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Examiners' report

CHEMISTRY B (SALTERS)

H433
For first teaching in 2015

H433/03 Summer 2018 series

Version 1

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Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper H433/03 series overview

H433/03 is one of the three examination components for the new revised A Level examination for GCE Chemistry B. This synoptic component links together different areas of chemistry within different contexts, some practical, some familiar and some novel. To do well on this paper, candidates need to be comfortable applying their knowledge and understanding to unfamiliar contexts and be familiar with a range of practical techniques.

H433/03 is much more application based than the other two A Level Chemistry components, H433/01 and H433/02, which have a greater emphasis on knowledge and understanding of the assessment outcomes from the specification.

H433/03 also contains more questions set in a practical context, including an insert based on a practical procedure, than H433/01 and H433/02.

Candidate performance overview

Candidates who did well on this paper generally did the following:

- Performed standard calculations following the required rubric (e.g. clear working, units, significant figures) relating to the ideal gas equation (2(b)), equilibrium (2(d)), analysis of titration results (3b(iii)), equilibrium (3c(ii)), and percentage yield (4a(ii)).
- Produced clear and concise responses for Level of Response questions: 2(c), 3(c).
- Drew clear diagrams for organic structures: 1b(i), 4a(i).
- Constructed and balanced equations for reactions: 3a(ii), 3b(ii), 4(a)i.
- Applied knowledge and understanding to questions set in a novel context: 2, 3.

Candidates who did less well on this paper generally did the following:

- Found it difficult to apply what they had learnt to unfamiliar situations.
- Produced responses that lacked depth, and were often rambling and peripheral to what had been asked, sometimes simply repeating information provided. e.g. 1(a), 2(b)(c), 3(b), 5(b).
- Showed poor setting out of unstructured calculations, e.g. 1(c)(d), 2(a), 3c(ii), 4a(ii), 4c(ii).
- Showed poor presentation of observations and data in an appropriate format (Assessment Objective 1.1.2(c)). e.g. 4a(i).
- Lacked precision in balancing equations, particularly charges on either side of the equation, e.g. 2(d)(iii), 4b(i)(ii), 5a(ii)(iv).

The paper showed good discrimination with marks ranging from single figures to the high fifties with a pleasing number on the higher side of 40.

Candidates on the whole seemed well prepared, with an encouraging improvement in the structuring within calculations (which allowed examiners to award 'error carried forward' marks)

There was no evidence that any time constraints had led to a candidate underperforming and scripts where there was no response to the final question also had large sections of the paper which had not been tackled.

Most successful question/part question	Least successful question/part question
2aii Oxidation states. 2b Calculation on gas volumes. 3ai Qualitative analysis. 4ai Organic structures. 4biv Criteria of purity.	1ci Modification of chromophores. 2ai Unfamiliar electrochemical cell systems. 3biv Percentage errors in titrations. 4biii Practical procedures – melting point. 4c Discussion of tlc in purity determination.

Question 1 (a)

1 A student decides to use a microscale method to synthesise an azo dye and dye a fabric.

(a) The student initially makes a small amount of a solution of the diazonium compound shown below, starting from an aromatic amine.
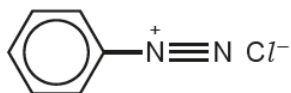
diazonium compound

Name the reagents and conditions needed to make this compound.

Reagents

....

Conditions

.... **[3]**

There were many good responses but the identity of phenylamine as one of the reagents was often missed, candidates perhaps not noticing the question asked for the reagents needed to make the particular compound shown in the stem.

Question 1 (b)(ii)

(ii) The azo dye formed above has an extended delocalised system.

Describe the bonding occurring in a delocalised system and explain why this can lead to organic compounds being coloured.

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.... **[4]**

This question was generally well answered, but some candidates treated the process as emission spectra (e.g. 'when the electrons drop back in energy level the **emitted** light is the complimentary colour.'

Question 1 (c)(i)

(c) Other functional groups can be attached to dye molecules and these can modify the properties of the dye.

(i) Give **one** property of the dye that might be affected if nitro, NO_2, groups are attached.

