G.C.E.(A.L.) Examination - 2015

Evaluation Report

02 - Chemistry

Curriculum
Assessment
&
Evaluation
Teaching Learning
N E T S

Research & Development Branch
National Evaluation & Testing Service
Department of Examinations

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Financial Aid

Transforming the School Education System as the Foundation of a Knowledge Hub Project (TSEP-WB)

INTRODUCTION

The General Certificate of Education (Advanced Level) Examination is the final certification examination of the Senior Secondary Education in Sri Lanka. Though certification of the students' achievement level at the end of Senior Secondary Education is the major aim of this examination, it bears a momentous position as an achievement test as well as a selection test because the eligible candidates for national universities and other higher education and vocational training institutes and also for the National Colleges of Education are selected on the results of this examination. This has also been accepted as an examination that certifies entry qualifications for the tertiary level employments. In the year 2015, 210340 school candidates and 44851 private candidates sat this examination.

Much pains are being taken by students to have a high achievement level at this examination and teachers and parents to fulfil their expectations. This evaluation report has been prepared by the Department of Examinations to assist the realization of their goals. It is certain that the information provided by this evaluation report is equally important for candidates, teachers, principals, in-service advisers, subject directors, parents and researchers in education. So it is appropriate to tender this report for wider reference.

This evaluation report comprises of three parts. I, II and III. Part I of this report consists of information related to aims and achievement of the subject Chemistry in G.C.E. (A.L) Examination. Presented under it are the statistical information on subject achievement, that is number of candidates sat for the subject, how they have obtained grades, how school candidates have obtained grades by district and distribution of marks according to class intervals and a comprehensive analysis of the subject achievement that reveals how candidates have selected questions in Papers I and II in Chemistry and how they have scored marks for the questions in them and the sub parts of each question. Part II of this report presents the questions in Paper I and Paper II of Chemistry in the G.C.E. (A.L) Examination 2015 and information about the candidates' responses to them. It encompasses expected answers for the questions of papers I and II, the mark scheme, observations on answers, conclusions and constructive suggestions.

This evaluation report prepared by the Research and Development Branch of the Department of Examinations is based on the information, observations, ideas and suggestions provided by chief examiners, additional chief examiners and assistant examiners involved in evaluating answer scripts and the information drawn through the analysis of candidates' responses using the Classical Test Theory and the Item Response Theory.

Part III of this report embodies the facts that should be taken into consideration by the candidates when answering each question and opinions and suggestions with regard to the learning teaching process. I think that this report is of immense value in the organization of the learning teaching process to achieve respective competencies and competency levels. You are kindly requested to direct your productive ideas and suggestions to us to improve the quality of our future evaluation reports.

I wish to extend my sincere thanks to the chief examiners, additional chief examiners and assistant examiners who provided information to prepare this report, the committee members who fervently and actively contributed to the task, the officers and the staff of the Department of Examinations who shouldered the responsibility, State Printing Co-operation who printed this material and the TSEP-WB that provided financial assistance for it.

W.M.N.J. Pushpakumara
Commissioner General of Examinations

29th June 2016
Research & Development Branch
National Evaluation & Testing Service
Department of Examinations.
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Part I

1. Subject objectives and information on subject achievements

1.1 Subject objectives

After following this course the student will :

* understand the basic concepts in chemistry required to comprehend the physical foundation of scientific explanations of natural phenomena.

* become knowledgeable about the total framework of chemistry including its main concepts, unifying themes and patterns enabling to understand the structure and changes in matter and lay the foundation for students who pursue the study of further chemistry in the future.

* incline to understand and appreciate the nature of the scientific process through direct experiences and inquiring into the historical development of chemistry.

* understand the limits of science and how it is applied in relation to technical, economics, social and personal development.

* understand the physico - chemical foundation of problems relating to the scientific usage and conservation of resources acquiring a general knowledge of them with special attention to the conditions prevailing in Sri Lanka.

* acquires knowledge and skills required for the application of basic concepts in chemistry for technical, social and economic development with special attention to Sri Lanka.

* develops interest for applying the knowledge and skills gained through the course for socio - economic development and conservation and utilization of natural resources.

1.2 Statistical information on subject achievement

1.2.1 Number of candidates sat for the subject

Medium	School	Private	Total
Sinhala	52040	13672	65712
Tamil	8539	1624	10163
English	2731	268	3299
Total	**63310**	**15684**	**79174**

Table 1

1.2.2 Grades obtained by the candidates

Grade	School Candidates		Private Candidates		Total	Percentage
	Number	Percentage	Number	Percentage		
A	3946	6.23	1132	7.14	5078	6.41
B	5334	8.43	1597	10.07	6931	8.75
C	11471	18.12	3023	19.06	14494	18.31
S	20639	32.60	5053	31.85	25692	32.45
F	21920	34.62	5059	31.89	26979	34.08
Total	**63310**	**100.00**	**15864**	**100.00**	**79174**	**100.00**

Table 2

1.2.3 Grades obtained by school candidates who sat the examination for the first time - Districtwise

District	No. Sat	Distinction (A)		Very Good Pass (B)		Credit Pass (C)		Ordinary Pass (S)		Pass (A+B+C+S)		Failed (F)	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
1. Colombo	5722	506	8.84	568	9.93	1174	20.52	1806	31.56	4054	70.85	1668	29.15
2. Gampaha	3336	178	5.34	251	7.52	534	16.01	1028	30.82	1991	59.68	1345	40.32
3. Kalutara	2140	56	2.62	99	4.63	262	12.24	680	31.78	1097	51.26	1043	48.74
4. Kandy	2828	129	4.56	195	6.90	486	17.19	883	31.22	1693	59.87	1135	40.13
5. Matale	712	12	1.69	38	5.34	108	15.17	216	30.34	374	52.53	338	47.47
6. Nuwara Eliya	846	19	2.25	32	3.78	105	12.41	264	31.21	420	49.65	426	50.35
7. Galle	2541	146	5.75	164	6.45	326	12.83	735	28.93	1371	53.96	1170	46.04
8. Matara	2078	97	4.67	113	5.44	312	15.01	691	33.25	1213	58.37	865	41.63
9. Hambantota	1539	45	2.92	55	3.57	206	13.39	619	40.22	925	60.10	614	39.90
10. Jaffna	1210	128	10.58	133	10.99	235	19.42	355	29.34	851	70.33	359	29.67
11. Kilinochchi	146	3	2.05	11	7.53	21	14.38	61	41.78	96	65.75	50	34.25
12. Mannar	174	4	2.30	5	2.87	26	14.94	62	35.63	97	55.75	77	44.25
13. Vavuniya	291	16	5.50	14	4.81	50	17.18	100	34.36	180	61.86	111	38.14
14. Mullativu	161	2	1.24	6	3.73	10	6.21	47	29.19	65	40.37	96	59.63
15. Batticaloa	676	58	8.58	52	7.69	132	19.53	233	34.47	475	70.27	201	29.73
16. Ampara	1085	28	2.58	63	5.81	152	14.01	354	32.63	597	55.02	488	44.98
17. Trincomalee	476	38	7.98	44	9.24	79	16.60	153	32.14	314	65.97	162	34.03
18. Kurunegala	3050	83	2.72	119	3.90	365	11.97	972	31.87	1539	50.46	1511	49.54
19. Puttalam	953	39	4.09	47	4.93	145	15.22	305	32.00	536	56.24	417	43.76
20. Anuradhapura	1340	32	2.39	66	4.93	176	13.13	357	26.64	631	47.09	709	52.91
21. Polonnaruwa	519	7	1.35	17	3.28	41	7.90	139	26.78	204	39.31	315	60.69
22. Badulla	1489	50	3.36	99	6.65	210	14.10	440	29.55	799	53.66	690	46.34
23. Monaragala	687	11	1.60	26	3.78	71	10.33	232	33.77	340	49.49	347	50.51
24. Ratnapura	1727	67	3.88	108	6.25	242	14.01	573	33.18	990	57.32	737	42.68
25. Kegalle	1563	29	1.86	83	5.31	258	16.51	547	35.00	917	58.67	646	41.33
All Island	**37289**	**1783**	**4.78**	**2408**	**6.46**	**5726**	**15.36**	**11852**	**31.78**	**21769**	**58.38**	**15520**	**41.62**

Table 3

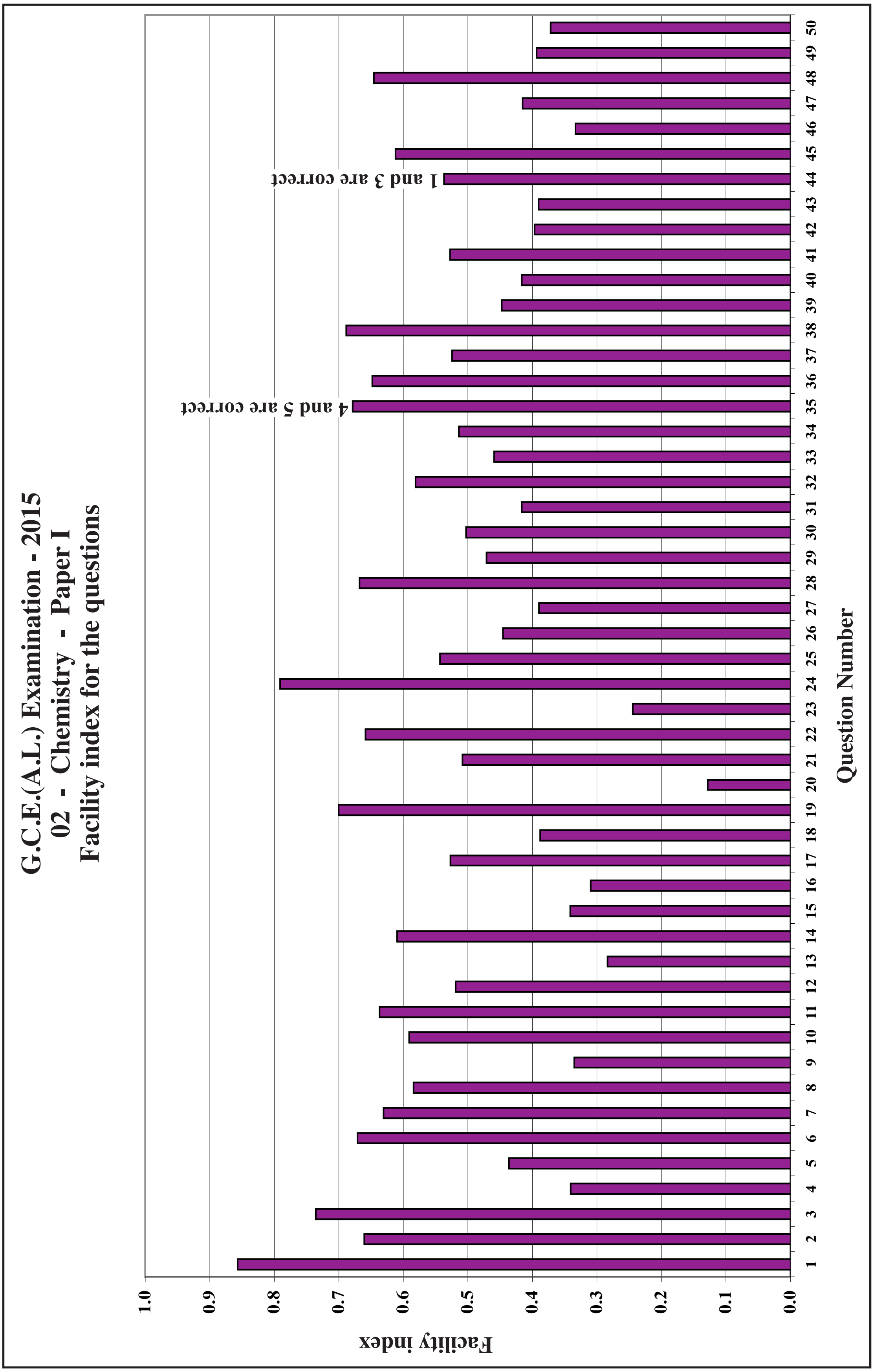
1.2.4 Marks obtained according to class intervals

Class Interval	Frequency	Frequency Percentage	Cumulative Frequency	Cumulative Frequency Percentage
91 - 100	110	0.14	79174	100.00
81 - 90	2039	2.58	79064	99.86
71 - 80	5459	6.89	77025	97.29
61 - 70	7746	9.78	71566	90.39
51 - 60	9967	12.59	63820	80.61
41 - 50	13342	16.85	53853	68.02
31 - 40	15080	19.05	40511	51.17
21 - 30	15220	19.22	25431	32.12
11 - 20	9743	12.31	10211	12.90
01 - 10	467	0.59	468	0.59
00 - 00	1	0.00	1	0.00

Table 4

The following example illustrates how information can be retrieved from the above table.
Ex : (Taking the class interval 21 - 30 for instance)
The number of candidates scoring from 21 - 30 is 15 220. As a percentage it is 19.22%. The number scoring below 30 marks is 25 431 and as a percentage it is 32.12%.

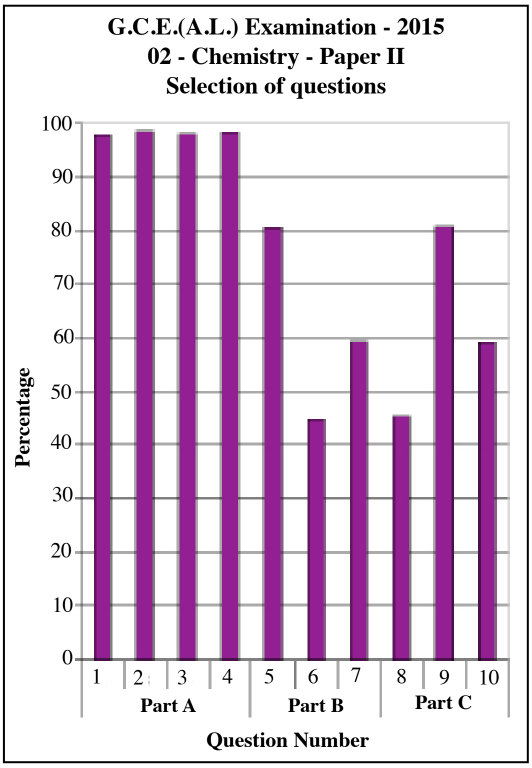
1.3 Analysis of Subject Achievement



Graph 1 (Prepared using the information collected from form RD/16/05/AL)

1.3.1 Achievement in Paper I

1.3.2 Selection of questions in paper II

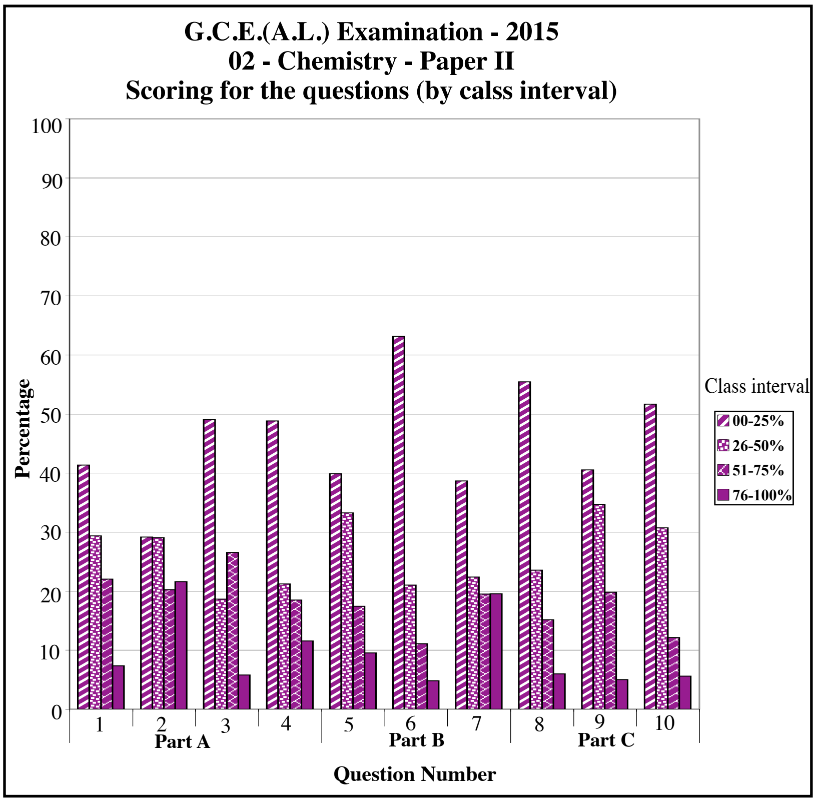


Graph 2 (Prepared using the information collected from the form RD/16/02/AL)

Though questions 1 - 4 were compulsory, a small number has not answered even the compulsory questions. Nearly 98% have answered question 1.

Of the questions from 5 - 10 in parts B and C, the question chosen by most is 9 and as a percentage it is 81%. Questions 6 and 8 have been selected by a least number of candidates. The percentage selecting them is 45% each.

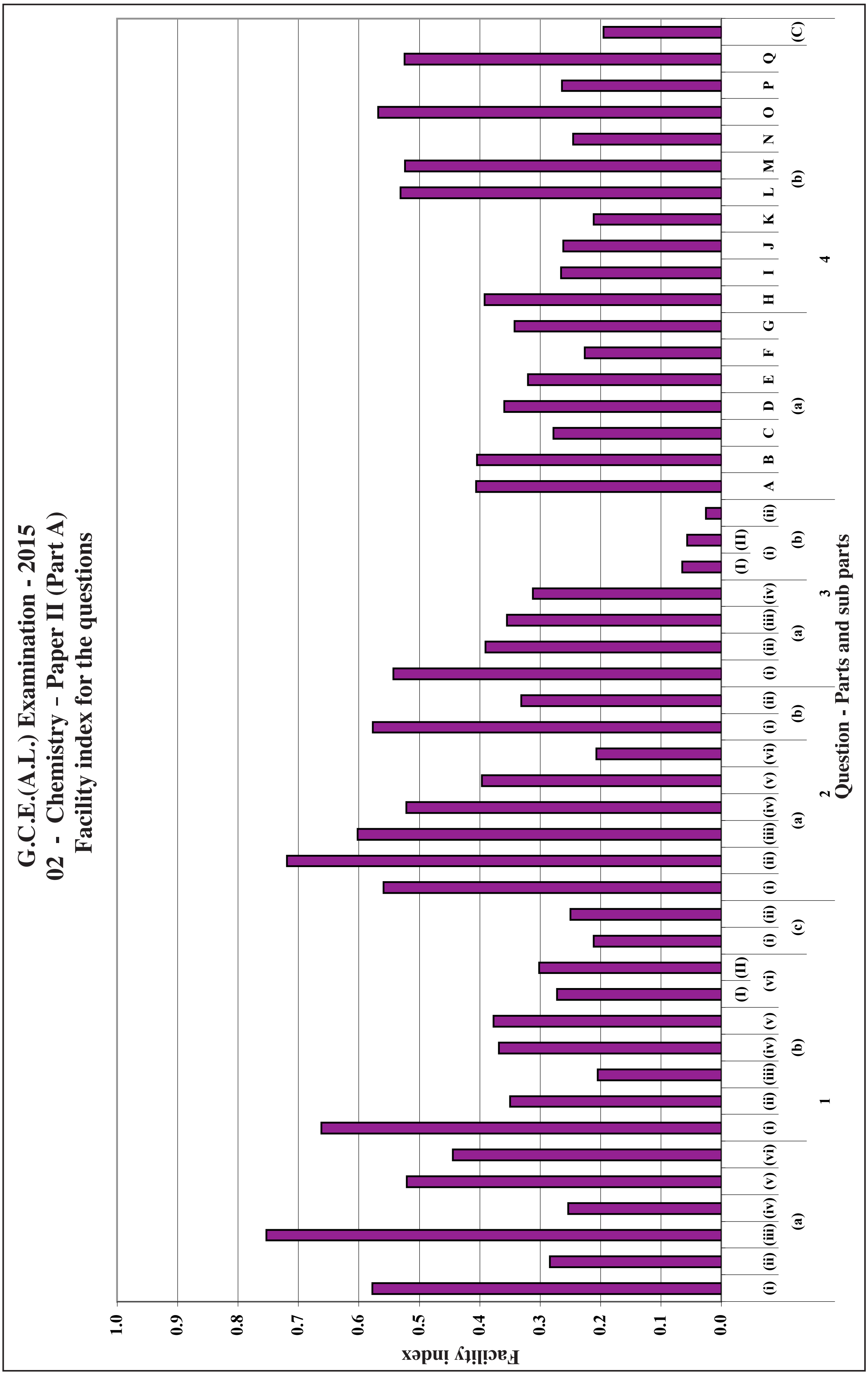
1.3.3 Scoring for the questions in paper II



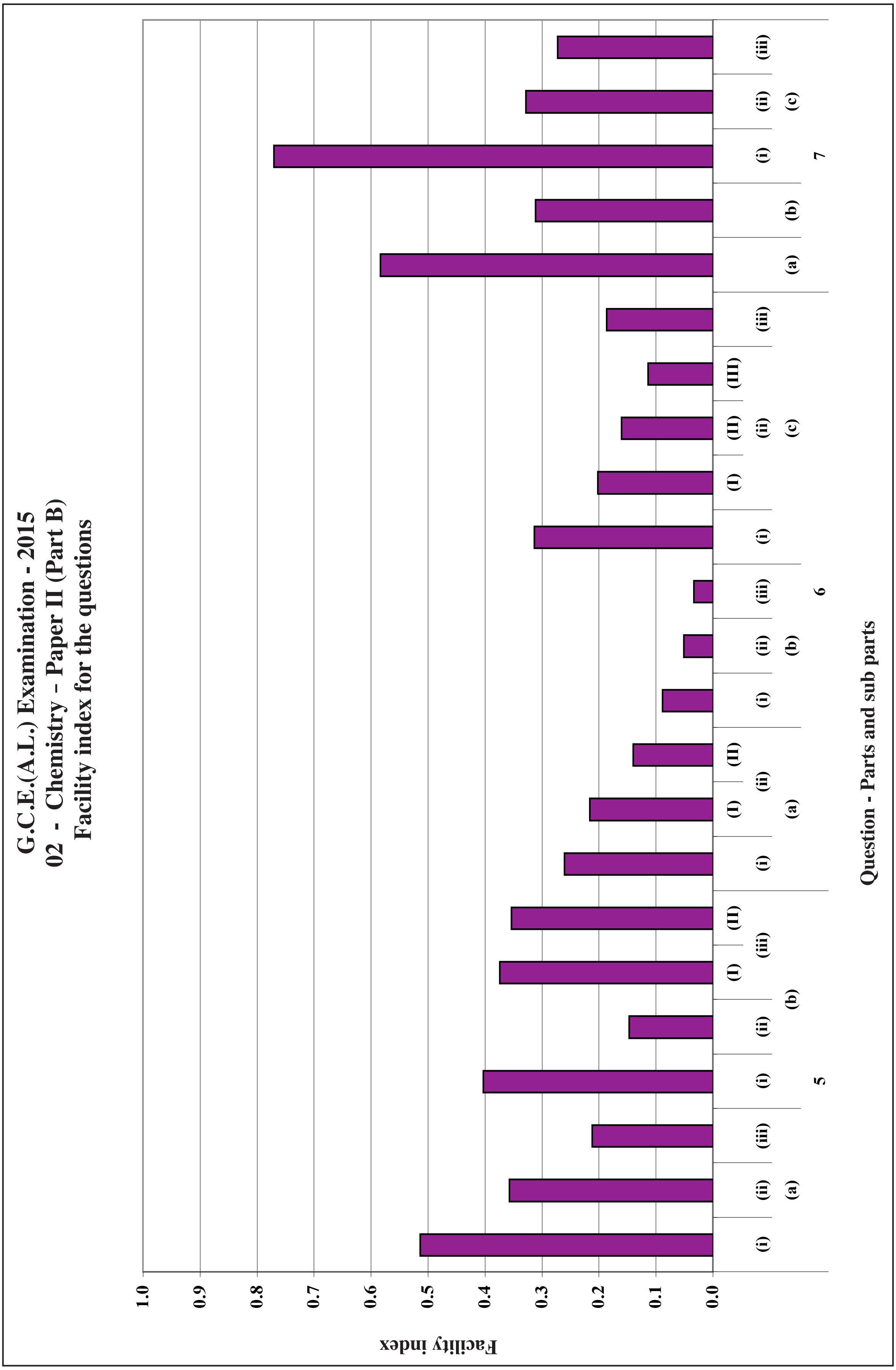
Graph 3 (Prepared using the information collected from the form RD/16/02/AL)

Ex: Marks allocated for question 1 is 100. The percentage scoring within the range of 76 - 100 is 7%. The percentage obtaining between 00 - 25 of the 100 marks allocated is about 41%.

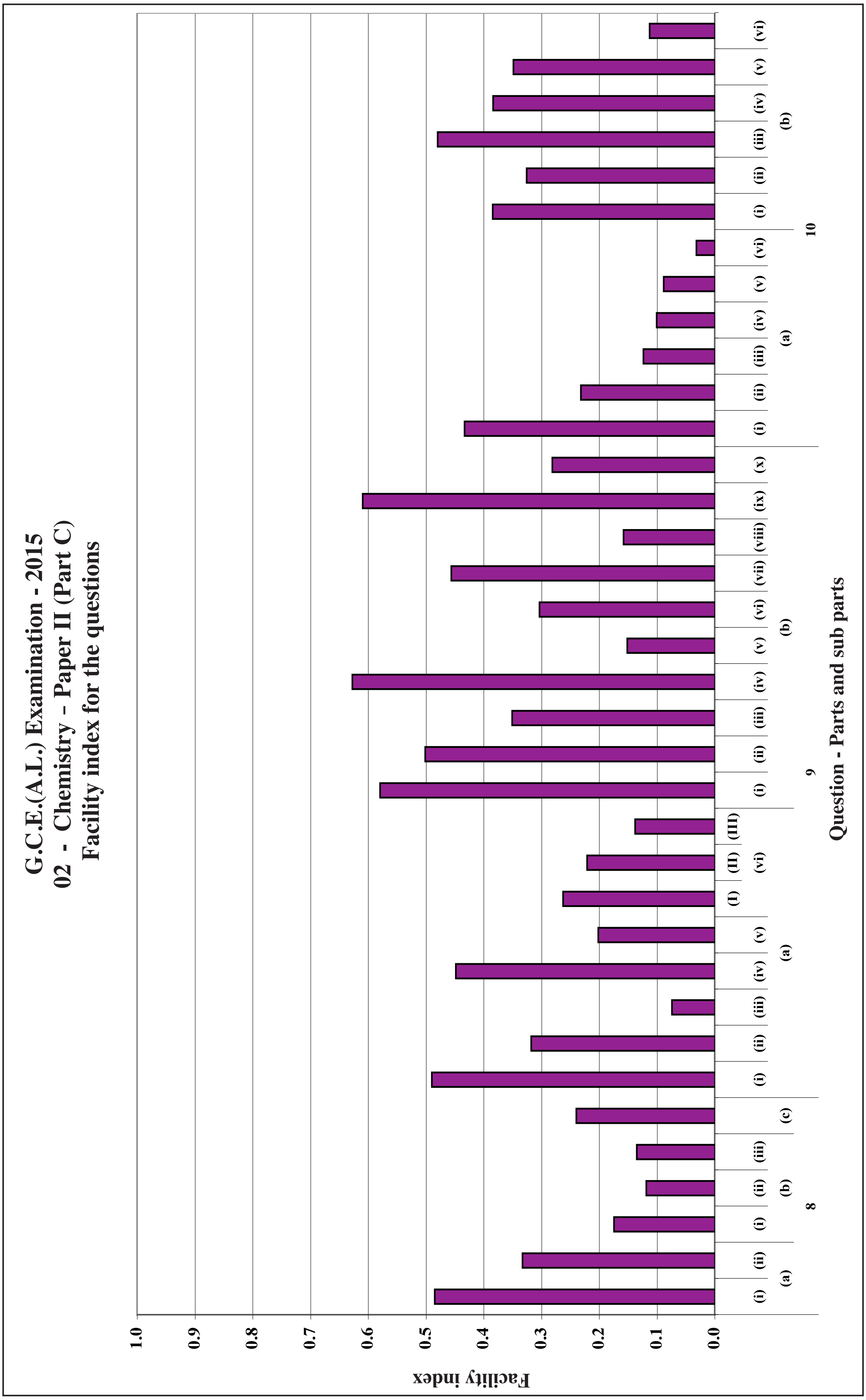
1.3.4 Achievement in Paper II



Graph 4.1 (Prepared using the information collected from the form RD/16/04/AL)


G.C.E.(A.L.) Examination - 2015
02 - Chemistry – Paper II (Part B)
Facility index for the questions
Facility index
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
(i)
(ii)
(iii)
(a)
(i)
(ii)
(I)
(II)
(iii)
(b)
5
(i)
(I)
(II)
(ii)
(a)
(i)
(ii)
(iii)
(b)
(i)
(I)
(II)
(III)
(ii)
(iii)
(c)
6
(a)
(b)
(i)
(ii)
(iii)
(c)
7
Question - Parts and sub parts

Graph 4.2


G.C.E.(A.L.) Examination - 2015
02 - Chemistry – Paper II (Part C)
Facility index for the questions
Facility index
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
(i) (ii) (i) (ii) (iii) (c) (i) (ii) (iii) (iv) (v) (I) (II) (III) (i) (ii) (iii) (iv) (v) (vi) (vii) (viii) (ix) (x) (i) (ii) (iii) (iv) (v) (vi) (i) (ii) (iii) (iv) (v) (vi)
(a) (b) (vi) (a) (b) (a) (b)
8 9 10
Question - Parts and sub parts

Graph 4.3

Part II

2. Information on questions and answers

2.1 Question paper I and information on answers to paper I

2.1.1 Structure of the paper I

Time is 02 hours. Total mark is 100.

