G.C.E.(A.L.) Examination - 2012

Evaluation Report

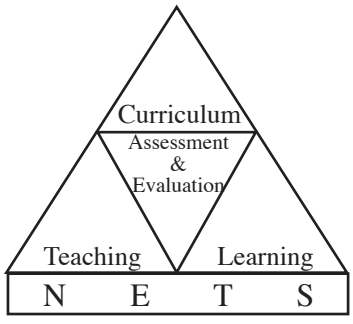
02 - Chemistry

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

G.C.E.(A.L.) Examination - 2012

Evaluation Report

02 - Chemistry



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

Chemistry
Evaluation Report - G.C.E.(A.L.) Examination - 2012

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 2012, 196954 school candidates and 10954 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 2012 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

1st December 2013
Research & Development Branch
National Evaluation & Testing Service
Department of Examinations.
Pelawatta, Battaramulla.

Guidance	:	W.M.N.J. Pushpakumara Commissioner General of Examinations
Direction and Organization	:	Gayathri Abeygunasekera Commissioner of Examinations (Research and Development
Co-ordination	:	Manomi Senevirathne Assistant Commissioner of Examinations
Editing	:	Prof. Samitha Deraniyagala Department of Chemistry University of Sri Jayawardenapura
		Prof. A.M. Abeysekera Department of Chemistry University of Sri Jayawardenapura
		Prof. Namal Priyantha Department of Chemistry University of Peradeniya
		Prof. Ramani Wijesekara Department of Chemistry University of Colombo
		Manomi Senevirathne Assistant of Commissioner of Examinations
Panel of Writers	:	S.A.S. Padmasiri Sri Lanka Teachers' Service Rathnawali Balika vidyalaya Gampaha
		S.L.A.P. Samarathunga Sri Lanka Teachers' Service Yasodara Balika Vidyalaya Colombo
		J.K.P.M. Jayakody Sri Lanka Teachers' Service Bandaranayaka Vidyalaya Veyangoda
		R.A.B. Ranathunga Sri Lanka Teachers' Service Devi Balika Vidyalaya Colombo
Translation	:	M.A.P. Munasinghe Former Chief Project Officer National Institute of Education
Computer Type Setting	:	Anusha Maduwanthi Dissanayake ICT Assistant

Contents

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	43774	706	44480
Tamil	6450	156	6606
English	2984	147	3131
Total	**53208**	**1009**	**54217**

Table 1

1.2.2 Grades obtained by the candidates

Grade	School Candidates		Private Candidates		Total	Percentage
	Number	Percentage	Number	Percentage		
A	1695	3.19	14	1.39	1709	3.15
B	3641	6.84	39	3.87	3680	6.79
C	10208	19.19	108	10.70	10316	19.03
S	17492	32.87	245	24.28	17737	32.71
F	20172	37.91	603	59.76	20775	38.32
Total	**53208**	**100.00**	**1009**	**100.00**	**54217**	**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	5366	275	5.12	429	7.99	1205	22.46	1707	31.81	3616	67.39	1750	32.61
2. Gampaha	2922	83	2.84	148	5.07	443	15.16	923	31.59	1597	54.65	1325	45.35
3. Kalutara	1859	25	1.34	72	3.87	226	12.16	563	30.29	886	47.66	973	52.34
4. Kandy	2312	74	3.20	142	6.14	394	17.04	697	30.15	1307	56.53	1005	43.47
5. Matale	526	4	0.76	13	2.47	64	12.17	168	31.94	249	47.34	277	52.66
6. Nuwara Eliya	663	4	0.60	10	1.51	78	11.76	224	33.79	316	47.66	347	52.34
7. Galle	2070	64	3.09	102	4.93	300	14.49	644	31.11	1110	53.62	960	46.38
8. Matara	1774	73	4.11	101	5.69	262	14.77	541	30.50	977	55.07	797	44.93
9. Hambantota	1149	33	2.87	38	3.31	161	14.01	392	34.12	624	54.31	525	45.69
10. Jaffna	1142	52	4.55	95	8.32	201	17.60	316	27.67	664	58.14	478	41.86
11. Kilinochchi	84	3	3.57	1	1.19	15	17.86	17	20.24	36	42.86	48	57.14
12. Mannar	123	1	0.81	2	1.63	11	8.94	35	28.46	49	39.84	74	60.16
13. Vavuniya	175	9	5.14	6	3.43	31	17.71	54	30.86	100	57.14	75	42.86
14. Mullativu	89	0	0.00	3	3.37	12	13.48	26	29.21	41	46.07	48	53.93
15. Batticaloa	508	14	2.76	34	6.69	102	20.08	171	33.66	321	63.19	187	36.81
16. Ampara	892	14	1.57	32	3.59	128	14.35	348	39.01	522	58.52	370	41.48
17. Trincomalee	333	4	1.20	18	5.41	53	15.92	101	30.33	176	52.85	157	47.15
18. Kurunegala	2397	45	1.88	74	3.09	317	13.22	747	31.16	1183	49.35	1214	50.65
19. Puttalam	740	12	1.62	29	3.92	137	18.51	222	30.00	400	54.05	340	45.95
20. Anuradhapura	1000	9	0.90	29	2.90	105	10.50	288	28.80	431	43.10	569	56.90
21. Polonnaruwa	406	1	0.25	16	3.94	44	10.84	108	26.60	169	41.63	237	58.37
22. Badulla	1050	34	3.24	43	4.10	197	18.76	342	32.57	616	58.67	434	41.33
23. Monaragala	389	1	0.26	15	3.86	57	14.65	121	31.11	194	49.87	195	50.13
24. Ratnapura	1548	25	1.61	71	4.59	198	12.79	444	28.68	738	47.67	810	52.33
25. Kegalle	1316	7	0.53	40	3.04	162	12.31	469	35.64	678	51.52	638	48.48
All Island	**30833**	**866**	**2.81**	**1563**	**5.07**	**4903**	**15.90**	**9668**	**31.36**	**17000**	**55.14**	**13833**	**44.86**

Table 3

1.2.4 Marks obtained according to class intervals

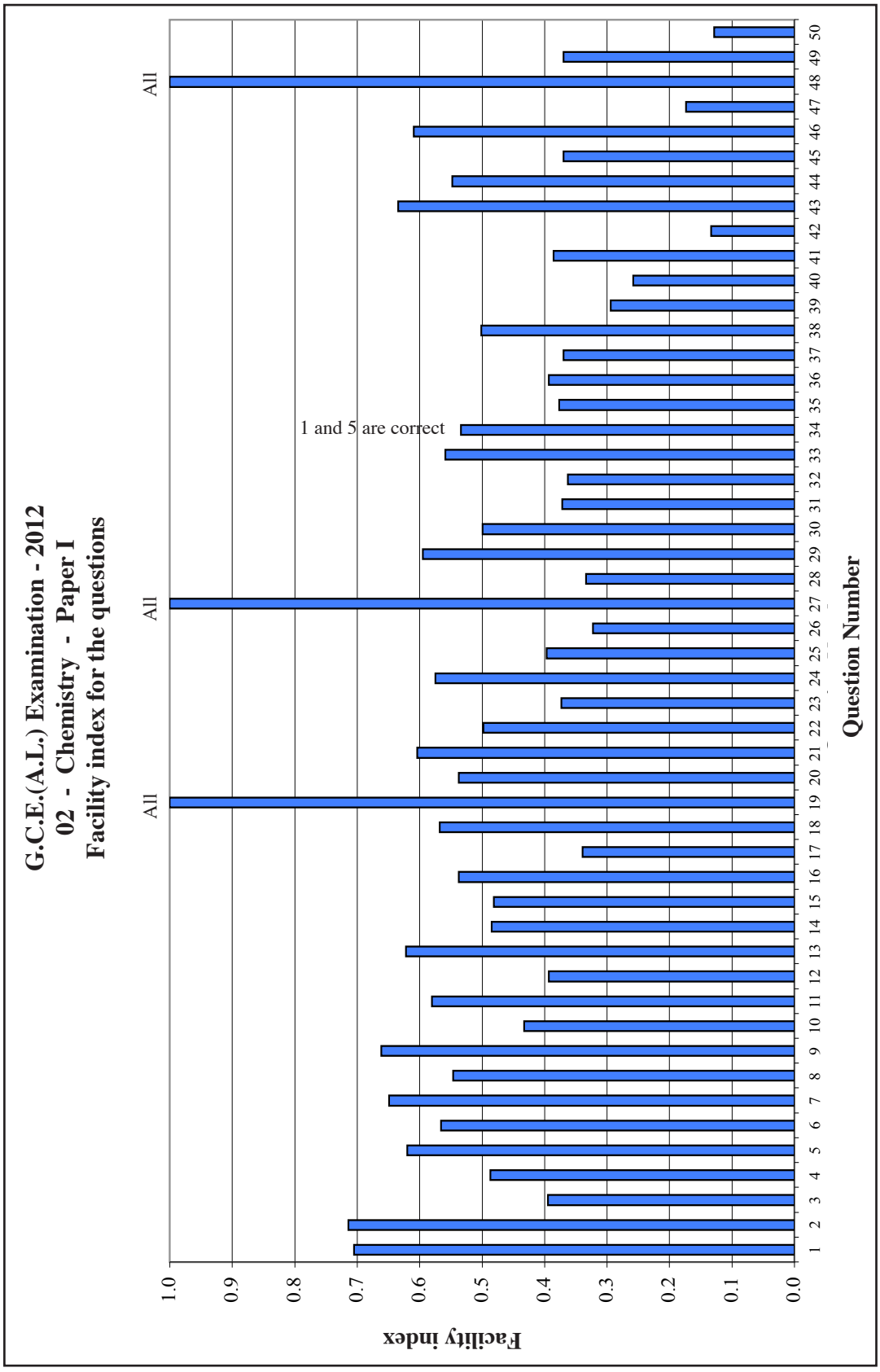
Class Interval	Frequency	Frequency Percentage	Cumulative Frequency	Cumulative Frequency Percentage
91 - 100	4	0.01	54217	100.00
81 - 90	189	0.35	54213	99.99
71 - 80	1790	3.30	54024	99.64
61 - 70	4450	8.21	52234	96.34
51 - 60	6683	12.33	47784	88.13
41 - 50	10139	18.70	41101	75.81
31 - 40	12846	23.69	30962	57.11
21 - 30	13075	24.12	18116	33.41
11 - 20	4964	9.16	5041	9.30
01 - 10	77	0.14	77	0.14
00 - 00	0	0.00	0	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 13075. As a percentage it is 24.12. The number scoring below 30 marks is 18116 and as a percentage it is 33.41.

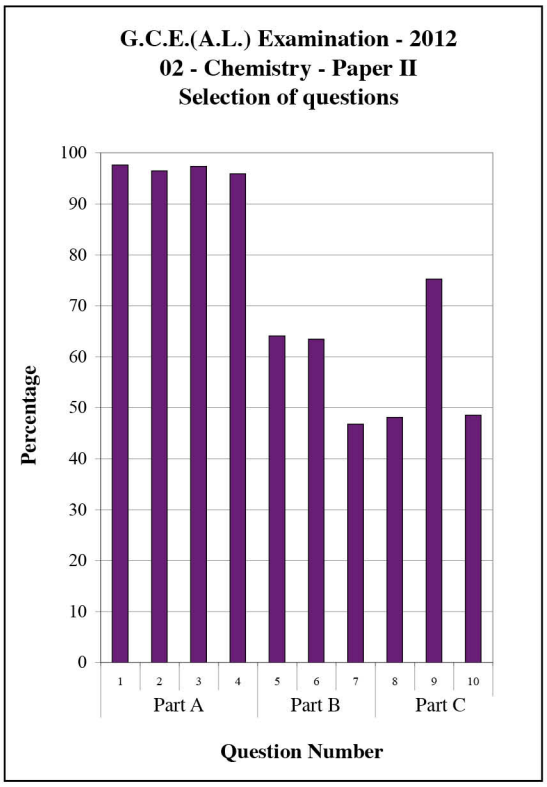
1.3 Analysis of Subject Achievement

1.3.1 Achievement in Paper I



Graph 1 (Prepared using the information collected from form RD/16/05/AL)
Retrieval of information from the above graph can be illustrated by the following example.
Ex : Highest number of candidates have correctly responded to question 2. Its percentage is 71%. Least number of candidates have correctly responded to questions are 42 and 50. Its percentage is 13%.

1.3.2 Selection of questions in paper II

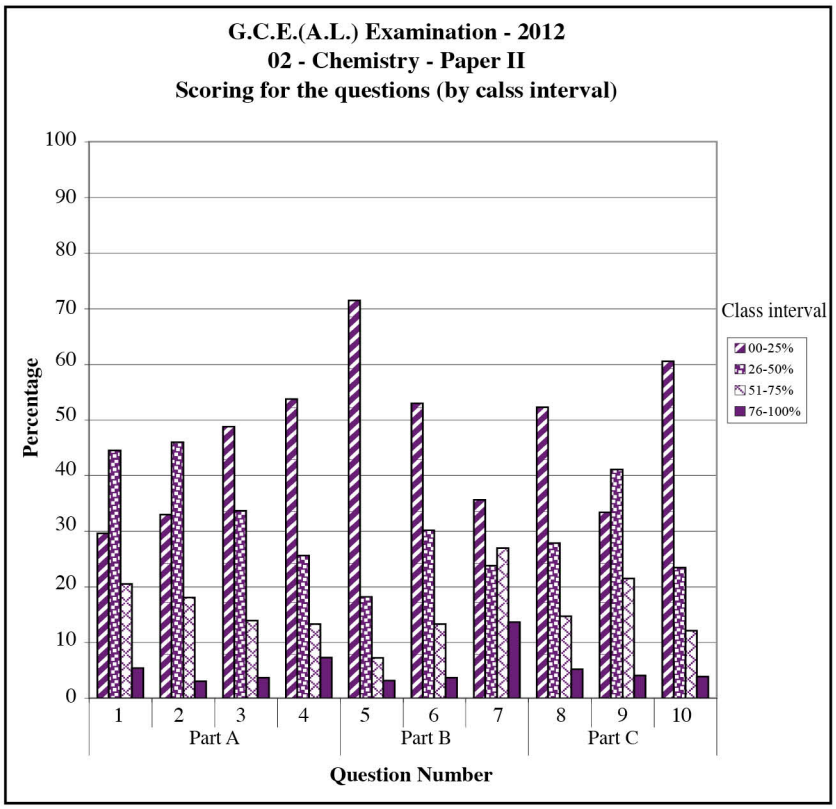


How information can be elicited from this graph is illustrated by the following example.

Ex : Though questions 1 - 4 were compulsory, a small number has not answered even the compulsory questions. Nearly 98% have answered question 1. The percentage selecting question 7 is about 46%.

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

1.3.3 Scoring for the questions in paper II

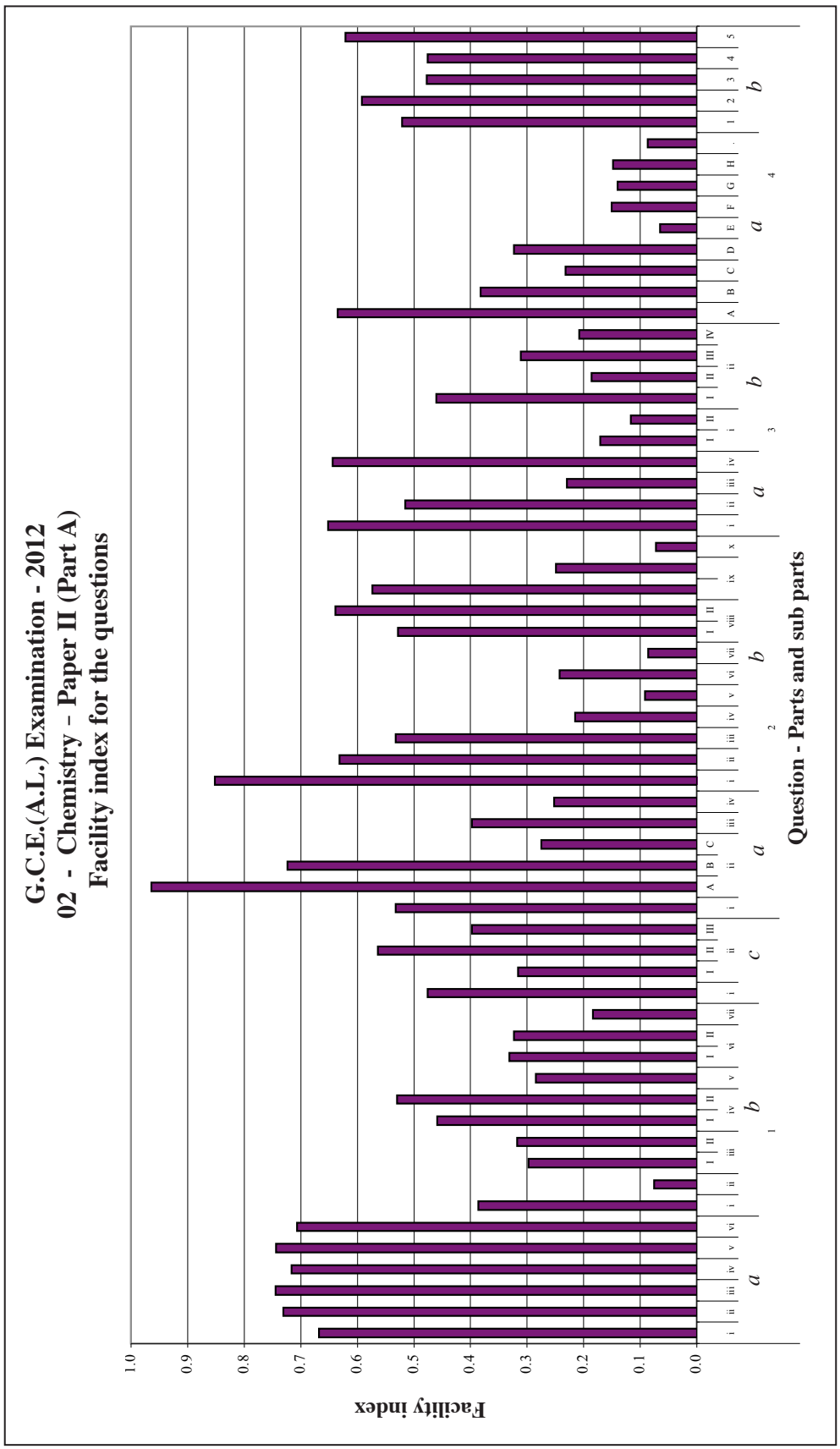


How information can be elicited from this graph is illustrated by the following example.

Ex: Marks allocated for question 1 is 100. The percentage scoring within the range of 76 - 100 is 5%. Moreover, the percentage obtaining between 00 - 25 of the 100 marks allocated is about 30%.

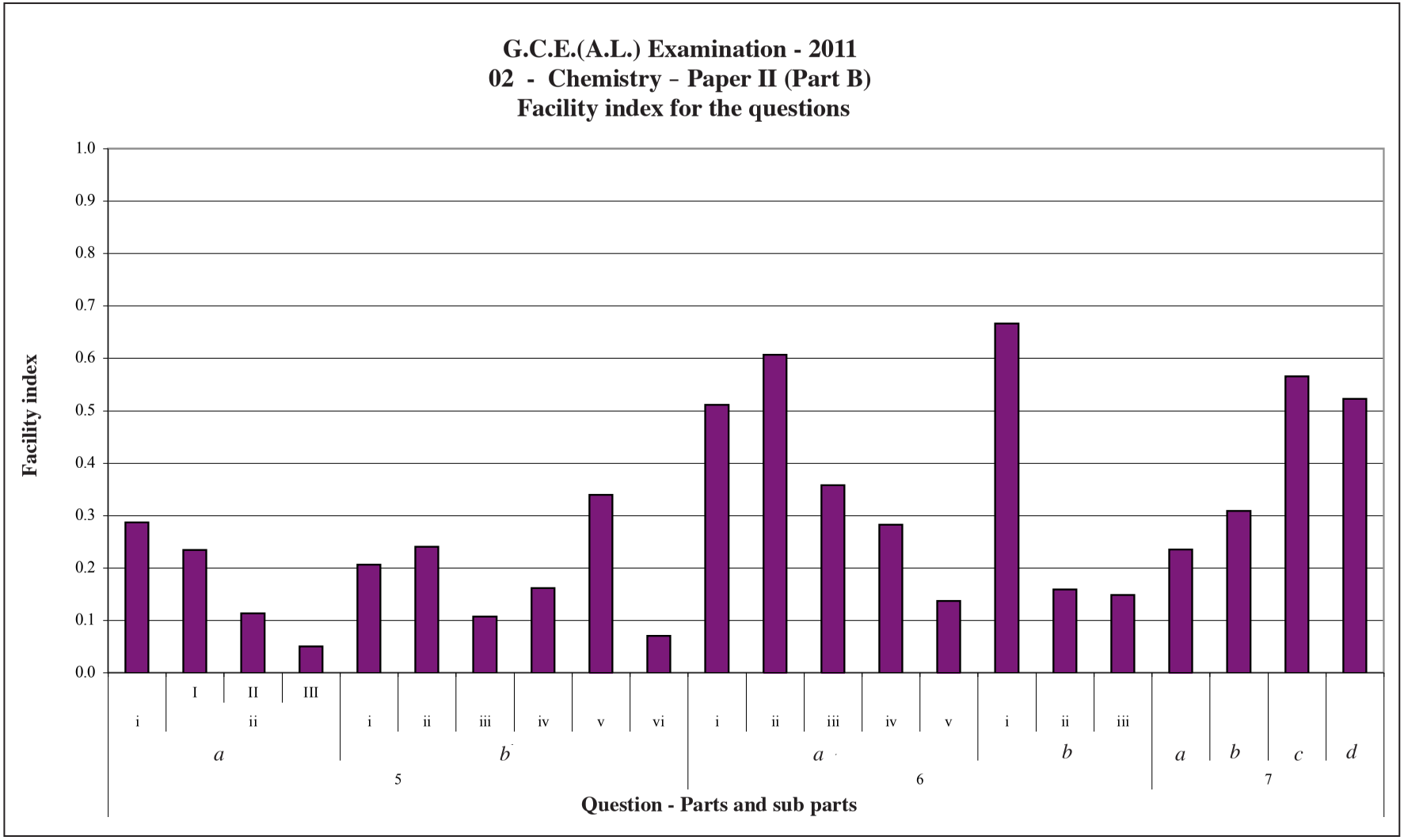
Graph 3 (Prepared using the information collected from the form RD/16/02/AL)

1.3.4 Achievement in Paper II

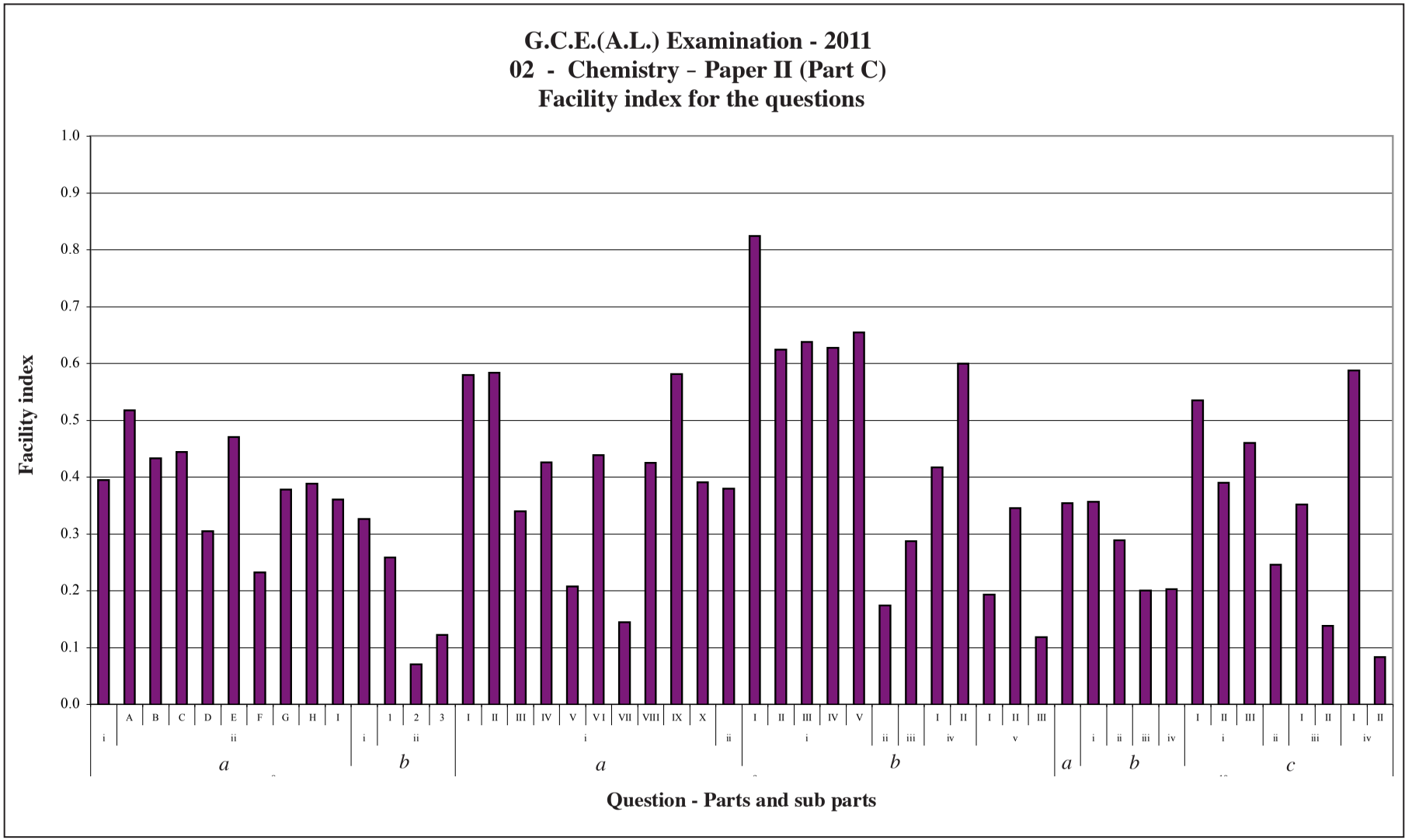


Graph 4.1 (Prepared using the information collected from the form RD/16/04/AL)

How information can be elicited from the above graph is illustrated by the following example.
Ex : The facility of part *a* (i) of question 1 is about 66% and the facility of part *b* (ii) is about 8%.


