Pearson

Examiners' Report
June 2017

IAL Chemistry 3 WCH03 01

ResultsPlus

edexcel

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk.

Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

ResultsPlus

Giving you insight to inform next steps

ResultsPlus is Pearson's free online service giving instant and detailed analysis of your students' exam results.

- See students' scores for every exam question.
- Understand how your students' performance compares with class and national averages.
- Identify potential topics, skills and types of question where students may need to develop their learning further.

For more information on ResultsPlus, or to log in, visit www.edexcel.com/resultsplus. Your exams officer will be able to set up your ResultsPlus account in minutes via Edexcel Online.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk.

June 2017

Publications Code WCH03_01_1706_ER

Introduction

This paper appeared to be accessible to candidates of all abilities and almost everyone finished the questions in the allotted time.

Qualitative inorganic and organic tests and their associated observations were generally well known and described. The three calculation questions were handled particularly well by the majority of candidates. Less successful were questions involving the explanation of processes and those which involved making suggestions in interpreting observations made during the laboratory experiment to determine the enthalpy change of combustion of methanol.

There was some carelessness in giving the correct units. An answer expecting concentration units was often given in "mol dm^{-}" instead of "mol dm^{-3}". In questions where units were not asked for, if these were given they had to be correct.

Candidates may have benefited from reading the question more thoroughly as many marks were lost as the correct significant figures were not given.

Also, quoting an intermediate answer to just one significant figure is likely to bring about large errors in subsequent calculations. These issues were particularly noticeable in Question 3(b).

Question 1 (a) (i)

Very few failed to get the mark here. A minority wrongly linked the lilac flame with lithium ions.

Question 1 (a) (ii)

Virtually all candidates realized that the gas relighting a glowing splint was oxygen, but a sizeable majority incorrectly thought that the metal compound decomposing to give this gas would be K_2O. The expected correct answer was KNO_3 or KO_2 (potassium superoxide). Examiners would have allowed K_2O_2 or $KClO_3$, but these were rarely given.

Question 1 (b) (i)

Almost all students correctly gave carbon dioxide as the gas evolved which turns limewater milky but most did not realise that this gas is evolved when **acids** are added to sodium hydrogencarbonate, and that therefore the ion responsible is the hydrogen ion, H^+. Giving the HCO_3^- or CO_3^{2-} ion as an answer instead - and this frequently was the case - demonstrates that the question had not been read carefully enough.

Observation	Inferences
Fizzing Limewater turned milky	The gas evolved is Carbon dioxide Therefore solution **B** contains ions with the **formula** ~~CO_3^{2-}~~ H^+ Cl^-

ResultsPlus
Examiner Comments

Here the candidate has identified the gas correctly, but has mentioned the presence of Cl^- ions in addition to H^+ ions. We cannot tell from the question at this stage which acid was used, so we cannot conclude that chloride ions <u>must</u> have been present. The candidate scored 1 mark.

ResultsPlus
Examiner Tip

The word "**formula**" implies that examiners are looking for <u>one</u> answer only. In this case the extra wrong answer cancels out the credit for the correct one.

Question 1 (b) (ii)

The test described here is for the presence of sulfate ions; consequently, most realised that the precipitate was barium sulfate, $BaSO_4$. Given that it is known already that solution **B** contains hydrogen ions, this liquid must be (dilute) sulfuric acid, H_2SO_4. Many scored full marks here.

Question 1 (c)

This question was answered well, with most students scoring 5 or 6 marks. The mark usually lost when candidates did not mention the observation that phosphorus(V) chloride gives misty/steamy fumes (of HCl(g)) with alcohols, as well as turning moist blue litmus to red. Several answers claimed that the litmus would bleach, presumably confusing hydrogen chloride with chlorine.

Question 2 (a)

A common mistake here was to describe the distillation as being a "**fractional** distillation". However, most gave "simple distillation" or "distillation", either of which was the correct answer.

Question 2 (b) (i)

There were several poor answers to this question and in many cases there was a lack of precision in explaining exactly what occurs during a "heating under reflux".

As the reagents are being heated vapours are being formed which try to escape, but are being condensed back by the reflux condenser.

