A Level

Chemistry

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CHEMISTRY

ADVANCED LEVEL

Paper 9250/1

Q.1 This was an unpopular question which tended to be chosen by the weaker candidates. The significance of the all-important word 'intermolecular' (italicised in the question) was missed by too many candidates who wrote at great length about ionic, covalent or metallic bonding. While some reasonably accurate accounts of the origin of van der Waals forces and hydrogen bonds were seen, their influence on the physical properties of substances tended to be treated superficially. Suitable examples for van der Waals forces might include the boiling points of the noble gases *or* halogens *or* alkanes, the boiling points of isomeric alkanes, and the softness of graphite; and, for hydrogen bonds, the boiling points of the hydrides of the Group V, VI or VII elements, the density of ice/water, and the dimerisation of carboxylic acids in non-polar solvents.

Q.2 *(a)* Some candidates attributed the various peaks to different *isotopes* of sulphur in spite of the wide range in mass. Others assumed that sulphur associates in the vapour state to give molecules of formula S_2 to S_8. Surprisingly few appeared to recognise that the molecular ion undergoes fragmentation.

(b) Many candidates asserted that the higher oxidation states arise from the *loss* of four or six electrons. Some candidates were content to quote examples of sulphur compounds in which the oxidation state of sulphur was II, IV or VI. It was hoped that answers would be based on the presence of two unpaired electrons in the ground state, with the possibility of four or six unpaired electrons arising from the promotion of a 3p or 3s electron to a 3d orbital.

(c) The white precipitate was often incorrectly identified as ammonium sulphate. The examiners expected candidates to explain the observations in terms of the effect of the addition of NH_4^+ ions on the position of the equilibrium $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$.

(d) This part produced the best answers in this question, although Boltzmann distribution graphs with the labels on the x- and y-axes reversed were common and the significance of the areas under the curves was not always clearly appreciated. The weaker candidates often confused the kinetic and equilibrium aspects and some asserted that, for an endothermic reaction, an increase in temperature produces a *decrease* in the rate of reaction.

Q.3 This was the most popular question in **Section A** and relatively high-scoring. The two definitions were generally well known. In the next part, candidates were expected to identify at least two factors, e.g. ionic charge and ionic radius, and to indicate how each affects the magnitude of a lattice energy.

The Born-Haber cycles were generally drawn accurately, though some candidates made heavy weather of the cycle in *(b)* where

$$KCl(s) \longrightarrow K^+(g) + Cl^-(g)$$
$$\searrow \quad \downarrow$$
$$K^+(aq) + Cl^-(aq)$$
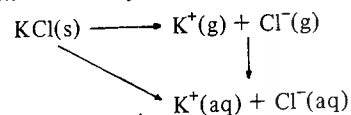
would have been perfectly adequate for the purpose. In the first calculation a common error was to divide the enthalpy change of atomisation of chlorine by two, presumably because the candidates concerned assumed that this quantity refers to 1 mol of $Cl_2(g)$ rather than to 1 mol of $Cl(g)$. In the second calculation many candidates correctly calculated the enthalpy change for the process $K(s) + \frac{1}{2}Cl_2(g) \rightarrow K^+(aq) + Cl^-(aq)$ as -421 kJ mol^{-1}, but this is *not* the enthalphy change of solution of potassium chloride as required in the question. In the last part candidates were merely expected to note that potassium chloride is soluble in water, although ΔH(solution) is endothermic. Some answers went a good deal further than the syllabus requires referring to the fact that the entropy change for this process is positive.

Q.4 This was the more popular question in **Section B**, but part *(a)* revealed widespread confusion in candidates' minds.

(a) (i) This was the only part to produce consistently convincing answers.

(ii) It was hoped that the increase in reducing power down the Group would be related to the E^θ values given in the *Data Booklet*.

(iii) There were some extremely confused ideas here. Contradictory statements such as 'thermal decomposition increases . . . carbonates become more stable' were common. It was hoped that candidates would relate the decreasing ease of thermal decomposition of the carbonates down the Group to the change from the larger CO_3^{2-} ion to the smaller O^{2-} ion and to the decreasing charge density (or polarising power) of the cation.