.... **[1]**

Common incorrect answers included solubility (the answer to 1cii), and colourfastness.

Question 1 (c)(ii)

(ii) Give a **different** property affected by the attachment of sulfonate, SO_3^-, groups.

.... **[1]**
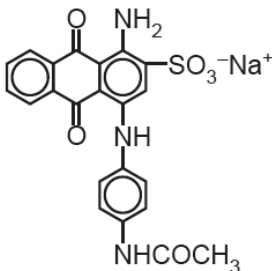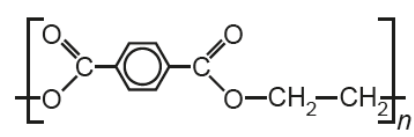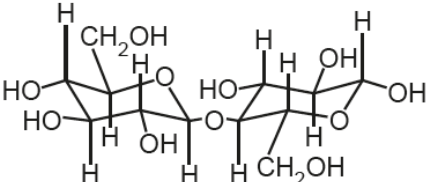
Some candidates talked about the nature of bonding to the fibre rather than a property of the dye.

Question 1(d)

(d) Attractions between dye molecules and polymer molecules in fabric fibres can be ionic, covalent or intermolecular bonds.

Use your knowledge of molecular interactions to fill in the empty boxes in the following table.

Type of fabric	Structure/features of polymer molecule	Structure/features of dye molecule	Strongest type of attraction between polymer and dye
Wool	A protein chain with $-NH_3^+$ groups at the end of side chains when dyed in acid solution		
		Few polar groups on dye molecule	
Cotton		Several $-NH_2$ groups. Linear molecule	

[2]

This question was generally well answered apart from the type of fabric. Many candidates suggested nylon despite there being no N atoms in the formula shown.

Question 2 (a)(i)

2   The use of a standard hydrogen electrode for measuring standard electrode potentials is often not practicable. The diagram below shows a calomel electrode. This is often used in preference to the standard hydrogen electrode and has a standard electrode potential, $E^{\ominus}$, of +0.27 V.

wire lead   salt bridge

Hg

solid KCl

disk or cotton plug

solution saturated
with KCl and Hg_2Cl_2

solid Hg_2Cl_2

Pt wire   Hg
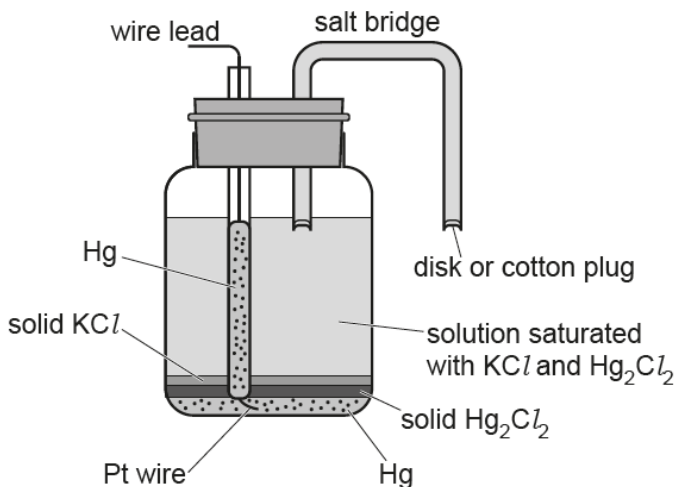
calomel electrode

(a)   The electrode is based on mercury metal, Hg, in contact with a saturated solution of Hg_2Cl_2.

(i)   Suggest **one** advantage and **one** disadvantage of using a calomel electrode over a standard hydrogen electrode.

Advantage ....

Disadvantage .... **[1]**

> This question proved very difficult for candidates with many responses going into theoretical reasons rather than looking at the practicalities. This was perhaps a case of candidates overthinking a question based around, as the stem of the question suggests, a practicable standard electrode.

Question 2 (b)

(b) A 25.0 g sample of Hg_2Cl_2 is vaporised at 400 °C and a pressure of 101 kPa.
A student assumes that the formula of the gaseous mercury chloride molecules is Hg_2Cl_2.