ResultsPlus

Examiner Comments

“vapours are being formed” is too vague. A mention of “boiling” or “evaporation”, or more specifically, “turning from liquid into vapour” describes the first part of this process well.

ResultsPlus

Examiner Tip

The question uses the phrase “*in terms of changes of state*“, and this involves describing a process in which **liquid** changes to **gas** (or vapour) and then from **gas** (or vapour) back to **liquid** again.

Question 2 (b) (ii)

There were several allowable reasons as to why the mixture is heated under reflux for such a long time. The commonest response was to allow the reaction to complete, or equivalent ideas, and this question was generally answered well. A common mistake was to link the need for heating under reflux with the fact that the reagents have high boiling points.

So that complete oxidation takes place.

ResultsPlus
Examiner Comments

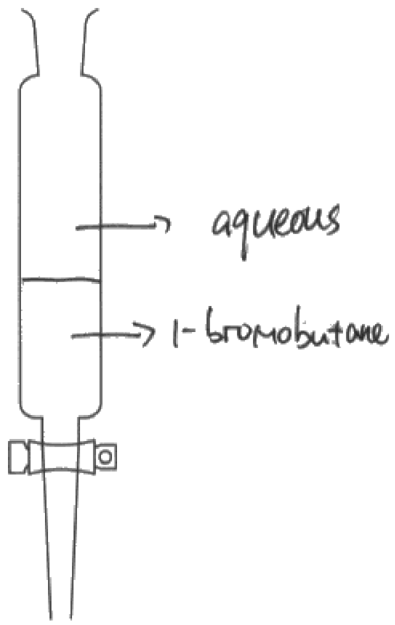
This frequently seen answer was not allowed since the conversion of butan-1-ol into 1-bromobutane is **not** an oxidation. This candidate was probably thinking of the conversion of butan-1-ol into butanoic acid.

ResultsPlus
Examiner Tip

Think carefully whether words like "**oxidation**" are relevant before using them.

Question 2 (c) (i)

The density of 1-bromobutane was given in the stem of the question, so it could be concluded that the upper layer would be the aqueous layer and the lower would consist of the crude 1-bromobutane.



ResultsPlus
Examiner Comments

This correctly shows the aqueous layer on top of the organic layer, but there is no upper boundary for the aqueous layer, so the mark was not scored.

ResultsPlus
Examiner Tip

Candidates are not meant to remember in advance which layer is the denser, so the information must be given in the stem of the question. In this case the relevant density information is given in a box two pages earlier.

Question 2 (c) (ii)-iv

Very few were able to score the mark in part (ii). The question refers to the "*donation of a proton to the butan-1-ol*". It follows that this must result in a species which is positively charged, ie an ionic species, and it is well known that ionic species tend to be relatively water-soluble and certainly more so than molecular butan-1-ol.

In part (iii) most students knew that anhydrous calcium chloride was being used to remove water from the organic layer, but it is important that they understand the distinction between a drying and a dehydrating agent.

Many appreciated that this process would be complete when the organic layer became clear, i.e. when the cloudiness disappeared. Several answers referred to "the solid no longer turning pink", presumably confusing calcium chloride with cobalt(II) chloride, and occasionally there was a mention of the mixture turning "colourless". A sizeable minority referred to the need to wait until the mixture had reached a constant weight, presumably confusing this operation with a thermal decomposition.

Alcohol ~~wt~~ is partially soluble in water and more soluble in concentrated hydrochloric acid. The acid and alcohol react to give ionic species $R-OH_2^{\oplus}$

(iii) What is the purpose of adding anhydrous solid calcium chloride in Stage **7**?

(1)

Anhydrous $CaCl_2$ is a drying agent.

(iv) How can you tell when Stage **7** is complete?

(1)

Liquid in conical flask will go clear

ResultsPlus

Examiner Comments

An excellent and well-expressed answer which obtains full credit.

ResultsPlus

Examiner Tip

If you don't immediately know the answer to part (ii), there is probably a clue in the question. Here, the adding of a proton means that the butan-1-ol molecule now has an extra **H**$^+$ attached, making it an ionic species. Hopefully then the link will be made between "ionic" and "good solubility in water".

