2005 Senior External Examination

Chemistry

Chief Examiner Report for Candidates and Teachers

In 2005, 33 candidates sat the first paper of the Senior External Examination in Chemistry and 32 candidates sat the second paper. The first paper covered Knowledge and Scientific Processes and the second paper covered Complex Reasoning Processes. The second paper must be taken into consideration for levels of achievement of Sound achievement and above. Of the 33 candidates, 22 were female and 11 male. There has been another decline in the number of candidates (2003 – 74, 2004 – 48, 2005 – 33).

The overall results for the 2005 examination were:

VHA	HA	SA	LA	VLA
2	9	9	6	7
6.1%	27.3%	27.3%	18.2%	21.2%

These results were better than those for 2004 and were on a par with the 2003 results.

Paper One

Section A (Knowledge, Recall and Simple Application)

Multiple-choice questions A1 to A10: the correct response is shaded.

	Number attempted	A	B	C	D	% correct
1	33	9	1	4	19	58
2	33	2	14	14	3	43
3	33	5	2	25	1	76
4	33	7	13	8	5	21
5	33	9	8	11	5	24
6	33	31	1	0	1	94
7	32	2	7	19	4	58
8	33	4	0	3	26	79
9	33	2	4	8	19	58
10	33	7	2	19	5	58

This reveals that the questions poorly done were:

- Question 2
- Question 4
- Question 5.

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Short answer questions Q11 to Q18 (60 marks)

This was the main part of the examination where the candidate must demonstrate knowledge and understanding of the eight topics of the syllabus. There seems to be some improvement in the standard of answers in this section, which gave rise to improved 2005 results.

In Question 11, several candidates had difficulty expressing themselves, e.g. in Question 11(a) “an element consists of one atom” instead of “an element consists of one type of atom” and in Question 11(b) an ion is “the charge on an atom”. Few, if any, mentioned “chemically combined” for a compound, and several used the word “mixture”. In Question 11(e), in many cases the only difference stated was that ionic bonds occur between metals and non-metals, and covalent bonds occur between non-metals. Several gave CO_2 as an example of a polar molecule.

In Question 12, since the empirical formula was not asked for, several candidates worked out the masses of the elements from the percentage composition and approximate molar mass and then calculated the molecular formula and exact molar mass.

Question 13(b) was probably the question answered worst. Many candidates used MnO_4^- instead of MnO_2 as the symbol for manganese oxide and several used Ti as the symbol for tin. E° values were not given.

Question 14, dealing with organic formulae according to classes, was usually either well done or very poorly done.

For Question 15, the periodic table was fairly well known, although some candidates thought Period 3 was row 4 of the table. The part handled worst was (e), referring to the simplest oxide of silicon.

In Question 16, not one candidate mentioned displacement of air in collecting the gas. Some described a tube going to a container, but others suggested placing an inverted test tube over the reaction vessel.

In Question 17(a) most candidates mentioned factors affecting the rate of a reaction and activation energy, rather than comparing different reactions. Most knew what an endothermic reaction is, but the calculation was not well done.

Parts (a), (c), and (f) of Question 18 were not well done. A number of candidates answered part (e) by stating a pH value less than 14 meant that some hydrogen ions were present in the solution. As mentioned in previous reports, to do well overall the candidate must do well in Section A of Paper One.

Section B (Scientific Process)

Question 1. Most candidates suggested using hot water, but none gave any procedural details such as stirring, filtering or drying.

In Question 2, very few candidates referred to E° values though other explanations were possible. While most realised the first three parts involved the reactivity of the metals, few realised that parts (d) and (e) concerned the relative reactivity of chlorine and bromine. Several showed one or both forming BrCl.

Though some candidates handled Question 3 well, the reactions which could be used to distinguish the organic compounds were not well known. Since chemical tests were not essential, some candidates described the molecular shape to distinguish hexanol and cyclohexane, and others assumed that benzoic acid is a liquid and that ethyl benzoate is soluble in water.

In Question 4, the graph was generally well done, and the time of reaction was correctly read by most candidates. However, some added the mass gains for successive time intervals in parts (c) and (d).

The first parts of Question 5 were fairly well done but the effect of adding water was not known. Many saw water as a source of hydrogen for the reaction.

Paper Two

Complex Reasoning Processes

This paper contained five questions, designed to assess the candidate's ability to use complex reasoning processes, and broadly covering:

- problem solving in challenging and unfamiliar situations
- making logical decisions and detailed explanations
- using either creative and/or critical thinking.

It was expected that candidates would attempt only four of the five questions and would spend half an hour trying to solve the question and enumerating relevant factual information which would help solve or explain the situation. Too many attempted all five and failed to delete one. Some initial analysis of the question and its key words, and planning of answers, would assist in developing better responses. More candidates cited references, but too many grasped at straws and wrote about irrelevant issues.

