South Pacific Board
For Educational Assessment

103/3

CHEMISTRY

Chief Marker's Report 2009

South Pacific Form Seven Certificate

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INTRODUCTION

This document has been produced for the teachers and candidates of the South Pacific Form 7 course in Chemistry. It provides comments with regard to responses to the 2009 South Pacific Form Seven Certificate Chemistry Examination, indicating the quality of candidate responses and highlighting the relative strengths and weaknesses of the candidatures in each section and each question.
It is essential for this document to be read in conjunction with the relevant syllabus, the 2009 South Pacific Form Severn Certificate examination, the marking schedules and other support documents which have been developed by the Board to assist in the teaching and learning of Chemistry. This document should read along with the relevant syllabus, the 2009 South Pacific Form Seven Certificate examination, the marking schedules and other support documents which have been developed by the Board to assist in the teaching and learning of Chemistry.

GENERAL COMMENTS

In 2009, 251 candidates attempted the South Pacific Form Seven Certificate Chemistry Examination.

A similar format for the examination was followed to that used for the past five years. The mark allocation was very similar to last year. It was hoped that this would enable candidates to budget their time wisely and pace themselves in order to complete the whole paper. The changes in mark allocation enabled most average candidates to complete Question Nine and Ten.

There was one critical error in the paper:
QUESTION EIGHT: Part (d) last sentence inside the box stated that " *Phenolphthalein is pink in acid and colourless in base*". This should be "*Phenolphthalein is colourless in acid and pink in base*". This error was cautiously taken into account when marking this part.
Each year's examination paper is able to examine a range of, but not all, outcomes. Candidates should go through more than just the previous year's examination paper to gain an understanding of the sort of questions that could be asked. Similarly, each year's examination report focuses on responses for that year and might not mention an outcome that could be examined the following year.

Teachers and candidates should be aware that examiners may write 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. This reflects the fact that the knowledge, understanding and skills developed through the study of discrete sections should accumulate to a more comprehensive understanding than may be described in each section separately. It is important to understand that the Pacific Senior Secondary Certificate Chemistry course is assumed knowledge for the South Pacific Form Seven Chemistry course. This aspect needs to be more fully appreciated by all system and candidates.

This year candidates seemed to have a greater awareness of the importance of the key words in the examination. Spelling, grammar and scientific expression were very poor from some candidates, with handwriting being more illegible than in the past. The skills of writing well-constructed sentences and developing logical and concise explanations were frequently lacking. Incorrect spelling detracted from many answers; both chemical and non-chemical words caused problems. Many candidates who wrote lengthy explanations frequently contradicted themselves or strayed from the topic. Candidates need to be encouraged to spend more time practicing writing logical, coherent, accurate responses. They should learn to develop logical step-by-step discussions and not assume that readers will fill in the gaps in their arguments or draw the correct conclusions for themselves. Candidates should be encouraged to read their finished work, to check that their answers make sense and do not contain contradictions. Top candidates distinguished themselves by the quality of their answers, including the depth and clarity of their discussions. It was surprising to note the significant number of candidates who could score full marks in the difficult calculations but were unable to give the simplest of explanations. Candidates need to read the question thoroughly and respond to each part. The best responses provided evidence that the candidate had planned out an answer to fit into the space provided.

Candidates need to set out their work clearly in calculation questions. Where appropriate, it is advisable to write balanced chemical equations, including the correct states of matter, to support an answer.

The variation in the quality of responses seems to suggest that candidates who have actively planned and performed a first-hand investigation are more likely to have retained knowledge and understanding of the experience than those who have rote learnt an expected answer. In addition, the development of the Chemistry stills will be more evident and rewarded with marks.

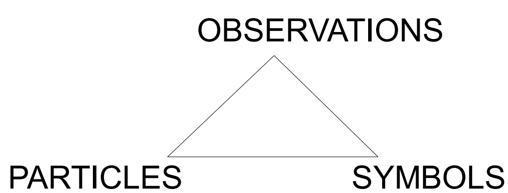
Candidates need to be reminded that the answer space allocated is a guide to the maximum length of response required. Similarly, the key word used in the question gives an indication of the depth of the required response. Candidates should use examination time to analyze the question and plan responses carefully, working within that framework to produce clear and concise responses. This is particularly so in holistic questions which need to be logical and well structured. The use of dot points, diagrams and/ or tables may be used to demonstrate their deeper level of understanding in Chemistry and avoid contradictions.

It is very important that candidates recognize that the three fundamental particles that make up all matter are atoms, ions and molecules and that these terms cannot be used interchangeably. Many observations can be explained by first identifying the particles involved and then considering the nature of the particles and their interactions with each other.

Teachers need to impress upon their students that they need to recognize that there are three different levels of thinking in chemistry. These are:

- ➔ **the observations (macromolecular)**
- ➔ **the nature and activity of the submicroscopic particles (micromolecular)**
- ➔ **and the symbolic representation (symbols and equations).**

Sometimes this is shown in a triangle as seen below.