Question 2 (d)

This calculation was generally done very well indeed with the majority of candidates obtaining full marks. Not all were able to calculate the density in part (i), but fortunately this had no bearing on their coping with the rest of the question. Transferred errors were fully allowable where necessary in this question.

Question 2 (e)

A full range of alternative answers was allowed here. Perhaps the commonest correct responses were linked with an incomplete reaction, the possibility of side reactions and transfer losses during the purification processes. Credit was not given for losses linked to human error, such as spillage, nor for losses of vapour during refluxing.

Reason 1: Some branching reactions took place which formed minor products which reduces the yield of ~~t~~ 1-bromobutane.

Reason 2: The reaction did not go to completion. and some vapours of product ~~and~~ and reactant ~~are~~ escaped through the reflux condenser.

ResultsPlus
Examiner Comments

Two reasons were required, so as three were given here, all three will be noted and any wrong reasons would cancel out marks gained for correct ones.

ResultsPlus
Examiner Tip

Always study the instructions given in questions. Here, “**two**“ in bold means that if more than two reasons are given you risk having marks deducted for wrong answers.

Question 3 (a)

Most realised that the assumption being made was that water has a density of 1(.0) g cm^{-3}. A few answers gave a value with incorrect units and several quoted the specific heat capacity of water instead of, or as well as its density. A surprising answer from some students was the assertion that the mass of the beaker was negligible and so could be ignored when measuring the mass of the beaker and water.

Question 3 (b)

Most calculated the heat energy correctly in joules in part (i) and some chose to convert their value into kilojoules at this stage.

In part (ii) the majority were able to calculate the number of moles of methanol correctly as 0.0341 or 0.034, but a sizeable minority went on to give the value to one significant figure, as 0.03. This produced a final answer in part (iii) over 12% different from the true value. Candidates should be made aware of the consequences of premature rounding in intermediate answers on the final answer.

The enthalpy change of combustion was generally calculated correctly with the correct sign and units, but was often given to an inappropriate number of significant figures. In this case the question asked the candidates to decide for themselves what was appropriate, based on the data given in the question. Consequently answers to more than 3 significant figures were penalized - many answers were seen giving values to 5 or 6 SF.

= 200 × 4.18 × 24.5

= 20482 J

(ii) Calculate the number of moles of methanol burned in the experiment.

(1)

Mass = 1.09 g

moles = $\frac{1.09}{32}$ = 0.03 moles

(iii) Hence calculate the enthalpy change of combustion of methanol.
Give your answer to a number of significant figures consistent with the data and readings in the table. Include a sign and units in your answer.

(3)

$\frac{20.482}{0.03}$ = 682.7 kJ / mol

ResultsPlus
Examiner Comments

The first answer to (i) is correct, but although the method used to calculate the number of moles in (ii) is also correct the answer has only been quoted to 1 SF. This highly inaccurate value has been transferred to the calculation in (iii), giving a value which is very different to the correct value of -601 kJ mol^{-1}. In addition, the final answer has been quoted to 4 SF, and yet it has been calculated using a value accurate to only 1 SF. Also being an exothermic process there should have been a negative sign for the enthalpy change of combustion. So this answer scored 1 mark in part (i), no mark for (ii) and, via a transferred error, was awarded 1 mark in part (iii), having lost two marks for an inappropriate number of significant figures and for the lack of a negative sign.

ResultsPlus
Examiner Tip

Always retain full values in the calculator during multi-step calculations, but quote intermediate answers to a sensible number of significant figures. However, use the full calculator values in subsequent calculations, always giving your final answer to an appropriate degree of accuracy.

Question 3 (c) (i)

Most candidates realized that an uncertainty of ± 0.5ºC would lead to a possible error of 1.0ºC in measuring the temperature change and hence to a percentage error of (1.0/24.5) x 100 = 4.1%. The commonest wrong answer was one half of this. Another occasional wrong answer resulted from taking the uncertainty as 0.05, instead of 0.5, giving an answer which was incorrect by a factor of 10.

Question 3 (c) (ii)

The majority appreciated that the maximum temperature change would be 24.5ºC +1.0ºC = 25.5ºC. Some candidates misread the question and gave the maximum temperature reached, instead of the maximum temperature change.