Question 1, on gas diffusion, was not a Knowledge question, but sought for candidates to use the given information on Graham's Law and relate it to knowledge of gas density, molar masses and so on. Because of poor algebra and mathematical techniques many candidates failed to solve the problem. There was no need to work out the density of each gas; many tried this way with all sorts of errors relating to conditions and molar volumes, and even gave an incorrect formula of oxygen. Some general comments relate to this question:

(a) Do not round calculations continuously, only once at the end.

(b) Check transcriptions of values from calculators to paper.

(c) Be critical of the answer obtained – is it reasonable or even possible? (0.01g for a molar mass is clearly impossible).

(d) If a text book is quoted, give the reference; many quoted the density of oxygen, but did not state the conditions or the reference.

(e) Many did not understand inverse proportion and the significance of the square root.

(f) Units for rate were not needed but raised interesting speculations.

(g) Some candidates attempted to use the gas equation PV=nRT without success.

(h) It was good to see from one candidate $R_1d_1 = R_2d_2$.

The correct answer was 288 $gmol^{-1}$. This is hardly chlorine and bromine as guesses at identifying the gas.

A sample solution is given in the worked solutions.

Question 2 related to whether there was sufficient heat released from a piece of sodium reacting with ice/water mixture to melt the ice. The question is clearly related to Hess's Law. A good candidate would first attempt to write the possible reactions occurring and then calculate the heats involved. As expected, too many guessed that there was enough heat to melt the ice, and then had trouble finding the final temperature.

A candidate sample answer which was awarded A contained a correct solution with good reasoning and a well explained response (see Sample answer for question 2 on pages 18 and 19).

Question 3 required the candidate to gather data or predict data on two oxides, fluorine oxide F_2O and sodium oxide Na_2O. It was not expected that candidates would know this information but that they would seek reference material and analyse the types of bonding/structure and hence, possible properties. Many could give physical properties and bonding, but were at a loss to predict/find any chemical properties. There were far too many who talked about fluorine and sodium instead of their oxides. For the record, neither are very stable. Of course, Na_2O reacts vigorously with water to produce NaOH. F_2O with water produces HF and O_2. Many candidates said F_2O was insoluble in water because of the covalent bond. Others said F_2O was polar, therefore water-soluble. Virtually no one suggested (critically) that it might react.

Please note that there is little merit in listing dot points or facts without any explanation or justification.

A candidate sample answer which made good use of available reference material is given (see Sample answer for question 3 on pages 20 and 21).

Question 4 called for evidence for the existence of ions **in solution**, not merely the formation of ions or just theory considerations. The question does not concern ions in solids and their consequent lattice structures and high melting properties. Issues which could have been considered included:

1. dissociation into ions (really theory but it defines the issue)
2. electrolytes and conductivity
3. the working of electrochemical and electrolytic cells
4. acid/base phenomena with ample evidence (by diagrams, experiments, theories explained)
5. speed of reactions — ionic ones are really fast
6. may be (but unlikely) abnormal BP/FP results compared to molecular substances in solution (open book may reveal this)
7. could use types of reaction such as neutralisation or precipitation
8. even analysis of metal ions, either cations or anions.

A good candidate answer is given (see Sample answer for question 4 on pages 22 and 23).

Question 5 sought to explain the phenomena occurring during a space shuttle blast-off. Parts (a) and (b) concerned the common misconception that all the white smoke during take off is steam from burning hydrogen and oxygen (or air). Reponses should have been directed by the guided questions asked. Only brief but succinct answers were required.

Question 5(c) required careful thought with creative and critical thinking coming into play. There must be a reaction between aluminium and ammonium perchlorate NH_4ClO_4, the powerful oxidizer. Otherwise why are they there?

Suggestions would be:

(1) $Al + O_2 \rightarrow Al_2O_3$ a fine white powder, or

(2) $Al + Cl_2$ (from NH_4ClO_4) $\rightarrow AlCl_3$, again a white (and volatile) powder, or

(3) Some reaction between $Al + NH_4ClO_4$ but doing more than just making $Al(ClO_4)_3$ — yes, the correct formula given by a couple of candidates. Too many suggested NH_4^+ reacting with O_2 to give all sorts of products, N_2, NH_3, H_2, etc. but no mention of the role of Al.

This question inclined to open-endedness was there to make candidates think and apply their chemistry. It worked really well from mere nonsense to some very thoughtful responses – a typical good candidate response is given, but possible products were not suggested (see Sample answer for question 5 on pages 24 and 25).

Sample solutions

These sample solutions show possible ways of answering questions. They do not provide the only method of approaching a question. Other approaches and problem-solving strategies would be acceptable. These solutions have been provided as a reference to assist teaching institutions in their preparation of candidates for the External Examination in Senior Chemistry.

Paper One

Part A: Knowledge and Simple Application

Multiple-choice keys

Question 1	D	Question 6	A
Question 2	B	Question 7	C
Question 3	C	Question 8	D
Question 4	A	Question 9	D
Question 5	B	Question 10	C

Short answer (60 marks)

Answer all questions (Questions 11 to 18).

