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1999 HSC

Chemistry

Enhanced Examination Report

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1999 Higher School Certificate Chemistry Enhanced Examination Report

Introduction

In 1999 there was a slight increase in candidature with 10 455 candidates presenting for the examination compared with 10 187 candidates in 1998.

General Comments

- Coverage of mandatory practical work clearly varies from examination centre to examination centre.

  Candidates appear most successful in outlining the practical work when they have performed the activity themselves. Demonstrations that have been carried out for the candidates, often using more sophisticated equipment, were not so well described. It is disturbing for markers when they see most of the candidates from a centre describing very hazardous use of apparatus.
- 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.
- The standard of responses to those questions requiring candidates to draw apparatus for carrying out a procedure still needs improvement. When candidates are asked to draw the apparatus it is assumed that they will draw the apparatus connected together and ready for use. Drawing individual items of apparatus and not showing how they should be connected is not considered appropriate from HSC candidates. When labels are asked for, they should be clearly connected to the appropriate part of the apparatus.
- Candidates should use the space in the answer book as a guide to the maximum amount to write, being mindful that a succinct correct answer scores as many marks as an expanded correct answer. Succinct answers can often fit into as little as a quarter of the space provided. With expanded answers going beyond the space provided, there is an added risk of internal inconsistencies creeping in or a significant qualifying term being left out. Time spent writing expanded answers would probably be better spent checking succinct answers.
- An improvement has been noted in the ability of candidates to:
  - explain their answers to structure and bonding questions. Samples of a range of candidates responses to this type of question are included in this report;
  - calculate H^+ from pH;
  - comprehend diagrams showing energy changes in the energy elective.
- A higher proportion of candidates are demonstrating skill in the way they apply IUPAC nomenclature to carbon compound structures. Most candidates who take care and check their work can successfully draw structural formulas from systematic names.

- Compared to previous years, more Chemistry candidates jeopardised their HSC by non-serious attempts. Candidates who decide not to attempt particular questions are advised to leave that part of the answer book blank and have those questions treated as non-attempts. Putting frivolous or objectionable material into the answer book may result in the candidate being ineligible for the award of the Higher School Certificate.

HSC Chemistry Marking Procedure 1999

1. Shortly after the HSC Exam has taken place, Examination Committee members have discussions with the Senior Markers, who have been assigned questions by the Supervisor of Marking. Using a set of answers supplied by the Examination Committee when the exam paper was finalised, a Trial Marking Scheme is established for each question.
2. Senior Markers use the Trial Marking Scheme on a sample of candidates' papers and, if necessary, modify and expand the marking criteria to produce Trial Marking Scheme II. No marks are placed on those candidates' papers used for trial marking. All marks are placed on separate sheets and these data are used for analysis of the scheme.
3. A Senior Marker and two experienced markers called Pilot Markers trial-mark a larger sample of candidates' papers. Input from the Pilot Markers is used to establish the Pilot Marking Scheme.
4. The Senior Marker and Pilot Markers brief the markers allocated to that question on the Pilot Marking Scheme and the Marking Rules. The Senior Marker, two Pilot Markers and five to seven markers use the scheme on a sample of up to 15% of the candidates' papers. Once again, no marks are placed on candidates' papers. Separate sheets are used to record marks allocated in Pilot Marking. These sheets are used to analyse the scheme and improve marker consistency and reliability. Input from the markers is used to produce a Final Marking Scheme.
5. Marking 'proper' does not start until the Final Marking Scheme is approved by an Exam Committee Member and the Supervisor of Marking. Markers must use the Final Marking Scheme and not impose their own standards. Difficult-to-mark or unusual responses are considered with marking colleagues and may be drawn to the attention of the whole marking group for consideration.
6. Consistency and reliability are stressed throughout the marking operation so that every candidate's paper is given careful consideration, no matter the stage of the marking operation at which the paper is marked.

2 Unit

Section I – Core

Part A – Multiple-choice Questions (15 marks)

The table shows the correct answers and the percentage of the candidature selecting these.

QUESTION	CORRECT ANSWER	PERCENTAGE OF CANDIDATURE
1	A	89.48
2	D	71.93
3	B	93.67
4	D	54.19
5	A	84.56
6	A	76.96
7	C	81.25
8	B	59.69
9	C	65.09
10	C	51.35
11	A	71.11
12	B	57.54
13	D	57.44
14	D	51.02
15	A	40.60

Mean score by candidates out of 15 = 10.06

Specific Comments

Question 2

Nearly 20% of candidates gave the answer for the sulfur atom rather than the sulfide ion.

Question 3

The ability of candidates to choose between alternative IUPAC nomenclature names successfully was high.

Question 4

Many candidates do not appear to know the species in solutions and how they could affect pH.

Question 8

More than one third of candidates did not realise that solids and liquids have fixed concentrations and therefore are not included in an equilibrium constant expression.

Question 9

Over a quarter of candidates did not appear to recognise 2-butanol as a secondary alkanol. These candidates predicted the type of product expected from a primary alkanol.

Question 10

Only half the candidates realised that adding more solid to a solid in equilibrium with its saturated solution will have no effect on the equilibrium.

Question 12

Many candidates were confused over the different uses of oxidising agent solutions.
Cold $KMnO_4$ solutions are used to produce diols from alkenes.
Acidified $KMnO_4$ or $K_2Cr_2O_7$ are used to oxidise primary or secondary alcohols.
Hot $KMnO_4$ solutions are used to cleave carbon to carbon double bonds.

Question 14

This is the third time in five years that a question asking for the pH of a barium hydroxide solution finds nearly half the candidature unable to do the calculation.

Question 15

As in last year’s exam, a searching question on equilibrium has less than half the candidature able to select the correct answer.

Part B – 3-mark Questions (30 marks)

Specific Comments

Question 16

Most candidates were successful in answering this question.

(a) Use of the term 'van der Waals forces' varied considerably. This is an imprecise term not listed in the syllabus. Some candidates regarded van der Waals forces as an additional intermolecular force. It would be better for candidates to use the terms listed in the syllabus (*Intermolecular forces* – dispersion forces, dipole-dipole interactions and hydrogen bonding) rather than a term which is non-specific and does not have the same meaning in all textbooks.

(b) Here candidates needed to relate the increase in dispersion forces to larger molecular mass, increased number of electrons or bigger molecules. Some candidates misinterpreted 'increasing period number' and used terms such as 'as you go down the period'.

(c) A common error was to imply that hydrogen bonding was within the molecule rather than between the molecules.

Question 17

This question was well answered by the majority of candidates.

(a) and (b) Problems arose when water was omitted from the equation or potassium hydrogen phosphate was used as the reactant. Some candidates had difficulty working out the charge on the ion after proton transfer had occurred.

(c) Candidates understood the concept of proton transfer. Some had difficulty in choosing a conjugate pair that was of the same species.

Question 18

Candidates benefited from the wording in *italics*. Most indicated a clear understanding of the difference between *equilibrium position* and *equilibrium constant*.

(b) Candidates needed to give an explanation, not just a description to gain the mark here.

