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Tel: (02) 9367 8111

Fax: (02) 9262 6270

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1997 HIGHER SCHOOL CERTIFICATE EXAMINATION REPORT
CHEMISTRY

In 1997, 10 179 students presented for the examination in 2 Unit Chemistry. This candidature was slightly greater than that for 1996.

General Comments

1 Candidates were aware of the amendments to the Syllabus that were being tested for the first time this year.

2 Although most students answered questions based on mandatory practical work very well, some indicated little or no knowledge of these experiments which suggests that the practical work had not been done in some cases.

3 The standard of drawing of laboratory equipment was generally very poor.

4 Students are advised to give relevant and concise explanations where appropriate rather than rambling answers, which can often lead to contradictions.

5 In questions requiring numerical answers, students should always show their working.

6 Candidates should be careful to complete all the sections in their chosen Elective.

Section 1 Core

Part A

Mean = 9.39	*			Correct response
Approximate percentage choosing each alternative				
Question	**A**	**B**	**C**	**D**
1	2.3	13.4	49.7*	34.6
2	58.3*	11.1	23.2	7.4
3	17.7	67.0*	10.1	5.1
4	8.8	26.9	19.9	44.5*
5	38.6	4.8	53.8*	2.8
6	69.4*	2.7	2.8	25.0
7	67.1*	24.2	8.1	0.6
8	13.5	9.9	10.3	66.2*
9	9.2	12.1	19.1	59.4*
10	4.8	10.1	54.0*	31.0
11	6.5	79.2*	3.9	10.3
12	3.9	5.2	6.6	84.3*
13	2.9	2.7	91.5*	2.8
14	69.6	13.5*	2.7	14.0
15	2.8	81.0*	14.1	2.0

Question 4

In this question, about half the candidature could not identify the sodium chloride solution as having the highest pH when compared with three acidic solutions.

Question 13

Since the majority of candidates answered this question correctly, students obviously knew the definition of equilibrium very well.

Question 14

This question proved very difficult, with most students choosing the strongest acid for their answer instead of the triprotic acid.

PART B

Question 16

(a) In this part of the question, many students did not seem to realise that, in order to write the Equilibrium Constant expression and hence find its value from the concentrations given, a balanced chemical equation for the equilibrium was needed. Many students simply used a 1:1:1 ratio, or calculated the value of *K* for the reverse reaction.

(b) Here, many students gave the equilibrium position without any relation to the calculated *K* value of the data given.

Question 17

(a) This was generally well answered, but 20% of students made the statement that the solution was neutral because a strong acid was reacting with a strong base.

(b) About 40% of students were able to calculate the pH correctly, and the majority showed the correct use of the pH expression. Common errors included:

- use of incorrect volume
- use of 1.5 mol *L* for [*H*+]
- using moles of *H* as the [*H*+].

Question 18

(a) This was answered quite well and most students realised that the difference in Boiling Points is due to the difference in strength of the intermolecular forces. Common errors included:

- referring to the ease of breaking covalent bonds
- referring to hydroxide ions in ethanol.

(b) Here, most students could state an appropriate use of 1, 2 – ethanediol, but a significant number had difficulty in explaining why its properties make it suitable.

Question 19

(a) This was poorly answered, mainly because students interpreted the question as involving *a single reaction* of two hydrocarbons with *HCI*, rather than *two separate reactions*. A common error was to include five bonds around carbon atoms; it was pleasing to see, however, that most students did put in the hydrogen atoms on the end of *C – H* bonds rather than omitting the hydrogen atoms.

(b) This was well answered, but some students gave a description of the compound, saying, for example, *toxic*, or *inflammable*, and did not state a safety precaution as was asked in the question.

Question 20

(a) This part of the question was very poorly answered, with many students failing to cope with the ionic equation. It would appear that a question in a context different from that previously encountered caused students a great deal of trouble, and having two powders as reactants created confusion.

(b) This part, being so closely linked to part (a) was again poorly answered.

(c) This was very well answered since most students knew that carbon dioxide gas was involved.

Question 21

(a) This was well answered, with the majority of students indicating the correct trend, but many failed to explain the result in terms of the conditions provided in the question.