- This question paper consists of 50 multiple choice questions each with five options. For each questions, candidates were expected to select the correct or the most suitable option from the options (1), (2), (3), (4) and (5).

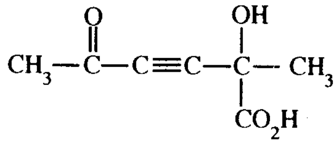
- Responding to all the questions is expected.

2.1.2 Paper I

1. The 'plum pudding' model of the atomic structure was put forward by
   (1) John Dalton. (2) J. J. Thompson. (3) Glenn Seaborg.
   (4) Ernest Rutherford. (5) Robert Millikan.

2. The **increasing** order of atomic/ionic radii of B, O, S, S^{2-} and Cl is
   (1) $B < O < Cl < S < S^{2-}$ (2) $S < S^{2-} < O < B < Cl$
   (3) $O < B < Cl < S < S^{2-}$ (4) $O < B < S < S^{2-} < Cl$
   (5) $B < O < S < S^{2-} < Cl$

3. What is the IUPAC name of the compound **X**?
   (1) 2–hydroxy–2–methyl–5–oxo–3–hexynoicacid
   (2) 2–hydroxy–2–methyl–5–oxo–3–hexynoic acid
   (3) 2–hydroxy–5–keto–2–methyl–3–hexynoic acid
   (4) 5–carboxy–5–hydroxy–3–hexyn–2–one
   (5) 2–carboxy–5–oxo–3–hexyn–2–ol



X

4. Which of the following statements regarding properties of atoms is **false**?
   (1) The covalent radius of the iodine atom is smaller than its van der Waals radius.
   (2) The first electron affinity of O atom is greater than that of N atom.
   (3) The ionization energy of an atom is determined only by its nuclear charge and radius.
   (4) The nuclear charge felt by the valence electron in a Li atom is less than 3.
   (5) The electronegativity of C atom is the same as that of S atom in the Pauling scale.

5. Which of the following compounds has the **lowest** volatility?
   (1) CBr_4 (2) $CHBr_3$ (3) CH_2Br_2 (4) CH_3Cl (5) CH_2Cl_2

6. A mixture of carbonates contains $MgCO_3$ and $CaCO_3$ in a 5 : 1 molar ratio respectively. When a known mass of this mixture is heated, the CO_2 formed occupied a volume of 134.4 dm^3 at standard temperature and pressure. The mass of the carbonate mixture heated is (C = 12, O = 16, Mg = 24, Ca = 40, At standard temperature and pressure one mole of gas occupies a volume of 22.4 dm^3.)
   (1) 52 g (2) 520 g (3) 750 g (4) 900 g (5) 1040 g

7. A_3B_2 is a sparingly water soluble salt. At 25 °C, its solubility and solubility product are **s** mol dm^{-3} and K_{sp} respectively. The **correct** expression for **s** is,

   (1) $\left(\frac{K_{sp}}{36}\right)^5$ (2) $\left(\frac{K_{sp}}{36}\right)^{1/5}$ (3) $\left(\frac{K_{sp}}{72}\right)^{1/5}$ (4) $\left(\frac{K_{sp}}{108}\right)^{1/5}$ (5) $\left(\frac{K_{sp}}{108}\right)^5$

8. Which of the following reactions correctly represents a propagation step in the free radical chlorination reaction of methane?
   (1) $Cl - Cl \xrightarrow{h\nu} \dot{C}l + \dot{C}l$ (2) $\dot{C}l \;\; \dot{C}l \longrightarrow Cl - Cl$
   (3) $\dot{C}H_3 \; Cl - Cl \longrightarrow CH_3Cl + \dot{C}l$ (4) $H - CH_3 \; \dot{C}l \longrightarrow CH_3Cl + \dot{H}$
   (5) $H - Cl \; \dot{C}H_3 \longrightarrow CH_3Cl + \dot{H}$

9. Which of the following statements is **false** with regard to the chemistry of Aluminium?
   (1) Aluminium compounds are used as catalysts.
   (2) Aluminium metal reacts with dilute HCl and forms H_2 gas.
   (3) The solution formed when solid Aluminium chloride is dissolved in water is basic.
   (4) The shape around the Aluminium atoms in solid Aluminium chloride is tetrahedral.
   (5) Aluminium chloride exists as a dimer in the solid state.

10. Which row of the following table gives the **correct** information with regard to the central S atom of the SSF_2 molecule?

	Oxidation state	Charge	Hybridization	Shape	Nature of S-S σ-bond in S-SF_2
(1)	+1	0	sp^3	Tetrahedral	S (3*p* a.o.) + S (sp^3 h.o.)
(2)	+2	0	sp^2	Trigonal planar	S (3*p* a.o.) + S (sp^2 h.o.)
(3)	+2	0	sp^3	Pyramidal	S (3*p* a.o.) + S (sp^3 h.o.)
(4)	+1	+1	sp^3	Pyramidal	S (3*p* a.o.) + S (sp^3 h.o.)
(5)	+2	+1	sp^2	Trigonal planar	S (3*p* a.o.) + S (sp^2 h.o.)

(a.o. = atomic orbital, h.o. = hybrid orbital)

11. **A** decomposes on heating to produce **B** and **C** according to the following equilibrium.

$$2A(g) \rightleftharpoons 2B(g) + C(g)$$

When *a* moles of pure **A** in a 1 dm^3 closed container is heated to a constant temperature **T**, the equilibrium mixture contained **c** moles of **C**. The **correct** expression for the equilibrium constant K_c for this reaction at temperature **T** is,

(1) $K_c = \frac{4c^3}{(a-2c)^2}$ (2) $K_c = \frac{4c^3}{(a-c)^2}$ (3) $K_c = \frac{c^3}{(a-c)^2}$ (4) $K_c = \frac{8c^3}{(a-2c)^2}$ (5) $K_c = \frac{c^3}{(a-2c)^2}$

12. Which of the following statements is **false** regarding the colours of complexes formed by 3*d* transition elements?

(1) $[Ni(NH_3)_6]^{2+}$ is deep blue in colour. (2) $[CuCl_4]^{2-}$ is pale blue in colour.

(3) $[NiCl_4]^{2-}$ is yellow in colour. (4) $[Co(NH_3)_6]^{2+}$ is yellow-brown in colour.

(5) $[CrCl_4]^-$ is blue-violet in colour.

13. A sample of liquid heptane (C_7H_{16}) weighing 10.0 g is mixed with 1.30 moles of O_2 gas. When heptane is burned **completely** a mixture of CO and CO_2 gases are formed. The total number of moles of gas present after the reaction (CO, CO_2 and O_2) is 1.1 at room temperature. (Assume that the water formed is present as a liquid and solubility of gases in it is negligible.) The moles of CO gas formed is, (H = 1, C = 12, O = 16)

(1) 0.40 (2) 0.45 (3) 0.50 (4) 0.52 (5) 0.54

14. Consider a closed system in which pure liquid **A** is in equilibrium with its vapour at 27 °C. The enthalpy of vaporization of liquid **A** at this temperature is 20.00 kJ mol^{-1}. The entropy of vaporization of **A** in J K^{-1} mol^{-1} at 27 °C is,

(1) 0.01 (2) 0.07 (3) 5.66 (4) 14.30 (5) 66.67

15. O_2 gas formed by the thermal decomposition of $KClO_3$ is collected by downward displacement of water. The volume of O_2 gas collected in such an experiment at 27 °C and 1.13 × 10^5 Pa pressure was 150.00 cm^3. Given that the saturated vapour pressure of water is 0.03 × 10^5 Pa at 27 °C, the mass of O_2 gas collected is, (O = 16)

(1) 0.212 g (2) 0.217 g (3) 198 g (4) 212 g (5) 217 g

16. The pH value of a solution which contains a weak acid HA and its sodium salt NaA is *a*. If the value of the concentrations of HA to NaA ratio is increased ten times, the new pH value of the solution is,

(1) *a* − 1. (2) *a* − 1/10. (3) *a* + 1. (4) *a* − 10. (5) *a* + 10.

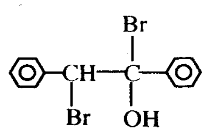
17. $C_6H_5-C\equiv C-C_6H_5 \xrightarrow[\text{dil. } H_2SO_4]{HgSO_4} A \xrightarrow[Br_2]{FeBr_3} B$

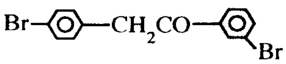
In the reaction scheme given above the structures of **A** and **B** are respectively,

(1) $C_6H_5COCH_2C_6H_5$, 

(2) $C_6H_5COCH_2C_6H_5$, 

(3) $C_6H_5COCOC_6H_5$, 

(4) $C_6H_5CH{=}C(OH)-C_6H_5$, 

(5) $C_6H_5CH_2COC_6H_5$, 

18. Select the answer with **correct** relationship for the rate of the reaction given below.

$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(\ell)$

(1) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = \frac{5}{2}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$ (2) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = -\frac{5}{2}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

(3) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = 10\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$ (4) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = \frac{2}{5}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

(5) $\frac{\Delta[MnO_4^-(aq)]}{\Delta t} = -\frac{2}{5}\frac{\Delta[C_2O_4^{2-}(aq)]}{\Delta t}$

19. The potential and cell reaction of the following electrochemical cell at room temperature are respectively,

$Ag(s) / AgCl(s), KCl(aq) // Ag^+(aq) / Ag(s)$

($E^o_{AgCl(s)/Ag(s)} = +0.22$ V $E^o_{Ag^+(aq)/Ag(s)} = +0.78$ V)

(1) +0.22 V , $AgCl(s) \longrightarrow Ag^+(aq) + Cl^-(aq)$ (2) +0.56 V , $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

(3) +1.0 V , $AgCl(s) + e \longrightarrow Ag(s) + Cl^-(aq)$ (4) −0.56 V , $Ag^+(aq) + e \longrightarrow Ag(s)$

(5) -1.0 V , $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

20. How many resonance structures can be drawn for the molecule N_2O_5 (skeleton O—N(—O)—O—N(—O)—O)?

(1) 5 (2) 6 (3) 8 (4) 9 (5) none of the answers given

21. Which of the following statements, is **false** with regard to the chemistry of Zinc (Zn)?

(1) Zn is a non transition element with +2 as the most abundant and stable positive oxidation state.
(2) In general solutions of Zn complexes are colourless.
(3) The melting point of Zn is considerably high compared to that of other 3*d*-block elements.
(4) The radius of Zn^{2+} is smaller than that of Ca^{2+}.
(5) ZnS cannot be precipitated by H_2S from acidic solutions.

22. Consider the following equilibrium that exists at a given temperature in a closed rigid container fitted with a valve.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

When an additional amount of $N_2(g)$ is introduced through the valve into the container the concentrations of $H_2(g)$ and $NH_3(g)$ respectively, will

(1) increase, increase. (2) decrease, decrease. (3) increase, decrease.
(4) decrease, increase. (5) not change, not change.

23. The reaction of CH_4 with excess O_2 to produce CO_2 and water is an exothermic process. The enthalpy change when 1 mole of CH_4 is reacted with O_2 under conditions where the water formed is in the liquid state is 890.4 kJ mol^{-1}. When this reaction is carried out under conditions where the water formed is in the vapour state, the enthalpy change is 802.4 kJ mol^{-1}. The enthalpy change (in kJ mol^{-1}) for the reaction $H_2O(l) \longrightarrow H_2O(g)$ is,

(1) −88 (2) −44 (3) 22 (4) 44 (5) 88

24. **X** is an element which belongs to the 3*d*-block. It shows the following properties.

I. It shows the highest positive oxidation state among the 3*d*-block elements.
II. It forms acidic, amphoteric and basic oxides.

X is

(1) Cr (2) Mn (3) Fe (4) Co (5) Zn

25. $CH_3COCH_2CO_2H \xrightarrow[(2)\ H_2O/H^{\oplus}]{(1)\ LiAlH_4} S \xrightarrow{PCC} T \xrightarrow[Conc.\ HCl]{Zn/Hg} U$

In the reaction scheme given above, the structures of **S**, **T**, and **U** are respectively

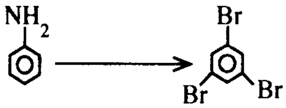
(1) $CH_3-CH(OH)-CH_2CH_2OH$, CH_3COCH_2CHO, $CH_3CH_2CH_2CH_3$

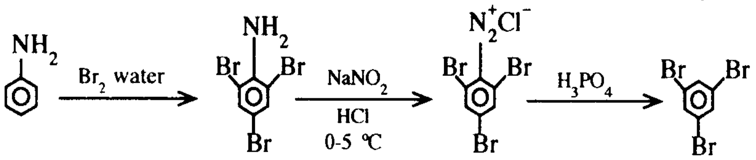
(2) $CH_3-CH(OH)-CH_2CO_2H$, CH_3COCH_2CHO, $CH_3CH_2CH_2CH_3$

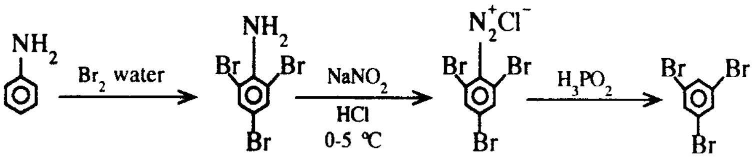
(3) $CH_3COCH_2CH_2OH$, CH_3COCH_2CHO, $CH_3CH_2CH_2CH_3$

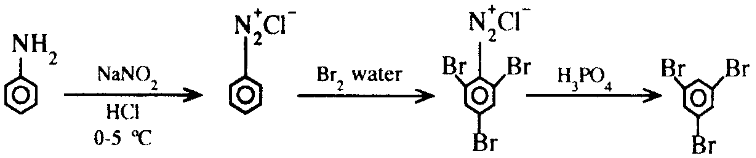
(4) $CH_3COCH_2CH_2OH$, CH_3COCH_2CHO, $CH_3COCH_2CH_3$

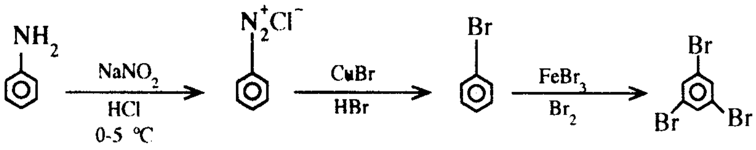
(5) $CH_3CH(OH)-CH_2CH_2OH$, $CH_3CH(OH)CH_2CHO$, $CH_3CH(OH)CH_2CH_3$

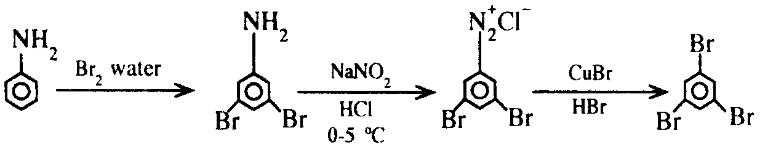
26. Which of the following methods is most suitable to transform,  ?

(1) 

(2) 

(3) 

(4) 

(5) 

27. Which of the following statements is **true** with regard to *s*-block elements (Group I, Li to Cs and Group II, Be to Ba) in the Periodic Table?

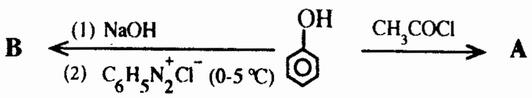
(1) All elements in Groups I and II react with water and give H_2 gas.
(2) All elements in Group I react with N_2 gas.
(3) Mg reacts with both dilute and concentrated H_2SO_4 and give $H_2(g)$ and $SO_2(g)$ respectively.
(4) Li reacts with air and forms a mixture of Li_2O, LiO_2 and Li_3N.
(5) All elements in Group I react with H_2 gas and form covalent hydrides.

28. Which of the following statements is **incorrect** with regard to a galvanic cell consisting of Cd(s) /Cd^{2+}(aq) and Zn(s)/Zn^{2+}(aq) electrodes?

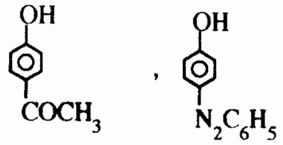
$$E^{o}_{Zn^{2+}_{(aq)}/Zn_{(s)}} = -0.76\ V, \quad E^{o}_{Cd^{2+}_{(aq)}/Cd_{(s)}} = -0.40\ V$$

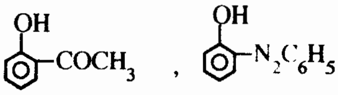
(1) The Zn electrode is the anode.
(2) When connected through an external circuit, electrons flow from the Zn electrode to the Cd electrode.
(3) Reduction occurs at the Zn electrode as the cell operates.
(4) The concentration of Cd^{2+} (aq) decreases as the cell operates.
(5) The concentration of Zn^{2+} (aq) increases as the cell operates.

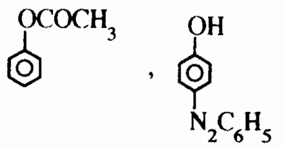
29. Consider the two reactions of phenol given below.

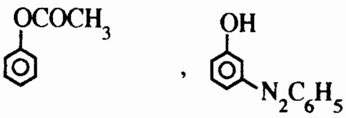


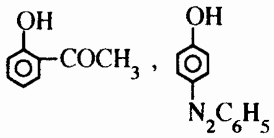
The structures of **A** and **B** are respectively

(1) 

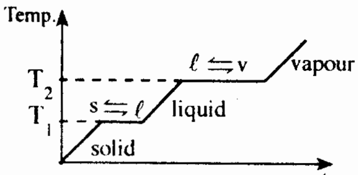
(2) 

(3) 

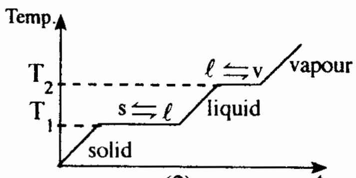
(4) 

(5) 

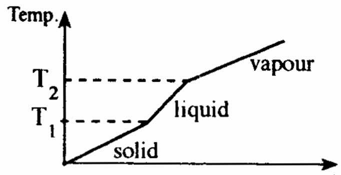
30. For the substance **X**, the magnitude of the value of ΔH_{fusion} is less than the magnitude of the value of $\Delta H_{vaporization}$ (i.e. $|\Delta H_{fusion}| < |\Delta H_{vaporization}|$). **X** melts at temperature T_1 and then vaporizes at temperature T_2 upon heating. Which diagram below best depicts the variation of temperature with time when a solid sample of **X** is heated at a constant rate? (**Note:** solid (s), liquid (ℓ), vapour (v))



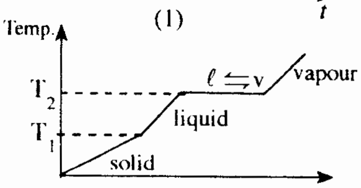
(1)



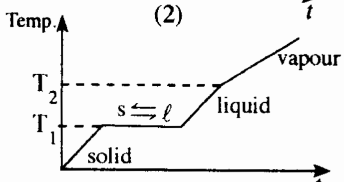
(2)



(3)



(4)



(5)

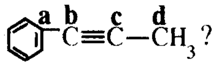
- For each of the questions **31** to **40**, one or more responses out of the four responses (*a*),(*b*),(*c*) and (*d*) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

(1) if only (*a*) and (*b*) are correct.
(2) if only (*b*) and (*c*) are correct.
(3) if only (*c*) and (*d*) are correct.
(4) if only (*d*) and (*a*) are correct.
(5) if **any other** number or combination of responses is correct.

Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (*a*) and (*b*) are correct	Only (*b*) and (*c*) are correct	Only (*c*) and (*d*) are correct	Only (*d*) and (*a*) are correct	**Any other** number or combination of responses is correct

31. Which of the following statements is/are **false** with regard to the order of a reaction?
(*a*) The order of an elementary reaction should be a whole number.
(*b*) The order of a reaction is an experimentally determined value.
(*c*) The order of a reaction is always equal to the sum of the stoichiometric coefficients of the reactants in the balanced equation.
(*d*) The order of a reaction is the sum of the powers of the molar concentrations of the reactants in the rate law expression.

32. Which of the following statements is/are **true** regarding the molecule,  ?
(*a*) Carbon atoms labelled as **a**, **b**, **c** and **d** do not lie in a straight line.
(*b*) Carbon atoms labelled as **a**, **b** and **d** are sp^2, sp and sp^3 hybridized respectively.
(*c*) All carbon, carbon bond lengths of the benzene ring are equal to each other and are longer than the C≡C bond length.
(*d*) All carbon, carbon bond lengths of the benzene ring are equal to each other and are shorter than the C≡C bond length.

33. Which of the following statements is/are **true** with regard to the manufacture of NaOH using the membrane cell?
(*a*) During electrolysis $Na^+(aq)$ ions migrate from the cathode compartment to the anode compartment across the membrane.
(*b*) The anode and cathode used are titanium and nickel respectively.
(*c*) High purity NaOH can be prepared by this method.
(*d*) $H_2(g)$ and $Cl_2(g)$ are formed as by-products at the anode and cathode respectively.

34. Which of the following statements is/are **false** with regard to the activation energy of a reaction?
(*a*) The activation energy of the forward reaction in an exothermic process is lower than that of the backward reaction.
(*b*) The activation energy of a slow reaction is less than that of a fast reaction.
(*c*) The activation energy of a given reaction pathway is unaffected by a catalyst.
(*d*) The higher the initial concentration of reactants, the lower the activation energy.

35. Which of the following statements is/are **true** regarding stereoisomerism?
(*a*) A pair of stereoisomers which are mirror images of each other are known as enantiomers.
(*b*) A pair of stereoisomers which are mirror images of each other are known as diastereoisomers.
(*c*) A pair of stereoisomers which are not mirror images of each other are known as enantiomers.
(d) A pair of stereoisomers which are not mirror images of each other are known as diastereoisomers.

36. Which of the following statements is/are **true** for an electron that has quantum numbers $n = 3$ and $m_l = -2$?
(*a*) The electron is in the third main energy level.
(*b*) The electron is in a *d* orbital.
(*c*) The electron is in a *p* orbital.
(*d*) The electron must have a spin quantum number $m_s = +1/2$.

37. Most reactions take place more rapidly at high temperatures than at low temperatures. Which of the following statement(s) give(s) the **correct** reason(s) to explain this observation?

(*a*) The increase in temperature increases the activation energy of the reaction.

(*b*) The increase in temperature decreases the activation energy of the reaction.

(*c*) When the temperature increases the number of collisions per unit time per unit volume increases.

(*d*) The increase in temperature results in increasing the percentage of high energy collisions.

38. Which of the following statements is/are **false** with regard to the equilibrium constant *K*, of an equilibrium reaction?

(*a*) It does not change when the pressure changes.

(*b*) It increases when the concentration of one product is increased.

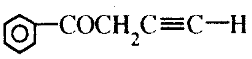
(*c*) It can change with change in temperature.

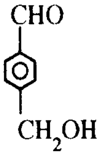
(*d*) It increases when the concentration of one reactant is increased.

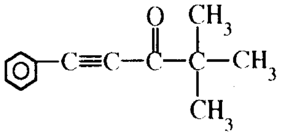
39. Which of the following compound/compounds undergo(es) **both** of the reactions given below?

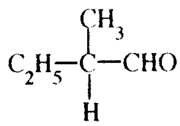
I. Self condensation with aqueous NaOH.

II. Oxidation with ammoniacal $AgNO_3$.

(*a*) 

(*b*) 

(*c*) 

(*d*) 

40. Which of the following statements is/are **true** regarding polymers?

(*a*) PVC is a thermoplastic polymer and does not catch fire easily due to the presence of chlorine.

(*b*) Bakelite is formed by reaction of phenol and formaldehyde in the presence of conc. H_2SO_4.

(*c*) Urea and formaldehyde react in the presence of conc. H_2SO_4 to form a thermoplastic polymer.

(*d*) Teflon is a thermosetting polymer.