(iv) The decreasing solubility of the sulphates down the Group can be related to the different rates at which the hydration energy of the cation and the lattice energy of the sulphate decrease down the Group.

(b) (i) There were some unacceptably high estimates in view of the closeness of the E^θ values for calcium and barium (the *Data Booklet* does not give a value for strontium).

(ii) Few candidates found any difficulty here, though some, having correctly identified element **X**, failed to state the Group of the Periodic Table to which it belongs.

Q.5 This straightforward question was not as high-scoring as expected.

(a) The white precipitate of aluminium hydroxide dissolves in an excess of aqueous sodium hydroxide as a complex 'aluminate' is formed.

(b) The silicon tetrachloride undergoes hydrolysis with the evolution of hydrogen chloride and the formation of an acidic solution.

(c) The ammonia evolved forms a dark blue complex with copper(II) ions.

(d) The chlorine oxidises iodide ions to iodine which gives a violet colour in the tetrachloromethane layer.

Q.6 This was the most popular question in **Section C**.

(a) Structural isomers have the same *molecular* formula (empirical formula is not sufficient here), but different structural formulae.

(b) In *cis-trans* isomerism restricted rotation about, for example, a carbon-carbon double bond means that

$$\begin{matrix} H & H \\ C{=}C \\ Cl & Cl \end{matrix} \; (cis) \quad \text{and} \quad \begin{matrix} H & Cl \\ C{=}C \\ Cl & H \end{matrix} \; (trans) \text{ are different compounds.}$$

The isomers **A**, **B** and **C** were often identified correctly, but candidates sometimes failed to explain their reasoning clearly. For example, the significance of the decolourisation of aqueous bromine, the formation of an orange precipitate with 2,4-dinitrophenylhydrazine and the positive Fehling's test was often ignored. The structural formula of isomer **C** was sometimes arrived at by a process of elimination and not deduced from the evidence.

Q.7 A wide variety of tests was produced here, not all of which were practicable. Candidates should realise that a particular test may be given by more than one of the compounds given; for example, compounds *(a)*, *(b)* and *(c)* all gave an ester on reaction with an alcohol under suitable conditions. A logical sequence of tests might be as follows:

(a) add acidified potassium manganate(VII), which would be decolourised only by HCO_2H;

(b) add phosphorus pentachloride, which would give fumes of $HCl(g)$ with CH_3CO_2H;

(c) add cold water, which would give fumes of $HCl(g)$ with CH_3COCl;

(d) and *(e)* warm with aqueous sodium hydroxide, acidify with nitric acid and add aqueous silver nitrate – a white precipitate (due to the presence of Cl^- ions) is given by $CH_3CH_2CH_2Cl$ and a yellow precipitate (due to the presence of I^- ions) is given by $CH_3CH_2CH_2I$.

Q.8 *(a)* The question asks for the identity of the product (how?) and the conditions under which it is formed. For phenylamine, therefore, one answer might be simply that a benzenediazonium salt is produced at a temperature less than $10°C$. However, many candidates discussed the reaction mechanism in some detail. Some candidates thought that the reaction of nitrous acid with phenylamine is an example of nitration. The industrial importance of the reaction of an aromatic amine with nitrous acid was often stated to be in the manufacture of phenol.

(b) The structural formula of the zwitterion was often given correctly (though not always in the *full* version required), but the recurring weakness here was the failure of candidates to relate the physical properties of the aminoacid to its structure.

(c) Candidates were expected to show clearly that water is eliminated between aminoacid molecules and to identify the peptide linkage.

Q.9 This was the more popular of the two Standard Option questions in **Section D**.

(a) It was not uncommon to find eutectic mixture defined in terms of boiling point, rather than melting point. The eutectic diagram was generally well drawn, though occasionally with excessively curved lines. The cooling of the melt presented more problems. Candidates were expected to sketch a cooling curve showing a break at $115-130°C$, where solid camphor begins to separate, and a horizontal section at $33°C$, where the solid which separates has the eutectic composition.

