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Examiners' Report
June 2014

IAL Chemistry WCH02 01

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Introduction

This paper contained some questions which were on familiar material and accessible to all candidates, but there were also several more challenging questions where careful reading and logical thought were necessary. Some parts of question 21 were not attempted in some cases, though this did not appear to be due to lack of time as the final question on the paper was usually completed.

The calculations in the paper were generally done well and candidates had good knowledge of inorganic reactions. In the questions on organic chemistry candidates showed a lack of understanding of the procedure needed to convert an alcohol to an aldehyde and had difficulty with skeletal formulae.

Question 18 (a)

Most candidates scored a mark here. The number of answers showing $NaHSO_4$ and Na_2SO_4 formation were roughly equal and both correct. Where errors occurred they were usually in the formula of sodium sulphate, or occasionally in balancing the equation.

Question 18 (b)

The first mark was usually scored for identifying gas **X** as ammonia. When hydrogen chloride and ammonia come into contact, a white smoke made of solid particles is seen. No mark was given for saying that ammonium chloride formed unless an observation was given as well. Description of ammonium chloride as white fumes or a white precipitate was not allowed.

(b) Fumes of hydrogen chloride gas can be identified by bringing the fumes into contact with another gas, **X**. Identify gas **X** and state the observation you would make.

(2)

Gas **X** Ammonia

Observation It forms white ~~etc~~ steamy/cloudy fumes

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Examiner Comments

Hydrogen chloride fumes are steamy, but this description does not apply to ammonium chloride.

(b) Fumes of hydrogen chloride gas can be identified by bringing the fumes into contact with another gas, **X**. Identify gas **X** and state the observation you would make.

(2)

Gas **X** NH_3

Observation white smoke (ppt)

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Examiner Comments

The best answer to this question was "white smoke". The smoke contains small particles of solid.

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Examiner Tip

A "Precipitate" is the word used to describe a solid which forms when two solutions react.
Do not give two alternative answers to a question, as if one is wrong you will not get the mark

Question 18 (c)

Nearly all candidates knew that a white precipitate would form on addition of silver nitrate, and many knew that the precipitate would dissolve in dilute aqueous ammonia. However the reason why concentrated ammonia should not be used was more challenging, especially if candidates had not read the first line of the question which said that the two-stage test was used to distinguish chloride ions from other halide ions. No marks were given for comments on the hazards of concentrated ammonia, or for saying that since the white precipitate dissolved in dilute ammonia there was no need to use concentrated ammonia. The answer had to say that silver bromide would also be soluble in concentrated ammonia, meaning that use of concentrated ammonia would not distinguish the chloride and the iodide.

(c) Chloride ions in solution can be distinguished from other halide ions by the addition of silver nitrate solution followed by dilute, aqueous ammonia.

State what you would see when silver nitrate solution is added to chloride ions, followed by dilute aqueous ammonia.

Suggest why concentrated ammonia should not be used to confirm that silver chloride has been formed.

(3)

Observation on addition of $AgNO_3$ White precipitate

Observation on addition of dilute NH_3 precipitate ~~dis~~ dissolve

Reason why concentrated NH_3 should **not** be used Because both AgCl and AgBr dissolve in concentrated NH_3

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Examiner Comments

This is an example of an answer which scored full marks.

(c) Chloride ions in solution can be distinguished from other halide ions by the addition of silver nitrate solution followed by dilute, aqueous ammonia.

State what you would see when silver nitrate solution is added to chloride ions, followed by dilute aqueous ammonia.

Suggest why concentrated ammonia should not be used to confirm that silver chloride has been formed.

(3)

Observation on addition of $AgNO_3$ White precipitate

Observation on addition of dilute NH_3 Precipitate dissolves to form stable compound

Reason why concentrated NH_3 should **not** be used Highly corrosive and if reaction can occur with dilute NH_3 there is no need to use concentrated.

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Examiner Comments

Answers like this were seen frequently and did not score the third mark.

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Examiner Tip

Make sure you read the question carefully. It was about distinguishing chloride ions in solution from other halide ions, and concentrated ammonia would not do this, as it dissolves both silver bromide and silver chloride.

Question 19 (a) (i)

Many candidates failed to recognise that electrons should be shown in bonds and provided all sorts of dot and cross diagrams without giving the correct number of crosses to bromine, or indeed the correct number of dots particularly to the right-hand oxygen. The candidates who showed electrons in pairs, making them easy to count, had the best chance of success.

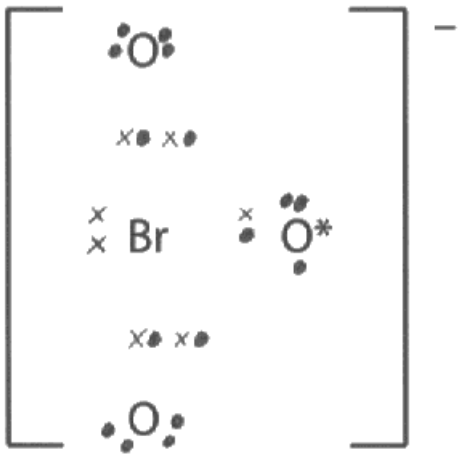
There were many ways of showing the position of the electrons, but it was assumed that electrons shown between the Br and O were shared.

(a) (i) Complete the dot and cross diagram for the bromate(V) ion. Show only the outer shell electrons.