It is very easy for teachers to switch between these three aspects of chemistry without indicating the change of level of to the students. Until they become chemically literate and are able to navigate these three levels for themselves they need to be guided to make that links between the observations, the explanations using ideas about the particles and the equations or symbols chemists use to represent the reaction/ change/ composition. If this does occur many misconceptions arise in the student's mind. An example of these levels is shown below:

Observations: when magnesium metal is added to hydrochloric acid bubbles of gas, identified as hydrogen, are seen.
Explanation: Magnesium atoms lose electrons to become magnesium ions, Mg^{2+} (they are oxidised) while hydrogen ions gain electrons (they are reduced) and hydrogen gas are formed.
Symbols: $2H^{+}_{(aq)} + 2e^{-} \rightarrow H_{2(g)}$ and $Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^{-}$
or $2H^{+}_{(aq)} + Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}$

Candidates need to be aware of errors that appear to repeat in spite of comments made about previous examinations. These include:

- ➔ the incorrect and/ or imprecise language used by candidates to discuss or explain ideas is a concern and suggest a lack of rigor in the learning of basic facts, definitions and concepts. This was particularly apparent in questions relating intermolecular forces where the term 'van der Waal's forces' is used carelessly. It is apparent that some candidates use it to describe only instantaneous- induced–dipoles forces excluding permanent dipole-dipole and hydrogen bonds. It should be encouraged at this level of chemistry to use more precise and descriptive terms for each of the three forces between molecules (induced dipole = temporary dipole =dispersion forces = London forces; permanent dipole; hydrogen bonds).
- ➔ failure to give the number of examples sought in a question. When asked for one example, some candidates gave two or three examples.
- ➔ failure to answer the specific question. Some candidates gave what appeared to be well learnt answers to questions they expected rather than to questions they were asked.
- ➔ problems with calculations included:
- ✓ setting out of work that cannot be followed.
- ✓ insufficient working shown – candidates cannot receive any credit for an incorrect answer with no working.
- ✓ incorrect or missing units.
- ✓ No attention to, or incorrect use of, significant figures.

It is recommended that teachers take note of the common misconceptions that are referred to in this report and try to address these in their teaching.

COMMENTS ON SPECIFIC EXAMINATION QUESTIONS

QUESTION ONE: PERIODIC TRENDS

Candidates should be looked at the structure of the whole question and noted that in some questions the parts followed on from each other. For example, the responses in part (a) lead to the required responses in part (b), (c) and (d). Although an improvement has been noted in the ability of candidates to explain their answers to periodic trends such as size and ionization questions, candidates still gave lengthy answers which can often lead to contradictions.

(a) Better responses indicated a clear understanding of the arrangement of electrons in the 4s and 3d orbitals.
Weaker responses showed similar problems exercised from last year paper. It was heavily emphasized in the report last year about the common mistakes in writing s,p,d notation such as :

- ✓ must include all the energy level number for each type of orbital i.e. $1s^2 2s^2 2p^6$ but not $1s^2 2s^2 p^6$
- ✓ never use commas to separate the energy level number i.e. $1s^2 2s^2 2p^6$ but not $1s^2, 2s^2, 2p^6$. It was obvious that average candidates used commas in writing basic shell electron configuration such as 2,8,8 still applied that to s,p,d,f notation which is not the case.

(b) (i) Better responses correctly identified that the energy level (ie distance) was the predominant factor that determined the size of S and Se.
Weaker responses showed that some candidates thought that Se has 5 energy level instead of 4 energy level. This suggested that candidates wrote the basic electron shell configuration of Se, ie 2,8,8,8 so they concluded that Se had 5 energy level instead of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$.

(ii) Better responses indicated that both S and Cl had same energy level but S had smaller nuclear charge hence it had less attraction for electrons.
Weaker responses missed out the points that both atoms, S and Cl, had their valence electrons in the same energy level. The weaker responses failed to recognise the number of protons (nuclear charge) was the predominant factor that determined the size but not the number of electrons.

(c) Better responses provided explanation for comparison of size for both Cl/Cl^- and Na/Na^+. The better responses showed that incoming electrons when Cl^- ion formed increased electron-electron repulsion forces hence electron clouds expanded to minimize repulsion resulting in bigger size of Cl^-ion than Cl atom. The better responses correctly explained Na^+ ion lose an electron resulting in removing of complete energy level hence Na^+ ion had smaller size than Na atom.
Weaker responses gave incomplete explanation. Most candidates only focused on comparison of Na and Na^+ and never compared Cl and Cl^- ion or vice versa. Candidates easily identified why Na^+ ions are smaller than Na atom due to completely loss of 3^{rd} energy level but gave vague explanation why Cl^- ion is larger than Cl atom.

(d) (i) Better responses correctly defined the term ionisation energy.
Weaker responses misused words such as "*maximum energy*" instead of "*minium energy*" and most definitions were incompleted such definition as "*energy needed to remove an electron*".