(b) (i) Raoult's law in this context is still not as widely known as it should be and there was some confusion with Raoult's law as it applies to a solution of an involatile solute.

(ii) Apart from some confusion between vapour pressure and boiling point, the diagram presented few problems.

(iii) Some candidates should have chosen their example more carefully in view of the fact that they were required to explain their choice, e.g. H_2O/H_2O_2. However, most candidates appreciated that the intermolecular forces in the mixture must be stronger overall than those in the separate liquids.

Q.10 (a) Most candidates managed to find a reasonable number of points of interest, such as the fact that the +2 oxidation state is common to all (except scandium), the maximum oxidation state often corresponds to the total number of 3d and 4s electrons, Fe(III) is more stable than Fe(II) (linked to the d^5 electron configuration), and the acidity of the oxides in which the d-block element is in its highest oxidation state.

(b) (i) This situation is specified in the syllabus, but there were relatively few convincing answers. Attempts to explain the delay in the appearance of the blue colour were rare.

(ii) Even if the basic chemistry here had been unfamiliar, candidates should have been able to deduce that the initial blue precipitate is $Co(OH)_2$, which dissolves in an excess of aqueous ammonia due to the formation of a complex ammine.

(iii) Most candidates appreciated that the copper(I) oxide disproportionates, but at this level the pale blue colour of the solution should be attributed more precisely (to Cu^{2+}(aq) for example) than it was by many candidates (to copper(II) sulphate).

Q.11 (a) Candidates were expected to explain the use of *all* the pieces of apparatus, but the inclusion of the empty flask was almost invariably ignored. Very few candidates were able to give *two* methods for the measurement of the rate of metabolism and some highly impractical methods were suggested. One suitable method would be to determine the increase in mass of the soda lime tube at several times.

(b) The replacement of air by a suitable 'inert' gas such as nitrogen was expected here.

(c) The two equations were often given correctly.

(d) The repetition of the experiment in the absence of yeast was usually suggested.

Q.12 (a) The essential point here is that a larger surface area than would be provided by the Liebig condenser is required, so that several smaller tubes would be used in practice.

(b) The build up of a cake on the filter is the cause of the problem here. This can be overcome either by increasing the pressure gradient or by scraping off some of the cake.

(c) Turbulent flow ensures efficient mixing of the hot and cold sections of the fluid, whereas in streamline flow the stationary layer next to the pipe wall effectively insulates the bulk of the fluid.

(d) The removal of heat from the reaction zone controls the temperature of the reaction; it can be used to pre-heat the reactants to the required reaction temperature.

(e) Slurries are dried by means of a rotary drier. This is a revolving cylinder in which the slurry enters at one end and the dry solid emerges at the other end. Drying may be achieved by means of hot air.

Q.13 There was a marked improvement in the standard of the answers compared with previous years. Parts (a) and (b) (i) were generally well answered, but marks were very low in part (b) (ii).

(a) Diagrams similar to those given in the *Notes for Guidance* (pages 14 and 15) would be appropriate here.

Hydrogen bonding between adjacent lamellae in montmorillonite is not possible, so that water can be trapped in the gap. In dry weather this water is released and the lamellae close together causing cracking.

(b) (i) Similarly sized cations can fit into the tetrahedral cavities in the silicate sheets or into the octahedral cavities in the gibbsite sheets. Typical substitutions include Al^{3+} for 'Si^{4+}' in the silicate sheets and Mg^{2+} for Al^{3+} in the gibbsite sheets, giving an excess of negative charge. Cations such as Na^+ or K^+ are held to counter-balance the charge between the lamellae.

(ii) At the surface of the structure O^{2-} ions are not electrically neutralised by other ions, so that cations are attracted. In acidic soils H^+ ions are removed into solution making the surface negative, so that cations may be held.

Q.14 (a) (i) Two distinct processes are involved in food deterioration — microbial spoilage and autolysis (the cellular breakdown by enzymes within the food). Oxidation by atmospheric oxygen and hydrolysis in the presence of moisture cause rancidity in fats. The outer surface of the food can become partially dehydrated by loss of water to the atmosphere.