In this ion, the bromine expands its outer shell to accommodate 12 electrons.

Use **x** for bromine electrons and • for oxygen electrons. The symbol * on the diagram represents the extra electron which gives the ion its charge.

(2)



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Examiner Comments

This answer is set out clearly and it is easy to interpret that the bromine is forming two double bonds to O atoms and a single bond to the O^- with a lone pair on the left. Unfortunately the right-hand oxygen has only four dots, so it scores one mark.

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Examiner Tip

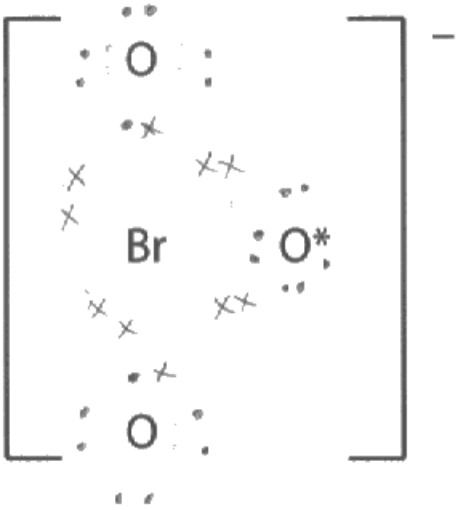
The oxygen with the * starts with seven electrons around it, so only forms a single bond. The other two O atoms need a share of two electrons from the Br to complete their octet.

(a) (i) Complete the dot and cross diagram for the bromate(V) ion. Show only the outer shell electrons.

In this ion, the bromine expands its outer shell to accommodate 12 electrons.

Use **x** for bromine electrons and • for oxygen electrons. The symbol * on the diagram represents the extra electron which gives the ion its charge.

(2)



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Examiner Comments

This answer did not score. The bromine is shown with ten crosses around it, and each oxygen has seven dots.

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Examiner Tip

Check the number of electrons in the outer shell of each atom is correct, and show them in pairs (bonding pairs or lone pairs) so that you can count them easily.

Question 19 (a) (ii)

Elements in Period 3 use vacant d orbitals to accommodate more than eight electrons in their outer shell. Many answers simply referred to shells expanding without making it clear that d orbitals are used.

(ii) Suggest how elements in Period 3 and higher can accommodate more than eight electrons in their outer shell.

(1)

Because above Period 3 ~~there~~ are the elements have many sub 6e Shells so it can accommodate more than 8 electrons.

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Examiner Comments

This answer was too vague to score.
The type of sub-shell had to be identified.

(ii) Suggest how elements in Period 3 and higher can accommodate more than eight electrons in their outer shell.

(1)

Because they have ~~d~~ block S, p, and d orbitals in ~~there~~ their outershell.

ResultsPlus
Examiner Comments

This named d orbitals as a possibility but did not score as it did not say which of the s, p or d were used to accommodate more than eight electrons.

Question 19 (b) (i)

This was a straightforward calculation and there were many correct answers. The question asked for the answer in mol dm^{-3}, and if candidates gave another unit which was incorrect they did not score the second mark.

(i) The first student was given the task of making up a potassium bromate(V) solution. A mass of 8.35 g of $KBrO_3$ was weighed out, dissolved in deionized water, the volume made up to 250 cm^3 in a volumetric flask and the mixture shaken.

Calculate the concentration of this potassium bromate(V) solution, in mol dm^{-3}.

(2)

moles = $\frac{8.35}{167}$ = 0.05 mol

$\frac{0.05}{1} = \frac{250}{1000} \times x$

$x = 0.2$ mol $/dm^3$.

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Examiner Comments

This is well set out, and though the final unit is not mol dm^{-3} it was acceptable and scored both marks.

(i) The first student was given the task of making up a potassium bromate(V) solution. A mass of 8.35 g of $KBrO_3$ was weighed out, dissolved in deionized water, the volume made up to 250 cm^3 in a volumetric flask and the mixture shaken.

Calculate the concentration of this potassium bromate(V) solution, in mol dm^{-3}.

(2)

moles = $\frac{\text{mass}}{\text{molar mass}}$

= $8.35/1067$

= 0.008 moles

$c = n/V$

$c = \frac{0.008}{250/1000}$

$c = 0.031$ mol dm^{-3}

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Examiner Comments

This candidate has made an error in calculating the relative molecular mass. However the method is shown clearly with correct units on each number, so the second mark was allowed as a transferred error.

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Examiner Tip

Think about whether the numbers you calculate are realistic. A relative molecular mass of over 1000 is unlikely here.

Question 19 (b) (ii)

Many candidates could calculate the minimum mass of potassium iodide required to react with the potassium bromate. However, many did not show appreciation of a suitable mass to be chosen which would give a reasonable excess.

(ii) The second student was asked to determine a suitable mass of potassium iodide to add to 0.0025 mol of potassium bromate(V) to ensure complete reaction. The equation for the reaction is

$BrO_3^-(aq) + 6H^+(aq) + 6I^-(aq) \rightarrow Br^-(aq) + 3I_2(aq) + 3H_2O(l)$

Calculate the minimum mass of potassium iodide, KI, required and hence suggest a suitable mass to use if the potassium iodide is to be in excess.

You **must** show your working and your mass should be reasonable.