(ii) Better responses included correct order with clear and correct reasons. Better responses answers showed that Cl had higher ionisation energy compared to S due to Cl had 2 more protons so greater effective nuclear attraction must be overcome even both atoms lose first electrons from 3p orbital. And comparing of S and Se clearly showed that Se lost its electron from 4^{th} energy

level which was more distant from the nucleus with more shielding than in S which lost its electrons from 3rd energy level (less distant so stronger attraction).
Weaker responses incorrectly arranged the atoms in order of increasing ionisation energy. This suggested that most candidates were misinterpreted the meaning of "*increasing order*" with "*decreasing order*". Weaker responses failed to recognize that the important factor that determines the differences in ionization enthalpy in this case was the **size** of nuclear charge. The trends in ionization energy were usually well understood although candidates must sort out their vocabulary especially when dealing with, energy levels, shells, orbitals and/or subshells. A significant number of candidates wrote excessively long answers. Such long answers are likely to have missed the point of the question or provide responses that contain contradictions.

(e) Better responses included clear explanation showing that Pu^{4+} had similar chemistry with Fe^{3+} so it could replaced Fe^{3+} and that allowed cell exposure to alpha radiation.
Weaker responses indicated that it was obvious most candidates memorised answers from previous exam papers and still thought of using it here. For instance, candidates thought of Pu caused mutation or changed to the DNA sequences. However, the examiner was seeking for those interpretation skills if candidates recognized that Pu^{4+} has similar chemistry t o Fe^{3+} and hence replaced Fe^{3+} in the body. Once in the blood system, this will allows cell exposure to damaging alpha radiation.

QUESTION TWO: PROPERTIES OF ELEMENTS

Although most candidates were successful in answering this question, there is still obvious that many do not **read the question carefully** but tempted to answer the question straight away which resulted in missing important parts or clue to what the question really needs.

(a) (i) Better responses showed that candidates were well familiar with using s,p,d, f notation.
(ii) Better responses correctly identified the transitional metal.
(iii) Weaker responses indicated that some candidates thought of Cr instead of Mn.
(iv) Better responses included both Cu and Cr demonstrating that candidates were well-understood this question.

(b) (i) Better responses correctly named the following ions given.
Weaker responses provided the colour of $Cr_2O_7^{2-}$ ion instead of CrO_4^{2-} ion. This suggested that some candidates thought that they were both the same.

(c) (i) Better responses easily identified that beta particle was formed.
Weaker responses carelessly excluded the negative sign of beta particle which resulted in positron (${}^{0}_{+1}e$) formed instead. This suggested that candidates were never used or exposed to that nuclide, positron.
(ii) Better responses gave the correct element.
Weaker responses heedlessly ignored the name of the element but used letter X or Y even candidates provided the correct mass number and/or atomic number.
(iii) Better responses included correct mass number with symbol of element.
Weaker responses carelessly excluded the symbol of the element.

(d) Better responses gave clear steps in the calculations. It was encouraging to see candidates used different methods to calculate the half-life.
Weaker responses got confused with "*what is the number of half-lives? (number of half-lives*

= 4)" and *"what is the half-life? (half-life = 32.20 days)"*. The weaker responses gave the answer for the first question but the required question which was the latter.

(e) (i) Better responses easily identified the correct equation with correct justification.
Weaker responses demonstrated some disappointing features such as candidates thought of *ions*, *atoms*, *molecules* were the same when they used those terms to justify their choice. For example, some candidates used their justification such as " *A larger molecules breaks down into smaller ions*". That was a common errors from candidates' responses.

(ii) Better responses gave concise, accurate two reasons linking to why nuclear fusion reactions were regarded as a better alternative to fusion reactions.
Weaker responses showed ambiguities in candidates responses which often resulted in provided reasons why fission reactions were better alternative instead of fusion reactions.

QUESTION THREE: MOLECULES

This question reflects the uncertainty in candidates responses to draw Lewis diagram. Teachers need to provide appropriate time for candidates to practice drawing Lewis diagram and naming shape of the molecules. It also worth noted that candidates could not able to express themselves clearly when asked to *explain* question such part (d) (iii) rather than *describe*, *list*, *identify* or *name*.

(a) (i) Better responses did contain a correctly drawn Lewis dot structure for all molecules given with correct naming of the shape.
Weaker responses indicated problems with drawing of Lewis diagram especially for O_3 and CO_3^{2-} ion. The weaker responses also excluded "dots" that represented non-bonding pairs of electrons or lone pairs.
A method that gives more success for students drawing these diagrams is given below.

RULES FOR DRAWING LEWIS DIAGRAMS:

1. Arrange the atoms on the page. Usually the least electronegative atom OR the first atom listed in the formula is the central atom unless it is hydrogen. Remember that hydrogen can only form 1 bond.
2. Count the total number of valence electrons in the molecule.
3. Form single bonds between each of the atoms. This will consume a pair of electrons.
4. Distribute pairs of e^-s around each outer atom so that the octet rule is obeyed (except H).
5. Place any remaining e^-s on the central atom.
6. If there are not enough remaining e^-s to place 8 e^-s on the central atom then take a pair of e^- from an outer atom and make a double bond (or a triple bond if necessary).