Question 3 (d) (i)

Several students wrongly thought that the combustion must be continuing, even when the burner wasn't in use. The fact that methanol is a relatively volatile liquid was appreciated by many, but it wasn't enough to give a relevant property of methanol - the question was concerned with an explanation of the loss in mass, so a mark was only given for a process occurring, i.e. evaporation or vaporisation.

Methanol is ~~so~~ volatile.

ResultsPlus

Examiner Comments

The volatility of methanol is highly relevant of course, but this answer does not answer the question as to what is happening to explain why the burner is continuing to lose mass.

ResultsPlus

Examiner Tip

Read the question carefully. It is not asking for a property of methanol responsible for the loss in mass - it is asking about what is going on to cause this.

Question 3 (d) (ii)

Whilst carbon or soot were correctly given as the likely identity of the black solid, wrong answers included iodine and copper(II) oxide, neither of which has any relevance in the burning of an alcohol. Even carbon monoxide cropped up as a surprisingly common answer.

Carbonmonoxide CO (carbon soot)

ResultsPlus
Examiner Comments

Two answers are given here, one of which is incorrect, so no mark can be awarded.

ResultsPlus
Examiner Tip

Careful thought would prevent the inclusion of carbon monoxide as being the possible identity of the **black solid**. Candidates would benefit from reading the question more thoroughly.

Question 3 (d) (iii)

Most candidates mentioned the fact that the formation of soot indicated that incomplete combustion had taken place. A few wrongly referred to an "incomplete reaction" having occurred. A perfectly acceptable alternative interpretation was that the layer of soot would insulate the beaker of water from the flame or that the soot itself would absorb energy, with less available for the water. This question was generally answered well.

More heat energy is required to form the black solid, carbon soot. As more heat energy is required, enthalpy change is less exothermic.

ResultsPlus

Examiner Comments

More heat energy is not "**required**" when the methanol burns forming carbon. This was a common incorrect answer.

ResultsPlus

Examiner Tip

Any type of combustion, incomplete or complete, involves the evolution of energy. The carbon, once formed, would certainly absorb heat energy, thus leaving less to be absorbed by the beaker of water, but this answer doesn't say that.

Question 4 (a)

Many candidates scored full marks on this question though, as in earlier calculations on this paper, marks were lost in later parts through premature rounding of values in the intermediate stages.

In part (i) many assumed that the first titration was a range-finder, and so just ticked the titres for titrations 2 and 3. Some realised correctly, however, that all three titres were in good agreement (were concordant) and ticked all three. In this situation it appears that the student carrying out these titrations dispensed with the need for a range-finder and carried out all three titrations very carefully.

In part (ii) the majority were able to determine the number of moles of sodium hydroxide used and full credit was given to those who had used the correct method but had based the mean titre in part (i) on only two readings. A surprising error from a significant minority was to forget to divide by 1000. Thus answers such as 2.29 moles were often seen.

Those who appreciated that the vinegar had been diluted 10 times found no difficulty in part (iii) and correctly multiplied their answer in part (ii) by 10. However, some candidates divided by 10 at this stage.

Most appreciated that in order to convert the number of moles present in 25 cm^3 into a concentration there was a need to multiply by ($^{1000}/_{25}$) in part (iv) and in part (v) it was simply a matter of multiplying this by the molar mass of ethanoic acid to arrive at the concentration in g dm^{-3}. A very large number of candidates did not give their final answers to three significant figures even though the need to do this had been clearly emboldened in the question.

Full consequential marking was applied throughout this question.

Number of titration	1	2	3
Burette reading (final) / cm^3	22.90	22.85	24.45
Burette reading (initial) / cm^3	0.00	0.00	1.50
Volume of NaOH used / cm^3	22.90	22.85	22.95
Used to calculate mean (✓)	✓	✓	✓

(a) (i) Show which titres are concordant by putting a tick (✓) in the appropriate boxes in the table of results and hence calculate the mean titre.

(1)

$(22.90 + 22.85 + 22.95) \div 3 = 22.90 (cm^3)$.

(ii) Calculate the number of moles of sodium hydroxide in the mean titre.