(ii) In the *osmotic method*, the addition of salt or sugar lowers the water activity of the food (high osmotic pressure), so that the micro-organism loses water by osmosis and hence is incapable of growth. An obvious disadvantage is the flavouring of the food by the additive. Examples include the salting of fish and the production of jam. In the *thermal method*, bacterial cells or spores are destroyed by heating the food to a high temperature in a sealed container. One disadvantage is that the food may be cooked during processing. Meat, fish, fruit and vegetables can all be preserved in this way.

(b) When meat is cooked the protein content is denatured, i.e. the bonds forming the tertiary structure are destroyed.

When cabbage is cooked ascorbic acid (Vitamin C) is destroyed by oxidation which is catalysed by oxidases present in the cabbage.

(c) Cellular breakdown of food begins immediately after harvesting or slaughter, leading to loss of nutrients. Frozen foods are normally processed within hours of harvesting or slaughter, whereas fresh foods may be consumed several days later.

Q.15 (a) On heating, the initiator produces radicals which react with the monomer to form more radicals, thereby propagating the chain. The formation of the radicals and breaking the double bonds in the monomer are endothermic processes, but the formation of single bonds in the polymer is an exothermic process, so the temperature must not be allowed to increase too far or the reaction would become uncontrollably fast. The less stable initiator starts the reaction at a fairly low temperature, while the more stable initiator enables controlled polymerisation to occur at a higher temperature. Candidates did not seem to be familiar with the reasons for the use of more than one initiator.

(b) Clear diagrams of the isotactic (highly crystalline due to the close packing of the chains), syndiotactic and atactic forms were required here.

(c) Very few candidates appreciated that the important factor here is the relative proportions of the two monomers. Buta-1,3-diene is present in the greater proportion in the copolymer used for making car tyres (predominant elastomer properties, hardened by phenylethene inclusion) and phenylethene is present in the greater proportion in the copolymer used for making containers for dairy products

predominant plastic properties, softened by butadiene inclusion).

Q.16 (a) The M + 1 peak is due mainly to the presence of ^{13}C atoms in an organic molecule and comparison of the M and M + 1 peak heights gives an indication of the number of carbon atoms present. M + 2 peaks generally indicate the presence of chlorine or bromine. For chlorine the M:M + 2 ratio is approximately 3:1 and for bromine the ratio is approximately 1:1.

(b) Protons and deuterium atoms do not absorb in the same region of the n.m.r. spectrum, so the presence of labile protons in a molecule can be confirmed by adding D_2O when the peaks caused by such protons disappear, e.g.

$C_2H_5OH \rightleftharpoons C_2H_5OD + HOD.$
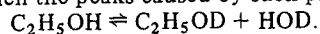
(c) According to the Beer-Lambert law $A = \lg \frac{I_0}{I} = \epsilon cl$. Provided ϵ is known, measurement of the absorbance of a solution may be used to determine its concentration. Examples of the uses of the law include the colorimetric determination of iron or manganese, measurement of rates of reaction, determination of K_a for an acid-base indicator and measurement of pH.

(d) A simple diagram showing the splitting of the five d-orbitals in a complex into two energy levels was expected here. Radiation in the visible region may then be absorbed when an electron moves from a d-orbital of lower energy to one of higher energy and the colour of a complex is seen as the complement of the colours absorbed. The colour of a complex depends on the nature of the ligand, as different ligands cause different energy separations.

Paper 9250/2

Q.1. Most candidates gave a balanced equation for the formation of hydrogen chloride gas. The reaction between potassium iodide and concentrated sulphuric acid in (b) is not so simple and a variety of answers was accepted; iodine appears as a purple vapour, but observation of the reduction products of sulphuric acid, e.g. sulphur, hydrogen sulphide were alternatives. The role of phosphoric(V) acid as a non-oxidising acid was generally known. In (d) only the hydrogen iodide with the spectacular formation of iodine, which was activated by the hot glass rod (a hot wire is equally effective). Part (iii) could be answered in terms of enthalpy changes of formation of the hydrogen halides, or for dissociation or in terms of the magnitude of bond energy. Each of these effectively said the same thing.