N.B. Many atoms will obey the octet rule i.e. be stable with 8 electrons in the valence shell. However, when atoms beyond the second period in the Periodic Table are in the centre of a molecule they may take up to 6 e^- pairs.

(ii) In the better responses, candidates demonstrated a thorough knowledge of both the number of regions of electron density (ie three electron clouds) around the central atom and provided a link as to how these bonding and non-bonding pairs of electrons directed towards the corner of a trigonal planar leading to bent or V-shaped.
Weaker responses indicated that how the arrangement of atoms determined the shape of the molecules. Candidates should be aware that the bonding pairs and non-bonding pairs of electrons were responsible for the shape of the molecule.

(b) (i) Better responses provided clear definition of electronegativity.
Weaker responses used the definition of ionization energy for electronegativity. The weaker responses gave vague definition such as "*electronegativity is a measurement of attraction of atom to bonded atoms*".

(ii) Better responses easily identified the correct order of increasing electronegativity of the elements given.
Weaker response gave the order in "*decreasing order*" of electronegativity not "*increasing order*"

(c) (i) Better responses clearly explained how differences in electronegativity influenced the polarity of S-F bond.
The weaker responses, most candidates surprisingly never explained this question clearly but this fundamental of polarity is a prerequisite in Form 6 Chemistry syllabus. Weaker responses incompletely mentioned that S and F unequally sharing electrons without justify why.

(ii) Better responses clearly stated that the symmetrical arrangement of S-F bonds around central S atom so dipoles cancel out.
Weaker responses indicated similar problems from last year paper. The weaker responses wrongly stated the S-F bond share electrons equally. Remember: non-polar molecules could have polar bonds but the symmetrical arrangement of the about the central atom where the polar bonds (which are vectors) would cancel.

(d) (i) Better responses reflected that candidates used this word often.
Weaker responses gave rambling answers which often lead to contradictions. The weaker responses indicated that candidates were unaware of how electrolysis directly related to redox reactions.

(ii) Better responses easily identified the Cl was the stronger oxidant.
Weaker responses indicated that candidates were guessing since their answers in part (iii) reflected poor understanding of how strength of oxidants affected their means of extraction.

(iii) Better responses gave correct and complete explanation.
Weaker responses suggested that this question caused a lot of problems for almost all candidates. The weaker responses failed to realise that the question was based on halogen oxidising ability of Cl and Br. Two points were required for candidates to know that Cl was a stronger oxidant than Br so Cl_2 could oxidise Br^- ion to Br_2 (and reduce itself to Cl^-) and second point stated that Cl_2 was a stronger oxidant and it was harder to oxidise hence energy input was required to get the oxidation reaction to occur.

QUESTION FOUR: ORGANIC NAMES AND ISOMERS

This question was generally well answered by a majority of the candidates. Candidates this year demonstrated an improved understanding of IUPAC nomenclature. Common errors included incomplete erasures of working and careless corrections and missing hydrogen atoms or bonds in full structural formulas.

(a) Better responses correctly named the functional groups and systematic names of the molecules given.
Weaker responses did not name the functional groups and systematic names rather than drawing them and/or swapped the names of the functional groups into systematic names. This pointed

out that candidates were uncertain about the differences of functional group and systematic name.

(b) Better responses included the correct formula of the 4-chloropentanoic acid and butanoyl chloride.
Weaker responses failed to correctly place Cl atom on 4^{th} carbon in 4-chloropentanoic acid which suggested that they did not count the first carbon from the carbon which contain the carboxylic group and incorrectly identified the functional group of acid chloride in butanoyl chloride.

(c) Better responses included correctly draw four isomers of C_4H_9Cl.
Weaker responses did drew two or three same structural formulas assuming they were both different. For instance, some gave $CH_3CH_2CHClCH_3$ and $CH_3CHClCH_2CH_3$ thinking they were both different.

(d) (i) Better responses identified glycine and alanine as amino acids.
Weaker responses wrongly identified glycine and alanine as carboxylic acid and/or protein.

(ii) Better responses identified alanine as the enantiomer saying it had a chiracl carbon in the molecule that contained four different groups attached.
Weaker responses failed to explain clearly the reason why alanine had enantiomers. The most common weaker responses included "*alanine has a carbon where different groups attached*" instead of "*alanine has a chiral carbon where <u>four</u> different groups attached to*".

(iii) Better responses correctly identified peptide or amide as the functional group.
Weaker responses gave the name of the class of the compounds such as dipeptide or protein or carboxylic acid rather than gave the name of the functional group.

QUESTION FIVE: ORGANIC REACTIONS

This question was one of the most poorly answered suggesting that candidates had no/little time in doing relevant exercises on organic reactions. Almost all candidates failed to gain full marks for part (a), (b) (ii) and (c). There is great need to spend more time on doing quality exercises on polymer such as nylon.

