Sri Lanka National Chemistry Olympiad

Preliminary Selection Test – 2024

Answer ALL questions Number of Pages 16 Time: 2 hours and 30 minutes

Composition: **45 Multiple Choice Questions**

a. Should indicate all your answers in the answer boxes provided to you.
b. Select the best answer out of the five choices for each question and mark a cross using a **carbon pen** (blue/black) as shown below.

17.	(a)	(b)	(c)	~~(d)~~	(e)

c. Mark only **one answer** to each question. (Marks will not be given for marking more than one answer.)
d. Clearly write your **index number** on the top right-hand corner of the answer sheet.

Calculators (scientific and normal) are allowed, but any other electronic devices (smart watches) are not allowed.

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)

Physical Constants

Gas Constant 8.314 J mol^{-1} K^{-1}	Avogadro Number 6.022×10^{23} mol^{-1}	0 °C = 273 K 1 atm = 760 mm Hg = 1.013 bar
Plank constant 6.6×10^{-34} m^2 kg s^{-1}	Standard temperature and pressure: 273 K and 100 kPa	

1) Consider the following molecules/ions.

(A) H_3O^+ (B) BH_3 (C) PCl_3

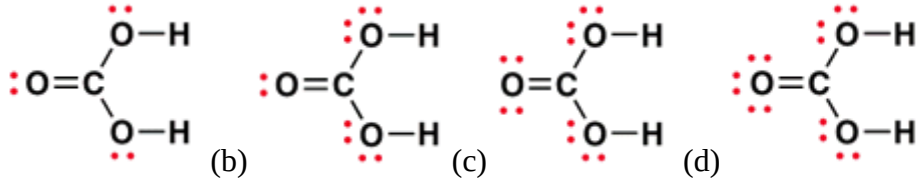
Which of the above (other than hydrogen) lacks an octet of valence electrons?

(a) Only B (b) Only C (c) Only A and B (d) Only B and C (e) All A, B. C

2) The correct dot formulation for nitrogen trichloride has:

(a) 3 N=Cl bonds and 6 lone pairs of electrons.
(b) 1 N-Cl bond, 2 N=Cl bonds and 7 lone pairs of electrons.
(c) 2 N-Cl bonds, 1 N=Cl bond and 8 lone pairs of electrons.
(d) 3 N-Cl bonds and 9 lone pairs of electrons.
(e) 3 N-Cl bonds and 10 lone pairs of electrons.

3) Which is the correct Lewis structure for carbonic acid, H_2CO_3?



(a) (b) (c) (d)

(e) None of the above

4) Select the isoelectronic structures from the following

I) CH^{3+} II) H_3O^+ III) NH_3 IV) CH_3^-

(a) Only I and III (b) Only III and IV (c) Only I and III
(d) Only II, III, and IV (e) Only I and II

5) If MX_6 is a regular octahedral molecule, then how many linear X-M-X bonds are in this molecule?

(a) 2 (b) 4 (c) 3 (d) 6 (e) 5

6) Select the strongest bond from the given answers

(a) C=N (b) C=C (c) C=O (d) C=S (e) C=P

7) Which of the following molecules has a nonpolar covalent bond?

(a) HCl (b) H_2O (c) CH_4 (d) NH_3 (e) NaCl

8) Consider the following elements:

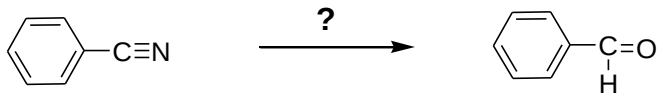
- Element P, a nonmetal in Group 16 of the periodic table
- Element Q, a metal in Group 1 of the periodic table
- Element R, a metal in Group 2 of the periodic table
- Element S, a metalloid in Group 15 of the periodic table

Which of the following compounds is most likely to have a high melting point and be a good conductor of electricity?

(a) PR (b) PS (c) QR (d) QS (e) RS

9) Which of the following factors is responsible for the denaturation of proteins?
   (a) pH change
   (b) Heavy metal poisons
   (c) Organic solvents
   (d) Heat
   (e) All the above

10) What would be the best reagent for the following transformation?