Q.2. The usual and expected answer to (a) was the formation of diethyl ethanedioate and water, though the question lends itself quite neatly to ethyl hydrogen ethanedioate being produced. The acid remaining in the equilibrium mixture was usually diluted to "freeze" the equilibrium and titrated with alkali using phenolphthalein or with acidified potassium manganate(VII) using either an Mn^{2+} catalyst (best) or by warming to 60°C.

The equilibrium constant (note the water cannot be disregarded) is determined by finding the initial number of moles of acid and alcohol (1, 2 respectively) and then the position of all four species at equilibrium, which leads to a value of K of 3.375. The same method gives 0.64 for K for the half-ester.

Q.3. The answers in (a) are straightforward. All candidates knew that Ca^{2+} has no d electrons but the other ions were often incorrect although they could almost be read from the Data Booklet. Too few candidates referred to one mole of gaseous M^{2+} ions in (b)(i). A common error was to say that all three electrons were lost from M atoms.

The value for Ca^{2+} is high since the complete octet of 3p electrons has to be destroyed. Scandium has the lowest nuclear charge of the 3d series of elements and has the weakest pull on the outer electrons. The stability of Mn^{2+} or Fe^{3+} is answered in terms of the maximum number of unpaired electrons in the 3d shell.

Q.4. Although Q.4. looks unusual and perhaps a bit formidable, it was a popular question and consistently scored high marks. Candidates seemed to enjoy answering it. The nuclei in (a) are ^2_1H, ^1_1H and ^3_2He as helium is formed from hydrogen. In (b) candidates had to find the velocity of light from the Data Booklet to convert the wavelength given into the frequency, which gives a value of 4×10^{-15} joules in (i), which is multiplied by L in (ii). Part (c) produced one of those rarities in an Advanced Level examination as all the answers from the candidates were different and in (ii) their speculations were largely their own. The examiners looked for answers in (i) which analysed spectral lines in the radiation from the sun, and in (ii) which referred to the even atomic numbers of the elements (there is a variety of ways of stating this point) and to their common unit of helium or α - particles.

Q.5. The example is familiar and well described in the text books. High marks were scored. The rate is second order overall and stage 1 is the slow, rate-determining step since it is catalysed and also does not involve the iodine, which makes stage 2 fast and zero-order. Alkaline conditions are necessary for the triiodomethane reaction.

Q.6. Many candidates wrote retention times on the scale of the trace and this facilitates the recognition of the six identifiable peaks. The expected answers in (ii) were adsorption, partition and volatility, but alternatives were accepted. Hydrogen-bonding is suggested as the cause of the stronger adsorption of propan-2-ol; The chromatography apparatus was well described. It was expected in (ii) that an ethanolic solution of 4-nitrophenol would be developed on the same chromatogram as the nitration mixture and the relative movements compared. Other methods of identifying the 4-nitrophenol received partial credit.

The answers to question 7 can be found in the Notes For Guidance on The First Row Transition Elements. Since the publication of these notes new uses for titanium have been found and its use in jewellry and in squash rackets were included in candidates' answers.

Q.8. Parts (b) and (c) had to be marked together. A competitive inhibitor of an enzyme is displaceable and has a similar chemical structure or shape as the substrate. A non-competitive inhibitor bonds permanently and renders the enzyme inactive if it is present in sufficient quantity. The inhibitor forms a stronger chemical bond than the substrate. Simple analogies were given by some candidates and these were helpful in clarifying their answers.

Q.9. Examiners looked for answers in (a) in terms of high capital investment and the inflexibility of high capacity plants. A variety of answers scored marks in (b). The capital cost is essentially the cost of construction, and the installation costs are likely to be about the same for any size of plant. The chemical industry is largely automated and the labour costs are low and unaffected by plant size. The fixed cost is unavoidable running costs and not much dependent on production levels. In (c) the change to petrochemical sources for ethanoic acid and the refinements of the Contact process were looked for.