(a) Better responses included identified the reagent correctly (ie $Cr_2O_7^{2-}/H^+$ or MnO_4^-/H^+ or MnO_4^-) for oxidation of primary alcohol, $CH_3CH_2CH_2CH_2OH$ to $CH_3CH_2CH_2COOH$. The better responses indicated that candidates identified that when chlorinating agent, $SOCl_2$, used in carboxylic acid, $CH_3CH_2CH_2COOH$ resulting in formation of acid chloride (ie $CH_3CH_2CH_2COCl$).
Weaker responses failed to distinguish the major ($CH_3CH_2CHOHCH_3$) and minor products ($CH_3CH_2CH_2CH_2OH$) formed from $CH_3CH_2CH{=}CH_2$. Weaker responses also did not include H^+ in $Cr_2O_7^{2-}$ (such as $Cr_2O_7^{2-}/H^+$) for those who used this reagent for oxidation of $CH_3CH_2CH_2CH_2OH$ to $CH_3CH_2CH_2COOH$. Weaker responses also failed to identified that the alcohol ($CH_3CH_2CHOHCH_3$) and carboxylic acid ($CH_3CH_2CH_2COOH$) are formed from acid hydrolysis of ester, $CH_3CH_2CH(CH_3)OOCCH_2CH_2CH_3$.

(b) (i) Better responses included such definition as "*substitution is a chemical reaction where the halogen is replaced by a group that is negatively charged or carries a lone pair of electrons, ie the nucleophile*" and *"elimination is a chemical reaction involves the removal of the halogen*

atom and a hydrogen atom to form an alkene".
Weaker responses showed poor knowledge of basic definitions specific to terminology associated with organic chemistry. The skills of writing well-constructed sentences and developing logical and concise explanations were frequently lacking.

(ii) Weaker responses included candidates failed to draw correctly the product/s for substitution reaction and elimination reaction respectively. Even the reagents (ie $KOH_{(aqueous)}$ for substitution reaction and $KOH_{(ethanol)}$ for elimination reaction) were given as a hint, candidates still could not able to give the correct products. For elimination reaction in particular, some candidates got only one alkene right as a product and hydrogen bromide (HBr) instead of both products were $CH_2{=}CHCH_2CH_3$ and $CH_3CH{=}CHCH_3$.

(c) Better responses showed only from top candidates.
Weaker responses included almost all candidates failed to draw the two correct products of the polymer which should be the dicarboxylic acid (HOOCCOOH) or diacid chloride (ClOCCOCl) and the diamine ($H_2N(CH_2)_4NH_2$. This weaker responses showed a lack of understanding of drawing monomers from a polymer such as nylon.

(d) Better responses clearly linked explanation why compound A was a primary alcohol with its correct structural formula (ie CH_3CH_2OH) and compound B was a secondary alcohol with its correct structural formula (ie $CH_3CHOHCH_3$) as well.
Weaker responses misinterpreted the question by identifying the product of compound A and compound B which was carboxylic acid, CH_3CH_2COOH and ketone, CH_3COCH_3 respectively instead of trying to identify what was compound A and B.
Mid-range responses included identifying only compound A and not compound B or vice versa.

QUESTION SIX: QUALITATIVE ANALYSIS

Candidates were successfully answered part (a) but surprisingly had problems with part (b) to (d). This implied that most were not doing practical works as much as quality exercises on this topic.

(a) (i) Better responses identified bromine water as the best reagent with correct description of observations.
Weaker responses identified the correct reagent but surprisingly gave incorrect observation or writing the equation for the reaction which was not asked.

(ii) Better responses clearly identified that candidates had good understanding about the reagent and observation for compound B which was an aldehyde.
Weaker responses pointed out confusing in some candidates of using acidified potassium dichromate rather than Tollen's reagent. Yes, acidified potassium dichromate could showed reaction with compound B so as compound C. This question was based on qualitative test to specifically distinguish these given compounds.

(iii) Better responses showed clearly that compound D that could change red litmus blue.
Weaker responses indicated a lack of understanding about amine and its full properties such act as a weak base which had similar properties as base, ammonia.

(iv) Better responses specifically identified compound E reacted violently with water or "spitting" occured.
Weaker responses distinctly showed that average candidates knew nothing about the common

properties of any acid chloride reacted with water.

(v) Better responses showed that candidates were well familiar with the expected observation when a primary alcohol reacted with acidified potassium dichromate solution by clearly stating the initial colour and final colour change with species responsible for those colour changes. Weaker responses failed to state the final colour after the reaction took place.

(vi) Better responses identified compound A (1-butene) was the correct answer. This suggested that candidates understood that alkene are common reactants for additional polymerisation reaction. Weaker responses confused with additional polymerisation and condensation polymerisation so two answers were given.

(b) (i) Better responses correctly wrote the formulae of the complex ion, $[Cu(NH_3)_4]^{2+}$ and balanced correctly the equation.
The weaker responses had difficulty in writing correct formulae of the complex ion as well as wrongly balanced the equation for formation of complex ions.