You must show all working.

Answer in the spaces provided.

Marks are shown for each question.

If you need more space for a response, you may continue your answer on pages 16 and 17. Make sure you label the page used with the question number that relates to your answer.

Question 11

(a) Explain the difference between an element and a compound. Illustrate your response with an example of each.

Elements contain only one kind of atom whereas compounds contain two or more different kinds of atoms chemically combined. eg. H_2 element H_2O compound

(2 marks)

(b) What is meant by the term "ion"? How is it formed? Give an example.

Ion is a charged atom or molecule formed by loss or gain of electrons

eg Na atom $-1e \rightarrow Na^+$ ion

and Cl atom $+1e \rightarrow Cl^-$ ion

(1½ marks)

(c) List the type and number of subatomic particles in the atom represented by ^{40}K.

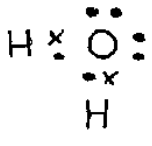
K is element 19

∴ 19 p } in nucleus
21 n }

19 e outer e's

(1½ marks)

(d) Draw the electron dot diagram for the water molecule.



(drawn H-O-H as linear only ½ mark)

(1 mark)

(e) What is the main difference between a covalent bond and an ionic bond?

Covalent bond has shared e's between atoms holding together

Ionic bond has electrons transferred from one group of atoms to another

(2 marks)

(f) Name a polar molecule other than water.

ammonia (NH_3)

hydrogen chloride (HCl) etc

(1 mark)

Question 12

(a) A cylinder holds 0.130g of ethane C_2H_6.

(i) How many moles of ethane are there in the cylinder?

$\frac{0.130\ g}{30\ g/mol} = 0.00433\ mol$

or $4.33 \times 10^{-3}\ mol$

(1½ marks)

(ii) How many molecules of ethane are there in the cylinder?

$0.00433 \times 6.02 \times 10^{23} = 2.61 \times 10^{21}$

(1½ marks)

(iii) The ethane gas empties into the atmosphere at 25°C and standard pressure. What volume of gas would there be?

1 mol has volume of 24.5 L at stated cond^{ns}

$\therefore$ 0.00433 mol has volume of 24.5×0.00433 L

$= 106$ mL

(2 marks)

(b) What mass of pure anhydrous sodium carbonate would be needed to react with 0.124 mol of pure hydrochloric acid according to the equation

$$Na_2CO_3 + 2\,HCl \rightarrow 2\,NaCl + H_2O + CO_2$$

(0.124 mol)

mol Na_2CO_3 needed = $\frac{1}{2}$ mol HCl = 0.062 mol

$m_{Na_2CO_3}$ = 0.062 mol × 106 g/mol

= 6.57 g

(2 marks)

(c) An organic chemical was found to have the following percentage composition by mass: carbon 40%, hydrogen 6.7% and oxygen 53.3%. Its approximate molar mass was 182. Calculate its molecular formula and exact molar mass. Show all working clearly.

C	40%	$n_C = \frac{40}{12} = 3.333$	1
H	6.7%	$n_H = \frac{6.7}{1} = 6.7$	2
O	53.3%	$n_O = \frac{53.3}{16} = 3.331$	1

Simplest ratio = EF = CH_2O (EFM = 30)

But MM ≈ 182

∴ MF = (EF) × 6

So its molecular formula is $C_6H_{12}O_6$

AND its "exact" molar mass is 180 g

(2 marks)

Question 13

(a) What are the oxidation states (or oxidation numbers) of chlorine in the following:

(i) Cl atom in chlorine gas Cl_2

Ox. state = 0 (an element)

(ii) Cl atom in hydrogen chloride gas

Ox. state of Cl is −1

(iii) Cl ion in sodium chloride

Ox. state of Cl^- is −1

(iv) Cl atom in potassium chlorate $KClO_3$.

K = +1, O = −2 ∴ Cl = +5

(2 marks)

Please do not confuse ox. states and charges on ions. Sometimes they are the same as in (iii) above. But no Cl ion exists in (i) (ii) or (iv)

(b) Using half-reactions, write and balance the net equation between tin (II) ions and solid manganese (IV) oxide in acid solution forming tin (IV) ions and manganese (II) ions respectively.

There is no need to calculate the overall E° (except that it tells the spontaneity of the reaction)
A suitable answer was:

$Sn^{2+} \rightarrow Sn^{4+} + 2e^-$ } from std reduction tables

$MnO_2(s) + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O(l)$

Add $Sn^{2+}_{(aq)} + MnO_2(s) + 4H^+_{(aq)} \rightarrow Sn^{4+}_{(aq)} + Mn^{2+}_{(aq)} + 2H_2O$ (2 marks)

(c) A current of 0.100 amperes flows through a solution of copper (II) sulfate $CuSO_4$ for 100 minutes. How many grams of copper will be deposited at the cathode?

