Chemistry Olympiad Sri Lanka

& All Island Chemistry Quiz

Preliminary Selection Test – 2018 – Model Paper

PAPER CODE: AXZ

Answer ALL questions Number of Pages 8 Time: 2 hours

Composition: **50 Multiple Choice Questions and 3 Structured Questions**.

Section A: Multiple Choice Questions: Chose the best answer out of the five choices.

a. You must indicate all your answers in the separate answer sheet.
b. Select the best answer for each question and mark a cross using a carbon pen as shown below.

1. a. b. ✗ d. e.

c. Mark only **one answer** to each question. No credit will be given for multiple answers.
d. Clearly write your **index number** and **paper code** (3 letters) in the answer sheet.

Section B: Structured Questions

e. For part B **use the given space** to write the answers.

PERIODIC TABLE OF THE ELEMENTS

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A																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 78.96	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 95.94	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 (Uut) (284)	114 Fl (289)	115 (Uup) (288)	116 Lv (293)	117 (Uus) (294)	118 (Uuo) (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)

Gas Constant 8.314 J $mol^{-1}K^{-1}$ Or 0.0821 L atm mol^{-1} K^{-1}	Avogadro Number 6.022×10^{23} mol^{-1}	0 °C = 273.15 K 1 atm = 760 mm Hg

Part A

1. What is the geometry of the chlorate ion, ClO_3^- ?
   (a) trigonal planar (b) trigonal pyramidal (c) T-shaped (d) Tetrahedral (e) Trigonal Bi-pyramidal

2. A strip of iron foil has a uniform width of 1.00 cm and a uniform thickness of 10 mm. If the density of iron is 7800 kg/m^3, how long a strip should be cut to obtain 1.00 g of the metal?
   (a) 24.2 cm (b) 18.1 cm (c) 15.4 cm (d) 12.8 cm (e) 8.5 cm

3. You need to fertilize an area with the equivalent of 25.0 kg of nitrogen, N. How much urea, CON_2H_4, should be used?.
   (a) 60.2 kg (b) 53.6 kg (c) 50.3 kg (d) 32.2 kg (e) 10. 2 kg

4. A sealed vessel contains 0.200 mol of oxygen gas, 0.100 mol of nitrogen gas, and 0.200 mol of argon gas. The total pressure of the gas mixture is 5.00 atm. The partial pressure of the argon is;
   (a) 0.200 atm (b) 0.500 atm (c) 1.00 atm (d) 2.00 atm (e) 2.5 atm

5. What is the most weakly bound diatomic molecule?
   (a) Cl_2 (b) O_2 (c) F_2 (d) He_2 (e) Ar_2

6. The hemoglobin from the red corpuscles of most mammals contains approximately 0.33% iron by weight. If physical measurements indicate a molecular weight for hemoglobin of 68000 g/mol, how many iron atoms are there in each molecule of hemoglobin? (AW Fe= 56)
   (a) 0 (b) 1 (c) 2 (d) 4 (e) 8

7. The radioactive half-life for a given radioisotope is the time for half the radioactive nuclei in any sample to undergo radioactive decay. The half-life of ^{55}Cr is about 2.0 hours. The delivery of a sample of this isotope from the reactor to a certain laboratory requires 12 hours. About what mass of such material should be shipped in order that 1.0 mg of ^{55}Cr is delivered to the laboratory?
   (a)130 mg (b) 64 mg (c) 32 mg (c) 16 (e) 11 mg

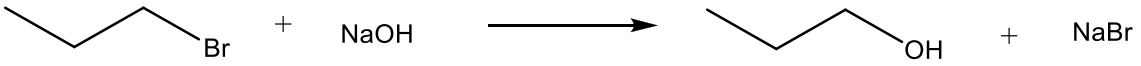
8. A 1.20 liter sample is drawn from a bottle labeled "80.0% by weight H_2SO_4, density 1.96 g/mL". What is the molarity of the sample? (Molar mass of H_2SO_4 is 98.0 g/mol)
   (a) 16.0 (b) 18.2 (c) 20.2 (d) 25.6 (e) 30. 1