- In question Nos. **41** to **50**, two statements are given in respect of each question. From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that **best** fits the two statements and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does **not** explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

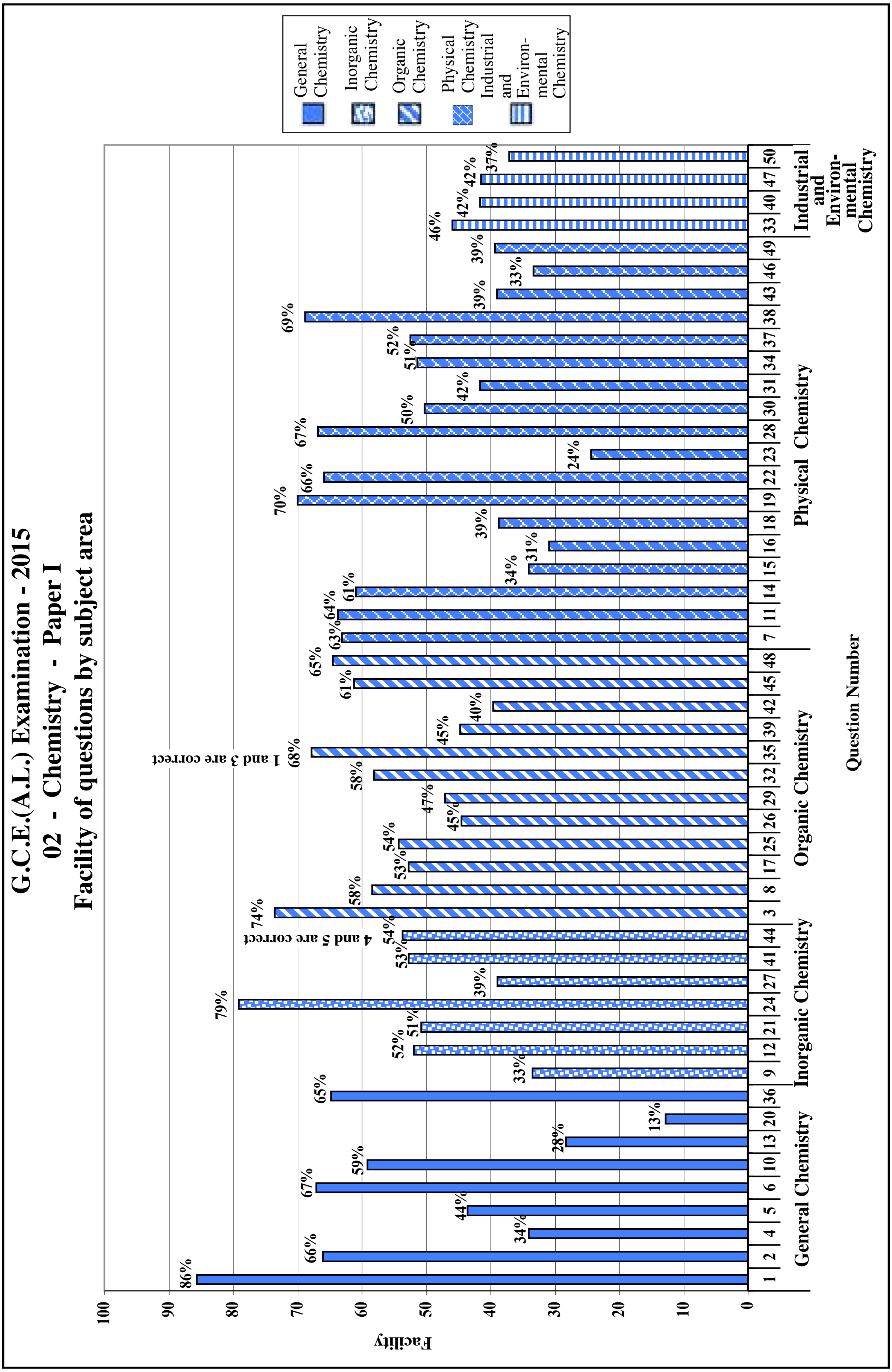
	First Statement	Second Statement
41.	NCl_3 can act as a bleaching agent in the presence of water.	NCl_3 reacts with water and gives NH_3 and HOCl.
42.	Vinyl chloride undergoes nucleophilic substitution reactions more easily than ethyl chloride.	Although the bond between carbon and chlorine in vinyl chloride has a double bond character due to resonance, this property is not present in ethyl chloride.
43.	The entropy of the surroundings goes down when water vapour condenses in a closed system.	Heat given out by a system increases the thermal motion of particles in the surroundings.
44.	The reaction of sulphur and NaOH is an example of a disproportionation reaction.	When an element is simultaneously oxidized and reduced, it is called disproportionation.
45.	Tertiary alcohols react faster than secondary alcohols in the Lucas test.	Tertiary carbocations are less stable than secondary carbocations.
46.	When a mixture of N_2O_4 and NO_2 in equilibrium in a closed system at a given temperature is cooled, the concentration of NO_2 increases.	The dissociation of N_2O_4 to NO_2 is an exothermic reaction.
47.	In the Solvay process KCl can be used instead of NaCl.	$KHCO_3$ and $NaHCO_3$ have very similar solubilities in water.
48.	Phenol is an aromatic compound whereas ethanol is not.	The stability of the phenate ion relative to phenol is greater than the stability of the ethoxide ion relative to ethanol.
49.	$BaF_2(s)$ has a higher solubility in an aqueous acid medium than in water.	When $BaF_2(s)$ is dissolved in an acid, due to the formation of HF, the $Ba^{2+}(aq)$ concentration increases in order to maintain K_{sp} constant.
50.	Greenhouse gases prevent infra-red radiation emitted from the sun reaching the earth surface.	An ability to absorb infra-red radiation is an important feature of a greenhouse gas.

2.1.3 Expected answers and the marking scheme for Paper I

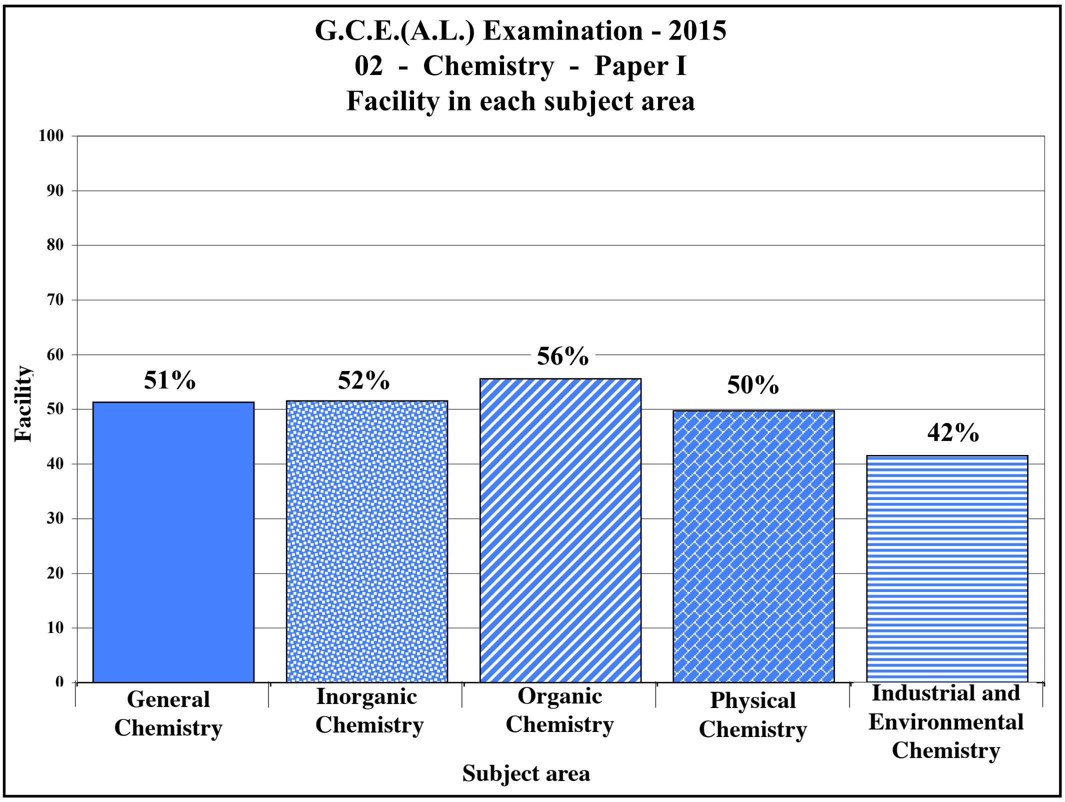
Question No.	Answer	Question No.	Answer
01.	2	26.	2
02.	3	27.	3
03.	2	28.	3
04.	3	29.	3
05.	1	30.	1
06.	2	31.	5
07.	4	32.	2
08.	3	33.	2
09.	3	34.	5
10.	3	35.	4, 5
11.	1	36.	1
12.	2	37.	3
13.	1	38.	5
14.	5	39.	5
15.	1	40.	1
16.	1	41.	1
17.	5	42.	4
18.	4	43.	4
19.	2	44.	1, 3
20.	4	45.	3
21.	3	46.	5
22.	4	47.	5
23.	4	48.	2
24.	2	49.	1
25.	1	50.	4

Each correct answer carries 02 marks, amounting the total to 100.

2.1.4 Observations on the responses to Paper I (by subject area) :



Subject area	The question of highest facility and its facility	The question of lowest facility and its facility
General Chemistry	1 (86%)	20 (13%)
Physical Chemistry	19 (70%)	23 (24%)
Organic Chemistry	3 (74%)	42 (40%)
Inorganic Chemistry	24 (79%)	9 (33%)
Industrial and Environmental Chemistry	33 (46%)	50 (37%)



Of the five main subject areas used to set question paper I, the facility of the area of organic chemistry is 56%. Apparently the candidates have answered organic chemistry questions better relative to past years. Industrial and environmental chemistry has become the area of lowest facility in paper I. But in past years, the facility in this area is greater than that in 2015.

2.1.5 Responses to the options in Paper I (as a percentage) :

Question Number	Correct Answer	Percentage of students selecting each option					
		1	2	3	4	5	Missing
1	2	5%	**86%**	1%	7%	1%	-
2	3	8%	4%	**66%**	7%	15%	-
3	2	11%	**74%**	7%	6%	2%	-
4	3	5%	27%	**34%**	10%	24%	-
5	1	**44%**	12%	9%	24%	11%	-
6	2	7%	**67%**	13%	7%	6%	-
7	4	4%	17%	11%	**63%**	5%	-
8	3	25%	4%	**59%**	8%	4%	-
9	3	5%	5%	**34%**	45%	11%	-
10	3	8%	18%	**59%**	7%	7%	1%
11	1	**64%**	14%	11%	5%	6%	-
12	2	8%	**52%**	18%	11%	11%	-
13	1	**28%**	16%	19%	26%	10%	1%
14	5	4%	14%	12%	8%	**61%**	1%
15	1	**34%**	19%	15%	20%	11%	-
16	1	**31%**	18%	33%	9%	9%	-
17	5	10%	18%	10%	9%	**53%**	-
18	4	26%	18%	7%	**39%**	10%	-
19	2	5%	**70%**	10%	12%	3%	-
20	4	17%	24%	15%	**13%**	31%	-
21	3	8%	6%	**51%**	18%	17%	-
22	4	7%	5%	7%	**66%**	15%	-
23	4	25%	19%	5%	**25%**	26%	-
24	2	7%	**79%**	6%	4%	4%	-
25	1	**54%**	13%	15%	6%	12%	-
26	2	21%	**45%**	13%	12%	9%	-
27	3	10%	8%	**39%**	23%	20%	-
28	3	8%	11%	**67%**	8%	6%	-
29	3	17%	10%	**47%**	12%	14%	-
30	1	**50%**	22%	10%	9%	9%	-
31	5	10%	11%	28%	9%	**42%**	-
32	2	11%	**58%**	4%	6%	21%	-
33	2	6%	**46%**	14%	9%	25%	-
34	5	7%	19%	14%	9%	**51%**	-
35	4, 5	10%	16%	6%	**56%**	**12%**	-
36	1	**65%**	3%	5%	8%	19%	-
37	3	2%	16%	**53%**	7%	22%	-
38	5	7%	6%	6%	12%	**69%**	-
39	5	8%	7%	9%	31%	**45%**	-
40	1	**42%**	10%	10%	16%	22%	-
41	1	**53%**	15%	8%	17%	7%	-
42	4	21%	13%	14%	**39%**	13%	-
43	4	12%	35%	9%	**39%**	5%	-
44	1, 3	**47%**	14%	**7%**	28%	4%	-
45	3	15%	8%	**61%**	7%	9%	-
46	5	24%	12%	14%	16%	**33%**	1%
47	5	14%	12%	12%	20%	**42%**	-
48	2	10%	**65%**	15%	6%	4%	-
49	1	**39%**	15%	22%	11%	12%	1%
50	4	24%	6%	6%	37%	**27%**	-

* Under each question the student percentage selecting the correct option is shaded.
* 'Missing' indicates the percentage of students selecting more than one option or none.

2.1.6 Overall observations, conclusions and suggestions regarding the answers to Paper I :

Of the first 30 questions, the percentage selecting the correct option for 9 questions (4, 9, 13, 15, 16, 18, 20, 23 and 27) is less than 40%. Of the questions 31 - 40, there is no question for which the correct response percentage goes below 40%. The percentage of correct responses is less than 40% for four questions (43, 46, 49, 50) in the range 41 - 50.

The question numbers for which the percentage of correct responses stayed below the 40% level and the relevant subject areas of them are presented below.

Subject area	Total number of questions	Facility 40% or below	
		Question numbers	No. of questions
Physical chemistry	18	15, 16, 18, 23, 43, 46, 49	7
General chemistry	09	4, 13, 20	3
Organic chemistry	12	42	1
Environmental and Industrial chemistry	04	50	1
Inorganic chemistry	07	9, 27	2

Of the questions belonging to the area of physical chemistry, the facility of 7 questions is 40% or less than that. When applying mathematical concepts and solving quantitative problems based on chemical principles, the relevant data should be manipulated through appropriate mathematical operations targeting the required answer. Therefore, simplification of data, use of units and accuracy in workout are necessary to solve problems in chemistry. Students' inadequate attention to these aspects has made physical chemistry a low scoring area.

In question 4 belonging to general chemistry the percentage selecting the correct option (3) is 34%. But 27% and 24% have selected options 2 and 5 respectively for not understanding the subject matter properly. The first electron affinity of oxygen is negative whereas in nitrogen it is positive. The selection of option (2) would be due to consideration that the negative value is smaller than the positive on that basis. So, apparently the students have not clearly understood the exothermic or endothermic nature of electron affinity in relation to the sign convention. The selection of option (5) by some is due to the lack of even a simple understanding about the electronegative values of elements.

The percentage of selecting the correct option (1) for question 5 belonging to general chemistry is 44%. But 24% have selected option (4) as correct. Thus it seems that candidates have not understood that dispersion forces of bromine which has a greater molar mass than that of chlorine are stronger. Less attention paid to the basic facts would be the reason for this. The students should understand that intermolecular forces are affected by volatility, mass of the molcule, size of the molcule and its polarity.

Option (3) is the correct response for question 8 chlorination which comes under the purview of organic chemistry. It records a facility of 59%. It is expected here that the candidates correctly identity the chain propagation steps in the free radical chlorination reaction of methane. Many have identified it correctly. But 25% have incorrectly identified the first distractor which is the chain initiation step. The reason for this may be not identifying the difference between initiation and propagation steps or not reading the question properly.

The correct option of question 9 belonging to inorganic chemistry is (3). Its facility is 34%. In this the candidates are expected to selected the false statement regarding the chemistry of aluminium. The statement is incorrect because it says an aqueous solution of aluminium chloride is basic though it is truly acidic. Option (4) though true has been taken as incorrect by 45% of the candidates. This would be due to their inability to deduce the structure of aluminium chloride dimer.

Question 13 connected with chemical calculation is a one examining the higher analytical skills. For this 28% have selected the correct option whereas 26% have selected distractor (4). The candidates should be given the understanding that under the stoichiometry of chemical reactions a variety of questions can be created to find the solution by combining data in a multitude of ways. In spite of this variation, only the basic principles are needed to solve them. For example, this problem can be solved by taking into consideration the conservation of mass of the elements carbon and oxygen in the given reaction. These skills improve on practice. Therefore, candidates are advised to improve necessary skills by working out problems that need different approaches to solve.

The correct response for question 15 is (1) and its facility is 34%. Nevertheless 20% have selected option (4) and 19% have selected option (2). Reason for selecting option (4) is not converting the units correctly. Reason for selecting options (2) and (5) would be the calculation of volume of oxygen by adding the saturated vapour of pressure of water instead of subtracting. Paying attention to the units from the beginning and appending relevant units to respective quantities in every step of calculation help get the answers correct.

Question 16 belongs to physical chemistry and its correct option is (1). It has been choosen by 31%. But a majority (33%) has selected option (3). They have not understood that pH decrease when the acidity of a solution increases. In this, the increase in acidity is implied by stating that the concentration ratio HA/NaA increases ten times. Hence many of the candidates do not seem to have an understanding about basic facts in chemistry.

The percentage picking out the correct option (4) in question 18 is 39%. 26% have gone for option (1). This question measuring the ability of expressing the rate of decrease of reactions is a very simple question. On the part of the students it is important to know that the rate of reactions is given negative (-) sign relative to reactants and the rates expressed in terms of the inverse of the stoichiometric coefficients of respective substances taking part in a reaction are equal. Selection of an option at the first sight of a question leads to loss of marks. Inability to understand the underlying chemical principle when the question is framed in a complex way is the reason for this.

The percentage selecting the correct option in the question of lowest facility which is question 20 is 13%. In this a majority (31%) has chosen option (5) as the correct answer which states "non of the given answers". As the question is based on an easy subject concept, less attention paid to the question would be the reason for this. Practicing to draw resonance structures following the rules and mentally analyzing them from the very first instance of learning the Lewis structures facilitate the finding of relevant answers.

Question 26 is related to the reactions of organic chemistry. The second option contains the steps suitable for the conversation required. The only difference in the first distractor from the second option is that it contains H_3PO_4 in place of H_3PO_2. 21% have gone for the first option possibility due to overlooking this subtle difference or not paying attention to the role of oxoacids of phosphorus in which phosphorus is in different oxidation states.

39% have selected the correct option (3) in question 27. 23% have had distractor (4) as their choice. This indicates that the ability to review the reactions of S block elements and the relevant conditions is low. Students specially need to understand that dilute and concentrated oxidizing acids give different products in reactions.

A glance at the responses for question 30 point to an attempt to find answers without reading and understanding a question well. Because of this the candidates seem to select wrong options even for very simple questions. This is pathetic. In this question, the reason for taking option (2) as correct by 22% is not understanding that the length of the segments of horizontal lines is proportional to the time.

The percentage selecting the correct response (4) in question 42 is 39%. But a sizeable number (21%) has gone for the distractor (1). In this the first statement is false and the second statement is true. Moreover, its first statement and second statement are paradoxial. But some have failed to understand this incompatibility.

In the case of question 43, the correct response is (4) and the percentage selecting it is 39%. Option (2) has also been selected by 35%. Answering this question without understanding the chemical principle "across a closed system energy can exchange, but not matter" has led some to select distractor (2).

Option (5) being the correct option for question 46 has been the choice of 33% whereas 24% hold the idea that option (1) is correct. Confusion of the heat changes associated with bond making and bond breaking with the enthalpy change accompanying the dissociation reaction has caused the selection of distractor (1). It is important to understand that dissociation of N_2O_4 is endothermic while its reverse reaction is exothermic through practical activities.

In question 49 correct option is (1). The percentage selecting it is 39%. Apparently the difficulty in graspring the information conveyed by the second statement has debarred the selection of the correct option. The students have not understood the fact that fluoride iron creates another equilibrium in the system by contributing to form a weak acid. This reflects a low level of synthetic and analytical skills. It has to be known that, if the anion of a water soluble salt is an anion of a weak acid, the tendency of such salts to dissolve in an acidic medium is high.

The correct response of question 50 is (4) and its facility is 37%. But 24% and 27% have opted for (1) and (5) respectively. This is a simple question relating to the last unit. Little attention paid to the last units by most of the students would be a reason for this situation.

Generic skills such as analysis and synthesis are highly utilized when answering questions from 31 to 50. Students seem to select options randomly when reading the questions with patience relating the subject matter coherently and answering with reason become difficult.

Some common shortcomings committed by students when answering a multiple choice question paper are noticeable.

i.e.
1. Not understanding basic subject matter clearly/ leaving out
2. Not reading and understanding the question well
3. Not reading the whole question
4. Thinking about time and not paying enough attention to the question
5. Not applying the principles of chemistry in relevant occasions

Overcoming the above drawbacks will help answer this question paper better.

2.2 Paper II and information on answers

2.2.1 Structure of the Paper II

Time is 03 hours. Total mark is 100.

This paper consists of three parts **A, B** and **C**.

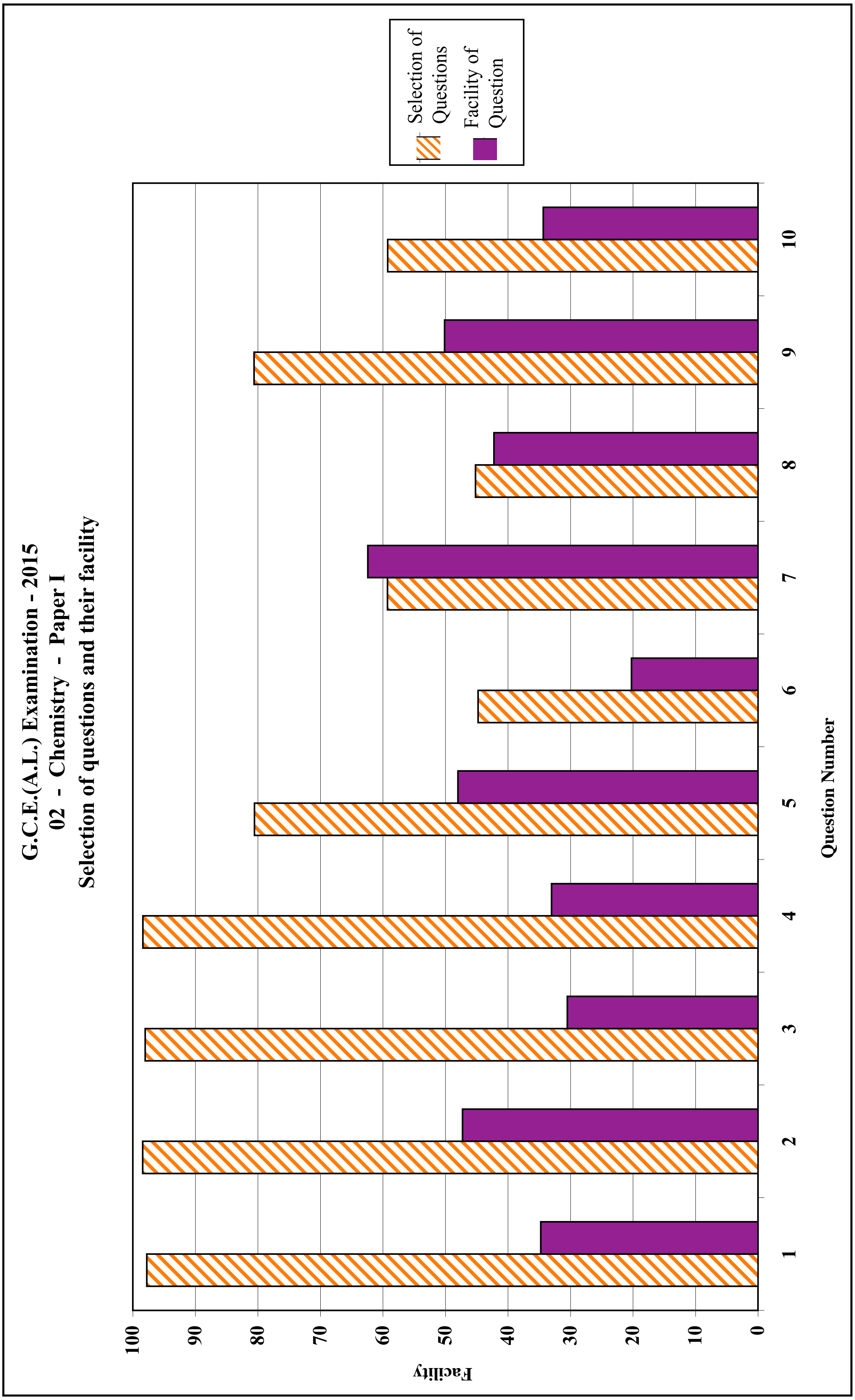
Part **A** – This contains **four structured essay** questions. All the questions should be answered. Each question carries 100 marks, so the total mark is 400.

Part **B** – This comprises **three essay** type questions of which **two** should be answered. Marks allocated for each question is 150. The total mark is 300.

Part **C** – This comprises **three essay** type questions of which **two** should be answered. Marks allocated for each question is 150. The total mark is 300.

Total mark for Paper II is 1000 ÷ 10 = 100

2.2.2 Selection and facility of questions in Paper II



2.2.3. Expected answers, marking scheme, observations, conclusions and suggestions related to paper II

★ **The observations related to the answers for Paper II have been presented by the graphs 2, 3, 4.1, 4.2 and 4.3.**

Question 01

PART A — STRUCTURED ESSAY

*Answer **all four** questions on this paper itself. (Each question carries **10** marks.)*

1. (*a*) Consider the following chemical species.

XeF_2, NO_3^-, SF_5^-, Na_2SO_4, SO_3, HF

Which one of the above species,

(i) has both ionic bonds and covalent bonds? .... Na_2SO_4 ....

(ii) is isoelectronic with BF_3? .... NO_3^- ....

(iii) has a square pyramidal shape? .... SF_5^- ....

(iv) has an equal number of bonding and non bonding electrons in its most stable structure? .... SO_3 ....

(v) has a σ–bond as a result of overlap of a 1*s* atomic orbital and a 2*p* atomic orbital? .... HF ....

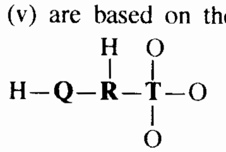
(vi) contains a bond angle of 180°? .... XeF_2 ....

(04 × 6)

(01 (a) = 24 marks)

(*b*) The compound, H_3O_3**QRT** shows acidic properties. It loses H^+ to form the anion $[H_2O_3\mathbf{QRT}]^-$ when dissolved in water. In the most acceptable Lewis structure for this anion, the negative charge is on an oxygen atom. There are no charges on the other atoms. The elements **Q**, **R** and **T** are non-metals with electronegativities greater than 2 (Pauling scale). The elements **Q** and **R** belong to the second period, whereas **T** belongs to the third period of the Periodic Table.

The following questions (i) to (v) are based on the anion $[H_2O_3\mathbf{QRT}]^-$. Its skeleton is given below.

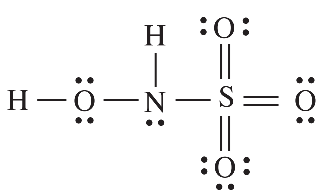


(i) Identify the elements **Q**, **R** and **T**.

Q = ... O ...., **R** = ... N ...., **T** = ... S ....

(02 + 02 + 02)

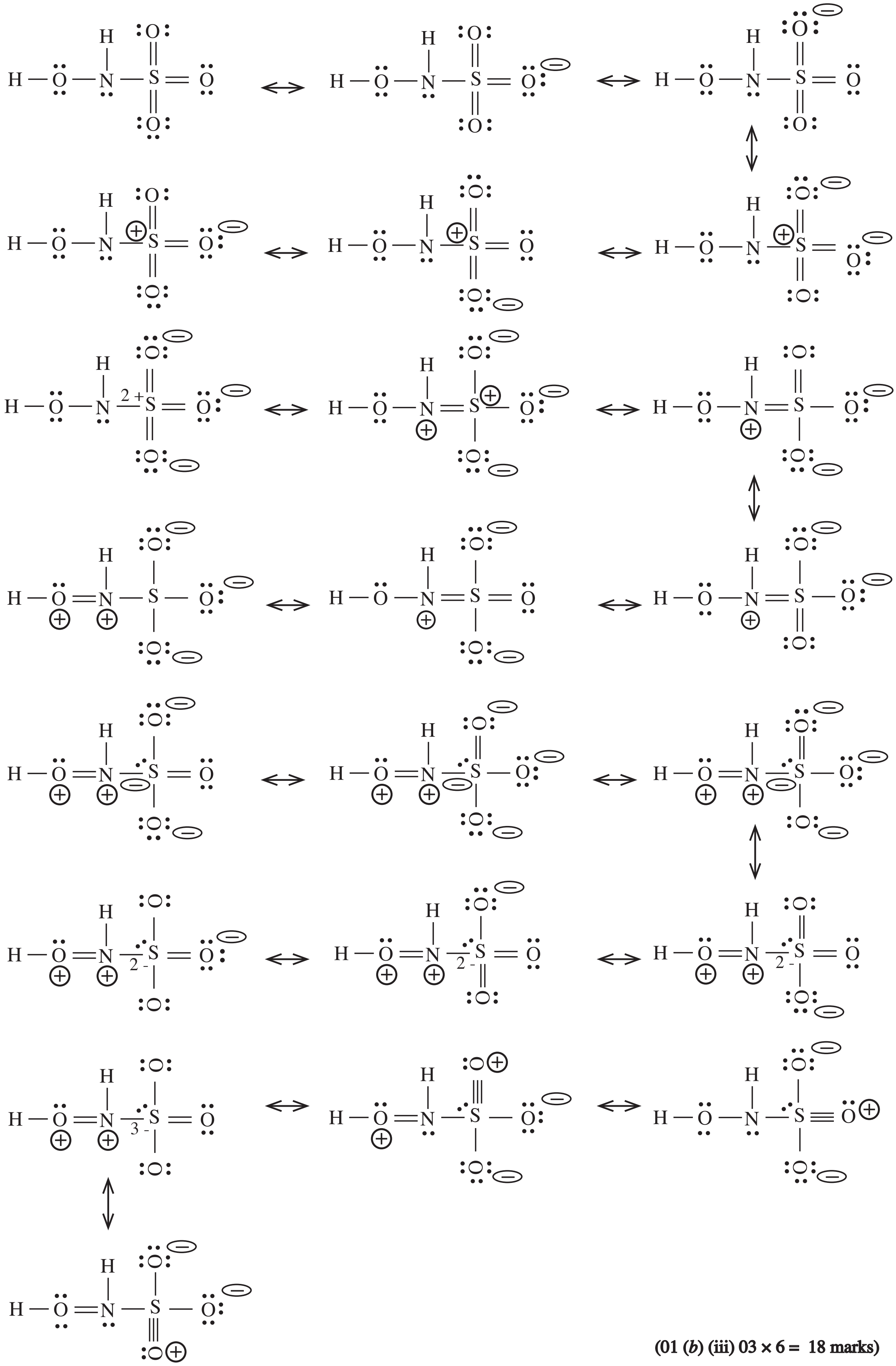
(ii) Draw the **most acceptable** Lewis structure for this anion.