(3)

1 : 6
0.0025 : x

$x = 0.015$ mol

$m = n \times Mr$
$m = 0.015 \times 166$
$m = 2.49$ g

1 : 3
0.0025 : x

$x = \frac{3}{400}$

$m = n \times Mr$
$= \frac{3}{400} \times 166$
$= 1.245$ g

Minimum mass required 1.245 g

Suitable mass to use 2.49 g

ResultsPlus
Examiner Comments

This candidate has done two separate calculations, but does not state what is being worked out in each. It is a good idea to state what is being calculated eg "mol KI = …" so that the working can be followed. The final mass is suitable, based on the incorrect minimum mass given, so the third mark was allowed.

(ii) The second student was asked to determine a suitable mass of potassium iodide to add to 0.0025 mol of potassium bromate(V) to ensure complete reaction. The equation for the reaction is

$$BrO_3^-(aq) + 6H^+(aq) + 6I^-(aq) \rightarrow Br^-(aq) + 3I_2(aq) + 3H_2O(l)$$

Calculate the minimum mass of potassium iodide, KI, required and hence suggest a suitable mass to use if the potassium iodide is to be in excess.

You **must** show your working and your mass should be reasonable.

(3)

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

~~0.05 A~~

$0.0025 = \frac{m}{166}$

$m = 0.415\,g$

$0.0025 = \frac{m}{167}$

$m = 0.417\,g$

Minimum mass required 0.415 g

Suitable mass to use 0.418 g

ResultsPlus
Examiner Comments

The calculation is incorrect here. Also suitable mass is not more than 0.1g above the calculated mass. This is too low in practice when an excess is needed, so the third mark was not given.

Question 19 (b) (iii)

The calculation of volume was not difficult for many candidates, though some confused cm^3 and dm^3. Another common error was not multiplying the number of moles by 2 for the first mark so the volume calculated was $10cm^3$.

(iii) The third student was given the following equation.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

This student was asked to estimate the titration reading.

Calculate the volume of 0.1 mol dm^{-3} of sodium thiosulfate solution, in cm^3, that would be needed to react with 0.00100 mol of iodine present in the conical flask.

(2)

$n = \frac{n}{c} \times V$

1 — 0·00100

2 — x

x = 0·002 moles

$V = \frac{n}{c} \times 1000$

$= \frac{0.002}{0.1} \times 1000$

$= 20\ cm^3$

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Examiner Comments

This is very clearly set out and scored both marks.

(iii) The third student was given the following equation.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

This student was asked to estimate the titration reading.

Calculate the volume of 0.1 mol dm^{-3} of sodium thiosulfate solution, in cm^3, that would be needed to react with 0.00100 mol of iodine present in the conical flask.

(2)

~~Volume = 0.00100~~

1 mol of I_2 reacts with 2 mole of $S_2O_3^{2-}$

∴ 0.00100 " " x "

$x = 0.00100 \times 2 = 2 \times 10^{-3}$ moles

∴ Volume = $\frac{2 \times 10^{-3}}{0.1} = 0.02$ ~~dm^3~~ dm^3

$= 2 \times 10^{-5}\ cm^3$

ResultsPlus
Examiner Comments

This is also clearly set out and scored the first mark, but the conversion of the volume in from dm^3 to cm^3 is done incorrectly.

Question 19 (b) (iv)

Few candidates realised that measuring the very small mass of potassium bromate to one significant figure would lead to a large uncertainty in this measurement. The most popular answer was the volume of sodium thiosulfate or volume of water. Candidates thought that since the volume was measured twice this gave the biggest effect on uncertainty.

There is uncertainty in the value of the calculated concentration of the sodium thiosulfate. Which measurement, given in the table, has the greatest effect on the uncertainty of this value? Justify your answer.

No calculation is required for this answer.

(2)

The volume of $Na_2S_2O_3$, the mass of $KBrO_3$ could be added in excess so the volume of $Na_2S_2O_3$ would have the greatest effect on the uncertainty of this value. any effect to the volume of $Na_2S_2O_3$ and the concentration changes.

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Examiner Comments

This candidate has not thought about the uncertainty in each of the three measurements so did not score.

There is uncertainty in the value of the calculated concentration of the sodium thiosulfate. Which measurement, given in the table, has the greatest effect on the uncertainty of this value? Justify your answer.

No calculation is required for this answer.

(2)

0.07g. or the Mass of $KBrO_3$. because the value for it so small, ~~so there must have been ten~~ a

ResultsPlus
Examiner Comments

For the second mark this candidate should have said that the very small mass would introduce a large percentage error or large uncertainty.

Question 20 (a)

The reasons for reduction in first ionization energy going down a group were well known to many candidates. However some referred to the difference in ionic radius which is not relevant, as the first electron is lost from an atom not from an ion, and some said "calcium is bigger" instead of referring to the atomic radius.

Some candidates discussed the charge density of the ion or its polarizing ability, both of which were irrelevant when considering the energy needed to remove an electron from an atom.

Some answers referred to the effect of the increasing number of electron shells and the atomic radius, but these are two aspects of the same change going down the group, so were not counted as two separate reasons. For both marks, shielding of the nucleus by the extra shells of electrons had to be given, as well as some sort of reference to the distance of the nucleus from the outer electrons.

20 This question is about Group 2 elements and their compounds.

*(a) Give **two** reasons why the first ionization energy of calcium is less than that of magnesium, even though the atomic number of calcium is greater than that of magnesium.

