2012 HSC Notes from the Marking Centre – Chemistry

Contents

Introduction

This document has been produced for the teachers and candidates of the Stage 6 course in Chemistry. It contains comments on candidate responses to the 2012 Higher School Certificate examination, indicating the quality of the responses and highlighting their relative strengths and weaknesses.

This document should be read along with the relevant syllabus, the 2012 Higher School Certificate examination, the marking guidelines and other support documents developed by the Board of Studies to assist in the teaching and learning of Chemistry.

General comments

Teachers and candidates should be aware that examiners may ask questions that address the syllabus outcomes in a manner that requires candidates to respond by integrating their knowledge, understanding and skills developed through studying the course, including the prescribed focus areas. It is important to understand that the Preliminary course is assumed knowledge for the HSC course.

Candidates need to be aware that the marks allocated to the question and the answer space (where this is provided on the examination paper) are guides to the length of the required response. A longer response will not in itself lead to higher marks. Writing in excess of the space allocated may reduce the time available for answering other questions.

Candidates need to be familiar with the Board's Glossary of Key Words, which contains some terms commonly used in examination questions. However, candidates should also be aware that not all questions will start with or contain one of the key words from the glossary. Questions such as 'how?', 'why?' or 'to what extent?' may be asked, or verbs that are not included in the glossary may be used, such as 'design', 'translate' or 'list'.

Teachers and candidates are reminded that mandatory skills content in Module 9.1 is examinable in both the Core and Option questions.

Candidates should use examination time to analyse the question, plan their responses carefully, and then work within that framework to produce clear, logical and concise responses. A response may include the use of dot points, diagrams and/or tables, and planning the response will help avoid internal contradictions. Holistic responses need to be logical, well constructed and relevant to the questions asked.

In better responses, candidates:

- set out all working for numerical questions and did not round off until the final answer

- used units and substituted quantities into formulae correctly
- did not repeat the question as part of the response
- looked at the structure of the whole question and noted that in some questions the parts followed on from each other, eg responses in part (a) led to the required response in part (b)
- used appropriate equipment, eg a pencil and a ruler to draw diagrams and graphs
- accurately transcribed and used values from the periodic table and data sheet for calculations
- included balanced chemical equations where appropriate, with the correct states of all species shown
- were guided by the space provided on the paper regarding the length of the response necessary.

Candidates should answer the question relating to the Option they studied in class.

Section I — Core

Part B

Question 21

(a) In better responses, candidates demonstrated knowledge of alkanol, alkanoic acid and ester functional groups. Structural formulae were correctly drawn and the equation included a correct catalyst.

In weaker responses, candidates omitted the catalyst and water as a product. In some responses, candidates showed structural formulae with an incorrect number of carbon atoms or incorrect functional groups for the acid and alkanol. Also in weaker responses, candidates confused the structure of ethylene and ethanol. In some responses, condensed formulae were used instead of structural formulae.

A structural formula should show every atom and every bond, including those between carbon and hydrogen.

(b) The majority of candidates recognised that refluxing is used in esterification. In better responses, candidates correctly linked the specific risk to the appropriate precaution, and referred to refluxing, using a water bath/hotplate and using boiling chips.

In weaker responses, candidates did not refer to safety issues specific to esterification. Generalised safety measures, such as using a safety flame, tying hair back, ensuring the availability of fire extinguishers or wearing covered shoes, are not specific to esterification. There was some confusion between the meanings of the words ‘volatile’ and ‘flammable’.

Question 22

(a) Most candidates correctly identified the chemical process being modelled as polymerisation. In weaker responses, some candidates identified the molecule formed and not the process, while others confused condensation and addition polymerisation.

(b) Many candidates gave two valid reasons for the use of models.

Question 23

In better responses, candidates included good explanations of the effect of increasing temperature in terms of Le Chatelier's principle; however, many candidates did not explain the effect of increasing pressure, often referring to the mole ratio of reactants to products, rather than specifying the number of gaseous moles. In better responses, candidates included the appropriate use of an equilibrium arrow and stipulated the endothermic/exothermic nature of the equation used to describe the solubility of carbon dioxide in water.