Q.10. Em^{2+} will bond more strongly than K^+ because it is doubly charged, but since Mg^{2+} is smaller than Em^{2+} the Mg^{2+} will be more strongly held at cation exchange sites. Em^{3+} has low mobility in the plant, unlike K^+ in (c)(i). In (ii) emium

deficiency occurs when oxygen circulation is restricted, i.e. in water-logged, acidic soils.

Q.11. **T** was dehydrated potato. In *(a)* lipids are absent since **T** eventually dissolves in the aqueous solutions. In *(b)* both polysaccharides and proteins are hydrolysed under acidic conditions. *(c)* could be answered in terms of water content, or of mineral content, and vitamin C content was also acceptable. *(d)* leads to the dehydrated nature of the product.

Q.12. **A** nylon can be prepared in the laboratory from the interface of solutions of an acyl dichloride in an organic solvent and a diamine in water. On a large scale, the chemical nature of the product is the same but the expensive acyl chloride is not used and the molecular mass of the polymer is undoubtedly greater. The structure of Terylene was usually correct in *(c)*. The advantages of the synthetic fibres were well known.

Q.13. **A** is the beam splitter. **B** and **C** are the sample and the reference (the control, the solvent). **D** is the monochromator. The purpose of **D** is to subtract the reference spectrum from the sample spectrum. The candidates seemed well prepared and most knew three ways of preparing the benzoic acid. In *(d)*, the impurity was an alcohol, probably propan-2-ol. Peak **D** was caused by OH group and **E** by the C=O group.

CHEMISTRY

ADVANCED LEVEL

Paper 9250/3 (Multiple Choice)

Item Number	Proportion choosing each option (key facilities are asterisked)					Discrimination (point biserial)
	A	B	C	D	E	
1	0.11	0.45	0.35*	0.02	0.07	0.28
2	0.14	0.14	0.55*	0.10	0.04	0.31
3	0.17	0.24	0.14	0.36*	0.08	0.26
4	0.03	0.12	0.09	0.42*	0.34	0.33
5	0.10	0.17	0.13	0.03	0.56*	0.40
6	0.69	0.08	0.29	0.27	0.28*	0.34
7	0.05	0.01	0.08	0.75*	0.11	0.30
8	0.16	0.53*	0.05	0.23	0.03	0.39
9	0.17*	0.23	0.13	0.39	0.05	0.29
10	0.08	0.64*	0.04	0.13	0.10	0.42
11	0.32	0.02	0.04	0.26*	0.35	0.12
12	0.26	0.12	0.14	0.22*	0.24	0.29
13	0.23	0.24	0.14	0.10	0.29*	0.31
14	0.09	0.02	0.08	0.04	0.77*	0.33
15	0.14	0.29	0.16	0.30*	0.09	0.42
16	0.05	0.06	0.06	0.77*	0.06	0.40
17	0.08	0.11	0.07	0.26	0.48*	0.32
18	0.10	0.12	0.60*	0.15	0.03	0.37
19	0.72*	0.07	0.04	0.07	0.09	0.34
20	0.06	0.08	0.53*	0.19	0.13	0.35
21	0.20	0.11	0.44*	0.13	0.12	0.45
22	0.64*	0.16	0.08	0.08	0.04	0.43
23	0.14	0.15	0.05	0.25	0.39*	0.44
24	0.10	0.07	0.70*	0.03	0.09	0.39
25	0.07	0.13	0.43	0.31*	0.05	0.31
26	0.04	0.19	0.44*	0.02	0.31	0.32
27	0.07	0.08	0.17	0.16	0.51*	0.43
28	0.06	0.59*	0.12	0.14	0.10	0.39
29	0.10	0.11	0.60*	0.10	0.08	0.48
30	0.16	0.14	0.49*	0.08	0.12	0.43
31	0.43*	0.28	0.08	0.14	0.05	0.22
32	0.08	0.12	0.44*	0.11	0.24	0.32
33	0.66*	0.13	0.04	0.15	0.02	0.38
34	0.04	0.61*	0.11	0.14	0.10	0.45
35	0.53*	0.23	0.16	0.05	0.02	0.36
36	0.10	0.46*	0.11	0.26	0.07	0.32
37	0.04	0.18	0.25	0.11	0.41*	0.45
38	0.13	0.17	0.53*	0.06	0.09	0.34
39	0.40*	0.12	0.29	0.04	0.12	0.14
40	0.08	0.24	0.11	0.40*	0.16	0.30

The examiners are grateful to supervisors for their cooperation in performing the experiments in questions 1 and 2.