(ii) Better responses showed clear, accurate and specific descriptions for the observations made.
Weaker responses identified the correct colour observed when $NH_{3(aq)}$ is added to copper sulfate solution but incorrectly identified the colour changes when excess $NH_{3(aq)}$ when copper sulfate solution was added. Candidates did not see that blue precipitate is different from blue solution or dark blue precipitate is not the right answer but dark blue solution.

(c) Better responses showed only the top students identified correctly the formulae.
Weaker responses indicated that this question was one of the poorest responses from the candidates. Candidates had no clue on how to write the correct formulae of the product from this equation.

(d) (i) Better responses indicated that candidates were familiar with this reaction by writing concise accurate observation.
Weaker responses did provide any incomplete or incorrect observation for the reaction.

(ii) Better responses wrote correctly the ionic equation including the states of the ions and product involved.
Weaker responses did not able to write the balanced ionic equation and/or unable to identify the correct states of matter of each reactant/s and product with wrong charges on each ions involved.

(iii) Better responses showed clear and accurate observation for this part.
Weaker responses showed lack of understanding about additional of aqueous ammonia to the product of silver nitrate and sodium chloride. Most candidates restated the same observations they gave in part (d) (i).

(iv) Better responses indicated that only top candidates identified that the formation of complex ion was responsible for dissolving of $AgCl_{(s)}$.
Weaker responses showed poor understanding of the nature and effects of complex ions as it formed.

QUESTION SEVEN: AQUEOUS CHEMISTRY

This was one of the most poorly done question in the whole examination paper. The concepts tested, explaining indicator choice and titration curve sketching, were not well understood by candidates. This could possibly be attributed to the fact that this section of the syllabus has had little coverage. This type of question once again highlighted the need for candidates to be exposed to the full range of mandatory practical experiences at school.

(a) (i) Better responses showed correct equation with correct charges of ions.
Weaker responses indicated that some candidates stragely could not able to write the charges of hydronium ion and ethanoate ion correctly.

(ii) Better responses correctly wrote the expression for the acidity constant, K_a, for ethanoic acid.
Weaker responses wrongly included water in the expression for the K_a for ethanoic acid.

(iii) Better responses showed clear working with the correct calculation of the pH of ethanoic acid. Better responses correctly applied a pH formula for calculation of weak acid such as ethanoic acid. The best responses did not round off at any step and gave answers correctly using three significant figures.
Weaker responses could only show one correct step of the calculation. Weaker responses did not include -log in equation for calculation of pH which resulting in totally wrong answer.

(iv) Better responses related the pH of the given acids to hydrogen ion concentration and were able to explain the difference due to the different degree of ionisation in each acid by refering to the value of K_a and/or pK_a.
A significant proportion of weaker responses referred to differences in acid strength without relating it to ionisation or did not explain why there was a difference between the two weak acids. Responses indicated that candidates' understanding of the terms '*ionisation*' and '*dissociation*' in relation to acids varied considerably.

(b) (i) Better responses clearly marked the equivalence point with an *X* at the centre of the steepest part of the titration curve.
Weaker responses indicated no understanding of where the equivalence point at the titration curve.
Better responses clearly showed precise zone for buffer region where one pH unit above and below the pK_a of NH_4^+.
Weaker responses showed no precision and lack of understanding in drawing the accurate buffer region. Average candidates circled the steepest part of the curve or the second plateau as the buffer region.

(ii) Better responses correctly determined the pK_a of NH_4^+ by applied accurately the concept that pK_a = pH at half the volume required for equivalence point, ie at 12.5 mL. From graph, pK_a = 9.6 (approx.)
Weaker responses indicated careless interpretation of the titration curve which led to incorrect identification of pK_a.

(iii) Better responses chose the correct indicator with clear explanation that indicator changes colour at a pH on the steepest part of the titration curve.
Weaker responses showed that the great majority of candidates were able to select the correct indicator but many failed to explain the reason why it was the most appropriate. A number of candidates indicated that litmus was unsuitable as an indicator because it was a "paper" and seemed unaware that it could be obtained in liquid form.

(c) (i) The better responses correctly identified the buffer solution with clear understanding that both an acid and its conjugate base were present in similar quantities.
Weaker responses showed candidates founnd it very hard to interpret the particles representation in model forms. It seemed that almost all candidates exposed to this sort of model representation of particles for the first time showing by lack or completely failed to give a clear

explanation

(ii) Better responses correctly described the pH remained the same when a small amount of acid was added. The better responses also provided balanced correct equation.
Weaker responses failed to give clear description of what happened to the pH of the buffer when small amount of acid was added and surprisingly gave incorrect equation.

(iii) Better responses gave concise and correct description that the pH of the buffer solution did not change.
Weaker responses provided vague and irrelevant answer.

QUESTION EIGHT: EQUILIBRIUM REACTIONS

There was one critical error in this question which was on the data given on part (d). The last sentence inside the box stated that "*Phenolphalein is* *pink* *in acid and* *colourless* *in base*" which should be "*Phenolphthalein is colourless in acid and pink in base*". Responses showed a significant lack of knowledge of the fundamentals of both applying Le Chatelier's principle and factors affecting equilibrium position. Most candidates showed no appreciation of the equilibrium situation; not linking a saturated solution to equilibrium;
• repeating or rewording the question data; and used of the term molecules instead of ionic substance or ions.