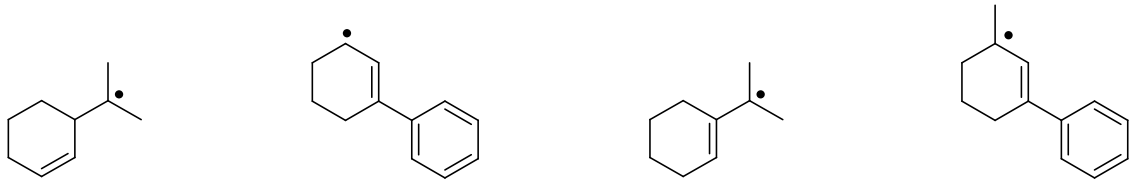


(a) $LiAlH_4$ (b) $NaBH_4$ (c) DIBAL-H (d) $BF_3.OEt$ (e) $HClO_4$

11) Which alkene/s is/are most suitable for the synthesis of 2-bromopentane?
   (a) 1-pentene
   (b) 2-pentene
   (c) 1-butene
   (d) both (a) and (b)
   (e) None of the above

12) Which of the following is the most stable radical?

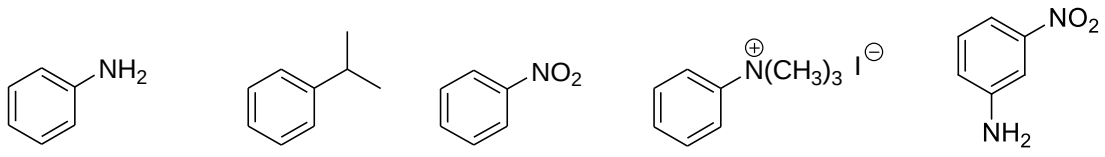
(a) (b) (c) (d)



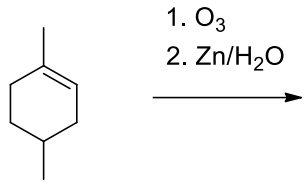
(e) All above radicals are equally stable

13) Which of the following substrate would undergo more facile Friedel-Crafts acylation reaction?

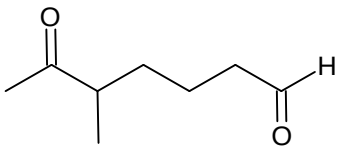
(a) (b) (c) (d) (e)



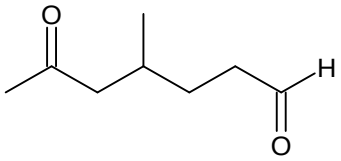
14) Which of the following is the main product of the following reaction?



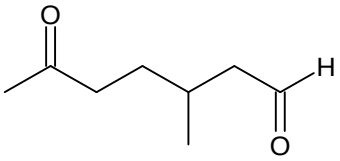
(a)



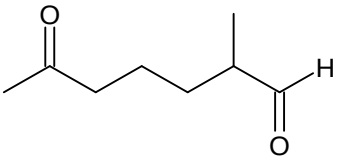
(b)



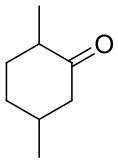
(c)



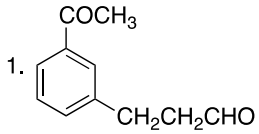
(d)

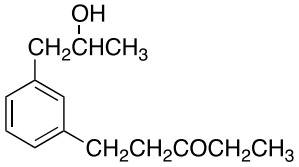


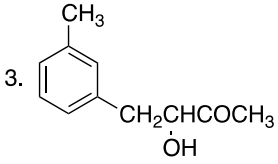
(e)

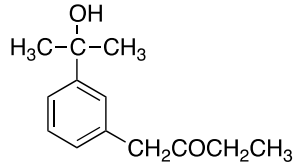


15) Consider the following compounds.

1. 

2. 

3. 

4. 

Which of the above compounds show/s all the following observations?

- An orange color precipitate is formed when reacted with 2,4-dinitrophenylhydrazine.
- Changed orange color of $K_2Cr_2O_7$ to green color in an acidic medium.
- Turns to turbid and oily layer in three to five minutes with conc. HCl and anhydrous $ZnCl_2$.

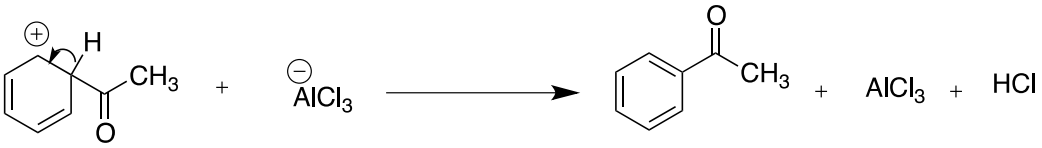
(a) Only (1) and (2) (b) Only (2) and (3) (c) Only (3) and (4) (d) Only (4) and (5)

(e) Any other number of combination of responses correct

16) Which of the following represent an incorrect step/s in the mechanism of the reaction between acetyl chloride and benzene in the presence of anhydrous $AlCl_3$.