(2)

As going down group 2 the number of ~~sheills~~ shells increase. This increases the sheilding effect as the distance between the outer shell electrons in calcium is greater than that of Magnesium.

The radius of calcium is also greater than that of Magnesium due to the attraction between the nucleus and the outer electron with [illegible]

ResultsPlus
Examiner Comments

This is an example of an answer which scored both marks.

20 This question is about Group 2 elements and their compounds.

*(a) Give **two** reasons why the first ionization energy of calcium is less than that of magnesium, even though the atomic number of calcium is greater than that of magnesium.

(2)

Because the size of calcium is greater than Magnesium so the outer atmost electrons of calcium is losely attracted to the nucleus than that of magnesium.

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Examiner Comments

The "size" of calcium, without reference to an atom was not allowed here. No second reason was given.

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Examiner Tip

When the question asks for two reasons try to give two distinct reasons, rather than having one reason and explaining it in detail.

Question 20 (b)

The origin of flame colour was very familiar to many candidates and they scored two marks for describing electrons being excited to a higher energy level and then falling back to their original state. The third mark was harder to score, as it was not good enough to say that this caused the flame colour. There had to be a reference to release of energy in the visible spectrum, or light or photons.

(b) A flame test was carried out on a solid calcium compound. Explain the origin of the flame colour in terms of electron movement.

(3)

A brick red flame will be produced. when the ~~cal~~ calcium compound is heated, electrons in the calcium ion gets excited and rise to higher energy level for few moments and then go back to their initial level by releasing the energy gained as light photon in the range of visible spectrum.

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Examiner Comments

This answer loses marks because it does not state that the particles which are excited are electrons.

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Examiner Tip

Be careful to choose the correct term when discussing electrons, atoms, ions or molecules.

(b) A flame test was carried out on a solid calcium compound. Explain the origin of the flame colour in terms of electron movement.

(3)

When the electron got excited it moved to a higher energy level. And when it went back to its ~~ground~~ ground state it emitted a yellow flame.

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Examiner Comments

This candidate lost the final mark as the answer did not say that light energy was released. Saying that a flame colour is produced just repeats the question.

Question 20 (c) (i)

Many correct answers were seen, but errors occurred in the formulae of the products and in balancing. A common error was writing calcium nitrate as $CaNO_3$.

(c) (i) Calcium oxide reacts with dilute nitric acid to form calcium nitrate. Write the equation for this reaction. State symbols are not required.

(1)

$$CaO + HNO_3 \longrightarrow Ca(NO_3)_2 + H_2$$

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Examiner Comments

It is disappointing to see an unbalanced equation and hydrogen as a product here, especially as the formula of the calcium nitrate is correct.

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Examiner Tip

Hydrogen is produced in reactions with metals, such as when an acid react with a metal or in organic chemistry when sodium reacts with alcohols. It does not form here.

Question 20 (c) (ii)

Production of the brown gas usually scored the first mark and the mark scheme gave plenty of opportunity to score the second mark. Some candidates were distracted by thinking about the relative polarizing ability of magnesium and calcium ions, and did not actually answer the question which was asked. Other answers quoted flame colours, which were not allowed as a way of contrasting thermal decomposition of the two salts.

(ii) Identify **two** ways, one of which should be an observation, in which the thermal decomposition of anhydrous calcium nitrate is different from that of anhydrous potassium nitrate.

(2)

There would be different volume of gases ~~comi~~ collected in a gas syringe if we thermally decompose calcium nitrate and potassium nitrate. ~~Potassium~~ Calcium nitrate has a higher decomposition energy as there is less distortion in atom and Ca^{+} has +2 charge.

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Examiner Comments

The comment on the volume of gas produced was not allowed as an observation, as it would depend on the conditions. Calcium nitrate is less stable to heat than magnesium nitrate so the second comment did not score either.

(ii) Identify **two** ways, one of which should be an observation, in which the thermal decomposition of anhydrous calcium nitrate is different from that of anhydrous potassium nitrate.

(2)

Thermal decompasitan of Potassium nitrate produces ~~gas~~ Potassium Nitrite and oxygen. The oxygen ~~a~~ that is produced can rekindle a glowing splint. Thermal decomposition of Calcium nitrate produces Calcium oxide, Nitrogen dioxide and Oxygen. ~~The Nitroge~~ We will observe a brown gas which is Nitrogen dioxide.

ResultsPlus
Examiner Comments

This is an example which scored both marks

Question 20 (d) (i)

Many correct answers were given here.

Question 20 (d) (ii)

Many candidates did not realise that calcium hydroxide is lime water and their equations implied that it could be used for all sorts of tests such as detecting acids. Those who knew it was the test for carbon dioxide usually wrote a correct equation.

(ii) An aqueous solution of calcium hydroxide is used for a common laboratory test. Give the observation for a positive result for this test and complete the equation for the reaction that occurs. State symbols are **not** required.

(2)

Observation the aqueous solution of $Ca(OH)_2$ turns milky

$Ca(OH)_2$ + CO_2 → $CaCO_3$ + H_2O

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Examiner Comments

This is an example which scored both marks.

Question 20 (d) (iii)

Many candidates remembered that the sulfates of Group 2 become less soluble going down the group and answered correctly.