G.C.E.(A.L.) Examination - 2011
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
I
II
III
ii
a
i
ii
iii
iv
v
vi
b
5
i
ii
iii
iv
v
a
6
i
ii
iii
b
a
b
c
d
7
Question - Parts and sub parts

Graph 4.2


G.C.E.(A.L.) Examination - 2011
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 A B C D E F G H I i 1 2 3 I II III IV V VI VII VIII IX X ii I II III IV V i ii iii I II I II III i ii iii iv I II III i ii iii iv I II
a b a b a b c
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).

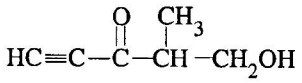
- Responding to all the questions is expected.

2.1.2 Paper I

1. The number of elements that can exist in liquid state at room temperature (25 °C) and atmospheric pressure (1.0×10^5 N m^{-2}) is,
   (1) 1 (2) 2 (3) 3 (4) 4 (5) 5

2. The correct **increasing** order of atomic radii of C, O, Al, P and Ca is,
   (1) O < C < Al < P < Ca (2) O < C < P < Al < Ca
   (3) C < O < P < Al < Ca (4) C < O < Al < P < Ca
   (5) C < O < Al < Ca < P

3. What is the IUPAC name of the following compound?



   (1) 1-hydroxy-2-methylpent-4-yn-3-one
   (2) 2-methyl-3-oxopent-4-yn-1-ol
   (3) 2-methyl-4-pentyn-1-ol-3-one
   (4) 5-hydroxy-4-methylpent-1-yn-3-one
   (5) 5-hydroxy-4-methyl-1-yne-3-pentanone

4. Which of the following statements is **not** true with regard to elements in the second period from Li to F?
   (1) The highest negative electron affinity is shown by F.
   (2) The highest positive electron affinity is shown by Be.
   (3) The highest oxidation state is exhibited by C.
   (4) Atomic radii decrease from Li to F.
   (5) The ability to form cations and to act as reducing agents decreases from Li to F.

5. The identity of an electron in an atom can be expressed using four quantum numbers (n, l, m_l, m_s). Identify which set of numbers given below is **not** acceptable as a set of quantum numbers for an electron in an atom.
   (1) $\left(4, 2, 0, +\frac{1}{2}\right)$ (2) $\left(3, 1, -1, +\frac{1}{2}\right)$ (3) $\left(3, 2, -3, +\frac{1}{2}\right)$
   (4) $\left(2, 1, 1, +\frac{1}{2}\right)$ (5) $\left(4, 0, 0, -\frac{1}{2}\right)$

6. Which row of the following table gives the correct information with regard to the NSF molecule?

	Oxidation state of S	Charge on S	Hybridization of S	$\hat{NSF}$ bond angle	Nature of S—F bond
(1)	– 4	– 2	sp	180°	S(sp h.o)—F(2p a.o)
(2)	–1	–1	sp^2	< 120°	S(sp^2 h.o)—F(2p a.o)
(3)	0	+1	sp^2	> 120°	S(sp^2 h.o)—F(2p a.o)
(4)	+1	0	sp^3	90°	S(sp^3 h.o)—F(2p a.o)
(5)	+4	0	sp^2	between 90° – 120°	S(sp^2 h.o)—F(2p a.o)

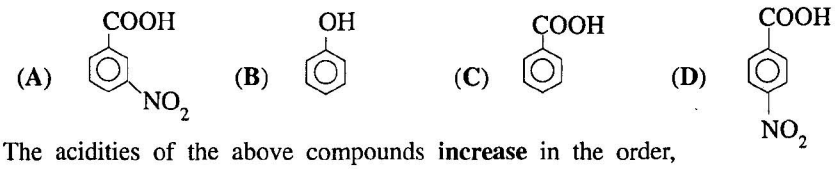
(h.o = hybrid orbital, a.o = atomic orbital)

7. A gaseous hydride of nitrogen, N_aH_b (20 cm^3) was burnt in excess O_2 to give 10 cm^3 of N_2 and 30 cm^3 of water vapour. The formula of the gaseous hydride is,
   (1) NH_3 (2) N_2H_2 (3) N_2H_4 (4) N_3H (5) N_3H_5

8. Thermal decomposition of 15.6 g of a hydrated metal carbonate, $MCO_3 . 4H_2O$ produces 4.0 g of the metal oxide. The relative atomic mass of the metal **M** is, (H = 1, C = 12, O = 16)
   (1) 63.5 (2) 56 (3) 40 (4) 26 (5) 24

9. Choose the molecule that **does not** have a dipole moment.
(1) SF_2 (2) PCl_4F (3) SF_4 (4) PCl_3 (5) SF_6

10. A solution has been prepared by mixing 250 cm^3 of a Na_2SO_4 solution of concentration 0.150 mol dm^{-3} and 750 cm^3 of a NaCl solution of concentration 0.100 mol dm^{-3}. The composition of this solution in terms of ppm Na is, (O = 16, Na = 23, S = 32, Cl = 35.5)
(1) 3450 (2) 2588 (3) 1725 (4) 3.45 (5) 0.15

11. 

The acidities of the above compounds **increase** in the order,
(1) **A < D < B < C** (2) **B < C < A < D** (3) **B < C < D < A**
(4) **C < B < A < D** (5) **D < A < B < C**

12. The IUPAC name of $[Cr(NH_3)_6][Fe(CN)_6]$ is,
(1) Hexaamminechromium(III)ionhexacyanoferrate(II) ion
(2) Hexaamminechromium(III) hexacyanoferrate(II)
(3) Hexaamminechromium(III)hexacyanoferrate(III)
(4) Hexaamminechromium(III) hexacyanoferrate(III)
(5) Hexaamminechromium(II) hexacyanoferrate(II)

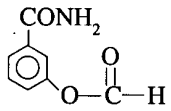
13. $\overset{\mathbf{a}}{CH_3}-\overset{\mathbf{b}}{CH_2}-\overset{\mathbf{c}}{C}\equiv\overset{\mathbf{d}}{C}-\overset{\mathbf{e}}{CH}=CH_2$

Which of the following arrangements gives the correct **increasing** order of the bond lengths of the bonds labelled as **a**, **b**, **c**, **d** and **e** in the above molecule?
(1) **a < b < d < e < c** (2) **c < d < e < b < a** (3) **c < e < d < a < b**
(4) **c < e < d < b < a** (5) **d < c < e < b < a**

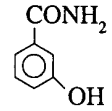
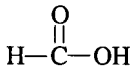
14. Vessel **A** contains helium gas at 27 °C. Vessel **B** contains oxygen gas at 127 °C. The ratio of the root mean square velocities of the gases in vessel **A** and vessel **B**, $\frac{\sqrt{\overline{C_A^2}}}{\sqrt{\overline{C_B^2}}}$ is, (He = 4, O = 16)
(1) 0.4 (2) 1.7 (3) 2.4 (4) 4.9 (5) 25

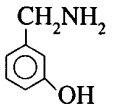
15. (**A**) $CH_3CH_2CH_2CH_2OH$ (**B**) $CH_3CH_2CH_2CH_2Cl$
(**C**) $HOCH_2CH_2CH_2CH_2OH$ (**D**) $CH_3CH_2CH_2CHO$
Which of the following arrangements shows the correct **increasing** order of solubilities of the above compounds in water?
(1) **B < A < D < C** (2) **B < C < D < A** (3) **B < D < A < C**
(4) **C < A < D < B** (5) **D < B < A < C**

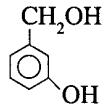
16. Which of the following systems liberates the largest amount of heat upon mixing 1.0 dm^3 of each of the following solutions?
(1) 0.100 mol dm^{-3} HCl and 0.200 mol dm^{-3} NaOH
(2) 0.100 mol dm^{-3} H_2SO_4 and 0.200 mol dm^{-3} NaOH
(3) 0.200 mol dm^{-3} CH_3COOH and 0.200 mol dm^{-3} KOH
(4) 0.400 mol dm^{-3} CH_3COOH and 0.200 mol dm^{-3} KOH
(5) 0.100 mol dm^{-3} HNO_3 and 0.200 mol dm^{-3} NaOH

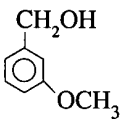
17. 

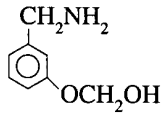
What are the products obtained when the above compound is reacted with $LiAlH_4$ followed by neutralization of the reaction mixture?

(1)  and 

(2)  and CH_3OH

(3)  , CH_3OH and NH_3

(4)  and NH_3

(5) 

- Questions **18** and **19** are based on the following paragraph. Read the paragraph carefully and select the answers for the questions.

When light strikes on certain metal surfaces, electrons can be ejected from it. The energy carried by the photons in light is transferred to electrons in the metal and if an electron acquires sufficient energy to overcome its attractive forces with the positively charged nucleus, it may escape from the surface as a photoelectron. The minimum energy required for the electron to escape varies from one metal to another.

18. The energy required for photoelectrons to be ejected from the surface of barium is 240 kJ per mole of electrons. The minimum frequency of light capable of producing a photoelectron in barium is,
(1) 5×10^{12} s^{-1} (2) 6×10^{12} s^{-1} (3) 2×10^{14} s^{-1} (4) 6×10^{14} s^{-1} (5) 5×10^{15} s^{-1}

19. The maximum wavelength of light that can produce this effect in barium is,
(1) 450 nm (2) 480 nm (3) 500 nm (4) 530 nm (5) 550 nm

20. The molecular shape and electron pair geometry of $XeOF_4$ are respectively,
(1) trigonal bipyramidal and octahedral.
(2) square pyramidal and trigonal bipyramidal.
(3) trigonal bipyramidal and square pyramidal.
(4) square pyramidal and octahedral.
(5) octahedral and square pyramidal.

21. Which one of the following statements is **correct** with regard to elements from Sc to Zn in the Periodic Table and their compounds?
(1) They have lower densities than K and Ca.
(2) Some of them exhibit non-metallic properties.
(3) $Cr_2O_7^{2-}(aq)$ is converted to $CrO_4^{2-}(aq)$ and $Cr^{3+}(aq)$ upon addition of dilute NaOH.
(4) They have electronegativities lower than *s* block elements in the same period.
(5) Mn forms acidic, amphoteric and basic oxides.

22. The standard enthalpies of combustion of C(s), S(s) and $CS_2(l)$ are –394 kJ mol^{-1}, –296 kJ mol^{-1} and –1072 kJ mol^{-1}, respectively. The standard enthalpy of formation of $CS_2(l)$ is,
(1) –86 kJ mol^{-1} (2) 86 kJ mol^{-1} (3) 382 kJ mol^{-1}
(4) –1762 kJ mol^{-1} (5) 1762 kJ mol^{-1}

23. **(A)** $CH_3CH_2CH{=}CH_2$ **(B)** $CH_2{=}CH_2$
(C) $CH_2{=}CH{-}CO_2H$ **(D)** $(CH_3)_2C{=}CH_2$

Which of the following arrangements gives the correct **increasing** order of the reactivities of the above compounds towards HBr?
(1) **B < A < C < D** (2) **B < A < D < C** (3) **C < B < A < D**
(4) **C < D < B < A** (5) **D < A < B < C**

24. Ammoniacal CuCl can be used to distinguish between $CH_3C{\equiv}CH$ and $CH_3CH{=}CH_2$ because,
(1) $CH_3C{\equiv}CH$ is oxidized by CuCl faster than $CH_3CH{=}CH_2$.
(2) $CH_3C{\equiv}CH$ is reduced by CuCl faster than $CH_3CH{=}CH_2$.
(3) $CH_3C{\equiv}CH$ can oxidize Cu^+ to Cu^{2+} while $CH_3CH{=}CH_2$ cannot.
(4) $CH_3C{\equiv}CH$ contains an acidic hydrogen which can be displaced by Cu^+ while $CH_3CH{=}CH_2$ does not.
(5) $CH_3C{\equiv}CH$ undergoes an electrophilic addition reaction with CuCl while $CH_3CH{=}CH_2$ does not.

25. An aqueous saturated solution of $\mathbf{M}(OH)_2$ has a pH of 10.0 at 25 °C. The solubility product of $\mathbf{M}(OH)_2$ at the same temperature is,
(1) 2.0×10^{-30} mol^3 dm^{-9} (2) 4.0×10^{-30} mol^3 dm^{-9}
(3) 5.0×10^{-13} mol^3 dm^{-9} (4) 2.0×10^{-12} mol^3 dm^{-9}
(5) 4.0×10^{-12} mol^3 dm^{-9}

26. The correct **decreasing** order of N—O bond distances in NH_2OH, NO, NO_2^- and NO_3^- is,
(1) $NO_2^- > NO_3^- > NO > NH_2OH$ (2) $NO_3^- > NO_2^- > NO > NH_2OH$
(3) $NO > NO_2^- > NO_3^- > NH_2OH$ (4) $NH_2OH > NO_3^- > NO_2^- > NO$
(5) $NO > NO_3^- > NO_2^- > NH_2OH$

27. Which of the following statements is **correct** with regard to the chemistry of Group I and II elements (*s* block elements) and their compounds?
(1) All Group I and II elements react with cold water to give H_2 and their metal hydroxides.
(2) $LiNO_3$ decomposes on heating to give NO_2 and O_2 as gases.
(3) The solubility of Group II sulphates decreases down the group.
(4) The basic strength of Group II hydroxides decreases down the group.
(5) The oxides of Group II elements can be obtained on heating their carbonates.

28. A sample of NaOH is contaminated with an inert impurity. 4.00 g of this NaOH sample was dissolved in 1.0 dm^3 of water, and a 50.0 cm^3 sample of the resulting solution was allowed to react with 50.0 cm^3 of 0.10 mol dm^{-3} HCl solution. The pH of the reaction mixture was found to be 2.0. The percentage purity of the NaOH sample is, (H = 1, O = 16, Na = 23)
(1) 12 (2) 20 (3) 60 (4) 80 (5) 90

29. At room temperature, a solution of 0.10 mol dm^{-3} HCl was slowly added to 100.0 cm^3 of a $Pb(NO_3)_2$ solution until the reaction was complete. The resulting solution was filtered, and the residue was dried to a constant mass. The mass of the dry residue was 0.139 g. The concentration of the $Pb(NO_3)_2$ solution is,
(N = 14, O = 16, Cl = 35.5, Pb = 207)
(1) 1.0×10^{-2} mol dm^{-3} (2) 8.4×10^{-3} mol dm^{-3}
(3) 5.0×10^{-3} mol dm^{-3} (4) 4.2×10^{-3} mol dm^{-3}
(5) 5.0×10^{-4} mol dm^{-3}

30. Which of the following compounds gives/give a basic gas on heating?
(A) $(NH_4)_2CO_3$ (B) NH_4Cl (C) NH_4NO_2 (D) NH_4NO_3 (E) $(NH_4)_2Cr_2O_7$
(1) **A** only. (2) **B** only. (3) **E** only. (4) **A** and **B** only. (5) **C** and **D** only.

● 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 **true** regarding electrochemical reactions and electrode potentials?
(*a*) Electrode potential is an intensive property.
(*b*) Half-cell reactions are reversible.
(*c*) Standard electrode potential changes its sign (+ or –) for the reverse reaction.
(*d*) Electrode potentials are independent of the temperature.

32. Which of the following statements is/are **true** regarding compound **A**?

(A) $HC{\equiv}C{-}CH_2CH_2CH_2NH_2$

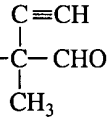
(*a*) **A** forms an aldehyde upon treatment with dil. H_2SO_4 in the presence of $HgCl_2$.
(*b*) **A** liberates H_2 when reacted with sodium.
(*c*) **A** liberates N_2 when reacted with $NaNO_2$/aq. HCl.
(*d*) **A** liberates CO_2 when treated with aq. $NaHCO_3$.

33. Which of the following statements is/are **true** regarding the polymers, polystyrene, polyvinylchloride, phenol-formaldelyde and nylon?
(*a*) Only polystyrene and polyvinylchloride are thermoplastic polymers.
(*b*) Only polystyrene, polyvinylchloride and nylon are thermosetting polymers.
(*c*) Only phenol-formaldehyde and nylon are prepared by condensation polymerization.
(*d*) Only polystyrene, polyvinylchloride and nylon are prepared by condensation polymerization.

34. Which of the following statement is/are **true** regarding natural rubber?
(*a*) The relative molecular mass of natural rubber is around 750 000.
(*b*) Ebonite is formed when natural rubber is heated with a large amount of sulphur.
(*c*) Although *cis* and *trans* isomers are possible in natural rubber due to the presence of double bonds, natural rubber has a *trans* configuration.
(*d*) Vulcanization of natural rubber reduces its hardness.

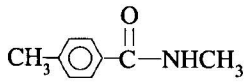
35. An ideal solution is prepared by mixing two miscible pure liquids. Which of the following statements is/are **true** regarding the above?
(*a*) The enthalpy change during mixing is zero.
(*b*) Raoult's Law cannot be applied to the above ideal solution.
(*c*) The vapour pressure of the solution is equal to the sum of the partial pressures of the two liquids.
(*d*) The vapour pressure of the solution varies linearly with the mole fraction of each of the liquids.

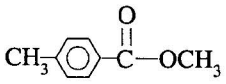
36.

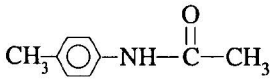
(A) 

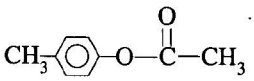
When one of the enantiomers of **A**,
(*a*) is treated with Zn(Hg)/conc. HCl, the product does not show optical activiy.
(*b*) is treated with $LiAlH_4$, the product does not show optical activity.
(*c*) is treated with ammoniacal $AgNO_3$, the product does not show optical activity.
(*d*) is treated with H_2/Pd, the product does not show optical activity.

37. Compound **B** was heated with aq. NaOH and the cooled reaction mixture was neutralized. When bromine water was added to the reaction mixture, it was decolorized. According to this observation, which of the following compounds could be **B**?

(*a*) 

(*b*) 

(*c*) 

(*d*) 

38. Which of the following statements is/are **true** regarding equilibrium systems?
   (*a*) The unit of the equilibrium constant of a chemical reaction can be deduced from the balanced chemical equation.
   (*b*) Equilibrium constants of both exothermic and endothermic reactions change with temperature.
   (*c*) Both gas phase and liquid phase chemical reactions can reach equilibrium in open systems.
   (*d*) If an equilibrium reaction can be expressed as the sum of two or more equilibrium reactions, the equilibrium constant for the overall reaction is given by the sum of the equilibrium constants of the individual reactions.

39. Which of the following statements is/are **true** regarding NH_3?
   (*a*) NH_3 can act as both an oxidizing agent and a reducing agent.
   (*b*) NH_3 is produced in large scale using the Haber process which employs N_2 and H_2 under high pressures and high temperatures.
   (*c*) When NH_3 reacts with excess Cl_2 gas, the products are N_2O and HCl.
   (*d*) NH_3 is used in the rubber industry to prevent premature coagulation of latex.

40. The only Group IA element to react with nitrogen gas is Li. In an experiment, 51 g of Li is allowed to react with 39 g of N_2. Which of the following statements is/are **true**? (Li = 7, N = 14)
   (*a*) Li will react completely and some N_2 will remain.
   (*b*) N_2 will react completely and some Li will remain.
   (*c*) Neither Li nor N_2 will react completely.
   (*d*) Theoretically, the amount of product formed will be 85 g.

● In questions No. **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.	NH_3 acts as a Lewis base, while BF_3 acts as a Lewis acid.	A Lewis base accepts protons, while a Lewis acid donates protons.
42.	The two N—O bond lengths in NO_2Cl are equal.	Two acceptable stable resonance structures can be drawn for NO_2Cl.
43.	The boiling point of butanoic acid is higher than the boiling point of 1-butanol.	No hydrogen bonds are present in 1-butanol.
44.	Enthalpy of mixing of an ideal solution is zero.	Attraction forces amongst different types of molecules and attraction forces amongst the same types of molecules are equal in an ideal solution.

45.	All three carbon atoms in propenal lie on one straight line.	All three carbon atoms in propenal are *sp* hybridized.
46.	Contribution to photochemical smog cannot be reduced by attaching catalytic converters to the tail pipes of vehicles.	In a catalytic converter, carbon monoxide and partially combusted hydrocarbons are oxidized to CO_2, and nitrogen oxides are reduced to N_2.
47.	The order of the reaction, $2N_2O_5(g) \xrightarrow{\Delta} 4NO_2(g) + O_2(g)$ can be determined by monitoring the volume change of the system with time when a sample of $N_2O_5(g)$ is heated.	The order of a chemical reaction with respect to a reactant does not depend on the concentration of the reactant.
48.	H_2S found in petroleum deposits is used in the large scale manufacture of sulphur.	Large underground deposits are the principal sources of elemental sulphur.
49.	If a yellow precipitate forms when $Pb(NO_3)_2$ solution is added to an aqueous solution, the only possible conclusion is that I^- ions are present.	The only water insoluble yellowish compound that Pb forms is PbI_2.
50.	Hydrochlorofluorocarbons are used as an alternative for chlorofluorocarbons to protect the ozone layer.	Hydrochlorofluorocarbons are not harmful to the ozone layer.

***

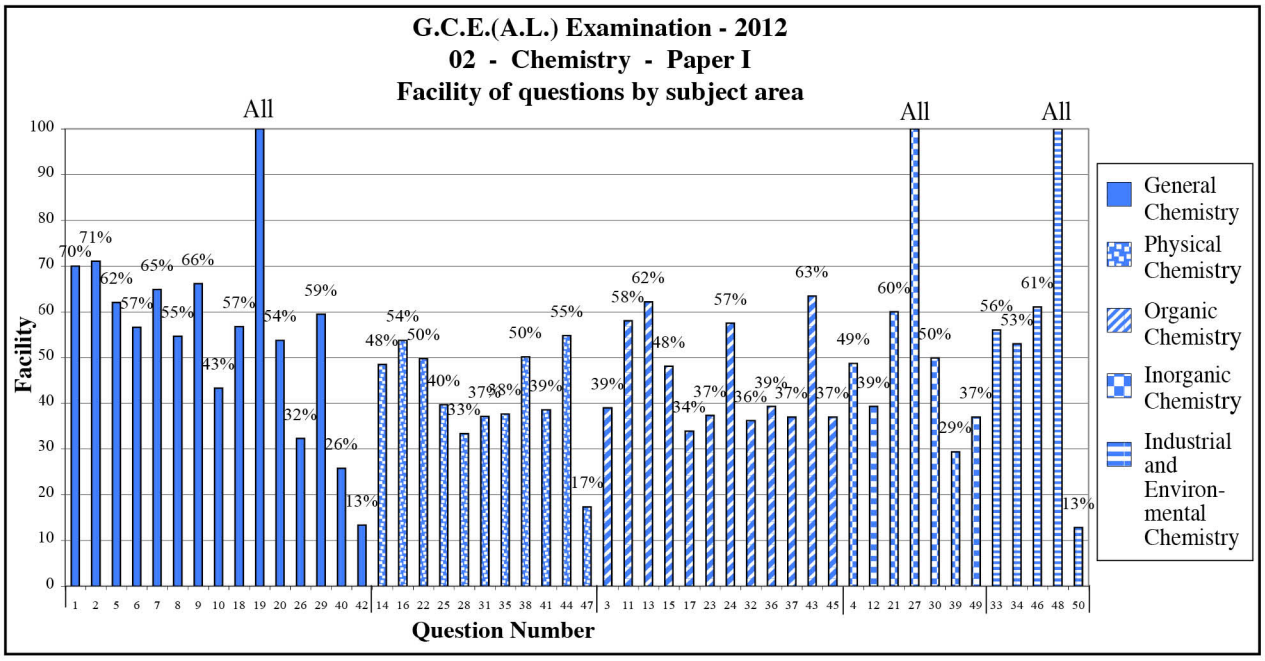
2.1.3 Expected answers and the marking scheme for Paper I

Marking Scheme - Paper I

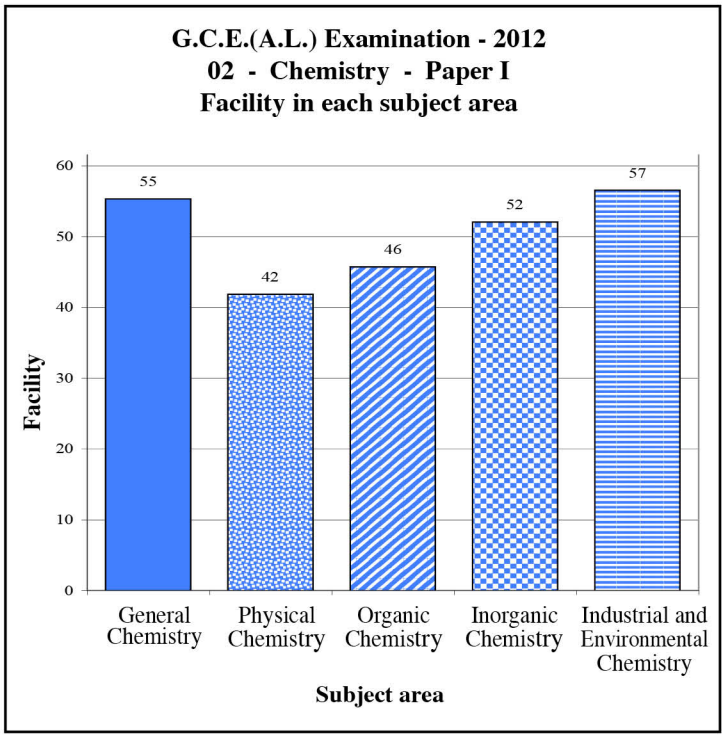
Question No.	Answer	Question No.	Answer
01.	2	26.	4
02.	2	27.	All
03.	4	28.	4
04.	3	29.	3
05.	3	30.	4
06.	5	31.	5
07.	1	32.	2
08.	5	33.	5
09.	5	34.	1, 5
10.	1	35.	5
11.	2	36.	4
12.	4	37.	3
13.	4	38.	1
14.	3	39.	4
15.	3	40.	4
16.	2	41.	3
17.	2	42.	1
18.	4	43.	3
19.	All	44.	1
20.	4	45.	5
21.	5	46.	4
22.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

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	2 (71%)	42 (13%)
Physical Chemistry	44 (55%)	47 (17%)
Organic Chemistry	43 (63%)	17 (34%)
Inorganic Chemistry	21 (60%)	39 (29%)
Industrial and Environmental Chemistry	46 (61%)	50 (13%)



Of the five major subject areas on which Paper I was set, Industrial and Environmental Chemistry had been a facile part for 57% of the students. General Chemistry had been an easier section for 55%. The most difficult area in Paper I had been Physical Chemistry. Its facility was 42%.