1. 

2. 

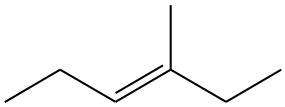
3. 

4. 

(a) Only (1) and (2) (b) Only (2) and (3) (c) Only (3) and (4) (d) Only (4) and (5)

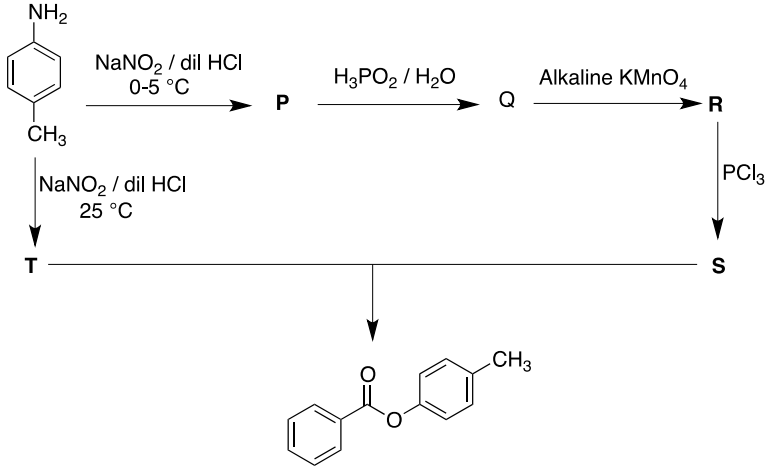
(e) Any other number of combination of responses correct

17) Which of the following is the best choice to prepare the following alkene using the Wittig reaction.

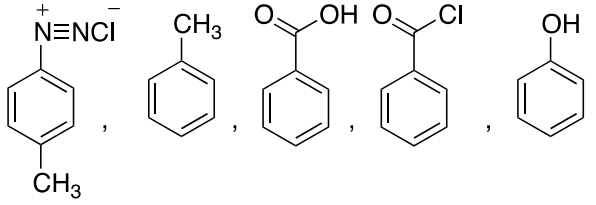


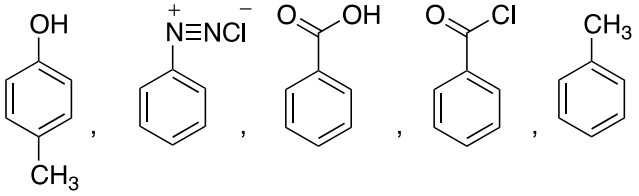
(a) Ethanal and 2-bromobutane/PPh_3
(b) Propanal and 1-bromobutane/PPh_3
(c) Butanal and 2-bromobutane/PPh_3
(d) 2-Butanone and 1-bromopropane/ PPh_3
(e) 2-Butanone and 2-bromopropane/ PPh_3

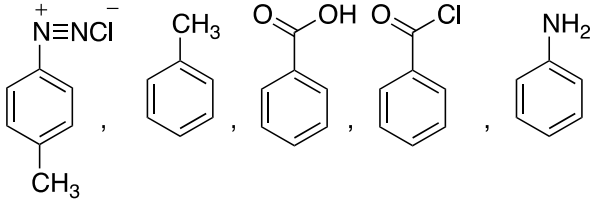
18) Consider the following reaction sequence.

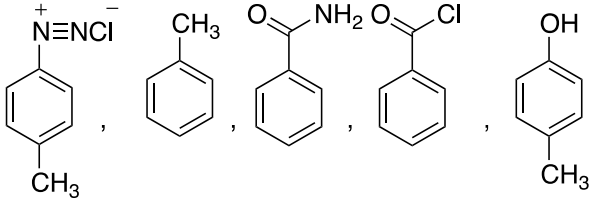


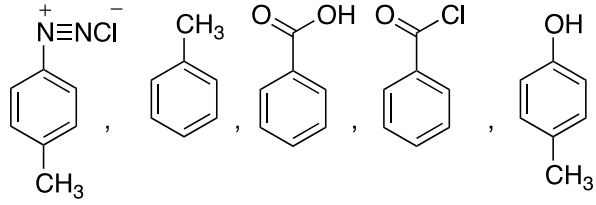
In the reaction scheme given above the structures **P**, **Q**, **R**, **S** and **T** respectively are,

(a) 