(b) This was poorly answered, with many candidates failing to answer the question in terms of what happened to the added hydrogen and giving a generic description of Le Chatelier's Principle.

(c) This was very well answered, with students showing a good knowledge of the role of a catalyst.

Question 22

(a) Answers here were generally very good, but some students gave a wrong similarity, stating the same number of electron shells, while others reacted the Group 1 metals with a halogen.

(b) This was generally well answered. A number of candidates, however, did not understand the difference between shells and subshells. Others thought that the ground-state electronic configuration was that of the corresponding ion; still others gave the wrong number of electrons in a subshell or the wrong number of the subshell.

c) On the whole, this question was poorly answered, with many students failing to understand the key cause of the reactivity of Group 1 metals.

Question 23

(a) This was fairly well answered, with the majority of students knowing the functional group of an ester. Common mistakes, however, were:

- putting the methyl group on the wrong carbon
- not knowing general organic nomenclature
- making errors in drawing the final product
- not knowing the type of reaction.

(b) With the close link to part (a), this was also fairly well answered.

(c) In contrast to parts (a) and (b), this part was generally poorly answered. While a number of students implied immiscibility and indicated a physical separation, many did not appreciate the fact that a physical separation was required and the majority could not recall the name of the equipment (*a separating funnel*), perhaps indicating that they had not done this experiment in the laboratory.

Question 24

(a) Only about half the students correctly answered this question, with many giving a mole amount instead of a concentration.

(b) The results here were very similar to those to part (a), with many giving mole amounts and missing the significance of the *5 L* container, while others simply made a qualitative statement.

(c) This was well answered by most students, although some gave an explanation without stating what the effect was, or stating the effect without giving an explanation.

Question 25

(a) This part was generally well answered. Common errors, however, included referring to *liquid bromine as aqueous bromine*, and having water, hydrogen, or hydrogen bromide as products.

(b) (i) This part was also generally well answered, but a significant number gave only 1 compound, and, in answers in which the equation was wrong, *HBr* or H_2 were often given as liquid products.

(ii) In this part, drawings were very poorly done, with little attempt being made to use scientific diagrams. Common errors included:

- the condensor shown as coming off anywhere at an angle
- no heat source
- a beaker used as the reaction vessel
- the apparatus open at the top, allowing gases to escape
- use of a separating funnel (often drawn as a burette).

PART C

Question 26

Most answers to this question showed reasonable competence in mass/mole/volume/concentration calculations as well as familiarity with the preparation of a standard solution. There were, however, a disturbing number of poor attempts or non–attempts.

(a) Here, candidates knew the two steps in calculating the required mass of anhydrous sodium carbonate. The main problem was uncertainty about the formula of sodium carbonate, with the most common error being giving it as *NaCO.* Also , many candidates did not appear to know the meaning of *anhydrous*; it was pleasing, however, to see very few answers being given without units and very few atomic mass values rounded off.

(b) Although most students seemed to have participated in this practical activity either directly or indirectly, a number had difficulty in expressing their answers and clearly showing the steps involved, with many answers being too long (some students spent time describing how to make sodium carbonate anhydrous!).

A common error was to describe the process of standardising a solution by means of a titration, while another common error was failure to realise that a volumetric flask was needed and that the solute must be fully dissolved before the solution is diluted to the correct volume.

(c) In this two-part question, the mole ratios of reactants was handled very poorly, while the calculation of a volume was done very well. Students are advised to show all relevant formulae, equations and especially calculations and, to avoid the formula C1V1= C2V2 since they lack the ability to use it and usually include mole ratios on the wrong side of the formula.

Question 27

(a) (i) This was answered quite well. Common mistakes, however, were:

- not stating clearly that it is ions that move in a solution
- stating that electrons move through solutions
- confusion between the terms ionisation and dissociation
- stating that only one of the dissociated ions is needed to complete the circuit.

(ii) This was poorly answered, with common mistakes being:

- using the term molecule to describe the sand structure
- not knowing that the dissolving process involves the breaking of bonds
- answering the question in terms of like dissolves like
- stating that silicon dioxide is not a continuous lattice.

(b) Over 95% of candidates knew that silicon dioxide has the higher melting point but very few could give the correct reason for this.