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu(s)$

Quantity of elect $= it = 0.100A \times 100 \times 60s = 600C$ (coulomb)

$= \frac{600}{96500} F$ (faraday)

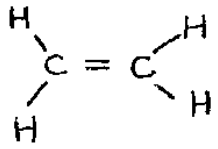
But 2 mol e $\rightarrow$ 1 mol (63.5g) Cu

$\therefore m_{Cu} = \frac{63.5 \times 600}{2 \times 96500} = 0.197g$ (2 marks)

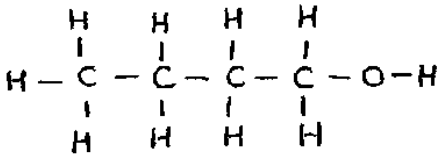
Question 14

Draw the full structural formula for each of the following named substances. Use the space provided. There is no need to draw electron dot diagrams.

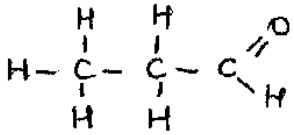
(a) ethene (ethylene)



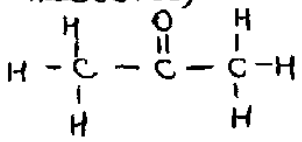
(b) 1-butanol



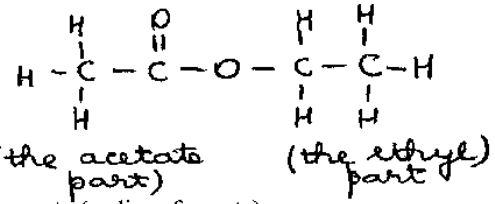
(c) propanal (an aldehyde)



(d) propanone (a ketone)

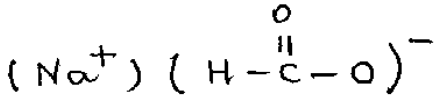


(e) ethyl ethanoate (ethyl acetate) (an ester)

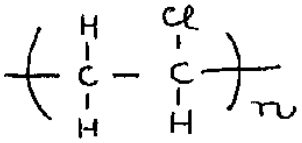


(f) sodium methanoate (sodium formate)

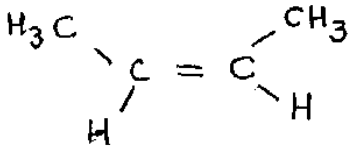
Note this is an ionic substance



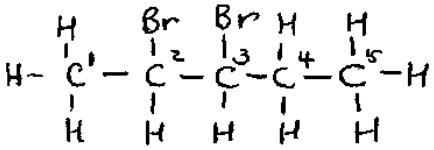
(g) poly (vinyl chloride) (a polymer with vinyl chloride the monomer)



(h) cis-butene



(i) 2,3 dibromopentane



(9 marks, 1 each)

Question 15

Answer the following questions concerning the Periodic Table and its elements.

(a) In which period of the Periodic Table is sulfur located?

third period

(1 mark)

(b) In which group of the Periodic Table is germanium located?

group 14

(1 mark)

(c) What is the electron configuration of the third element in Period 3?

$_{13}Al$ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

(1 mark)

(d) Use the Periodic Table to determine the number of valence electrons in chlorine.

being a halogen, it has 7 val. es

(1 mark)

(e) What will be the formula of the simplest oxide of silicon?

Si has 4 val es so SiO_2

(1 mark)

(f) Would the oxide of aluminium, Al_2O_3, be acidic, basic or amphoteric?

amphoteric

(1 mark)

Question 16

(a) Describe how a small sample of carbon dioxide gas could be prepared and collected in the laboratory. Give the reaction and how the gas is collected. No diagrams are needed.

Prepared from dil HCl on marble chips $CaCO_3(s)$

$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

Collect via delivery tube by upward displacement of air.

(2 marks)

(b) Describe how you could tell that the container was full of gas.

Place burning taper near mouth of gas jar. Extinguished if full (CO_2 does not support combustion).

(1 mark)

(c) Describe how you could prove the collected gas was carbon dioxide.

Shake with limewater solution ($Ca(OH)_2$)
goes milky

(1 mark)

(d) Identify two ways in which carbon dioxide is important for human welfare.

Any two applications
eg fire extinguishing material
part of photosynthesis process
aerating drinks

(1 mark)

Question 17

(a) Explain why some chemical reactions are very fast and why others are quite slow.