On the whole, the facility of Paper I was 50.4%.

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	9%	**70%**	11%	5%	5%	-
2	2	4%	**71%**	10%	13%	2%	-
3	4	19%	16%	10%	**39%**	16%	-
4	3	6%	27%	**49%**	9%	9%	-
5	3	4%	7%	**62%**	6%	21%	-
6	5	14%	12%	11%	6%	**57%**	-
7	1	**65%**	10%	18%	4%	3%	-
8	5	6%	13%	14%	12%	**55%**	-
9	5	9%	9%	7%	9%	**66%**	-
10	1	**44%**	15%	16%	16%	8%	1%
11	2	8%	**58%**	18%	7%	9%	-
12	4	6%	13%	38%	**39%**	4%	-
13	4	6%	19%	11%	**62%**	2%	-
14	3	11%	26%	**49%**	8%	6%	-
15	3	15%	9%	**48%**	9%	19%	-
16	2	11%	**54%**	12%	13%	10%	-
17	2	9%	**34%**	23%	14%	20%	-
18	4	5%	17%	14%	**57%**	7%	-
19	All	5%	13%	62%	10%	9%	1%
20	4	12%	11%	13%	**54%**	10%	-
21	5	3%	10%	14%	13%	**60%**	-
22	2	16%	**50%**	20%	9%	5%	-
23	3	14%	25%	**37%**	10%	14%	-
24	4	6%	7%	18%	**58%**	11%	-
25	3	5%	12%	**40%**	17%	26%	-
26	4	8%	21%	23%	**32%**	16%	-
27	All	5%	21%	26%	8%	40%	-
28	4	8%	21%	27%	**33%**	10%	1%
29	3	7%	10%	**59%**	15%	9%	-
30	4	11%	11%	12%	**50%**	16%	-
31	5	18%	18%	10%	17%	**37%**	-
32	2	20%	**36%**	15%	10%	19%	-
33	5	5%	14%	7%	18%	**56%**	-
34	1, 5	**27%**	21%	15%	10%	**27%**	-
35	5	4%	9%	20%	29%	**38%**	-
36	4	11%	9%	15%	**39%**	26%	-
37	3	11%	13%	**37%**	9%	29%	1%
38	1	**50%**	15%	8%	6%	21%	-
39	4	20%	6%	7%	**29%**	38%	-
40	4	3%	6%	15%	**26%**	49%	1%
41	3	30%	16%	**39%**	10%	5%	-
42	1	**13%**	28%	16%	33%	10%	-
43	3	9%	10%	**63%**	7%	11%	-
44	1	**55%**	15%	16%	8%	6%	-
45	5	10%	7%	37%	9%	**37%**	-
46	4	12%	8%	7%	**61%**	12%	-
47	4	5%	22%	35%	**18%**	20%	-
48	All	22%	36%	10%	26%	6%	-
49	5	35%	6%	10%	12%	**37%**	-
50	3	50%	7%	**13%**	5%	25%	-

* 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 :

Questions 1 - 30 had only a single correct answer while the questions 31 - 40 require the selection of correct statement/statements. When responding to the reason - assertion type questions from 41 to 50, the truism or falsity of two statements and if both are true whether the second is a correct explanation of the first has to be decided.

Of the first 30 questions, the number of questions for which less than 35% had responded correctly was 3(10%). Of the questions 31 - 40, two questions (20%) had been correctly responded by less than 35% whereas of questions 41 - 50, the number of questions getting correct responses by less than 35% was 3(30%).

From this it is clear that, in spite of the candidates had knowledge, they have a difficulty in selecting the most correct option in questions 31 - 50. The numbers of questions for which the percentage of correct responses was less than 35% along with corresponding subject areas are given below.

Question number	Subject area
17	Organic Chemistry
26	General Chemistry
28	General Chemistry (Chemical calculation)
39	Inorganic/Environmental Chemistry
40	Inorganic Chemistry
42	General Chemistry
47	Physical Chemistry
50	Environmental Chemistry

Of the questions 1 -30, the percentage selecting the correct response 2 for the question 17 was 34%. The percentages selecting options 3 and 5 were 23% and 20% respectively. This question relates to Organic Chemistry. The given organic compound consists of two functional groups and the question inquires into the products formed by a reagent after reacting with both the functional groups. To answer this question, the reactions of the reagent with each of the functional group should be known correctly. The basic knowledge on the products of organic compounds with respective reagents needs to be improved.

Question 26 is related to General Chemistry. The correct response, option 4 for this question was selected by 32%. To answer this problem, understanding of the principles relevant to the determination of the bond length of the N - O bond in several nitrogen containing species is essential. In all these N is the central atom. Not achieving the required level with regard to the knowledge of the hybridisation of the N atom, the number of possible resonance structures of each species and bond order relevant to the bond derived thereof is the reason for low performance in this question. The student should be engaged in the exercises on bond order during the learning teaching process.

Question 28 is connected with chemical calculation coming under General Chemistry. The percentage selecting the correct option (4) for this question was 33%. Twenty seven percent had taken option 3 as the correct response. This differs from the conventional problems given on the calculations related to acid - base reactions. Given as datum is the pH of the solution obtained after adding a specified amount of an acid to a solution of a base. The competency of determining the concentration of a solution using the pH has to be developed in the student. Moreover, the student needs to have an understanding about the change in concentration of the components when mixing two solutions. With such an understanding, this problem can be solved easily.

Of the multiple completion type questions from 31 to 40, question 39 belongs to the area of Inorganic Chemistry. Option 4 which is the correct response for this had been selected by 29% while 38% had selected option 5. When answering this question it is seen that students have taken statement (b) as correct. In this question related to the chemistry of ammonia, it should be emphasized that the conditions of 250 atm pressure and 400 - 450°C temperature related to the industrial manufacture of ammonia are medium conditions.

Question 40 is related to Inorganic Chemistry. It also contains a chemical calculation. The correct option 4 for this question had been selected by 26% while 49% had selected option 5. The shortcomings noticed in deducing the correct response to this question are due to the weakness in determining the correct stoichiometric ratio of the reactants by writing the relevant balanced equation for the reaction, flaws in computing the amounts of reactants in moles and inability to find the limiting factor from the reactants provided.

Question 42 comes under the purview of General Chemistry. Thirteen percent of the candidates had succeeded in selecting the correct option, which was 1 for this question. Options 2 and 4 had been choosen by 28% and 33% respectively. Though the first statement in this question is true, majority of the students had taken it as false. The reason for this is the failure of the student to achieve the expected level in relation to the bond order of the bond concerned in the given molecule.

Question 47 pertains to chemical kinetics coming within the ambit of Physical Chemistry. The percentage selecting the correct response (4) for this is as low as 18%. Thirty five percent had choosen the option 3. Options 2 and 5 had been selected by 20% and 22% respectively. In order to select the correct response, the students must have a correct understanding about the practical application of determining the order of a chemical reaction. The understanding about the quantities that can be practically used as measures when determining order of a reaction should be developed in students. To decide whether the second statement is true or false, the students should be aware of the factors that affect the rate of a reaction.

Question 50 examines the knowledge in the area of Industrial Chemistry. Thirteen percent had selected the correct option 3, while 50% had selected option 1. Lack of the correct understanding about the depletion of the ozone layer and the relevant reaction mechanisms is the reason for this. So, the teachers need to plan their lessons so that the students can apply the knowledge gained through the syllabus and the Teacher's Instruction Manual to other similar situations.

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 Expected answers, marking scheme and observations and conclusions 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.**

PART A — STRUCTURED ESSAY

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

1. (*a*) Answer the questions given below in the space provided.

(i) Of the three isolated ions Fe^{3+}, Cr^{3+} and Co^{2+}, which one has **three** unpaired electrons? Cr^{3+} or Co^{2+} (or Both)

(ii) Of the three 3*d* block elements Ti, V and Cr, which one has a maximum of **five** electrons that can participate in bonding? V

(iii) Of the three elements C, N and Si, which one has the **lowest** electronegativity? Si

(iv) Of the three elements Na, Mg and Al, which one has the **highest** first ionization energy? Mg

(v) Of the three isoelectronic anions N^{3-}, O^{2-} and F^-, which one has the **largest** ionic radius? N^{3-}

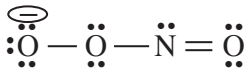
(vi) Of the three cations Na^+, Ca^{2+} and Al^{3+}, which one has the **smallest** ionic radius? Al^{3+}

(05 × 6 = 30 marks)

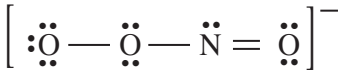
(*b*) Peroxonitrous acid (HOONO) is formed as an intermediate during the oxidation of acidified aqueous solutions of nitrites to nitrates using H_2O_2. Answer the Parts (i) to (vii) which are based on the peroxonitrite ion, $[OONO]^-$. Its skeleton is given below:

O—O—N—O

(i) Draw the **most** acceptable Lewis structure for this ion.

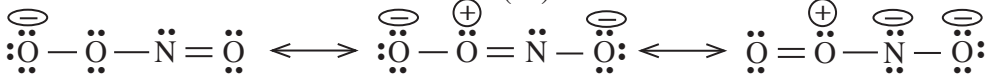


(06 marks)

No marks for 

(ii) Draw resonance structures for this ion. Giving reason/s comment on their relative stabilities.

(02) (02)



stable (01)
Reason : Negative charge on most electronegative oxygen atom (01)

unstable (01)
Greater charge separation or electronegative O carries a positive charge (02)

unstable (01)
Greater charge separation or electronegative O carries a positive charge (02)

(12 marks)

(iii) Deduce the shapes around the following atoms using the VSEPR theory.

I. **N**

Valence electron pairs = 4 (01 mark)

VSEPR pairs Or sigma bonds and lone pairs = 3 (01 mark)

Lone pairs of electrons = 1 (01 mark)

Shape = angular or V (01 mark)

II. **O** attached to both **N** and **O**

Valence electron pairs = 4 (01 mark)

VSEPR pairs Or sigma bonds and lone pairs = 4 (01 mark)

Lone pairs of electrons = 2 (01 mark)

Shape = angular or V (01 mark)

(iv) State the following:

I. electron pair geometry (arrangement of electron pairs) around the atoms

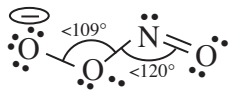
II. hybridization of the atoms

given in the table below.

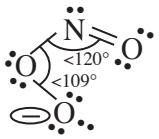
		N	O attached to both N and O
I.	electron pair geometry	Trigonal planar	Tetrahedral
II.	hybridization	sp^2	sp^3

(02 × 4 = 08 marks)

(v) Sketch the shape of the Lewis structure drawn in Part (i) above showing approximate bond angles.



or



sketch (03)

angles (01) × 2 = 05 marks

(vi) Identify the atomic/hybrid orbitals involved in the formation of the following bonds in the Lewis structure drawn in Part (i) above. Oxygen atoms are labelled 1, 2 and 3 as given below:

$O^1—O^2—N—O^3$

I. O^1 and O^2 — 2p atomic orbital and sp^3 hybrid orbital (01 + 01 + 01 + 01 = 04 marks)

II. O^2 and N — sp^3 hybrid orbital and sp^3 hybrid orbital (01 + 01 + 01 + 01 = 04 marks)

(vii) Give an isomer of peroxonitrous acid.

HNO_3 (nitric acid) [nitric(v) acid is acceptable] (03 marks)

(*c*) (i) Select **two** polar species from the list given below.

H_2CO (formaldehyde), SF_6, COS, ICl_4^-, $SiCl_4$ — H_2CO and COS

(05 × 02 = 10 marks)

(ii) State the type(s) of intermolecular forces that exist between the molecules in each of the following pairs.

I. HBr(g) and H_2S(g) — dipole – dipole + London forces *

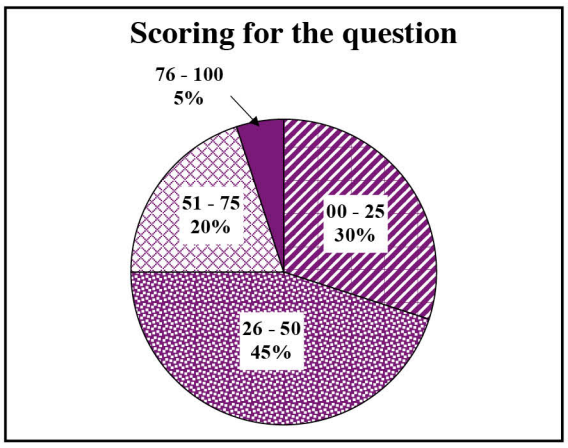
II. Cl_2(g) and CCl_4(g) — London forces *

III. CH_3OH(l) and H_2O(l) — Hydrogen bonding + London forces *

(02 × 05 = 10 marks)

* London forces / London dispersion forces / id – id / vander Waals forces

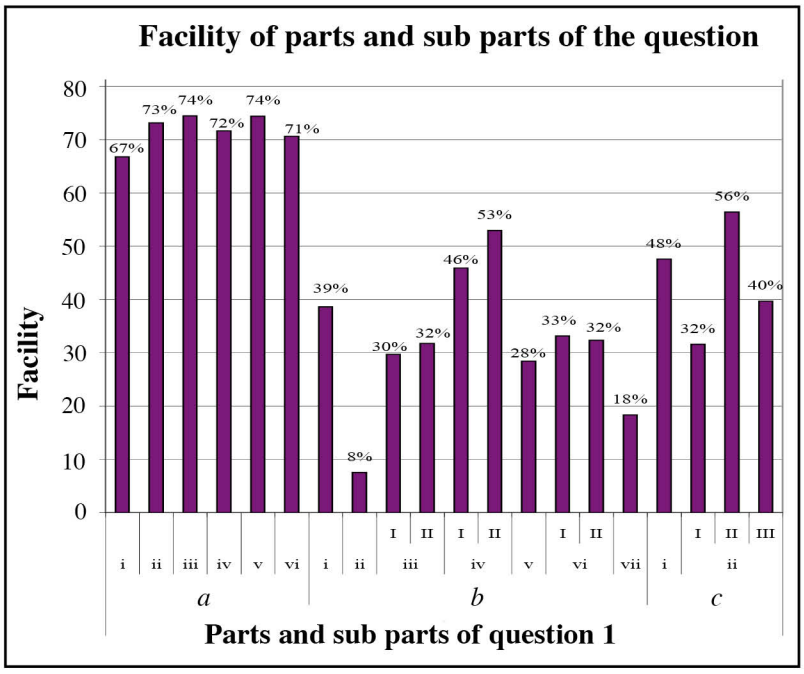
Overall observations and conclusions regarding the answers to Question 1 :



Although question 1 is compulsory, 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	–	30%
26 - 50	–	45%
51 - 75	–	20%
76 - 100	–	5%

The percentage scoring above 76 for this question is 5% while 30% have scored less than 25 marks.



* This question comprises 20 sub parts of which the facility of 10 parts is above 45%. The sub part with minimum facility is *b* (ii) for which the facility is 8%. The facility of *b* (vii) is 18%. The easiest sub parts had been *a* (iii) and *a* (v). For each of them the facility is 74%.

In totality the facility for part (*a*) of the question is above 65%. Compared to it, 50% facility is exceeded only in (*b*) (iv) (II) and (*c*) (ii) (II) of 14 sub parts in (*b*) and (*c*) parts of the questions. The facility for (*b*) (i) and (*b*) (ii) sub parts are 39% and 8% respectively. Though the candidates have some understanding about the Lewis structures, the data show a difficulty of writing resonance structures using them. Attention of the students should be drawn to the strategies of drawing Lewis structures and the factors affecting their stability. Facility for (*b*) (iii) (I) and (II)are 30% and 32% respectively. Students should be guided to deduce the structure using the formula as well as the skeleton of a given compound.

The facility of sub part (*b*) (v) is 28%. The students have had a difficulty in deciding the correct answer due to overlooking the repulsion caused by lone pairs in the valence shell in the central atom of a given species.

The facility of sub part (*b*) (vii) is 18%. Yet, if the question was read carefully from the begining and understood, getting the answer would have been a very easy task.

The facility for (*c*) (ii) (I), (II) and (III) are 32%, 56% and 40% respectively. Being unable to identify and understand correctly the all possible intermolecular forces among the molecules, it has become difficult for students to present the correct answer. Hence, the students should be involved in exercises that improve their ability of identifying the types of intermolecular forces and their strengths.

2. (*a*) (i) Give the formulae of the oxides with the highest oxidation state formed by the elements in the third period. Comment on their acidic / amphoteric / basic nature using the following list.

very strongly acidic, strongly acidic, weakly acidic, very weakly acidic, weakly basic, basic, strongly basic, amphoteric, neutral

Na_2O - strongly basic P_2O_5 or P_4O_{10} - weakly acidic

MgO - weakly basic / basic SO_3 - strongly acidic / very strongly acidic

Al_2O_3 - amphoteric Cl_2O_7 - very strongly acidic

SiO_2 - very weakly acidic (01 × 7 + 01 × 7 = 14 marks)

(ii) State how the electronegativity, atomic radius and first ionization energy vary from left to right across the third period.

electronegativity Na < Mg < Al < Si < P < S < Cl or Increases (03 marks)

atomic radius Na > Mg > Al > Si > P > S > Cl or Decreases (03 marks)

first ionization energy Na < Mg > Al < Si < P > S < Cl or Cl > P > S > Si > Mg > Al > Na (03 marks)

Drawing zig-zag variation with correct labelling of elements' zig-zag variation (01) only. (03 marks)

(iii) Give the general reaction to show the thermal decomposition of Group II nitrates using **M** as the metal. $2M(NO_3)_2 \longrightarrow 2MO + 4NO_2 + O_2$ (03 marks)

If products are correct, but equation is not balanced (02)

(iv) Arrange the Group II nitrates in the order of **increasing** thermal stability (use the notation <). Explain your answer based on polarization of ions.

Increasing thermal stability : $Be(NO_3)_2 < Mg(NO_3)_2 < Ca(NO_3)_2 < Sr(NO_3)_2 < Ba(NO_3)_2$ (04 marks)

anion same (01), cation charge same (01), but size increases, down the group (01)

$\therefore$ polarizing power $Be^{2+} > Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$ (01)

Hence polarization of nitrate by cations becomes difficult down the group (01), Thus thermal stability increases down the group. (05 marks)

(*b*) The following questions are based on the transition metal, Mn and its compounds.

(i) Give the electronic configuration of Mn.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$ or ..... $4s^2\ 3d^5$ (06 marks)

(ii) State the common oxidation states of Mn.

+2, +4, +7 (+6) (any three) or +II, +IV, +VII, (+VI) (any three)

(02 × 3 = 06 marks)

(iii) Give the chemical formulae of the oxides formed by Mn in these common oxidation states. Indicate whether each of these oxides is acidic, amphoteric or basic.

MnO - basic (02 + 01 = 03 marks)

MnO_2 - amphoteric (02 + 01 = 03 marks)

Mn_2O_7 - acidic MnO_3 - acidic (any three) (02 + 01 = 03 marks)

(iv) Give the IUPAC name of $KMnO_4$.

potassium manganate(VII) (06 marks)

(v) Mn has the lowest melting point and lowest boiling point among the 3*d* transition elements. Explain why this is so.

Both 3*d* and 4*s* electrons are delocalized to form metalic bonds. (02)

Mn has a half filled 3*d* sub shell and a completely filled, 4*s* sub shell (02) making the electrons less available for delocalizaion. (02) (06 marks)

(vi) What would you expect to observe when a dilute ammonia solution is added to an aqueous solution of Mn^{2+} and then left exposed to the air?

beige / pale pink / (white) precipitate (03)

precipate turns brown / brownish black on exposure to air (03) (06 marks)

* No marks for black precipitate

(vii) An aqueous solution of $KMnO_4$ turns green upon addition of conc. KOH. On diluting the green solution with water or acid, a purple solution and a blackish brown precipitate are obtained. Write balanced chemical equations to explain these observations.

$4MnO_4^- + 4OH^- \longrightarrow 4MnO_4^{2-} + 2H_2O + O_2$ (04 marks)

$3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$

or

$3MnO_4^{2-} + 2H_2O \longrightarrow 2MnO_4^- + MnO_2 + 4OH^-$ (04 marks)

(viii) Give **one** important use of each of the following.

I. $KMnO_4$ (other than as an oxidizing agent)

disinfectant / germicide / deodorant / self-indicator / identification of anode and cathode preparation O_2 (03 marks)

II. Mn metal

steel / alloys (03 marks)

(ix) Give half reactions to show how $KMnO_4$ behaves as an oxidizing agent in acidic and basic media.

acidic medium : $MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O$ (03 marks)

basic medium : $MnO_4^- + 2H_2O + 3e \longrightarrow MnO_2 + 4OH^-$ or $MnO_4^- + e \longrightarrow MnO_4^{2-}$ (03 marks)

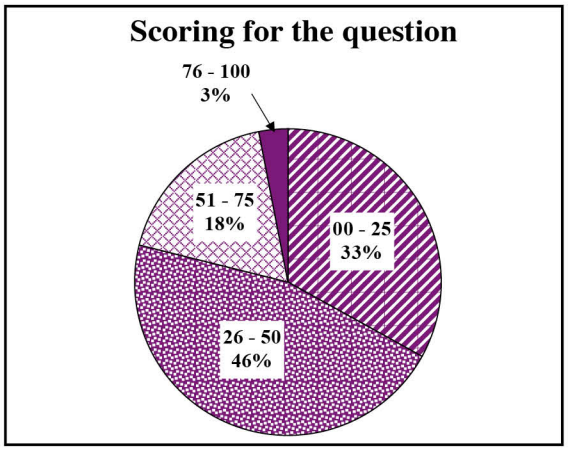
(x) Indicate **two** problems you may expect when using $KMnO_4$ as an oxidizing agent.

