

**UNIVERSITY OF MALTA**

**MATRICULATION CERTIFICATE EXAMINATION  
ADVANCED LEVEL**

**CHEMISTRY**

**MAY 2015**

**EXAMINERS' REPORT**

**MATRICULATION AND SECONDARY EDUCATION  
CERTIFICATE EXAMINATIONS BOARD**

**Chemistry**  
**Advanced Level**  
**May 2015**

**Part 1: Statistical Information**

The examination consisted of three papers namely; Paper I, consisting of 9 compulsory, structured questions; Paper II, which consisted of 8 longer-answer questions from which students choose 5; and Paper III, a practical examination which consisted of 3 compulsory questions. Paper I and II carried 40% of the total mark each, while Paper III carried 20%.

Five hundred and sixteen students registered for the May 2015 examination and, of these, 495 candidates presented themselves for the examination.

The grade distribution was as shown below in Table 1.

**Table 1: Distribution of the grades awarded for MATSEC Chemistry May 2015**

GRADE	A	B	C	D	E	F	Abs	Total
Number	38	80	147	75	48	107	21	516
% of Total	7.4	15.5	28.5	14.5	9.3	20.7	4.1	100

**Part 2: Comments regarding performance****Overall Comments**

The average mark obtained in Paper 1 was 9 percentage points higher than in Paper 2 and in the practical paper, the average mark was 12 points higher than in Paper 1. There were 22.9 % of candidates who got a grade A or B, which is 4.2 percentage points lower than in 2014.

In the following sections, specific comments related to candidates' performance in each question are given. For each item the average mark scored and the Facility Index of the item are given. The Facility Index is an indication of how difficult an examination item is for the particular group of students sitting for the examination. A high Facility Index

(maximum 1.0) indicates an easy item while a low Facility Index shows a more difficult item.

## General Comments

### Paper 1

This paper was attempted by 493 candidates. The average mark scored per question and the Facility Index of each question in Paper 1 is given in Table 2. Question 7, the question involving the interpretation of a mass spectrum of an organic compound, proved to be one of the most challenging questions. The least challenging question was question 4 about the ideal gas law.

**Table 2: Average mark scored and Facility Index of questions in Paper 1**

Question	1	2	3	4	5	6	7	8	9
Mean	5.7	4.8	4.5	7.5	6.0	6.4	2.7	6.3	6.2
Maximum	9	11	9	11	11	12	10	14	13
Facility Index	0.63	0.43	0.49	0.68	0.55	0.54	0.27	0.45	0.47

### Paper 2

This paper was attempted by 488 candidates. Table 3 gives the average mark scored per question in Paper 2 together with the Facility Index and the percentage of candidates who attempted each question. Question 7, the question involving the interpretation of an IR spectrum, proved to be one of the most challenging questions and least attempted. The least challenging question and most attempted, was question 5 about ionic equilibria.

**Table 3: Average mark scored and Facility Index of questions in Paper 2**

Question	1	2	3	4	5	6	7	8
Mean	7.2	6.8	8.2	7.4	9.4	9.0	6.0	8.9
Facility Index	0.36	0.34	0.41	0.37	0.47	0.45	0.30	0.45
% of candidates who attempted question	42	63	53	73	89	75	26	79

**Paper 3**

This paper was attempted by 480 candidates. Table 3 gives the average mark scored per question in Paper 3 together with the Facility Index. Questions 2 and 3, the questions involving the identification of inorganic and organic compounds, proved to be more challenging than question 1, which involved a titrimetric exercise.

**Table 4: Average mark scored and Facility Index of questions in Paper 3**

Question	1	2	3
Mean	36.2	15.6	10.3
Maximum	50	30	20
Facility Index	0.72	0.52	0.51

**Part 3: Specific comments about candidates' performance in each question****Paper 1**

**Question 1** tested the candidates' knowledge of first ionisation energy trends in the Periodic Table. Most candidates had a good grasp of the topic. Marks were generally lost when explaining the change in the first ionisation energies of elements with atomic numbers 12 and 13, as well as 15 and 16.