A good sample response gaining the mark

Since there are more molecules of gas on the left hand side (reacting to form products) then increased volume means the equilibrium position shifts left as the system tries to compensate by producing more $PCl_{3(g)}$ *and* $Cl_{2(g)}$ *to fill up the new volume.*

A sample response without explanation and hence no mark
Decreasing pressure, therefore less effective collisions between PCl_3 *and* Cl_2.
The equilibrium shifts left.

A restatement of Le Chatelier's Principle was not considered a sufficient explanation.

Question 19

(a) The most common error was the use of commas instead of dashes in the systematic name.

(b) The nature of oxidation under these conditions was not well understood. Some candidates interpreted oxidation as combustion producing carbon dioxide and water. Another common error was the formation of an alkanone and an alkanal rather than an alkanone and an alkanoic acid. Candidates need to realise the intermediate nature of alkanal formation in oxidation to alkanoic acid, particularly when the conditions (hot, acidic) indicate strong oxidation.

Question 20

The majority of candidates showed a clear understanding of the processes needed to answer this question. With both numeric values to three significant figures it was expected that candidates' answers would be given to three significant figures. Rounding off to only one significant figure or not rounding off at all and giving all numeric values on the calculator screen are not appropriate.

In order to achieve maximum marks, candidates need to ensure when writing answers that all ions have their respective positive or negative sign and that all concentrations in K_a expressions have square brackets.

A response scoring 3 marks

$$C_2H_5COOH_{(aq)} \rightarrow C_2H_5COO^-{}_{(aq)} + H^+{}_{(aq)}$$

$$Ka \quad = \quad \frac{[C_2H_5COO^-][H^+]}{[C_2H_5COOH]}$$

$$= \quad \frac{(10^{-2.78})^2}{0.2}$$

$$= \quad 1.38 \text{ x} 10^{-5}$$

Another response scoring 3 marks

$$C_2H_5COOH_{(aq)} \underset{H_2O}{\rightleftharpoons} C_2H_5COO^-{}_{(aq)} + H^+{}_{(aq)}$$

$$K_A = \frac{[H^+] \text{ x} [C_2H_5COO^-]}{[C_2H_5COOH]}$$

	C_2H_5COOH	C_2H_5COO	H^+
initial	$0.2 moL^{-1}$	0	0
equilibrium	$1.98 x 10^{-1}$	$1.66 x 10^{-3}$	$1.66 x 10^{-3}$

pH = 2.78

$\therefore [H^+] = 1.66 x 10^{-3}$

$$\therefore \quad K_A \quad = \quad \frac{(1.66 \text{ x } 10^{-3})^2}{(1.98 \text{ x } 10^{-1})}$$

$$K_A \quad = \quad 1.38 \times 10^{-5}$$

Question 21

Most candidates answered this question well.

Some candidates were influenced by the graph given for the equilibrium in question 24. They did not appreciate that sharp angles only occur on the sudden addition or sudden removal of a species involved in an equilibrium. As the equilibrium position adjusts, graphs should show curves.

Question 22

In parts (a) and (b), candidates demonstrated a good knowledge of the three types of intermolecular force and related them well to the formulae. Candidates were expected to recognise that Cl_2 is non-polar and would only have dispersion forces. CO, being composed of two elements of different electronegativity, would have dispersion forces and dipole-dipole interactions. HF would have hydrogen bonding as well.

However, part (c) was poorly answered. A significant number of candidates mentioned that carbon tetrachloride (tetrahedral shape) experienced dipole-dipole interactions. It is apparent that these candidates do not appreciate the impact of the symmetry of this molecule on its overall polarity and therefore its intermolecular force.

Question 23

(a) Most candidates drew the correct structural formula, although some confused the alkanoic acid group with the alkanal or alkanol functional groups.

(b) This part was poorly answered. Many candidates circled a hydrogen bonded to a carbon or circled the whole OH group.

(c) Few candidates appreciated the covalent nature of the acetic acid molecule. Many implied that the acidic hydrogen was an ion when present within the molecule.

Candidates could offer an explanation coming from the pure (glacial) acetic acid context, for example:

Acidic hydrogen in glacial acetic acid is locked in the molecule and is not ionised; no hydrogen ions are produced and the blue litmus paper does not change colour.

or from the aqueous acetic acid context, for example:

Glacial acetic acid reacts with water to form H_3O^+ *ions. These ions cause the blue litmus paper to change to a red colour.*

Question 24

Generally this question was well answered.

(a) Common errors were having the equilibrium constant expression upside down or substituting a mixture of initial and final concentrations.

(b) Errors were due to candidates not appreciating the significance of the sudden rise in CO concentration.

Question 25

This question was poorly answered.

(a) Only about 20% of the candidates could write a balanced equation showing the formation of NaOH. Most candidates did not appreciate that the large amount of water (about 100 g) compared with sodium (0.23 g) would not lead to the formation of Na_2O.

(b) Candidates obtained only one of the two marks available if they:

- gave the correct answer but did not show any relevant working
- did not get the correct answer but calculated a correct concentration
- calculated an incorrect concentration then calculated a pH value consistent with this incorrect concentration.

This illustrates the importance of the statement at the beginning of parts of the paper:

In questions involving calculations you are advised to show working as marks may be awarded for relevant working.

Part C – 5-mark Questions (30 marks)

Question 26

In general, the terms in this question were well understood by candidates and used in their correct context. An impressive level of understanding was evident in many candidates' answers that were good enough to be awarded four or five marks. Long, expansive answers should be avoided as they take up too much of the candidates' time and increase the risk of contradictions or of a significant descriptive term being left out of a description.

(a) Most candidates obtained both marks. Losses occurred when candidates failed to appreciate that water's polarity is due to the existence of polar bonds and the shape of the water molecule, or claimed there were two dipoles in fluorine which cancelled out. Other candidates wrote about hydrogen bonding or showed full charges over atoms in water rather than partial charges.

(b) Most candidates in their answer highlighted that water has strong hydrogen bonding, carbon monoxide has weak dipole-dipole bonding and fluorine has very weak dispersion forces. It was surprising to find a small number of candidates interpreting the zero for the melting point of water as meaning that water has no melting point!

A response scoring 5/5 marks

26 (a) ↑ δ^-
O
/ \
$H^{\delta+}$ $H^{\delta+}$
F – F
No net dipole

Water has the polar bonds of $O^{\delta-}$…$H^{\delta+}$ and a net resulting dipole. Difference in electronegativities means individual $O^{\delta-}$….$H^{\delta+}$ bonds are polar. Fluorine does not have a net dipole as the bond F-F is not polar.

26 (b) δ^+ $O^{\delta-}$ δ^{+} $^{\delta-}$
CO …….CO
dipole – dipole
$O^{\delta-}$
/ \
$H^{\delta+}$ $H^{\delta+}$
⋱ ⋰
O
/ \
$H^{\delta+}$ $H^{\delta+}$ hydrogen bonds

Fluorine – lowest melting point as only dispersion forces between non-polar molecules. These are easy to overcome. Carbon Monoxide – polar molecules have dipole-dipole attraction between molecules – require more energy to separate molecules. Water – Highest melting point as more energy is required to break hydrogen bonds between molecules. The strength of hydrogen bonds > dipole-dipole > dispersion
∴ differences in melting points.