(08)

Note : If Q, R and T have been identified correctly in b (i), marks can be awarded for the use of Q, R and T in drawing the correct Lewis structure.

(iii) Draw **six** resonance structures for this anion.



(01 (*b*) (iii) 03 × 6 = 18 marks)

(iv) State the following regarding **Q**, **R** and **T** atoms in the table given below:

I. electron pair geometry (arrangement of electron pairs) around the atom
II. shape around the atom
III. hybridization of the atom
IV. approximate bond angle around the atom

		Q	R	T
I	**Electron pair geometry**	tetrahedral	tetrahedral	tetrahedral
II	**Shape**	angular / V	pyramidal	tetrahedral
III	**Hybridization**	sp^3	sp^3	sp^3
IV	**Bond angle**	103 - 105°	106 - 108°	108 - 110°

(01 (*b*) (iv) 01 × 12 = 12 marks)

(v) Identify the atomic / hybrid orbitals involved in the formation of the following σ–bonds in the Lewis structure drawn in part (ii) above.

I. **Q—R** **Q** sp^3 (h.o.), **R** sp^3 (h.o.)

II. **R—T** **R** sp^3 (h.o.), **T** sp^3 (h.o.)

III. **T**—O^- **T** sp^3 (h.o.), O^- 2p (a.o.) or sp^3 (h.o.)

(01 (*b*) (v) 01 × 6 = 06 marks)

Note : Even if the Lewis structure in b(ii) is incorrect, if the arrangement around the central atom/s is/are correct, award marks accordingly for b(iv) and b(v).

(vi) I. State what information is **directly** provided by a Lewis structure of a covalent compound/ion.

(1) Distribution of valence electrons (as bond pairs / lone pairs)
(2) Charges on atoms **(02 + 01)**

II. State what information is **not directly** provided by a Lewis structure of a covalent compound/ion.

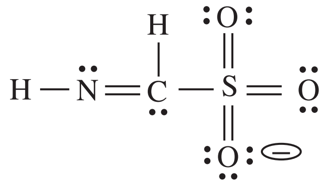
(1) shape (around central atom/s)
(2) hybridization
(3) how bonds are formed or what orbitals overlap to form bonds
(4) nature of orbitals occupied by lone pairs
(5) bond angles

(any two 02 + 01)
(01 (*b*) (vi) = 06 marks)

Alternative answer

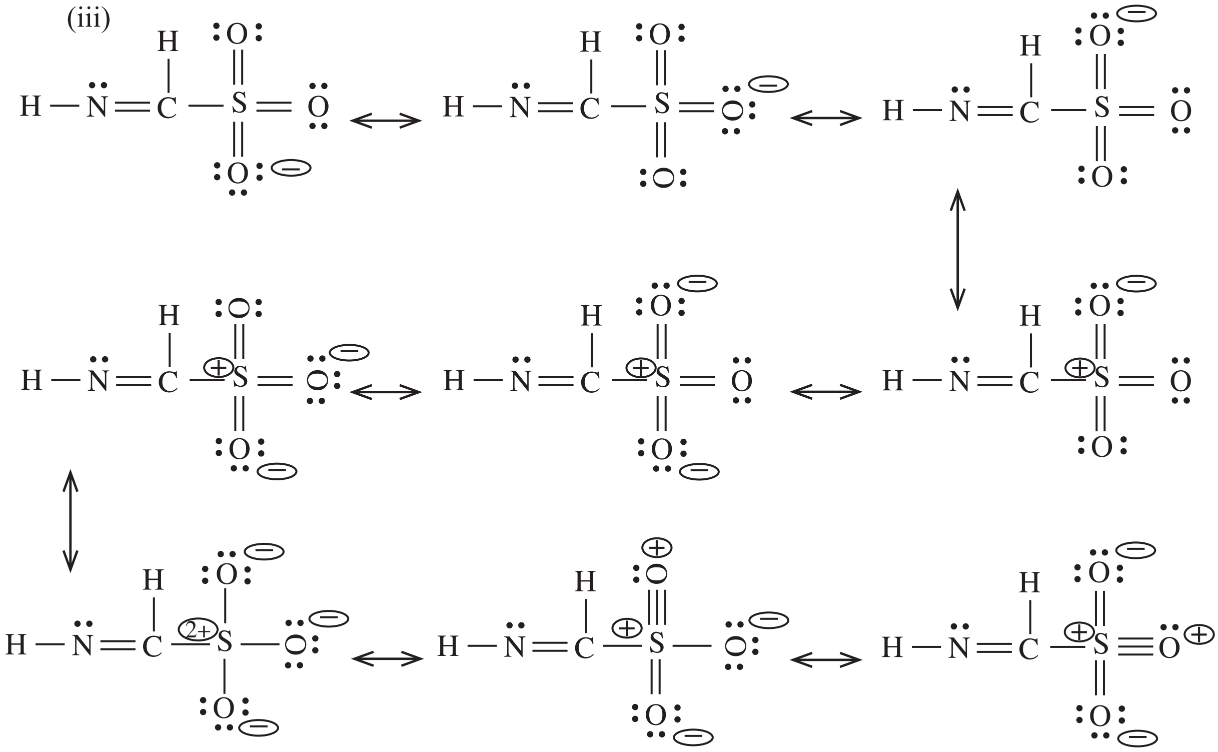
(b) (i) Q = N R = C T = S **(02 + 02 + 02)**

(ii)



(08)

(iii)



(01 (*b*) (iii) 03 × 6 = 18 marks)

Note : If Q, R and T have been identified correctly in b(i), marks can be awarded for the use of Q, R and T in drawing the correct Lewis structure

(iv)

		Q	R	T
I	Electron pair geometry	trigonal planar	trigonal planar	tetrahedral
II	Shape	angular V	trigonal planar	tetrahedral
III	Hybridization	sp^2	sp^3	sp^3
IV	Bond angle	119 - 121°	119 - 121°	108 - 110°

(01 (*b*) (iv) 01 × 12 = 12 marks)

(v)
I. **Q** sp^2 (h.o.) ……, **R** sp^2 (h.o.) ……
II. **R** sp^2 (h.o.) ……, **T** sp^3 (h.o.) ……
III. **T** sp^2 (h.o.) ……, O^- 2p (a.o.) or sp^3 (h.o.) ……

(01 (*b*) (v) 01 × 6 = 06 marks)

Note : Even if the Lewis structure in b (ii) is incorrect, if the arrangement around the central atom/s is/are correct, award marks accordingly for b (iv) and b (v).

(c) State whether the following statements are **true** or **false**. Give reasons for your choice.

(i) The **decreasing** order of electronegativity of nitrogen in NH_3, NO_2F and NO_4^{3-} is

$NO_2F > NO_4^{3-} > NH_3$.

True **(04)**

	NO_2F	No_4^{3-}	NH^3		
Charge on N	+1	+1	0	OR	**(02)**
Oxidation state of N	+5	+5	-3		**(02)**
Hybridization of N	sp^2	sp^3	sp^3		

Higher the S character, higher the electronegativity **(01)**

Higher the positive charge/oxidation state, greater the electronegativity than neutral **(01)**

Therefore, electronegativity of N in $NO_2F > NO_4^{3-} > NH^3$

Note : In each row, all three answers must be correct , in order for the mark to be awarded.

(ii) The **increasing** order of melting points of lithium halides is LiF < LiCl < LiBr < LiI.

False **(04)**

Cation : Same **(01)**

Anion: Charge same **(01)** but size increases from F to Cl **(01)**

Therefore, polarizability of $I^- > Br^- > Cl^- > F^-$

Therefore, covalency in Lil > LiBR > LiCl > LiF OR

Ionic character in LiF > LiCl > LiBr > Lil **(02)**

Therefore, melting points Lil < LiBr < LiCl < LiF

<u>**Alternative answer**</u>

False **(04)**

Electronegativity difference Lil < LiBr < LiCl < LiF **(03)**

Therefore, ionic character in Lil > LiBR > LiCl > LiF **(03)**

melting points < LiBr < LiCl < LiF

OR

False **(04)**

Size: I > Br > Cl > F **(02)**

Therefore, lattice energy Lil < LiBr < LiCl < LiF **(02)**

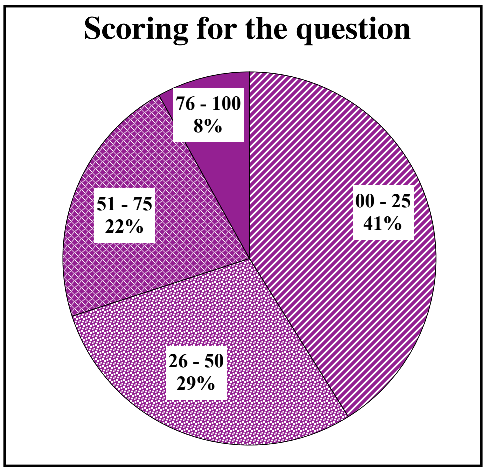
Therefore, ionic character Lil < LiBr < LiCl < LiF **(02)**

melting points Lil < LiBr < LiCl < LiF **(02)**

(01 (*c*) = 20 marks)

(Total 100 marks)

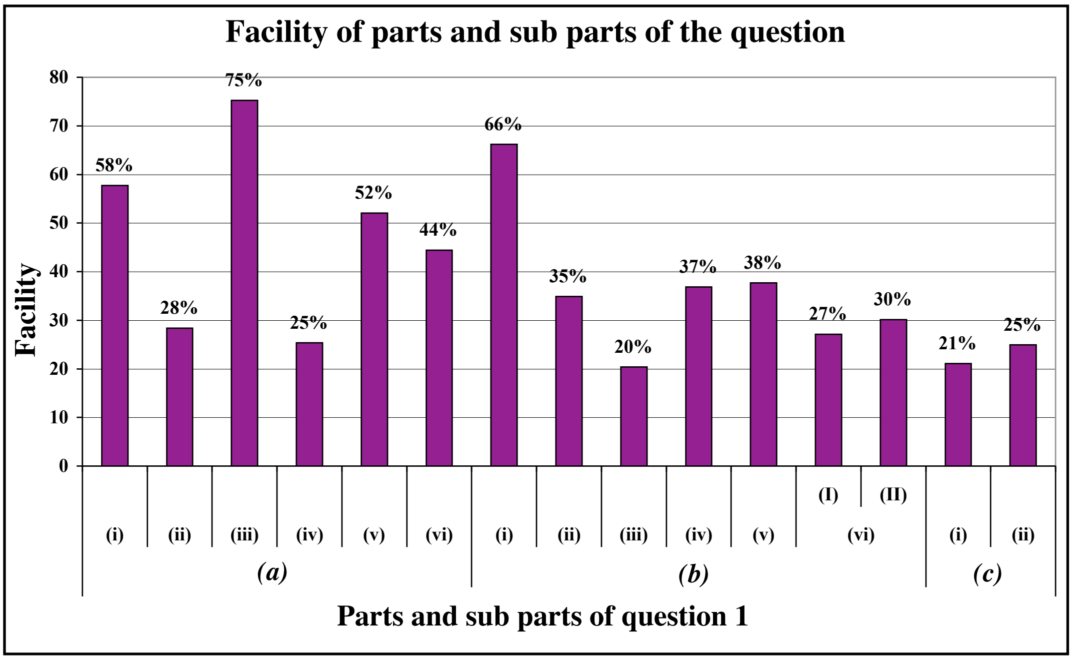
Overall observations and conclusions regarding the answers to Question 1 :



Although question 1 is compulsory, about 98% have answered it. 100 marks have been allocated for this question. The percentages of candidates scoring within the following four intervals are:

00	-	25	-	41%
26	-	50	-	29%
51	-	75	-	22%
76	-	100	-	8%

For this question 8% have scored above 76 whereas 41% have scored 25 or below.



- ⋆ This question comprises 15 sub parts. Of them the facility of five sub parts is greater than 40%. The sub part of lowest facility is *(b)* (iii) and its facility is 20%. Sub part *(a)* (iii) records highest facility and its facility is 75%. The facility of 75% in part (iii) and 25% in part (iv) show that though the students can draw Lewis structures, the ability of predicting electronic effects and chemical properties based on them is poor.

The overall facility of this question is about 35%. The facility of parts *(a)* (ii) and *(a)* (iv) is between 25% - 28%. This reflects that students understanding about the concepts such as isoelectronic species, bond electrons and non-bonding electrons is at a very low level. Though memorisation of electronegativity values of elements is not expected, students should have an understanding about their pattern of variation.

In this a considerable percentage of students had identified element T as chlorine. So the reason for having low scores by students is not their inability to draw Lewis structures but their failure to identify relevant principles correctly.

Part *(b)* has 7 sub parts. Of these, facility of 6 sub parts is below 40%. All these sub parts are based on Lewis structures, so more attention should be focused on these aspects.

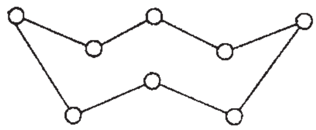
In part *(c)*, the total facility of both the sub parts is less than 25%. The understanding about the variation of electronegativity of an element with factors such as hybridisation, charge, oxidation number and polarizability is at a low ebb. Therefore, students' understanding about this should be broadened using examples.

Question 02

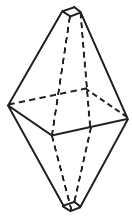
2. (*a*) **X** is a *p*-block element in the Periodic Table with an atomic number less than 20. On burning **X** in air, the colourless gas $\mathbf{X_1}$ is formed. $\mathbf{X_1}$ has a pungent smell. $\mathbf{X_1}$ is readily soluble in water. When a solution of $BaCl_2$ is added to this solution, a white precipitate $\mathbf{X_2}$ is formed. $\mathbf{X_2}$ dissolves in dil. HCl to give a weak acid $\mathbf{X_3}$ as one of the products. $\mathbf{X_1}$ decolorizes an acidified solution of potassium permanganate. A gas $\mathbf{X_4}$ is formed when $\mathbf{X_1}$ is oxidized. $\mathbf{X_4}$ is used in the industrial manufacture of the strong acid $\mathbf{X_5}$.

(i) Identify **X** and draw its structure in the crystalline state.

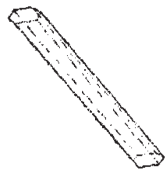
X : S or Sulphur **(04)**



OR



OR



(04)

Structure of X

(ii) Write the ground state electronic configuration of **X**. $1s^2 2s^2 2p^6 3s^2 3p^4$ **(04)**

(iii) What are the common positive oxidation states of **X**? +2, +4 , +6 or +II, +IV, +VI **(any two)**

Note : Award marks for any two correct answers within the first three given. **(02 + 02)**

(iv) Write the chemical formulae of the following compounds.

$\mathbf{X_1}$: SO_2

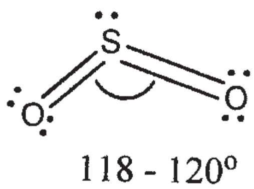
$\mathbf{X_2}$: $BaSO_3$

$\mathbf{X_3}$: H_2SO_3

$\mathbf{X_4}$: SO_3

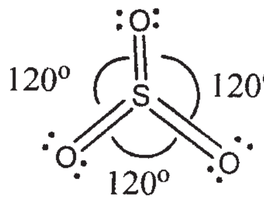
$\mathbf{X_5}$: H_2SO_4 **(04 × 05)**

(v) Sketch the most stable structures of $\mathbf{X_1}$ and $\mathbf{X_4}$. Indicate approximate bond angles, in each sketch.



$\mathbf{X_1}$

(sketch must show V or angular arrangement)



$\mathbf{X_4}$

(sketch must show trigonal planar arrangement)

(sketch (02 + 01) + (02 + 01); angle (01) + (01)

Note : Lone pairs of electrons on oxygen are not required

(vi) Write the balanced chemical equation for the reaction of X_1 with acidified potassium permanganate.

$5(SO_2 + 2H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e)$ $(SO_2 + H_2O \longrightarrow H_2SO_3)$

$2(MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O)$

$2(MnO_4^- + 5SO_2 + 2H_2O \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 4H^+$ **(06)**

OR

$5(SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e)$

$2(MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O)$

$2(MnO_4^- + 5SO_3^{2-} + 6H^+ \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$ **(06)**

OR

$2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow 2MnSO_4 + K_2SO_4 + 2H_2SO_4$ **(06)**

(If only half reactions are given, award (02) for each)

(02 (*a*) = 50 marks)

(*b*) Test tubes labelled **A** to **E** contain the following solids (not in order): $Mg(NO_3)_2$, $(NH_4)_2CO_3$, $(NH_4)_2SO_4$, NH_4NO_3 and $NaHCO_3$.

A description of the products formed when each of these solids is heated is given in the table below.

Solid	Description
A	**1.** A basic white powder; **2.** Water vapour; **3.** A colourless, odourless gas that turns lime water creamy.
B	Three products which are in the gaseous state.
C	**1.** A strong acid; **2.** A colourless gas that gives a brown precipitate / colouration with Nessler's reagent.
D	**1.** A white oxide which reacts with water to form a weakly basic solution; **2.** A colourless, diatomic gas at room temperature; **3.** A red-brown gas.
E	**1.** Water vapour; **2.** A colourless, tasteless, non-toxic triatomic gas with a linear structure.

(i) Identify solids **A** to **E**.

A : $NaHCO_3$ **B** : $(NH_4)_2CO_3$

C : $(NH_4)_2SO_4$ **D** : $Mg(NO_3)_2$

E : NH_4NO_3 **(05 × 05)**

(ii) Write balanced chemical equations for the reactions that take place on heating each of the solids **A** to **E**.

$2NaHCO_3(s) \xrightarrow{\Delta} Na_2CO_3(s) + H_2O(g) + CO_2(g)$

$(NH_4)_2CO_3(s) \xrightarrow{\Delta} 2NH_3(g) + CO_2(g) + H_2O(g)$

$(NH_4)_2SO_4(s) \xrightarrow{\Delta} 2NH_3(g) + H_2SO_4$

$2Mg(NO_3)_2(s) \xrightarrow{\Delta} 2MgO(s) + 4NO_2(g) + O_2(g)$

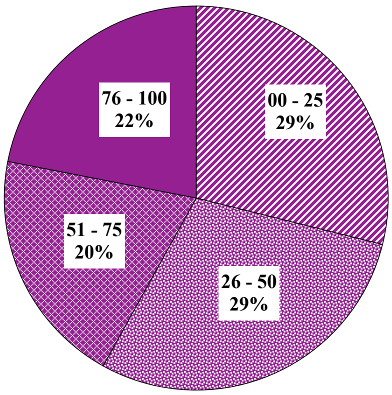
$NH_4NO_3(s) \xrightarrow{\Delta} N_2O(g) + 2H_2O(g)$ **(05 × 05)**

Note : Physical states are not required **(02 (*b*) = 50 marks)**

(Total 100 marks)

Overall observations and conclusions regarding the answers to Question 2 :

Scoring for the question



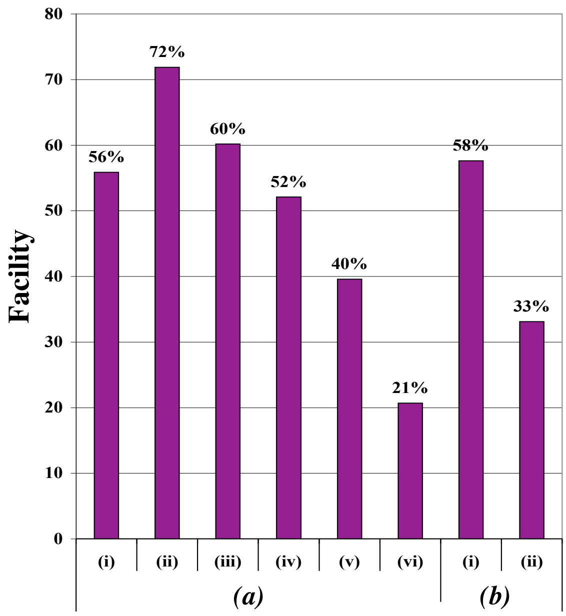
Despite question 2 is compulsory, only 98% had answered it. This question is also worth of 100 marks.

The distribution of candidates among the four selected class intervals were as follows.

00	-	25	-	29%
26	-	50	-	29%
51	-	75	-	20%
76	-	100	-	22%

For this question 22% had scored 76 or above but 29% had obtained 25 or below.

Facility of parts and sub parts of the question



Parts and sub parts of question 2

★ The question has 8 sub parts. Of them, the number of sub parts with the facility of 40% or less is three. The sub part of lowest facility is (a) (vi) and its facility is 21%. The most facile part is (a) (ii) and its facility is 72%.

The overall facility of this question is nearly 48%. Sub part *(a)* (vi) relates to writing balanced chemical equations using oxidation numbers. To promote the ability of writing balanced chemical equations, students should be involved in exercises. Not getting correct stoichiometric coefficients for all the reactions and products when resorting to short cuts would have brought the facility down.

Sub part *(b)* (ii) concerns the thermal dissociation reactions of salts of the S block and ammonium salts. The ability of writing reactions and balancing equations in chemistry appears to be low. It is important to stress to the students that this type of questions can be answered successfully by relating the practical knowledge on the decomposition of S block compounds and ammonium salts.

Question 03

3. (*a*) The kinetics of the following reaction can be studied by measuring initial rates.

$$A(aq) + 5B(aq) + 6C(aq) \longrightarrow 3D(aq) + 3E(aq)$$

Four experiments carried out by changing initial concentrations of **A**, **B** and **C** at a given temperature are described in the following table. $[\Delta A]_0$, the change in concentration of **A**, with time (t/s) was measured.

Expt.	$[A]_0$ / mol dm^{-3}	$[B]_0$ / mol dm^{-3}	$[C]_0$ / mol dm^{-3}	$[\Delta A]_0$ / mol dm^{-3}	t/s	Initial Rate(R)/mol dm^{-3} s^{-1}	
1	0.2	0.2	0.2	0.040	50	R_1 = 8.0×10^{-4}	**(05)**
2	0.4	0.2	0.2	0.096	60	R_2 = 1.60×10^{-3}	**(05)**
3	0.4	0.4	0.2	0.128	40	R_3 = 3.20×10^{-3}	**(05)**
4	0.2	0.2	0.4	0.080	25	R_4 = 3.20×10^{-3}	**(05)**

(i) Calculate initial rates R_1, R_2, R_3 and R_4 and complete the table.

(ii) Taking **a**, **b** and **c** as orders with respect to each of the reactants **A**, **B** and **C** respectively, and the rate constant as k, calculate **a**, **b**, **c** and write the rate expression for the reaction using the calculated values.

Rate $= k [A]^a [B]^b [C]^c$ **(05)**

From Experiment 1 : $8.0\times10^{-4} = k [0.20]^a[0.20]^b[0.20]^c$ *(1)*

From Experiment 2: $16.0 \times10^{-4} = k [0.40]^a[0.20]^b[0.20]^c$ *(2)* Units are not included.

From Experiment 3: $32.0\times10^{-4} = k [0.40]^a[0.40]^b[0.20]^c$ *(3)*

From Experiment 4: $32.0\times10^{-4} = k [0.20]^a[0.20]^b[0.40]^c$ *(4)* **(2.5 × 4)**

(1)/(2): $1/2 = (1/2)^a$: a = 1 **(05)**

(2)/(3): $1/2 = (1/2)^b$: b = 1 **(05)**

(1)/(4): $1/4 = (1/2)^c$: c = 2 **(05)**

$\therefore$ Rate = $k [A] [B] [C]^2$ **(05)**

(iii) State the overall order of the reaction.

Overall order = 4 **(05)**

(iv) Calculate the rate constant k of the reaction.

From Equation (1):

$k = 8.0 \times 10^{-4}$ mol dm^{-3} s^{-1} / (0.20) (0.20) $(0.20)^2$ mol^4 dm^{-12} **(05)**

$k = 0.5$ mol^{-3} dm^9 s^{-1} **(04 + 01)**

Note : Same answer from other equations too

(03 (*a*) = 70 marks)

(*b*) (i) I. In another experiment, if the concentrations are, $[\mathbf{A}]_0 = 1.0 \times 10^{-3}$ mol dm^{-3}, $[\mathbf{B}]_0 = 1.0$ mol dm^{-3} and $[\mathbf{C}]_0 = 2.0$ mol dm^{-3}, show that the rate expression for the reaction can be given by Rate $= k'[\mathbf{A}]^{\mathbf{a}}$. ($k'$ is the rate constant of the reaction under these conditions.)

Rate $= k [A] [B] [C]^2$ or $[A] = 1 \times 10^{-3}$ mol dm^{-3}, $[B] = 1$ mol dm^{-3}, $[C] = 2$ mol dm^{-3}

$k = [B] [C]^2 = k'$ **(05)**

$\therefore$ Rate $= k' [A]^a$ (or Rate $= k' [A]$)

II. State the assumption(s) made in deriving the expression in I above.

Assumption : = [B], [C] >> [A] OR **(05)**

[B] and [C] do not change during the experiment OR B and C are in excess.

(ii) In the above (*b*)(i) experiment, the concentration of **A**, [**A**], changes with time (t) according to the following equation. $2.303 \log [\mathbf{A}] = -k't + 2.303 \log [\mathbf{A}]_0$. ($[\mathbf{A}]_0$ is the initial concentration of **A**.) Show that the half-life ($t_{1/2}$) of the reaction is given by $0.693/k'$ and calculate $t_{1/2}$ by using the data in (*a*)(iv) and (*b*)(i) above.

$2.303 \log [A] = - k' t + 2.303 \log [A]_0$ → given

After half life

$t = t_{1/2}$, $[A] = [A]0 /2$ **(05)**

$\therefore 2.303 \log \{ [A]0 /2 \} = - k' t_{1/2} + 2.303 \log [A]_0$

$k' t_{1/2} = 2.303 \log 2 = 0.693$ **(05)**

$t_{1/2} = 0.693/k'$

$k' = k [B] [C]^2$

$= 0.5$ mol^{-3} dm^9 s$^{-1} \times 1$ mol dm$^{-3} \times (2$ mol dm$^{-3})^2$

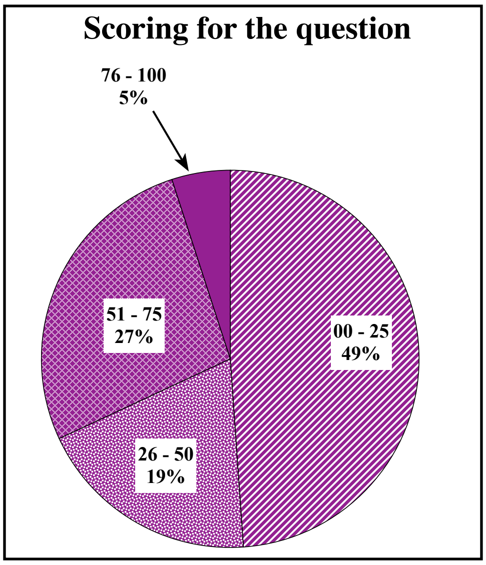
$= 2$ s^{-1} **(04 + 01)**

$\therefore t_{1/2} = 0693/2$ s^{-1} $= 0.347$ s (or 0.35 s) **(04 + 01)**

(03 (*b*) = 30 marks)

(Total 100 marks)

Overall observations and conclusions regarding the answers to Question 3 :

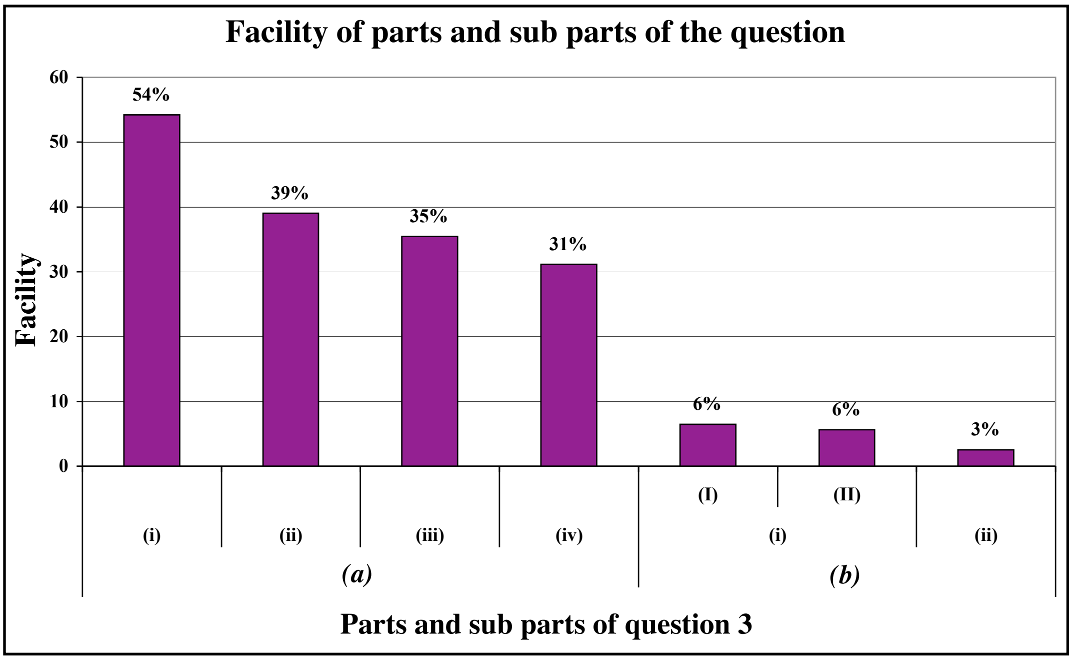


Being compulsory notwithstanding, question 3 had been answered by 98%. The question carried 100 marks.