Very fast have low activation energy.
Usually ionic reactions are very fast (or instantaneous)
Slow reactions have high E_a, involve much bond breaking and poor collision geometry (2 marks)

(b) What is meant by an endothermic reaction? Give one example.

energy (eg heat) must be put INTO the system
eg. any decomposition
eg $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

(2 marks)

(c) Calculate ΔH° for the following reaction at 25°C:

$$C_{(s)} + \tfrac{1}{2} O_{2(g)} \rightarrow CO_{(g)}$$

given the following reactions at 25°C:

$$C_{(s)} - O_{2(g)} \rightarrow CO_{2(g)} \qquad \Delta H^\circ = -393.2\text{kJ}$$
$$CO_{(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow CO_{2(g)} \qquad \Delta H^\circ = -282.8\text{kJ}$$

Reverse (2) $CO_2 \rightarrow CO + \frac{1}{2}O_2 \quad \Delta H^\circ = +282.8\ kJ$

Adding $C + \frac{1}{2}O_2 \rightarrow CO \quad \Delta H^\circ = -393.2 + 282.8\ kJ$

$= -110.4\ kJ$ (2 marks)

Question 18

(a) Write the ionic dissociation equation for sodium hydroxide in water.

$NaOH_{(s)} + H_2O \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$

(1 mark)

(b) 8.0 g of sodium hydroxide were dissolved in 750 mL of aqueous solution. Calculate the molarity of the solution.

$8.0\text{g NaOH} = \frac{8.0}{40} = 0.200\text{ mol}$

$\therefore c = \frac{0.200}{750/1000}\ \text{mol L}^{-1} = 0.267\ \text{mol L}^{-1}$

(2 marks)

(c) Calculate the concentration of the ions causing the alkalinity.

ie the $[OH^-]$ $c = 0.267\ \text{mol L}^{-1}$

(1 mark)

(d) What is the pH of the solution?

$pOH = -\log[OH^-] = -\log(2.67 \times 10^{-1}) = 0.573$

$\therefore pH = 14 - pOH = 14 - 0.573 = 13.4$

(2 marks)

(e) Are there any hydrogen ions (H^+ or H_3O^+) present in the solution? Explain.

yes, from dissociation of $H_2O \rightleftharpoons H^+ + OH^-$

$[H^+] = 10^{-13.4} = 4.0 \times 10^{-14}\ \text{mol L}^{-1}$

(2 marks)

(f) An aqueous solution of ammonia can be classified as a Bronsted-Lowry base. Show this by means of a suitable equation, clearly showing the conjugate pairs.

$NH_{3(g)} + H_2O \rightleftharpoons NH_{4(aq)}^+ + OH^-_{(aq)}$

$\text{base}_1 + \text{acid}_2 \rightleftharpoons \text{acid}_1 + \text{base}_2$

(2 marks)

End of Part A

Part B—Scientific processes

Section B assesses scientific processes, reasoning based on the eight syllabus topics and practical work.

Section B is worth 30 marks.

Answer **all** questions.

Short-answer questions (30 marks)

Question 1 – Separating minerals

A mineral called gay-lussite, named after the French 19th century chemist Gay-Lussac, is a mixture composed of calcium carbonate (limestone) and sodium carbonate (soda ash) and water.

Some properties of calcium carbonate and sodium carbonate are given in the table below:

Property	Calcium carbonate	Sodium carbonate
Melting point	Decomposes at 825°C	Melts at 851°C
Solubility in water	Insoluble	7g/100mL at 0°C 45g/100 mL at 100°C
Solubility in alcohol	Insoluble	Insoluble
Solubility in hydrochloric acid	Soluble (reacts)	Soluble (reacts)

Describe how you would separate the two substances from the mineral gay-lussite. Give details of the procedures, and make sure that you recover the two mineral samples.

• using solubility differences, especially in hot water

Procedure must be given

(1) Treat powdered mixture with hot (boiling water

(2) Stir

(3) Decant

(4) Filter / washing (6 marks)

(5) Residue in filter paper is $CaCO_3$
Dry naturally

(6) Filtrate collected is Na_2CO_3 solution
Evaporate to dryness.

Question 2 – Predicting chemical reactions

Predict whether chemical reactions would occur in each of the following. Where a reaction (or reactions) could occur, write a balanced equation for each reaction, and give a reason. Where no reaction could occur, write no reaction **and** give a reason. E° tables need not be used, just activity

(a) zinc is added to an aqueous solution of silver nitrate ($AgNO_3$).

$Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$

(zinc has greater tendency to lose e's than Ag)

(b) zinc is added to an aqueous solution of iron (II) sulfate ($FeSO_4$).

$Zn - 2e \rightarrow Zn^{++}$ $E^\circ = +0.76V$

$Fe^{2+} + 2e \rightarrow Fe$ $E^\circ = -0.44V$

$\therefore Zn + Fe^{2+} \rightarrow Zn^{2+} + Fe$ $E^\circ = +0.32V$ (spontaneous)

(c) excess zinc is added to an aqueous solution of iron (III) sulfate ($Fe_2(SO_4)_3$).