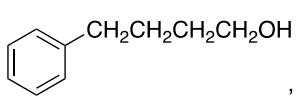
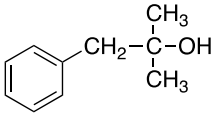
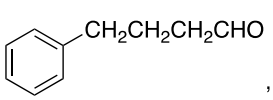
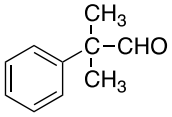
(b) 

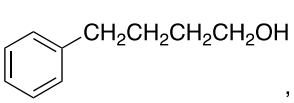
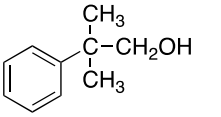
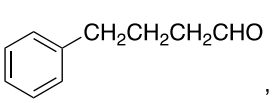
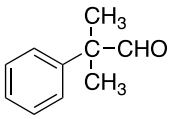
(c) 

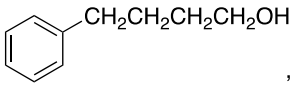
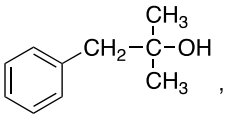
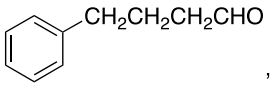
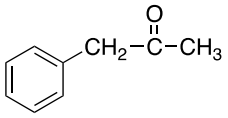
(d) 

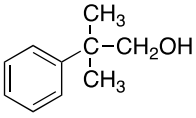
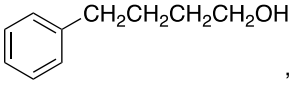
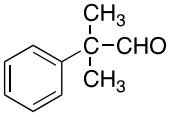
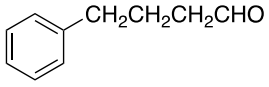
(e) 

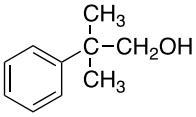
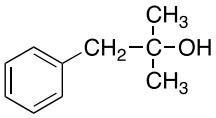
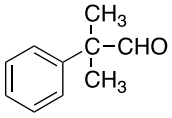
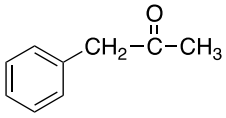
19) **A** and **B** are isomeric, optically inactive, monosubstituted aromatic compounds. **A** and **B** when reacted with pyridinium chlorochromate give compounds **C** and **D**, respectively. Compound **C** undergoes aldol type condensation in the presence of dil. NaOH while **D** does not. The compounds **A**, **B**, **C** and **D** respectively are,

(a)  ,  ,  , 

(b)  ,  ,  , 

(c)  ,  ,  , 

(d)  ,  ,  , 

(e)  ,  ,  , 

20) Vinegar is a dilute aqueous solution of acetic acid produced by the bacterial fermentation of certain carbohydrates. A 5.00 mL sample of a particular vinegar is titrated with 0.100 M NaOH (aq) and the endpoint is obtained as 38.05 mL. The percentage of acetic acid content is (Density of vinegar 1.05 g/mL)

(a). 4.4 % (b) 8.2 % (c) 17.2 % (d) 43.4 % (e) Not enough data to calculate

21) Steel is an alloy of iron and carbon. A steel ball has a radius of *r* and a density of *d*. The ball contains 0.25% carbon, by mass. Given that the percent natural abundance of ^{13}C is *y* % correct mathematical expression for the number of ^{13}C atoms present in a ball is (Avogadro number is N_A)

(a) $\frac{\pi y r^3 N_A}{3900 d}$ (b) $\frac{4\pi r^3 N_A}{90000 dy}$ (c) $\frac{\pi y r^3 d N_A}{390000}$ (d) $\frac{4\pi r^3 dy}{30000}$ (e) None of the above

22) Molecules of a dicarboxylic acid have two carboxyl groups (-COOH). A 2.250 g sample of dicarboxylic acid was burned in excess of oxygen and yielded 4.548 g CO_2 and 1.629 g H_2O. Molar mass is 174 g/mol. The number of C atoms in this molecule is

(a) 5 (b) 6 (c) 7 (d) 8 (e) 9

23) Consider the reaction $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$. Initially, a 10.0 L container at 300 K holds 2.00 mol of NO and 0.50 mol of O_2. The reaction goes to completion, and the total pressure at the end is found to be 1.00 atm. What is the partial pressure of NO_2 at the end of the reaction?

(a) 0.25 atm (b) 0.50 atm (c) 0.75 atm (d) 1.00 atm (e) 1.25 atm

24) When 0.25 moles of Fe_2O_3 react with excess I^-, only 60% of Fe_2O_3 reacts. If Fe^{2+} ions are formed in the reaction, and resulting solution is titrated with 3.0 M I_2, what is the volume of I_2 needed to reach the endpoint?