The approximate percentages falling into the respective class intervals were:

00	-	25	-	49%
26	-	50	-	19%
51	-	75	-	27%
76	-	100	-	5%

The percentage obtaining 76 marks or above for this question was 5%. 49% have scored 25 or below for this question.



- There are 7 sub parts in this question. Though the facility of sub part (a) (i) is little above 50%, the facility of all the sub parts stays below 40%. On the whole answering questions on kinetics is not satisfactory. For instance, as sub part 3 (a) (i) displays, about 50% of the students were not able to understand that rate is the change in concentration in unit time, so in part 3 (a) (i) the rate can be calculated by the relation, $R = \frac{\Delta[A_0]}{\Delta t}$. From the responses to part 3 (a) (ii) it is apparent that 60% of the students do not have the skill of writing the rate expression and finding the order from it.

Facility of part (b) remains at a very low level. Students answers to this part are not satisfactory. The facility of all the sub parts is less than 6%. The overall facility of question 3 is about 30%. Of the four compulsory structured essay questions this shows the lowest facility.

The facility of sub part (a) (i) is 54% whereas the facility of all the three other parts is between 30% - 40%. This indicates that the skill of substituting figures in the rate expression and making necessary computation is leaving a lot to be desired.

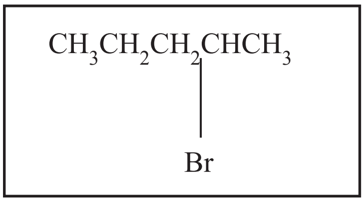
It is very clear that the candidates have failed to understand the fact that when the concentration of one reaction becomes relatively very low (eg. $[A_0] = 10^{-3}$ mol dm^{-3}) while that of the other reactants remain very high (e.g. $[B_0] = 1$ mol dm^{-3} and $[C_0] = 2$ mol dm^{-3}), the percentage of the change in concentration of the component at low concentration is considerably high. For example, when $[A_0]$ decreases from 1×10^{-3} mol dm^{-3} to 5×10^{-4} mol dm^{-3}, the change in initial concentration of A is 50%. The corresponding change in the concentration of B is $5 \times 0.5 \times 10^{-3}$ mol dm^{-3}. As the change in concentration of B and C is negligibly small relative to that of A, the total rate depends on the initial concentration of A. Students have failed to understand this.

Students seem to have baffled because the equation in part (b) (ii) had been given in an unfamiliar way. This shows that the students lack the skill of dealing with a new situation presented extempore and solve problems within the limited time available.

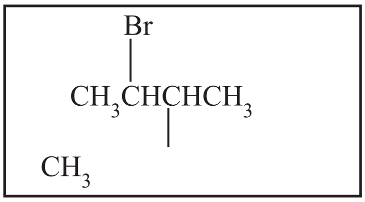
Part (a) (ii) examines the calculation of order. Weakness in calculating order has erred the workouts in parts (iii) and (iv).

Question 04

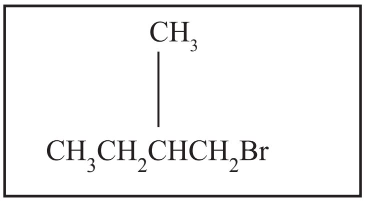
4. (*a*) **A**, **B** and **C** are structural isomers with the molecular formula $C_5H_{11}Br$. All three isomers exhibit optical isomerism. When reacted with alcoholic KOH, **A**, **B** and **C** give **D**, **E** and **F** respectively. **D** exhibits geometric isomerism, while **E** and **F** do not exhibit geometric isomerism. When reacted with HBr, **E** and **F** both give the same compound **G**. **G** is a structural isomer of **A**, **B** and **C**. **G** does not exhibit optical isomerism. Draw the structures of **A**, **B**, **C**, **D**, **E**, **F** and **G** in the boxes given below. (It is **not necessary** to draw stereoisomeric forms.)



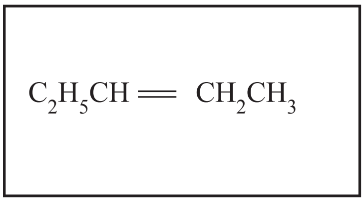
A



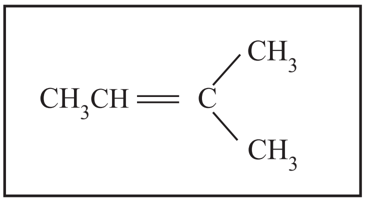
B



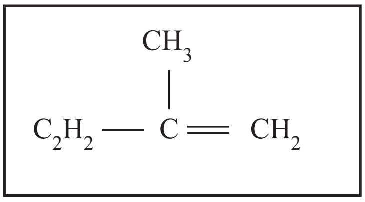
C



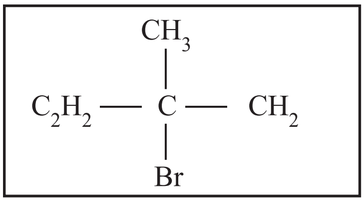
D



E



F



G

(07 × 07)

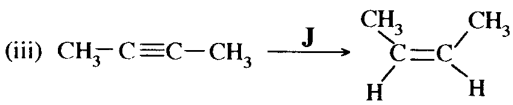
(04 (*a*) = 49 marks)

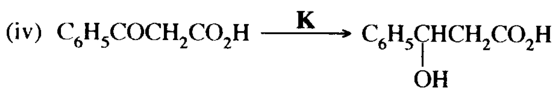
Note : B and C can be interchanged. If so, E and F should also be interchanged

(*b*) Write the reagent(s) / catalyst(s) **H**, **I**, **J**, **K**, **L**, **M**, **N**, **O**, **P** and **Q** (with suitable conditions, if any, of the following reactions in the boxes given on page 8.

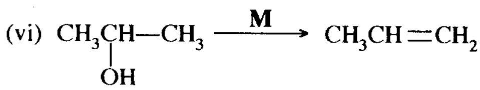
(i) $CH_2{=}CH_2 \xrightarrow{\textbf{H}} HOCH_2CH_2OH$

(ii) $C_6H_5\overset{\oplus}{N_2}\overset{\ominus}{Cl} \xrightarrow{\textbf{I}} C_6H_5I$





(v) $C_2H_5CH_2OH \xrightarrow{\textbf{L}} C_2H_5CO_2H$



(vii) $CH_3C{\equiv}CH \xrightarrow{\textbf{N}} CH_3C{\equiv}CCu$

(viii) $C_6H_5CO_2H \xrightarrow{\textbf{O}} C_6H_5COCl$

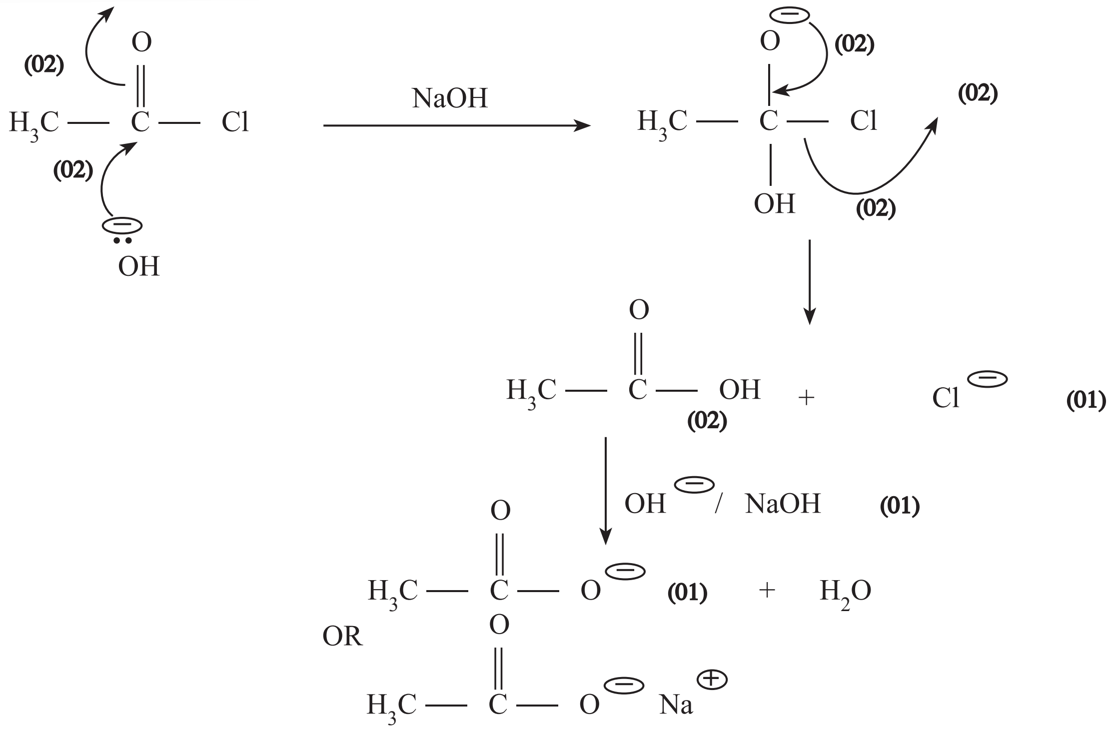
(ix) $C_6H_5CONH_2 \xrightarrow{\textbf{P}} C_6H_5CH_2NH_2$

(x) $C_6H_6 \xrightarrow{\textbf{Q}} C_6H_5COCH_3$

(cold) alkaline $KMnO_4$ or cold $KMnO_4$ **(04)**	Kl **(03)**	H_2/ pd/$BaSO_4$/ Quinonline or H_2/ Lindlar catalyst **(04)**
H	**I**	**J**
$NaBH_4$ **(03)**	$KMnO_4$ or H+/ $KMnO_4$ or H^+/ $K_2Cr_2O_7$ or H^+/ CrO_3 **(04)**	anhydrous Al_2O_3/ Δ or H_2SO_4 or P_2O_5 **(04)**
K	**L**	**M**
NH_3/ Cu_2Cl_2 or NH_3/ CuCl or ammoniacal CuCl or NH_4OH/ Cu_2Cl_2 or NH_4OH/ CuCl **(03)**	PCL_5 or PCl_3 **(03)**	$LiaAlH_4$ **(03)**
N	**O**	**P**
CH_3COCl anhydrous $AlCl_3$ **(04)**		
Q		

(04 (*b*) = 35 marks)

(*c*) Write the mechanism for the reaction of CH_3COCl with aqueous sodium hydroxide.

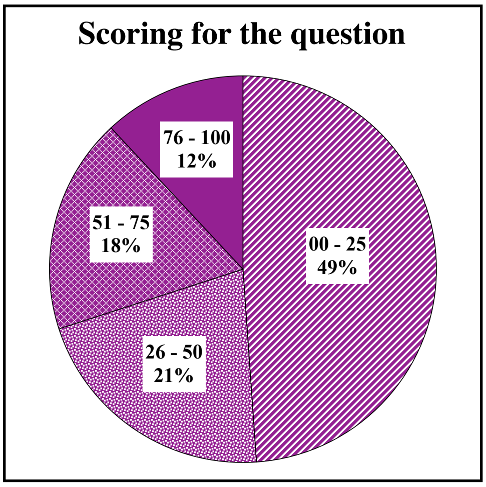


Note : Lone pair need not be included for the award of marks.

(04 (*c*) = 16 marks)

(Total 100 marks)

Overall observations and conclusions regarding the answers to Question 4 :

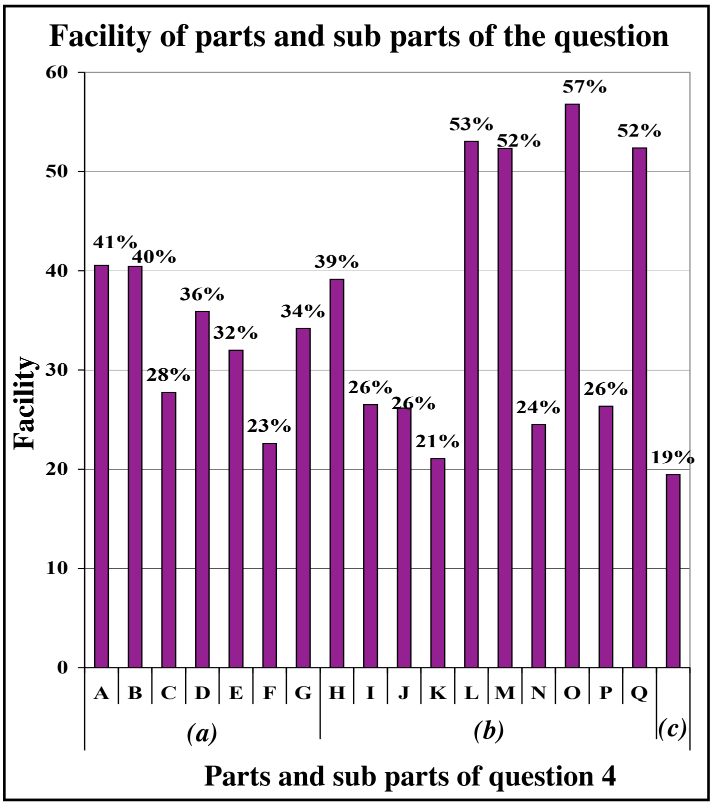


In spite of the fact that question 4 was compulsory, only 98% have answered it. The total mark for the question was 100.

The percentage of candidates scoring within the four class intervals were:

00	-	25	-	49%
26	-	50	-	21%
51	-	75	-	18%
76	-	100	-	12%

So, 12% have scored 76 or above while 49% have scored 25 or below for this question.



* The question carried 18 sub parts. Of them, the facility of 8 were between 19% and 30%.

The overall facility of this question is about 32%. The facility of five sub parts in part 4 (b) lies between 21% and 26%. Four sub parts have their facility between 50% - 60%. This comprises several questions testing the ability of writing reagents/ catalysts of some single step reactions in organic chemistry. This examines only the basic knowledge of organic chemistry.

The facility of part (c) is 19%. Understanding of reaction mechanisms needs to be improved further. Because of poor understanding of the mechanism, the ability to make a theoretical evaluation about the products of a reaction is lessened. One reason for the facility of 4 (a) to go below 40% or less is the poor knowledge of reaction mechanisms. The skill of reading a given description with patience is also equally important.

Question 05

PART B — ESSAY

Answer ***two*** *questions only.* (*Each question carries* **15** ***marks.***)

5. (*a*) Consider the following reaction at a temperature of 25 °C.

$$\mathbf{AB}(s) \longrightarrow \mathbf{C}(s) + \mathbf{D}(g)$$

The following data are given for ΔH°_f and S° at 25 °C.

	ΔH°_f /kJ mol^{-1}	S° /J K^{-1} mol^{-1}
AB(s)	– 1208	100
C(s)	– 600	50
D(g)	– 500	170

(i) Show that the reaction is **non-spontaneous** at 25 °C.

(ii) This reaction is spontaneous when the temperature is greater than T °C. This reaction is non-spontaneous when the temperature is less than T °C. Calculate T.

(iii) State the assumptions you made in the calculation in (ii) above.

(5.0 *marks*)

(*b*) When the reaction described in (*a*) above is carried out in a closed container of volume 2.00 dm^3 at 930 °C, the system reaches an equilibrium as given below.

$$\mathbf{AB}(s) \rightleftharpoons \mathbf{C}(s) + \mathbf{D}(g)$$

(i) The pressure of the container was found to be 4.00 × 10^5 Pa. Calculate K_p and K_c at 930 °C. State the assumptions you made. (Consider that 8.314 J K^{-1} mol^{-1} × 1203 K = 10 000 J mol^{-1})

(ii) When the above reaction in (*b*)(i) is carried out in the presence of **X**(g) at 930 °C, the yield of **D**(g) can be enhanced. Then the system shows a new equilibrium as given below.

$$\mathbf{AB}(s) + \mathbf{X}(g) \rightleftharpoons \mathbf{C}(s) + 2\mathbf{D}(g)$$

When this reaction is carried out with 2.25 × 10^{-1} moles of **X**(g) at 930 °C in a closed container of volume 2.00 dm^3, the partial pressure of **D**(g) is found to be 7.50 × 10^5 Pa. Calculate K_p and K_c for the new equilibrium.

(iii) Explain qualitatively the changes that could take place in the equilibrium in part (*b*)(ii) in the following instances.

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5. **(a)** (i)

AB(s) C(s) + D(g)

ΔH°_m = ΔH°_f(**C**) + ΔH°_f(**D**) - ΔH°_f(**AB**) or $\Delta H^\circ_m = \Delta H^\circ_{products} - \Delta H^\circ_{reactants}$ **(01)**

= {(-600) + (-500) - (-1200)} kJ mol^{-1} **(04)**

= 108 kJ mol^{-1} **(04 + 01)**

ΔS°_m = S°_f(**C**) + S°_f(**D**) - S°_f(**AB**) or $\Delta S^\circ_m = \Delta S^\circ_{products}$ - $\Delta S^\circ_{reactants}$ **(01)**

= {(50) - (170) - (100) } J K^{-1} mol^{-1} **(04)**

= 120 J K mol (120 × 10^{-3} kJ K^{-1} mol^{-1} or 0.120 kJ K^{-1} mol^{-1}) **(04 + 01)**

ΔG°_m = ΔH°_{rn} - T ΔS°_{rn} **(05)**

= 108 kJ mol^{-1} - 298 K × 120 × 10^{-3} kJ K^{-1} mol^{-1} **(04 + 01)**

= 72.2 kJ mol^{-1} (or 72 kJ mol^{-1}) **(01)**

ΔG°_{rn} is positive quantity **(05)**

∴ Reaction is non-spontaneous at 298 K (25 °C)

(ii) **according to the given description of temperature T:**

ΔG°_{rn} = O = ΔH°_{rn} - (**T + 273**) ΔS°_{m} **(05)**

(or ΔG°_{rn} = O = ΔH° - T ΔS°_{rn})

$\therefore$ (T + 273) = $\Delta H^\circ_{rn} / \Delta S^\circ_{rn}$

= $108\ kJ\ mol^{-1} / 120 \times 10^{-3}\ kJ\ K^{-1}\ mol^{-1}$

T = 627 **(05)**

[or 900K **(04 + 01)**]

(iii) Temperature dependence of ΔH°_{rn} and ΔS°_{rn} is neglected. **(05)**

(or ΔH°_{rn} and ΔS°_{rn} have same value at 298 K and 900 K)

(or ΔH°_{rn} and ΔS°_{rn} are assumed to be temperature independent) **(5 *(a)* = 50 marks)**

(b) (i) **AB(s) $\rightleftharpoons$ C(s) + D(g)**

System has only **D(g)** as **gaseous** species, Assuming ideal behavior **(05)**

$\therefore$ **Kp = P_D = 4.0 × 10^5 Pa** **(04 + 01)**

$Kp = K_C(RT)^{\Delta n}$ **(05)**

$\Delta n = 1 - 0 = 1$ **(05)**

$\therefore K_C = Kp / (RT)$

= $4.0 \times 10^5\ Pa / 8.314\ J\ K^{-1}\ mol^{-1} \times 1203\ K$

= $4.0 \times 10^5\ Pa / 10000\ J\ mol^{-1}$

= $40\ mol\ m^{-3}$ ($4 \times 10^{-2}\ mol\ dm^{-3}$) **(04 + 01)**

Note : Award 15 marks if K_C is calculated by another correct acceptable method.

(ii) PV = nRT for D(g) **(04 + 01)**

Amount of D(g), n_D = $P_D V / RT$ **(05)**

= $7.5 \times 10^5\ Pa \times 2.00 \times 10^{-3}\ m^3 / 8.314\ J\ K^{-1}\ mol^{-1} \times 1203\ K$ **(05)**

= $7.5 \times 10^5\ Pa \times 2.00 \times 10^{-3}\ m^3 / 10000\ J\ mol^{-1}$

= $7.5 \times 10^5\ J\ m^{-3} \times 2.00 \times 10^{-3}\ m^3 / 10000\ J\ mol^{-1}$

= 0.15 mol **(04 + 01)**

Consumed amount of X(g) = 0.15/2 mol = 0.075 mol (P:D = 1.2) **(05)**

Remaining amount of X(g) = 0.225 - 0.075 = 0.15 mol **(05)**

Mole fractions: X_D = 1/2, X_X = 1/2 **(05)**

$P_D = P_{total} X_D$

$\therefore P_{total} = 7.5 \times 10^5 \times 2\ Pa = 15 \times 10^5\ Pa$ **(04 + 01)**

$\therefore P_X = 15 \times 10^5 \times 1/2\ Pa = 7.5 \times 10^5\ Pa$ **(04 + 01)**

(or $P_X = P_{total} - P_D$)

$AB(s) + X(g) \rightleftharpoons C(s) + 2D(g)$

$Kp = (P_D)^2 / P_X$ **(05)**

$= (7.5 \times 10^5 \text{ Pa})^2 / 7.5 \times 10^5 \text{ Pa}$

$= 7.5 \times 10^5 \text{ Pa}$ **(04 + 01)**

$K_p = K_C(RT)^{\Delta n}$

$\Delta n = 2 - 1 = 1$ **(05)**

$\therefore K_C = K_p / (RT)$

$= 7.5 \times 10^5 \text{ Pa} / 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 1203 \text{ K}$

$= 7.5 \times 10^5 \text{ Pa} / 10000 \text{ J mol}^{-1}$

$= 75 \text{ mol m}^{-3}$ ($7.5 \times 10^{-2} \text{ mol dm}^{-3}$) **(04 + 01)**

Note: Award 10 marks if K_C is calculated by another correct acceptable method.

(iii) I No effect to the equilibrium as C is a solid **(05 + 05)**

II Equilibrium shifts to right as yield of C increases. **(05 + 05)**

OR according to the le Chatelier Principle, the equilibrium shifts to the right.

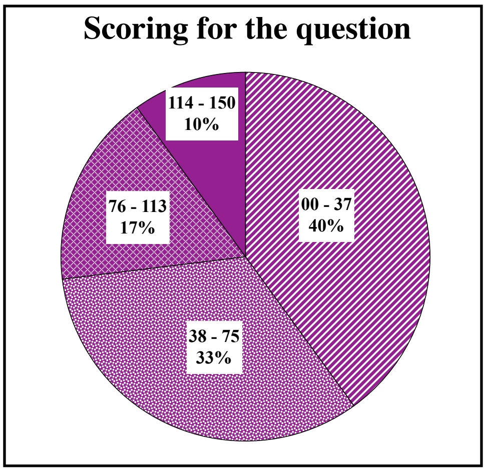
OR as the amount of D decreases, according to the le Chatelier Principle the equilibrium shifts to the right.

Note : The second (05) marks can be awarded only if the first part of the answer is correct

(5 *(b)* = 100 marks)

(Total 150 marks)

Overall observations and conclusions regarding the answers to Question 5 :

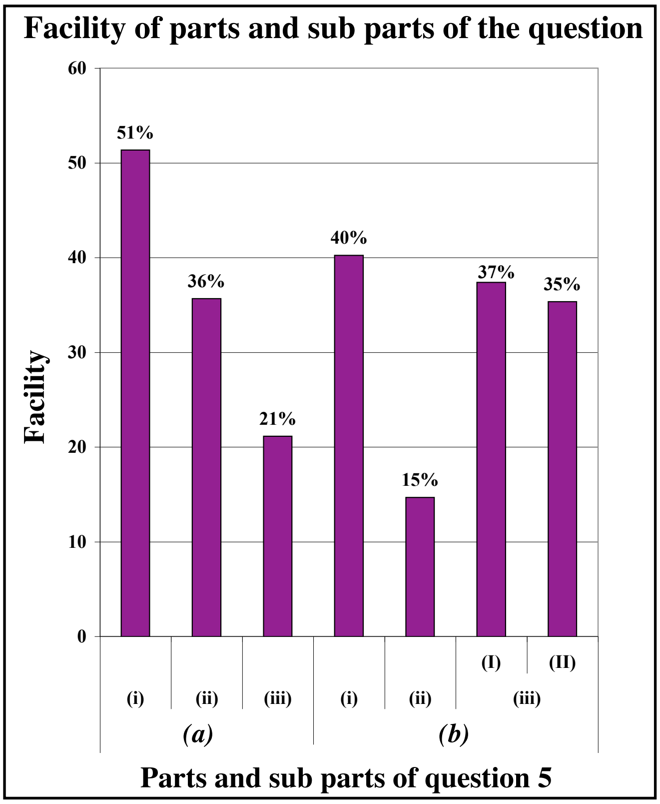


About 81% had chosen this question. Of the two physical chemistry questions in part B, this was the one answered by a majority.

The question carries 150 marks. The distribution of candidates in the four class intervals was as follows.

00	-	37	-	40%
38	-	75	-	33%
76	-	113	-	17%
114	-	150	-	10%

The percentage scoring 114 or above was 10% while 40% had scored 37 or below.



- ⋆ This question comprises 7 sub parts. Its most facile part is (a) (i) and its facility is 51%. In all the other sub parts the facility is 40% or less. Facility is least in sub part (b) (ii) and its facility is 15%.

Being a popular question 81% of the students have had this question in their choice, yet the facility is about 48%. Initial sub parts of (a) and (b) involve direct manipulation of data so their facility is greater than that of the rest.

Despite calculations are done, the facility values indicate less understanding about the requirements needed for it. The facility of 21% in 5 (a) (iii) shows that the candidates lack a proper understanding about assumptions.

In 5 (b) (i), the lowering of facility to nearly 40% mirrors the inadequacy of skills required to solve mathematical expressions related to the equilibria reached by the decomposition of a compound in solid state yielding products in the solid and gaseous states. Because of this low facility (40%) of part (b) (i), it is not surprising to see a further fall off in the ability in solving the problem related to the new equilibrium in (b) (ii). So it is required to develop the skill of solving problems on gas phase equilibria and working out calculations related to the changes brought about in a system in equilibrium by the introduction of a component. In spite of the flaws in computations related to equilibria, students show some ability to make deduction about equilibria using LeChatelier principle.

Part (b) (ii) aims to examine the ability of solving problems related to a new equilibrium system established. But low facility reflects poor skills of analysis. However students display an ability of explaining qualitative changes taking place in a system to some extent.

Question 06

6. (*a*) **XA**(s) and **YA**(s) are two sparingly water soluble salts.