- cannot be used in the presence of Cl^- or Br^-
- Not a primary standard (aqueous) solutions not stable
- Strongly coloured that it is impossible sometimes to see whether crystals are dissolved
- formation of MnO_2 as a brown precipitate when kept in solution

(any 02) (03 × 2 = 06 marks)

(To award marks for any other answers obtain approval from Controlling Chief)

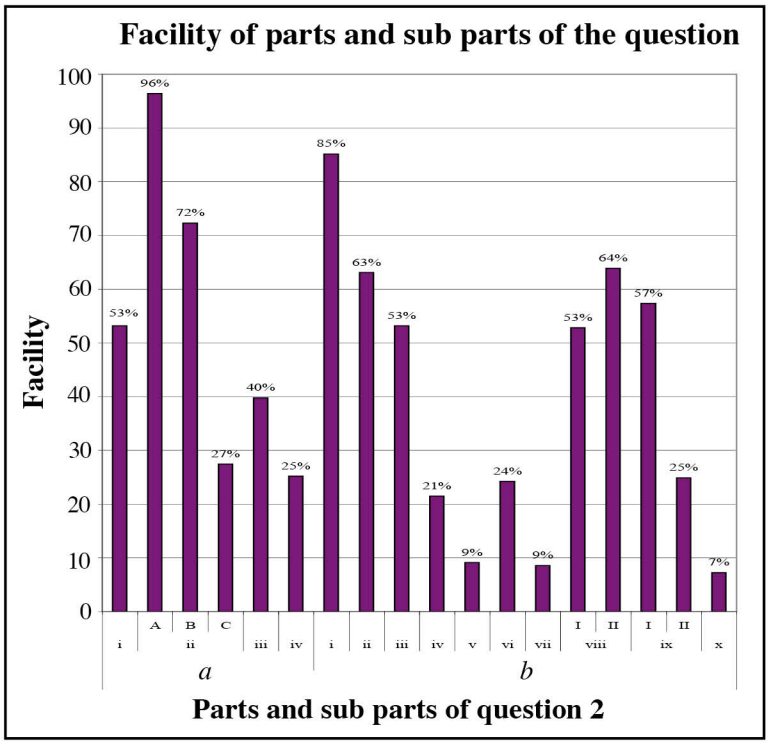
Overall observations and conclusions regarding the answers to Question 2 :



Despite question 2 is compulsory only 97% have answered it. The mark allocated for this question is 100. The percentages of candidates scoring within the following four intervals are:

00 - 25 – 33%
26 - 50 – 46%
51 - 75 – 18%
76 - 100 – 3%

3% of the candidates have scored 76 or more for this question whereas 46% have scored between 25 and 50.



* This question comprises 18 sub parts of which the facility of 9 sub parts is above 50%. The most difficult sub part *b* (x) has the facility of 7%. The easiest sub part *a* (ii) (A) has the facility of 96%.

The facility of sub part (*a*) (iii) is 40%. The ability of writing correct balanced equations for the thermal dissociation of group II nitrates is not adequate. The ability of writing the balanced equation for a reaction should be developed during the learning teaching process. Facility of sub part (iv) is 25%. The reason for low facility is the lack of clear understanding about the variation of the polarizing power of cations and polarizability of anions down the group to explain the thermal stability of group II nitrates. During learning teaching process emphasis should be laid on the fact that a cation has a polarizing power and an anion has a polarizability.

The sub part (*b*) (iv) has a facility of 21%. The possible reason for this is the paucity of knowledge about the rules that should be obeyed during the IUPAC nomenclature of an inorganic compound. The knowledge of naming compounds needs to be strengthened during the learning teaching process. The facility of responding to sub part (*b*) (v) is 9%. The students had not explained reasons for the lowest melting point and boiling point of Mn among the transition elements. The reason should have been presented clearly in terms of the difficulty of delocalising electrons for metallic bonding due to the stability of the electron configuration.

The facility of part (*b*) (vi) is 24%. Students seem to have little knowledge about the colours of the compounds and metal cations in the aqueous medium. It should be stressed that the correct colour of MnO_2(s) is dark brown.

The facility of the sub parts (*b*) (vii) and (*b*) (ix) (I), (II) are 9% and 25% respectively. The facility of the question has gone so low because of the inability to identify the compounds through the colour changes associated with a given test. Further, the ability of writing balanced chemical equations for changes and reactions in basic media has to be improved. The skill of balancing redox equations in basic media should be developed in the learning teaching process. Also, the ability of explaining reasons for the changes taking place during practical test should be enhanced.

The facility of sub part (*b*) (x) is as low as 7%. The low value owes to the inability to identify the problems encountered when using $KMnO_4$ as an oxidising agent through practical activities. Hence the use of engaging student in practical work is reiterated.

3. (*a*) At pressure P and temperature T, a mixture of $O_2(g)$ and $O_3(g)$ exists at equilibrium in a closed rigid container of volume V.

(i) Express the density of the gas mixture (d), in terms of n_1, n_2, M_1, M_2 and V, where

n_1 = number of moles of O_2 $\quad$ n_2 = number of moles of O_3

M_1 = molar mass of O_2 $\quad$ M_2 = molar mass of O_3

density (d) = mass / volume (03 marks)

$= \dfrac{m_{O_2} + m_{O_3}}{V}$ (03 marks)

$= \dfrac{n_1 M_1 + n_2 M_2}{V}$ (04 marks)

Note : Award full marks (10) if the last step is correct. (Total 10 marks)

(ii) Express the above relationship in terms of X_1, X_2, M_1, M_2, V and n, where,

X_1 = mole fraction of O_2 $\quad$ X_2 = mole fraction of O_3

n = total number of moles of both gases

$n = n_1 + n_2$ (03 marks)

$d = \dfrac{\left[\dfrac{n_1}{n_1 + n_2}\right] M_1 + \left[\dfrac{n_2}{n_1 + n_2}\right] M_2}{V} (n_1 + n_2)$ (03 marks)

$= \dfrac{X_1 M_1 + X_2 M_2}{V} \times n$ (04 marks)

Note : Award full marks (10) if the last step is correct. (Total 10 marks)

(iii) Hence show that, $X_1 = \left(3 - \dfrac{dRT}{16P}\right)$,

where R is the universal gas constant. (relative atomic mass of O = 16)

$X_2 = 1 - X_1$ or $X_1 + X_2 = 1$ (04 marks)

$d = \dfrac{X_1 M_1 + (1 - X_1) M_2}{V} n$ (04 marks)

For the mixture $pV = nRT$ or $\dfrac{n}{V} = \dfrac{p}{RT}$ (04 marks)

$d = [X_1 M_1 + (1 - X_1) M_2] \dfrac{p}{RT}$ (04 marks)

$X_1 M_1 + (1 - X_1) M_2 = \dfrac{dRT}{p}$

Substituting for molar mass, $32 X_1 + 48(1 - X_1) = \dfrac{dRT}{p}$ (04 marks)

$16 X_1 = 48 - \dfrac{dRT}{p}$

$X_1 = 3 - \dfrac{dRT}{16p}$ (03 + 01 marks)

(Total 24 marks)

(iv) State the assumption/s you made in the above steps.

Assumptions : $O_2(g)$ are $O_3(g)$ do not react with each other, or

Mixture of $O_2(g)$ and $O_3(g)$ behaves ideally. (06 marks)

(Total 50 marks)

(*b*) (i) Consider the following standard reduction potentials:

$$E^{\ominus}\left[Br_2(l)/Br^-(aq)\right] = 1.07\ V$$

$$E^{\ominus}\left[I_2(s)/I^-(aq)\right] = 0.54\ V$$

I. What reaction would you expect to take place when liquid bromine is added to an aqueous solution of 1.0 mol dm^{-3} KI?

$Br_2(l) + 3I^-(aq) \longrightarrow 2Br^-(aq) + I_3^-(aq)$ or $Br_2(l) + 2I^-(aq) \longrightarrow 2Br^-(aq) + I_2(s)$

(10 marks)

Note : Do not award marks if the physical states are not given or the equation is not balanced.
Award full marks for the balanced equation with K^+.

II. Write the colour changes you would expect in the above experiment.

colourless / Pale yellow solution turns brown. (05 marks)

(ii) Consider the following electrochemical reaction:

$$Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$$

I. Write the cathodic reaction of the Galvanic cell consistent with the above reaction.

$2H^+(aq) + 2e \longrightarrow H_2(g)$ or $2H_3O^+(aq) + 2e \longrightarrow H_2(g) + 2H_2O(l)$ (05 marks)

Note : Do not award marks if the physical states are not given or the equation is not balanced.

II. Write the conventional notation for representing the above cell, which includes a salt bridge.

$Mg(s) / Mg^{2+}(aq) // H^+(aq) / H_2(g), Pt(s)$ (10 marks)

[$Mg(s) / Mg^{2+}(aq) // H^+(aq) / H_2(g) / Pt(s)$ is also accepted]

Note : Do **not** award marks if the physical states are **not** given.

H_3O^+ is acceptable instead of H^+

III. Does the entropy increase, decrease or remain constant when the above cell reaction proceeds?

Entropy increases (05 marks)

Briefly explain your answer.

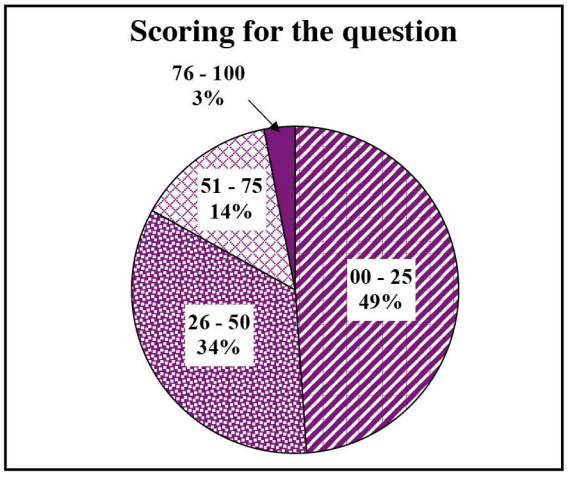
A gaseous product [or $H_2(g)$] is formed from reactants in solid and liquid phases. (05 marks)

IV. What should be the relationship between enthalpy change (ΔH) and entropy change (ΔS) for the above reaction to be spontaneous at temperature T?

$\Delta H - T\Delta S < 0$ or $\Delta H < T\Delta S$ or $\Delta H / T < \Delta S$ (10 marks)

or any other acceptable form (Total 50 marks)

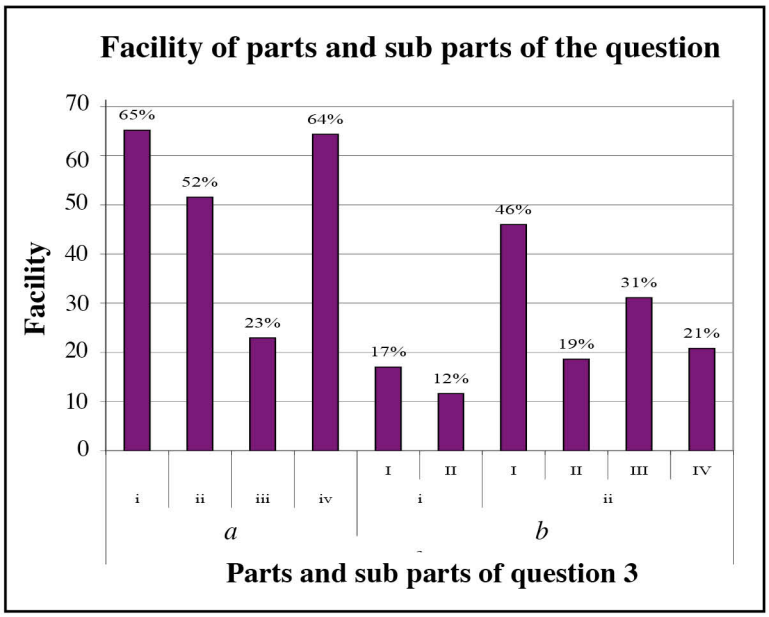
Overall observations and conclusions regarding the answers to Question 3 :



Despite the question 3 is compulsory, 98% have answered it. The total mark for the question is 100. The percentages scoring in the respective four ranges are:

00 - 25	–	49%
26 - 50	–	34%
51 - 75	–	14%
76 - 100	–	3%

3% have obtained above 76 for this question while 49% have scored below 25.



* This question consists of 10 sub parts of which the facility of 4 sub parts is above 45%. The easiest sub part *a* (i) records a facility of 65% whereas the sub part of least facility *b* (i) (II) has the facility of 12%.

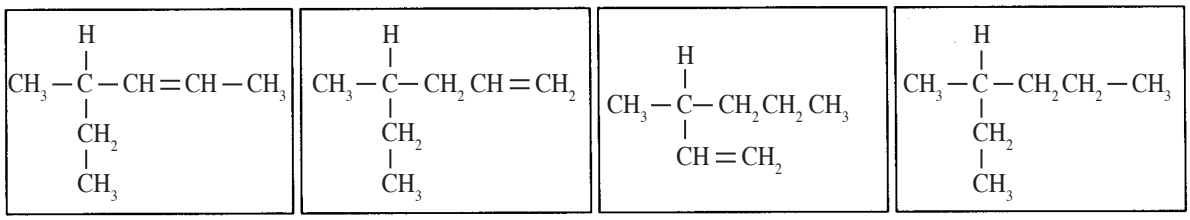
The facility of parts (*a*) (iii) is about 23%. This shows that the capacity to solve problems using symbols is low. For example, it was evident than most of the students were unable to understand that the equation $PV = nRT$ has to be used when $\frac{RT}{P}$ is given in the answer.

Low marks for sub parts (*b*) (i) I is caused by either not indicating the physical states or putting the incorrect state symbols. The main reason for low marks for this question is due to the fact that majority of the candidates had forgotten that I_2 mainly exists in the solid state in the medium. Though it had been indicated as $I_2(s)$ in the electrode potential relationship to make it identify easily, the hint had been ignored.

When going through the answers for sub part (*b*) (ii) (II), it was apparent that the understanding of the symbols used for the salt bridge and the porous partition is poor. Generally the knowledge of representing an electrochemical cell according to the conventional notation seems to be poor. The candidates are advised to improve their knowledge on symbols used when writing electrodes and cell conforming to the standard notation.

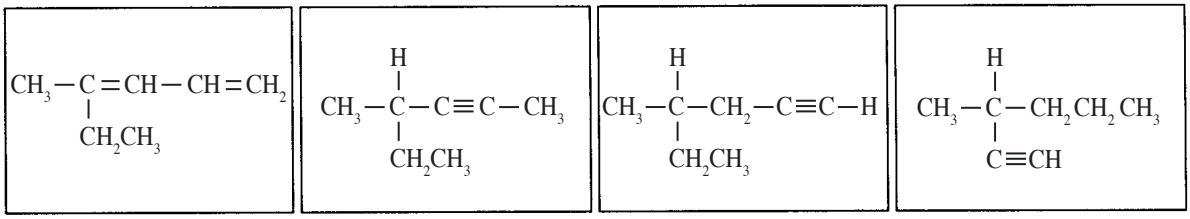
The facility of sub part(*b*) (ii) (III) is 31%. In a reaction, the entropy of a gaseous substance is much greater than that of a solid or a liquid. This part examines the students' understanding about the effect of the change in entropy. When applying this concept in answering a question, physical states of both the reactants and the products must be compared. The failure of many candidates to present the answer on such a comparative basis has led to low scores for this question.

4. (*a*) **A**, **B** and **C** are three isomeric hydrocarbons with the molecular formula C_7H_{14}. Compound **A** shows geometrical isomerism while compounds **B** and **C** do not. All three compounds exhibit optical isomerism. On catalytic hydrogenation, all three compounds yield compound **D** (C_7H_{16}). Compound **D** also shows optical isomerism. Give the structures of **A**, **B**, **C** and **D**. (It is **not** necessary to draw the stereoisomeric forms.)



A **B** **C** **D**

On treatment with bromine followed by dehydrobromination with alcoholic KOH, **A** forms two compounds **E** and **F**, while **B** forms compound **G**, and **C** forms compound **H**. All four compounds **E**, **F**, **G** and **H** have the same molecular formula of C_7H_{12}. Compound **E** shows geometrical isomerism, while **F**, **G** and **H** do not. Give the structures of **E**, **F**, **G** and **H**.



E **F** **G** **H** (08 × 8 marks)

- If A is incorrect, no marks for E and F; if B is incorrect, no marks for G; if C is incorrect, no marks for H.
- For A and E - Disregard geometrical isomers.
- B and C can be interchanged. If so G and H should also be interchanged.

Give **one** chemical test to distinguish between **F** and **G**.

Add ammoniacal $AgNO_3$ or ammoniacal CuCl. (02 marks)

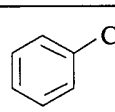
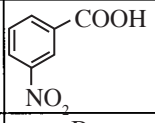
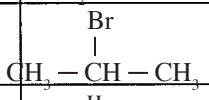
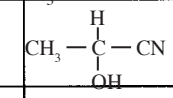
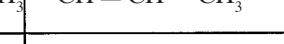
F - no precipitate (02 marks)

G - (white) precipitate with $AgNO_3$ or (chocolate brown) precipitate with CuCl (02 marks)

- Colour of precipitate is not required (08 × 8 + 02 × 3 = 70 marks)

(*b*) The reactant and reagent in each of the reactions 1 - 5 are given in the table below.

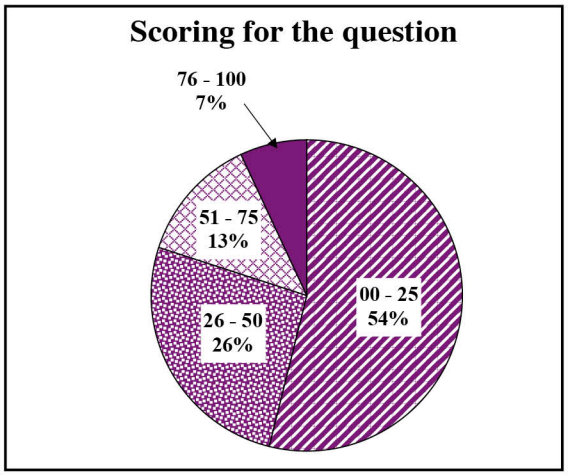
For each reaction, write the reaction type [Nucleophilic addition (A_N), Electrophilic addition (A_E), Nucleophilic substitution (S_N), Electrophilic substitution (S_E), Elimination (E)] and the major product in the relevant boxes.

	Reactant	Reagent	Reaction type	Major product
1		conc. HNO_3/conc. H_2SO_4	S_E	
2	$CH_3CH{=}CH_2$	HBr	A_E	
3	CH_3CHO	H^+/KCN	A_N	
4	$CH_3CH_2CHBrCH_3$	alcoholic KOH	E	
5	CH_3CH_2I	aq. KCN	S_N	CH_3CH_2CN

(03 × 10 = 30 marks)

- Reaction types could be given in words.
- Award marks independently for reaction type and major product.

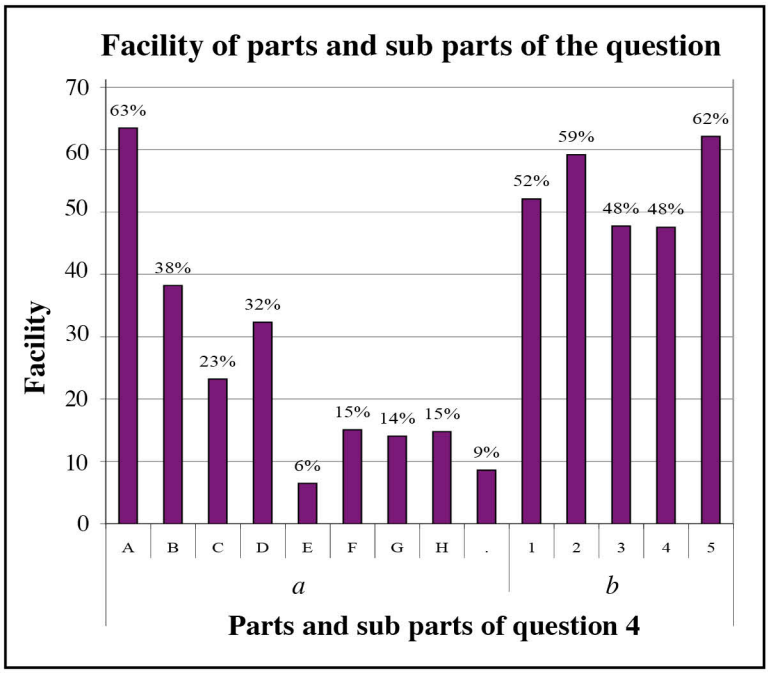
Overall observations and conclusions regarding the answers to Question 4 :



Notwithstanding that question 4 is compulsory, the percentage answering it is 94%. The question carries 100 marks. The percentages scoring within the following four intervals are:

00 - 25	–	54%
26 - 50	–	26%
51 - 75	–	13%
76 - 100	–	7%

For this question 7% have obtained above 75 while 54% have got less than 25.



* Of the 14 sub parts of this question, the facility of *b* is above 45%. Part *a* (A) has the highest facility and its facility is 63%. The lowest facility, 6%, is for sub part *a* (E).

Part (*a*) of question 4 shows a relatively low facility. Part (A) of (*a*) displays a facility of 63% but B and C have shown a lower level of facility. The probable reason for this is the inability of the candidates to understand the problem through its analysis. The question states that compound D is formed by the catalytic hydrogenation of A, B and C. Therefore the carbon skeleton of A, B and C should be the same. So, the candidates should be able to understand that it is only the position of the carbon-carbon double bond in A, B and C is different. As B and C do not exhibit geometrical isomerism, they should understand that in these compounds the double bond is terminal. Owing to the difficulty in understanding this, candidates have failed to show the correct structures of B and C though they were successful in writing the correct structure of A. Thus, the ability of students to analyse a problem needs to be developed.

The facility for sub part E has plummeted to 6%. Facility of part F has gone up above that of E. Possibly this is due to the inclination of the candidates to memorise facts rather than understanding them. It has been learnt that A reacts with bromine to give an alkyne dihalide which undergoes dehydrohalogenation with alcoholic KOH giving an alkyne. Yet the candidates have failed to apply this knowledge to see that a compound with two carbon-carbon double bonds can be formed by this reaction. Perhaps the reason for this is that this alternate reaction has not been taught in the classroom. Nevertheless, the teachers should develop in students the ability of applying to new situations their knowledge in the patterns of chemical reactions.

PART B — ESSAY

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

Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$, Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$

5. (*a*) Consider the following equilibria exhibited by gas **A**, contained in a closed rigid vessel.

(i) At a temperature T (in Kelvin), **A** undergoes the reaction,

$$2A(g) \rightleftharpoons B(g) \qquad (1)$$

After equilibrium is reached, it has been found that 40% of the initial amount of **A** has been converted to **B**, and that the total pressure of the system is $4 \times 10^5\ N\ m^{-2}$. Calculate the equilibrium constant K_p at temperature T for this equilibrium.

(ii) When the temperature of the system is increased to $2T$ (in Kelvin), in addition to the above reaction, **A** undergoes another reaction as shown below.

$$2A(g) \rightleftharpoons C(g) + D(g) \qquad (2)$$

After the system reaches equilibrium at $2T$, it has been found that 20% of the initial amount of **A** has been converted to **C** and **D**, and that 20% of the initial amount of **A** remains.

I. Calculate separately, the number of moles of **A**, **B**, **C** and **D** at this equilibrium if the initial number of moles of **A** was a.

II. Calculate the equilibrium constant K_p for equilibrium (2) at $2T$.

III. Calculate the equilibrium constant K_p for equilibrium (1) at $2T$.

(8.5 ***marks)***

(*b*) A student used the following procedure to determine the distribution coefficient of acetic acid between water and *n*-butanol phases at a constant temperature.
Different volumes of *n*-butanol, 1.0 mol dm^{-3} aqueous acetic acid and water were added to numbered reagent bottles 1 and 2 as shown in the table below.

Reagent bottle	Volume of *n*-butanol/cm^3	Volume of aqueous acetic acid/cm^3	Volume of water/cm^3
1	20.00	40.00	0.00
2	20.00	30.00	10.00

The bottles were shaken well and then, each system was allowed to reach equilibrium. After the layers were separated, 10.00 cm^3 each from the aqueous layer and the butanol layer were withdrawn and titrated with a standard NaOH solution of concentration 0.500 mol dm^{-3}. The reading obtained at the end point on titrating the aqueous layer taken from bottle (1) is given in the table below.

Reagent bottle	Volume of NaOH required for 10.00 cm^3 of aqueous layer / cm^3	Volume of NaOH required for 10.00 cm^3 of *n*-butanol layer / cm^3
1	16.00	x
2	y	z

(i) Calculate the end point x that would have been obtained for the *n*-butanol layer of bottle (1).

(ii) Calculate the distribution coefficient of acetic acid between water and *n*-butanol using the system in bottle (1).

(iii) Calculate the volumes y and z that would have been obtained for the system in bottle (2).

(iv) State the assumptions you made in the above calculations.

(v) Name an indicator that could be used for these titrations.

(vi) State whether the pH of the aqueous layer would change during the period when the bottles were being shaken. Explain your answer.

(6.5 ***marks)***

5. (*a*) (i) $2\mathbf{A}(g) \rightleftharpoons \mathbf{B}(g)$

Initially,	a	--	mol
At eqm.,	$a - \frac{40}{100}a$	$\frac{20}{100}a$	mol
	= 0.6 a	= 0.2 a	mol

2 × (02 + 01)

mole fraction $\frac{0.6\,a}{0.8\,a} = 3/4$ $\frac{0.2\,a}{0.8\,a} = 1/4$ **(03)**

$$K_p = \frac{p_B}{p_A^2}$$ **(03)**

$$K_p = \frac{\frac{1}{4} \times (4 \times 10^5 \text{ N m}^{-2})}{\left[\frac{3}{4} \times (4 \times 10^5 \text{ N m}^{-2})\right]^2}$$ **2 × (02 + 01)**

$$= \frac{1}{9} \times 10^{-5} \text{ N}^{-1} \text{ m}^2 \text{ or } 1.1 \times 10^{-6} \text{ N}^{-1} \text{ m}^2$$ **(02 + 01)**

***Total for* 5(*a*)(i) 21 marks**

(ii) I. $2\mathbf{A}(g) \rightleftharpoons \mathbf{B}(g)$ (1)

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

Initial amount of **A**(g) = a

At equilibrium, Amount of **C**(g) = $\frac{1}{10}$ a **(03)**

Amount of **D**(g) = $\frac{1}{10}$ a **(03)**

Amount of **A**(g) = $\frac{2}{10}$ a **(03)**

Amount of **A**(g) that participates in Eqm. (1) = $\frac{6}{10}$ a **(03)**

Amount of **B**(g) = $\frac{3}{10}$ a **(03)**

Logical approach for the above calculations **(03)**

Note : If a symbol other than 'a' has been used to calculate the amounts of C, D and A, award only (02) marks for each step.