Question 28

(a) (i) This part was very poorly answered, with only about 10% of candidates scoring a mark. Many did not recognise this as a question on rates and, instead, compared the curves in terms of temperature.

(ii) Most students were able to identify the equilibrium phase of the graph, but many were unable to offer an explanation for its existence; a significant number of students were confused by the term *level off* and discussed the approach to equilibrium rather than the *equilibrium plateau*.

(b) Candidates generally scored well here. The relationship between temperature change and equilibrium position was well understood, but poor expression was a feature of many answers.

(c) This was answered very well, with 90% of students scoring a mark. The majority understood the effect of a catalyst on the formation of methanol at 400K, but poor drawings were responsible for the failure of some students to score the mark.

(d) Here, most students answered well, but a number saw 400K as giving a higher *graph level* and thus assumed that this was the same for the value of the equilibrium constant, without explaining the fact that product yield is higher at low temperatures.

Question 29

(a) It seemed apparent from students' responses that many had not carried out the mandatory practical work although the majority knew the theory well and were able to describe how they would perform the experiment; a number of students, however, gave incorrect formulae for the oxidising agents.

(b) (i) For many students writing condensed structural formulae proved difficult.

(ii) From part (i), many students were able to give here the correct name of the principal organic product of the oxidation, but some could not name their product correctly, and, in a number of cases, gave general formulae or general names.

Question 30

(a) In this part, a significant proportion of candidates incorrectly believed that bromine is the halogen in the third period, while a number did not seem to know the difference between a *halogen* and a *halide.*

(b) In this part, many candidates were confused by the choice of *any halogen*. As a result, some chose an incorrect symbol or did not indicate by a key what their symbol represented. In addition, a significant number of students incorrectly used a line, rather than dots, to represent the two electrons in the bond.

(c) Here again, candidates confused *halogen* and *halide.*

(d) This part was very poorly answered, and the majority of students did not explain that stronger dispersion forces result from a greater number of electrons.

(e) Most students answered this part correctly, but some gave more information than was required and, at times, contradicted themselves.

Question 31

(a) This part was attempted by most candidates and they had the correct concept of a *weak* acid. The most common error was to say a *weak acid has a low pH or a pH close to 7.*

(b) (i) This was generally well answered, although a few candidates included [H_2O] in the denominator, and some could not write the correct formula for the acetate ion. Students are advised to take care in the setting out of the expression, their writing of the concentration brackets, and where they place the charge on the ions.

(ii) This was answered reasonably well, with the most common error being failure to take the square root of 1.76×10^{-6} to find the [H^+] of the solution. Other students used a quadratic equation and had trouble in solving the expression, while still others did not show their working.

(iii) This was attempted by most students and the main difficulty was the conversion of *pOH* to [*OH*].

Section II Electives

Number of Candidates choosing each Elective

	Elective Name	Number of Candidates	Percentage of Candidates
Question 32	Chemical Energy	5225	52.34
Question 33	Oxidation and Reduction	3751	37.58
Question 34	Biological Chemistry	655	6.56
Question 35	Chemistry and the Environment	300	3.0

Question 32 Chemical Energy

(a) (i) The majority of students were able to determine the relationship between *P* and *T*, but many did not show their working over the range of values to reach a conclusion, instead, often using only the first two values. Some students calculated the *P/T* ratio to four significant figures and then concluded that ethene was not behaving as an ideal gas over the given range, since the values were not the same, thus showing lack of understanding of errors in experiments and calculations.

(ii) This was generally well answered, although some students did not distinguish between *gas volume* and *volume of gas molecules*.

(b) Most candidates correctly used *PV = nRT* to calculate the number of moles of N_2 (including conversion of temperature from Celsius to Kelvin) needed to inflate a *50L* air-bag at *20˚ C* and *110k Pa*.

(c) Answers here indicated that most students had done the mandatory practical work, which was a big improvement on the numbers of those who had done so in previous years.

(i) Diagrams were generally good, but a large number of students used a bunsen burner as their heat-source (sometimes heating styrofoam cups with a naked flame), and a significant number described *a heat of solution experiment*.

(ii) Answers here were good, but many students did not distinguish between *measured* quantities (temperature of water before and after heating) and *calculated* quantities (temperature change), while some did not clearly indicate that it was the temperature of the water that was being measured.

