the container.
- (D) surface area of the solid.

26. The gas phase decomposition of dinitrogen pentoxide is represented by this equation.



What is the rate of formation of oxygen gas (in $\text{mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$) in an experiment where 0.080 mol of N_2O_5 is consumed in a 4.0 L container every 0.20 seconds?

- (A) 0.020 (B) 0.050 (C) 0.10 (D) 0.20
27. Which accounts for the increase in the rate of a reaction when a catalyst is added to a chemical system?
- (A) a decrease in the enthalpy change between the reactants and products
 (B) an increase in the potential energy of the reactants
 (C) a decrease in the potential energy of the activated complex
 (D) a decrease in the entropy of the activated complex

28. For this first-order isomerization reaction,



how do the properties of the reaction in the table below vary as the reaction proceeds?

	Rate of reaction $-\frac{\Delta[\text{CH}_3\text{NC}]}{\Delta t}$, ($\text{M}\cdot\text{s}^{-1}$)	Half-life, (s)
(A)	remains the same	decreases
(B)	decreases	remains the same
(C)	remains the same	remains the same
(D)	decreases	decreases

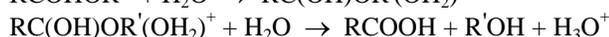
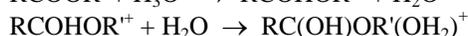
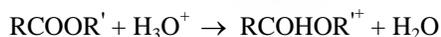
- (A) A (B) B (C) C (D) D

29. The rate of a reaction between A and B follows the rate law $\text{Rate} = k[\text{A}]^2[\text{B}]$. Determine the rate of Experiment Two in the table below at the same temperature as Experiment One.

Experiment	[A], M	[B], M	Observed Rate, $\text{mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$
1	0.10	0.10	R
2	0.30	0.20	?

- (A) 3R (B) 6R (C) 12R (D) 18R

30. One proposed mechanism for the hydrolysis of an ester is shown below.



Which species is considered an intermediate?

- (A) RCOHOR'^+ (B) H_3O^+
 (C) RCOOR' (D) $\text{R}'\text{OH}$

31. Which statement(s) characterize(s) a chemical system at equilibrium?

I The rate of the forward reaction is equal to the rate of the reverse reaction.

II The concentrations of the reactants and products are equal.

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

32. What is the solubility in pure water of $\text{Ba}(\text{IO}_3)_2$ in moles per liter at 25 °C? [$K_{\text{sp}}(25\text{ °C}) = 6.0 \times 10^{-10}$]

- (A) 1.2×10^{-5} (B) 1.7×10^{-5}
 (C) 5.3×10^{-4} (D) 8.4×10^{-4}

33. $\text{C}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2(\text{g}) \quad \Delta H > 0$

For the system above at equilibrium, which changes will increase the amount of $\text{H}_2(\text{g})$?

I Adding $\text{C}(\text{s})$

II Increasing the volume of the container

III Increasing the temperature

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

34. Determine the volume of 0.125 M NaOH required to titrate to the equivalence point 25.0 mL of a 0.175 M solution of a monoprotic weak acid that is 20% ionized.

- (A) 7.00 mL (B) 17.9 mL
 (C) 28.0 mL (D) 35.0 mL

35. A 75 mL solution that is 0.10 M in $\text{HC}_2\text{H}_3\text{O}_2$ and 0.10 M in $\text{NaC}_2\text{H}_3\text{O}_2$ has a pH of 4.74. Which of the following actions will change the pH of this solution?

I Adding 15 mL of 0.10 M HCl

II Adding 0.010 mol of $\text{NaC}_2\text{H}_3\text{O}_2$

III Diluting the solution from 75 mL to 125 mL

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

36. Which acid-base indicator will give the best results for the titration of an aqueous ammonia solution with 0.10 M HCl?

Indicator	Color change	pH range
Methyl violet	red \rightarrow blue	0 \rightarrow 2
Methyl red	red \rightarrow yellow	4 \rightarrow 6
Cresol red	yellow \rightarrow purple	7 \rightarrow 9
Phenolphthalein	colorless \rightarrow pink	8 \rightarrow 10

- (A) Methyl violet (B) Methyl red
 (C) Cresol red (D) Phenolphthalein

37. Which species has an atom with an oxidation number of +3?
 (A) ClO_2^- (B) PO_4^{3-} (C) $\text{S}_2\text{O}_3^{2-}$ (D) NO_2^+

38. According to the reduction potentials in the table below, which statement is true at standard conditions?

Reaction	E° , V
$\text{L}^{2+} + 2\text{e}^- \rightarrow \text{L}$	-0.13
$\text{M}^{2+} + 2\text{e}^- \rightarrow \text{M}$	-0.44
$\text{N}^{2+} + 2\text{e}^- \rightarrow \text{N}$	-0.76

- (A) L^{2+} ions oxidize M metal.
 (B) M metal reduces N^{2+} ions.
 (C) M is a better reducing agent than N.
 (D) M^{2+} ions are better oxidizing agents than L^{2+} ions.
39. How many H^+ ions are required when the equation below is balanced with the smallest whole number coefficients?
 $\text{Cu(s)} + \text{NO}_3^-(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{NO(g)} + \text{H}_2\text{O(l)}$
 (A) 2 (B) 4 (C) 6 (D) 8