***Total for* 5(*a*)(ii)I 15 marks**

II. Total number of mol of **A**(g), **B**(g), **C**(g) and **D**(g) = $\frac{2}{10}$ a + $\frac{3}{10}$ a + $\frac{1}{10}$ a + $\frac{1}{10}$ a

= $\frac{7}{10}$ a **(03)**

Mole fraction of **A** = $\frac{2a/10}{7a/10} = \frac{2}{7}$ **(03)**

Mole fraction of **B** = $\frac{3a/10}{7a/10} = \frac{3}{7}$ **(03)**

Mole fraction of **C** = $\frac{a/10}{7a/10} = \frac{1}{7}$ **(03)**

Mole fraction of **D** = $\frac{a/10}{7a/10} = \frac{1}{7}$ **(03)**

$$K_p = \frac{p_C\, p_D}{p_A^2} \qquad \textbf{(03)}$$

$$K_p = \frac{\frac{1}{7}P \times \frac{1}{7}P}{\left[\frac{2}{7}P\right]^2} \qquad \textbf{(03)}$$

$$= \quad 1/4 \quad \text{or} \quad 0.25 \qquad \textbf{(02 + 01)}$$

Total for **5(*a*)(ii)II** **24 marks**

III. Total mol of gases $T = 0.6a + 0.2a = 0.8a$

$$pV = nRT \quad \text{or} \quad \frac{p}{T} \propto n \text{ at constant } V \qquad \textbf{(03)}$$

At T, $\quad \frac{4 \times 10^5\,\text{N m}^{-2}}{T} \propto 0.8a \quad (1)$

At $2T$, $\quad \frac{p}{2T} \propto 0.7a \quad (2)$ For both (1) and (2) **(02+01)**

$$\frac{(1)}{(2)} \qquad \frac{4 \times 10^5\,\text{N m}^{-2}}{P/2} = \frac{0.8a}{0.7a} \qquad \textbf{(03)}$$

$$P = 7 \times 10^5\,\text{N m}^{-2} \qquad \textbf{(02 + 01)}$$

Note : Award full marks **(12)** for the calculation of total pressure using $pV = nRT$

Partial pressure of **A** $= \frac{2}{7} \times (7 \times 10^5\,\text{N m}^{-2}) = 2 \times 10^5\,\text{N m}^{-2}$ **(02+01)**

Partial pressure of **B** $= \frac{3}{7} \times (7 \times 10^5\,\text{N m}^{-2}) = 3 \times 10^5\,\text{N m}^{-2}$ **(02+01)**

$$K_p = \frac{(3 \times 10^5\,\text{N m}^{-2})}{(2 \times 10^5\,\text{N m}^{-2})^2} \qquad \textbf{02+01)}$$

$$= \quad 7.5\times 10^{-6}\,\text{N}^{-1}\,\text{m}^2 \qquad \textbf{(03 + 01)}$$

Total for **5(*a*)(ii)III** **24 marks**

Total for **5(*a*)** **85 marks**

(*b*) (i) Initial amount of mol of CH_3COOH $= 1.0\ \text{mol dm}^{-3} \times \frac{40.00}{1000}\ \text{dm}^3$

$= 0.040$ mol **(02 + 01)**

$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

After partitioning

Amount of CH_3COOH in 10.00 cm^3 of the aqueous layer

$= 0.5\ \text{mol dm}^{-3} \times \frac{16.00}{1000}\ \text{dm}^3$

$= 0.008$ mol **(02 + 01)**

Amount of CH_3COOH in the aqueous layer

$= 0.008\ \text{mol} \times \frac{40.00\,\text{cm}^3}{10.00\,\text{cm}^3}$

$= 0.032$ mol **(02 + 01)**

Amount of CH_3COOH in the butanol layer = 0.040 mol − 0.032 mol

= 0.008 mol **(02 + 01)**

Amount of CH_3COOH in 10.00 cm^3 of the butanol layer

$$= 0.008 \text{ mol} \times \frac{10.00\,cm^3}{20.00\,cm^3}$$

= 0.004 mol **(02 + 01)**

Expected end point (x)

$$= \frac{0.004 \text{ mol}}{0.50 \text{ mol dm}^{-3}}$$

= 0.008 dm^3 or 8.0 cm^3 **(02 + 01)**

***Total for* 5(*b*)(i) 18 marks**

(ii) Amount of CH_3COOH in 10.00 cm^3 of the aqueous layer = 0.008 mol

Amount of CH_3COOH in 10.00 cm^3 of the butanol layer = 0.004 mol

$$\text{Partition coefficient} = \frac{[CH_3COOH]_{but}}{[CH_3COOH]_{H_2O}}$$ **(03)**

$$= \frac{0.004 \text{ mol}/(10.00/1000\ cm^3)}{0.008 \text{ mol}/(10.00/1000\ cm^3)} = 0.5$$ **(02 + 01)**

.....

Alternative answer for 5(*b*)(ii)

Butanol layer required half the volume of NaOH solution required for the aqueous layer. **(03)**

$$\text{Therefore, Partition coefficient} = \frac{[CH_3COOH]_{but}}{[CH_3COOH]_{H_2O}} = 0.5$$ **(02 + 01)**

.....

Note : 1. $\text{Partition coefficient} = \frac{[CH_3COOH]_{H_2O}}{[CH_3COOH]_{but}} = 2$ is also accepted for full marks.

2. The number of moles of acetic acid in 10.00 cm^3 of each layer can also be used to calculate the partition coefficient.

***Total for* 5(*b*)(ii) 06 marks**

(iii) Before partitioning

$$\text{Amount of } CH_3COOH = 1.0 \text{ mol dm}^{-3} \times \frac{30.00}{1000}\ dm^3$$

= 0.030 mol

Volume of NaOH required for the total volumes of both phases **(03)**

$$= \frac{0.030 \text{ mol}}{0.50 \text{ mol dm}^{-3}}$$

= 60.0 cm^3 **(02 + 01)**

$4y + 2z = 60.0$ (1) **(03)**

$\frac{z}{y} = \frac{1}{2}$ (2) **(03)**

By solving (1) and (2),

$y = 12.00\,cm^3$ **(02 + 01)**

$z = 6.00\,cm^3$ **(02 + 01)**

.....

Alternative answer for 5(*b*)(iii)

Initial concentration of acetic acid in bottle 1 = $1.0\,mol\,dm^{-3}$

Initial concentration of acetic acid in bottle 2 = $\frac{3}{4} \times 1.0\,mol\,dm^{-3}$ **(05 + 01)**

Therefore, y = $\frac{3}{4} \times 16.00\,cm^3$ **(03)**

= $12.00\,cm^3$ **(02 + 01)**

z = $\frac{3}{4} \times 8.00\,cm^3$ **(03)**

= $6.00\,cm^3$ **(02 + 01)**

Total for **5(*b*)(iii) 18 marks**

(iv) 1. Butanol and aqueous layers do not mix with each other.

2. Butanol does not vaporize or the volume of the butanol layer does not change.

3. Extent of ionization of CH_3COOH is negligible.

4. Acetic acid does not undergo dimerization in the butanol layer or acetic acid remains in the same molecular form.

Any <u>two</u> correct assumptions **(03 × 2 = 06)**

(v) Phenolphthlein or Bromothymol blue **(03)**

(vi) Yes **(02)**

During partitioning CH_3COOH molecules are transferred to the butanol layer **(03)**

$[CH_3COOH]_{aq}$ decreases **(03)**

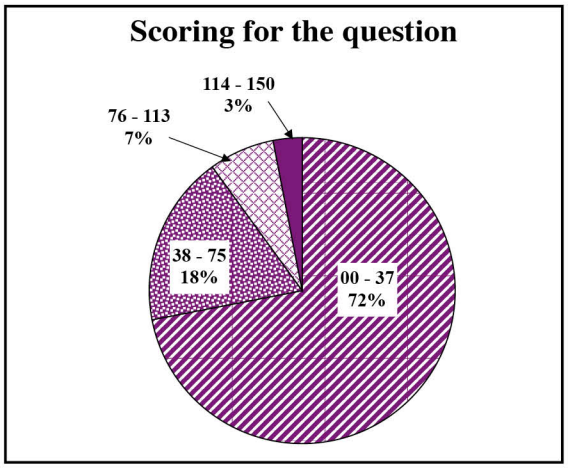
$[H_3O^+]_{aq}$ decreases **(03)**

thus, pH increases **(03)**

Total for **5(*b*)(iv) 14 marks**

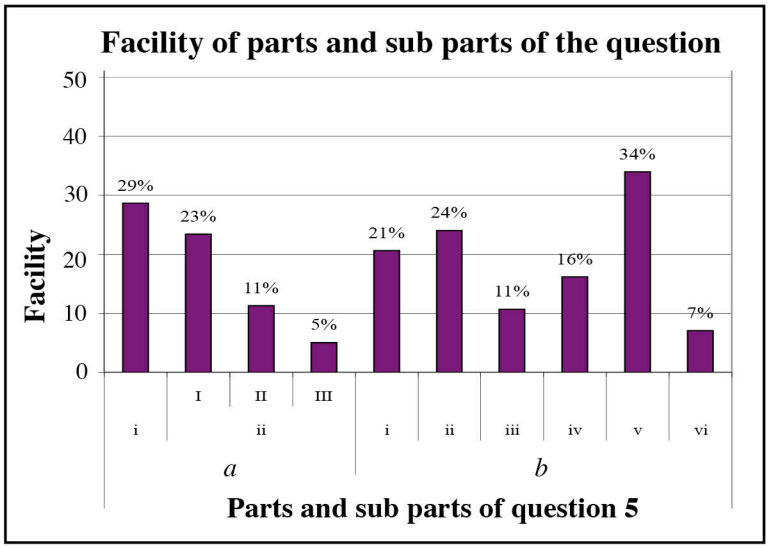
Total for **5(*b*) 65 marks**

Overall observations and conclusions regarding the answers to Question 5 :



Sixty four percent have selected this question. Of the two Physical Chemistry questions in Part B this is the question selected by most of the candidates. 150 marks have been allocated for this question. The percentages scoring within the following four intervals are:

00 - 37	–	72%
38 - 75	–	18%
76 - 113	–	7%
114 - 150	–	3%



* The question comprises 10 sub parts. The sub part of highest facility is *b* (v). Its facility is 34%. The facility of all the other 9 sub parts is below 30%. *a* (ii) (III) is the sub part of lowest facility. Its facility is 5%.

Part (*a*) of this question is related to chemical equilibrium and as usual many students (64%) had selected it. Nevertheless, of all the 3 essay questions in Part B this had been the question of lowest facility. 72% of the candidates have scored less than 37 for this question out of 150.

Expectation of (*a*) (i) was to examine the ability to apply the basic knowledge of stoichiometric coefficients for the chemical systems in equilibrium. For not understanding this correctly, some candidates had taken the amount of B formed after equilibrium as 40%. The way they had presented answers showed their scant knowledge about the percentages. Not determining the mole fractions of compounds correctly, not indicating the physical states of substances, not using units in substitution of values and errors in mathematical simplifications have brought about lowering of marks.

Part (*a*) (ii) examines the application of the students' knowledge of the following to solve problems.

* changes taking place in equilibrium systems when the temperature changes
* corresponding changes in the composition of the equilibrium systems
* inapplicability of Boyle's law, Charles' law and combined gas law which hold only for a fixed mass of a gas

Lack of proper understanding of the above has erred the calculation of the equilibrium amounts of moles which in turn led to miscalculate the mole fractions. The candidates should develop the ability of calculating with reasoning the quantities related to different equilibrium systems and their changes on external conditions.

Part (*b*) (ii) aimed to examine the students' knowledge in the relationship between the partition coefficient and concentration and changes in concentration due to dilution.

The substitution of the amount of moles by many candidates in places where concentration is the necessity, had made their answers unsuccessful. Lack of proper understanding about the practical tests and their recording is also a reason for the failure.

Though candidates knew the correct answer for part (iv), they have got low marks because of their inability to present it logically to suit the question.

The candidates should develop the skill of writing in brevity containing only the relevant scientific facts logically.

6. (*a*) (i) Derive an expression for the pH of an aqueous CH_3COOH solution of concentration c mol dm^{-3}, in terms of the acid dissociation constant K_a and c.

(ii) Write the assumptions you made in the above derivation.

(iii) A 100.0 cm^3 sample of the above acid solution was diluted to 1.00 dm^3 by adding distilled water. Write an expression for the pH of this acid solution with the help of the expression obtained in Part (i) above.

(iv) Using the answers obtained in Parts (i) and (iii) above, show that the difference in pH values of the two acid solutions is 0.5 pH units.

(v) Calculate the pH of the solution prepared by mixing 220.0 cm^3 of the acid solution in Part (i) above and 20.0 cm^3 of NaOH solution of concentration c mol dm^{-3}.

(7.5 *marks*)

(*b*) (i) The solubility product of $BaSO_4$ is 1.0×10^{-10} mol^2 dm^{-6} at 25 °C. Calculate the Ba^{2+} concentration in a saturated aqueous solution of $BaSO_4$ at this temperature.

(ii) Calculate the mass of pure solid Na_2SO_4 that should be added to 1.0 dm^3 of the solution in Part (i) above to halve the concentration of Ba^{2+} at 25 °C. (O = 16, Na = 23, S = 32)

State assumptions, if any, you made in this calculation.

(iii) The solubility product of $PbSO_4$ is 1.6×10^{-8} mol^2 dm^{-6} at 25 °C. Calculate the concentrations of Ba^{2+} and Pb^{2+} separately in an aqueous solution saturated with both $BaSO_4$ and $PbSO_4$ at this temperature.

(7.5 *marks*)

6. (*a*) (i)

$$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq) \quad \textbf{(03)}$$

Initially,	c	---	---	mol dm^{-3}	
At eqm.,	$c - x$	x	x	mol dm^{-3}	**(02 + 01)**

$$K_a = \frac{[H_3O^+(aq)]\,[CH_3COO^-(aq)]}{[CH_3COOH(aq)]} \quad \textbf{(03)}$$

$$= \frac{x^2}{c - x} \text{ mol dm}^{-3} \quad \textbf{(03)}$$

Note : Award **no** marks for the chemical equation and for the expression of K_a if physical states are **not** given.

$c - x \approx c$

$$K_a = \frac{x^2}{c} \quad \textbf{(03)}$$

$$x^2 = K_a\, c \quad \textbf{(03)}$$

$$x = [H_3O^+(aq)] = \sqrt{K_a\, c}$$

$$pH = -\log(\sqrt{K_a\, c})$$

or

$$pH = -\frac{1}{2}\log K_a - \frac{1}{2}\log c \quad \textbf{(03)}$$

***Total for* 6(*a*)(i)** **21 marks**

(ii) Assumption : x is negligible compared to c or $c - x \approx c$ or amount ionized is negligible. **(03)**

***Total for* 6(*a*)(ii)** **03 marks**

(iii) Concentration of the diluted solution $= c \text{ mol dm}^{-3} \times \frac{100\,\text{cm}^3}{1000\,\text{cm}^3}$

$= \frac{c}{10} \text{ mol dm}^{-3}$ **(02 + 01)**

$\text{pH} = -\log (\sqrt{K_a\, c/10})$ or

$\text{pH} = -\frac{1}{2} \log K_a - \frac{1}{2} \log \frac{c}{10}$ **(06)**

***Total for* 6(*a*)(iii)** **09 marks**

(iv) pH of the diluted solution – pH of the initial solution

$= -\log (\sqrt{K_a\, c/10}) - [-\log (\sqrt{K_a\, c})]$ **(03)**

$= -\frac{1}{2} \log K_a - \frac{1}{2} \log \frac{c}{10} - \left(-\frac{1}{2} \log K_a - \frac{1}{2} \log c\right)$ **(03)**

$= -\frac{1}{2} \log K_a - \frac{1}{2} \log \frac{c}{10} + \frac{1}{2} \log K_a + \frac{1}{2} \log c$

$= \frac{1}{2} \log c - \frac{1}{2} \log \frac{c}{10}$ **(03)**

$= \frac{1}{2} \log \frac{c}{c/10}$ **(03)**

$= \frac{1}{2} \log 10$ **(03)**

$= 0.5$ **(03)**

***Total for* 6(*a*)(iv)** **18 marks**

(v) $CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$ **(03)**

Total volume of solution $= 240.0\ \text{cm}^3$

Concentration of the salt formed $= \frac{20.0\,\text{cm}^3}{240.0\,\text{cm}^3} \times c \text{ mol dm}^{-3}$ **(02 + 01)**

Concentration of the remaining acid $= \frac{200.0\,\text{cm}^3}{240.0\,\text{cm}^3} \times c \text{ mol dm}^{-3}$ **(02 + 01)**

$\text{pH} = \text{p}K_a + \log [\text{ salt }] / [\text{ acid }]$ **(06)**

$= \text{p}K_a + \log \left[\frac{\frac{20.0\,\text{cm}^3}{240.0\,\text{cm}^3} \times c \text{ mol dm}^{-3}}{\frac{200.0\,\text{cm}^3}{240.0\,\text{cm}^3} \times c \text{ mol dm}^{-3}} \right]$ **(03)**

$= \text{p}K_a + \log (1/10)$ **(03)**

$= \text{p}K_a - 1$ **(03)**

***Total for* 6(*a*)(v)** **24 marks**

(*b*) (i) Let 's' ($mol\,dm^{-3}$) be the concentration of Ba^{2+} in a saturated solution of $BaSO_4(s)$.

$$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq) \quad \textbf{(03)}$$

At eqm., -- s s **(03)**

$$K_{sp} = [Ba^{2+}(aq)]\,[SO_4^{2-}(aq)] \quad \textbf{(03)}$$

$$= s^2$$

$$s^2 = 1.0 \times 10^{-10}\,mol^2\,dm^{-6} \quad \textbf{(02 + 01)}$$

$$s = 1.0 \times 10^{-5}\,mol\,dm^{-3}$$

Concentration of $Ba^{2+} = 1.0 \times 10^{-5}\,mol\,dm^{-3}$ **(02 + 01)**

Note : Award **no** marks for the chemical equation and for the expression of K_{sp} if physical states are **not** given.

***Total for* 6(*b*)(i) 15 marks**

(ii) $$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$$

At eqm., -- $5.0 \times 10^{-6}\,mol\,dm^{-3}$ x **(03)**

where x = concentration of $SO_4^{2-}(aq)$ ($mol\,dm^{-3}$) in solution at precipitation.

$$K_{sp} = [Ba^{2+}(aq)]\,[SO_4^{2-}(aq)] \quad \textbf{(03)}$$

$$= (5.0 \times 10^{-6}\,mol\,dm^{-3})\ x = 1.0 \times 10^{-10}\,mol^2\,dm^{-6} \quad \textbf{(02 + 01)}$$

$$x = 2.0 \times 10^{-5}\,mol\,dm^{-3} \quad \textbf{(02 + 01)}$$

Concentration of $SO_4^{2-}(aq)$ from Na_2SO_4

$$= 2.0 \times 10^{-5}\,mol\,dm^{-3} - 5.0 \times 10^{-6}\,mol\,dm^{-3} \quad \textbf{(03)}$$

$$= 1.5 \times 10^{-5}\,mol\,dm^{-3} \quad \textbf{(02 + 01)}$$

.....

Alternative answer for 6(*b*)(ii)

$$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$$

At eqm., -- $5.0 \times 10^{-6}\,mol\,dm^{-3}$ $5.0 \times 10^{-6}\,mol\,dm^{-3} + y$ **(06)**

where y = concentration of $SO_4^{2-}(aq)$ ($mol\,dm^{-3}$) due to Na_2SO_4 at precipitation

$$K_{sp} = [Ba^{2+}(aq)]\,[SO_4^{2-}(aq)] \quad \textbf{(03)}$$

$$(5.0 \times 10^{-6}\,mol\,dm^{-3})\,(y + 5.0 \times 10^{-6}\,mol\,dm^{-3}) = 1.0 \times 10^{-10}\,mol^2\,dm^{-6} \quad \textbf{(02 + 01)}$$

$$y + 5.0 \times 10^{-6}\,mol\,dm^{-3} = 2.0 \times 10^{-5}\,mol\,dm^{-3} \quad \textbf{(02 + 01)}$$

$$y = 1.5 \times 10^{-5}\,mol\,dm^{-3} \quad \textbf{(02 + 01)}$$

.....

Amount of Na_2SO_4 to be added = $1.5 \times 10^{-5}\,mol\,dm^{-3} \times 1.0\,dm^3$ or $1.5 \times 10^{-5}\,mol$ **(02 + 01)**

Mass of Na_2SO_4 to be added = $1.5 \times 10^{-5}\,mol \times 142\,g\,mol^{-1}$ **(02 + 01)**

$$= 2.13 \times 10^{-3}\,g \text{ or } 2.13\,mg \quad \textbf{(02 + 01)}$$

Assumption : Volume of the solution is not changed during the addition of Na_2SO_4 **(03)**

***Total for* 6(*b*)(ii) 27 marks**

(iii) Let s = solubility of $BaSO_4(s)$ ($mol\,dm^{-3}$) and s' = solubility of $PbSO_4$ ($mol\,dm^{-3}$).

$$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$$

At eqm., -- s $s + s'$ **(06)**

$$PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq) \quad \textbf{(03)}$$

At eqm., -- s' $s + s'$ **(03)**

$$K_{sp}(BaSO_4) = [Ba^{2+}(aq)]\,[SO_4^{2-}(aq)]$$

$$s(s + s') = 1.0 \times 10^{-10}\,mol^2\,dm^{-6} \quad (1) \quad \textbf{(02 + 01)}$$

$$K_{sp}(PbSO_4) = [Pb^{2+}(aq)]\,[SO_4^{2-}(aq)] \quad \textbf{(03)}$$

$$s'(s + s') = 1.6 \times 10^{-8}\,mol^2\,dm^{-6} \quad (2) \quad \textbf{(02 + 01)}$$

$$\frac{(2)}{(1)} \quad \frac{s'}{s} = \frac{1.6 \times 10^{-8}}{1.0 \times 10^{-10}} = 160 \quad \textbf{(03)}$$

$$(1) \quad s(s + 160\,s) = 1.0 \times 10^{-10} \quad \textbf{(03)}$$

$$s = 7.9 \times 10^{-7}$$

Note : It can be assumed that $160 + 1 \approx 160$

Concentration of $Ba^{2+} = 7.9 \times 10^{-7}\,mol\,dm^{-3}$ **(02 + 01)**

Concentration of $Pb^{2+} = 160 \times 7.9 \times 10^{-7}\,mol\,dm^{-3}$

$= 1.3 \times 10^{-4}\,mol\,dm^{-3}$ **(02 + 01)**

.....