(a) 5.0 mL (b) 10.0 mL (c) 20.0 mL (d) 25.0 mL (e) 50.0 mL

25) When Mg_3N_2 reacts with excess H_2O, only 70% of Mg_3N_2 reacts. If the resulting solution is titrated with 6 M HCl, what volume of HCl is needed to react with 0.02 moles of unreacted Mg_3N_2?

(a) 4.0 mL (b) 8.0 mL (c) 10.0 mL (d) 16.0 mL (e) 20.0 mL

26) Two identical containers contain the same amount of gas at the same temperature. One container contains an ideal gas, and the other contains a real gas. Let P_I be the pressure of the container containing the ideal gas, and P_R be the pressure of the container containing the real gas. The behaviour of a real gas is described by the Van der Waal's equation:

$$\left(\mathrm{P} + \frac{\mathrm{n}^2 a}{\mathrm{V}^2}\right)(\mathrm{V} - \mathrm{nb}) = \mathrm{nRT}$$

Consider the following statements.

A. If $a = 0$ and $b > 0$ then $P_I > P_R$
B. If $b = 0$ and $a > 0$ then $P_I > P_R$
C. If $a = 0$ and $b > 0$ then $P_I < P_R$
D. If $b = 0$ and $a > 0$ then $P_I < P_R$
E. If $a = 0$ and $b = 0$ then $P_I = P_R$

Choose the correct answer from the following.

(a) Only statements (A), (B), and (E) are true.
(b) Only statements (A), (D), and (E) are true.
(c) Only statements (B), (C), and (E) are true.
(d) Only statements (B), (D), and (E) are true.
(e) Only statement (E) is true.

27) What is the correct statement regarding surface adsorption?
(a) It is an exothermic reaction.
(b) It is a bulk phenomenon.
(c) It is an endothermic reaction.
(d) It occurs at a uniform rate.
(e) The molecule is not on the surface but is uniformly distributed throughout the medium.

28) Adsorption is defined as the deposition of molecular species on a solid surface. The adsorption can be categorized as physical adsorption and chemical adsorption. If gas molecules are getting adsorbed onto a solid surface, the amount of gas molecules adsorbed on the solid surface,
(a) increases with an increase in the temperature.
(b) increase with a decrease in the temperature.
(c) independent of temperature.
(d) independent of temperature and pressure.
(e) depends only on the temperature.

Consider the following reaction for (29) and (30).

$2NO + Cl_2 \rightarrow 2NOCl$

29) Which of the following statements is correct

(a) The rate of consumption of NO is equal to twice the rate of formation of NOCl
(b) The rate of consumption of NO is equal to half of the rate of formation of NOCl
(c) The rate of consumption of Cl_2 is equal to twice the rate of formation of NOCl
(d) The rate of consumption of Cl_2 is equal to half of the rate of formation of NOCl
(e) The rate of consumption of Cl_2 is equal to the rate of formation of NOCl

30) The following mechanism was proposed for the formation of NOCl.

$$NO + Cl_2 \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} NOCl_2 \text{ (fast equilibrium)}$$

$$NO + NOCl_2 \xrightarrow{k_2} 2NOCl \text{ (slow)}$$

According to the above mechanism, the rate of formation of NOCl would be (where k is a constant)

$(a)\ k[NO]$ $(b)\ k[NO]^2$ $(c)\ k[Cl_2][NO]^2$ $(d)\ k[Cl_2]^2[NO]$ $(e)\ None\ of\ the\ above$

Answer the questions (31) and (32) based on the experimental details given below

The reaction between $BrO_3^-\ (aq)$ and $Br^-(aq)$ in acidic solution is given by the following equation.

$$5\ Br^-(aq) + BrO_3^-\ (aq) + 6\ H^+ \rightarrow 3\ Br_2\ (aq) + 3\ H_2O$$

The rate law of the reaction is

$$rate = k\ [Br^-(aq)][BrO_3^-\ (aq)][H^+]^2$$

The Kinetics of the above reaction was studied by adding phenol and a drop of dilute methyl orange to the reaction mixture. The addition of phenol to the above mixture gives the following reaction

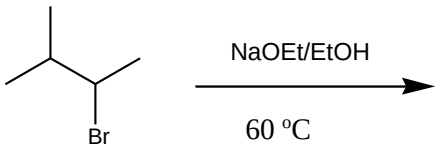
$$3\ Br_2\ (aq) + C_6H_5OH \rightarrow BrC_6H_4OH + Br^-\ (aq)$$

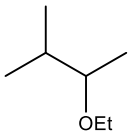
Methyl orange gets bleached in the presence of Br_2. Therefore, completion of the reaction is detected as the colour of the solution changes from orange to colourless.