**Question 2** concerned the chemical structure of a number of compounds. Drawing chemical structures using the VSEPR theory proved problematic. Many gave incorrect representations and molecular shape names. The wedge-dash notation was often not used while some students gave dot-cross diagrams instead. Students were asked to draw the unit cell of caesium chloride, which many also found problematic. Furthermore, few students could name the unit cell as body-centred cubic. When asked to explain the type of bonding in metallic sodium, very few explained that the best arrangement of ions is the one with the lowest energy that allows the greatest number of contacts between oppositely charged ions.

**Question 3** was about Group IV of the Periodic Table. When asked to explain the fact that  $\text{CO}_2$  is a gas at room temperature while  $\text{SiO}_2$  is a solid, many candidates did not specify the type of Van der Waals forces, namely weak intermolecular induced dipole-induced dipole attractions, in the case of carbon dioxide. Many candidates failed to mention that this phenomenon is due to the amount of energy required to overcome the intermolecular attraction.

The majority of candidates didn't find any problems to explain how the two equal and opposite dipoles in the linear carbon dioxide molecule cancel each other out resulting in the absence of a permanent dipole moment. A number of candidates, however, identified the carbon dioxide molecule as being V-shaped.

When asked to explain why tin(II) compounds show reducing properties while lead(II) compounds do not, a number of candidates failed to explain the concept in terms of stability and energetic feasibility.

Candidates found **Question 4** to be very straightforward and as a result obtained relatively high marks. The majority of candidates had no problem deducing the units of the ideal gas constant and calculating the number of moles of gas present in a particular scenario. Some candidates struggled in calculating the mass of oxygen needed for complete combustion of a quantity of a specific hydrocarbon as calculated in a previous section.

**Question 5** concerned the galvanic cell of copper and zinc. A number of candidates found this question challenging with many struggling to identify the anode and the cathode of the cell. When asked to explain the difference between the reaction taking place in the galvanic cell and when the same reaction is produced in a beaker, very few pointed out that the energy released in the electrochemical cell is in the form of electricity while that in the beaker is released as heat.

The first part of **Question 6** dealt with enthalpy of formation and Hess diagrams. While most candidates were able to define the *standard enthalpy of formation*, few could correctly define the *standard enthalpy of reaction*. Candidates found this part of the

question concerning the construction of a Hess diagram to be fairly straightforward. Some found the part concerning the proposal of a synthetic pathway for the conversion of ethanol to methylamine more demanding.

When it came to explaining why the base dissociation constant of propanamide is much lower than that of propylamine, a large number of candidates failed to mention the delocalisation of the lone pair of electrons in amides.

**Question 7** presented the candidates with the mass spectrum of a secondary halogenoalkane in order to identify it and its peaks. Candidates found this question very challenging. A number of candidates did not attempt most parts of this question while others failed to notice that the compound under investigation was a secondary halogenoalkane and identified it as 1-chloropropane instead. Furthermore, from those who correctly identified the compound as 2-chloropropane, almost nobody could explain why the spectrum could not have been given by 1-chloropropane. In the last part of this question, few candidates identified reagent Z as  $\text{SOCl}_2$ .

The first part of **Question 8** concerned the reductive ozonolysis of an unknown alkene. In general, students answered this part of the question well. The most problematic part concerned the conversion of an unknown substance into a primary alcohol through a synthetic process involving a Grignard reagent. Many students were not able to describe the process by stating the reagents and conditions required.

**Question 9** concerned the laboratory preparation of ethanal through the controlled oxidation of ethanol. A diagram of the experimental set up was presented and candidates were expected to label it and describe the contents of the vessels. A number of candidates were unable to correctly name the components. An even larger percentage of candidates were unable to identify the contents in the appropriate vessels. Almost no one mentioned the use of anti-bumping granules.

