2025-Revision

Advanced Level Chemistry – Model Paper - 12

Time – 1 hour

(01) a) The following questions are relevant to the elements of the **third period** of the periodic table. Write the symbol of the suitable element in the spaces given below.

i) Identify the monoatomic ion with the smallest size. (This ion should be stable.) …….

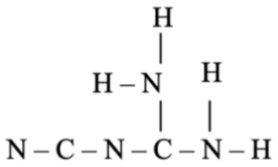
ii) Identify the element which has the second higher first ionization energy. ……..

iii) Identify the element which has a stable configuration although it does not have electrons in **p** sub energy level ……....

iv) Identify the element which forms electron deficient compounds and exists as a dimer in the gaseous state. ……..

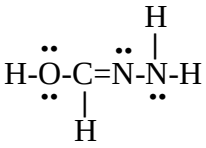
v) Identify the least electronegative element. (Ignore the noble gas.) ……..

b) The Skelton of $C_2H_4N_4$ is given below.



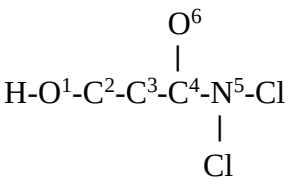
i) Draw the most acceptable Lewis structure for the above structure.

ii) The most acceptable Lewis structure for the molecule H_4CN_2O is given below. Draw two other Lewis structures for the compound. Write the word 'unstable' under the **<u>most unstable</u>** structure which is drawn by you.



Vajira Seneviratne (Ph.D. – Cantab)

iii) Fill the table given below by considering the most acceptable Lewis structure of $C_3NO_2Cl_2H$ molecule. Skeleton of this molecule is given below.



	O^1	**C^2**	**C^3**	**N^5**
***VSEPR* pairs**				
Electron pair geometry				
Shape				
Hybridization				
Oxidation Number				

iv) Identify the atomic / hybrid orbitals which are participated to form the following σ bonds, present in the Lewis dot dash structure of part (iii) above.

I. $C^4 – O^6$ C^4 - …… O^6 - ……..

II. $H – O^1$ H - …… O^1- ……

III. $O^1 – C^2$ O^1- …… C^2 -……

IV. $C^2 – C^3$ C^2 - ……. C^3- ……

V. $C^3 – C^4$ C^3 - ……. C^4 - ……..

VI. $C^4 – N^5$ C^4 - ……. N^5 - ……..

v. Identify the atomic orbitals which are participated for the formation of the following π bonds present in the Lewis structure given in part (iii).

I. $C^2 – C^3$ - ……...

II. $C^4 – O^6$ - ……...

vi. I. What is the orientation of the two π bonds in the triple bond of the Lewis dot dash structure in part (iii) above.

……...

……

II. Give an example for a molecule / an ion which is having a triple bond between 2 different atoms. (The elements used should be limited to first and second periods of the periodic table)

……...

……

C) i. The atomic orbitals are described by the 3-quantum number n, l and m_l. Write the relevant quantum number and the name of the atomic orbital in the spaces given below.

I.	……	……	-1	4p
II.	4	2	0	…….
III.	……	…….	…….	3s

ii. Arrange the following in the increasing order of the property indicated inside the parenthesis.

I. $BeCO_3$, $MgCO_3$, $CaCO_3$ (decomposition temperature)

…… < …… < ……

II. NO_2^+, NO_2, NO_2^- (ONO bond angle)

…… < …… < ……

III. C_6H_6, C_3H_4, C_2H_4 ($C-C$ bond length)

…… < …… < ……

(02) a) **X** is an element of s-block in the periodic table. The first, second, and third ionization energies of $\boldsymbol{X}$ are 519, 7300, 11800 in $kJ\ mol^{-1}$ respectively. $\boldsymbol{X}$ reacts with water slowly at the room temperature. forming its hydroxides and liberating $H_{2\,(g)}$. The hydroxide is basic. When $\boldsymbol{X}$ reacts with dilute acids, $H_{2\,(g)}$ gas is released. When $\boldsymbol{X}$ is heated in air, a mixture of two solid compounds is formed. When those two compounds are reacted with water the basic gas $\boldsymbol{Y}$ is evolved.

i. Identify **X**.

……..

ii. Write the electron configuration of the ground state of $\boldsymbol{X}$.

……..

iii. Write the chemical formulae of the compounds formed in combustion of $\boldsymbol{X}$ in air.

……..

iv. Consider the following compounds of the elements of the other group except the group of $\boldsymbol{X}$ in s-block. Inside the given spaces, mention whether the given properties below increases or decreases when going down the group.

I. The water solubility of sulphites. ……

II. The water solubility of hydroxides. ……...

III. Thermal stability of metal nitrates. ……

Give reasons for your answer for (III)

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v. Identify the element of *s*-block which does not belong to the group of **X** of the periodic table, but reacts with $H_{2\,(g)}$, $O_{2\,(g)}$ and $N_{2\,(g)}$ in a similar manner as **X**.