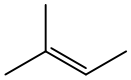
31) Two experiments of the above reaction were conducted keeping $BrO_3^-\ (aq)$, $Br^-(aq)$ and acid concentrations same but doubling the concentration of phenol and measuring the time taken for the solution to become colourless. Upon doubling the concentration of phenol time taken for the colour change has increased by more than a factor of two. Accordingly, which of the following statements is true?
   (a) At high concentrations of phenol, methyl orange decolouration time decreases.
   (b) The bromination of phenol slowed down at higher concentrations of phenol
   (c) At higher concentration of phenol, BrC_6H_4OH started converting to $Br_2C_6H_3OH$
   (d) The rate of the BrO_3^- and Br^-reaction decreases with the progress of the reaction over time.
   (e) At higher concentrations of phenol, the simplified rate law derived is no longer valid

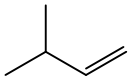
32) In another experiment, phenol concentration was kept fixed and the BrO_3^- concentration varied. Other concentrations were also kept fixed. Which of the following is true, if *t* is the time taken for the colour change.
   (a) *t* will increase as initial $[BrO_3^-\ (aq)]$ increases
   (b) k can be obtained from the initial slope of $[BrO_3^-\ (aq)]$ vs *t* plot
   (c) the orders of the reactants change with temperature
   (d) *t* will be independent of $[BrO_3^-\ (aq)]_0$
   (e) None of the above statements are true

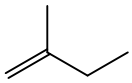
33) Which is the major product of the following reaction?



(a) 

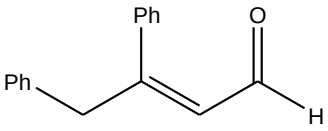
(b) 

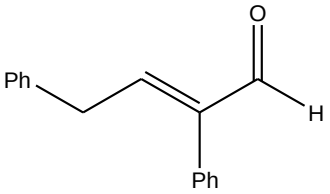
(c) 

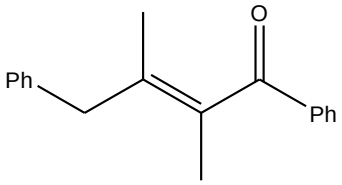
(d) 

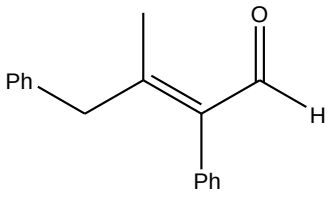
(e) None of the above

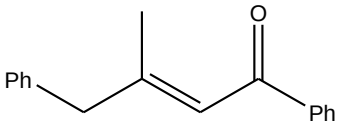
34) Which of the following compounds can be prepared by an Aldol condensation treating a single carbonyl compound with a base?

(a) 

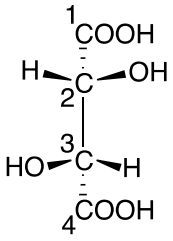
(b) 

(c) 

(d) 

(d) 

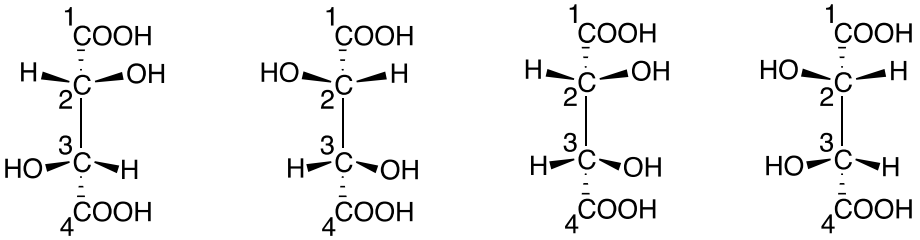
- Answer to the questions 35 - 37 based on the compound given below.



35) The absolute configuration of the C-2 and C-3 respectively are,

(a) R,R (b) S,R (c) R,S (d) S,S (e) None of the above

Consider the following stereoisomers of the above compounds.



36) The stereochemical relationships of the pairs of stereoisomers **B**-**C**, and **C**-**D** respectively are,

(a) Enantiomeric and meso compounds

(b) Enantiomeric and diastereomeric

(c) Diastereomeric and enantiomeric

(d) Diastereomeric and meso compounds

(e) Identical and diastereomeric

37) Which of the following statement/s is/are true regarding the pair of stereoisomers **A**-**B**.