Question 24

In better responses, candidates effectively linked the properties of ammonia with its uses in industry.

In weaker responses, candidates tended to include information about the historical development of the Haber process as a means of producing ammonia, rather than explaining its current industrial uses. In these responses, candidates stated several uses of ammonia, but did not explain why these uses were important.

Question 25

In better responses, candidates clearly linked the reasons for monitoring eutrophication with the chemicals used and related tests that needed to be conducted.

In weaker responses, candidates identified substances that can cause eutrophication but did not consider the monitoring tests. In some of these responses, candidates confused eutrophication with water treatment processes.

Question 26

(a) In better responses, candidates included clear and comprehensive flowcharts showing the processes and conditions required for the production of ethanol from both petroleum and sugar cane. These flowcharts showed a number of steps, placed in the correct sequence, and identified physical and chemical processes, including appropriate catalysts.

In mid-range responses, candidates often included flowcharts that lacked the conditions or processes used, omitting distillation or the correct catalysts. Such flowcharts often started with ethane and glucose, without indicating how these chemicals were derived from petroleum and sugar cane respectively.

In weaker responses, candidates often provided badly drawn flowcharts, which confused the production of ethanol with the production of LDPE and HDPE or which omitted most of the major steps in the production of ethanol.

(b) In better responses, candidates included a good comparison of the renewable and non-renewable nature of both starting materials, and considered that some processes used in the production of ethanol from sugar cane were not always environmentally sustainable. In these responses, candidates often compared the large energy inputs involved in producing ethanol from both raw materials.

In weaker responses, candidates often did not compare both production methods or confused renewable with non-renewable resources.

Question 27

(a) In better responses, candidates linked the uses of both Iodine-123 and Iodine-131 with the type of radiation each emitted. They indicated that the Iodine-123 and Iodine-131 concentrated in areas of the body where gamma rays, which have high penetration of biological tissue, could be detected outside the body by a gamma ray detector/scanner, providing a diagnostic image of the organ. Such responses also linked Iodine-131 as a beta particle emitter, which has a low ability to penetrate biological tissue, and hence can be used to destroy cancer cells close to where they are inside the body.

In weaker responses, candidates tended to repeat the information in the question, referring to either gamma or beta emission. In some responses, candidates compared the energy or penetration of both types of radiation using the information provided in the question, or included general comments about beta particles and gamma rays causing damage to cells.

(b) In better responses, candidates included a correctly balanced nuclear equation with mass numbers on the top left-hand side of the element symbol and atomic numbers on the bottom left-hand side of the symbol. The mass numbers and atomic numbers were added correctly on both sides of the equation.

In weaker responses, candidates did not correctly show beta particles in an equation, used an incorrect notation for a beta particle, or included the beta particle on the wrong side of the equation. In many responses, candidates failed to recognise that a change in atomic number resulted in a change of element.

Question 28

In better responses, candidates used a balanced chemical equation to correctly calculate the pH of the resulting solution to be 1.4.

In weaker responses, candidates included a balanced chemical equation but usually showed one or more errors in the calculation of the number of moles of HCl and NaOH. Such errors may have included not subtracting the number of moles of NaOH from the number of moles of HCl to find the excess HCl, not adding the volumes of HCl and NaOH to find the total volume of the resultant solution, or not converting the volume of 100 mL to 1000 mL to find the final concentration in moles L^{-1}. In several responses, candidates showed the use of natural logarithms instead of logarithms to the base ten.

Question 29

In better responses, candidates clearly demonstrated a thorough understanding of the structure of the atmosphere and correctly located pollutants and their sources.

In mid-range responses, candidates drew and labelled the two layers closest to Earth and identified the correct position in the layers for the pollutants named.

Weaker responses showed a limited understanding of the structure of the atmosphere, and the position and source of the pollutants were often incorrectly named. Some candidates did not draw a diagram showing the layered structure of the atmosphere.