Calculate the volume of gas, in dm^3, that would be expected under these conditions.

volume of gas = ... dm^3 **[3]**

A pleasing number of candidates were successful in this calculation. The careful laying out of the steps in the calculation also allowed examiners to be able to award error carried forwards marks on a wrong final answer. Typical errors in the calculation included calculating the wrong value for the formula mass of Hg_2Cl_2 and a failure to convert from m^3 to dm^3.

Question 2 (c)

(c)* A student investigating the rusting of iron is given a calomel electrode.

The diagram shows a simplified calomel electrode.

KCl solution

mercury and Hg_2Cl_2

mercury   platinum wire

simplified calomel electrode

The student wants to use this electrode to measure the standard electrode potential of a Fe^{2+}(aq)IFe(s) half-cell.

Give instructions on how to do this, justifying the uses of the pieces of apparatus you name. You may add to the diagram above to illustrate your answer.

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.... **[6]**

Many candidates produced, solid, well-structured responses, although some seemed to think that |Fe was a material. However, there were only a limited number of responses which came to grips with the requirement to justify the apparatus and conditions which would allow access to the higher mark level.

Justification of apparatus would include some comment as to role of the salt bridge and perhaps why a high resistance voltmeter is desirable. A top answer would also make it clear that conditions, e.g. concentration of electrolyte, affect electrode potentials; hence standard conditions have to be employed.

Exemplar 1

Put around 100cm³ of a 1moldm⁻³ solution of Fe²⁺ ions in a beaker. Dip the other end of the salt bridge into the solution. Attach the wire from the calomel electrode to a high resistance voltmeter - ensures no current flows so the maximum potential difference is recorded. Connect the other side of the voltmeter to an iron metal electrode which also dips into the Fe²⁺ ion solution - allows contact between the Fe atoms and Fe²⁺ ions involved. The salt bridge allows electrical contact between the solutions without them mixing to balance charge. The voltmeter reading is equal to the more positive half cell potential minus the more negative half cell potential. Given that the potential of calomel is +0.27V, rearrange the equation to find the iron reading. Subtract 0.27 to get the standard potential cell potential. [6]

This response addresses all the chemical ideas involved in the practical use of electrochemical cells, including how to calculate the standard potential from E_cell, the role of the salt bridge and high resistance voltmeter; it is also clear and well-organised and could be followed and set-up by a fellow candidate.

Examiners are not looking for the 'perfect' answer to score top marks but a scientifically accurate, well-developed discussion.

Question 2 (d)

(d) An equilibrium, represented by **equation 2.1**, exists between the solid Hg_2Cl_2 and its ions in solution.

$$Hg_2Cl_2(s) \rightleftharpoons Hg_2^{2+}(aq) + 2Cl^-(aq) \qquad \textbf{Equation 2.1}$$
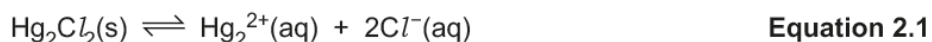
The solubility of the solid Hg_2Cl_2 in a saturated solution at 298 K is $3.5 \times 10^{-4}\,g\,dm^{-3}$.

Calculate the solubility product, K_{sp}, for Hg_2Cl_2 at 298 K. Include the units.

Give your answer to an **appropriate** number of significant figures.

solubility product, K_{sp} = ... units ....**[5]**

There were a good number of fully correct answers, although some candidates used mass rather than moles. Units were generally correct even when mass was used. This question in particular showed good discrimination.

Question 3 (a)(i)

3   Iodine, I_2, is an essential dietary element. The recommended maximum daily intake of iodine for an adult is $1.5 \times 10^{-4}\,g$ (150 μg).

A group of chemistry students read that fish is a good source of iodine in the form of iodide ions. They decide to extract the iodine from 600 g of fish.

The students blend the fish in a food processor with $100\,cm^3$ of water, leave it to stand overnight and then filter the mixture into a beaker.