1. They have different melting points.

2. They can be separated using silica column chromatography.

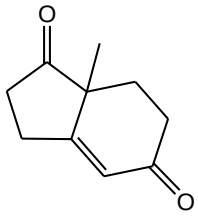
3. They have identical chemical shifts in ^{1}H NMR spectra.

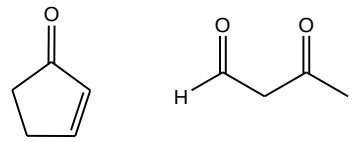
4. They have identical boiling points.

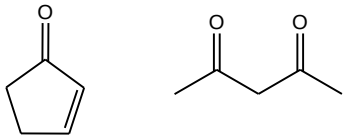
(a) Only (1) and (2) (b) Only (2) and (3) (c) Only (3) and (4) (d) Only (1) and (3)

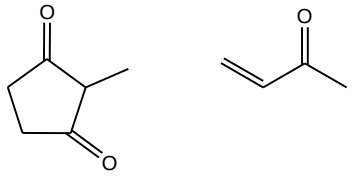
(e) Any other number of combination of responses correct

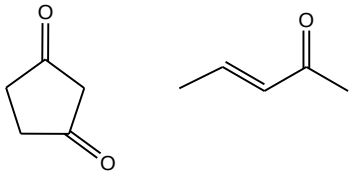
38) Which two compounds can be used to prepare the following molecule using Robinson Annulation?



(a) 

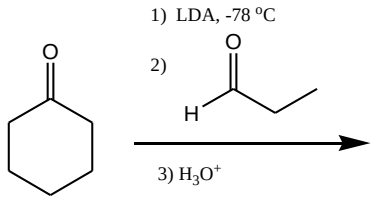
(b) 

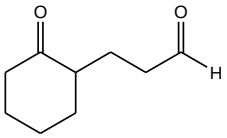
(c) 

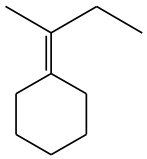
(d) 

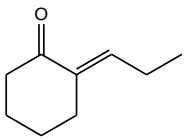
(e) None of the above

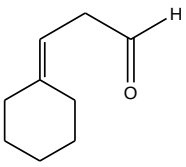
39) What is the major organic compound of the following reaction?

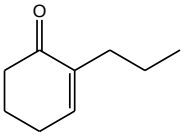


(a) 

(b) 

(c) 

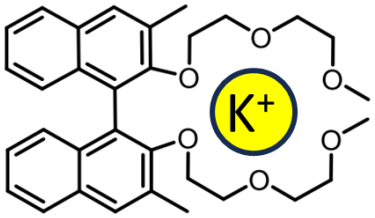
(d) 

(e) 

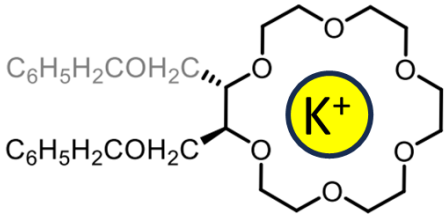
40) A salt has a formula of the type $M_xL_y.zH_2O$. In this formula M^{n+} is a metal cation, L^{b-} is a polyatomic anion and x, y and z are all unknown integers. $M^{(n-1)+}$ and I_2 are formed when M^{n+} reacts with I^-. If 23.45 mL of 0.03 M sodium thiosulphate is required to titrate 0.4232 g sample of the salt dissolved with excess KI, the amount of M^{n+} present in 0.4232 g of solid $M_xl_y.zH_2O$ is.

(a) 1.41×10^{-3} mol (b) 2.64×10^{-4} mol (c) 7.04×10^{-4} mol (d) 3.69×10^{-4} mol
(e) 3.52×10^{-4} mol

Receptor-1 (R1) has an open polyether chain while Receptor-2 (R2) is a closed macrocycle. The cavity size of R2 is complementary in size to K^+ cation.



Receptor-1 (R1)



Receptor-2 (R2)

41) Which of the following is most likely to be true regarding the binding constant of K^+ with R1 and R2?

(a) Binding constant of K^+ with R1 > Binding constant of K^+ with R2
(b) Binding constant of K^+ with R1 = Binding constant of K^+ with R2
(c) Binding constant of K^+ with R1 < Binding constant of K^+ with R2
(d) All the above possibilities are equally likely to be true
(e) Insufficient information to compare binding constants

42) Cavity size of R2 is too small to bind a Cs^+ cation. Based on this information which of the following is most likely to be true regarding Cs^+ binding constant?