Question 20 (e) (i)

Not all candidates read the instruction "describe what you would see" and knowing that barium sulphate formed did not get the mark without the observation. Some candidate mistakenly thought that a precipitate of magnesium sulfate would form and then dissolve, but this was not allowed.

(e) (i) Describe what you would see if a solution of barium chloride was added to dilute sulfuric acid. State why this observation would differ if magnesium chloride solution was used instead of barium chloride.

(2)

-we will see a white ppt forms of $BaSO_4$.

-This would differ in case of $MgCl_2$ because $MgSO_4$ produced is soluble and $BaSO_4$ is insoluble. Solubility of Sulphates decreases down the group.

ResultsPlus
Examiner Comments

This is an example of a good answer.

(e) (i) Describe what you would see if a solution of barium chloride was added to dilute sulfuric acid. State why this observation would differ if magnesium chloride solution was used instead of barium chloride.

(2)

Barium ~~Sulfate~~ chloride is insoluble in sulfuric acid. Through x-ray Barium chloride will show many electrons. Magnesium chloride is ~~soluble~~ soluble in sulfuric acid.

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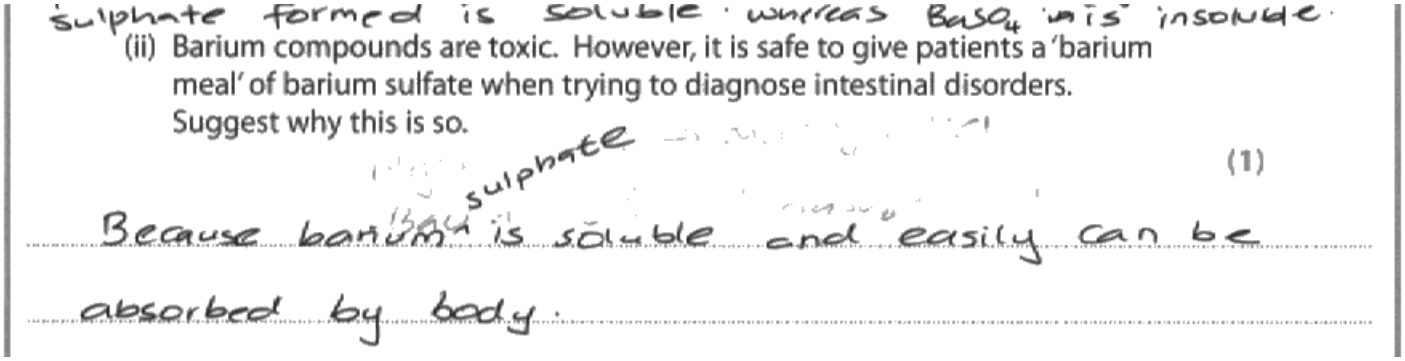
Examiner Comments

This answer refers to the solubility of the chlorides in sulfuric acid, ignoring the reaction to form sulfates, so did not score.

Question 20 (e) (ii)

Many candidates knew that barium sulfate is safe to use as its insolubility means that it is not absorbed in the body. Some answers said it was unreactive but this did not explain why it is safe to use when barium compounds are toxic.



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Examiner Comments

This candidate has not read the question carefully. Despite the fact that barium sulfate was described as insoluble in the previous answer, the reverse statement is made here.

Question 20 (f)

Marks were often lost by careless use of language in this relatively straightforward question on rates of reaction. Many candidates did not read the question and discussed the effect of catalysts, pressure or temperature. Many others talked about increasing the concentration of calcium carbonate. The explanations of how the different factors altered rate were poorly expressed. Candidates thought rate would increase because more of a substance was present and did not distinguish this from an increase in concentration, where there are more particles in the same volume. A common mistake was to say a smaller surface area would increase the rate.

Some thought that the kinetic energy of particles would increase when the concentration increased. A significant number of answers also discussed how changes in concentration would affect equilibrium position.

*(f) Calcium carbonate, $CaCO_3$, readily reacts with hydrochloric acid. State **two** factors, other than a change in temperature, which would affect the rate of this reaction.

Neither pressure nor the use of a catalyst should be considered.

Explain how each of the **two** factors you have chosen alters the reaction rate.

(4)

1. increase the concentration of the reactants. When there are more molecules per unit volume there is a higher chance of more successful collisions per second, therefore increasing the rate.

2.

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The solid, calcium carbonate, is one of the reactants. As it is insoluble in water its concentration cannot be increased, so the factor given was not allowed.

*(f) Calcium carbonate, $CaCO_3$, readily reacts with hydrochloric acid. State **two** factors, other than a change in temperature, which would affect the rate of this reaction.

Neither pressure nor the use of a catalyst should be considered.

Explain how each of the **two** factors you have chosen alters the reaction rate.

(4)

Surface area of $CaCO_3$. Increasing the surface area causes more successful collisions. Reaction rate increases. Concentration of acid. Increasing the concentration causes higher the yield.

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The two factors given are correct, and the explanation of increase in rate with surface area was allowed. The candidate may have confused rate with equilibrium when referring to the increased yield with more concentrated hydrochloric acid.

Question 20 (g)

Many candidates knew that pressure only affects the rate of reactions with gaseous reactants. As in the previous question, some were thinking about equilibria and said that the increase in pressure would affect the yield. A few said that neither of the products were gases, and this was not allowed.