(a) (i) Better responses correctly wrote a balanced chemical equation for the dissolving of lead chromate in water.
Weaker responses showed that candidates were not considered how important to include correct charges of ions in the equation.

(ii) Better responses show clear working with the correct calculation of the solubility of lead chromate. Better responses also gave correct unit for the final answer.
Weaker responses showed lack of understanding in how to calculate solubility of sparingly soluble solids by calculating the solubility product and not the solubility. It seemed that candidates were misinterpreted the term "*solubility*" and "*solubility product*".

(iii) Better responses showed systematic and correct ways in calculation the solubility of lead chromate in 2.55×10^{-4} mol L^{-1} lead nitrate. The better responses showed that candidates identified that lead ion (Pb^{2+}) was a common ion.
Weaker responses indicated that most candidates could not deal with calculations of solubility of solutions containing a common ion. It showed that there is still lack of exercises in this part of the course. Weaker responses indicated that rounding off to only one significant figure or not rounding off at all and giving all numeric values on the calculator screen were not appropriate.

(iv) Better responses used Le Chatelier's principle to explain that the reaction of CrO_4^{2-} in acid solution to form $Cr_2O_7^{2-}$ resulting in decreasing of CrO_4^{2-} concentration that altered the equilibrium to oppose the effect of the change by moving towards the product side resulting in dissolving more $PbCrO_4$.
Weaker responses showed that candidates found this question very difficult to interpret. It showed that candidates had difficulty with applying the Le Chatelier's principle and its effects on solubility of salts. The weaker responses provided vague answers failing to relate equilibrium and its effects on solubility of $PbCrO_4$.

(b) Better responses correctly listed all species present in 0.100 mol L^{-1} NH_4Cl solution.
Weaker responses indicated that candidates had difficulty with this question. Candidates are

advised to spend time in doing exercises on identifying species in solution.

(c) (i) Better responses identified the correct statement with correct equation to justify that the hydrolysis of methanoic acid to produce hydronium ions that responsible for pH of HCOOH less than 7.

Weaker responses either incorrectly identified the statement nor gave incorrect equation. It was surprised to see a lot of incorrect unbalanced equation.

(ii) Better responses showed correct identification of statement with correct two equations to justify their choices.

Weaker responses showed that candidates had difficulty with this particular question. Candidates could not understand that HCOONa must first dissolved in water before it hydrolysed to produce $OH^-_{(aq)}$ which responsible for pH greater than 7.

(d) (i) Better responses showed only top candidates answer this question correctly. The better responses used Le Chatelier's principle to explain that Reaction (1) was endothermic so when warmed the equilibrium shifted to the product side forming more OH^- causing the solution basic. Therefore the phenolphthalein turned pink.

Weaker responses showed almost all candidates could not able to identify that Le Chatelier's principle must apply. Weaker responses were excessively long and did not use the number of lines as a guide to structuring the response or never provided any answers.

(ii) The better responses once again confirmed that only the top candidates had the ability to answer this question. Better responses identified how both equations (Reaction (1) and (2)) related to one another and top candidates distinctly applied Le Chatelier's principle to explain how CO_2 in Reaction (2) pushed equilibrium to the product side forming more H_2CO_3. H_2CO_3 was a product in Reaction (1) so causing equilibrium to shift to the reactant side resulting in less OH^- ions. Hence, the solution becomes less base so phenolphthalein turned colourless.

Weaker responses showed that this was one of the most difficult question for candidates. Weaker responses indicated that this sort of questions where Le Chatelier's principles applied required more time for teachers to address their candidates clearly and thoroughly. It seemed there are lack of exercises on this concept since there were less or no improvement from previous examinations.

QUESTION NINE: OXIDATION-REDUCTION REACTIONS

Electrochemical cell calculations were again probably the most successful part of the exam overall although there were concerned over the understanding of using oxidation numbers and balancing redox equations. This probably reflected the lack of exposing to practical activities and not thoroughly completed the projects.

(a) Better responses showed good understanding in determining the oxidation number.

(b) (i) Better responses correctly identified the colour change.

Weaker responses indicated that candidates had lack of practical exercises by giving totally incorrect answer.

(ii) Better responses correctly completed and balanced the oxidation and reduction half equations for this reaction.

Weaker responses showed that candidates did try to get a balance in terms of the multiplier and cancelling electrons from the half equations. However, a significant number failed to check the balance of the total number of atoms and electrical charge.

(c) (i) Better responses described the colour changes accurately as well as showing good

understanding of the species responsible for the colour changes.
Weaker responses showed that candidates had lack of practical experiences by failing to describe the observation for this chemical reaction.

(ii) Better responses showed that only top candidates provided correct answer for this question. Weaker responses pointed out that candidates had difficulty in identifying the product when $S_2O_3^{2-}$ ion reduced. This suggested that candidates had less time in practicing completing and balancing redox half-equations.