Question 30

(a) In better responses, candidates calculated the molarity of NaOH to 4 significant figures, and showed all working in the process, including the initial moles of HCl and its relationship to the reaction stoichiometry.

In weaker responses, candidates used incorrect volumes of either NaOH or HCl and did not show full working and/or omitted units.

(b)(i) In better responses, candidates used the correct average volume, transferred the correct data from the Periodic Table, and converted grams to milligrams. In weaker responses, candidates did not show full working or did not calculate correctly.

(ii) In better responses, candidates related the non-polar nature of the aspirin to the role of ethanol as a solvent.

In weaker responses, candidates stated that ethanol was a universal solvent.

Question 31

(a) In better responses, candidates clearly labeled the *x*-axis with carbon chain length or molecular mass and the *y*-axis with boiling point, including units. A linear scale was shown and the data was plotted accurately, including a line of best fit.

In weaker responses, candidates demonstrated incorrect plotting of data for butan-1-ol, confusing its boiling point with that of propan-1-ol. In some weaker responses, candidates were imprecise when plotting points.

(b) In better responses, candidates accurately interpolated by showing their working on the graph to obtain the boiling point of butan-1-ol.

In weaker responses, candidates did not interpret the vertical scale correctly or did not indicate a specific boiling point using their line of best fit.

(c) In better responses, candidates correctly indicated dispersion forces.

In weaker responses, candidates identified hydrogen bonding or dipole–dipole forces, or stated multiple intermolecular forces.

Question 32

In better responses, candidates read from the graph the concentration of Hg in the sample solution as 0.17 mg L^{-1}. The amount of Hg in the 25 ml sample was correctly calculated to be 0.00425 mg and the concentration of Hg in the fish was determined to be 0.228 mg kg^{-1}. In better responses, candidates also concluded that the fish was safe to eat as its concentration was below the limit of 0.5 mg kg^{-1}.

In mid-range responses, candidates correctly read the concentration of Hg from the graph and determined the amount of Hg in the 25 ml sample.

In some poorer responses, candidates read the concentration of mercury in the sample solution using the graph, but did not continue the calculation, often confusing the use of units such as grams and millilitres. In a number of these responses, candidates used a value not derived from the graph to perform a calculation.

Question 33

In better responses, candidates provided the correct name for an electrochemical cell and also provided a suitable description of the possible environmental impacts of the cell. Valid reasons for the need for collaboration between chemists were also stated, as were the consequences and effects of a lack of collaboration.

In mid-range responses, candidates often provided the roles of chemists and gave the effect of a correctly name electrochemical cell on the environment. In these responses, candidates provided a valid reason for the need for collaboration.

In low-range responses, candidates identified a role of a chemist and showed a basic understanding of an environmental impact of an electrochemical cell. In these responses, candidates often stated that chemists collaborate, but did not provide reasons for the collaboration.

Section II — Options

Question 34 — Industrial Chemistry

(a) The majority of candidates recognised the equipment shown as an example of electrolysis or as an electrolytic cell. In better responses, candidates correctly identified the process as using brine to produce sodium hydroxide. In some of these better responses, candidates described the effect of concentration of the sodium chloride solution on the production of different product gases, and included the use of correct half equations.

(b) In weaker responses, candidates did not correctly identify the electrode where oxygen/chlorine was produced as *P* or the electrode where hydrogen was produced as *Q*. In a significant number of these responses, candidates identified the gases as being produced at the cathode or anode, or referred to the site of oxidation or reduction, rather than using the letters *P* and *Q* as shown on the diagram. A common misconception was that the pink colour of the phenolphthalein was somehow caused by the chlorine, leading to incorrect electrode identification.

(i) In the majority of responses, candidates provided a correctly balanced equation reaction, based on the equilibrium expression. Correct subscripts (g) and equilibrium double arrows for the reaction are a requirement in an equilibrium equation involving gases.