(g) Suggest why pressure has little or no effect on the rate of the reaction of calcium oxide and hydrochloric acid, the equation for which is given below.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

(1)

The change of pressure can only affect the reaction with the presence of gas molecules. There ~~is no~~ has no gas molecules in the above equation.

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Examiner Comments

This was allowed the mark

(g) Suggest why pressure has little or no effect on the rate of the reaction of calcium oxide and hydrochloric acid, the equation for which is given below.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

(1)

Number of moles in the forward reaction is 2 while backward reaction is 3, the difference between the number of moles in both reaction is ~~two~~ too small, so ~~it~~ pressure has little or no effect.

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Examiner Comments

This candidate was probably thinking about the effect of pressure on an equilibrium so the answer did not score.

Question 21 (a)

Candidates struggled to provide a definition for the term "functional group". Some showed the idea that it gives specific reactivity but were unable to say what the group actually was. Many candidates instead described a homologous series. Others said the functional group was a molecule attached to the carbon chain which gave particular properties, and this was not given the mark.

It was quite common for candidates to start with the explanation of the term "functional group" and then forget to classify the type of alcohol. Those who did start with the alcohol often simply said it had a functional group –OH.

(a) Retinol has an alcohol functional group. Classify the type of alcohol group in retinol and explain the meaning of the term 'functional group'.

(2)

Retinol is a primary alcohol. Functional group is the group of organic molecules with same chemical property and same general formula.

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Examiner Comments

This answer is describing a homologous series

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Examiner Tip

Make sure you know the meaning of the terms which are used in organic chemistry.

(a) Retinol has an alcohol functional group. Classify the type of alcohol group in retinol and explain the meaning of the term 'functional group'.

(2)

It is a primary alcohol

Functional group is the part of a molecule to cause changes and reaction with other molecules.

ResultsPlus
Examiner Comments

This answer was allowed as it implies that the functional group is the part of the molecule where chemical reactions occur.

Question 21 (b)

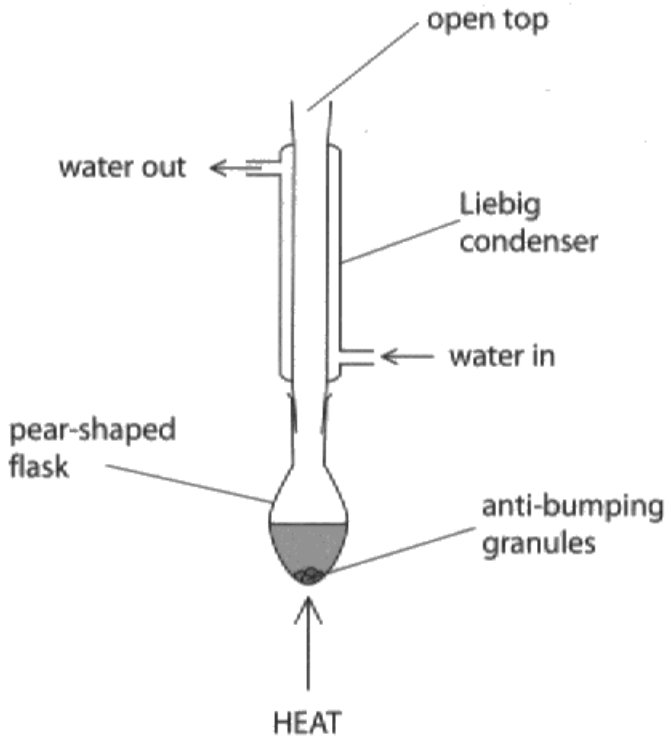
This proved a very challenging question. Many candidates counted the number of carbon atoms correctly, but then made an error with hydrogen atoms. The answer $C_{20}H_{29}OH$ was seen regularly and it scored one mark as it showed that the candidates did not understand the meaning of the term "molecular formula".

Question 21 (c) (i)

The first two marks were scored frequently but very few scored the third marking point. Many candidates did not identify the apparatus as reflux and said that, to get the aldehyde, heating under reflux was needed. Of those that correctly identified the need for distillation to get the aldehyde, many suggested fractional distillation as a method. Very few appeared to realise that the aldehyde has to be distilled off as soon as it forms to avoid further oxidation. Other candidates failed to score because their answers were in terms of using water baths, using round bottomed flasks or the need for stoppers or anti-bumping granules.

(c) Retinol can be oxidized to the aldehyde, retinal.

*(i) To illustrate the conversion of an alcohol to an aldehyde in the laboratory, a student suggested using the following apparatus and an excess of an oxidizing agent. Explain why this proposed method would have been unsuitable for the production of an aldehyde and explain what modifications are necessary for successful conversion. A new diagram is not required. (3)



Excess oxidising agent should not be used. Limited oxidising agent should be used to prevent formation of carboxylic acid. Distillation apparatus should be used to produce an aldehyde. If vertical condenser is used carboxylic acid is produced, because the aldehyde will condense and flow back to the flask. Electrical heater should be used for safety.

ResultsPlus
Examiner Comments

This is an example of an answer scoring all three marks.

(c) Retinol can be oxidized to the aldehyde, retinal.