$Fe^{3+} + e \rightarrow Fe^{2+}$ $E^\circ = +0.77V$

$Zn - 2e \rightarrow Zn^{2+}$ $E^\circ = +0.76V$

$\therefore Zn + 2Fe^{3+} \rightarrow Zn^{2+} + 2Fe^{2+}$ $E^\circ = +1.53V$ (spontaneous)

(d) chlorine is added to an aqueous solution of sodium bromide (NaBr).

$Cl_2 + 2e \rightarrow 2Cl^-$ $E^\circ = +1.36V$

$2Br^- - 2e \rightarrow Br_2$ $E^\circ = -1.06V$

$\therefore Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ $E^\circ = +0.30V$ (spontaneous)

(e) bromine is added to an aqueous solution of sodium chloride (NaCl).

from (d)

$Br_2 + 2Cl^- \rightarrow 2Br^- + Cl_2$ is non-spontaneous

ie No reaction (6 marks)

Question 3 – Distinguishing organic substances

Distinguish between the following pairs of organic substances using any knowledge, reasoning or suitable tests. Any distinguish property, structure or test.

(a) cyclohexane and hexanol

Either structures or hydrocarbon v. alcohol

$\therefore$ solubility in water tests (insoluble v. how? sol)

OR Oxidisation of alcs v. non-oxidn of h/cs

(3 marks)

(b) benzoic acid and ethyl benzoate

Classification eg organic acid v. ester

OR acid tests eg. pH etc (slight acid v. none?)

OR action of water – some solub v. cloudiness due to hydrolysis of ester (3 marks)

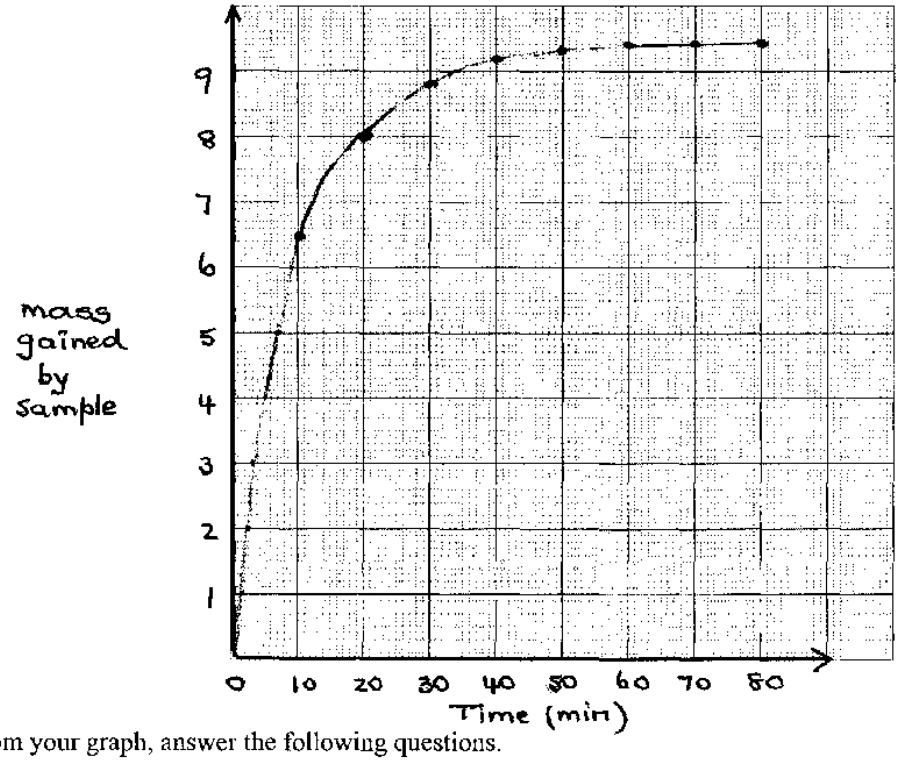
Question 4 – Reaction progress

A 25.0 g sample of powdered iron was heated in a crucible with a Bunsen burner for 10 minutes. After the crucible was allowed to cool, it was weighed to determine the increase in mass of the iron. Then the sample was heated again for another 10 minutes, allowed to cool and weighed again. The process was repeated a further six times until 80 minutes heating had been done.

The following masses were recorded at the corresponding time intervals:

Time (min)	0	10	20	30	40	50	60	70	80
Mass gained by sample (g)	0	6.5	8.0	8.8	9.2	9.3	9.4	9.4	9.4

(a) Plot the increase in mass in the iron against time elapsed on the graph paper below. Make sure you draw a tidy, fully labelled graph in pencil.



(2 marks)

From your graph, answer the following questions.

(b) When was the reaction complete?

Between 50 + 60 min, certainly at 60 min

(1 mark)

(c) What is the final ratio of the mass of the original iron to the mass of the **product**? Show your working.

$\frac{\text{Mass Fe}}{\text{Mass product}} = \frac{25.0}{34.4} = 0.727$

(2 marks)

(d) What ratio would you get if you stopped heating the sample at the end of 20 minutes?