(ii) in better responses, candidates processed the numerical data and correctly calculated the equilibrium constant. In most of these responses, candidates also successfully interpreted the size of the equilibrium constant as indicating that the position of the equilibrium lies on the right-hand side.

In weaker responses, candidates did not correctly calculate the concentration of NO from the provided initial concentration and the 2:1 ratio in the equation.

(iii) In most responses, candidates correctly stated that temperature alone could change the value of the equilibrium constant.

(c)(i) In better responses, candidates correctly described the two-step process for making sulphuric acid from SO_3, and supported this description with correctly balanced equations that included appropriate states, showing oleum as a liquid.

In weaker responses, candidates omitted or provided some, but not all, states, or incorrectly described oleum as being in the aqueous state. In many weaker responses, candidates recounted the stimulus material but did not coherently describe any correct process or provide balanced equations.

(ii) In the majority of responses, candidates stated that reacting SO_3 directly with H_2O was a very exothermic reaction that created a violent or explosive mist/vapour/gas.

(d)(i) In many responses, candidates provided a balanced equation for a step in the Solvay process. In better responses, candidates also described the procedure of a step of the Solvay process that is able to be chemically modelled in a school laboratory.

There was evidence that candidates were unfamiliar with the practical requirements included in the study of the Solvay process. It should be noted that module 9.1 is examinable in a variety of contexts.

(ii) In better responses, candidates clearly identified a risk related to the model described in (d)(i) and a difficulty in actually modelling the process, as opposed to a difficulty in carrying out the procedure itself.

In weaker responses, candidates described a chemical step of the Solvay process that cannot be modelled in the laboratory.

(e) In many responses, candidates demonstrated a good understanding of the cleaning action of surfactants and distinguished between the structure and uses of three different classes of detergent.

In weaker responses, candidates did not discuss the structure and uses of soap, despite soap being specifically named as a surfactant in the question. In these responses, candidates generally displayed knowledge of the environmental impacts of soaps and detergents, but did not account for the changes in products over time in a coherent and logical manner.

Question 35 — Shipwrecks, Corrosion and Conservation

(a) In better responses, candidates included a process and the specific damage to a type of material that would result. In most responses, candidates identified that some damage would be caused; however, many failed to identify the materials that could be affected within the container.

(b)(i) In better responses, candidates demonstrated a clear understanding of the workings of impressed current and identified the components of cathodic protection using appropriate terminology. In weaker responses, candidates made contradictory statements in their explanation, referring to sacrificial anodes or the oxidation of graphite electrodes.

(ii) In better responses, candidates identified sacrificial anodes as an alternative chemical process and included two relevant half equations. In weaker responses, candidates did not distinguish between physical and chemical methods of protection.

(c)(i) In most responses, candidates included a condition under which the reaction shown in the stimulus equation occurs. In better responses, candidates succinctly described the location and processes involved in the reaction. In weaker responses, candidates seemed confused about the role of the sulphate reducing bacteria in the specific environment in which the corrosion process occurs.

(ii) In better responses, candidates included a fully balanced equation to support their calculation of the mass of iron lost. In many of these responses, candidates provided two balanced half equations, then compiled the overall equation. In weaker responses, candidates did not include a balanced equation or included incorrect equations. In most responses, candidates showed the calculation of the number of moles of hydrogen sulphide; however, many did not identify the 1:4 ratio involved in the reaction.

(d)(i) In many responses, candidates only identified the differences between the two beakers without clearly explaining why these differences made the investigation invalid, ie they did not state that in a valid experiment, only one variable should be changed, with all other variables kept constant.

(ii) In better responses, candidates provided neatly drawn and clearly labelled diagrams showing beakers containing an electrolyte of specific concentration, electrode material and applied voltage, illustrating a valid 'controlled' investigation for two identified factors that affect electrolysis. Expected results were also provided either in words or clearly illustrated on the diagrams. In mid-range responses, candidates provided correctly drawn fully labelled diagrams for valid controlled investigations for two factors that affect electrolysis, but did not state or indicate on their diagrams the expected results of the investigations depicted.