Another response scoring 5/5 marks

(a) The water molecule contains 2 O-H bonds, which are polar, since oxygen is more electronegative than hydrogen.

The molecule is bent, so there is a net dipole, hence H_2O is polar. The F-F bond is not polar, as both F atoms have equal electronegativity. Hence F_2 is not polar.

(b) Water has strong hydrogen bonds between its molecules and hence has the highest melting point. Carbon monoxide has weaker dipole-dipole interactions between its molecules and hence has a lower melting point. Fluorine has only very weak dispersion forces between its molecules and hence has the lowest melting point.

A below average response scoring 2/5 marks

(a) Each atom in fluorine has equal electronegativity whereas the atoms in water — H_2O — have different electronegativities. The electronegativity of the fluorine atoms cancel each other out — while the H and O atoms do not — making it polar.

(b) In terms of strength dispersion is weaker than dipole-dipole forces. Dipole-dipole forces are weaker than hydrogen bonding. Therefore molecules having dispersion forces as their prime IMF, like Fluorine, have much lower mpt and bpt. Molecules with dipole-dipole forces as their main IMF are stronger forces to overcome in order to reach mpt and bpt while hydrogen bonding is the strongest force to overcome in reaching mpt and boiling point.

Question 27

This question rewarded candidates who had carried out and revised the mandatory practical experiences for equilibrium. Over 15% of candidates did not attempt this question.

Many candidates were unable to recall any equilibrium experiment they had conducted and chose to use one of the five reactions written as equilibria in other parts of the examination paper. They were consequently unable to answer the two marks part (d) by describing clearly how they measured the concentration of species.

(a) Only the candidates who could identify an equilibrium experiment that could be carried out safely in a school laboratory were awarded the mark. Other candidates 'synthesised' equilibrium systems or described reactions from the exam paper that could not be carried out safely in a school laboratory.

(b) and (c) were well answered.

(d) Candidates who had completed the mandatory practical experience, measurement of an equilibrium constant, first hand and had identified a suitable experience in part (a), answered this part well. Students who had completed this activity as a computer simulation were usually unaware of how the concentrations they had manipulated were measured.

An excellent answer receiving 5/5 marks

(a) Acetic acid, in solution with its ions.

(b) $CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

(c) $K = \dfrac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$

(d)
1. Make a standard solution of acetic acid from glacial acetic acid.
2. Measure the pH of the solution using a pH meter.
3. Calculate the H_3O^+ concentration, which is equal to the CH_3COO^- concentration.
4. Subtract the H_3O^+ concentration from the original CH_3COOH concentration to give the CH_3COOH concentration at equilibrium.

An answer based on a computer simulation receiving 4/5 marks

(a) Reaction between nitrogen dioxide, and dinitrogen tetroxide

(b) $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

(c) $Ka = \dfrac{[N_2O_4]}{[NO_2]^2}$

(d) A program on a computer was set up, so that it had the values recorded of the concentrations as the reaction took place on screen.

Question 28

This was 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 examination coverage in the past.

(a) and (b) tested the concept of indicator choice. Many candidates failed to relate their responses to the data, relying rather on general answers. The great majority of candidates were able to select the correct indicator in part (ii) but many failed to explain the reason why it was the most appropriate. A significant number of candidates confused equivalence point with end-point. Approximately a third of candidates indicated that litmus was unsuitable as an indicator because it was 'paper' and seemed unaware that it could be obtained in liquid form. Expression and incorrect scientific usage were causes for concern.

(c) The sketching of a titration curve caused problems for many candidates. Approximately 10% of candidates failed to recognise that the curve would commence in the basic pH range. A number of candidates were confused by the fact that the reaction involved a weak base and a strong acid. Some misinterpreted this as an equilibrium system and attempted to sketch such a system, while others were unable to predict the likely pH of a weak base or a final pH after the reaction has been completed. Few candidates scored two marks for this part.

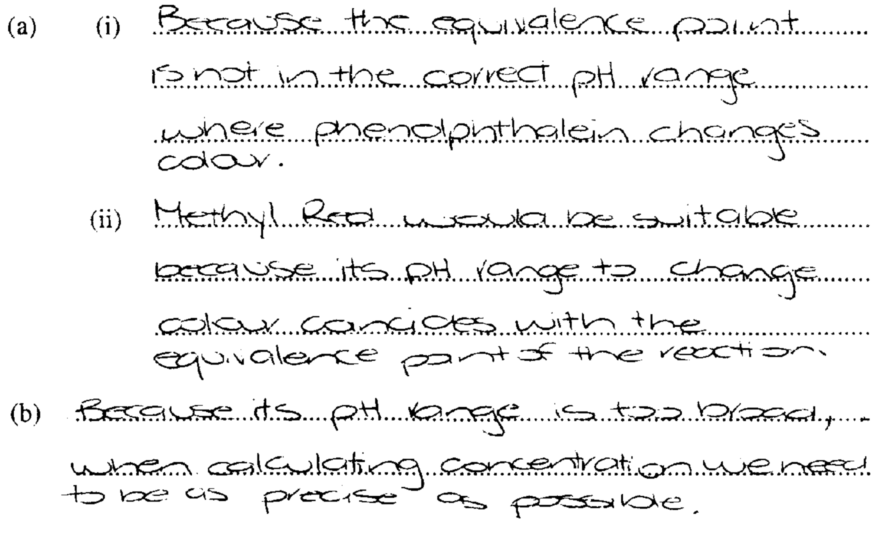
This type of question once again highlighted the need for candidates to be exposed to the full range of mandatory practical experiences at school.

A sample answer receiving 5/5 marks

(a) (i) Because the equivalence point is not in the correct pH range where phenophthalein changes colour.

(ii) Methyl Red would be suitable because its pH range to change colour coincides with the equivalence points of the reaction.

(b) Because its pH range is too broad. When calculating concentration we need to be as precise as possible.

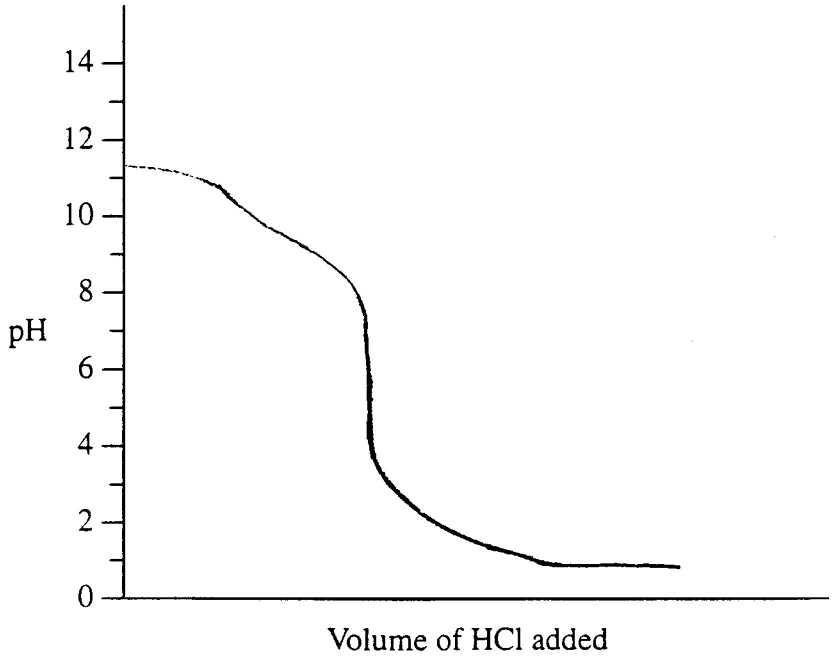


(a) (i) Because the equivalence point is not in the correct pH range where phenolpthalein changes colour.