Mass Fe / Mass prod at t = 20 = 25.0 / 33.0 = 0.758

(Notice how these show the progress of the reaction)

(1 mark)

Question 5 — Changing equilibria

The Haber Process for producing ammonia may operate at 200 atm and 500°C with an iron catalyst or with a mixture of metal oxides as the catalyst.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2\,NH_{3(g)} \qquad \Delta H° = -92 \text{ kJ}$$

What effect, if any, would each of the following have on the equilibrium – that is, on the amount of ammonia present when equilibrium was restored? Justify your answers.

(a) Increasing the pressure to 400 atm.

Favours using up molecules to reduce pressure
∴ more ammonia as product

(b) Lowering the temperature to 300°C without changing the pressure.

Favours release of heat from the exothermic
ie forward favoured ∴ more ammonia

(c) Adding water to the system.

NH_3 is very soluble in water
So equil is upset — removing NH_3
∴ favour formation of MORE NH_3

(6 marks, 2 each)

Sample answer for question 2
"A"

Question 2 – Sodium reaction and its effect on ice

Criteria for marking: ability to solve the problem correctly ✓
ability to reason logically by giving full explanation ✓
ability to use critical thinking ✓
ability to use creative solution. ✓

For an A standard on this question: solve problem correctly and demonstrate two other criteria.

For a B standard on this question: solve problem correctly and demonstrate one other criterion.

For a C standard on this question: some attempt at the question with valid reasoning but without correct solution.

For a D standard on this question: little progress towards a correct solution and with invalid reasoning.

Write your answers in the space below.

$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)} \quad \Delta H = -368\ kJ$

0·25 g ÷ MM(23·0g) ✓ ; 50·0g ✓ ÷ MM(18·0g) ✓

0·0109 mol (rounded to 3 sf) ; 2·78 mol

✓ ∴ Na is the limiting reactant and only 0·0109 moles of Na react with 0·0109 moles of H_2O, to produce 0·0109 moles of NaOH and 5.43×10^{-3} moles of H_2. The remaining H_2O (unreacted) equals 2·77 moles (2·78 moles − 0·0109 moles).

✓ Heat produced = $0.0109\ \text{mol Na} \times \frac{368\ kJ}{2\ \text{mol Na}} = 2.01\ kJ$ ✓

$50.0\ g\ H_2O_{(l)} \times \frac{1\ \text{mol}\ H_2O_{(l)}}{18.0\ g\ H_2O_{(l)}} = 2.78\ \text{mol}\ H_2O_{(l)}$

✓ $2.78\ \text{mol}\ H_2O_{(l)} \times \frac{6.01\ kJ}{1\ \text{mol}\ H_2O_{(l)}} = 16.7\ kJ$

$2.01\ kJ \times \frac{1\ \text{mol}\ H_2O_{(l)}}{6.01\ kJ} \times \frac{18.0\ g\ H_2O}{1\ \text{mol}\ H_2O}$

Heat produced : 2·01 kJ
Moles of $H_2O_{(s)}$: 2·78 mol $H_2O_{(s)}$
Moles of $H_2O_{(l)}$: 2·77 mol $H_2O_{(l)}$ remaining
ΔH_{fus} for H_2O : 6·01 kJ/mol
∴ kJ required to melt 50·0 g $H_2O_{(s)}$ is 16·7 kJ.
As the reaction does not produce enough heat energy to melt the ice the answer to question
a) is no the ice will not completely melt.
However, 6·02 g of ice will melt.

b) The final temperature of the water will remain at 0°C because the heat energy from the reaction did not melt all of the ice. The temperature of the water will not increase until the phase change from solid to liquid is complete.

(A)

Sample answer for question 3
"A–"

Question 3 – Oxides of fluorine and sodium

Criteria for marking: ability to find differences
ability to use critical thinking
ability to reason logically.

For an A standard on this question: able to give full account of differences and explain logically and with critical thinking.

For a B standard on this question: able to give four correct differences with logical explanations and some critical thinking.

For a C standard on this question: able to give two correct differences with some logical explanations and some critical thinking.

For a D standard on this question: attempt made without success or logical reasoning, and with no critical thinking.

Write your answers in the space below.

Although both fluorine and sodium form oxides with similar formulas (F_2O and Na_2O respectively) there are many differences, both chemically and physically between the 2 compounds.
The flourine oxide molecule is made up of 2 F atoms and 1 oxygen atom.
Because these elements are both non-metals the flourine oxide molecule will be formed by
(1) covalent bonding of the 2 elements. Because the molecules are covalently bonded ~~they~~ ~~the~~ flourine oxide would not be a very
(2) good electrical conductor when in solid or molten state as the molecules of the compound are uncharged and there are no delocalised electrons or ions to carry the charge. Because of a fairly large gap in the ~~reduction~~ charge separation ~~potentials~~ of both flourine + oxygen, there is a good chance that the

shape affects this

F_2O molecule is polar and will dissolve in water and other polar substances. Flourine oxide will also have low melting and boiling points which are due to the weak inter molecular forces of covalent bonds. Because of this, the F_2O will be very soft in solid form and will be a brittle compound. non-metal oxides are acidic in solution. ∴ produce H^+ ions.