In weaker responses, candidates showed an investigation for only one factor that affected electrolysis, provided diagrams that were incompletely labelled or showed incorrect expected results.

(e) In the best responses, candidates linked information on the history of the materials used to the building of ocean-going vessels. Factors such as the composition of steel and the ways steel is protected from corrosion were linked to the benefits of using steel as a shipbuilding material. A clear critical evaluation of the continued use of steel for building ocean-going vessels was also provided.

In mid-range responses, candidates showed a good understanding of the major ways of protecting steel from corrosion, ie cathodic protection, modifying its composition (alloying), use of protective non-metallic coatings and passivating metallic coatings.

In weaker responses, candidates provided details on the history of ocean-going vessels, the composition of steel and methods of steel corrosion protection, but did not link this information to the benefits of using steel as a shipbuilding material.

Question 36 — Biochemistry of Movement

(a) The majority of candidates identified that the diagram showed the proteins, actin and myosin and that the metal ion was calcium. In better responses, candidates correctly identified *X*, *Y* and *Z*. In weaker responses, candidates confused the identity of *X* and *Y* and gave a range of ions for *Z*.

(b)(i) In better responses, candidates provided a correct general formula. In weaker responses, candidates either included an incorrect formula or stated a specific example of a fatty acid.

(ii) In better responses, candidates included a structural formula showing the correct orientation of the covalent bonds from the carbon atoms to either the hydrogen or the oxygen atoms. In weaker responses, candidates either attempted to show a condensed formula or did not show the correct orientation of the covalent bonds from the carbon, suggesting ambiguity as to the bond between the carbon and oxygen.

(iii) In the majority of responses, candidates compared the relative solubility of the three compounds, but did not explain the effects of polarity and non-polarity in fatty acids and triacylglycerols. In better responses, candidates provided a detailed description of the bonding in glycerol. In weaker responses, candidates did not distinguish between fatty acids and triacylglycerols.

(c)(i) In better responses, candidates included a comparison of the amount of energy obtained from the metabolism of fats as compared to carbohydrates. In weaker responses, candidates did not consider different oxidation states or the fact that carbohydrates were already partially oxidised.

(ii) Most candidates used a flow diagram to show some parts of the biochemical metabolism of fats and carbohydrates. In better responses, candidates included a clear diagram showing at least 8 steps, with the point of production of carbon dioxide and ATP clearly labeled. In weaker responses, candidates named only one or two intermediates and did not show any overlap between the two pathways.

(d)(i) In better responses, candidates described the bonds in both secondary and tertiary structures of proteins and also mentioned the peptide bonds in the primary structure. In most responses, candidates did not make the connection between the types of bonds present in the primary, secondary, tertiary and quaternary structure of proteins and the actual structure itself.

(ii) In most responses, candidates identified the need to maintain the narrow pH range for the functioning of proteins. In better responses, candidates included an explanation about how denaturation was caused by changes to the bonding in the secondary structure.

(e) In most responses, candidates discussed the differences in aerobic and anaerobic metabolism. In better responses, candidates showed a specific link to the type of muscle fibres associated with each form of metabolism, as well as the different types of activities that would require aerobic or anaerobic metabolism to produce ATP. In these responses, candidates also discussed the difference in the ATP generated and the relative time frames under which these processes were able to perform. There was a clear statement linking muscle fatigue with lactic acid production, resulting in muscle cramping as a result of overuse of anaerobic metabolism.

Question 37 — Chemistry of Art

(a)(i) This question was generally well answered, with many candidates indicating the correct oxidation state for the manganese ion.

(ii) In better responses, candidates included a complete Lewis electron-dot diagram for one of the identified complex ions, showing all bonding and non-bonding electrons. In these better responses, candidates also included a description of coordinate covalent bonding between the metal ion and the ligands.

(b)(i) In better responses, candidates related one of the properties of the compound to an issue associated with its potential use as a pigment. In many responses, candidates identified the toxicity of the compound as an issue, demonstrating a lack of understanding of the fact that many widely used pigments contained toxic heavy metals.