(ii) Methyl Red would be suitable because its pH range to change colour coincides with the equivalence point of the reaction

(b) Because its pH range is too broad, when calculating concentration we need to be as precise as possible.

(c)



Question 29

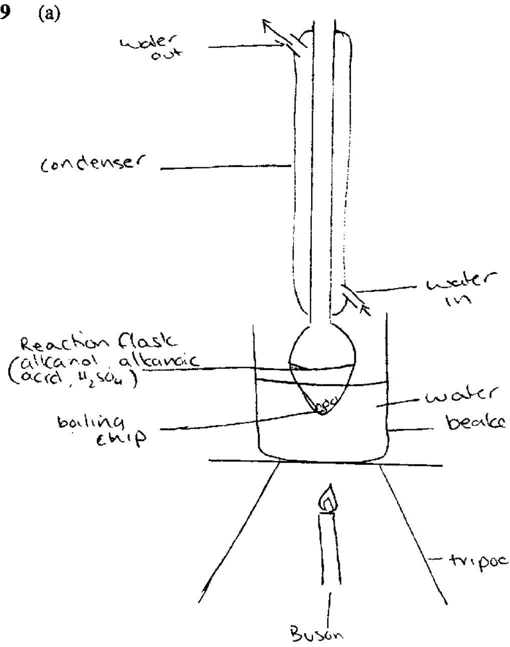
(a) Most candidates were able to draw the assembled apparatus for refluxing. However, approximately 15% drew distillation apparatus and approximately 5% showed the appropriate apparatus but unassembled. Some candidates lost marks for careless diagrams, eg no water jacket shown for a water-cooled condenser. There was also evidence that some candidates had never carried out refluxing. A few candidates drew the flammable mixture being heated in an open beaker by a bunsen flame, which is a safety concern.

(b) Approximately 85% of candidates gave the correct structural formula for the alkanol. The most common error was to give the ester's structural formula. Other errors were drawing the bond from the H of the OH group to the carbon and leaving out the bonds between carbon and hydrogen atoms.

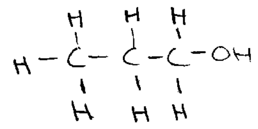
(c) Only a third of candidates stated that a separating funnel could be used and many of these students could not indicate how they would drain off the lower aqueous layer. Most candidates do not appear to be familiar with the technique of separating aqueous and non-aqueous layers.

An example of a response scoring 5/5 marks

29 (a)



(b)



$$\begin{array}{ccccccc} & & H & & H & & H \\ & & | & & | & & | \\ H & - & C & - & C & - & C-OH \\ & & | & & | & & | \\ & & H & & H & & H \end{array}$$

(c) Propyl acetate and water have different densities so can be separated by using a separation funnel.

Question 30

(a) Most candidates gave the correct answer — KF — but a significant number responded with $K_{13}F_{14}$, indicating that they did not know how to interpret the diagram.

(b) Most candidates recognised that the two compounds had different empirical formulas and therefore a different arrangement of ions within the ionic lattice.

(c) While many candidates obviously had an understanding of bonding and its effect on melting point, responses to this part of the question tended to be poorly expressed. Frequently, candidates did not refer to the forces between the ions in KF or between the molecules in CF_4 and many responses referred to the covalent bonds within the CF_4 molecule as being weak. Some candidates incorrectly identified the particles present in KF as atoms and many neglected to state that ionic bonds are strong forces of attraction between the oppositely charged ions requiring a substantial amount of energy in order to break them. When explaining the melting point of CF_4, many candidates were unclear as to whether they were referring to the intermolecular forces or intramolecular forces as being weak dispersion forces requiring little energy to break. A number of candidates incorrectly identified the forces between the molecules as dipole-dipole and many merely stated that dispersion forces are broken which, as a stand-alone answer, is insufficient.

(d) Good candidates recognised that in the solid state the ions are held in fixed positions in the lattice, unable to move, whereas in solution the ions dissociate and become mobile. Unfortunately, many candidates wrongly stated that free mobile electrons were required for electrical conductivity.

Question 31

This question was generally well answered by a majority of the candidates. Errors included:

- reversing the order of the isomers so that compound A was given the 1-hexene structure and compound C the 3-hexene structure;
- using other C_6H_{12} isomers such as methyl pentenes, dimethyl butenes or cyclohexane;
- naming the compounds instead of drawing structural formulas;
- adding Br_2 instead of HBr;
- showing products of substitution rather than addition;
- presenting a trivalent or pentavalent carbon in full or condensed structural formulas;
- incomplete erasures of working and careless corrections;
- missing hydrogen atoms or bonds in full structural formulas.

Section II – Electives

ELECTIVE	ELECTIVE NAME	NO. OF CANDIDATES	CANDIDATURE %
Question 32	Chemical Energy	5367	52%
Question 33	Oxidation and Reduction	3967	38%
Question 34	Biological Chemistry	845	8%
Question 35	Chemistry and the Environment	204	2%

Question 32 – Chemical Energy

(a) (i) This part was well done by most candidates.

(ii) Most candidates gained some marks on this question but the majority could not apply the mole ratio to obtain moles of gaseous products. Most were able to calculate the moles of nitroglycerine, manipulate PV = nRT, convert °C to Kelvin and use correct units.

(b) (i) It was obvious from the quality of the answers that many of the candidates did not recall details of practicals that they had done. Many had difficulty writing a procedure in clear, logical steps. Care is needed in labelling diagrams clearly and completely.

(ii) The graph was well done. The most common error was to draw a straight line relationship for P vs V.

(c) (i) The equation was reasonably well done but states were frequently omitted.

Some candidates did not know the correct formula for ammonia gas or that nitrogen and hydrogen are diatomic. A common error was to give $\Delta H = -46$ kJ for an equation involving 2 moles of ammonia.

(ii) This part was not well done. Most candidates had difficulty in using the -46 kJ value in their calculation.

A common error was to use ΔH = bonds formed – bonds broken. Many candidates did not calculate bond energy for a *single* mole of N-H bonds.

(d) (i) This equation was straightforward, involving a simple mathematical procedure that most candidates were able to perform well. However, it was disappointing to find that many were unable to give the correct units in their answer.

(ii) Most candidates found difficulty in giving TWO advantages. A significant number recognised that ethanol is a renewable resource. Many candidates wrongly equated the compound octane with the mixture petrol.

(iii) Some candidates did not realise that combustion where the fuel to air ratio is too high would involve incomplete combustion.

(iv) Ignition temperature was often confused with flash point and many candidates did not understand the difference between temperature and energy.

(e) Most candidates did not complete this part. Once again, many were unable to provide the correct units.

(f) Some candidates had difficulty interpreting the diagram.