……..

vi. Identify **Y**.

……..

vii. Write an experiment to identify **Y**.

……..

viii. What is the observation of the above experiment?

……..

……..

b) The test tubes labelled as **A** to **E** contain the aqueous solution of Na_2SO_4, Na_2SO_3, $NaOH$, K_2CrO_4 and $Ca(NO_3)_2$ (not in order). The relevant tests carried out for each of these test tubes **A** to **E** and the relevant observations are given below.

Test tube	Test	Observations
A	Add 1 cm^3 of $BaCl_2$ then add dil. HCl.	A white colour precipitate is formed, and it dissolves in acid.
B	Add $Mg(NO_3)_2$ solution.	A white colour precipitate is obtained.
C	Add 1 cm^3 of $BaCl_2$ then add dil. HCl.	A white colour precipitate is formed. it does not dissolve in HCl.
D	Add about 1 cm^3 of Na_2CO_3 solution then add dil. HCl.	A white colour precipitate is formed. The precipitate dissolves.
E	Add 1 cm^3 of $BaCl_2$ solution.	A yellow colour precipitate is formed.

i. Identify the solutions present in test tubes **A** to **E**.

……..

……

ii. Write the balanced chemical / ionic equations for the reactions taking place in **A**, **B**, **C**, **D** and E.

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(03) a) To prepare 250 cm^3 of 1 mol dm^{-3} $KAl(SO_4)_2$ solution in the laboratory, $KAl(SO_4)_2.12H_2O$ is provided to you. (K = 39, Al = 27, O = 16, H = 1, S= 32)

i. Calculate the number of moles of $KAl(SO_4)_2$ required.

ii. Calculate the mass of $KAl(SO_4)_2.12H_2O$ that should be weighed?

iii. What is known as a primary standard solution?

……..

……..

iv. Give 2 examples for the primary standards.

……..

v. The concentration of 1 $mol\ dm^{-3}$ $KAl(SO_4)_2$ solution prepared is slightly different than the intended value. Give 2 reasons for this observation.

……..

……..

vi. Calculate the volume that should be measured from the above 1 mol dm^{-3} $KAl(SO_4)_2$ solution to prepare 100 cm^3 of 0.25 mol dm^{-3} $KAl(SO_4)_2$ solution.

(04) a) In a certain compound, 30.44% of nitrogen and 69.56% of oxygen is present by mass. The relative molecular mass of the compound is within 90-95.

i. Determine the empirical formula of the compound. (N = 14, O = 16)

ii. Determine the molecular formula of the compound and draw its' structure.

iii. If the experimentally determined molar mass of this compound is 69 under a certain pressure. Explain the reason for this observation and determine the molar fraction of the pure compound identified in (ii) above.

b) $KMnO_4$ is a purple-coloured compound.

i. Write the $IUPAC$ name of $KMnO_4$.

……..

ii. Write the chemical formula of the oxides derived by Mn and state their acidic and basic properties.

……..

……..

iii. Write the election configuration of Mn.

……..

iv. In acidic medium $KMnO_4$ reacts with $FeSO_3$.

I. Write the oxidation half reaction.

……..

II. Write the reduction half reaction.

……..

III. Write the balanced ionic reaction.

……..

……..

……..

IV. Write the balanced chemical equation if dil. H_2SO_4 is used to make the medium acidic.

……..

C) Consider the following reaction at 298 K temperature.

$$2NH_{3\,(g)} \rightarrow N_{2\,(g)} + 3\,H_{2\,(g)}$$

The standard molar enthalpy - 90 kJ mol^{-1}.
At 298 K, the standard entropy change - 250 J mol^{-1} K^{-1}.

i. Calculate ΔG^{θ} for the reaction.

ii. Explain the spontaneity of the reaction at 298 K.

……

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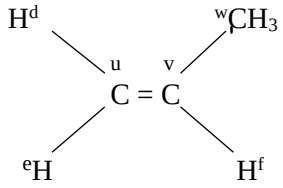
……

iii. Calculate the maximum temperature required for the reaction to be spontaneous.

iv. Draw a graph depicting the variation of ΔG^{θ} with t/℃ for the above reaction. Indicate the intercept clearly.