Alternative answer for 6(*b*)(iii)

$$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$$

$$PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq) \quad \textbf{(03)}$$

$$K_{sp}(BaSO_4) = [Ba^{2+}(aq)]\,[SO_4^{2-}(aq)] = 1.0 \times 10^{-10}\,mol^2\,dm^{-6} \quad (1)$$

$$K_{sp}(PbSO_4) = [Pb^{2+}(aq)]\,[SO_4^{2-}(aq)] = 1.6 \times 10^{-8}\,mol^2\,dm^{-6} \quad (2) \quad \textbf{(02 + 01)}$$

$$\frac{(2)}{(1)} \quad \frac{[Pb^{2+}]}{[Ba^{2+}]} = \frac{1.6 \times 10^{-8}}{1.0 \times 10^{-10}} = 160 \quad \textbf{(03)}$$

$$[Ba^{2+}(aq)] + [Pb^{2+}(aq)] = [SO_4^{2-}(aq)] \quad (3) \quad \textbf{(09)}$$

$$1 + \frac{[Pb^{2+}]}{[Ba^{2+}]} = \frac{[SO_4^{2-}]}{[Ba^{2+}]} \quad \textbf{(03)}$$

$$1 + 160 = \frac{[SO_4^{2-}]}{[Ba^{2+}]}$$

$$1 + 160 = \frac{[Ba^{2+}][SO_4^{2-}]}{[Ba^{2+}]^2} \quad \textbf{(03)}$$

$$161 = \frac{1.0 \times 10^{-10}\,mol^2\,dm^{-6}}{[Ba^{2+}]^2} \quad \textbf{(02 + 01)}$$

$$[Ba^{2+}] = 7.9 \times 10^{-7}\,mol\,dm^{-3} \quad \textbf{(02 + 01)}$$

Note : It can be assumed that $160 + 1 \approx 160$

Concentration of $Ba^{2+} = 7.9 \times 10^{-7}\,mol\,dm^{-3}$

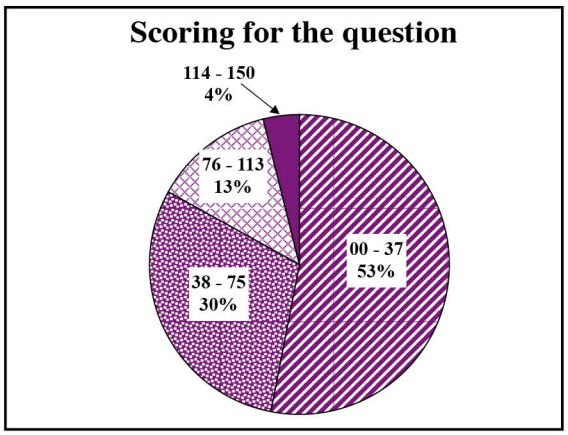
Concentration of $Pb^{2+} = 160 \times 7.9 \times 10^{-7}\,mol\,dm^{-3}$

$= 1.3 \times 10^{-4}\,mol\,dm^{-3}$ **(02 + 01)**

***Total for* 6(*b*)(iii) 33 marks**

***Total for* 6(*b*) 75 marks**

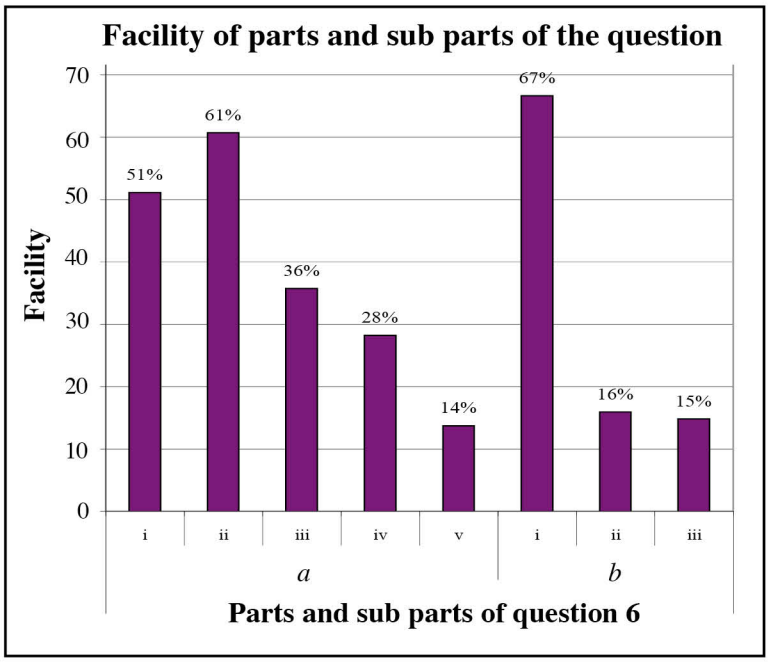
Overall observations and conclusions regarding the answers to Question 6 :



About 63% have selected question 6. The question carries 150 marks. Given below are the percentages scoring within the four selected intervals:

00 - 37 – 53%
38 - 75 – 30%
76 - 113 – 13%
114 - 150 – 4%

The percentage scoring above 114 is 4% while 53% have scored below 37.



* This question comprises 8 sub parts. The facility of 3 of them is greater than 50%. *a* (v) had been the least facile sub part with a facility of 14. *b* (i) being the most facile has the facility of 67%.

In spite of the general reluctance of the candidates to select questions relating to ionic equilibria (calculation of pH) and precipitation equilibria (calculation of Ksp), more than 60% had selected question 6. This question aimed to examine the knowledge about the change in pH on dilution and buffer solutions and the competency of calculating the pH of a weak acid and buffer solutions. So, during the learning teaching process it is a requirement to develop in students the ability of reaching the answer logically so that they can successfully deal with the questions based on pH.

In this, the facility of parts (i) and (ii) are 51% and 61% respectively. But the facility of parts (iii), (iv) and (v) decreases as reflected by the respective values 36%, 28% and 14%. The first two parts of this question can be answered in a very short time using the theoretical facts of chemistry that are familiar to students.

The problem in part (iii) is on calculating the pH of the new solution obtained by diluting a given solution whereas in part (iv) the problem has been presented in terms of an expression giving the difference of pH in two solutions. Yet, the students have not been successful in answering the question. Clearly they have to develop the ability of mathematical operations.

In sub part (v), excess of a weak acid had been mixed with a strong base producing the components of a buffer solution namely a weak acid and its salt. Henderson equation can be used to determine the pH of such a solution. Nonetheless, it was seen that the students lack adequate knowledge to calculate the concentrations of the acid and the salt using the above concept and substitute correctly in the relevant equation.

Aim of part (*b*) was to examine the competency of calculating the solubility of a sparingly soluble salt in water and applying the concept of common ion effect to determine the relative decrease in solubilities of two salts containing the common ion. The facility of part (i) is relatively high (67%). But parts (ii) and (iii) declare much lower facilities of 16% and 15% respectively. In parts (ii) and (iii) of this question, the students had made an attempt to apply mechanically the assumptions generally made when solving problems related to common ion effect irrelevantly. So, in the process of learning and teaching, attention must be paid to solve mathematical problems related to Physical Chemistry in different directions.

7. (*a*) Grignard reagents are prepared by reacting alkyl or aryl halides with Mg in dry ether. However, the Grignard reagent given below **cannot** be prepared using the following reaction. Explain why it cannot be.

$$HOCH_2CH_2CH_2Br \xrightarrow{Mg\,/\,dry\ ether} HOCH_2CH_2CH_2MgBr$$

(2.0 *marks*)

(*b*) Provide a mechanism for chlorination of benzene in the presence of $FeCl_3$.

(3.0 *marks*)

(*c*) Using **only** the chemicals given in the list, show how you would carry out the following conversion.

$$(CH_3)_2C=CH_2 \longrightarrow (CH_3)_3C-\overset{\overset{O}{\|}}{C}-OC(CH_3)_3$$

List of chemicals
conc. H_2SO_4, dil. H_2SO_4, PCl_5,
Mg, Ether, HCHO, $K_2Cr_2O_7$

(5.0 *marks*)

(*d*) Show how you would synthesize the following compound using propanal as the **only** organic starting material.

$$CH_3-CH_2-\overset{\overset{O}{\|}}{C}-NH-CH_2-CH_2-CH_3$$

(5.0 *marks*)

7. (*a*) As soon as the Grignard reagent $HOCH_2CH_2CH_2MgBr$ is formed in the reaction vessel, it will react with another molecule of $HOCH_2CH_2CH_2Br$ / $HOCH_2CH_2CH_2MgBr$ (10) to from $HOCH_2CH_2CH_3$ (05)

(15)

or

$$HOCH_2CH_2CH_2Br \xrightarrow{Mg/dry\ ether} HOCH_2CH_2CH_2MgBr \quad \textbf{(05)}$$

$$\textbf{(05)} \downarrow \; HOCH_2CH_2CH_2Br$$

$$HOCH_2CH_2CH_3 + MgBr-OCH_2CH_2CH_2Br$$
$$\textbf{(05)}$$

(15)

Therefore Grignard reagent formed is decomposed in the presence of alcohols. **(05)**

(The final product will be $BrMgOCH_2CH_2CH_3$)

(Alternative statements indicating that RMgBr will decompose in the presence of active H compounds are acceptable)

Part marks may be awarded as follows :

Grignard reagents react with alcohols (or any proton donating agents) as given below : **(05)**

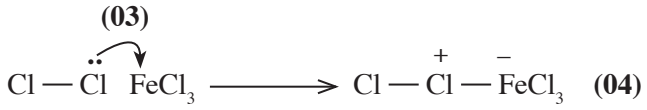
$$ROH + R'MgBr \longrightarrow R'H + MgBr$$

or

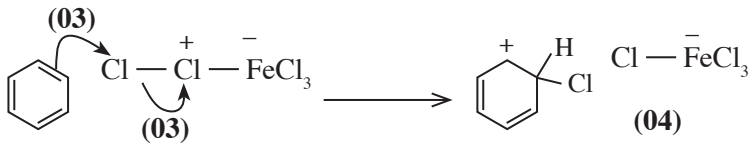
$$H^+ + R'MgBr \longrightarrow R'H$$

***Total for* 7(*a*) 20 marks**

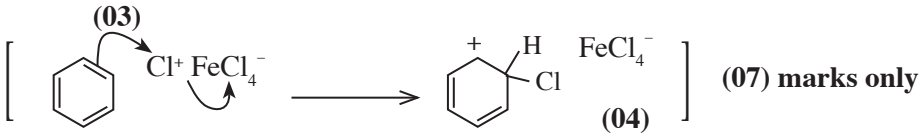
(*b*)



[Cl_2 + $FeCl_3$ ⟶ Cl^+ $FeCl_4^-$] **(04) marks only**

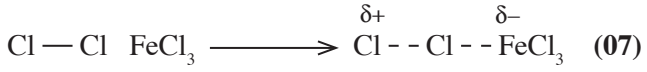


(10 marks)

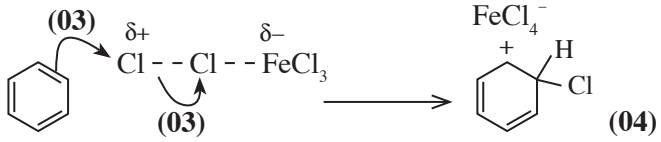


(07) marks only

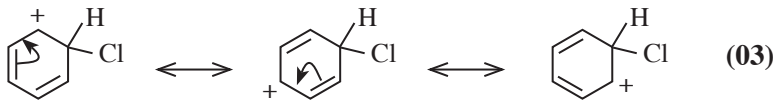
or

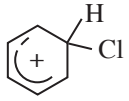


If arrow is drawn deduct 03 marks, otherwise award full marks.



The intermediate ion is stabilized by resonance.

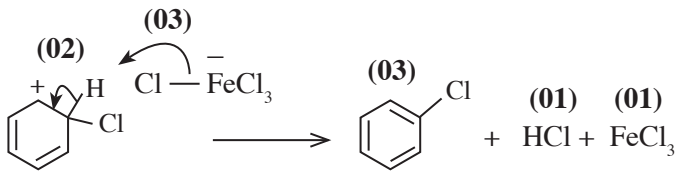


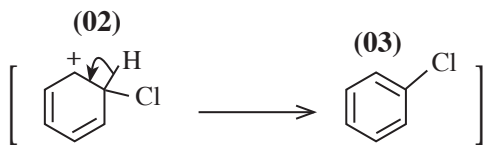


only (01) mark

- Drawing of arrows indicating electron movement is not necessary.
- If only two resonance structures are drawn (02) marks only.
- If ⟷ is not given, no marks.

Loss of a proton from the intermediate ion restores the stable aromatic sextet.

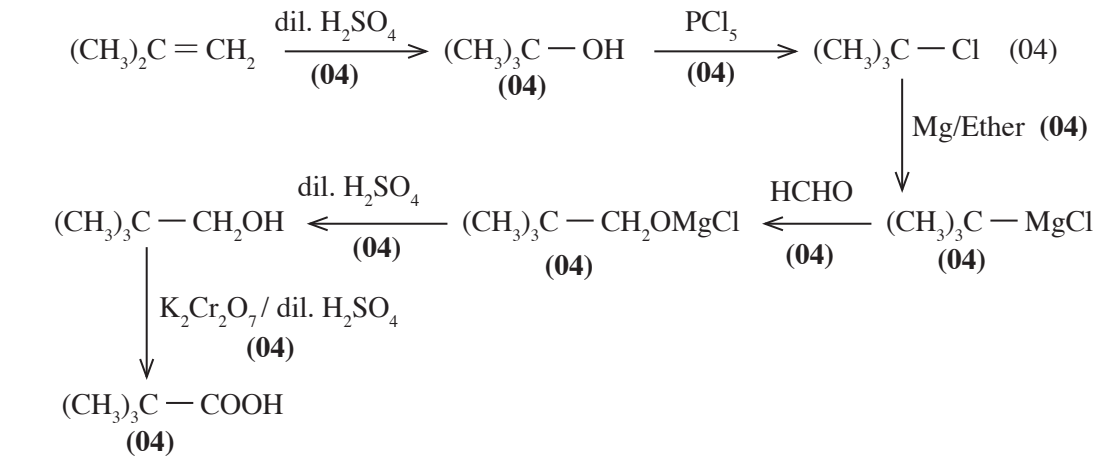


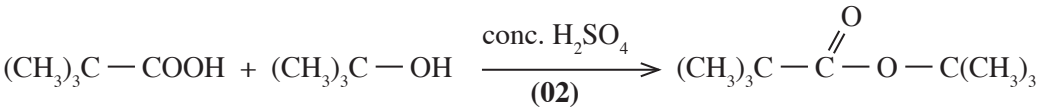


(05) marks only

Total for **7(*b*)**	**30 marks**

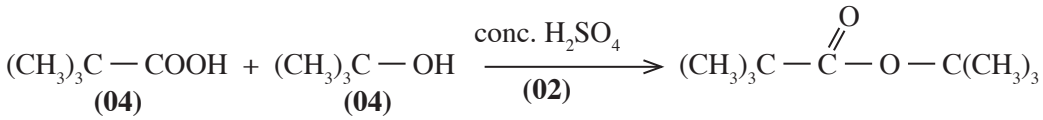
(*c*)





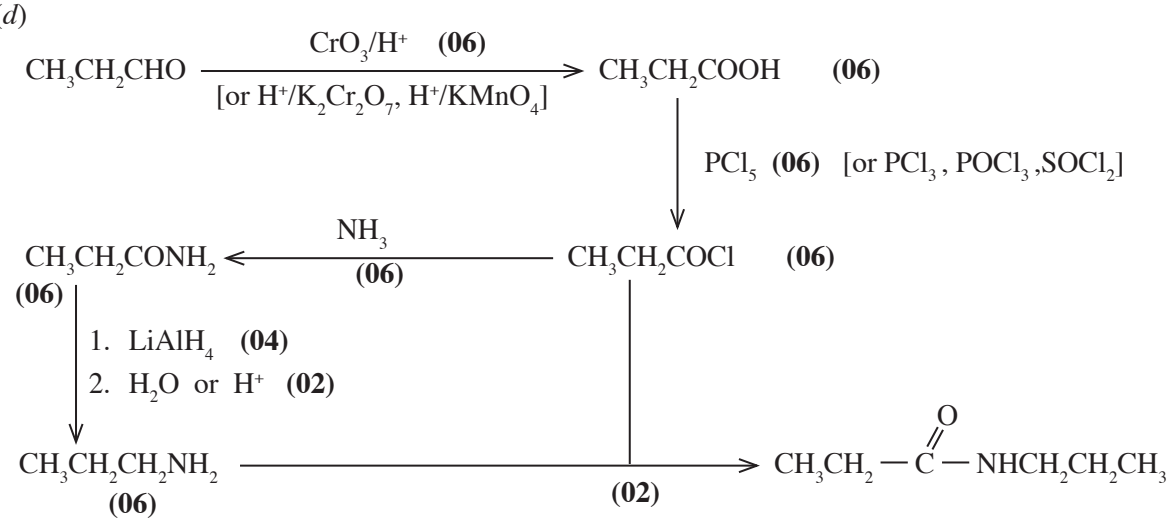
(04) × 12 + (02) × 1 = 50 marks

If only the following is given, award (10) marks



***Total for* 7(*c*)**	**50 marks**

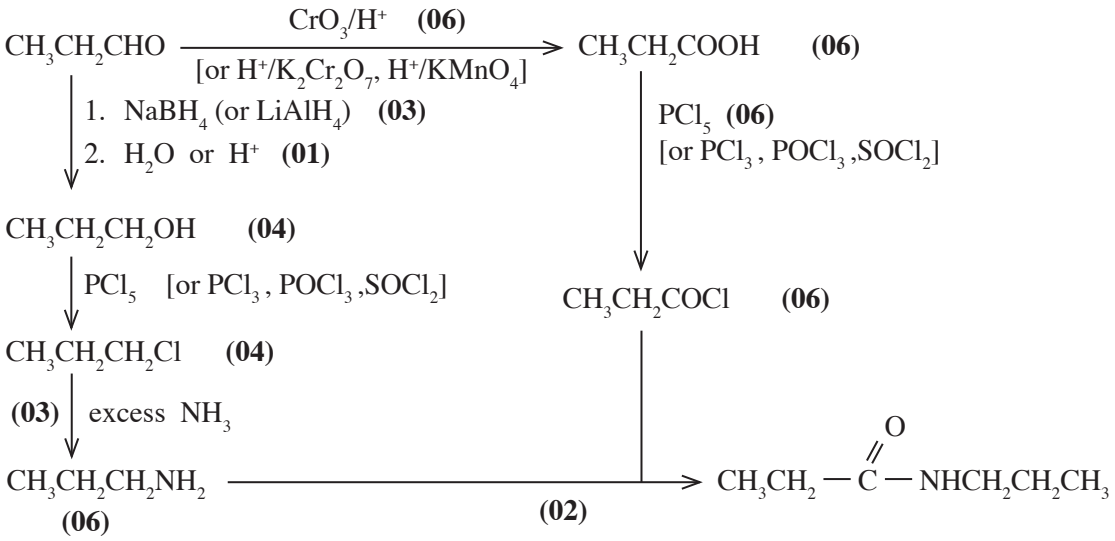
(*d*)



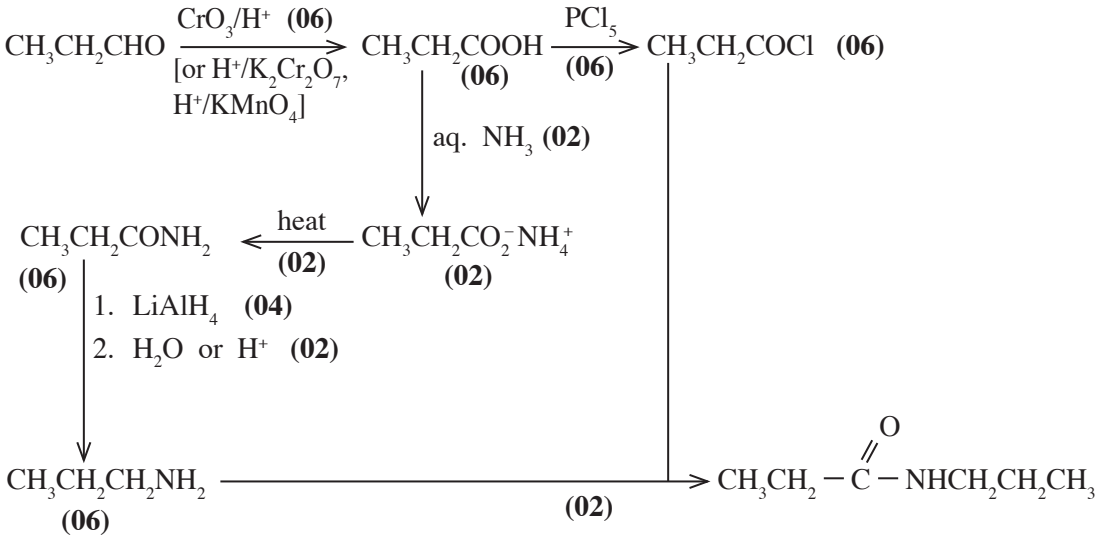
(06) × 8 + (02) × 1 = 50 marks

This is the most acceptable method. However, marks may be awarded for the following alternate methods.

Alternate method I :



Alternate method II :

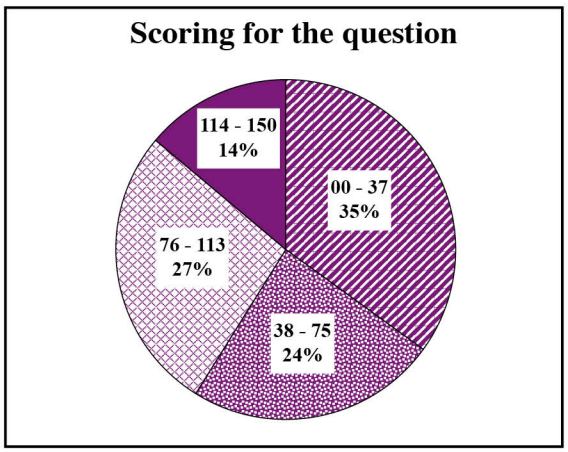


In all three schemes, if the final product is obtained by **heating** the carboxylic acid with the amine (without going through the acid halide), award **(14)** marks for that step.

Note : In the conversions, if the product is correct, but the reagent is incorrect, **award** marks for the product. If the product is incorrect, but the reagent is correct, **do not** award marks for the reagent.

***Total for* 7(*d*)**	**50 marks**

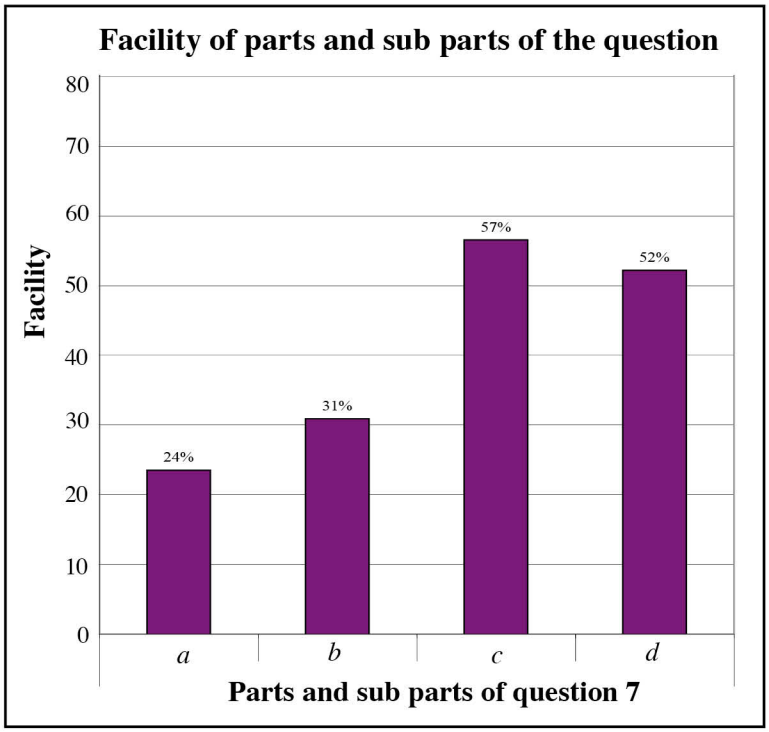
Overall observations and conclusions regarding the answers to Question 7 :



The percentage selecting question 7 is 46%. Out of the 3 questions in part B this is the one receiving lower choice. This embodies 150 marks. The percentages scoring within the four selected class intervals are as follows:

00 - 37 – 35%
38 - 75 – 24%
76 - 113 – 27%
114 - 150 – 14%

The percentage scoring above 114 for this question is 14% while 35% have rated below 37.



* The question has 4 sub parts. Of them, the facility of two parts stands above 50%. The easiest part, (*c*) has a facility of 57%. Sub part (*a*) is the one of lowest facility. Its facility is 24%.

Even though the least number of candidates selected this question from the 3 questions in part B, the achievement shown by students in this question is higher compared to other two questions. The facility of sub parts 7 (*a*) and 7 (*b*) are 24% and 31% respectively. Sub parts 7 (*c*) and 7 (*d*) record a facility of 57% and 52% respectively. The low facility for part 7 (*a*) has been caused by the lack of clear understanding about the reactivity of this reagent in students though they have learnt the reactions which involve it. Students should understand that Grignard's reagent is a powerful nucleophilic reagent and acts as a base in the presence of compounds which have active hydrogen.

Candidates have shown a low facility (31%) for the sub part 7 (*b*) based on the fundamental principles related to a mechanism in the syllabus. The students have failed to present the correct answer for not indicating the electron shifts and the structure of the intermediate products in the mechanism correctly. The candidates should be more attentive in presenting mechanisms to avoid such situations.