(ii) In many responses, candidates identified a method used to attach pigments to surfaces, although some responses incorrectly described a method to colour the bulk of a material, eg colouring glass. In better responses, candidates described a process of pigment attachment, including the chemistry of paints and how the binder changes upon drying to attach the pigment to the surface.

(c) Most candidates demonstrated a good understanding of successive ionisation energies and how they relate to electron configurations. In better responses, candidates included an analysis of the electron configuration of vanadium and how this related to the data in the graph, showing sound understanding of the electrostatic attractions in atoms and why they vary as electrons are removed. These candidates also included explanations of why successive ionisation values always increase in terms of reducing electron–electron repulsion, why there was only a gradual increase for the first five electrons, and an explanation for the large increase between the fifth and sixth successive ionisation values.

(d)(i) In many responses, candidates showed limited understanding of how an experiment could be carried out to observe the different colours in solutions of iron(II) and iron(III) ions. In better responses, candidates described a procedure to oxidise the iron(II), including knowledge of a suitable oxidising agent, as well as a knowledge of the colour of iron(II) and iron(III) in solution.

(d)(ii) In many responses, candidates included correct electron configurations, although common errors included removal of the 3d electrons prior to the 4s electrons.

(e) In many responses, candidates demonstrated a sound knowledge of Bohr's model, including a number of its benefits and limitations. In better responses, candidates described the place of Bohr's model in the development of our understanding of atoms, linking it to the prior model (Rutherford) and the successive model (quantum-mechanical model).

Question 38 — Forensic Chemistry

(a) In better responses, candidates identified the characteristics of soil that are used in forensics and linked how the soil origin can be traced by looking for similarities with other samples through comparisons with databases. In weaker responses, candidates tended to repeat the question or include very general characteristics, such as stating that soil was organic in origin.

(b)(i) In better responses, candidates demonstrated knowledge of the procedures followed for the collection of samples and related this to the level of reliability and accuracy necessary for admissibility in court. In weaker responses, candidates indicated a lack of familiarity with the steps involved in the collection of forensic material. In many responses, candidates did not mention reliability and accuracy as important factors related to admissibility in court.

(ii) In better responses, candidates clearly explained a specific case and the appropriate new technology that assisted in changing the outcome. In weaker responses, candidates tended to use general terms to describe a technology or did not mention a specific case.

(c)(i) In better responses, candidates identified the least polar pigment and included an appropriate justification related to the non-polar nature of the solvent.

In weaker responses, candidates failed to correctly identify carotene or did not include an appropriate justification, confusing the non-polar nature of the solvent with the pigment.

(ii) In better responses, candidates included a clear explanation that by changing the solvent to one that was polar, both of the chlorophylls are more soluble in the mobile phase and therefore will move faster up the paper. In these better responses, candidates also explained that paper chromatography separation is based on differences in solubility and the distribution between the mobile and stationary phase, and is dependent on the difference in polarity of materials been separated. In weaker responses, candidates tended to confuse solubilities and charges.

(d)(i) In the best responses, candidates drew the sucrose molecule correctly, clearly indicating the glycoside bonds and elimination of water. In weaker responses, candidates did not transcribe the molecules correctly, or show the formation of the glycoside bond correctly, linking the sugar molecules through a carbon–carbon bond.

(ii) In better responses, candidates showed an outline of a suitable chemical test, using a correctly balanced chemical equation. In mid-range responses, candidates did not include an equation or did not indicate the observed colour change. In poorer responses, there was confusion between reducing and non-reducing sugars, or incorrect tests, such as the Biuret test, were included.

(e) In better responses, candidates clearly and concisely described the analysis of DNA and linked the manipulations to appropriated features of DNA. In these better responses, candidates explained how DNA profiles are unique, including the existence of introns and non-coding sections of the molecule. In poorer responses, candidates confused the steps of DNA analysis or described other forensic techniques.