Sodium oxide however is an ionic compound because it is formed from the joining of a metal and a non-metal. When placed in water ~~NaO~~ would ~~Ea~~ dissociate to $2Na^+$ ions and ~~OH ions gas~~. Because there are ions in solution, this oxide may act as a weak electrolyte. Because of the high degree of electronegativity of the oxygen + the low degree of the sodium, the melting point of sodium oxide would be higher than other ionic oxides with ~~less~~ a smaller electronegativity difference between its compounds (due to stronger bonds). When solid, Na_2O will not conduct electricity, but will conduct when aqueous or molten due to +ve + -ve ions. ionic substances ~~they~~ have high melting + boiling points due to strong bonds in the ionic lattice. They are also hard but very brittle compounds. metal oxides are basic in solution. ∴ produce OH^- ions.

(A-)

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Sample answer for question 4
"A"

Question 4 – Existence of ions in solution

Criteria for marking: ability to be thorough
ability to justify selections
ability to communicate effectively
ability to be critical
ability to be creative.

For an A standard on this question: a thorough treatment, with full justification and effective communication.

For a B standard on this question: fewer examples given, but with justification and effective communication.

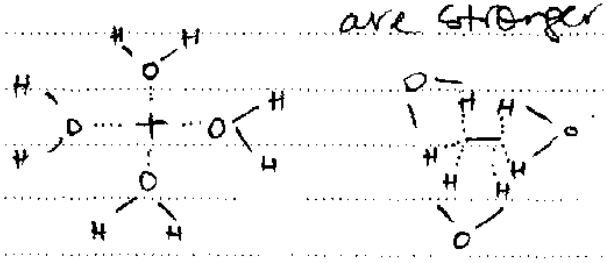
For a C standard on this question: some attempt at the question, with some correct claims, but without evidence of critical thinking and with limited justification.

For a D standard on this question: some attempt at the question without correct evidence.

Write your answers in the space below.

i) Conductivity ⇒ when an ionic compound is dissolved in water to produce an aqueous solution, it is possible (although voltages vary greatly) to conduct an electric current. for example, water alone is an extremely weak electrolyte, ✓ it produces only very few ions in solution. However, if you dissolve an ionic compound such as NaCl in the same water, the NaCl ✓ dissociates nearly 100% & the current becomes much stronger. This is due to the NaCl breaking down into Na^+ ions & Cl^- ions which in turn migrate towards the opp. charged electrode in a conductivity test.

ii) dissolving/solvation ⇒ The process of an ionic substance dissolving requires each positively charged ion becoming surrounded by the more negatively charged part of a water molecule (O) & the negatively charged ions becoming solvated, surrounded by the more positively charged part (H) of the water molecule. Without this attraction between positives & negatives the ionic substance would not dissolve. (given that the new attractive forces from the H_2O molecules are stronger than those in the ionic cmpd.)



iii) Electrochemistry & ions in soln:

~~⇒ The attraction between non-metals & metals~~

⇒ ions themselves are charged particles, metal atoms always form positive ions and non-metal atoms generally form negative ions. This allows for metals & non-metals to

Sample answer for question 5
"B–"

Question 5 – Space shuttles blast-off

Criteria for marking: ability to be analytical
ability to be creative and critical in thinking
ability to reason logically.

For an A standard on this question: ability to analyse all the given information correctly and find logical and creative solutions.

For a B standard on this question: ability to explain the rocket exhaust chemistry, without analysing all the given information.

For a C standard on this question: some valid and correct scientific explanations but without full analysis and without critical thinking.

For a D standard on this question: little progress in finding a valid explanation.

Write your answers in the space below.

a) People often believe the clouds of smoke released in a space shuttle launch are water droplets. Possibly, this misconception is created by the knowledge that the large cylinder contains liquid hydrogen and oxygen. The assumption is then made that hydrogen and oxygen react explosively to produce water, and energy.

b) In reality the liquid hydrogen and oxygen that are stored in the large cylinder are, during the launch ~~the liquid hydrogen and oxygen are~~ fed into the rocket engine.
Upon closer inspection of the photograph, the smoke isn't released from the large cylinder at all, which is where the liquid hydrogen and oxygen are stored, but from the two smaller cylinders and rocket engine itself.
This is evidence that the hydrogen and oxygen are not used up or in the take off, and that the aluminium powder and ammonium perchlorate are used in the initial launch.

c) The white clouds are some sort of by product.
The by product released, as smoke, is most likely to have been caused by the oxidation-reduction reaction of the aluminium powder and the ammonium perchlorate.

yes, but what possibilities?

B-