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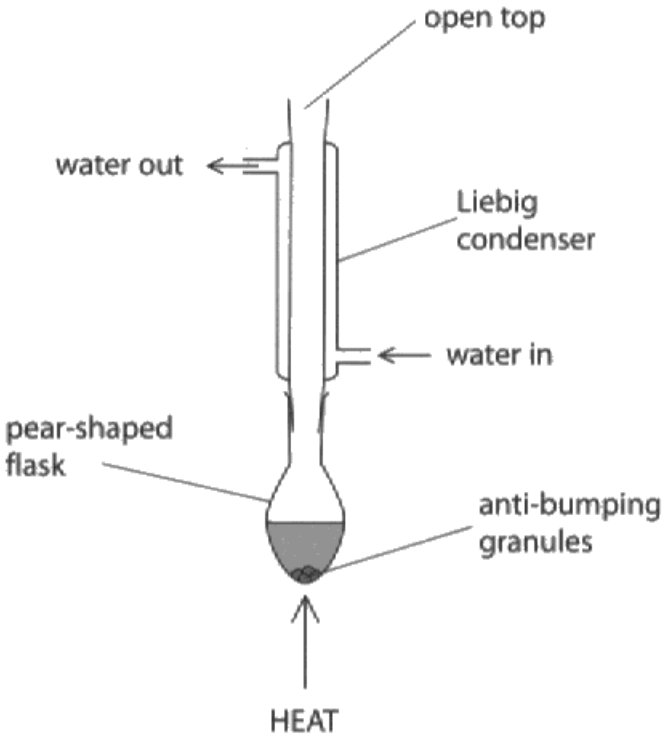
(3)



this process is oxidation under reflux and when oxidation takes place under reflux primary alcohol turns to aldehyde the further oxidation takes place and carboxylic acid forms so. You must use lid and thermometer and different beaker to collect aldehyde in it also you can use electrical heate and round bottom flask.

ResultsPlus
Examiner Comments

This candidate scored the first mark only. The answer does not explain how to modify the apparatus for distillation.

ResultsPlus
Examiner Tip

It is important to understand when stoppers are needed. Apparatus cannot be completely sealed when it is being heated as pressure builds up. The top of a reflux condenser has to be open, but in simple distillation there can be a stopper above the point where the condenser leads out as the lower end of the condenser is open.

Question 21 (c) (ii)

(ii) The oxidizing agent suggested was sodium dichromate, $Na_2Cr_2O_7$, in acidic solution. Complete the ionic half-equation below. Give the oxidation numbers of the chromium in the chromium species and state their colours.

(5)

$Cr_2O_7^{2-}(aq)$ + 7 $H^+(aq)$ + 2 e^- → 2 $Cr^{3+}(aq)$ + 7 $H_2O(l)$

Oxidation Number: 2− ... 3+

Colour: Orange ... green.

ResultsPlus

Examiner Comments

This candidate has confused the charge on the ion with the oxidation number and failed to balance the equation.

Question 21 (c) (iii)

Most candidates identified one of the peaks which identify an aldehyde. Fewer then went on to get the second mark as they did not give evidence that the retinol has been completely converted to retinal. For this they had to state that the peak due to O-H at 3750-3200 cm^{-1} would be absent.

This would be a very obvious change and candidates who had looked at spectra should have remembered it.

The question instructed candidates to select data to support their answers, but this was sometimes missing.

*(iii) Describe **two** features on the infrared spectrum which could be used to determine whether the retinol has been completely converted to retinal.

Select some of the following infrared data to support your answer.

(2)

O—H stretching in alcohols (variable, broad) at	3750 – 3200 cm^{-1}
O—H stretching in carboxylic acids (weak) at	3300 – 2500 cm^{-1}
C=O stretching in aldehydes (strong) at	1740 – 1720 cm^{-1}
C=O stretching in ketones (strong) at	1700 – 1680 cm^{-1}
C=O stretching in carboxylic acids, alkyl (strong) at	1725 – 1700 cm^{-1}
C—H stretching in aldehydes (weak) at	2900 – 2820 cm^{-1}
C—H stretching in aldehydes (weak) at	2775 – 2700 cm^{-1}

The spectrum would show a larger ~~wave~~ spectrum (wave) ~~of~~ between 1740–1720 and a decrease in the spectrum between 3750–3200 which indicates that the OH in alcohols has decreased and the C=O in aldehyde group has increased. Also the spectrum (wave) will be quite big between 2900–2800 and 2775–2700. All these changes in the spectrum indicate that the retinol (alcohol) has been converted into retinal (aldehyde).

ResultsPlus
Examiner Comments

This candidate thinks that the size of the peak is proportional to the amount of substance present. The mark for a characteristic aldehyde peak was allowed, but for full marks the answer had to say that the O-H peak was no longer there.

*(iii) Describe **two** features on the infrared spectrum which could be used to determine whether the retinol has been completely converted to retinal.

Select some of the following infrared data to support your answer.

(2)

O—H stretching in alcohols (variable, broad) at	3750 – 3200 cm^{-1}
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C—H stretching in aldehydes (weak) at	2900 – 2820 cm^{-1}
C—H stretching in aldehydes (weak) at	2775 – 2700 cm^{-1}

As the ~~ethanol~~ retinol is formed, there will be a carbonyl group attached to hydrogen in one site and to alkyl group in other side R-C(=O)-H.

So we need to look C=O stretching in aldehydes and C-H stretching in aldehydes to ensure that retinol is formed. Also we need to look if there is a peak for O-H stretching in alcohols, ~~to~~ if there is no we can sure that all retinol has been completely converted into retinal

ResultsPlus
Examiner Comments

This candidate knows what to look for in the spectrum but only scored one mark as no data was given

ResultsPlus
Examiner Tip

You should select the relevant data and include it in your answer when describing the features which you would use.