Solutions provided at most centres were exactly as requested. This lead to the first titre in question 1 being the same as the volume of **FA 1** which had been diluted and to the second titre being 12.50 cm³ less than the first. Accuracy marks (2 x 8) were thus readily allocated to candidates from these centres. Where solutions differed from the concentrations specified in the *Instructions* the supervisor's figures were taken as standard for accuracy purposes whilst, in a very small minority of cases, an average of candidates' results had to be used due to the unreliability of the supervisors' figures.

In view of the difficulty of determining the end-point in this particular titration, full marks were given for titres within 0.2 cm³ of the standard. A 'spread' penalty was then applied to candidates who had used titres more than 0.2 cm³ apart in the calculation of their average values. This ranged from 1 mark to 8 marks, (when titres more than 2 cm³ apart had been used).

The instruction to indicate how the values for the volumes of **FA 2** were derived was an innovation which seemed to put-off only the less able candidates. Signs of sensible arithmetic or a sentence to indicate how the values were derived were equally acceptable. Indeed 'nil' tended to be awarded here only to those candidates who left the spaces blank or who used rough values in their determinations.

Candidates were guided through the calculation in a series of steps and full marks (31) for this question were not uncommon, though candidates who fail to take full advantage of excellent provision made for them by their schools must be a source of frustration to their teachers as they either read their burettes to the nearest cm³ or use their results which are accurate to 2 decimal places and immediately begin to work to one significant figure as they start the calculation.

From letters received, some supervisors seemed concerned over the reproducibility of results in the three thermochemical experiments in *Q.2*. Experiment 1 ($CuSO_4$ - NaOH) is a popular exercise and has appeared in many textbooks of practical Chemistry. Pretesting showed that results of experiment 2 ($CuSO_4$ - Fe) and experiment 3 ($CuSO_4$ -Zn) were also reproducible, though not to the same degree of accuracy as experiment 1. This was partly because different samples of metal reacted at varying and uneven rates. Hence a wide tolerance was allowed in the award of accuracy marks for these two experiments. Supervisors' results were taken as standard and 0.2 K, 0.5 K and 0.4 K g^{-1} respectively, were the variations allowed for full marks (3 x 4).

Thermometers were usually, as expected, read to 1 decimal place, and again stepwise guidance through the calculation produced some excellent answers (full marks 36), though it was surprising to see so many unbalanced ionic equations.

There were fewer really good answers to *Q.3*. than to the other two questions. Candidates at some centres are obviously better prepared than at others for this type of question. The following points summarise where most marks remained unearned;

1. Despite instructions in the stem of the question to perform tests on gases evolved this was was not always done e.g. CO_2 in *(a)* was left undetected and described merely as 'effervescence' and thus a mark for the test, another for identification of the gas and a third for the deduction, 'carbonate' were missed.

2. In *(c)* and *(h)* candidates tended to describe the solutions formed as 'clear' when they meant 'colourless'.

3. Addition of one reagent often causes two changes, both of which should b recorded.

4. Tests *(h)*(ii) and (iii) separated the thinking candidates from the regurgitator of analysis tables. In both tests lead was precipitated by the first reagent and the separated from the solution by filtration. Subsequent acidification in (ii) an addition of NaOH in (iii) however were used to deduce 'lead' in the filtrate.

5. The onus is on the candidate to indicate clearly at what stage in a test a chang occurs and this needed to be obvious in those tests where two reagents are added (*(a), (e), (f), (h)*(ii) and *(h)*(iii)). Similarly it should be made clear on what evidenc a particular deduction is made – mere lists of possible ions stretching down th deduction column rarely earned marks in these tests.

45 marks were allocated to this question with a stipulation to examiners that 3 was to be the maximum awarded. In the event the number of marks cancelled ove the whole entry did not reach double figures.