(i) The solubility of salt **XA**(s) in water is 2.01 mg dm^{-3} at 25 °C. Calculate the solubility product K_{sp} of **XA**(s) at 25 °C. (**X** = 110 g mol^{-1}, **A** = 40 g mol^{-1})

(ii) A completely water soluble solid Na**A** is added slowly to a 1.00 dm^3 aqueous solution containing 0.100 moles of X^+(aq) and 0.100 moles of Y^+(aq).

I. Predict which of the salts precipitates first. (K_{sp}(**YA**) = 1.80×10^{-7} mol^2 dm^{-6}).

II. Calculate the cation concentration that remains in solution of the salt which precipitated first when the second salt begins to precipitate.

(5.0 *marks*)

(*b*) (i) When a weak acid **HA**(aq) is titrated with a solution of NaOH, considering the hydrolysis of A^-(aq), show that the pH of the solution at the equivalence point is given by $pH = \frac{1}{2} pK_w + \frac{1}{2} pK_a + \frac{1}{2} \log [A^-(aq)]$.

(You are given that pH + pOH = pK_w, $pK_a + pK_b = pK_w$ and $K_b = \frac{[OH^-(aq)][HA(aq)]}{[A^-(aq)]}$)

(ii) Calculate the pH at the equivalence point when a solution of 1×10^{-3} mol dm^{-3} **HA**(aq), is titrated with a 1×10^{-3} mol dm^{-3} solution of NaOH. ($K_a = 1.8 \times 10^{-5}$ mol dm^{-3}).

(iii) A 500.00 cm^3 solution of 2×10^{-3} mol dm^{-3} Y^+(aq) is added to a 500.00 cm^3 of 2×10^{-3} mol dm^{-3} solution of **HA**(aq). Solid Na**A** was slowly added to this solution in order to precipitate **YA**(s). Calculate the pH of the solution when **YA**(s) begins to precipitate. (K_{sp}(**YA**) = 1.80×10^{-7} mol^2 dm^{-6}).

(7.0 *marks*)

(*c*) Benzene and toluene mix completely with each other to form a binary mixture. Boiling points of benzene and toluene are 80 °C and 110 °C respectively.

(i) Draw an appropriate temperature - composition phase diagram for the above system.

(ii) Consider the distillation of a liquid mixture (**P**) with 30% of benzene.

I. Mark the boiling point T_1 of liquid mixture **P** on the phase diagram above.

II. Mark the composition (**Q**) of the vapour phase at temperature T_1 on the phase diagram above.

III. Explain qualitatively, the difference in composition between the liquid and vapour phases at temperature T_1. Name the technique which is used to separate benzene from the above binary mixture based on this difference.

(iii) Draw the temperature - composition phase diagram for a binary mixture formed by two fully miscible liquids with equal boiling points.

(3.0 *marks*)

6. (a) (i) $XA(s) \rightleftharpoons X^+(aq) + A^-(aq)$

at equilibrium x x mol dm^{-3} **(05)**

Solubility(x) = 2.01 mg dm^{-3} = 2.01×10^{-3} g dm^{-3} = 2.01×10^{-3}/ 150 mol dm^{-3}

= 1.34×10^{-5} mol dm^{-3} **(04 + 01)**

K_{sp} = $[X^+(aq)][A^-(aq)] = x^2$ **(05)**

= $(1.34 \times 10^{-5} \text{ mol dm}^{-3})^2$

= 1.80×10^{-10} mol^2 dm^{-6} **(04 + 01)**

(or 1.79×10^{-10} mol^2 dm^{-6})

(ii) I.

For XA	For YA
$K_{sp} = [X^+(aq)]\,[A^-(aq)]$	$K_{sp} = [Y^+(aq)]\,[A^-(aq)]$
$[A^-(aq)] = Ksp / [X^+(aq)]$	$[A^-(aq)] = K_{sp} / [Y^+(aq)]$ **(05)**
$= (1.80 \times 10^{-10} / 0.100)$ mol dm^{-3}	$= (1.80 \times 10^{-7} / 0.100)$ mol dm^{-3}
$= 1.80 \times 10^{-9}$ mol dm^{-3} **(04 + 01)**	$= 1.80 \times 10^{-6}$ mol dm^{-3} **(04 + 01)**

∴ XA precipitates first

Alternative Answer

XA and YA has same stoichiometry **(05)**

$[X^+(aq)] = [Y^+(aq)]$ **(05)**

$K_{sp}(XA) < Ksp(YA)$ **(05)**

∴ XA precipitates first **(05)**

II. $K_{sp(XA)} = [X^+(aq)]\,[A^-(aq)]$

∴ $[X^+(aq)]$ left in the solution $= (1.80 \times 10^{-10} / 1.80 \times 10^{-6})$ mol dm^{-3} **(05)**

(at this stage $[A^-(aq)]$ is the $[A^-(aq)]$ needed to start precipitation of YA

$= 1.0 \times 10^{-4}$ mol dm^{-3} **(04 + 01)**

(or 9.9×10^{-5} mol^2 dm^{-3})

(6 *(a)* = 50 marks)

(b) (i) At the equivalence point

$HA(aq) + NaOH(aq) \longrightarrow NaA(aq) + H_2O(l)$ **(04 + 01)**

Hydrolysis reaction of NaA(aq) (or A^-(aq)

$A^-(aq) + H_2O(l) \rightleftharpoons HA(aq) + OH\text{-}(aq)$ **(04 + 01)**

$K_b = [HA(aq)]\,[OH^-(aq)] / [A^-(aq)]$ (given)

$[HA(aq)] = [OH^-(aq)]$ **(04 + 01)**

$\therefore K_b = [OH^-(aq)]^2 / [A^-(aq)]$

$[OH^-(aq)] = \{K_b\,[A^-(aq)]\}^{1/2}$

$\therefore pOH = \frac{1}{2}\,pK_b - \frac{1}{2}\log[A^-(aq)]$ **(04 + 01)**

$pK_w - pH = \frac{1}{2}\,pK_w - \frac{1}{2}\,pK_a - \frac{1}{2}\log[A^-(aq)]$ **(04 + 01)**

$\therefore pH = \frac{1}{2}\,pK_w + \frac{1}{2}\,pK_a + \frac{1}{2}\log[A^-(aq)]$

Note : The (01) mark is allocated for the physical state.

(ii) At the equivalence point, $[A\text{-}(aq)] = (1\times 10^{-3} / 2)$ mol dm^{-3} (volume is doubled)

$= 5 \times 10^{-4}$ mol dm^{-3} **(04 + 01)**

$\therefore pH = \frac{1}{2} \times 14 + \frac{1}{2} \times 4.74 + \frac{1}{2}\log[5 \times 10^{-4}]$

$= 7.69 = 7.69\ (7.69 - 7.72)$ **(05)**

Alternative Answer

$K_b = \frac{K_w}{K_a} = [OH^-(aq)]^2 / [A^-(aq)]$

$\frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = [OH^-(aq)]^2 / 5 \times 10^{-4}$

$[OH^-(aq)] = 5.24 \times 10^{-7}$ mol dm^{-3}

Therefore, pH = 7.72 **(05)**

(iii) $[Y^+(aq)] = 1.0 \times 10\text{-}3$ mol dm^{-3} **(04+01)**

$[A^-(aq)]$ needed to precipitate YA $= (1.80 \times 10^{-7} / 0.001)$ mol dm^{-3}

$= 1.80 \times 10^{-4}$ mol dm^{-3} **(04+01)**

$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$ **(04+01)**

$K_a = [H^+(aq)] [A^-(aq)] / [HA(aq)]$ **(04+01)**

$\therefore 1.80 \times 10^{-5}$ mol dm^{-3} = $\{ [H^+(aq)]\ 1.80 \times 10^{-4} / 0.001\}$

$\{(1\text{-}\alpha) \sim 1\}$ **(05)**

$[H^+(aq)] = 1.0 \times 10^{-4}$ mol dm^{-3} **(04+01)**

$\therefore$ pH = 4 **(05)**

Alternative Answer

$K_a = [H^+(aq)] [A^-(aq)] / [HA(aq)]$

$pH = pKa + \log \{[A^-(aq)] / [HA(aq)]\}$ **(04+01)**

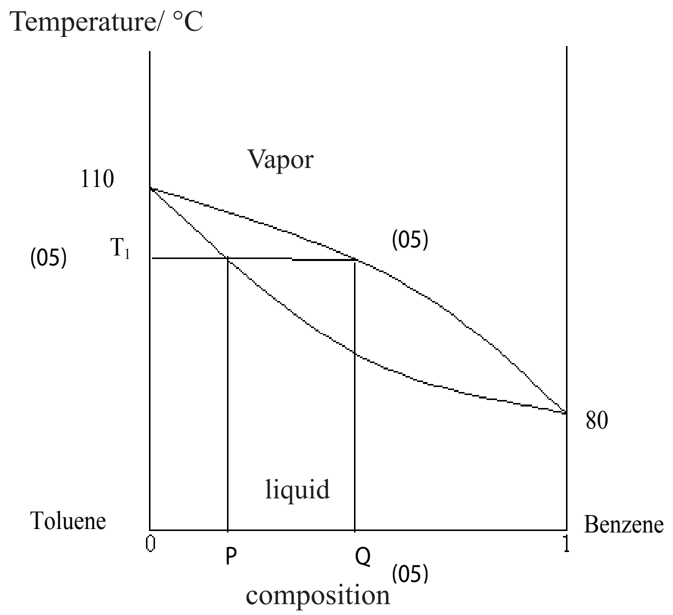
$= 4.74 + \log \{1.80 \times 10^{-4} / 0.001\}$ **(05)**

$= 4.74 - 0.74 = 4$ **(05)**

Note : The (01) mark is allocated for the physical state.

(6 *(b)* = 70 marks)

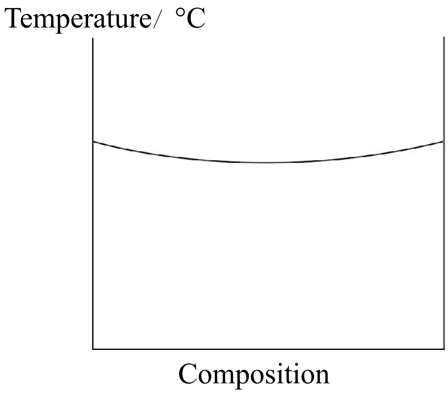
(c) (i), (ii) for parts I - II



III. Composition : vapor > liquid for benzene **(05)**

Fractional Distillation **(05)**

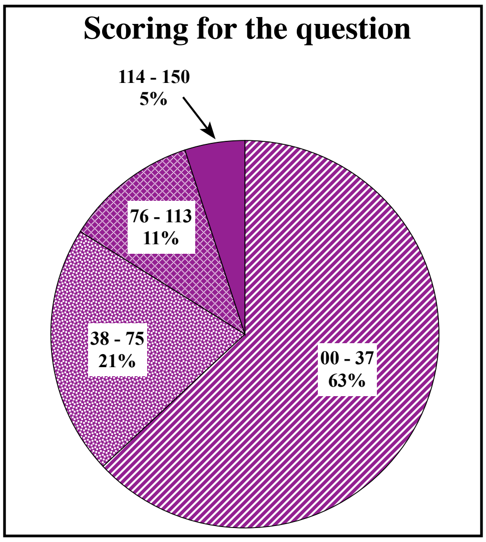
(iii)



(05)
(6 *(c)* = 30 marks)

(Total 150 marks)

Overall observations and conclusions regarding the answers to Question 6 :

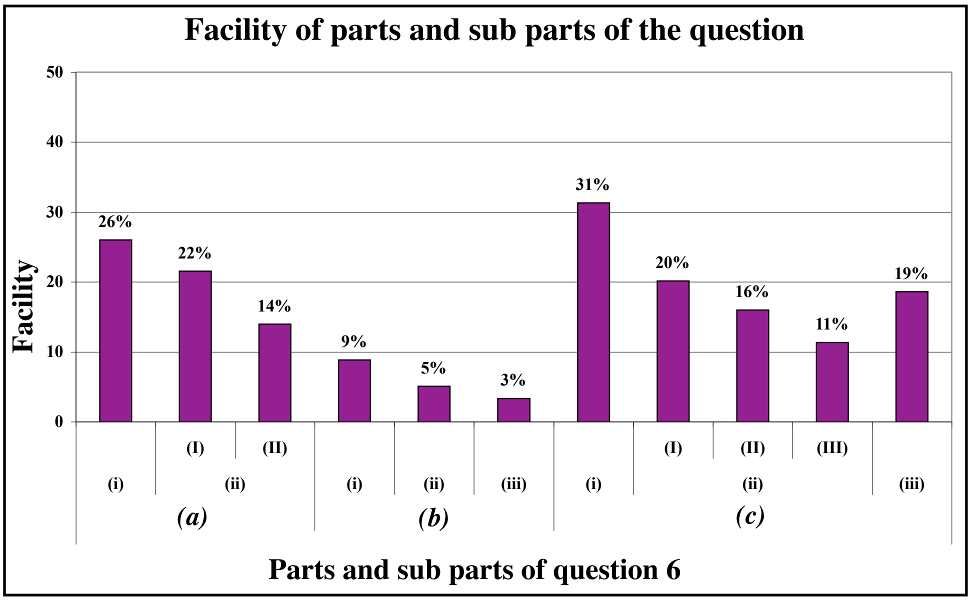


About 45% has selected question 6. The question carries 150 marks. This is the least popular question in part B.

Given below were the percentage scoring within the four class intervals.

00	-	37	-	63%
38	-	75	-	21%
76	-	113	-	11%
114	-	150	-	5%

Candidates scoring 114 or above for this question constitute 5% whereas 63% had obtained 37 or below.



★ Of the 11 sub parts included in this question, 8 sub parts register a facility less than 20%. It is minimum in sub part (b) (iii) and its facility is only 3%. Part (c) (i) has the highest facility of 31%. Overall facility of this question is 16%.

Part (a) aims to measure the ability of applying solubility product principle and common iron effect. Lack of correct understanding about the manipulation of units in solubility product calculations would be a reason for the drop of facility in 6 (a) (i) to a value as low as 26%. This would have caused a further decrease in facility in subsequent parts of 6 (a).

Of the three essay questions in part B, this is the question selected by the least percentage (45%) of candidates and is also the question showing lowest facility.

Part (b) of this question examines the ability to derive and expression to find the pH value at the equivalence point of a titration. Seemingly, students' ability of building up new relationships from given data and concept is very low. They also lack the practice of solving problems using symbols in place of numbers. Problematic situations arising when theoretical knowledge on pH is applied to an unfamiliar situation coupled with the difficulty in managing time therein would have plummeted the facility to a low level. It is very important to understand that at equivalence point, all the weak acid molecules are neutralised and converted to the salt and the salt hydrolyses and comes to a state of equilibrium.

Part (c) expects an analysis of the concepts relating to Raoult's law. Understanding about these aspects appear to be very low (this situation was observed in the past years too). Ability to understand even a simple fact and drawing temperature-composition graphs seems to have dwindled. Students have not discerned how Raoult's law is used to explain fractional distillation employed to separate components in a binary system.

Question 07

7. (*a*) Show how the conversion given below could be carried out using **only** the chemicals given in the list.

$$\underset{\text{(Benzene)}}{C_6H_6} \longrightarrow C_6H_5-\overset{\overset{\large OH}{|}}{\underset{\underset{\large C_2H_5}{|}}{C}}-C_2H_5$$

List of chemicals
$KMnO_4$, PBr_3, Mg, dry ether, CH_3Cl, C_2H_5OH, Anhydrous $AlCl_3$, conc. H_2SO_4

(5.0 *marks*)

(*b*) Show how compound **B** could be synthesized in less than 7 steps, using compound **A** as the **only** organic starting material.

$$\underset{\textbf{A}}{C_6H_5CH_2CONHC_6H_5} \qquad\qquad \underset{\textbf{B}}{C_6H_5CH_2CH{=}N-C_6H_5}$$

(7.0 *marks*)

(*c*) Methyl iodide reacts with ethylamine as shown below.

$$CH_3I \;+\; CH_3CH_2NH_2 \longrightarrow CH_3-CH_2-\overset{\overset{\large H}{|}}{N}-CH_3 \;+\; HI$$

(i) State whether ethylamine reacts as a nucleophile or an electrophile in this reaction.

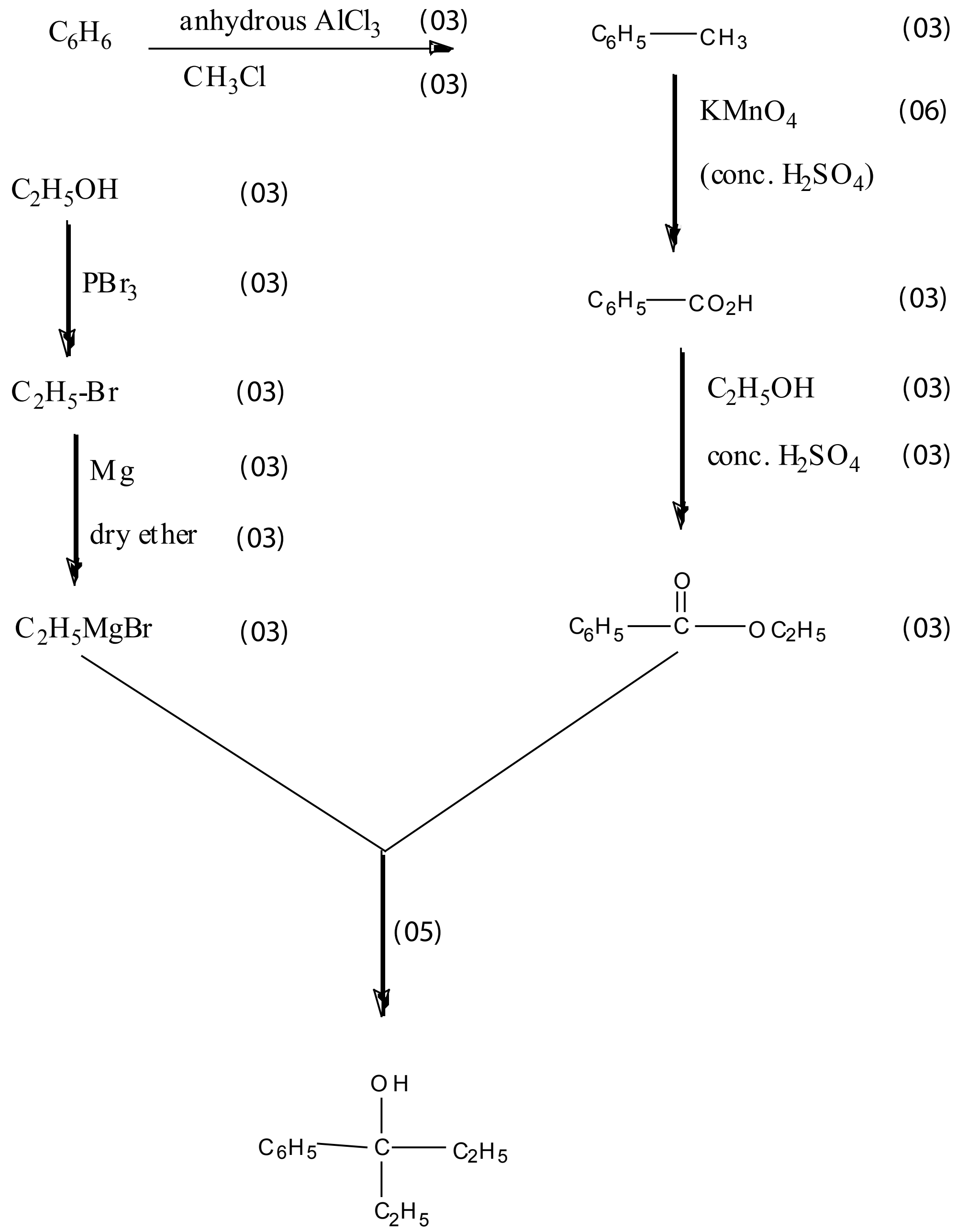
(ii) Indicate the mechanism of the reaction by the use of curved arrows.

(iii) Taking into account that amides are less basic than amines, explain why the methyl iodide **does not** react with propionamide according to the reaction given below.

$$CH_3I \;+\; CH_3CH_2CONH_2 \longrightarrow CH_3CH_2CONHCH_3 \;+\; HI$$

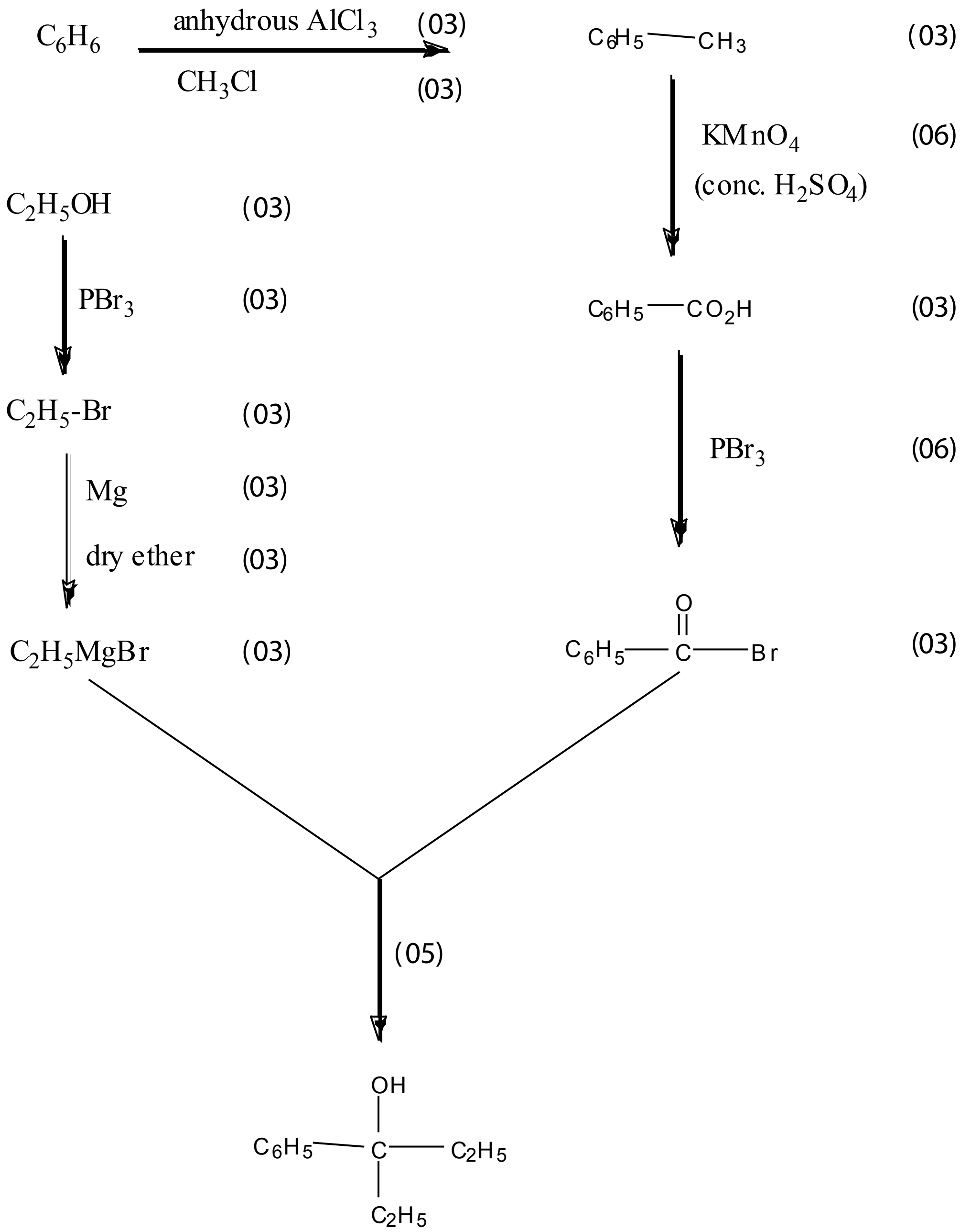
(3.0 *marks*)

7. (a)



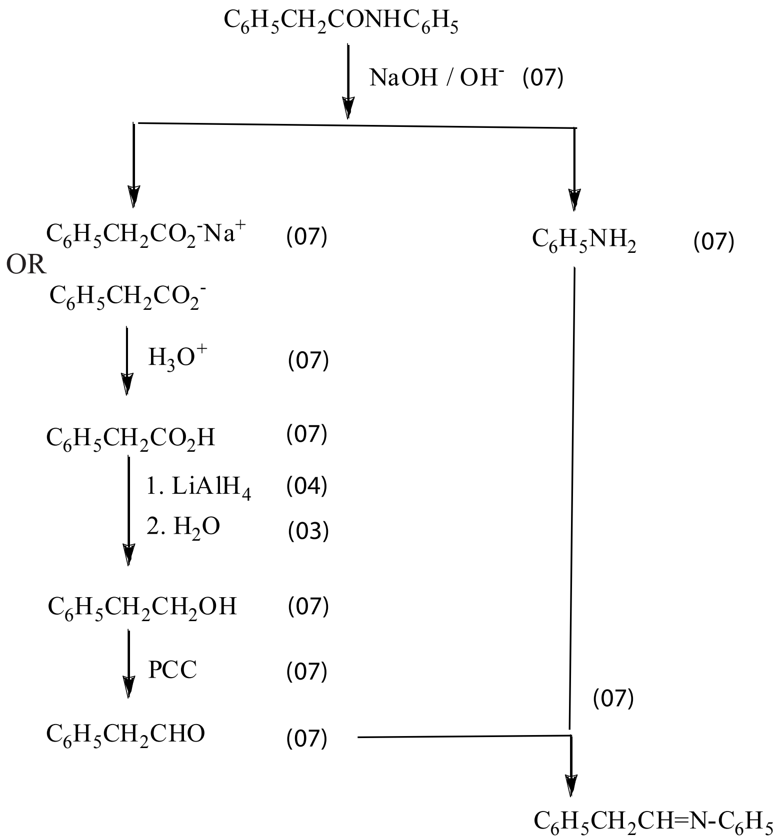
[(3×6) (48 + 02) 7 *(a)* = 50 marks)

Alternative Answer

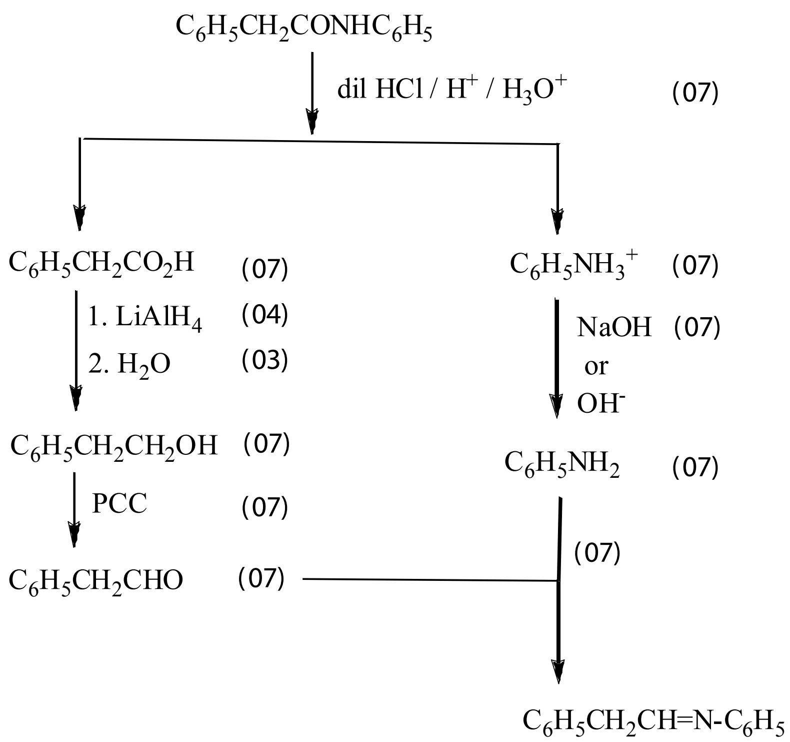


(7 *(a)* = 50 marks)

(b)