(i) This part was well answered.

(ii) and (iii) were effective in determining candidates' understanding.

An example of a response scoring 25/25 marks

(a) (i) ΔH must be negative, as the reaction is exothermic, explosive → heat released.

(ii) No. of moles of nitroglycerine $= \dfrac{22.7}{MW}$

$(3 \times C + 5 \times H + 3 \times N + 9 \times O) = \dfrac{22.7}{227.1}$

$= 0.1$ moles

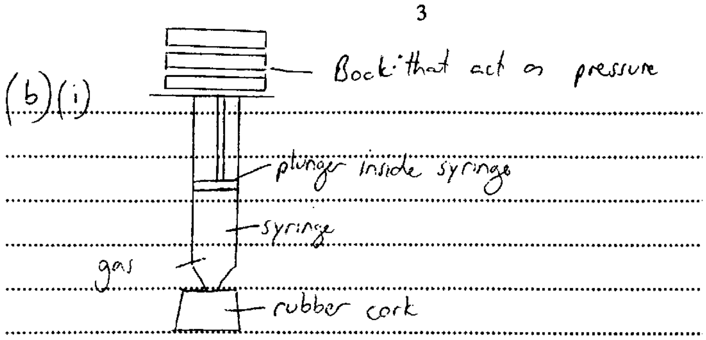
if there is 0.1 moles of nitroglycerine then there is $\frac{29}{4}$ times as many moles of products.

No. of moles of products = 0.725 mole in 2L.

$PV = nRT$
$P = ?$
$V = 2L$
$n = 0.725$
$R = 8.314\ JK^{-1}\ mol^{-1}$
$T = 773K$

$2P = 0.725 \times 8.314 \times 773$
$2P = 4639.37$
$P = 2329.7$ kPa
The pressure exerted would
$\therefore$ be 2329.7 kPa

(b) (i)

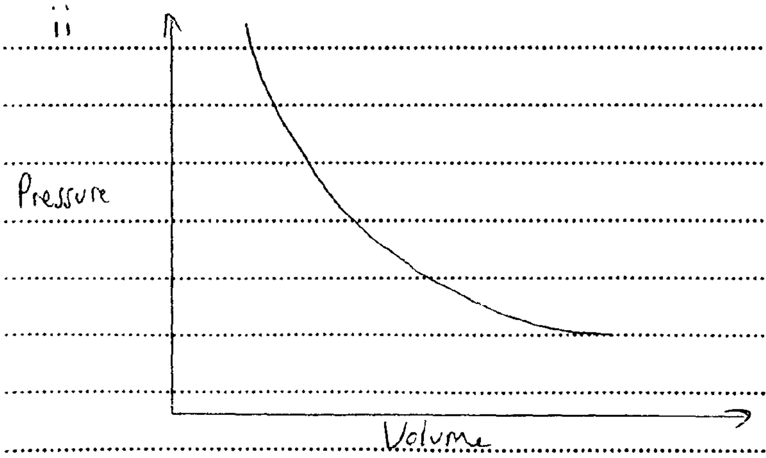


The above diagram is the set up of the experiment.

The following is how the experiment was carried out:

1. The syringe was pushed into the rubber cork so that no air could escape.
2. The plunger was pushed into the syringe.
3. Books of known mass were placed on top of the plunger to act as the pressure.
4. The volume of the gas was measured after each book was added.
5. The volume of the gas decreased with each book that was added.

ii



(c) (i) $\frac{1}{2}N_{2(g)} + \frac{3}{2}H_{2(g)} \rightarrow NH_{3(g)}$ $\Delta H = -46$ KJ

(ii)

Bonds Broken	Bonds Formed
(N≡N) $\frac{1}{2}$ x 945 (H-H) $\frac{3}{2}$ x 436	N-H 3χ
1126.5	-3χ

$\Delta H = \Sigma$ Bonds broken + Σ Bonds formed

$-46 = 1126.5 - 3\chi$

$\therefore \quad 3\chi = 1172.5$

$\therefore \quad \chi = 390.8$

$\therefore$ N-H bond = 390.8 kJ

(d) (i) 1367/46.1 = 29.65 kJ/g energy released

(ii) The production of ethanol is easier than the production of octane, which needs to undergo series of refinement.

Ethanol is cleaner than octane since it produces less CO_2 and H_2O per mole, whereas the higher carbon concentration of octane produces more CO_2 as well as products of incomplete combustion.

(iii) $C_2H_5OH_{(l)} + \frac{5}{2} O_{2(g)} \rightarrow CO_{(g)}+, CO_{2(g)} + 3H_2O_{(l)}$

(iv) The ignition temperature is the minimum temperature a fuel-oxidiser mixture need to be heated to combust spontaneously.

(e) H = MCΔT

$= 50 \times 4.18 \times (25.4 - 21.1)$

$= 898.7$ J

No. of mol of Ag^+

$= 0.05 \times 0.1$

$= 0.005$ mol.

$\therefore$ 0.0025 mol of $Zn_{(s)}$

$\therefore$ ΔH for reaction

$$= \frac{-898.7}{0.0025}$$

$= -359480$J

$= -359.5$kJ

$$\therefore \Delta H = \frac{-359.5\text{kJ}}{\text{per mol of Zn}}$$

(f) (i) Enthalpy of formation of methane

(ii) $C_{(s)} + 2H_{2(g)} \rightarrow C_{(g)} + 4\,H_{(g)}$

$C_{(S)} \rightarrow C_{(g)}$ $\quad \Delta H = 717$

$\frac{1}{2} H_{2(g)} \rightarrow H_{(g)}$ $\quad \Delta H = 218$

$\therefore$ $\Delta H_3 = 717 + 4 \times 218$

$\Delta H_3 = 1589$ kJ

(iii) $CH_{4(g)} \rightarrow C_{(g)} + 4H_{(g)}$

$CH_{4(g)} \rightarrow C_{(s)} + 2H_{2(g)} \qquad \Delta = +74$

$C_{(s)} + 2H_{2(g)} \rightarrow C_{(g)} + 4H_{(g)} \qquad \Delta = 1589$

$\therefore \quad \Delta H_1 = 74 + 1589$

$= 1663$ kJ

Question 33 – Oxidation and Reduction

(a) (i) Although given a specific equation and asked to explain why this reaction is classified as an oxidation-reduction equation, some candidates gave general answers without specifying which species was oxidised and which species was reduced.

(ii) This part was better answered than (i). Most candidates recognised that the reductant is itself oxidised.

(b) (i) Although asked to describe ‘changes you would see’, many candidates gave inferences instead of observations.

(ii) This was well answered although sometimes (s) was omitted for Mg and Cu.

(c) (i) Less than half the candidates could draw a satisfactory labelled diagram.

Essential features that should have been shown were erosion of the + electrode while the – electrode is plated or increases in size.

(ii) Each half equation needed to be linked to a particular electrode.

(d) (i) This part was well answered except for candidates who gave a ‘molecular’ equation rather than the ionic equation required.

(ii) Candidates must refer to the ions as bromide or fluoride not bromine or fluorine.

(iii) Candidates found it difficult to explain why nothing happens.