(1)

$0.100\ mol\,dm^{-3} \times 22.90 \times 10^{-3}\ dm^3 = 2.29 \times 10^{-3}\ mol$.

(iii) The equation for the reaction between ethanoic acid and sodium hydroxide is shown.

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$$

Calculate the number of moles of ethanoic acid in the 25.0 cm³ sample of **undiluted** vinegar. Assume that no other acids are present in the vinegar.

(2)

$\frac{250 cm^3}{25 cm^3} = 10.$

$10 \times 2.29 \times 10^{-3} mol = 2.29 \times 10^{-2} mol.$

(iv) Calculate the concentration, in **mol dm⁻³**, of the ethanoic acid in the sample of **undiluted** vinegar.

(1)

$\frac{2.29 \times 10^{-2} mol}{25 \times 10^{-3} dm^3} = 0.916 mol dm^{-3}.$

(v) Calculate the concentration, in **g dm⁻³**, of the ethanoic acid in the sample of **undiluted** vinegar.
Give your answer to **three** significant figures.

(3)

$M_{CH_3COOH} = 12+3+12+2\times16+1 = 60 g mol^{-1}.$

$concentration = 60 g mol^{-1} \times 0.916 mol dm^{-3} = 55.0 g dm^{-3}.$

ResultsPlus

Examiner Comments

This is a well set out series of answers, clearly showing the reasoning at each stage. This answer scored the full 8 marks.

ResultsPlus

Examiner Tip

Always show working when carrying out calculations. The units are already given in all parts of this question, so there is no need to repeat these in the answers. For each question look carefully to see whether there is an instruction as to how many significant figures should be given in your answer. Here, in part (v), **three** significant figures are required. If there is no instruction about this give the number of significant figures compatible with the data provided. Giving values to only one significant figure is rarely appropriate.

Question 4 (b)

A surprising minority thought that "vinegar would neutralise the acid left in the pipette" and that the reason why it is used rather than water is because "it is a better cleaning agent".

A relatively small number of answers suggested correctly that washing the pipette with the diluted vinegar was linked with cleaning it of any impurities, or of water, but only a few could explain clearly why vinegar was used as a rinsing agent, instead of water. There were several answers which addressed only one of the two questions asked.

Pippette is rinsed to make sure no other substance is present in it. It is rinsed with vinegar because if it was filled with water, the vinegar will have more water than required so its concentration will change.

ResultsPlus

Examiner Comments

This answer clearly implies that impurities will be removed during rinsing, and although this candidate states that the concentration of the vinegar will change, this answer would have been a better one if it had mentioned that the vinegar would be **diluted** if water had been used as the rinsing agent; however, on this occasion full credit was allowed for this response.

ResultsPlus

Examiner Tip

There are two parts to this question: "why is the pipette rinsed?" and "why is diluted vinegar used rather than water?". Make sure that what you write answers **each** of these questions. Another clue is to look at the number of marks awarded.

Question 4 (c)

Somewhat surprisingly, many candidates thought that blowing out the last drop would improve the accuracy, whereas others reckoned that doing so would introduce bubbles of air which would react with the vinegar. However, the majority understood that pipettes are calibrated without the expulsion of the drop at the tip of the pipette, and so appreciated that blowing out this vinegar would increase the number of moles of vinegar introduced into the conical flask, thereby increasing the mean titre. Many candidates also realised correctly that this increase would, however, only be very small.

Paper Summary

There were several questions which required careful reading in order to arrive at a fully creditworthy answer.

Too many marks continue to be lost in calculations owing to a lack of appreciation of the importance of retaining intermediate answers in a calculator when carrying out a multi-step calculation.

Based on their performance on this paper, candidates are offered the following advice:

- Always read the question carefully. If it helps to do so, use a highlighter to indicate the key phrases.
- Always show how you have arrived at the answer in your calculations. Marks are often given for a clearly set out method.
- When quoting an answer to a calculation, always think "**SUS**".

  Do I need to include a **S**ign?
  Should I be including the **U**nits?
  Have I given the appropriate number of **S**ignificant figures?

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Rewarding Learning

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London WC2R 0RL.