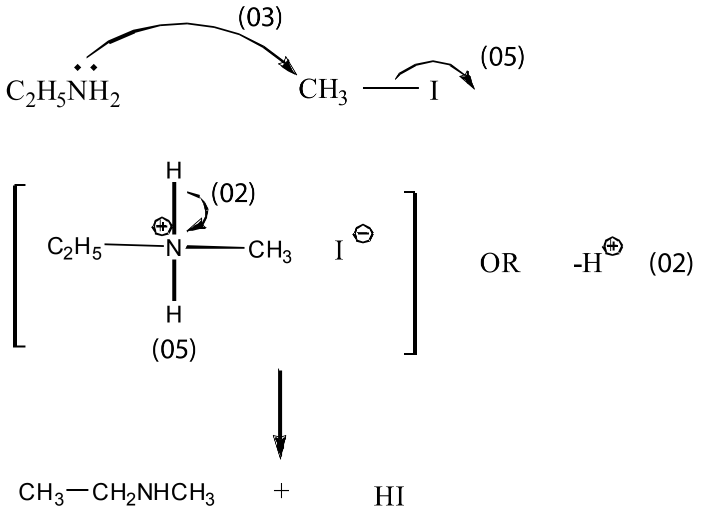
Alternative Answer



(7 *(b)* 7 × 10 = 70 marks)

(c) (i) Nucleophile **(05)**

(ii)



(20)

(iii) The loner pair on N in propionamide is not available / less available to take part in a nucleophilic reaction. **(05)**

Reason

It is delocalized on to the $>$= 0 **(05)**

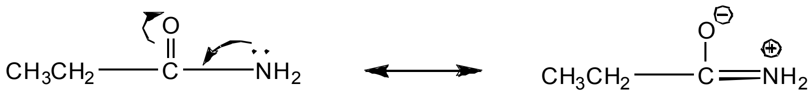
or

Lone pair on nitrogen overlaps with the C = 0 double bond/ π bond

or

Due to resonance

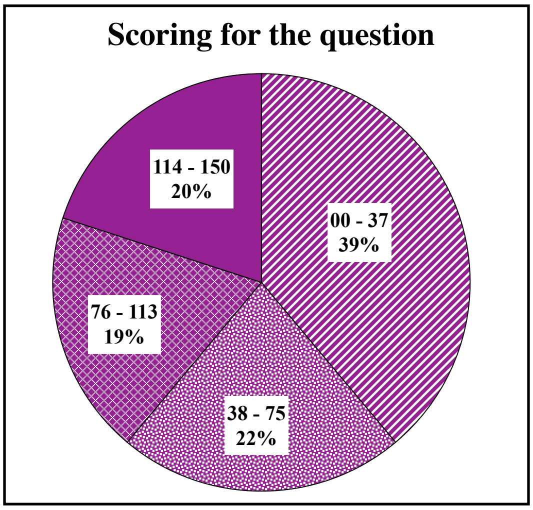
or



(7 *(c)* = 30 marks)

(Total 150 marks)

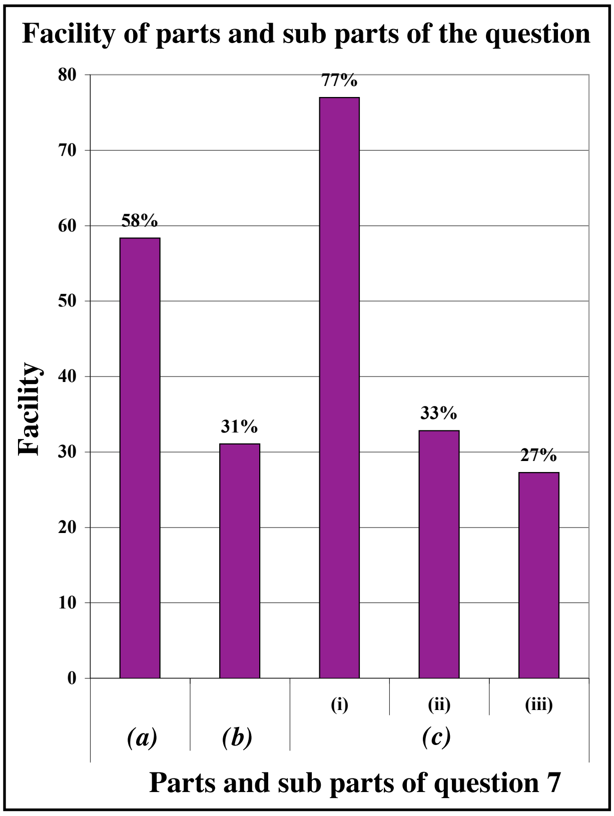
Overall observations and conclusions regarding the answers to Question 7 :



The percentage selecting question 7 is 59%. This embodies 150 marks. The percentages scoring within the four selected class intervals are as follows:

00	-	37	-	39%
38	-	75	-	22%
76	-	113	-	19%
114	-	150	-	20%

The percentage scoring above 114 for this question is 20% while 39% have rated 37 or below.



- Of the 5 sub parts of this questions, sub part (c) (iii) shows the lowest facility.

Of the five sub parts of this questions, (c) (iii) shows the lowest facility.

The percentage selecting question 7 is 59% and its facility is around 62%. Facility of part 7 (a) is 62%. In paper II this is the question with highest facility. In organic chemistry, reactions of Grignard reagent with aldehydes and ketones are frequently used. But the question becoming facile only for half of the candidates opted for it shows that they are less familiar with its reaction with acid chlorides and esters.

The facility of part 7 (b) is 31%. Chemistry of amines is studied at the end of organic chemistry section and apparently the students are less oriented towards them. This part contains both analysis and synthesis and limitation of it to given steps has made scoring difficult. Lack of sound knowledge about the products of acid and alkaline hydrolysis is also a reason for low scoring. On the whole this reflects shortness of analytical and synthetic skills.

The facility of (c) (i) sub part is relatively high (77%). Students have understood that the anime acts as a nucleophile due to the presence of a lone pair on the nitrogen atorn. The facility of sub parts 7 (c) (ii) and (iii) turns out to be 33% and 27% respectively. The questions in part (ii) are based on the mechanism of the reaction between amines and alkyl halides and the students are less capable of applying what is learnt to a new situation. As they are used to present answers mechanically, they are less skilled in giving explanations comparatively.

Question 08

PART C — ESSAY

Answer ***two*** *questions only. (Each question carries* **15** ***marks.****)*

8. (*a*) A metal **M** belongs to the *s*-block of the Periodic Table. It burns with a yellow flame in the presence of excess oxygen gas to give a solid, $\mathbf{M_1}$. On treatment with cold water $\mathbf{M_1}$ gives a clear basic solution, $\mathbf{M_2}$ and a covalent compound, $\mathbf{M_3}$. $\mathbf{M_3}$ reacts with acidified Ag_2O to give a colourless diatomic gas, $\mathbf{M_4}$. Excess of $\mathbf{M_2}$ reacts with metal **T** to give a colourless diatomic gas $\mathbf{M_5}$, and a water soluble compound, $\mathbf{M_6}$. The addition of dilute HCl dropwise to an aqueous solution of $\mathbf{M_6}$ gives a white gelatinous precipitate, $\mathbf{M_7}$ which dissolves in excess acid. $\mathbf{M_7}$ does not dissolve in dilute NH_4OH.

(i) Identify **M**, $\mathbf{M_1}$, $\mathbf{M_2}$, $\mathbf{M_3}$, $\mathbf{M_4}$, $\mathbf{M_5}$, $\mathbf{M_6}$, $\mathbf{M_7}$ and **T**.

(ii) Predict the products of the reaction of $\mathbf{M_1}$ with hot water.

(5.0 *marks*)

(*b*) A crystalline ionic inorganic compound **Q** (molar mass = 248 g mol^{-1}) when heated gently releases a substance which turns anhydrous $CuSO_4$ blue.

Three tests (1), (2) and (3) were carried out with an aqueous solution of **Q**. Tests and observations are given below.

Test	Observation
(1) Added dilute HCl.	Solution turned turbid with the evolution of a colourless gas. Burning a Mg ribbon in this gas gave two solids white and yellow in colour.
(2) Added $AgNO_3$ solution dropwise.	White precipitate. It turns black on heating.
(3) Added $Pb(NO_3)_2$ solution dropwise.	White precipitate. It turns black on heating.

(i) Identify **Q** and draw the most acceptable Lewis structure for its anion.

(ii) Write balanced chemical equations for the reactions taking place in tests (1), (2) and (3). Indicate the precipitates with an arrow (↓) in the equations.

(iii) Give **two** uses of **Q**.

(H = 1, O = 16, Na = 23, S = 32)

(5.0 *marks*)

(*c*) The following procedure was used to determine the percentage by mass of $KClO_3$ and KCl in a mixture **X**. Mixture **X** contains $KClO_3$, KCl and a water soluble inert material.

A mass of 1.100 g of **X** was dissolved in 50 cm^3 of distilled water in a 250 cm^3 volumetric flask and diluted with distilled water to give a final volume of 250.0 cm^3. (**Solution Y**).

A 25.00 cm^3 portion of this solution was treated with $SO_2(g)$ to reduce the ClO_3^- to Cl^-. The excess $SO_2(g)$ was removed by boiling the solution. Aqueous $AgNO_3$ was added to this solution to precipitate the total Cl^- as AgCl. The precipitate was then filtered, washed with distilled water, and dried at 105°C until a constant weight was obtained. The mass of the AgCl precipitate formed was 0.135 g.

Another 25.00 cm^3 portion of **Solution Y** was heated with 30.00 cm^3 of 0.20 mol dm^{-3} Fe(II) solution, in acidic medium. The volume of 0.02 mol dm^{-3} $KMnO_4$ required to oxidize the unreacted Fe(II) was 20.00 cm^3.

Fe(II) reacts with ClO_3^- as given below.

$$H^+ + ClO_3^- + Fe^{2+} \longrightarrow Cl^- + Fe^{3+} + H_2O \quad \text{(unbalanced)}$$

Calculate separately the percentage by mass of $KClO_3$ and KCl in **X**.

(O = 16, Cl = 35.5, K = 39, Ag = 108)

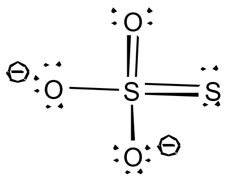
(5.0 *marks*)

8. **(a)** (i) M : Na M_1 : Na_2O_2 M_2 : NaOH
M_3 : H_2O_2 M_4 : O_2 M_5 : H_2
M_6 : $NaAlO_2$ M_7 : $Al(OH)_3$ T : Al
or $NaAl(OH)_4$ or $NaAlO_2$, 2 H_2O

Note: Mark independently **(5 × 9 = 45 marks)**

(ii) NaOH **(02)** O_2 **(03)** **(8 *(a)* = 50 marks)**

(b) (i) Q : $Na_2S_2O_3.5H_2O$ **(10)**



(04)

(ii) 1. $S_2O_3^{2-}$ + $2H^+$ → $H_2S_2O_3$ → S↓ + SO_2 + H_2O **(05)**

or

$S_2O_3^{2-}$ + $2H^+$ → S↓ + SO_2 + H_2O

or

$Na_2S_2O_3$ + 2HCl → 2NaCl + S↓ + SO_2 + H_2O

2Mg + SO_2 → 2MgO + S↓ **(05)**

(Award marks even if ↓ is not given.)

2. $Na_2S_2O_3$ + $2AgNO_3$ → $Ag_2S_2O_3$↓ + $2NaNO_3$

or

$S_2O_3^{2-}$ + $AgNO_3$ → $Ag_2S_2O_3$↓ + $2NO^{3-}$

or

$S_2O_3^{2-}$ + $2AgNO_3$ → Ag_2S + SO_3 + $2NO_3^-$

$Ag_2S_2O_3$ + H_2O → Ag_2S↓ + H_2SO_4 **(05)**

3. $Pb(NO_3)_2$ + $Na_2S_2O_3$ → PbS_2O_3 + $2NaNO_3$

or

$Pb(NO_3)_2$ + $S_2O_3^{2-}$ → PbS_2O_3↓ + $2NO^{3-}$

or

$Pb(NO_3)_2$ + $S_2O_3^{2-}$ → PbS + SO_3 + $2NO_3^-$

PbS_2O_3 + H_2O → PbS↓ + H_2SO_4 **(05)**

Note : If the precipitate is not shown with an arrow in an equation, award only (04) marks for that equation. For S, instead of the arrow, 'turbidity' can be accepted.

(iii) Used in: Iodometry / Iodimetry; Photographic processing; Preparation of colloidal sulphur; Medicine (antidote for cyanide poisoning); Gold extraction; Neutralization of bleach, chlorinated water (de-chlorinate tap water etc.) **(03 + 03)**

Note: If b(i) is incorrect, do not award marks for b(iii)

Award marks for b (iii) if $S_2O_3^{2-}$ is given for B (i) **(8 *(b)* = 50 marks)**

(c) (i) $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+}\ Mn^{2+}\ 4H_2O$

Moles of $KMnO_4$ $= \frac{0.02}{1000} \times 20$ **(02)**

Therefore, moles of Fe^{2+} remaining $= 5 \times \frac{0.02}{1000} \times 20$ **(03)**

Moles of Fe^{2+} added $= \frac{0.02}{1000} \times 30$ **(03)**

Therefore, moles of Fe^{2+} reacted with ClO_3^- $= \frac{0.02}{1000} \times 30 - \left(5 \times \frac{0.02}{1000} \times 20\right)$ **(03)**

$6Fe^{2+} + ClO_3^- + 6H^+ \rightarrow 6Fe^{3+} + Cl^- + 3H_2O$

Therefore, moles of ClO_3^- $= \dfrac{\frac{0.02}{1000} \times 30 - \left(5 \times \frac{0.02}{1000} \times 20\right)}{6}$ **(03)**

$= 0.00067$

Relative molecular mass: AgCl = 143.5, KCl = 74.5, KClO3 = 122.5 **(01 × 03)**

Moles of Cl^- in AgCl contributing from ClO_3^- = 0.00067 **(03)**

Mass of AgCl corresponding to this amount Cl^- = 0.00067 × 143.5 g

= 0.096 g **(03)**

Mass of AgCl corresponding to KCl = 0.135 – 0.096 g

= 0.039 g **(03)**

Mass of $KClO_3$ in 25.0 cm^3 = 0.00067 × 122.5 g

= 0.082 g **(03)**

Mass of $KClO_3$ in 250.0 cm^3 = 0.82 g **(03)**

Mass of KCl in 25.0 cm^3 $= \frac{0.039}{143.5} \times 74.5$ g

= 0.020 g **(03)**

Mass of KCl in 250.0 cm^3 = 0.20 g **(03)**

Mass % of $KClO_3$ $= \frac{0.82}{1.1} \times 100$

= **74.6** **(03)**

Mass % of KCl $= \frac{0.20}{1.1} \times 100$

= **18.2** **(03)**

Note : Assumption: Interference by Cl^- in the titration is neglected.

(8 *(c)* = 50 marks)

Alternative Answer

$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} \ Mn^{2+} \ 4H_2O$ **(02)**

Moles of $KMnO_4$ $= \frac{0.02}{1000} \times 20$ **(02)**

Therefore, moles of Fe^{2+} remaining $= 5 \times \frac{0.02}{1000} \times 20$ **(03)**

Moles of Fe^{2+} added $= \frac{0.02}{1000} \times 30$ **(03)**

Therefore, moles of Fe^{2+} reacted with ClO_3^- $= \left(\frac{0.02}{1000} \times 30\right) - \left(5 \times \frac{0.02}{1000} \times 20\right)$ **(03)**

$6Fe^{2+} + ClO_3^- + 6H^+ \rightarrow 6Fe^{3+} + Cl^- + 3H_2O$

Therefore, moles of ClO_3^- in sample $= \frac{\left(\frac{0.02}{1000} \times 30\right) - \left(5 \times \frac{0.02}{1000} \times 20\right)}{6}$ **(03)**

$= 0.00067$

Moles of AgCl formed from ClO_3^- (in 25.0 cm^3) $= 0.00067$ **(03)**

Relative molecular mass of AgCl $= 143.5$ **(01)**

Moles of AgCl in the precipitate $= \frac{0.135}{143.5} = 9.4 \times 10^{-4}$ **(03)**

Relative molecular mass of $KClO_3$ $= 122.5$ **(01)**

Mass of $KClO_3$ in 25.0 cm^3 $= 0.00067 \times 122.5$ g **(03)**

Mass of $KClO_3$ in 250.0 cm^3 $= 0.00067 \times 10 \times 122.5$ g **(03)**

Mass % of $KClO_3$ $= \frac{0.00067 \times 10 \times 122.5}{1.10} \times 100$

$=$ **74.6** **(03)**

Moles of KCl in AgCl precipitate (25.0 cm^3) $= \left(\frac{0.135}{143.5} - 0.00067\right)$ **(03)**

Relative molecular mass of KCl $= 74.5$ **(01)**

Mass of KCl in 25.0 cm^3 $= \left(\frac{0.135}{143.5} - 0.00067\right) \times 74.5$ g **(03)**

Mass of KCl in 250.0 cm^3 $= \left(\frac{0.135}{143.5} - 0.00067\right) \times 10 \times 74.5$ g **(03)**

= 20.0 **(03)**

Mass % of KCl $= \frac{0.20}{1.1} \times 100 =$ **18.2** **(03)**

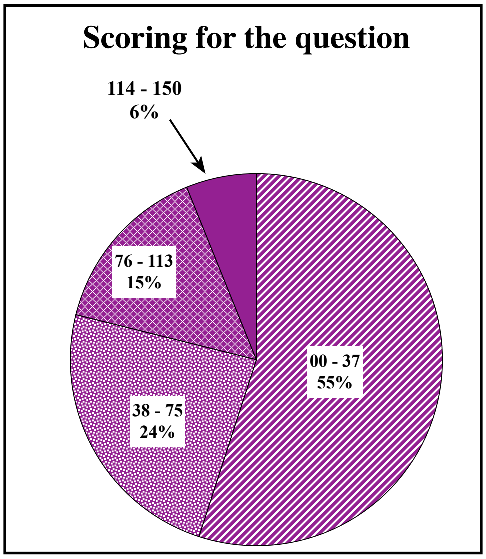
Note:

1. **Assumption: Interference by Cl^- in the titration is neglected.**
2. **Mass % KCl from 18.1 to 18.6 and Mass % $KClO_3$ from 74.2 to 74.7 can be accepted.**

(8 *(c)* = 50 marks)

(Total 150 marks)

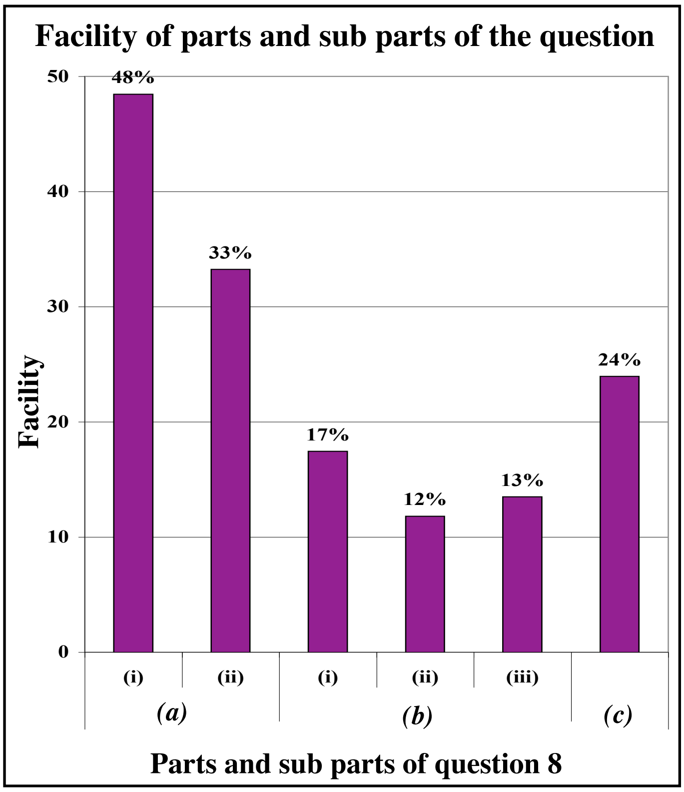
Overall observations and conclusions regarding the answers to Question 8 :



Of the questions in part C, this is the question opted by a least number of candidates. It is 45%. This question carries 150 marks. The percentages scoring within the following four intervals are:

00	-	37	-	55%
38	-	75	-	24%
76	-	113	-	15%
114	-	150	-	6%

Fifteen percent of the candidates had obtained 114 or above for this question while 52% had scored 37 or below.



- ⋆ The question has 6 sub parts. Of them, the facility of four sub parts was below 25%. The sub part of highest facility was (a) (i) and its facility was 48%. The sub part of lowest facility was (b) (ii) and its facility was 12%.

The overall facility of question 8 is about 42% and 45% of the candidates have selected this question. Part (a) is about the S block elements and their compounds. It enquires into the comprehension of students. When comparing with other sub parts, this records the highest facility.

Part (b) of minimum facility is a question based on practical experiments. Low facility relflects little exposure of students to practical activities. Hence getting students to engage in practical work and gaining correct understanding about them is emphasized.

The facility of part 8 (c) is 24%. Answers imply that the skills in writing half ionic equations for redox reactions, balancing them and working out stoichiometric calculations are at a low level. Orienting students to solve problems related to this type of reactions will help promote students' achievement level.

Question 09

9. (*a*) The following questions are based on the properties of nitric acid and the Ostwald's process used in its manufacture.

(i) State the raw materials used in this process.

(ii) Write balanced chemical equations with appropriate conditions, for the reactions taking place in this process.

(iii) Calculate the maximum amount of nitric acid that can be produced from 1000 moles of the diatomic gas present in one of the raw materials identified in (i) above.

(iv) Give **three** uses of nitric acid.

(v) Pure concentrated nitric acid is a colourless liquid. It turns yellow when exposed to light. Explain this observation with the aid of a balanced chemical equation.

(vi) Give balanced chemical equations for the following reactions.

I. $S(s) + \text{conc. } HNO_3 \xrightarrow{\Delta}$

II. $Cu(s) + \text{conc. } HNO_3 \xrightarrow{\Delta}$

III. $Cu(s) + \text{dil. } HNO_3 \xrightarrow{\Delta}$

(**7.5 *marks***)

(*b*) The following questions are based on N_2 (the major component in the earth's atmosphere) and nitrogen containing compounds which contribute to a variety of environmental problems.

(i) Special conditions are required to fix N_2 due to its inert nature. Explain why N_2 is inert.

(ii) State the **two** natural N_2 fixing processes.

(iii) State the name of the main industrial process used to fix N_2.

(iv) Identify the **two** nitrogen compounds that contribute to photochemical smog.

(v) Explain how the compounds you mentioned in (iv) above contribute to photochemical smog.

(vi) Identify **two** nitrogen containing organic compounds that contribute to photochemical smog.

(vii) Name **two** detrimental effects that photochemical smog has on the environment.

(viii) Identify the main nitrogen compound that contributes to the greenhouse effect.

(ix) Identify the **two** gaseous nitrogen compounds that contribute to acid rain.

(x) N_2 gas can be prepared in the laboratory by thermal decomposition of compounds. Give balanced chemical equations for **two** such reactions.

(**7.5 *marks***)

9. **(a)** (i) NH_3, air and water **(03 + 03 + 03)**

(ii) $$4NH_3(g) + 5O_2(\text{excess}) \xrightarrow[\substack{\text{Catalyst, Pt containing 10\% Rh (02)} \\ \text{or Pt - Rh or Pt} \\ 850 - 1250\ ^\circ\text{C (02)}}]{\text{1- 9 atm (02)}} 4NO(g) + 6H_2O(g) \text{ ----- (1)}$$ **(05)**

Mixture cooled **(01)** and temperature less than or equal to 150 °C **(01)**

$$2NO(g) + \underset{\text{(cold air) (01)}}{O_2(g)} \longrightarrow 2NO_2(g) \qquad \text{------ (2)}$$

$$4NO_2(g) + 2H_2O(l) + O_2(g) \xrightarrow[\text{(01)}]{\text{extensive cooling of gas}} 4HNO_3(l) \qquad \text{------ (3)}$$

or
$$2NO_2(g) + H_2O(l) \longrightarrow HNO_3 + HNO_2$$
$$2HNO_2 \longrightarrow H_2O + NO + NO_2$$

or
$$2NO_2(g) + H_2O(l) \longrightarrow HNO_3 + HNO_2$$
$$3HNO_2 \longrightarrow 2NO + HNO_3 + H_2O$$

Note : Physical states are not required.

(iii) (1) + (2) ×2 + (3)

$4\ NH_3(g) + 8\ O_2(g) \longrightarrow HNO_3(l) + 4H_2O(l)$ or **(05)**

$NH_3(g) + 2O_2(g) \longrightarrow HNO_3(l) + H_2O(l)$

8 moles of O_2 $\longrightarrow$ 4 moles of HNO_3 or

2 moles of O_2 $\longrightarrow$ 1 mole of HNO_3

Amount of moles of HNO_3 from 1000 moles of O_2 4/8 × 1000 = 500 mol or **(05)**

Amount of moles of HNO_3 from 1000 moles of O_2 1/2 × 1000 = 500 mol

(iv)
- ★ Synthesis of fertilizers (NH_4NO_3, KNO_3)
- ★ Synthesis of explosive substances (TNT, TNG, NH_4NO_3)
- ★ Food preservatives ($NaNO_2$, $NaNO_3$)
- ★ To make aqua regia
- ★ $AgNO_3$ preparation for use in photographic films
- ★ Plastics
- ★ Drugs
- ★ Lacquers
- ★ To clean soldering surfaces
- ★ Gun powder (KNO_3) **(03 × 03)**

(v) HNO_3 decomposes when exposed to light. **(02)**

This gives a yellow colour due to the mation of NO_2 **(02)**

$4HNO_3(l) \longrightarrow 4NO_2(g) + O_2(g) + 2H_2Og(l)$ **(03)**

(vi)

$$S + 6HNO_3 \xrightarrow{\Delta} H_2SO_4 + 6NO_2 + 2H_2O$$

$$Cu + 4HNO_3\ (conc) \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

$$3Cu + 8HNO_3\ (dil) \xrightarrow{\Delta} 3Cu(NO_3)_2 + 2NO + 4H_2O$$

$$S + 4HNO_3 \xrightarrow[\Delta]{} SO_2 + 4NO_2 + 2H_2O$$

(05 × 03)

(9 *(a)* = 75 marks)

(b) (i) N_2 has a triple bond **(03)** and therefore has a high bond dissociation energy / difficult to break. **(03)**

(ii) 1. Lightening (atmospheric fixation) **(04)**

2. Fixing of nitrogen in plants by bacteria (biological fixation) **(04)**

(iii) Haber process **(04**

(iv) NO, NO_2 **(04 + 04)**

(v) $NO_2 \xrightarrow{hv\ (01)} NO + O$ **(03)**

$O + O_2 + M \longrightarrow O_3 + M$ **(04)**

(M: external body that can absorb excess energy e.g: gas, airborne particles)

$O + H_2O \longrightarrow 2\ OH$ **(04)**

NO_2, NO, O_3, O and OH **(any three, 01 + 01 + 01)** convert airborne chemicals **(01)**

to produce various organic compounds **(01)**

(vi) PAN (peroxyacetyl nitrate), PBN (peroxybenzoyl nitrate), CH_3ONO_2 (methyl nitrate).

(any two) **(04 + 04)**

(vii) Reduces visibility, toxic to plants, effect on fabric, rubber **(02 + 02)**

(viii) N_2O **(04)**

(ix) NO, NO_2 **(04)**

(x) $NH_4NO_2(s) \longrightarrow N_2(g) + 2\ H_2O$ **(04)**

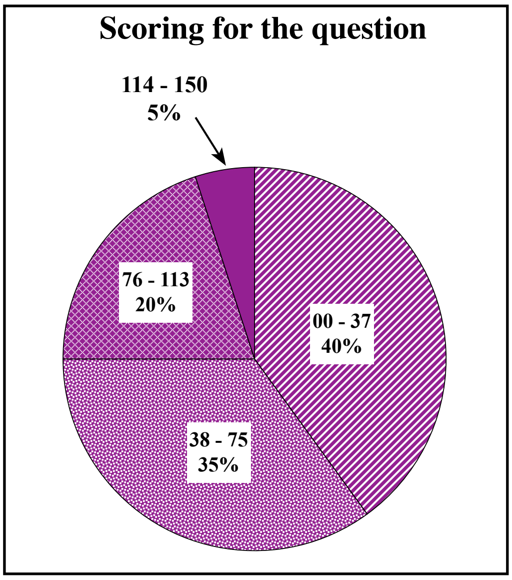
$(NH_4)_2Cr_2O_7(s) \longrightarrow N_2(g) + Cr_2O_3(s)\ .+ 4\ H_2O$ **(04)**

Note : Physical states are not required.