(e) (i) This part was generally well done. Most candidates were able to show a functional electrochemical cell. Some candidates lost marks by describing an incorrect ion flow through the salt bridge, or even electron flow. An appropriate soluble salt that will not react with any ions in the solutions, eg KNO_3, should be shown in the salt bridge and the salt bridge must be drawn so that its ends are in both solutions.

(ii) This part was well attempted. Some candidates wrongly presented both half-equations as reductions even though they knew how to reverse one of them to obtain the final equation.

(iii) Most candidates were able to successfully add the E° values to give a positive value. Candidates who had shown two reduction half-equations were aware that a positive voltage is obtained even though they had a half-equation reversed.

(iv) This presented problems for a significant number of candidates. Explanations relying on physical causes (internal resistance, equipment errors) were not accepted. Good responses gave chemical reasons (standard conditions, approaching equilibrium, oxide coating on Al).

Note:

Candidates who attempted part (e) by describing a cell they were familiar with and not the one stipulated in the question could at most score 3 out of the 7 marks.

(f) (i) The most frequent response involved a sacrificial anode attached to the hull of the ship. Many candidates had difficulty in writing an outline of a method, ie describing what would be done. Many included the explanation asked for in part (ii), and then repeated the explanation in part (ii). Candidates can use their exam time more effectively if they read the parts of a question first, then underline the key requests in the question ('outline another method' and 'explain this method') before commencing their answers. There was a poor understanding of the difference between a sacrificial anode and galvanising.

(g) (i) This part was reasonably well done.

(ii) Many candidates had difficulty in recognising which species was being oxidised. The answers given indicated a confusion about the term 'species'.

(iii) and (iv) were generally well done except by candidates who could not tell the difference between an oxidation half-equation and a reduction half-equation.

(v) This part well done if parts (iii) and (iv) were correct.

An example of a response scoring 25/25 marks

$Zn_{(s)} + Cl_{2(g)} \rightarrow ZnCl_{2(s)}$

(a) (i) The $Zn_{(s)}$ has become Zn^{2+} meaning it has lost e^- or has been oxidised.

The $Cl_{2(g)}$ has become $2Cl^-_{(aq)}$ meaning it has gained e^- or has been reduced.

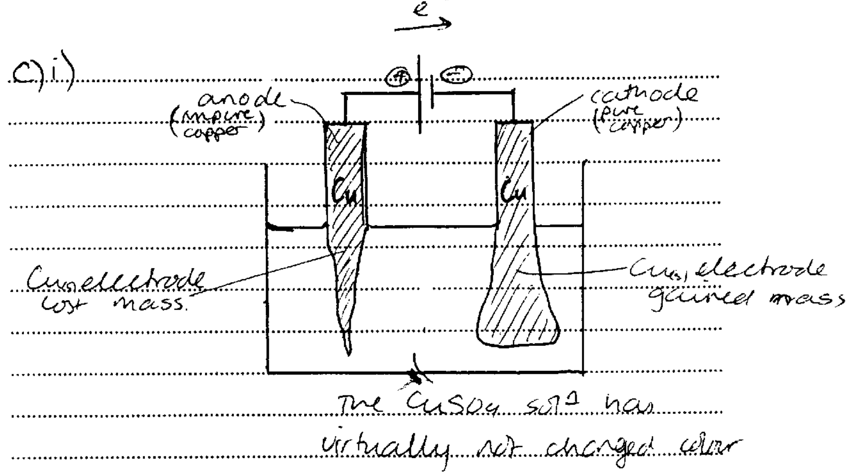
Since $Zn_{(s)}$ has been oxidised and $Cl_{2(g)}$ has been reduced, then the reaction is a redox reaction.

(ii) $Zn_{(s)}$, since $Zn_{(s)}$ has been oxidised, it has caused $Cl_{2(g)}$ to be reduced. Hence $Zn_{(s)}$ is the reducing agent.

(b) (i) The $Mg_{(s)}$ would be coated by a dark, orangy-brown solid. The $CuSO_4$ solution will become a lighter blue colour.

(ii) $Mg_{(s)} + Cu^{2+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$

(c) (i)



The $CuSO_4$ sol^n^ has virtually not changed colour

(ii) At the anode (+ electrode) $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$
the impure copper becomes oxidised to $Cu^{2+}_{(aq)}$ and enters the sol$^{\underline{n}}$.

At the cathode (-electrode)
$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$

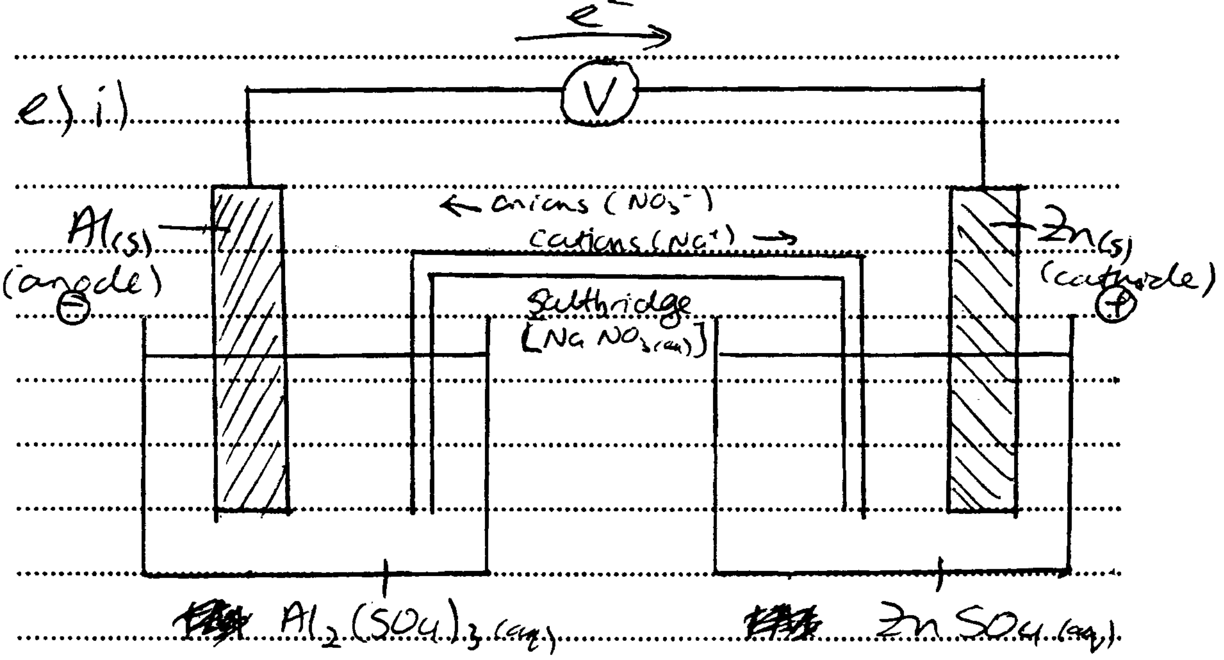
the $Cu^{2+}_{(aq)}$ is being reduced to pure $Cu_{(s)}$

(d) (i) $2\,Br^-_{(aq)} + F_{2(g)} \rightarrow 2F^-_{(aq)} + Br_{2(\ell)}$ (E° cell = 1.81V).