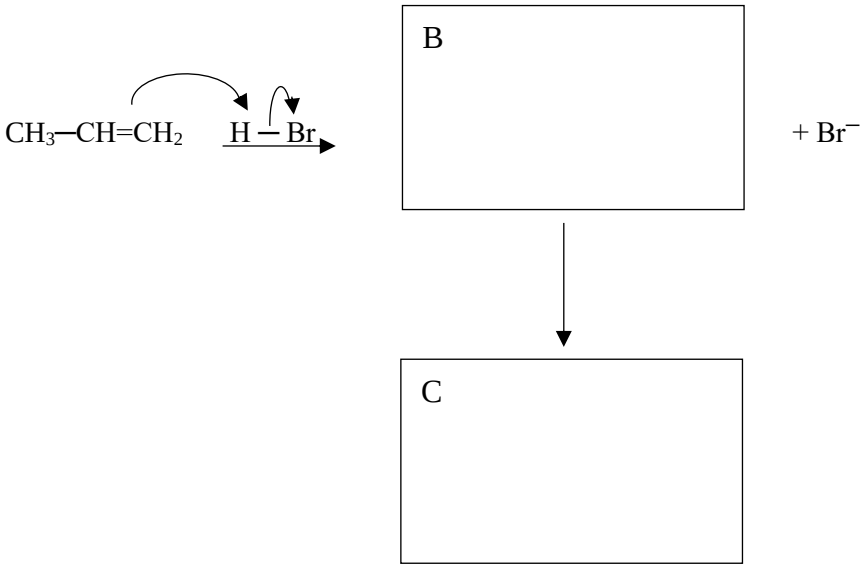
05)

a) Consider the molecule A given below. (Superscripts *d, e, f, u, v* and w used to label the H and C atoms)



A

i) A part of the mechanism of the reaction of A with HBr is depicted below. Writing the structures corresponding to B and C in the boxes below, complete the mechanism using curved arrows where appropriate.



ii) The following statements refer to **A** and its reaction with HBr. Indicate whether each of these statements are correct or wrong in the appropriate box. If you are unable to evaluate any of these statements keep the box vacant.

N.B: For each correct answer 0.5 marks will be awarded.
For each incorrect answer 0.2 marks will be deducted.
If a box is kept vacant, no mark will be awarded or deducted.
However, the minimum marks for this part (a) (2) will be zero (0).

1. Carbon atom denoted by u is sp^2 hybridized. ☐
2. Carbon atom denoted by w is sp^2 hybridized. ☐
3. Carbon atom denoted between C atoms denoted by u and v consists of a σ bond and a $\underline{\pi}$ bond. ☐
4. A $\underline{\pi}$ bond is formed by the lateral overlap of two sp^2 orbitals. ☐

5. The bond between **C** atoms denoted by v and w is formed by the linear overlap of two hybridized orbitals. ☐

6. All the atoms in **A** lie in the same plane. ☐

7. In this reaction bonds undergo heterolytic cleavage. ☐

8. A curved arrow (↷) indicates the movement of an atom or a group of atoms, from one position to another. ☐

9. This reaction is a nucleophilic reaction. ☐

b)

i) Write down in the box below, the structure of the acyclic hydrocarbon **D** (C_6H_{12}) which is optically active.

N.B: It is not necessary to draw the three-dimensional structure.

D

ii) Does this compound show geometrical isomerism?

……

i) Write down the structure of the product **E** formed when **D** is treated with H_2/Pt.

E

ii) Giving a reason state whether **E** could exist in optically active forms.

……

……

iii) Write down the structure of the products **F** formed when **D** is reacted with Br_2/CCl_4

F

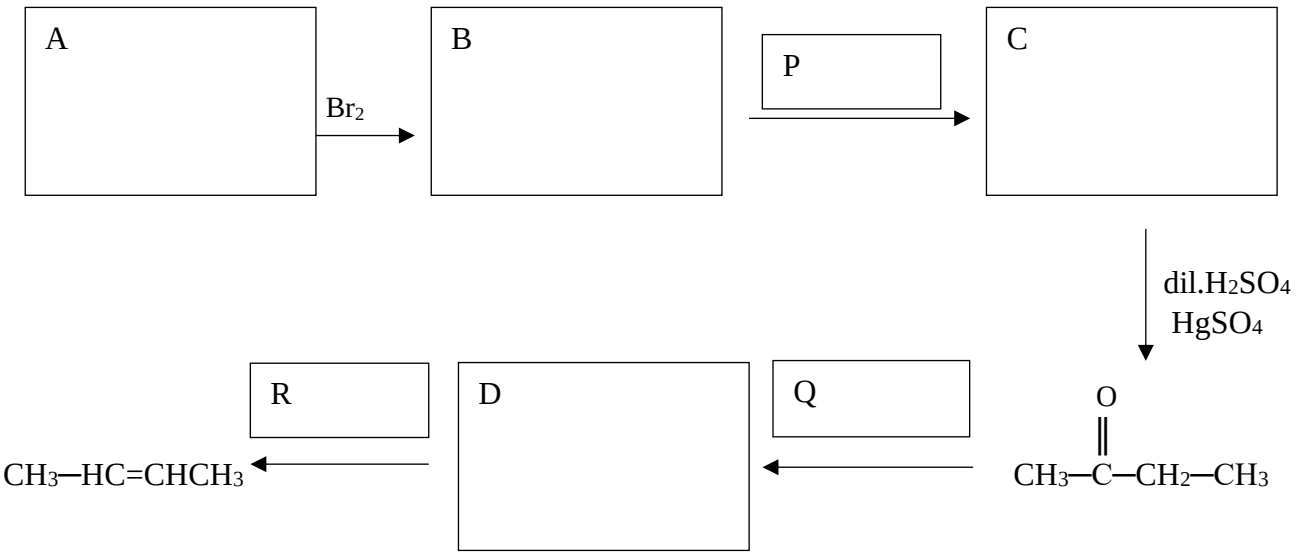
iv) How many asymmetrical carbon atoms are there in the molecule **F**? ……