40. $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag} \quad E^\circ = 0.80 \text{ V}$
 $\text{Co}^{2+} + 2\text{e}^- \rightarrow \text{Co} \quad E^\circ = -0.28 \text{ V}$
 What is the E° value for the voltaic cell using the half-reactions above at standard conditions?
 (A) 0.52 V (B) 1.08 V (C) 1.32 V (D) 1.88 V

41. $\text{Sn(s)} \mid \text{Sn}^{2+}(\text{aq}) \parallel \text{Cu}^{2+}(\text{aq}) \mid \text{Cu(s)}$
 For the voltaic cell represented above, which change will increase the voltage?
 (A) increasing the size of the Sn electrode
 (B) increasing the size of the Cu electrode
 (C) increasing the $[\text{Sn}^{2+}]$
 (D) increasing the $[\text{Cu}^{2+}]$

42. For how many seconds must a current of 5.00 A flow in order to deposit 1.30 g of nickel from a solution of nickel(II) nitrate? (Coulombs = Amperes \times seconds)
 (A) 2.14×10^2 (B) 4.28×10^2
 (C) 8.55×10^2 (D) 4.28×10^3

43. The isotope ^{14}C undergoes radioactive decay slowly. Which mode of decay is most likely?
 (A) alpha emission (B) beta emission
 (C) positron emission (D) electron capture

44. The quantum numbers, $n = 4$, $l = 1$, $m_l = 0$ could represent a valence electron in which atom in its ground state?
 (A) Fe (B) In (C) Pd (D) Se

45. A gas phase atom with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$ loses three electrons. What is the electron configuration of the resulting gas phase ion?
 (A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
 (B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^4$
 (C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
 (D) $1s^2 2s^2 2p^6 3s^2 3p^5 4s^1 3d^5$

46. Which existing element would the chemistry of element 119 most resemble?
 (A) Rn ($Z = 86$) (B) Fr ($Z = 87$)
 (C) Ra ($Z = 88$) (D) Ac ($Z = 89$)

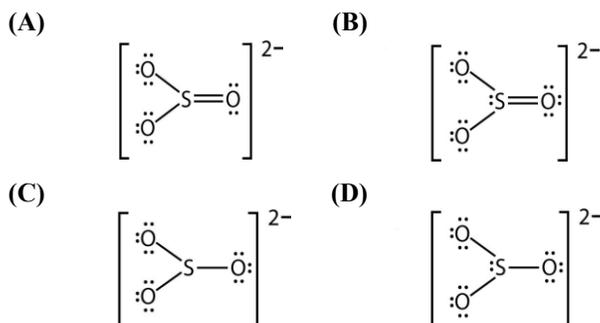
47. Which atom has the largest atomic radius?
 (A) S (B) Cl (C) Se (D) Br

48. Of the elements listed, which has the highest first ionization energy?
 (A) Li (B) Be (C) Na (D) Mg

49. Which species contains only covalent bonds?
 (A) AlF_3 (B) NH_4NO_3
 (C) H_2SO_4 (D) $\text{K}_2\text{Cr}_2\text{O}_7$

50. In which species can we describe the central atom as having sp^2 hybridization?
 (A) BeF_2 (B) CO_2 (C) KrF_2 (D) SO_2

51. Which Lewis dot structure is a valid representation for the sulfite ion, $[\text{SO}_3]^{2-}$?



52. In which species does sulfur have the lowest oxidation state?

- (A) SCl_2 (B) OSF_2 (C) H_2SO_3 (D) SF_6

53. A triple bond is found in which of the following species?

- I CO II C_2H_2 III CN^-

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

54. Which of the following compounds has a non-zero dipole moment?

- (A) CO_2 (B) AsH_3 (C) CCl_4 (D) PF_5

55. Which molecule contains the fewest hydrogen atoms?

- (A) cyclopropane (B) propane
(C) propene (D) propyne

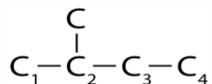
56. What is the difference between 2-chloropentane and 3-chloropentane?

- (A) the number of carbon atoms in the molecule
(B) the number of chlorine atoms in the molecule
(C) the position of the chlorine atom in the molecule
(D) the geometry of the carbon chain

57. Alanine is a(n)

- (A) amino acid. (B) ester.
(C) nucleic acid. (D) sugar.

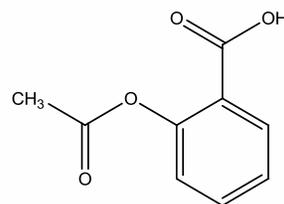
58. A secondary alcohol results from the attachment of a hydroxyl group to which carbon atom?



- (A) C_1 (B) C_2 (C) C_3 (D) C_4

59. Aspirin has the structural formula below. Which functional groups does this molecule contain?

- I acid II alcohol III ester IV ether



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

60. Which substance yields the most energy per gram of sample upon metabolism?

- (A) carbohydrate (B) fat
(C) protein (D) vitamin

KEY

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