PART C — ESSAY

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

8. (*a*) (i) A solid mixture contains only **two** of the following:

$Ba(NO_3)_2$ $Zn(NO_3)_2$ $AgNO_3$ $CaCO_3$ NaOH

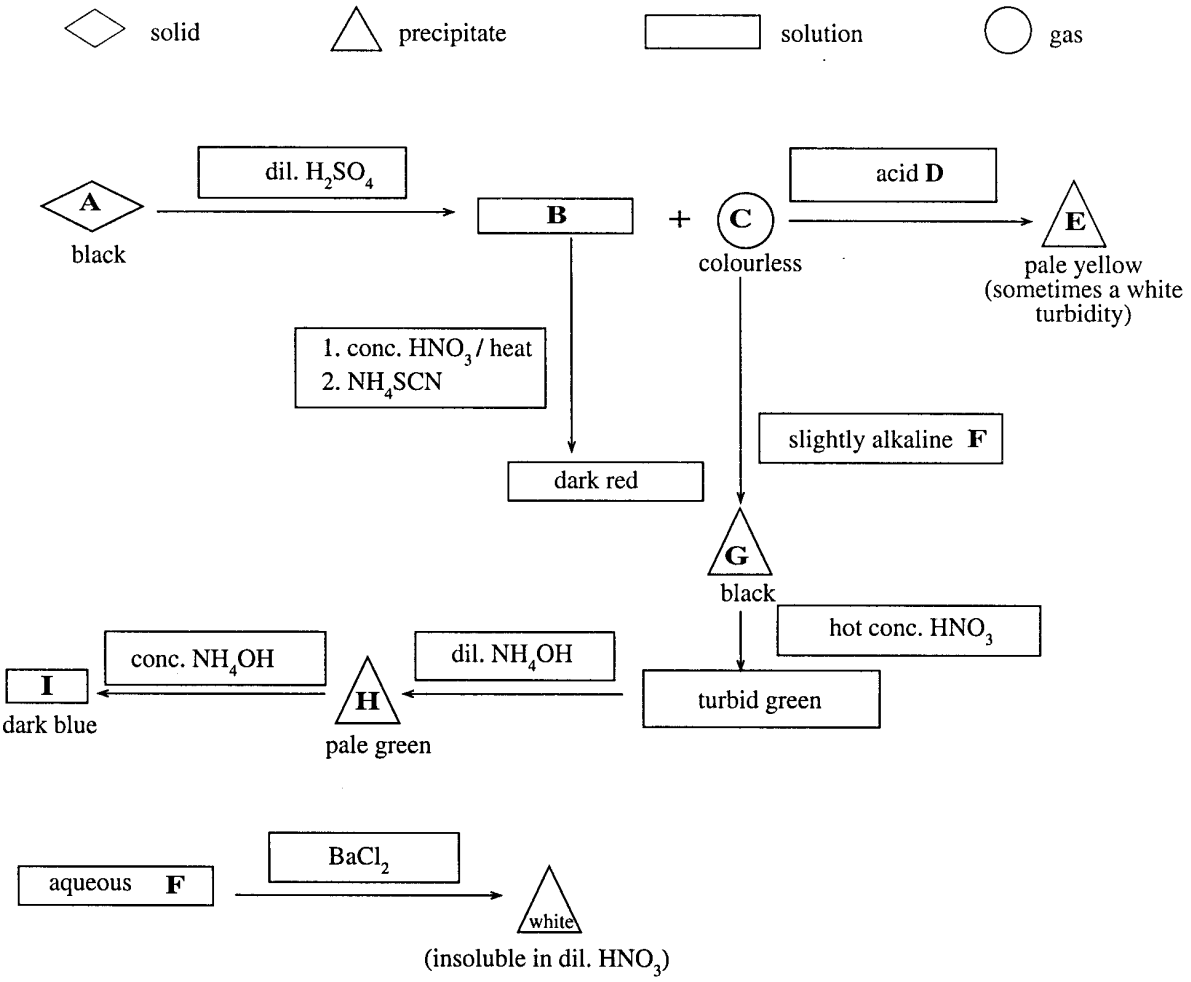
Tests carried out along with the observations to identify them are as follows:

Test	Observation
1. Water was added to the mixture.	The mixture dissolved giving a clear solution.
2. A few drops of phenolphthalein were added to a portion of the aqueous solution obtained from 1 above.	The clear colourless solution turned pink.
3. Dilute HCl was gradually added to another portion of the aqueous solution obtained from 1 above.	A white precipitate formed. It dissolved on further addition of the acid.

Giving reasons, identify the **two** compounds present in the mixture.

(ii) Write the **formulae** of the compounds **A – I** given in the diagram below. (**Balanced chemical equations and reasons are not required.**)

The following symbols are used to represent solids, precipitates, solutions and gases.



(7.0 *marks*)

(*b*) (i) A 3*d* block element **M** forms an ion M^{n+}. This ion can be oxidized by MnO_4^- in a dil. H_2SO_4 medium to give the MO_2^+ ion. In an experiment, 30.0 cm^3 of 0.100 mol dm^{-3} $KMnO_4$ was required to oxidize 5.00×10^{-3} mol of M^{n+} to MO_2^+. Use this data to calculate the value of *n*.

(ii) The following procedures **I** and **II** were used to determine the percentage of Cu in the Cu–containing alloy **Z**.

Procedures:

I. A sample of 2.80 g of the alloy **Z** was dissolved in 500.0 cm^3 of dil. H_2SO_4. Addition of excess KI to 25.0 cm^3 of this solution produced the white precipitate CuI, and I_2 as the only products. The liberated I_2 was titrated with $Na_2S_2O_3$ solution using starch as the indicator. The volume of $Na_2S_2O_3$ solution required was 30.0 cm^3.

II. To 25.0 cm^3 of $K_2Cr_2O_7$ solution, prepared by dissolving 1.18 g in 500.0 cm^3 of distilled water, 20 cm^3 of dil. H_2SO_4 and excess KI were added. The liberated I_2 was titrated with the $Na_2S_2O_3$ solution used in procedure I with starch as the indicator. The volume of $Na_2S_2O_3$ required was 24.0 cm^3.

1. Give balanced chemical equations for the reactions taking place in procedures I and II.
2. Determine the percentage of Cu in alloy **Z**.
3. Indicate the colour changes you would observe at the end points of the titrations in procedures I and II.

(O = 16, K = 39, Cr = 52, Cu = 63.5)

(8.0 *marks*)

8. (*a*) (i)

Test	Inference	
1	absence of $CaCO_3$	**(03)**
2	presence of NaOH	**(03)**
3	presence of $Zn(NO_3)_2$	**(03)**

Therefore, the two compounds present in the mixture are **NaOH** and **$Zn(NO_3)_2$** **(08 + 08)**

***Total for* 8(*a*)(i) 25 marks**

(ii) A = FeS B = $FeSO_4$ C = H_2S

D = HNO_3 / H_2SO_4 E = S F = $NiSO_4$

G = NiS E = $Ni(OH)_2$ I = $[Ni(NH_3)_6]^{2+}$

(05 × 9)

***Total for* 8(*a*)(ii) 45 marks**

***Total for* 8(*a*) 70 marks**

(*b*) (i) $(5 - n)\,(MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O)$ **(04)**

$5\,(M^{n+} + 2H_2O \longrightarrow MO_2^+ + 4H^+ + (5 - n)e)$ **(04)**

$(5 - n)\,MnO_4^- \equiv 5M^{n+}$ -------- (relationship 1) **(04)**

Moles of $KMnO_4$ $= \frac{0.100}{1000} \times 30.0$ **(04)**

Therefore, Moles of MnO_4^- $= \frac{0.100}{1000} \times 30.0$

Moles of M^{n+} = 5.00×10^{-3}

From (relationship) : $\frac{0.100}{1000} \times 30.0 \times \frac{5}{5-n} = 5.00 \times 10^{-3}$ **(04)**

$3 = 5 - n$

$n = 2$ **(05)**

***Total for* 8(*b*)(i) 25 marks**

(ii) **1. Procedure I**

$2Cu^{2+} + 4I^- \longrightarrow 2CuI + I_2$ -------- (eq. 1) **(03)**

$I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$ -------- (eq. 2) **(03)**

Procedure II

$Cr_2O_7^{2-} + 14H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O$

$3(2I^- \longrightarrow I_2 + 2e)$

$Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow 3I_2 + 2Cr^{3+} + 7H_2O$ -------- (eq. 3) **(03)**

$I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$ -------- (eq. 4) **(03)**

2. METHOD 1

Considering Procedure II

Combining (eq. 3) + (3 × eq. 4)

$Cr_2O_7^{2-} \equiv 6S_2O_3^{2-}$ **(03)**

Molar mass of $K_2Cr_2O_7$ = 294 g mol^{-1} **(02)**

Concentration of $K_2Cr_2O_7$ solution = $\frac{1.18}{294} \times \frac{1000}{500.0}$

= 0.0080 mol dm^{-3} **(03)**

Moles of $K_2Cr_2O_7$ in 25.0 cm^3 = $\frac{0.0080}{1000} \times 25.0$ **(03)**

Therefore, moles of $S_2O_3^{2-}$ = $\frac{0.0080}{1000} \times 25.0 \times 6$ **(03)**

$[S_2O_3^{2-}] = \frac{0.0080}{1000} \times 25.0 \times 6 \times \frac{1000}{24.0}$

Concentration of $Na_2S_2O_3$ solution = 0.050 mol dm^{-3} **(02 + 01)**

Considering Procedure I

No. of moles of $S_2O_3^{2-}$ = $\frac{0.050}{1000} \times 30.0$ **(03)**

Combining (eq. 1) + (eq. 2)

$2Cu^{2+} \equiv 2S_2O_3^{2-}$

Hence, $Cu^{2+} \equiv S_2O_3^{2-}$ **(03)**

Therefore, moles of Cu^{2+} present in 25.0 cm^3 = $\frac{0.050}{1000} \times 30.0$ **(03)**

Moles of Cu^{2+}in 500.0 cm^3 = $\frac{0.050}{1000} \times 30.0 \times \frac{500.0}{25.0}$ **(03)**

Therefore, weight of Cu^{2+} = $\frac{0.050}{1000} \times 30.0 \times \frac{500.0}{25.0} \times 63.5$ **(03)**

= 1.90 g

% Cu in alloy Z = $\frac{1.90}{2.80} \times 100.0$

= 67.9% (68% is acceptable) **(05)**

METHOD 2

If the concentration of $S_2O_3^{2-}$ is M mol dm^{-3}, **(02)**

Moles of I_2 evolved on reaction with $Cr_2O_7^{2-}$ = $\frac{M}{1000} \times 24.0 \times \frac{1}{2}$ **(03)**

Moles of $Cr_2O_7^{2-}$ required = $\frac{M}{1000} \times 24.0 \times \frac{1}{2} \times \frac{1}{3}$ **(03)**

Moles of $Cr_2O_7^{2-}$ in 500.0 cm^3 = $\frac{M}{1000} \times 24.0 \times \frac{1}{2} \times \frac{1}{3} \times \frac{500.0}{25.0} = \frac{1.18}{294}$

(06)

M = 0.050 mol dm^{-3} **(02 + 01)**

Moles of I_2 evolved on reaction with Cu^{2+} = $\frac{0.050}{1000} \times \frac{30.0}{2}$ **(05)**

Moles of Cu^{2+} in 500.0 cm^3 = $\frac{0.050}{1000} \times \frac{30.0}{2} \times 2 \times \frac{500.0}{25.0}$ **(05)**

Weight of Cu^{2+} in 500.0 cm^3 = $\frac{0.050}{1000} \times \frac{30.0}{2} \times 2 \times \frac{500.0}{25.0} \times 63.5$

= 1.90 g **(05)**

% Cu in alloy Z = $\frac{1.90}{2.80} \times 100$

= 67.9% (68% is acceptable) **(05)**

3. End points

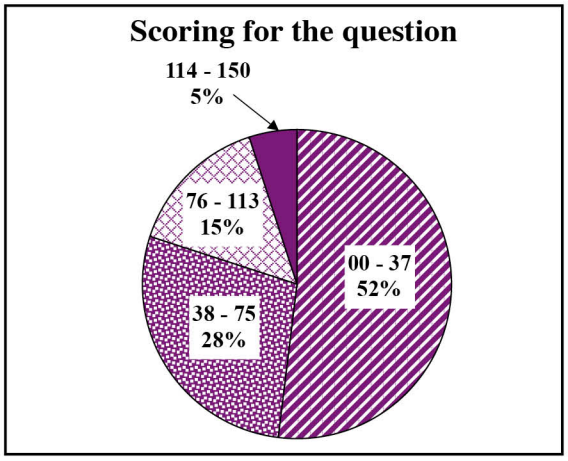
Procedure I Blue ⟶ colourless **(03)**

Procedure II Blue ⟶ (pale) green **(03)**

***Total for* 8(*b*)(ii) 55 marks**

***Total for* 8(*b*) 80 marks**

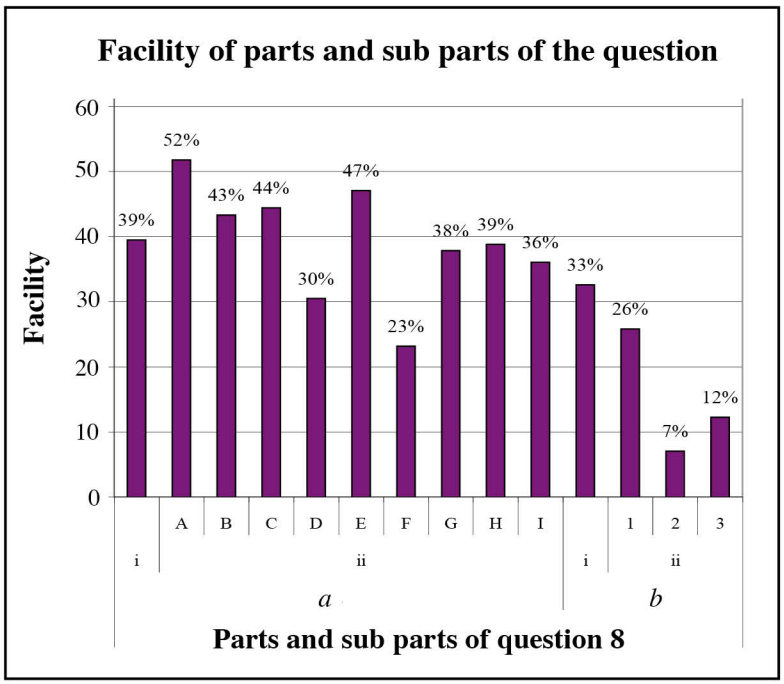
Overall observations and conclusions regarding the answers to Question 8 :



The percentage of selecting question 8 is 47%. This question carries 150 marks. The percentages scoring within the following four intervals are:

00 - 37	–	52%
38 - 75	–	28%
76 - 113	–	15%
114 - 150	–	5%

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



* There are 14 sub parts in this question of which the facility of 4 sub parts is above 40%. The easiest sub part had been *a* (ii) (A) holding a facility of 52% while the least facile sub part (*b*) (ii) (2) records a facility of 7%.

Out of the 3 questions in Part C, this is the least popular question. On the whole a lesser tendency among the candidates is evident to select question 8 based on Inorganic Chemistry.

The facility of sub part 8 (*a*) (i) is 39%. It is evident that a majority of the candidates has a difficulty in building up and presenting an answer logically. The solution would become easier if this type of problems are given for evaluating practical tests.

Of the sub part 8 (*a*) (ii) the facility of part (A) is greater than 50%. Most of the candidates have identified the correct compound but shows less ability in identifying the other compounds. Poor knowledge about practical observations has been a reason for this.

This much easier section 8 (*b*) (i) offers full marks for several alternate answers but the facility has gone down to 33%. Seemingly the candidates have failed in tackling new problems using the learned material and exercises worked out.

In order to facilitate answering Inorganic Chemistry questions, the importance of the involvement in practical work is accentuated.

9. (*a*) (i) Answer the following questions which are based on the manufacture of sodium using Down's cell.

I. Name the starting material used in the manufacture of sodium.

II. A substance is added to lower the melting point of the starting material before electrolysis. Identify this substance.

III. State the approximate temperature at which the electrolytic cell operates.

IV. Identify the anode and cathode used in the Down's cell.

V. Give the balanced chemical equations for the half cell reactions that take place at the anode and cathode.

VI Why is it necessary to separate the anode from the cathode by a steel gauze?

VII Apart from separating the anode from the cathode, state an important precaution that must be taken during the manufacturing process.

VIII. State whether the following statement is true or false.
"A small current and a large voltage are used in the manufacture of sodium."

IX. Give the physical state in which sodium is obtained by this method.

X Give **two** uses of sodium and **one** use of the product obtained at the anode.

(ii) **Briefly** describe the four steps involved in the manufacture of soap.

(7.5 *marks*)

(*b*) (i) Consider the statements I to V given below:

I. Natural processes that support life on earth

II. Unfavourable processes that occur due to the interaction of solar radiation with atmospheric gases

III. Processes that may introduce harmful gases leading to environmental problems

IV. Environmental damage due to some agricultural practices

V. Environmental damage due to acid rain

Write the **three most suitable** choices from the list given below for each of the statements from I to V. (Write the statement numbers I to V on your answer script and the notation **A**, **B**, **C** . . . *etc.* of the three relevants choices in front of each statement number. You may use one choice more than once.)

A - photosynthesis	B - corrosion of metal or limestone structures
C - global warming	D - absorption of UV radiation by ozone layer
E - volcanic eruptions	F - dissolution of heavy metal salts in sediments
G - greenhouse effect	H - ozone layer depletion
I - coral reef distortion	J - fossil fuel combustion
K - photochemical smog	L - pollution of ground water
M - metal refining	N - rapid growth of algae in reservoirs (Eutrophication)

(ii) Contribution to acid rain from a coal power plant can be reduced by controlling the emissions of acidic gases. Suggest a suitable method to control the acidic emissions using locally available raw materials. Write balanced chemical equations to support your answer.

(iii) The acidic gases NO and SO_2 released to the atmosphere through numerous processes result in the formation of the acids HNO_3 and H_2SO_4 respectively, in the atmosphere. Write balanced chemical equations for the formation of these acids.

(iv) Consider the following compounds:

$CH_3(CH_2)_4CH_3$ $CFCl_3$ CF_2Cl_2 N_2 NO

Of these, identify the compounds that contribute to,

I. global warming

II. ozone layer depletion

(v) In the ozone layer, ozone is formed and destroyed naturally. Ozone is also lost catalytically on inclusion of radical forming compounds to the ozone layer region. Write balanced chemical equations for the following processes in the ozone layer:

I. Natural formation and destruction of ozone

II. Formation of radicals

III. Catalytic destruction of ozone

(7.5 *marks*)

9. (*a*) I. NaCl **(04)**

II. $CaCl_2$ **(04)**

III. ~ 600 °C **(04)**

IV. anode - graphite **(04)**
cathode - steel **(04)**

V. anode - $2Cl^-(l) \longrightarrow Cl_2(g) + 2e$ **(04)**
cathode - $Na^+(l) + e \longrightarrow Na(s)$ or $Na(l)$ **(04)**
To award marks, physical states and **irreversible** arrows should be given.

VI. to [prevent the reaction of Na with Cl_2 **(04)**

VII. to prevent Na from reacting with O_2 and moisture **(02 + 02)**

VIII. incorrect **(04)**

IX. liquid **(04)**

X. **Na**

- In sodium vapour lamps
- To dry solvents such as ether and benzene
- In organic synthesis
- In preparation of $NaNH_2$
- As a coolant in nuclear reactors

(Any two of the above, 04 × 2) **(08)**

Cl_2

- In the preparation of HCl
- In the preparation of bleach
- In the preparation of PVC
- As a disinfectant
- To produce insecticides, drugs and dyes

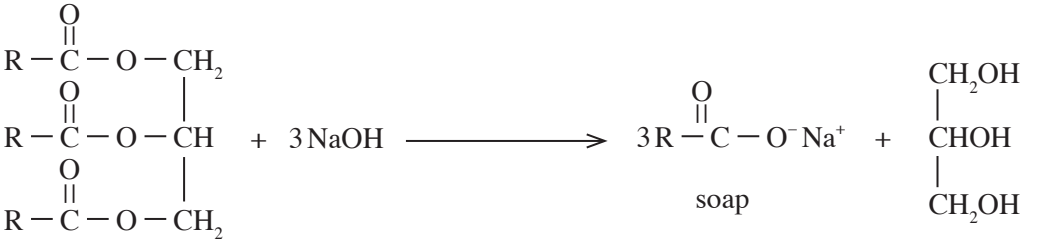
(Any one of the above) **(03)**

(To award marks for any other answers obtain approval from the Controlling Chief)

***Total for* 9(*a*)(i) 55 marks**

(ii) 1. Saponification - involves the boiling of animal fat or vegetable oil with NaOH giving glycerol and soap.

or



(R - long chain alkyl group) **(08)**
(Balanced equation not required)

2. Removal of glycerol **(04)**

3. Purification - remaining NaOH is neutralized by weak acid and 2/3 removal of water to get soap. **(02 + 02)**

4. Finishing - mixing additives and shaping into bars. **(02 + 02)**
Purification only (01), Finishing only (01)

***Total for* 9(*a*)(ii) 20 marks**

***Total for* 9(*a*) 75 marks**

(*b*) (ii) I. A, D, G

II. C, H, K

III. E, J, M

IV. C, L, N

V. B, F, I **(02 × 15)**

***Total for* 9(*b*)(i) 30 marks**

(ii) Scrub the acidic gases using a base (oxides, carbonates or hydroxides of Ca and Mg or dolomite) **(03)**

$SO_2(g) + CaO(s) \longrightarrow CaSO_3(s)$

or $SO_2(g) + Ca(OH)_2(aq) \longrightarrow CaSO_3(s) + H_2O(l)$

or $SO_2(g) + CaCO_3(aq) \longrightarrow CaSO_3(s) + CO_2(g)$ **(02)**

***Total for* 9(*b*)(ii) 05 marks**

(iii) $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$ **(02)**

$2NO_2(g) + H_2O(l) \longrightarrow HNO_2(aq) + HNO_3(aq)$ **(02)**

or $2NO(g) + O_2(g) + H_2O(l) \longrightarrow HNO_2(aq) + HNO_3(aq)$ **(04)**

or $4NO(g) + 3O_2(g) + 2H_2O(l) \longrightarrow 4HNO_3(aq)$ **(04)**

and

$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$ **(02)**

$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq)$ **(02)**

or $2SO_2(g) + O_2(g) + 2H_2O(l) \longrightarrow 2H_2SO_4(aq)$ **(04)**

***Total for* 9(*b*)(iii) 08 marks**

Note : Award full marks for using hydroxyl radical [OH(g)], atomic oxygen [O(g)], hydrogen peroxide [HOOH(g)], organic peroxides [ROOH(g)] as the oxidizing agent. Hydroxyl radical is the most probable oxidizing agent, peroxides are rare.

(iv) I Global warming : $CH_3(CH_2)_4CH_3$, $CFCl_3$, CF_2Cl_2, NO

II Ozone layer depletion : $CFCl_3$, CF_2Cl_2, NO **(02 × 7)**

***Total for* 9(*b*)(iv) 14 marks**

(v) I Natural formation of ozone

$O_2(g) \xrightarrow{h\nu} 2O(g)$ (do not penalize for radical on O) **(02)**

$O(g) + O_2(g) + M \longrightarrow O_3(g) + M$ (M is the third body to absorb excess energy)

or $O(g) + O_2(g) \longrightarrow O_3(g)$ + energy **(02)**

Natural destruction of ozone

$O_3(g) \xrightarrow{h\nu} O(g) + O_2(g)$ (do not penalize for radical on O) **(02)**

$O(g) + O_3(g) \longrightarrow 2O_2(g)$ (do not penalize for radical on O) **(02)**

II Formation of radicals

$CCl_3F \xrightarrow{h\nu} \cdot Cl + \cdot CCl_2F$ (need to indicate the two radicals) **(02)**

III Catalytic destruction of ozone

$\cdot Cl + O_3 \longrightarrow \cdot OCl + O_2$ (need to indicate the two radicals) **(02)**

$O_2 \longrightarrow 2O$ (do not penalize for radical on O) **(02)**

$\cdot OCl + O \longrightarrow \cdot Cl + O_2$ (need to indicate the two radicals) **(02)**

- - - - - - - - - - - - - - - - - - -

$2O_3 \longrightarrow 3O_2$ (net) **(02)**

$\cdot Cl$ serves as a catalyst

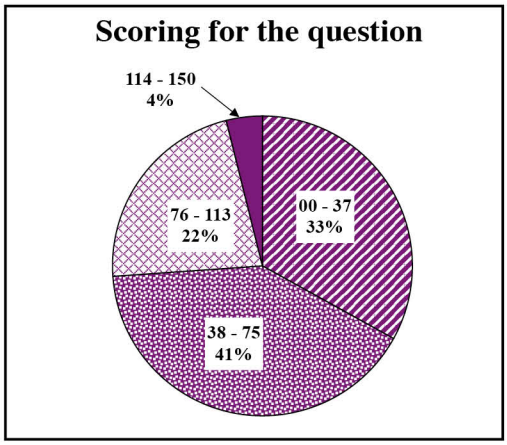
Note : Give marks if 9 (b) (v) II is within 9 (b) (v) III

Award full marks even if physical states are not given in the equations.

***Total for* 9(*b*)(v) 18 marks**

***Total for* 9(*b*) 75 marks**

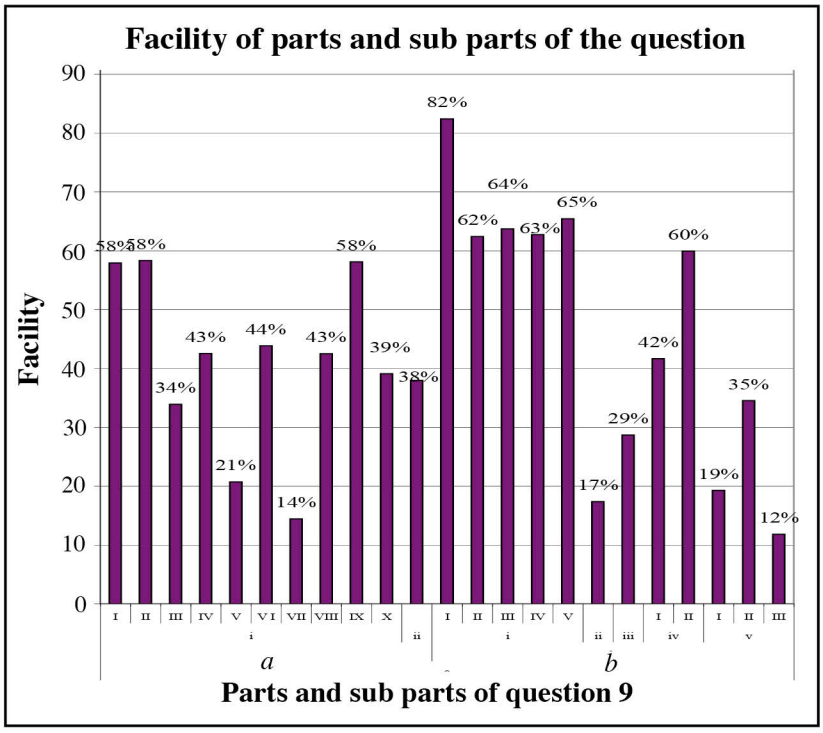
Overall observations and conclusions regarding the answers to Question 9 :



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

00 - 37 – 33%
38 - 75 – 41%
76 - 113 – 22%
114 - 150 – 4%

The percentage scoring above 114 for this question is 4% wheres 33% have scored below 37.