When asked about the use of an ice bath, candidates described its function as that of a condenser rather than a means of reducing the loss of the product through evaporation due to its low boiling of ethanal.

When asked to describe a test to confirm the formation of an aldehyde, the majority of candidates had no problem identifying an appropriate test. Quite a few, however, did not provide a correct balanced equation under basic conditions. A substantial number of students incorrectly mentioned the iodoform test, the formation of a 2,4-dinitrophenylhydrazone and the use of  $\text{NaHSO}_3$ .

Candidates had a good understanding of the Cannizzaro reaction. As for modifying the experiment to produce ethanoic acid instead of ethanal, few were those who mentioned both heating the reaction mixture under reflux as well as using excess oxidising agent.

## Paper 2

**Question 1** tested candidates on their knowledge of various concepts.

- When asked why phosphorus is a volatile solid whereas nitrogen is a gas, most explanations did not specify the type of Van der Waals forces present.
- The students' failure to include the use of a 50:50 aqueous solution of nitric acid in the preparation of NO was consistent in most scripts.
- Marks were mainly lost in this part of the question, which consisted of a back titration, which overall was tackled very badly by the majority of candidates who chose it.

**Question 2** was about the d-block elements. Candidates were asked to give concise explanations on various concepts and include relevant chemical/ionic equations. The part of this question which candidates found most challenging was part d, which involved the identification of an unknown inorganic complex and its subsequent conversions into other complexes.

Furthermore, when candidates were asked to comment on the ability of manganese to exist in several oxidation states, almost no one mentioned that in the +6 and +7 oxidation states, manganese forms complex ions while in its +4 state, it shares electrons forming covalent compounds.

**Question 3** required the candidates to explain in detail a number of statements. Many candidates were able to successfully explain why not all hydrogen halides can be

prepared by the reaction of the sodium halide with concentrated sulfuric(V) acid and why a sodium chloride solution is neutral while a solution formed by adding aluminium chloride to water is acidic. However, students found it difficult to explain why  $\text{SiH}_4$  is a gas at room temperature and insoluble in water. Again, very few candidates explain which type of Van der Waals forces is present.

Equations related to the disproportionation of  $\text{Cl}_2$  in basic conditions and further disproportionation on heating proved to be problematic to some students.

**Question 4** was on chemical equilibria.

- a) Part A concerned the partition constant of iodine in water and tetrachloromethane. Most candidates could easily explain why the two liquids are immiscible although a substantial number did not identify tetrachloromethane as the better solvent for iodine. An inverted expression for the partition coefficient of iodine was given by an overwhelming majority of candidates, despite the fact that some had previously stated that iodine is more soluble in tetrachloromethane. This cascaded in a series of incorrect calculations. A relatively large number of those who gave the correct partition coefficient expression were also unable to calculate the total amount of iodine extracted from the aqueous layer by the organic layer through two successive extractions.
- b) Candidates did considerably better in the second part of this question, which dealt with the dissociation of  $\text{NOBr}$ . However, most were unable to explain why the position of equilibrium is not affected by the addition of an inert gas and instead suggested a shift.

**Question 5** was on ionic equilibria.

- a) In part (i), most candidates aptly indicated that a weak acid is one, which partially dissociates or ionises in solution. Furthermore, the rate expression was written correctly. Most candidates in part (ii) also identified the presence of an acidic buffer and gave an adequate explanation for its action. In part (iii), candidates did manage to attain the correct pH value, but in their working overlooked to

calculate the concentration of  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COONa}$  by considering total volume of the buffer solution.

- b) In part (i), candidates gave the correct definition of the term *sparingly soluble solid*, but failed to give the complete definition of  $K_{\text{sp}}$ . In part (ii), the  $K_{\text{sp}}$  expression of  $\text{AgCl}$  and respective units were usually correct, and in part (iii) solubility calculated accurately. The majority of candidates did not realise that the concentration values could not be used as is. Notwithstanding, their reasoning behind whether the precipitation of silver chloride was adequate.