(iii) This was well answered, with most students giving a correct source of error and a method of reducing the error.

(iv) This was also well answered, with the majority of students showing a good understanding of complete and incomplete combustion and demonstrating ability to write a balanced equation.

(d) (i) This question involving simple calculations was well answered.

(ii) Answers here were also good, although some students used complicated ways of solving a simple problem.

(e) (i) This part was very well answered, with candidates having little trouble with the concepts involved.

(ii) A significant number of students failed to recognise the fact that the reaction was endothermic and, therefore, they could not link this with their definition of a fuel.

(f) (i) Some students found the calculations in this question difficult.

(ii) This part elicited a wide range of responses. Some students correctly discussed safety and storage, while others discussed properties relating to the combustion of fuels. Many failed to recognise the fact that propane requires greater pressure to liquefy than butane, and some suggested that propane reacts with the plastic containers.

(g) This was fairly well answered, with the most common errors involving failure to handle the signs correctly and substitution of incorrect values from the table.

(h) (i) The definitions required were reasonably well explained.

1 The most common error here involved linking the definition of the volatility of a fuel to combustion.

2 Very few students defined ignition temperature in terms of the temperature required for spontaneous combustion.

(ii) A significant number of students failed to realise that the flashpoint of a fuel involves a spark, a flame, or a hot filament, whilst ignition temperature does not.

Question 33 Oxidation and Reduction

(a) (i) This was well answered, but some responses showed 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) This part was answered well, but it was disappointing to find that about 20% of students did not know the difference between an *anode* and a *cathode* in the galvanic cell.

(iii) Here, it was pleasing to see that most students correctly described what happens to the copper electrode as the cell is operating, as well as explaining the chemistry involved.

(iv) This was well answered.

(v) The calculation of the maximum possible voltmeter reading was very good, but some responses referred incorrectly to the E value for the reduction half–equation for CU+ ions.

(b) (i) Although most answers referred here to electrical energy *output/input* or *non-spontaneous/ spontaneous* reaction comparisons, some students showed confusion in their understanding of polarity by incorrect reference to:

- the direction of electron flow in the external current, or
- anode or cathode sites (not identified in terms of the definition of the point at which oxidation and reduction occur).

(ii) Despite some confusion between the movement of ions and electrons through the solution, candidates gave good responses in terms of ions:

- moving to complete the circuit, or
- improving electrical conductivity.

(iii) Very few students were able to write down the four ions that migrate to:

1 the cathode, and

2 the anode.

Most gave two ions, and a large number overlooked the hydronium and hydroxide ions present in the aqueous solution.

(iv) Here, a large number of students were not able to use the standard potential table to select the reaction occurring at each electrode. All the half-cell equations (quite often in the wrong direction) were listed, but no choice was made as to which was the most likely to occur.

(v) This was very well answered, but some candidates failed to use a balanced chemical equation in their answers.

(c) (i) 50% of students were able to balance half-equations to get a redox reaction, with some having difficulty with molecular and/or structural formulae of ethanoic acid and ethanol, while for the reaction of 02 many had difficulty in selecting the appropriate half-equation for neutral conditions.

(ii) 80% of students were able to add half-equations to obtain a balanced redox equation, but some did not realise the need to cancel common species on either side of the equation.

(d) (i)

and Most students were able to calculate oxidation numbers competently and identify the

(ii) oxidant in a redox reaction.

(iii) 85% of students were able to complete the titration calculation and obtain a correct answer.

(iv) Some of the difficulties that students had in this question were:

- lengthening the response unnecessarily by reverting back to moles instead of staying in concentration units for the final answer;
- failing to show working even though it was explicitly asked for;
- trying to compare two values that have different units.

(e) (i) Although many students knew that salt water accelerates rusting, they could not give a satisfactory explanation of this. Some common misconceptions included, *salt acting as a catalyst, salt causes rust*, and *salt or sodium ions react with the iron.*

(ii) The majority of students had a good understanding of how inert physical barriers stop corrosion, but a few wrongly thought that *the concretion layer acts as a sacrificial anode*.