(a) Binding constant of Cs^+ with R1 = Binding constant of Cs^+ with R2
(b) Binding constant of Cs^+ with R1 > Binding constant of Cs^+ with R2
(c) Binding constant of Cs^+ with R1 < Binding constant of Cs^+ with R2
(d) Binding constant of Cs^+ with R1 << Binding constant of Cs^+ with R2
(e) Insufficient information to predict binding constants

Questions 43-45 are based on the following description

In statistical thermodynamics, a configuration refers to a unique arrangement of particles in a system. Assume that the particles are independent, that is they do not interact with each other. Each possible arrangement of the particles within the system is a different configuration.

The individual particles can occupy particle energy states (like atomic or molecular orbitals). Suppose there are L particle energy states. A general configuration will have n_i particles occupying the particle state with energy ϵ_i. Suppose we have a system of N particles with total energy E.

43) What are the correct expressions for E and N?

	E	N
(a)	$\epsilon_1 + \epsilon_2 + \cdots + \epsilon_L$	$n_1 + n_2 + \cdots + n_L$
(b)	$\epsilon_1 + 2\epsilon_2 + \cdots + L\epsilon_L$	$n_1 + 2n_2 + \cdots + Ln_L$
(c)	$n_1\epsilon_1 + n_2\epsilon_2 + \cdots + n_L\epsilon_L$	$n_1 + n_2 + \cdots + n_L$
(d)	$n_1\,\epsilon_1 + n_2^2\epsilon_2 + \cdots + n_L^2\epsilon_L$	$n_1^2 + n_2^2 + \cdots + n_L^2$
(e)	$n_1\epsilon_1 + 2n_2\epsilon_2 + \cdots + Ln_L\epsilon_L$	$n_1 + 2n_2 + \cdots + Ln_L$

A configuration is defined by specifying the populations (the number of particles) in each particle energy state in the form $\{n_1, n_2, \ldots, n_N\}$. The ground state configuration is $\{N, 0, 0, \ldots, 0\}$. The first excited state is formed by exciting any of the N particles in the particle state ϵ_1, and therefore the configuration $\{N-1, 1, 0, \ldots, 0\}$. This configuration is N times more likely to occur than the ground state. For very large N, it can be shown that the particle state population of the most likely configuration is given by the Boltzmann distribution:

$$\frac{n_i}{N} = \frac{e^{-\beta\epsilon_i}}{\sum e^{-\beta\epsilon_i}}$$

β is a measure of the inverse temperature. Specifically,

$$\beta = \frac{1}{kT}$$

where k is the Boltzmann constant and T is the temperature (in Kelvin) of the system.

44) Consider a two-level system, with an energy gap ΔE, and a ground state energy of zero. What will be the probability of occupation of each state?

	$P_1 = \frac{n_1}{N}$	$P_2 = \frac{n_2}{N}$
(a)	0.5	0.5
(b)	1	0
(c)	$1 - e^{-\beta\Delta E}$	$e^{-\beta\Delta E}$
(d)	$\frac{1}{1 + e^{-\beta\Delta E}}$	$\frac{e^{-\beta\Delta E}}{1 + e^{-\beta\Delta E}}$
(e)	$\frac{e^{-\beta\Delta E}}{1 + e^{-\beta\Delta E}}$	$\frac{1}{1 + e^{-\beta\Delta E}}$

The denominator of the Boltzmann distribution expression is an important thermodynamic property of the system. It's called the partition function q, and is given by,

$$q = \sum e^{-\beta\epsilon_i}$$

The partition function can be used to calculate the vibrational spectra of a molecule. Nuclear motion of a small diatomic molecules, like I_2 can be approximated as a simple harmonic oscillator. For a system of such molecules, their vibrational energy levels are equally spaced. If the spacing between two vibrational levels is ΔE, then the partition function of such a diatomic gaseous system is given by,

$$q = \frac{1}{1 - e^{-\beta\Delta E}}$$

45) A linear diatomic molecule has a vibrational wavelength of λ. What is the probability of finding that molecule in its ground state at temperature T, given that the ground state energy is zero? Planck constant is h, and c is the speed of light.

(a) $p_1 = 1 + e^{\frac{-hc\,\lambda}{kT}}$

(b) $p_1 = 1 - e^{\frac{-hc}{\lambda kT}}$

(c) $p_1 = \frac{1}{1 - e^{\frac{-hc}{\lambda kT}}}$

(d) $p_1 = \frac{1}{1 + e^{\frac{-hc\,\lambda}{kT}}}$

(e) $p_1 = 0.5$

……END……