v)

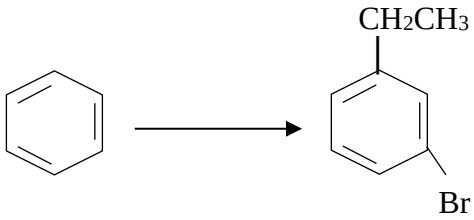
06)

a) Consider the following reaction statements.
Write down in the appropriate boxes the structures corresponding to compounds, A, B, C, D, E, F, and G.
Also indicate in the appropriate boxes the reagents corresponding to P, Q, R, S, T, U and V.

i)



c) Show, how you would carry out the following conversion.



NB: This conversion can be out in three steps.
Marks will not be awarded to answers containing more than five steps.

b) The Kinetics of the following reaction can be studied by measuring initial rates.

$$P(aq) + 5Q(aq) + 6R(aq) \longrightarrow 3S(aq) + 3T(aq)$$

The experiment carried out by changing Initial concentration of P, Q, R at a constant temperature are given in the table. The change in the concentration of P $[\Delta P]_0$with me[t/s] was measured.

Expt.	$[P]_0$/ Mol dm^3	$[Q]_0$/ Mol dm^3	$[R]_0$/ Mol dm^3	$[\Delta P]_0$/ Mol dm^3	t/s	Initial Rate (R) $moldm^{-3}s^{-1}$
1.	0.2	0.2	0.2	0.040	50	R_1 = ……..
2.	0.4	0.2	0.2	0.096	60	R_2 = ……..
3.	0.4	0.4	0.2	0.123	40	R_3 = ……..
4.	0.2	0.2	0.4	0.080	25	R_4 = ……..

1. Calculate initial rates R_1, R_2, R_3, R_4 and complete the table above.

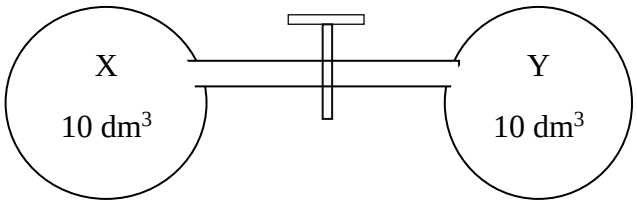
2. Deduce and write the rate orders corresponds to P, Q and R.
   ……..……
   ……..
   ……..……
   ……..
   ……..……
   ……..

3. Hence calculate the overall order of the reaction.
   ……...

4. Calculate the rate constant *k* of the reaction.
   ……...

07.

A) Two rigid vessels **X** and **Y** each of 10 dm^3 volume were connected by a small tube, volume of that tube was negligible, and tap was placed with a small tube, which was connected to two vessels.



Initially the tap was closed at 300 K. Vessel **X** contains 1.4 mol of $AB_{(g)}$ and **Y** is empty. When the system was increased to 350 K $AB_{(g)}$ is dissociated into $A_{2(g)}$ and $B_{2(g)}$ according to the equilibrium reaction given bellow,

$$2AB_{(g)} \rightleftharpoons A_{2(g)} + B_{2(g)}$$

When the system has reached equilibrium at 350 K the amount of $B_{2(g)}$ is 0.2 mol. After that the tap was opened and the system was allowed to reach second equilibrium at the same temperature 350 K and amount of $B_{2(g)}$ is b mol.

i) Write down the equation K_C for the above reaction with related to the concentration of products and reactant,
ii) Calculate the value for K_C at 350 K when the tap was closed.
iii) Calculate the value for 'b' in the second equilibrium when the tap was closed.
iv) Explain your answer (iii) above using the Le Chatterliers principle.
v) The temperature of the system was increased to 500 K. Then the system was allowed to reach third equilibrium K_C of this equilibrium was 9×10^{-2}. Calculate the amount of $B_{2(g)}$ at this equilibrium.
vi) Show that the equilibrium is endothermic or exothermic with reasons.