(iii) The better responses showed that only top candidates that got the correct answer for part (ii) achieved full mark for this part.
Weaker responses surprisingly indicated most candidates could not able to balance this overall redox reaction.

(d) Better responses correctly identified the strongest reductant.
Weaker responses showed that most candidates were still uncertain about the concept of strength of reductant and/or oxidant.

(e) (i) Better responses showed that candidates had better understanding of the roles of salt bridge. The best responses even gave detailed explanations such as "*the negative ions move through the salt bridge into the Zn^{2+}/Zn half-cell to offset the increase in positive charge (due to the formation of Zn^{2+}) while the positive ions will move into the Cu^{2+}/Cu half-cell where there is a decrease in positive ions (due to reduction of Cu^{2+})*".
Weaker responses indicated students' failure to understand that the salt bridge allowed ions to move and that electrons did not travel through the solution in
the beakers and the salt bridge.

(ii) Better responses gave the correct cell diagram for the cell.
Weaker responses indicated poor understanding of using the conventions in writing standard cell diagram. Weaker responses showed that most candidates failed to know that cathode is placed on the right and anode is placed on the left. The weaker responses also included Pt electrode in the cell diagram indicating candidates had no understanding that Zn and Cu solid were acted as electrode.

(iii) Better responses showed clear equation with correct calculations providing correct answer with unit.
Weaker responses misplaced values into the equation resulting in negative answer with no unit.

(f) Better responses included clear working, showing the correct calculation of E^0_{cell} for both reaction Zn with acid and reaction of Cu with acid with the correct link of values of E^0_{cell} to why hydrogen gas given in Zn reaction but no reaction when copper metal reacted with acid.
Weaker responses indicated very lack of understanding in applying calculated values of E^0_{cell} to determine whether the reaction was spontaneous or not.

QUESTION TEN: ENERGY

It seemed that the problems with intermolecular and intramolecular bonds was raised in examiner's report last year was not addresses thoroughly by both teachers and candidates. Expressions and using of scientific terminology were very poor and lots of ambiguities were shown. Teachers are encouraged to take time to give concise and clear answers for this type of questions for candidates to follow.

(a) (i) Better responses wrote correctly the letter that represented the hydrogen bond.
Weaker responses showed that majority of candidates were unable to identify the correct letter that represented the hydrogen bond by wrote letter "*d*" instead of letter "*e*". Some obviously confused hydrogen bonding with the hydrogen-oxygen covalent bond.

(ii) Better responses correctly identified the letter "*e*" that represented the bond(s) broken when ethanol boiled.
Weaker responses included more than one letters indicating lack of understanding of intermolecular and intramolecular bond.
[N.B. : letter a, b, c and d all represented intramolecular bonds which required very high energy to break whereas only letter e represented intermolecular bond which required less energy to break]

(b) (i) Better responses correctly identified the intermolecular forces for both Cl_2 and Br_2. In better responses, candidates explained clearly that both molecules were non-polar but Br_2 was larger so had more electrons making it more polarisable therefore it had larger dispersion forces between the molecules.
Weaker responses incorrectly identified the intermolecular forces with very poor number who showed virtually no understanding of the topic. Many had difficulty in confining their answers to the space available, while the standard of written expression was poor, with many students confusing concepts and their uses. Here candidates needed to relate the increase in dispersion forces to larger molecular mass, increased number of electrons or bigger molecules.

(ii) Better responses correctly identified the intermolecular forces for both H_2O and H_2S. The better responses provided clear explanation that strong hydrogen bonds between H_2O molecules are stronger than permanent dipole-dipole attractions between H_2S molecules.
Weaker responses failed to identify that both H_2O and H_2S had different type of intermolecular forces. Weaker responses demonstrated the inability of candidates to recognise how different type of intermolecular contributed to differences in physical properties (eg boiling point) of molecules given. A common error was to imply that hydrogen bonding was within the molecule rather than between the molecules.

(c) The best responses clearly set out all relevant working, showing all bonds involved by rewriting the structural formulae for all molecules involved in the reaction. Better responses correctly calculated the energy for bond breaking and bond forming resulting in correct final answer.
Weaker responses showed lack of systematic and logical steps. Failing to write the structural formulae for reactants and products and so missing some of the bonds to be broken and formed. Candidates seemed to be overconfident about how to tackle this problem but needed to be more careful in order to consider all bonds involved. Few candidates got the correct values for '*bond breaking*' and '*bond forming*' but misuse the formula to get the final answer.

(d) (i) Better responses included correct definition of $\Delta_{vap}H^0$.
Weaker responses reinstated the question. The weaker responses suggested that less time on learning basic terminology of energy chemistry.

(ii) Better responses included correct, balanced equation with correct states of molecules involved.
Weaker responses demonstrated an inability to balance equations, particularly the amount of oxygen involved.

(iii) Better responses included relevant equation with correct substitution of values resulting in accurate answer.
Weaker responses showed that most candidates incorrectly substituted values resulted in positive values.