* Of the 23 sub parts in question 9 the facility of 13 sub parts is above 40%. Sub part *b* (v) (iii) had been the most difficult of this question. Its facility is 12%. The easiest part had been (*b*) (i) (I). Its facility is 82%.

Being a popular question, a majority of the candidates had answered question 9 fairly well.

However a low facility (14%) has been apparent for the sub part 9 (*a*) (vii) which expects a precaution that has to be taken in the production of sodium, in addition to the separation of the anode from the cathode. The students would have bent to give an answer with regard to the very cell that is used for the manufacturing process. Though the question expected to draw the students' attention to the reactivity of sodium, it had been overlooked.

Part 9 (*b*) is related to environmental chemistry. Answers to sub part (*b*) (i) are fairly successful. But the facility of (*b*) (ii) was at a lower level of 17%. The problem had been presented as 'suggest a suitable method with balanced chemical equations to control the acidic emissions using locally available raw materials'. Seemingly, the students lacked sufficient knowledge to select a suitable local raw material to control the emission of acidic gases. They also didn't have adequate understanding to suggest how to prepare them to suit the need.

Though part (*b*) (iii) was a very easy section its facility was as law as 29%. The facility of parts (*b*) (v) (i) and (iii) are 19% and 12% respectively. The theoretical facts relevant to all these questions is a part of the syllabus. However, the reason for the weakness evident in answering this question may be due to the non - coverage of these sections which come under the last unit of the syllabus. It is emphatically stated that, to answer the chemistry question paper, the entire syllabus has to be covered and the students should prepare to answer questions relevant to all the sections therein.

10. (*a*) Give **four** important differences between fluorine chemistry and the chemistry of the rest of the halogens.

(2.5 *marks*)

(*b*) Sodium sulphite (Na_2SO_3) is sometimes added to sausage meat as a preservative. The following procedure was used to determine the amount of the preservative, Na_2SO_3 present in a sample of meat.

Step 1 : One kilogram (1.00 kg) of meat was boiled with an excess of dil. HCl.

Step 2 : The gas released was completely absorbed in an excess of 0.050 mol dm^{-3} I_2 solution. The volume of I_2 solution used was 40.0 cm^3.

Step 3 : The resulting solution from Step 2 was titrated with a 0.100 mol dm^{-3} $Na_2S_2O_3$ solution using starch as the indicator. The volume of the $Na_2S_2O_3$ solution required was 26.0 cm^3.

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

(i) Write balanced chemical equations for the **three** steps involved in the above procedure.

(ii) Calculate, in moles, the amount of Na_2SO_3 present in 1.00 kg of meat sample.

(iii) The amount of preservative present in meat samples is usually expressed as parts per million (ppm). (Hence, 1 ppm = 1 g of Na_2SO_3 in 10^6 g of meat).

Express in ppm, the amount of Na_2SO_3 determined in Part (ii) above.

(iv) Indicate the colour change at the end point of the titration.

(5.0 *marks*)

(*c*) A student conducted three experiments to investigate the kinetics of the following reaction at a constant temperature.

$$2I^-(aq) + S_2O_8^{2-}(aq) \longrightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

(i) In the first experiment, 500 cm^3 of 0.160 mol dm^{-3} solution of $I^-(aq)$ and 500 cm^3 of 0.040 mol dm^{-3} solution of $S_2O_8^{2-}(aq)$ were mixed to allow the above reaction to proceed. It was found that 2.8×10^{-5} moles of I_2 have been formed at the end of the initial 5 second period.

I. Calculate the rate of production of $I_2(aq)$.

II. Calculate the rate of consumption of $I^-(aq)$.

III. Calculate the rate of consumption of $S_2O_8^{2-}(aq)$.

(ii) In the second experiment, 500 cm^3 of 0.320 mol dm^{-3} solution of $I^-(aq)$ and 500 cm^3 of 0.040 mol dm^{-3} solution of $S_2O_8^{2-}(aq)$ were mixed. The rate of the reaction was then determined to be 1.12×10^{-5} mol dm^{-3} s^{-1}.

Calculate the order of the reaction with respect to $I^-(aq)$ using the information given in Parts (i) and (ii).

(iii) The order of the reaction with respect to $S_2O_8^{2-}(aq)$ was determined to be 1 in the last experiment conducted by changing the concentration of $S_2O_8^{2-}(aq)$.

I. Write the rate equation for this reaction.

II. Calculate the rate of the reaction when the volumes of both solutions in Part (ii) are doubled by adding distilled water and the solutions are then mixed.

(iv) I. What is meant by the half-life of a first order reaction?

II. The half-life of the above reaction when the concentration of $I^-(aq)$ is kept constant, is independent of the initial concentration of $S_2O_8^{2-}(aq)$. Explain this statement with the help of a graphical representation.

(7.5 *marks*)

10. (*a*)
- Fluorine exhibits only the oxidation states –1 and 0, whereas, others exhibit positive oxidation states as well (+1, +3, +5, +7)
- F_2 has a higher oxidizing power than other halogens.
- F_2 forms compounds with nobel gases Kr and Xe, whereas others do not.
- F has an ionization energy much higher than that of the other halogens.
- Boiling point of HF is completely out of line with the other hydrogen halides (HCl, HBr and HI)
- Electronegativity of F is significantly higher than that of the other halogens.
- Fluorine is restricted to covalency of one since easily accessible low energy *d* - orbitals are not available, where as others show covalencies 1, 3 and 5 due to participation of *d* - orbitals.
- HF is a weak acid in water whereas others are strong acids.
- F forms stronger bonds with other non - metals than other halogens.
- F_2 oxidizes water whereas the others do not.
- AgF and PbF_2 are soluble in water whereas other halides of Ag and Pb are insoluble.

any **four** **(06 × 4)**

All four answers correct **(01)**

(To award marks for any other answers approval should be obtained from Controlling Chief.)

***Total for* 10(*a*) 25 marks**

(*b*) (i) Step 1 $Na_2SO_3 + 2HCl \longrightarrow 2NaCl + SO_2 + H_2O$ **(06)**

Step 2 $SO_2 + 2H_2O + I_2 \longrightarrow 4H^+ + SO_4^{2-} + 2I^-$ **(06)**

Step 3 $I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$ **(06)**

***Total for* 10(*b*)(i) 18 marks**

(ii) Moles of $S_2O_3^{2-}$ $= \frac{0.100}{1000} \times 26.0$ **(03)**

Moles of I_2 reacted with $S_2O_3^{2-}$ $= \left[\frac{0.100}{1000} \times 26.0 \right] \Big/ 2$ **(03)**

Moles of I_2 added $= \frac{0.050}{1000} \times 40.0$ **(03)**

Moles of I_2 reacted with SO_3^{2-}

$= \frac{0.050}{1000} \times 40.0 - \frac{0.100}{1000} \times \frac{26.0}{2}$ **(03)**

$= \frac{1}{1000} \left[0.050 \times 40.0 - 0.1 \times \frac{26.0}{2} \right]$

$= 7.0 \times 10^{-4}$ **(03)**

Therefore, moles of SO_2 $= 7.0 \times 10^{-4}$

Therefore, **moles of Na_2SO_3 present in 1kg of meat = 7.0×10^{-4}** **(03)**

***Total for* 10(*b*)(ii) 18 marks**

(iii) Molar mass of Na_2SO_3 = $126\,g\,mol^{-1}$ **(02 + 01)**

Mass of Na_2SO_3 in 1kg of meat = $7.0 \times 10^{-4} \times 126\,g$

= $0.088\,g$ **(02 + 01)**

Amount of Na_2SO_3 in 10^6 g meat = $\frac{0.088}{1000} \times 10^6$

= 88 (ppm) **(03)**

***Total for* 10(*b*)(iii) 09 marks**

(iv) Colour change : blue to colourless **(05)**

***Total for* 10(*b*)(iv) 05 marks**

***Total for* 10(*b*) 50 marks**

(*c*) (i) I. Rate of production of $I_2(aq)$ = $\frac{2.8 \times 10^{-5}\,mol}{1.0\,dm^3} \times \frac{1}{5\,s}$ **(02 + 01)**

= $5.6 \times 10^{-6}\,mol\,dm^{-3}\,s^{-1}$ **(02 + 01)**

II. Rate of consumption of $I^-(aq)$ = $2 \times 5.6 \times 10^{-6}\,mol\,dm^{-3}\,s^{-1}$ **(02 + 01)**

= $1.12 \times 10^{-5}\,mol\,dm^{-3}\,s^{-1}$ **(02 + 01)**

III. Rate of consumption of $S_2O_8^{2-}(aq)$ = $5.6 \times 10^{-6}\,mol\,dm^{-3}\,s^{-1}$ **(02 + 01)**

***Total for* 10(*c*)(i) 15 marks**

(ii)

	Concn. of $I^-(aq)$ ($mol\,dm^{-3}$)	Concn. of $S_2O_8^{2-}(aq)$ ($mol\,dm^{-3}$)
Expt 1	0.080	0.020
Expt 2	0.160	0.020

Rate $\propto [I^-]^\alpha [S_2O_8^{2-}]^\beta$ **(04)**

Expt 1, $5.6 \times 10^{-6}\,mol\,dm^{-3}\,s^{-1} \propto (0.080\,mol\,dm^{-3})^\alpha (0.020\,mol\,dm^{-3})^\beta$ (1) **(03 + 01)**

Expt 1, $1.12 \times 10^{-5}\,mol\,dm^{-3}\,s^{-1} \propto (0.160\,mol\,dm^{-3})^\alpha (0.020\,mol\,dm^{-3})^\beta$ (2) **(03 + 01)**

(2)/(1) $2 = 2^\alpha$

$\alpha = 1$ or order with respect to $I^- = 1$ **(04)**

Note : Award only **(04)** marks for valid qualitative arguments to show that $\alpha = 1$.

***Total for* 10(*c*)(ii) 16 marks**

(iii) I. Rate $\propto [I^-] [S_2O_8^{2-}]$ **(04)**

II. After dilution, $[I^-] = 0.080\,mol\,dm^{-3}$

$[S_2O_8^{2-}] = 0.010\,mol\,dm^{-3}$

For both concentrations **(03 + 01)**

Rate $\propto [I^-] = (0.080\,mol\,dm^{-3})\,(0.010\,mol\,dm^{-3})\,(3)$ **(03 + 01)**

$$\frac{(3)}{(2)}\ \text{Rate} / 1.12 \times 10^{-5}\,mol\,dm^{-3}\,s^{-1} = \frac{(0.080\,mol\,dm^{-3})\,(0.010\,mol\,dm^{-3})}{(0.160\,mol\,dm^{-3})\,(0.020\,mol\,dm^{-3})}$$ **(03 + 01)**

$$\text{Rate} = \frac{1.12 \times 10^{-5}\,mol\,dm^{-3}\,s^{-1}}{4}$$

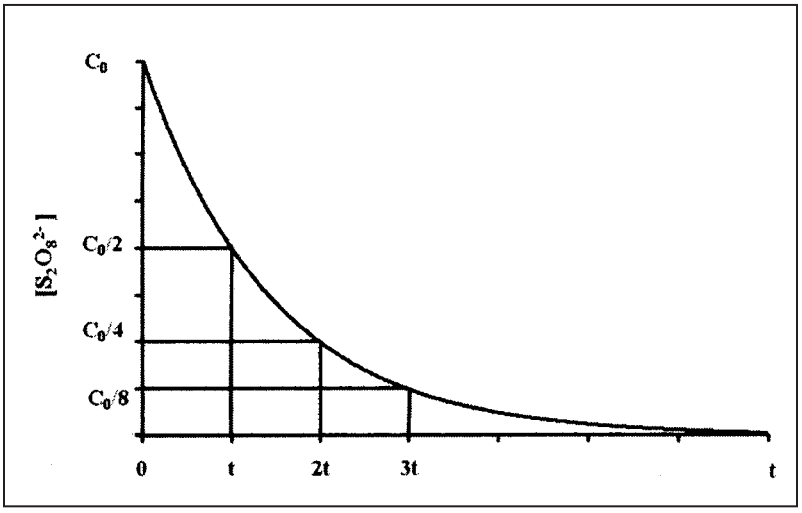
$= 2.8 \times 10^{-6}\,mol\,dm^{-3}\,s^{-1}$ **(03 + 01)**

***Total for* 10(*c*)(iii) 20 marks**

(iv) Half - life : The time taken to decrease the concentration of the reactant to half of the initial value **(06)**

The reaction appears to be first order when the concentration of I^- is kept constant. **(04)**

[Correct X - axis **(01)**, Correct Y - axis **(01)**, Initial point **(02)**,Correct shape **(04)**]



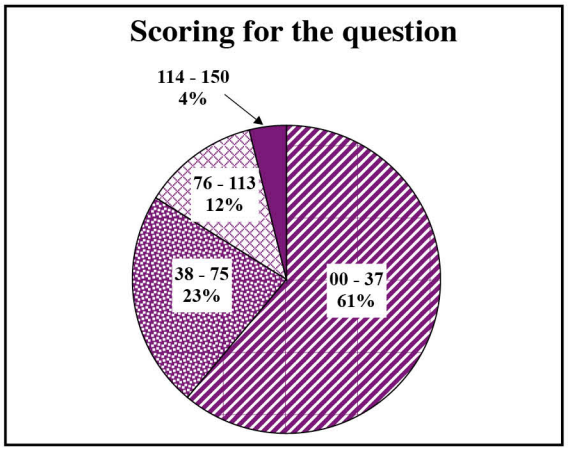
Explanation :

As shown in the graph, the time taken to decrease the concentration of $S_2O_8^{2-}$ from C_0 to $C_0/2$ is the same as the time taken to decrease the concentration from $C_0/2$ to $C_0/4$. **(06)**

***Total for* 10(*c*)(iv) 24 marks**

***Total for* 10(*c*) 75 marks**

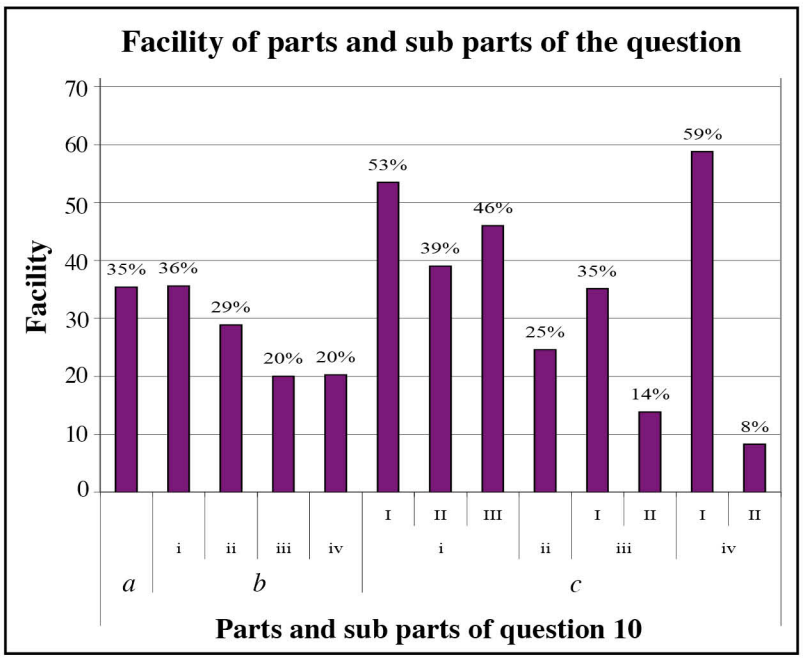
Overall observations and conclusions regarding the answers to Question 10 :



The percentage selecting question 10 is 48%. The question carried 150 marks. The percentages scoring within the four class intervals are as follows.

00 - 37	–	61%
38 - 75	–	23%
76 - 113	–	12%
114 - 150	–	4%

The percentage scoring above 114 for this question is 4% while 61% have scored below 37.



* Question 10 consists of 13 sub parts. Of them, the facility of 3 sub parts is greater than 45%. The most difficult of this question (*c*) (iv) (II) has a facility of 8% while the most facile sub part had been (*c*) (iv) (I) which holds the facility of 59%.

Of the students who attempted question 10, the score of nearly 61% is below 37. Despite the fact that part (*a*) can be answered by even recall, it is a part of low facility. The first element of some of the groups of the periodic table, deviates from the rest of the group in their properties (eg. Li, Be, F). The students should study how these elements deviate from the rest comparatively.

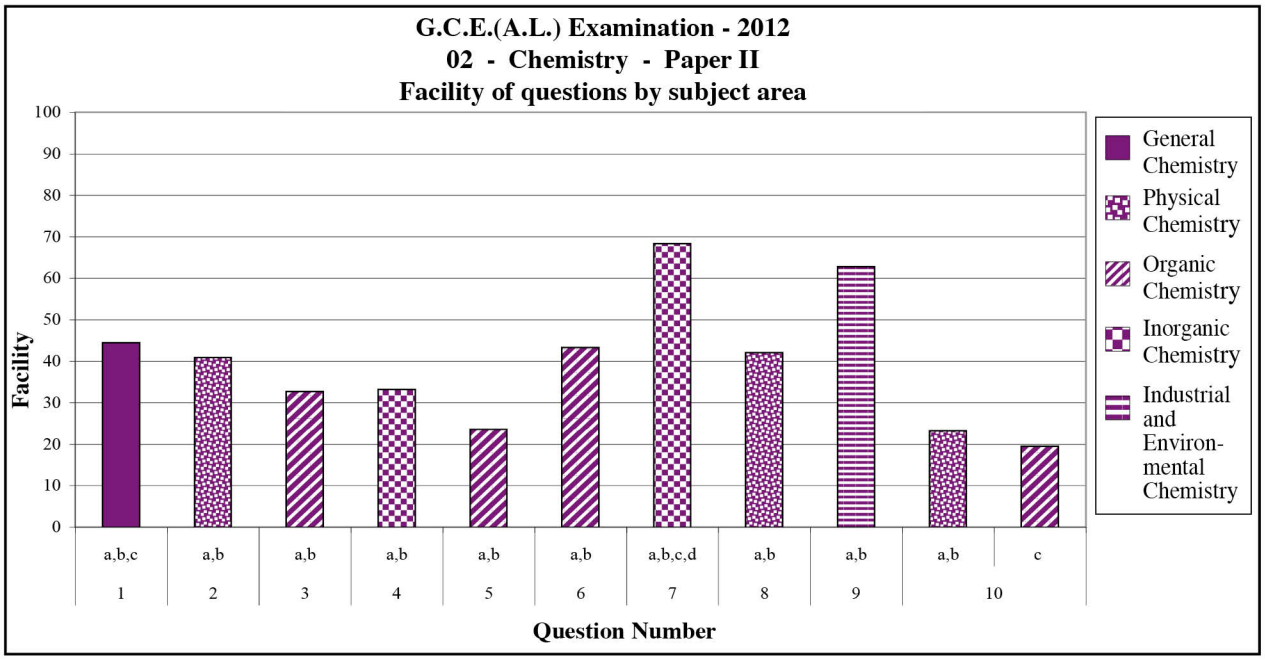
The facility of parts (*a*) and (*b*) is less than that of (*c*). It is seen that the ability to write balanced equations for redox reactions is low. When the ability of writing the equation is low, chemical calculation becomes difficult. This situation can be eased by practicing the writing of balanced equations more and more.

Students' ability of expressing the composition of a mixture in ppm too seemed to be low. They have little knowledge about the colour changes at the end point of titrations. Thus the students should involve in the practical work prescribed in the syllabus and have an understanding about their observations and inferences.

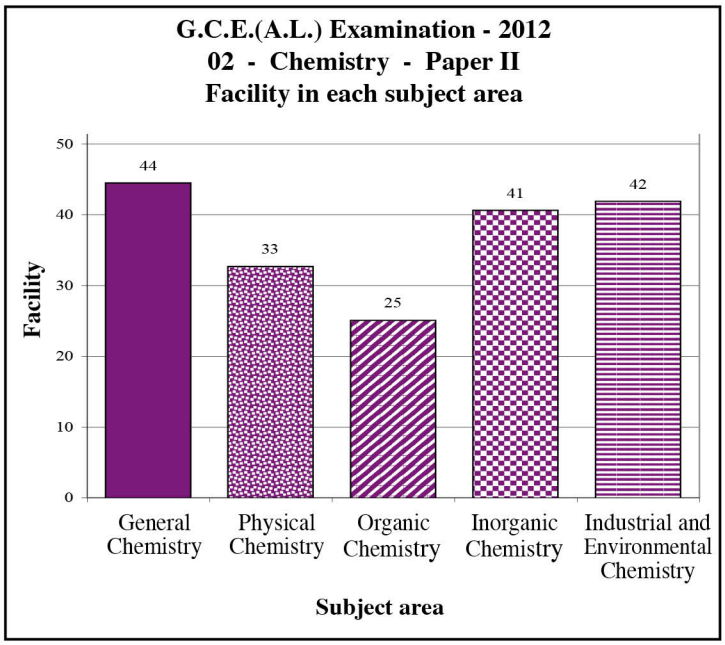
The aim of sub part 10 (*c*) (ii) was to make students calculate the rate of a reaction using the change in concentration of reactants or products and find the order of a reaction with respect to a given reactant. Many of the candidates had not identified the decrease in concentration of the reactants due to dilution after mixing the reactants of a reaction. Therefore, though (*c*) (ii) was a familiar question, students had not substituted correct data in the rate equation.

Most of the students had presented the definition in part (*c*) (iv) correctly. But the students would haven't had an opportunity to gain a broad understanding in this section because the relevant principles were introduced to the new syllabus.

2.2.3 Overall observations and conclusions regarding the answers to Paper II



Of the four compulsory structured questions, question 1 shows highest facility. Among the essay type questions in part B, question 7 carries highest facility which is related to organic chemistry. Though this was the least popular question, those who had choosen it has responded more successfully to it compared to other questions.



As regards the Chemistry paper II of the essay type questions in section C, question 9 holds highest facility and was the one selected by the highest number of candidates too of G.C.E.(A.L.) Examination, 2012 the facility indices in relation to different sections are as follows.

General Chemistry	44%
Physical Chemistry	33%
Organic Chemistry	25%
Inorganic Chemistry	41%
Industrial and Environmental Chemistry	42%

General Chemistry, Inorganic Chemistry and Industrial and Environmental Chemistry show a facility greater than 40%. Organic Chemistry had been the most difficult section and Physical Chemistry seems to be inadequate.

The achievement level in Chemistry could be raised by identifying the sections that are difficult for students and shaping the learning teaching process accordingly.

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 candidates' 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.

Special instructions :

* In places where the chemical equations should be written, they should be balanced.
* In relevant occasions, correct units should be used.
* In chemical calculations, stoichiometric coefficients should be taken into consideration.
* When writing Lewis structures, lone pairs and charges should be indicated correctly.
* Correct methods must be followed when presenting organic reaction mechanisms.

3.2. Comments and suggestions about the teaching learning process :

* The questions based on practical activities were very poorly answered. Thus the engagement of students in practical activities and related exercises is emphasized.

* Students' attention should also be drawn to the sections newly introduced to the syllabus.

* Chemistry is a practical subject. Chemistry cannot be successfully learnt merely by cramming and memorising concepts. So, it is a must that the ability of solving problems using concepts learned be developed.

* In chemistry, practical activities and experiments are designed not only to develop the behavioural skills but also to develop the capacity of linking the practical observations and results with principles learnt in the classroom and arriving at conclusions. Therefore, both teachers and students should pay greater attention to the practical work.

* Attention should be paid to prepare short notes creatively and involve students in innovative exercises especially when teaching sections such as organic chemistry that are taught according to a systematic sequence.

* The units of the chemistry syllabus are mostly interconnected. Therefore, after studying a certain unit the students need to envision a concept of its wholeness in the form of a summary.

* It is of commonplace that students become unsuccessful due to weaknesses in mathematical simplifications though they have a correct understanding about the subject matter and concepts in chemistry. Therefore, a need has emerged to improve the mathematical knowledge of even the students with very good ordinary level results. The practice may involve mathematical operations, easy and short methods of simplification and the use of log tables.

* It is important to present the subject content by way of discussions rather than lectures during the learning teaching process. The students should be given a training on how subject matter can be applied in practice and used to solve problems related to similar situations.

* It is also appropriate to give a training on problem solving through analysis and synthesis of subject matter.

LOL.lk
Learn Ordinary Level

විභාග ඉලක්ක
පහසුවෙන් ජයගන්න
පසුගිය විභාග ප්‍රශ්න පත්‍ර

• Past Papers • Model Papers • Resource Books
for G.C.E O/L and A/L Exams

සමනල දැනුම

Knowledge Bank Publications

විභාග ඉලක්ක ජයගන්න
Knowledge Bank

Master Guide

WWW.LOL.LK

CASH ON DELIVERY

HOME DELIVERY

Whatsapp contact
+94 71 777 4440

Website
www.lol.lk

Order via WhatsApp

071 777 4440