9. The temperature of a gas sample is increased from 50 °C to 100 °C. By what factor must the pressure be changed if the volume is to be kept constant?
   (a) 0.5 (b) 0.87 (c) 1.15 (d) 2.0 (e) 4.0

10. Which is the best explanation for the negative sign of ΔS^o in the following reaction?
$CaSO_4(s) \rightarrow Ca^{2+}(aq) + SO_4^{2-}(aq)$ $\Delta S^o = -143$ J mol^{-1} K^{-1}

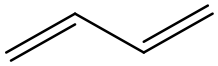
(a) There are more ways of arranging the Ca^{2+} and SO_4^{2-} ions in aqueous solution than in the crystal lattice.
(b) Solid $CaSO_4$ is a network covalent solid, whereas it separates into ions in aqueous solution.
(c) Aqueous Ca^{2+} and SO_4^{2-} ions are tightly solvated, decreasing the number of ways of arranging water molecules when the solid dissolves.
(d) Calcium sulfate dissolves exothermically, leading to a net loss of entropy
(e) None of the above

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



(a) Lewis acid (b) Base (c) Nucleophile (d) Catalyst (e) Reducing agent

12. How many C-C sigma and C-C pi bonds are in the following molecule?

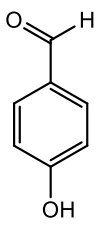


(a) three sigma bonds one pi bond
(b) three sigma bonds two pi bonds
(c) one sigma bond two pi bonds
(d) one sigma bond four pi bonds
(e) two sigma bonds one pi bond

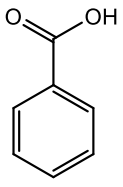
13. Which contains sp-hybridized carbon atoms?
(a) Ethane, C_2H_6 (b) Ethene, C_2H_4 (c) Benzene, C_6H_6 (d) Ethyne, C_2H_2 (e) Methane CH_4

14. Which of the following molecules has a dipole moment of zero?
(a) CO_2 (b) SO_2 (c) $CHCl_3$ (d) HCN (e) CH_2Cl_2

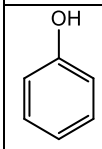
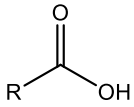
15. Based on the below information, select the best method for separation of 4-hydroxybenzaldehyde from benzoic acid from a mixture. Note that dichloromethane and water are immiscible with each other.



4-hydroxybenzaldehyde



Benzoic acid

Structure	Solubility in Dichlomethane (CH_2Cl_2)	Aqueous Sodium hydroxide (NaOH)	Saturated Sodium bicarbonate ($NaHCO_3$)	Aqueous Hydrochloric acid (HCl)
 Phenol	soluble	soluble	insoluble	insoluble
 Carboxylic acid	soluble	soluble	soluble	insoluble

(a) Dissolve the mixture in dichloromethane followed by adding aqueous HCl and shanking
(b) Dissolve the mixture in dichloromethane followed by adding aqueous NaOH and shanking
(c) Dissolve the mixture in dichloromethane followed by adding saturated $NaHCO_3$ and shanking
(d) Dissolve the mixture in dichloromethane followed by adding water and shanking
(e) None of the above

16. The British thermal unit (Btu) is commonly used in engineering applications. A Btu is defined as the amount of heat required to raise the temperature of 1 lb of water by 1 °F. There are _____ joules in one Btu. 1 lb = 453.59 g; °C = (5/9)(°F - 32°); specific heat of H_2O (l) = 4.184 J/g-K.

(a) 3415 (b) 60.29 (c) 1054 (d) 5.120×10^{-3} (e) additional information is needed to complete the calculation.