(ii) As bromide ion was oxidised to bromine liquid, the solution turned brown as a result of the increasing quantity of brown $Br_{2(\ell)}$
(ie the $F_{2(g)}$ displaced the $Br^-_{(aq)}$ to form brown $Br_{2(\ell)}$
E° cell = 1.81V.

(iii) No reaction (ie both solutions mix with each other without a colour change). This occurs as both $Br^-_{(aq)}$ and $F^-_{(aq)}$ are in the most reduced state possible, and so no reaction occurs.

(e) (i)



(ii) $Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-$ (oxidation)

$Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$ (reduction)

$$\therefore 2Al_{(s)} + 3Zn^{2+}_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3Zn_{(s)}$$

(iii) E° cell = E° cathode - E° anode

= -0.76 – (-1.68)

= 0.92V

(iv) The cell was not set up in standard conditions (25°C, 1 Mol L^{-1} Sol$^{\underline{n}}$, 1 atm pressure).

(f) (i) Attaching a sacrificial anode of Magnesium metal to the hull.

(ii) $Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^-$ E° = 2.36V

$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ E° = 0.44V

Since $Mg_{(s)}$ has a higher oxidation E° value than $Fe_{(s)}$, the $Mg_{(s)}$ will oxidise to $Mg^{2+}_{(aq)}$ in preference to the $Fe_{(s)}$ preventing the steel from rusting. Also, since there is an abundance of e^-, any Fe^{2+} will be reduced to $Fe_{(s)}$ [E° cell = 1.92V], further preventing the rusting of ships.

(g) (i) $-1 = Br + 3(-2)$

$Br = -1 + 6$

∴ Bromine has an oxidation number of +5.

(ii) $(COOH)_{2(aq)}$

(iii) $(COOH)_{2(aq)} \rightarrow 2CO_{2(g)} + 2H^+_{(aq)} + 2e^-$.

(iv) $BrO_3^-\ (aq) + 6H^+_{(aq)} + 6e^- \rightarrow Br^-_{(aq)} + 3H_2O_{(\ell)}$

(v) $BrO_3^- + 6H^+ + 3(COOH)_2 \rightarrow Br^- + 3H_2O + 6CO_2 + 6H^+$

$BrO_3^-{}_{(aq)} + 3\ (COOH)_{2\ (aq)} \rightarrow Br^-_{(aq)} + 3H_2O_{(\ell)} + 6CO_{2(g)}$

Question 34 – Biological Chemistry

(a) (i) This part was generally well answered.

(ii) Most candidates were able to correctly name an appropriate test reagent, though some did not describe *how* the test would be performed (need for warming, signs of a positive result). Many candidates wrongly believed that a negative result indicates that sucrose *must* be present. Relatively few candidates went beyond the initial negative test to describe hydrolysis and the consequent positive result. A small number of candidates chose chromatography but provided insufficient information (eg use of standards for comparison).

(iii) Unfortunately, some candidates are still giving biological differences rather than chemical differences for questions of this type.

(iv) Most candidates were able to give at least one property.

(b) (i) A significant number of candidates gave unnecessarily extended answers, sometimes with diagrams, that were factually incorrect or self-contradictory. Many candidates simply defined aerobic and anaerobic respiration and ignored the context of ‘what is the difference between’.

(ii) The role of cytochromes was not generally well understood. Relatively few candidates associated cytochromes with electron transport.

(iii) Many candidates confused the light reaction with either the dark phase of photosynthesis or with respiration. Some candidates believed photolysis results in the formation of hydrogen *molecules.*

(iv) This part was correctly answered by many candidates. Lack of stoichiometric skills is a problem for some candidates.

(c) (i) Most candidates responded correctly with amino acids.

(ii) Most common errors were leaving the positive charge off NH_3^+, failing to show four bonds to the central carbon, drawing an uncharged amino acid and giving NH_2^+ or NH_4^+.

(iii) 80% of candidates correctly responded with peptide bond.

(iv) Most candidates correctly gave the helical or pleated sheet structure.

(v) A large number of candidates answered this correctly but incorrect answers included many different types of bonding.

(vi) A detailed explanation of catalyst action without relating this to specific features of enzyme catalytic action did not gain the mark.

(vii) The best answers supported the explanation with a clear, labelled diagram.

(viii) Over 90% of candidates answered correctly. Answers were expected to be in the range 7.8 – 8.2.

(ix) 80% of candidates recognised that denaturation had occurred. Writing that the enzyme had died or deactivated is insufficient to gain a mark.

(x) Most candidates received a mark here.

An example of a response scoring 25/25 marks

(a) (i) 1. Milk – I and III.

2. Malt – III

(ii) Perform Benedicts test on the solution. It should produce a negative result. Then add some dilute HCI to the solution to hydrolyse the sucrose if it is there. Then perform Benedicts test again. It should be positive this time due to glucose and fructose being present. (Note: Benedicts test involves heating the sugar with an alkaline solution of Cu^{2+} ions to product a brick red precipitate of Cu_2O if a reducing sugar is present).

(iii) Glycogen has ∝-1, 4- glysosidic links between glucose units, cellulose has β-1, 4-glycosidic linkages between its glucose units.

(iv) 1. Low solubility (Clothes won't dissolve)

2. Strong, rigid, fibrous molecule (eg this is apparent in plant cells; cotton).

(b) (i) Nothing. Glycolysis proceeds in the same fashion regardless of whether oxygen is present or not. It is an anaerobic process — oxygen is not needed until the citric acid cycle. The end products of aerobic and anaerobic glycolysis differ, though; if O_2 is present the pyruvic acid will enter the citric cycle as Acetyl Co enzyme A, if O_2 is not present then the pyruvic acid is converted into ethanol and CO_2 in plants and lactic acid in animals.

(ii) Cytochromes allow for the production of 34 molecules of ATP using the NADH molecules and the free electrons produced in the citric acid cycle. They take part in the reaction that produce these molecules of ATP.

(iii) The capture of sunlight by the chloroplasts of a plant for use in breaking apart water molecules in order to extract the Hydrogen atoms and electrons therein. ATP is also produced for later use in the carbon fixation reactions.

(iv) $6H_2O + 6CO_2 \rightarrow C_6H_{12}O_2 + 6O_2$

$$\text{moles of water} = \frac{1000 \times 1000}{18}$$

$$= 55555.5\dot{5} \text{ moles}$$

∴ moles Glucose produced: $\frac{1}{6} \times 55555.\dot{5}$

= 9259.26 moles

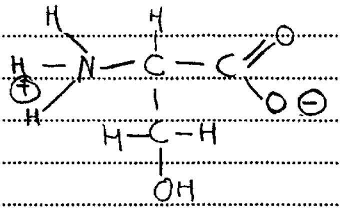
∴ grams Glucose= 9259.26 x 180

= $1,666660.6\dot{6}$ grams

= 1666.67 kg of glucose is produced

(c) (i) amino acids make up proteins.

ii)



(iii) Peptide bond

(iv) α– helix structure where the polypeptide coils into a spiral coil and maintains this shape by the hydrogen bonding between adjacent loops, usually between C=O of one amino acid and N–H of another.