(9 *(b)* = 75 marks)

(Total 150 marks)

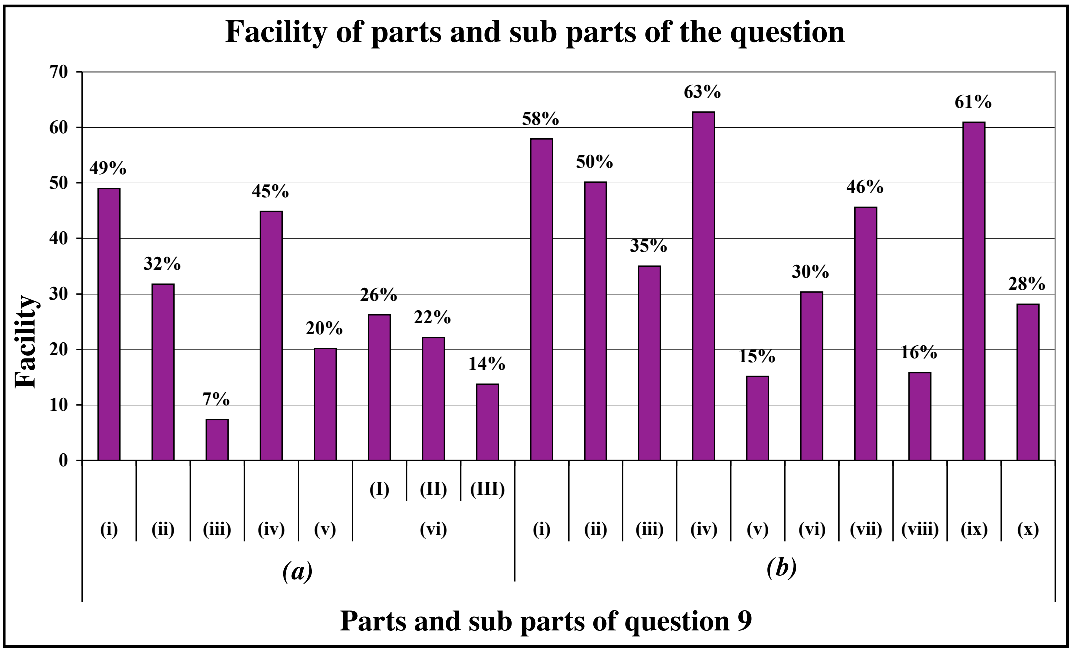
Overall observations and conclusions regarding the answers to Question 9 :



Eighty one percent of the candidates have selected question 9. Allocated marks for it is150. Of the three questions in part C, this was the question selected by most. The percentages scoring within the four class intervals concerned were as follows.

00	-	37	-	40%
38	-	75	-	35%
76	-	113	-	20%
114	-	150	-	5%

The percentage scoring 114 or above for this question was 5% whereas 40% have scored 37 or less.



⋆ This question has 18 sub parts and has a facility of about 34%. The number of sub parts in which the facility is less than 34% is 10. In this question sub part (a) (iii) is the easiest and sub part (b) (iv) is the most difficult.

Part (a) of the question is based on the production of nitric acid. Selection of this question by 80% shows the fact that even the clever students have choosen this question. To some extent, writing reactions and conditions relating to the industry is satisfactory. Though 9 (a) (iii) is a simple question relating to stoichiometry only 7% were successful in answering it. This indicates a drawback in motivating students to work out problems using stoichiometric relationships under industrial chemistry.

Though the students are able to produce answers by memorising facts they are less capable of using learnt facts analytically and solve problems.

Facility of part (b) is relatively higher than that of (a). Students seem to be comfortable in answering the questions presented under environmental chemistry. Increase in the number of parts and the shortness of the expected answers seem to have raised the students' level of performance.

Question 10

10. (*a*) **A**, **B**, **C** and **D** are coordination compounds (complex compounds) of chromium. They have an octahedral geometry. All the compounds consist of a single chromium ion, three chlorine atoms which could be either covalent and/or ionic and molecules of water. The number of molecules of water in the compounds vary. The chromium ion in all the compounds has the same oxidation state. The **complex ion part** (metal ion and ligands coordinated to it) of **A**, **B**, **C** and **D** have charges of +3, +2, +1 and zero respectively. **Note**: Disregard geometric isomers.

(i) Give the oxidation state of chromium in the coordination compounds.

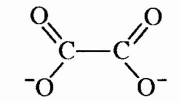
(ii) Write the electronic configuration of chromium in these compounds.

(iii) Write the structural formulae of **A**, **B**, **C** and **D**.
Note: Disregard geometric isomers.

(iv) Give the IUPAC name of **A**.

(v) Give a chemical test that could be used to distinguish between **A** and **D**.
Note: State the test as well as the observation.

(vi) Given below is the structure of the oxalate ion.



oxalate ion (ox)

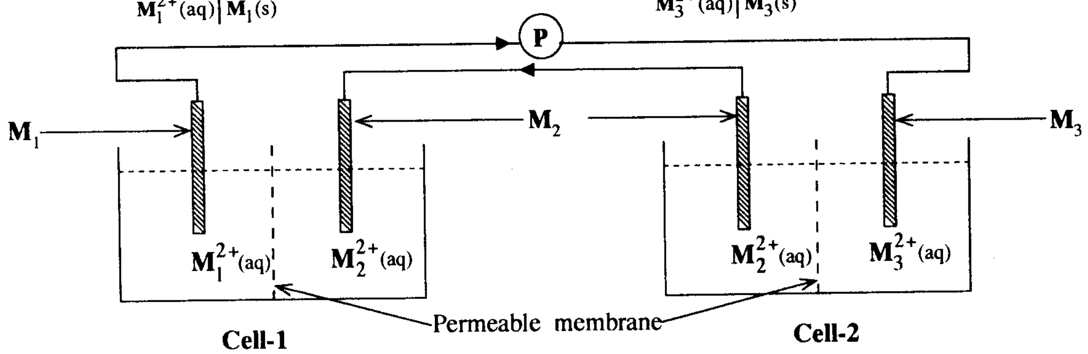
The oxalate ion coordinates the chromium ion through the two negatively charged oxygens to give a **complex ion part**, **E**, which has an octahedral geometry. Write the structural formula of **E**. (The chromium ion in **E** has the same oxidation state as the chromium in compounds **A** - **D**.)

Note: Use the abbreviation 'ox' to denote the oxalate ion in your structural formula.

(7.5 marks)

(*b*) The diagram given below shows two electrochemical cells connected in series at 25 °C. $\mathbf{M_1}$, $\mathbf{M_2}$ and $\mathbf{M_3}$ metals are dipped in aqueous solutions of their own ions $\mathbf{M_1^{2+}}$(aq), $\mathbf{M_2^{2+}}$(aq) and $\mathbf{M_3^{2+}}$(aq), respectively. The concentrations of all solutions are 1.0 mol dm^{-3}. The standard electrode potentials for the metals $\mathbf{M_1}$ and $\mathbf{M_3}$ are given below.

$E^{\circ}_{M_1^{2+}(aq)|M_1(s)} = -2.36\ \text{V}$ $\qquad$ $E^{\circ}_{M_3^{2+}(aq)|M_3(s)} = +0.34\ \text{V}$



[Arrows (→ and ←) show the direction of electron flow]

(i) Giving reasons, identify the anode and the cathode of each cell.

(ii) Write the reactions taking place at the anode and the cathode in each cell.

(iii) Calculate the reading of the digital voltmeter, **P**.

(iv) The electromotive force of **cell–1** $\left(E^{\circ}_{\text{cell-1}}\right)$ was found to be +1.60 V. Calculate the standard electrod potential $\left(E^{\circ}_{M_2^{2+}(aq)|M_2(s)}\right)$ of the $\mathbf{M_2^{2+}}(aq)/\mathbf{M_2}(s)$ electrode.

(v) Calculate the electromotive force of **cell–2** $\left(E^{\circ}_{\text{cell-2}}\right)$.

(vi) If you are provided only a metal $\mathbf{M_4}$ and a solution of $\mathbf{M_4^{2+}}$ (aq, 1.0 mol dm^{-3}) in addition to th above set up, suggest an experimental method in brief to determine the value of $E^{\circ}_{M_4^{2+}(aq)|M_4(s)}$

(7.5 mark

10. (a) (i) +3 or + lll / Cr^{3+} **(05)**

(ii) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$ **(05)**

(iii)

A	$[Cr(H_2O)_6]Cl_3$	or	$[Cr(H_2O)_6]^{3+}3Cl^-$		**(05)**
B	$[CrCl(H_2O)_5]Cl_2$	or	$[Cr(H_2O)_5Cl]Cl_2$	or	**(05)**
	$[CrCl(H_2O)_5]^{2+}2Cl^-$	or	$[Cr(H_2O)_5Cl_2]^{2+}2Cl^-$		
C	$[CrCl_2(H_2O)_4]Cl$	or	$[Cr(H_2O)_4Cl_2]Cl$	or	**(05)**
	$[CrCl_2(H_2O)_4]^+Cl^-$	or	$[Cr(H_2O)_4Cl_2]^+Cl^-$		
D	$[CrCl_3(H_2O)_3]$	or	$[Cr(H_2O)_3Cl_3]$		**(05)**

Note: Correct structures showing octahedral arrangement with bonds are accepted.

(iv) hexaaquachromium(III) chloride **(Note: Correct spelling is required.)** **(05)**

(v) Test : Add $AgNO_3$ solution or $Pb(NO_3)_2$ solution **(05)**

Observation : A gives a white precipitate (of AgCl/ $PbCl_2$)
D does not give a precipitate **(05)**

or **Only A** gives a white precipitate

or Test : Chromyl chloride test **(05)**

Observation : A - deep red vapour is evolved. **(05)**
D - no deep red vapour **(05)**

(vi) $[Cr(ox)_3]^{3-}$ / $[Cr(ox)_2(H_2O)_3]^-$ / $[Cr(ox)(H_2O)_4]^+$ **(05)**

Note : Award only (05) marks for $[Cr(C_2O_4)_3]^{3-}$

(10 *(a)* = 75 marks)

(b) (i) $E^{o}_{M_1^{2+}(aq)/M_1(s)}$, is more negative than $E^{o}_{M_3^{2+}(aq)/M_3(s)}$. **(08)**

or

since $E^{o}_{M_1^{2+}(aq)/M_1(s)} < E^{o}_{M_3^{2+}(aq)/M_3(s)}$

Therefore, oxidation at $\mathbf{M_1}$ and reduction at $\mathbf{M_3}$ **(02)**

Oxidation at anode and reduction at cathode **(02)**

or

Electrons are given out from $\mathbf{M_1}$ (oxidation).Therefore, $\mathbf{M_1}$ is the anode **(04)**

Electrons are taken up by $\mathbf{M_3}$ (reduction). Therefore, $\mathbf{M_3}$ is the cathode **(04)**

Therefore in **Cell - 1**, Anode $\mathbf{M_1}$, Cathode $\mathbf{M_2}$ **(02)**

Cell - 2, Anode $\mathbf{M_2}$, Cathode $\mathbf{M_3}$ **(02)**

(ii) **Cell - 1**

Anode $M_1(s) \rightarrow M_1^{2+}(aq) + 2e$ **(04)**

Cathode $M_2^{2+}(aq) + 2e \rightarrow M_2(s)$ **(04)**

Cell - 2

Anode $M_2(s) \rightarrow M_2^{2+}(aq) + 2e$ **(04)**

Cathode $M_3^{2+}(aq) + 2e \rightarrow M_3(s)$ **(04)**

(iii) $P = E^{o}_{M_3^{2+}(aq)/M_3(s)} - E^{o}_{M_1^{2+}(aq)/M_1(s)}$ or $P = E^{o}_{cathode} - E^{0}_{anode}$ **(04)**

$= 0.34 - (-2.36)\ V$ **(04)**

$= 2.7\ V$ **(01 + 01)**

or

$P = E_{cell-1} + E_{cell-2}$ **(04)**

$= E^{o}_{M_2^{2+}(aq)/M_2(s)} - E^{o}_{M_1^{2+}(aq)/M_1(s)} + E^{o}_{M_3^{2+}(aq)/M_3(s)} - E^{o}_{M_2^{2+}(aq)/M_2(s)}$

$= E^{o}_{M_2^{2+}(aq)/M_2(s)} - (-2.36) + (+0.34) - E^{o}_{M_2^{2+}(aq)/M_2(s)}$ **(04)**

$= 2.7\ V$ **(01 + 01)**

(Deduct 04 marks if physical states are not given.)

(iv) $E^{o}_{cell-1} = E^{o}_{M_2^{2+}(aq)/M_2(s)} - E^{o}_{M_1^{2+}(aq)/M_1(s)}$ or

$E^{o}_{cell-1} = E^{o}_{cathode} - E^{0}_{anode}$ **(04)**

$1.6 = E^{o}_{M_2^{2+}(aq)/M_2(s)} - (-2.36)$ **(04)**

$E^{o}_{M_2^{2+}(aq)/M_2(s)} = -0.76\,V$ **(03 + 01)**

(v) $E^{o}_{cell-2} = E^{o}_{M_3^{2+}(aq)/M_3(s)} - E^{o}_{M_2^{2+}(aq)/M_2(s)}$ or **(04)**

$E^{o}_{cell-2} = E^{o}_{cathode} - E^{0}_{anode}$

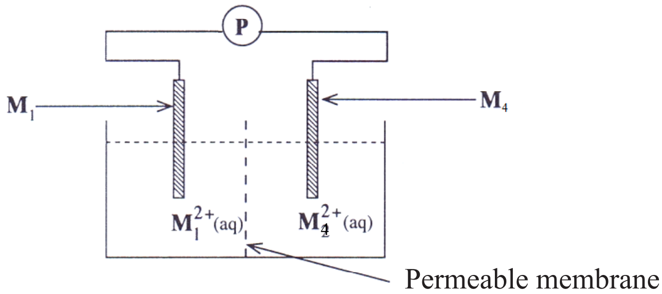
$= 0.34 - (-0.76)\ V$ **(04)**

$= 1.1\ V$ **(01 + 01)**

(vi) Construct a cell as given below OR refer to the cell given in the question with the necessary changes

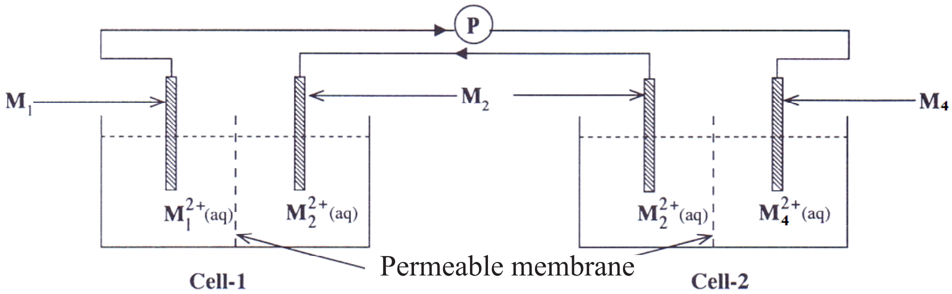
Either diagram OR cell notation in either direction and measure P **(04)**

$M_4(s)/M_4^{2+}(aq)//M_1^{2+}(aq)/M_1(s)$ OR



similarly M_1 or M_2 can be replaced with M_4

(cell can be drawn with salt bridge instead of permeable membrane)



[P = Digital voltmeter recording (assuming a positive reading)]

$P = E^{o}_{M_4^{2+}(aq)/M_4(s)} - E^{o}_{M_1^{2+}(aq)/M_1(s)}$ **(04)**

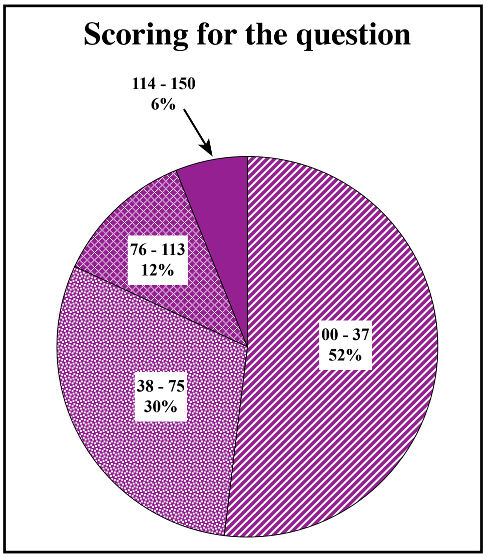
$E^{o}_{M_1^{2+}(aq)/M_1(s)}$ is known **(04)**

$E^{o}_{M_4^{2+}(aq)/M_4(s)}$ can be obtained. **(03)**

Note : Instead of M_1, M_2 or M_3 can be used. **(10 *(b)* = 75 marks)**

(Total 150 marks)

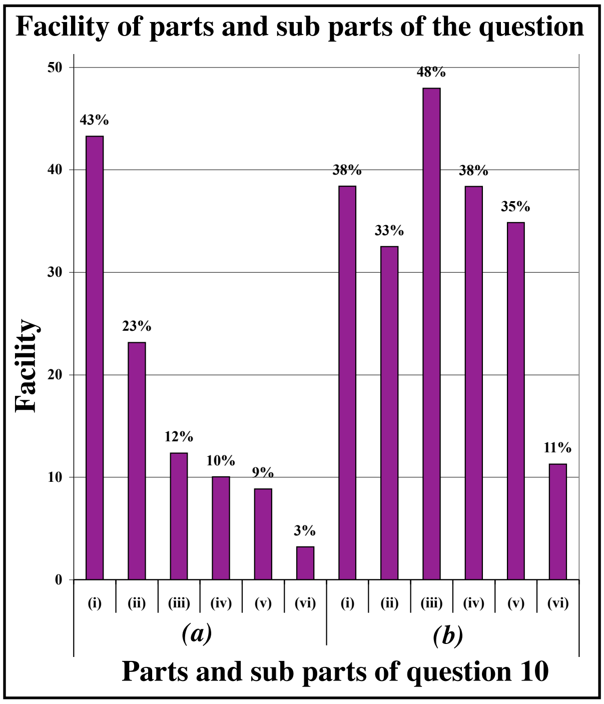
Overall observations and conclusions regarding the answers to Question 10 :



The percentage selecting question 10 is about 59%. The question carried 150 marks. The percentages scoring within the four class intervals are as follows.

00	-	37	-	52%
38	-	75	-	30%
76	-	113	-	12%
114	-	150	-	6%

The percentage scoring 114 or above for this question is 6% while 52% have scored 37 or below.

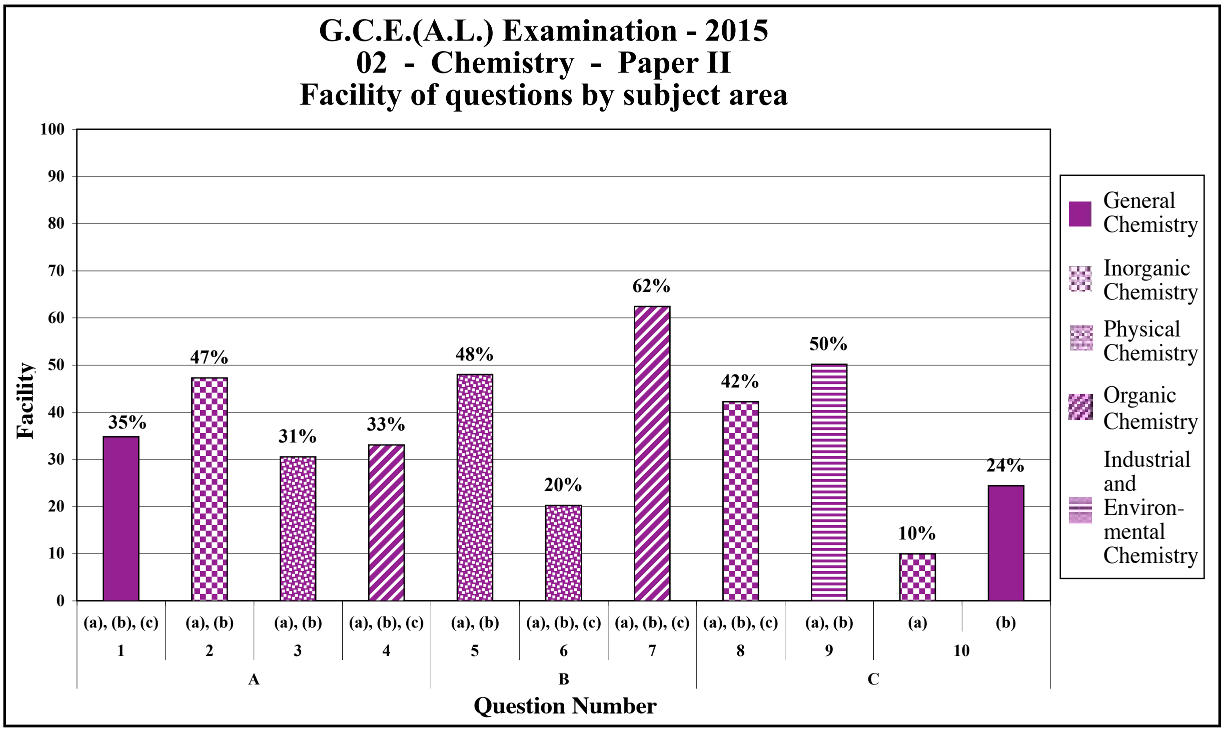


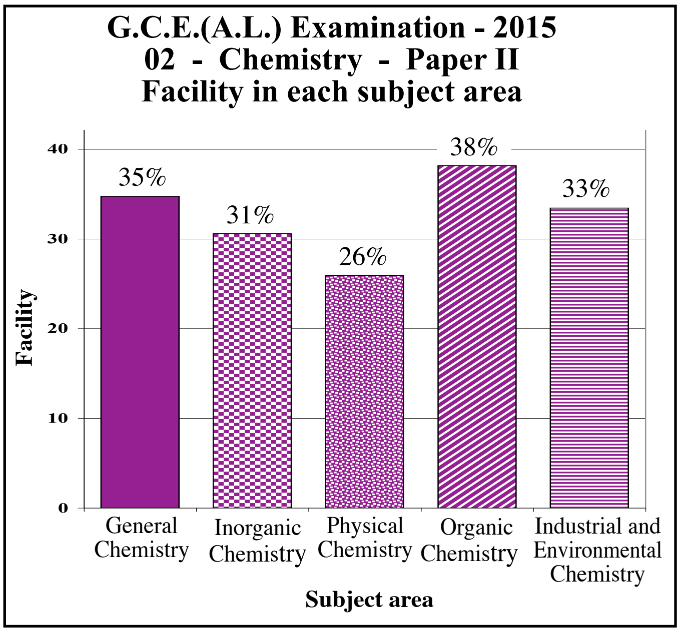
★ Question 10 consists of 12 sub parts. Its overall facility is 75%. The number of sub parts having a facility less than this is 6. In this question the least facile part is (a) (iv) and its facility is 3%. The most facile part is (b) (iii) and its facility is 48%.

Sub part (a) of this question is connected with the complexes formed by the d block elements. The low facility (23%) of sub part (a) (ii) witnesses a decrease in the ability of presenting the electronic configuration of an ion formed by a d block element. As the ability of writing the formulae of complexes (facility 12%) and their IUPAC names (facility 10%) seem to have dropped these areas need to be remedied through exercises. The facility of (a) (v) being at 9% signals the lack of proper understanding about how a coordinated complex exists. Minimum facility of (a) (vi) which is only 3% shows the poor ability of applying what is learnt.

Facility of 10 (b) is greater than the overall facility of the question. That means, students have the ability to solve problems using their knowledge about the electrochemical cells they learn under electrochemistry. However, in sub part (b) (vi) in which the students are expected to apply creatively what they have learnt, the facility has shrunk to 11%.

2.2.4 Overall observations, conclusions and suggestions regarding the answers to Paper II





The facility of different subject areas of the G.C.E.(A.L.) Chemistry Paper (II) are as follows.

General Chemistry	35%
Inorganic Chemistry	31%
Physical Chemistry	26%
Organic Chemistry	38%
Industrial and Environmental Chemistry	33%

The overall facility of chemistry paper II is about 33%. Facility of the physical chemistry section of this paper is 26%. This is the area which shows the lowest facility in paper II.

In previous years maximum facility could be observed in the inorganic section, but this year it has shifted to the area of organic chemistry. Its facility is 38% as against the facility of 31% in inorganic chemistry. Accordingly it is understandable that the question in the area of inorganic chemistry has become difficult for students compared to previous years.

The essay questions 5 and 6 in part B of question paper II examines the knowledge in physical chemistry. Of these a greater preference is noticeable for question 5 (energetics, gaseous state and equilibria) and the answers are average in quality. Less preference is shown for question 6 (ionic equilibrium, phase equilibrium) and the answers too are far from being satisfactory. Therefore it is important to draw the attention to ionic equilibrium and solving of problem related to it.

Part III

3 Facts to be considered when answering questions and suggestions :

3.1. Facts to be considered when answering :

Common instructions :

* The candidates should read and understand well the basic instructions given in the question paper. They should be considerate as to the facts such as how many questions be answered in each section, which questions are compulsory, what time is affordable and how much marks are allocated. They should also read the questions carefully and select the questions with a clear mind set.

* When responding to the questions in Paper I, one option which is the most correct needs to be selected. Also, one cross must be placed clearly.

* When answering questions in Paper II, every new question should be started in a new page.

* Answers should be written in clear and correct handwriting.

* The candidate's` index number should be written on every page in the relevant box.

* Numbers of questions, parts and sub parts should be indicated correctly.

* Long descriptions shouldn't be given when short specific answers are expected. Similarly short answers should be avoided in places where descriptive answers are preferred.

* According to the way the question is posed, facts should be presented logically and analytically.

* When answering paper II, all the sub parts given under the main question should be read carefully and only the target answer relevant to each sub part should be presented.

* Care should be taken to manage time properly when answering questions.

* Candidates shouldn't use red and green pens to write answers.

* When the bell starts ringing indicating that the time set apart for writing is about to be over, all the answer scripts should be arranged and tied up properly.

* In order to manage time more effectively, it is better to answer the easier questions first and then more difficult ones rather than answering them in the given sequence.

Special instructions :

* In case the chemical equations need to be written for reactions, they must always be balanced. The physical states of the reactions should always be indicated when required.
* Every instance the physical quantities are stated, relevant units should always be given along with their numerical value.
* When drawing Lewis structures and cononical structures, lone pairs and the charge should be indicated correctly.
* As regards chemical calculations, more exercises should be done to promote the ability of solving problems using the skills related to analysis and synthesis.

3.2. Comments and suggestions about the teaching learning process :

- As the ability answering questions related to practical activities is generally low, students should be engaged in practical activities during the learning teaching process.
- Students are not required to by heart all the concepts in chemistry but they should be oriented to solve problems applying them correctly at relevant instances.
- Since a large number of compounds are studied under organic chemistry more attention should be paid for the preparation of short notes creatively and work out suitable exercises.
- When writing mechanisms for organic reactions students need to practice the correct method along with correct usage of symbols.
- When explaining concepts in chemistry, suitable learning teaching methods and equipment should be used to facilities understanding.
- In every possible instance of the learning teaching process, the concepts need to be related to the day to day living in a practical perspective.
- A greater attention of students should be drawn to the sections newly introduced to the syllabus.
- Exercises should be done following the common method of solving problems correctly. First the problem should be studied and the shortest route to be taken to get the correct answer should be stressed.
- Since the achievement level of the last units of the syllabus is relatively low, the learning teaching process should be geared to draw more attention towards them.