17. Calculate the mole fraction of phosphoric acid (H_3PO_4) in a 25% (by mass) aqueous solution. (Molar Mass of phosphoric acid is 97.99 g/mol)

(a) 0.058 (b) 0.072 (c) 2.5 (d) 1.0 (e) 4.1

18. Which of the following ions have the electron configuration $1S^2\ 2S^2\ 2P^6$?

O^{2-} (b) Ca^{2+} (c) Sr^{2+} (d) Na^{+} (e) none

19. Most abundant element in the earth crust is

(a) Fe (b) Al (c) Si (d) O (f) S

20. A type of mineral sand not found in Sri Lanka

(a) Monazite (b) Thorianite (c) Ilmenite (d) Rutile (e) Leucoxene

21. Which of the mineral sand contain Titanium?

(a) Monazite (b) Thorianite (c) Ilmenite (d) Rutile (e) None of the above

22. What is the main element found in Quartz?

(a) Si (b) Fe (c) Ca (d) Al (e) C

23. In 1996 the Noble price for Chemistry was awarded to Harold Kroto, Robert Curl, and Richard Smalley for the discovery of fullerenes. Number of carbon atoms found in a fullerenes cannot be
(a) 48 (b) 60 (c) 70 (d) 80 (e) 120

24. Which of the following is not an allotrope of Carbon?
(a) Graphite (b) Diamond (c) Quarts (b) Fullerenes (e) Carbon Nanotubes

25. Based on the general trends in the periodic table which of the following statements are not true.
(a) Atomic Radius of K is greater than Na
(b) Atomic Radius of P is greater than N
(c) Atomic Radius of Te is greater than Se
(d) Atomic Radius of As is greater than Se
(e) Atomic Radius of Sr is greater than Rb

26. Which of the following elements has the most metallic Character?
(a) Ba (b) Ca (c) K (d) Al (e) Mg

27. Select the symbols of the elements that respectively fits each of the following description.

I The alkali metal in the fourth period
II The halogen in the third period
III The rare earth with the lowest atomic mass
IV The metal in Group VIIB/7 and period 4
(a) K, Ar, Li, Fe
(b) K, Cl, Sc, Mn
(c) K, Cl, Ba, Mn
(d) Na, Cl, Ba, Mn
(e) K, Cl, Ba, Cu

28. A burning splint will burn more vigorously in pure oxygen than in air because

(a) oxygen is a reactant in combustion and concentration of oxygen is higher in pure oxygen than is in air.
(b) oxygen is a catalyst for combustion.
(c) oxygen is a product of combustion.
(d) nitrogen is a product of combustion and the system reaches equilibrium at a lower temperature.
(e) nitrogen is a reactant in combustion and its low concentration in pure oxygen catalyzes the combustion.

29. Bleach is a chemical compound use to whiten cloths. Which of the following are not a bleaching agent.
(a) Sodium hypochlorite (b) Calcium hyperchorite (c) Chlorine (d) Bromine (e) H_2O_2

30. What is the pH value of 0.01 M NaOH solution?
(a) 2.0 (b) 4.0 (c) 8.0 (d) 12.0 (e) 13.0

31. Calculate the energy released by the reaction

$$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$$

when a 55.8 g sample of iron reacts completely with 1.00 mole of oxygen. The enthalpy of formation (ΔHf°) of $Fe_2O_3(s)$ is –826 kJ mol–1.
(a) 206 kJ/mol (b) 413 kJ/mol (c) 826 kJ/mol (d) 165 kJ/mol (e) none of the above

32. The specific heat capacities of three metals are given below.

Metal	Fe	Pb	Zn
Specific heat J $g^{-1}°C^{-1}$	0.470	0.130	0.388

If 1.00 g of each metal is heated to 100 °C and added to 10.0 g of H_2O at 25.0 °C, what is the order of the temperatures of the final mixtures from the lowest to the highest?
(a) Fe < Zn < Pb
(b) Pb < Zn < Fe
(c) Zn < Pb < Fe
(d) Pb < Zn < Fe
(e) Fe < Pb < Zn