(iii) Most students readily chose an appropriate metal to act as a sacrificial anode, and there were a significant number of students who correctly extracted the correct E° values from the table of Standard Reduction Potentials, but were unable to justify their answers. Students need to avoid statements such as *magnesium has a higher* E° *value than iron and will corrode first*, and to appreciate what E° values mean.

Question 34 Biological Chemistry

(a) (i) This was well answered.

(ii) About 50% of candidates answered this question correctly.

(iii) 60% of students could write a balanced equation for hydrolysis, but only 10% could write correct structural formulae. Most marks were lost by careless errors such as not drawing the covalent bond to a hydroxy group clearly to the oxygen atom or by not giving every bond to a CH_2OH drawn to the carbon atom.

(iv) This was well answered.

(v) Answers here were also good.

(vi) Only about 15% of candidates could answer in terms of bonding between compounds I and III and water.

(b) (i) This was well answered.

(ii) Candidates answered this well.

(iii) Only slightly more than half of the candidature showed understanding of tertiary structure and gave a satisfactory answer.

(c) (i) This question was correctly answered by 95% of students.

(ii) Most candidates were able to give an explanation of how testing brings about the specific change in terms of the breaking of secondary and tertiary interactions.

(iii) Here, most students could name a suitable chemical but were unable to give reasonable explanations of how it would bring about the change.

(iv) This question was poorly answered, with many students attempting an explanation in terms of disulfide bonds, and showing little awareness of the importance of hydrophobic groups in tertiary structure.

(d) (i) Parts 1 and 2 were both well answered.

(ii) Most candidates could satisfactorily name one of the types of biomolecules named here and describe a chemical test, to verify its presence in either potato or egg white.

(e) (i) Approximately 50% of candidates answered in terms of *ATP* providing heat.

(ii) This was very poorly answered, with less than 5% of students realising that the amount of energy released in both cases would be the same.

(iii) Most candidates did well with this calculation, with 60% gaining full marks.

(iv) In this, students gave varied responses, indicating that they knew that *ATP* is a product of cellular respiration but wrote in general terms, giving little specific information about *ATP* and cellular respiration.

(f) (i) Good explanations were given here, mostly in terms of a *lock* and *key* model.

(ii) Approximately 60% of candidates could draw a satisfactory graph, but many labelled the axes incorrectly.

Question 35 Chemistry and the Environment

(a) (i) This was answered well, with 75% of candidates giving a satisfactory response.

(ii) This question was also answered well, with over 80% of students answering correctly.

(iii) 1 65% of students gave two correct reasons here.

2 This caused trouble for the candidates and only 15% could give both a containment and a safe storage method for the disposal of plutonium.

(b) (i) Less than 50% of students answered correctly here, with the most common error being providing a *biological* reason, such as, *to see if water can support life*, rather than a chemical reason.

(ii) In this part, most students were able to state correctly the difference between the two water samples, but only 60% could explain the reason for the difference between the oxygen concentration of both samples.

(ii) 1 There was very little indication that this practical activity had been undertaken and many students were confused by the information given. Only half the candidature answered correctly, and numerically correct answers were often given in terms of mol/L rather than in *mol.*

2 A Here 40% of students answered correctly, with many overlooking the volume of 0.5L.

B This was very poorly done.

(c) This question was not answered very satisfactorily, with only 20% of students scoring both marks and 67% scoring zero. Many saw heat energy from the sun as the major factor in decreasing the concentration of carbon dioxide, while another common error was stating that photosynthesis produces carbon dioxide.

(d) (i) Here, most candidates described the increase in the carbon dioxide concentration satisfactorily.

(ii) In this part, only about 25% of students could give both a cause for the increase in the carbon dioxide concentration and a balanced equation.

(iii) 1 Here, 60% of students gave a satisfactory response, correctly stating an environmental problem that may result.

2 In this part, 40% of candidates gave a satisfactory description. A common error in this section was giving *UV* as the cause of temperature rise in the *Greenhouse Effect*.

(e) (i) This was answered well, with about 90% of students correctly stating that the ozone layer reduces *UV* exposure.

(ii) 1 This was also answered well, with 95% of students answering correctly.

2 Here, only half the candidates could give a suitable structural formula for a freon.

3 This was poorly answered, with only 10% of candidates correctly giving two properly balanced equations, to explain how a freon destroys ozone.