Question 21 (c) (iv)

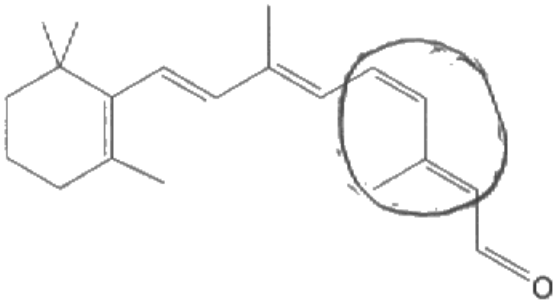
This was probably the question candidates found hardest. Very few realised that the structural change which occurs when retinol is converted to retinal is in the arrangement of groups joined to the third C=C double bond from the ring and that an *E/Z* change is occurring. Many did not read the question carefully enough and circled the =O part of the retinal.

(iv) The structure of the retinal molecule that combines with opsin in the human body differs from the structure expected from the oxidation of retinol.

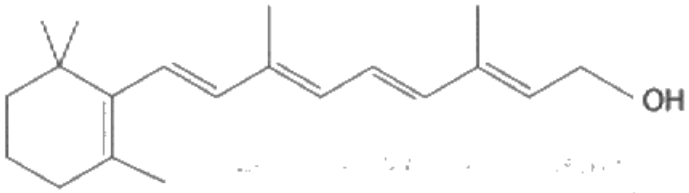
The structures of retinal and retinol are shown below.

(1)

Retinal



Retinol



As well as an oxidation, a structural change has occurred within the molecule. Circle only the part of the **retinal** molecule where this change has occurred.

ResultsPlus
Examiner Comments

This candidate is looking at the right part of the molecule but has included too many carbon atoms. The part of the molecule where the change is occurring is at one end of the upper of the two double bonds which are circled.

Question 21 (c) (v)

Most candidates referred to the term 'three bond pairs' round the carbon atom without qualifying that double bond was being treated as one bond pair. Very few candidates referred to regions of electron density. A significant number of candidates thought that the carbon atom had three bond pairs and one lone pair of electrons. Many answers included statements about maximum separation and minimum repulsion without it being clear what was causing the repulsion. Use of these terms does not automatically get a mark unless they are in a meaningful context. The trigonal planar shape was reasonably well known if not well spelt.

(v) The bond angle around each carbon atom in a carbon-carbon double bond is about 120°. Explain the reason for this bond angle and state the name of the shape around each carbon atom.

(3)

Reason To minimise the repulsion between electron pairs present in the bond.

Shape Trigonal planar

ResultsPlus
Examiner Comments

This scored the second and third marks, but the answer omits to give the number of bonds or regions of electron density which are repelling each other.

(v) The bond angle around each carbon atom in a carbon-carbon double bond is about 120°. Explain the reason for this bond angle and state the name of the shape around each carbon atom.

(3)

Reason To minimise the repulsion and maximise the attraction

Shape Trigonal planar.

ResultsPlus
Examiner Comments

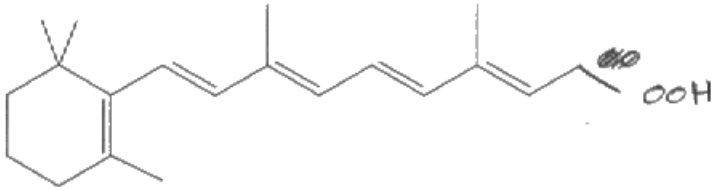
This scored the third mark only. There is no reference to bonds or electrons, so no explanation of what is causing the repulsion.

Question 21 (d)

This proved to be a lot easier than 21c (iv) but it suggested that some candidates are not sure how to interpret and count the carbon atoms in skeletal formulae.

(d) Complete the diagram below to show the skeletal formula of retinoic acid.

(1)



ResultsPlus
Examiner Comments

This candidate is probably unsure where the C of the COOH group should be shown.

Question 21 (e)

This reaction was well known although candidates should be told that safety precautions specific to the chemicals involved are required and not just general ones such as the need for lab coats and goggles.

*(e) Retinoic acid and retinol both have OH groups. Suggest **one** chemical reagent that you could use to test for the presence of an OH group which would work for both compounds. You may assume that both organic compounds are dissolved in suitable solvents.

Give the positive observation for the test and state **one** necessary experimental precaution that you would make to reduce the risk from carrying out this test.

(3)

Reagent dry solid PCl_5

Observation steamy fumes are observed if OH group is present

Precaution PCl_5 is corrosive, so wear gloves

ResultsPlus
Examiner Comments

This candidate scored the first two marks only.

ResultsPlus
Examiner Tip

When you are asked for a safety precaution try to find something specific for the reaction. Wearing a lab coat and goggles are routine precautions, and something extra is expected.

Paper Summary

Advice to candidates:

- make sure you know the meaning of frequently used terms such as functional group, homologous series, molecular formula;
- practice using skeletal formulae and make sure you know where the C atoms are in them;
- show your working in calculations so that if you make a mistake you have a chance of scoring some part marks;
- read the question very carefully! This advice is given every exam series but careless reading is one of the most common reasons for losing marks.

Grade Boundaries

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