33. The enthalpy of formation, ΔH_f°, equals zero at 25 °C for which of the following in their standard states?
(a) Elements (b) Gases (c) Compounds (d) Solids (e)None of the above

34. Vanillin, $C_8H_8O_3$ (M = 152 g/mol), is the molecule responsible for the vanilla flavor in food. How many oxygen atoms are present in a 45.0 mg sample of vanillin?
(a) 1.78×10^{20} (b) 5.35×10^{20} (c) 1.78×10^{23} (d) 5.35×10^{23} (e) 5.35×10^{24}

35. Which one of the following cannot act as an oxidizing agent?
(a) S^{2-} (b) SO_3^{2-} (c) SO_4^{2-} (d) $S_2O_8^{2-}$ (e) S(s)

36. Which of these reactions has $\Delta S° > 0$?

(a) $S_8(l) \rightarrow S_8(s, \text{monoclinic})$
(b) $H_2(g) + O_2(g) \rightarrow H_2O_2(aq)$
(c) $H_2(g) + 2\ Ag^+(aq) \rightarrow 2\ H^+(aq) + 2\ Ag(s)$
(d) $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$
(e) None of the above

37. Electrolysis of 10.00 g of a binary metal chloride deposits 6.207 g of the pure metal. What is the metal?
(a) Mg (Z= 12) (b) Cu (Z = 29) (c) Cd (Z = 48) (d) Ce (Z = 58) (e) Th (Z = 90)

38. Permanganate ion oxidizes hydrogen peroxide in acidic solution according to the following equation:
$2\ MnO_4^-(aq) + 5\ H_2O_2(aq) + 6\ H^+(aq) \rightarrow 2\ Mn^{2+}(aq) + 5\ O_2(g) + 8\ H_2O(l)$
If 35.0 mL of an acidic 0.150 M $KMnO_4$ solution is required to consume all the H_2O_2 in 50.0 mL of a disinfectant solution, what is the concentration of H_2O_2 in the disinfectant?
(a) 0.0420 M (b) 0.105 M (c) 0.263 M (d) 0.368 M (e) 0.412 M

39. Which class of compounds consists exclusively of saturated hydrocarbon?
(a) alkanes (b) alkenes (c) alkynes (d) aromatics (e) all

40. Which compound has the largest lattice energy?
(a) NaF (b) CsI (c) MgO (d) CaS (e) NaCl

41. The geometry of the atoms in the species PCl_4^+ is best described as
(a) tetrahedral (b) see–saw (c) square (d) trigonal bipyramidal (e) Octahedral

42. What are the hybridizations of carbon 1 and carbon 2 in the hydrocarbon?

$\underset{1}{CH_3}\underset{2}{CH}CH_2$

(a) sp3 , sp (b) sp3 , sp2 (c) sp2 , sp2 (d) sp, sp2 (e) sp, sp

43. What is the total number of valence electrons in the thiosulfate ion, $S_2O_3^{2-}$?
(a) 24 (b) 26 (c) 28 (d) 30 (e) 32

44. Which type of radiation has the highest frequency?
(a) infrared (b) microwave (c) ultraviolet (d) X-ray (e) Radio wave

45. How many isomers exist for dibromobenzene ($C_6H_4Br_2$)?
(a) one (b) two (c) three (d) four (e) five

46. In which pair of formulas are both species polar?
(a) CO_2 and H_2O (b) BF_3 and PCl_3 (c) SO_2 and SCl_2 (d) CS_2 and NO_2 (e) CH_4 and H_2O

47. Which must represent an atom in an excited state?
(a) $1s^2\ 2s^2\ 2p^1$ (b) $1s^2\ 2s^2\ 2p^2$ (c) $1s^2\ 2s^2\ 2p^2\ 3s^1$ (d) $1s^2\ 2s^2\ 2p^5$ (e) $1s^2\ 2s^2\ 2p^6$

48. A sample of gas at 273 K has a pressure of P_1 and a volume of V_1. When the pressure is changed to P_2, what is the volume V_2? (Assume the temperature remains constant.)