(v) Intermolecular forces such as hydrogen bonding, usually with C=O group of one amino acid and HN of another. Electrostatic forces between charged ions in side chains or at the end of peptide chains. Disulfide bonds where the sulfur in cystine [oxidised form of cysteine] forms a covalent bond with another sulfur of a cystine amino acid. This covalent bond can occur between two separate peptide chains or two areas of a peptide chain, a bond important in holding the tertiary structure together.

Hydrophobic side chains coil within the protein while hydrophilic side chains interact with polar water, bonding which is important especially for determining the tertiary structure of globular proteins.

(vi) Enzymes are physiologically active proteins that are biological catalysts. They catalyse metabolic reactions by lowering the activation energy.

(vii) Enzymes are highly specific and usually catalyse one type of reaction. Enzymes have an active site in their structure which forms a close fit with the particular substrates and is able to catalyse the reaction by forming the enzyme-substrate complex. The specificity of the active site does not allow any other substrates to bond in this area, so does not catalyse any other reaction except the specific one where the substrate fits the active site.

(viii) Optimum pH is 8.

(ix) Because of the high pH, the tertiary structure has been disturbed, denaturing the enzyme. The inteference with bonds such as electrostatic bonds altered the tertiary structure, and therefore the active site where catalysis takes place. This change of shape cannot form the enzyme-substrate complex, therefore the enzyme is biologically inactive and rate of reaction decreases because of denaturation. If the pH change is strong enough to affect the secondary structure, the active site is further altered.

(x) By heating above the optimum temperature of the aspase-3 enzyme, the high temperature breaks hydrogen bonds and other bonds such as electrostatic forces, altering the tertiary structure of the enzyme and changing its active site. The enzyme can no longer form an enzyme-substrate complex so is unable to catalyse the reaction, decreasing its rate of reaction.

Question 35 – Chemistry and the Environment

A significant number of candidates gave general, non-technical answers that scored few marks.

(a) (i) and (ii) were well answered.

(iii) Few candidates knew that UF_6 was a gas. Of those that did, few showed real knowledge of isotopic separation by diffusion or recent developments in methods.

(iv) This part was generally well answered, although many candidates thought that uranium isotopes were directly used in medical procedures.

(b) (i) Few candidates wrote correctly balanced equations. Working and chemical reasoning were not well shown. Many candidates had difficulties with large numbers and correct units.

(ii) Some candidates misinterpreted the word ‘neutralised’, thinking that the metal or radioactivity needed ‘neutralising’.

(iii) 1 There were some good answers that focused on toxicity and biomagnification. Poor answers focused on water hardness, which was not the issue.

2 This part was not well answered. Many candidates thought that the metals were present as solids rather than soluble ions. Few gave chemical equations to illustrate their answers.

(c) (i) This part was well answered.

(ii) Those who used the correct data generally answered well but many misread the question and answered for the days given in part (i).

(iii) Some candidates had little knowledge of how to test for microorganisms in water. Others gave a good general outline but rarely indicated quantitative techniques.

(iv) Once again, in a quantitative calculation based on a chemical reaction few candidates started with a balanced equation. There was evidence of poor conversions of concentrations to moles.

(d) (i) 1 Most candidates had a general idea of what a greenhouse gas is but few were able to define it using appropriate scientific language.

2 Much confusion about the mechanism of the greenhouse effect was evident, particularly the difference in wavelength of incoming and outgoing radiation. Few stated that greenhouse gases absorb infrared radiation. Many thought that the radiation was reflected. There was also much confusion between the greenhouse effect and problems with ozone depletion.

3 Most candidates could name another greenhouse gas.

(ii) This question required a gas other than carbon dioxide which is normally present in rainwater. Many candidates who chose appropriate gases could not write a balanced equation.

(iii) This part was poorly done. Few candidates showed essential processes such as nitrogen fixation and the assimilation of nitrogen into organic compounds.

An example of a response scoring 25/25 marks

(a) (i) U_3O_8

(ii) Radon gas → radioactive

→ alpha emitter – carcinogenic

(iii) UF_6 (gas) is injected into the centre of a chamber. This gas is collected from around the edges and from centres. Because lighter isotopes diffuse faster than heavier ones, the gas around the edges will contain U-235 more than normal and vice versa for centre. This is called gaseous diffusion (ie. more U-235 than usual).

(iv) Used as a nuclear fuel for nuclear power stations. Used for the production of nuclear weapons.

(b) (i) number moles H_2SO_4 $= [\ ] \times v$

$= .15 \times 1 \text{ x } 10^9$

$= 150 \times 10^6$ moles

$H_2SO_4 + Ca(OH)_2 \rightarrow 2H_2O + CaSO_4$

$\therefore$ 1 : 1

$\therefore$ 150×10^6 moles $Ca(OH)_2$ needed

$$n = \frac{m}{m}$$

$m = n \text{ x } m$

$= 150 \times 10^6 \times (40.08 + 32 + 2.02)$

$= 1.1115 \times 10^{10}$g/year

= 11,115 tonnes needed /year

(ii) so as to prevent Finiss River becoming acidic and hence killing aquatic life.

(iii) 1 they accumulate in the food chain, resulting in damage and poisoning of large predators, ie large fish, humans.

2 This can be achieved either through sediment traps (heavy metals accumulate at the bottom) or through ion exchange membranes that trap heavy metals (still very much experimental at this stage).

(c) (i) it rained $\therefore$ increasing river flow which stirred up sediments. This can be seen from higher levels of dissolved oxygen (from river flow). Also higher levels of nitrates washed in.

(ii) lower water temperature would mean more O_2 could be absorbed
$\therefore$ DO would increase ie. 9.0 - 11.0.
$\therefore$ this can be seen from Temp readings (reduction from 17 to 15).

(iii) get several agar plates, on half of them place a 2ml sample of water; leave in warm (30-37°C) place for 24 - 48 hours and count colonies formed. Take an average of the ones to which water was added and subtract from the average count of the control ones. This is CFU and multiply to obtain CFU/100ml.

(iv) 200mg NaC1

$$\text{n moles} = \frac{.200}{22.99 + 35.45}$$

$$= 3.42 \times 10^{-3}$$

$\therefore$ mass formed $= 3.42 \times 10^{-3}$ x Molar mass Ag C1

$= 3.42 \times 10^{-3}\ (107.9 + 35.45)$

$NaCl_{(aq)} + Ag\ NO_{3(aq)} \rightarrow Ag\ C1_{(s)} + NaNO_3$ $= 490.6 \times 10^{-3}\ g\ L^{-1}$

$= 490.6\ mg / L$

$= 24.53\ mg / 50ml$

(d) (i) 1 gas that can trap outgoing radiation thus warming the air creating a 'green house'

2 A green house gas allows higher frequency radiation to pass through it. This radiation is re-emitted by the earth as infra-red which greenhouse gases trap resulting in an increase in temperature of earth.

3 Methane CH_4

(ii) $SO_{2(g)}$ emitted from combustion

$2SO_{2(g)} + O_{2\,(g)} \rightarrow 2SO_{3(g)}$

Equation $\rightarrow SO_{3(g)} + H_2O_{(\ell)} \rightarrow H_2SO_{4(aq)}$ ie. sulfuric acid.

iii)