**Question 6** was on aromatic organic chemistry.

- a) Candidates stated the correct conditions required for the preparation of nitrobenzene and gave an adequate mechanism for nitrobenzene formation. However, marks were lost as they did not give the mechanism for the formation of the electrophile.
- b) Most candidates devised a correct synthetic route for the preparation of chlorobenzene from nitrobenzene.
- c) In their majority, candidates gave incorrect conditions. For example, many gave conditions for the mono-nitration but then gave the di-nitrated products or vice versa.
- d) Candidates gave satisfactory descriptions of the different conditions required to prepare the different given compounds.

**Question 7** was on carboxylic acids and IR spectra. Not many candidates attempted this question.

- a) Candidates attempting the question drew the correct structural formulae of the geometric isomers of Compound X.
- b) Not all candidates gave the correct synthetic route to prepare butenedioic acid from ethyne. Candidates often gave an incorrect first step, as they converted ethyne into ethane.

- c) The products obtained on reaction with alkaline manganate(VII) were correct, but the candidates' answers regarding stereoisomerism were either inaccurate or incomplete.

**Question 8** was on kinetics.

- a) In part (i), candidates in their majority, did not provide an adequate description of the experiment that should be carried out to determine the initial rate of reaction of a reactant. Particularly candidates did not mention that the experiments should be carried out at constant temperature. In part (ii), the definition of *rate of reaction* was adequate, but that of *order* was at times incomplete. In part (iii), candidates identified the overall order as being *first order* but, in their majority, they determined the order of RBr before that of OH<sup>-</sup> thus disregarding the fact that this result was required to justify that of RBr. Most candidates gave correct answers to both parts (iv) and (v) respectively.
- b) The graphs in part (b)(i) were drawn correctly, but most candidates did not determine the half-life. Furthermore, in part (ii), subsequent half-lives were not calculated.

### **Paper 3**

**Question 1** required candidates to carry out two sets of titrations. A good number of candidates acquired full marks while the titre values of a few were substantially inaccurate. In general, recorded values were very concordant.

The last part of this question required candidates to calculate the number of water molecules of crystallisation in a disodium tetraborate salt, by using values obtained from the two titrations and values derived from subsequent calculations. This was the most challenging part of Question 1 and was not attempted by some.

**Question 2** concerned the qualitative analysis of two inorganic substances. Marks were lost mainly in the inference parts of the question due to incorrect explanations or missing information. For example, when dilute sodium hydroxide solution was slowly added until

excess to a sample of substance Y, most candidates successfully identified the presence of an amphoteric cation due to the presence of a white precipitate which formed a colourless solution in excess NaOH. Few, however, explained this in terms of the formation of the soluble tetrahydroxo complex ion.

A large number of candidates did not correctly identify substance X as  $\text{Cr}(\text{NO}_3)_3$ . Problems arose in the identification of the anion. When dilute sodium hydroxide solution was added slowly until in excess to a sample of X, followed by two pieces of aluminium foil and the application of heat, few reported that an alkaline vapour was given off. Consequently, many candidates did not infer the formation of ammonia vapours and hence suggest the presence of nitrate(III) or nitrate(V) ions. When dilute sulfuric acid solution was added to X and no visible reaction was observed, many candidates were unable to eliminate the presence of nitrate(III) and hence confirm the presence of nitrate(V) ions.

**Question 3** concerned the qualitative analysis of an unknown organic solid which students had to identify as a short chain length aliphatic alkene with one or more COOH groups. Marks were mainly lost in the test which required students to burn a small quantity of the unknown. A considerable number of students reported a luminous sooty flame, which led them to deduce the presence of an aromatic ring. This in turn led to an incorrect proposed structure for Z.

**Chairperson  
2015 Examination Panel**