(a) $P_1P_2/\ V_1$ (b) P_1V_1/P_2 (c) $P_2V_1\ /P_1$ (d) $P_2\ P_1/V_1$ (e) $(P_1+P_2)/V_2$

49. A typical polyethylene bag from a grocery store weighs 12.4 g. How many molecules of ethylene, C_2H_4, must be polymerized to make such a bag?
(a) 1.36×10^{24} (b) 6.02×10^{23} (c) 5.33×10^{23} (d) 2.67×10^{23} (e) 4.12×10^{24}

50. How many resonance forms can be written for the nitrate ion, O_3^- ?

(a) 1 (b) 2 (c) 3 (d) 4 (e) more than 4

Part B

1. (a) Chain isomers are types of structural isomers which has the same molecular formula, but different arrangements of the carbon 'skeleton'. These *isomers* arise because of the possibility of branching in carbon chains**.**

   Petane (C_5H_{12}) can have three chain isomers. Draw the structures of them.

   (b) When two similar groups are attached to the two sp^2 carbons on the same side, it is termed as *cis* isomer and when it is attached to the opposite side it is called *trans* isomer.

   There are three C_4H_8 structural isomers that are alkenes. Draw the structures of the *cis* and *trans* isomers of C_4H_8.

2. A mixture contains a metal carbonate, MCO_3 and its metal oxide, MO. When this mixture was heated CO_2 gas is released and covered completely to the metal oxide.

   When 0.65 g of this sample was heated, it was found that 0.1517 L of CO_2 gas was released at 25.0 0C and pressure 700.0 mm Hg.

   (a) Determine the number of CO_2 moles formed.
   (b) 0.3891g of the product formed from resulting process (heating) was titrated with 0.500 M HCl. Titrant volume was 38.60 mL. Determine the number of moles of MO in 0.3891 g.
   (c) Identify the metal M.
   (d) Determine the ratio of MCO_3 and MO in the original sample.

3. The self-**ionization of water** is described according to the equilibrium shown below.

$$H_2O\ (l) \leftrightharpoons H^+(aq) + OH^-(aq)$$

   The equilibrium constant, Kw is 1.0×10^{-14} at 25 ^{0}C.

   Equilibrium constant (K) and Gibbs free energy is related by the following equation.

$$\Delta G = -RT\ 2.3 \log K$$

   Standard enthalpy of formation and standard entropy values are given in the Table below

Specie	ΔH_f^0 (kJ/mol)	S^0 (kJ/mol K)
H+ (aq)	0	0
OH- (aq)	-230	
H2O (l)	-286	70

Calculate

   b. ΔH^0 for self ionization of water
   c. ΔG^0 for self ionization of water
   d. ΔS^0 for self ionization of water and explain the sign
   e. Calculate S^0 for $OH^-(aq)$.

Answers for Part A

1. (b)	2. (d)
3. (b)	4. (d)
5 (d)	6. (d)
7. (b)	8. (a)
9. (a)	10. (c)
11. (c)	12. (b)
13. (d)	14. (a)
15. (c)	16. (c)
17. (a)	18. (a)
19. (d)	20. (e)
21. (c)	22. (a)
23. (a)	24. (c)
25. (e)	26. (a)
27. (c)	28. (a)
29. (d)	30. (d)
31. (b)	32. (b)
33. (a)	34. (b)
35. (a)	36. (d)
37. (e)	38. (c)
39. (a)	40. (c)
41. (a)	42. (b)
43. (e)	44. (d)
45. (c)	46. (c)
47. (c)	48. (c)
49. (d)	50. (c)