(a) One of the students suggests that if they add silver nitrate solution they can confirm the presence of iodide ions in the solution.

   (i) Describe what the students would observe if the only halide ion present in the solution was the iodide.

   .... **[1]**

This question was particularly well-answered.

Question 3 (a)(ii)

(ii) Write an **ionic** equation for this reaction. Include state symbols.

[1]

Done well, however a minority used Ag^{2+} and some candidates wrote full equations. For questions which require writing of equations, candidates are encouraged to check that they write the type of equation specified in the question stem.

Question 3 (b)(i)

(b) The students pour the filtered mixture into a separating funnel containing $20\,cm^3$ of hexane, $5\,cm^3$ of dilute sulfuric acid and $5\,cm^3$ of hydrogen peroxide solution.

Iodine is formed and dissolves in the hexane layer which goes purple. The purple layer is separated from the aqueous layer and transferred to a conical flask.

The purple coloured solution is titrated with standard $0.0010\,mol\,dm^{-3}$ sodium thiosulfate solution. The end point is indicated by the disappearance of the purple colour.

(i) The hydrogen peroxide oxidises the iodide ions in the fish to iodine.

Write a half equation for this oxidation reaction.
Explain why this reaction is classified as oxidation.

Half equation ....

Explanation .... [1]

Question 3 (b)(ii)

(ii) The equation for the titration reaction is given below.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$
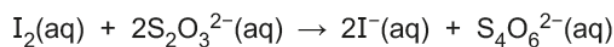
Name the element oxidised in this reaction. Give its oxidation state before and after the reaction.

Element oxidised ....

Oxidation state before reaction .... oxidation state after reaction .... [2]

Question 3 (b)(iii)

(iii) The students obtained an average titre of $5.30\,cm^3$ of $0.0010\,mol\,dm^{-3}$ sodium thiosulfate.

Calculate the **mass** of iodine in μg in a **120 g** portion of fish.

Give your answer to **two** significant figures.

mass of iodine = ... μg **[4]**

The relationship between micrograms and grams caused some problem with a number of candidates being unable to convert between them A number of answers were given to 3 or more significant figures. The need to use the formula mass of molecular iodine, I_2 was commonly missed, with the atomic mass of iodine used instead.

Question 3 (b)(iv)

(iv) One of the students suggests that the titre value is too small and will lead to an unacceptably high percentage error.

Calculate the percentage error based on the students' titre value.

percentage error = ... % **[1]**

This question proved difficult for many candidates. Common errors included answers being a factor of 10 too big. Some candidates also forgot that, as two burette readings are necessary to take a titre reading (initial and final), the uncertainty for individual readings ($0.05\ cm^3$) must be doubled when calculating the percentage uncertainty.

Question 3 (b)(v)

(v) Suggest how the experiment could be modified to improve the accuracy of the result.

....

....

.... **[1]**

Many candidates simply wanted to repeat the number of titrations involved without realising that accuracy is about closeness to the 'correct value'. This is improved by a method which gives a greater titre value (reducing the percentage error), hence using less concentrated standard thiosulfate .

Question 3 (c)

(c)* The mass of the iodine in the hexane solution could also have been determined using colorimetry.

Suggest a suitable method that could be used to measure the mass of iodine in the hexane solution using a colorimeter or visible spectrophotometer.

Show how you would process the results.

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.... **[6]**

This level of response question proved to be slightly easier than 2(c) to obtain the higher marks, probably because the practical technique was more familiar.

Many candidates chose to zero the colorimeter with water instead of hexane, however the majority of candidates explained the choice of filter. The transfer of graphical information to calculation of mass was not so well explained. In terms of the communication criteria, a good rule of thumb to help with explaining the requirements of this extended question would be to consider whether a fellow candidate could successfully follow the candidate's methodology and successfully complete the experiment.

Exemplar 2

First, you need to produce standard solutions of iodine dissolved in hexane. You need to dissolve different mass of iodine into the same volume of hexane to produce many different standard solutions of different known concentrations. These will all be of different colour intensities. Select appropriate filter for colorimeter - filter with maximum absorbance - yellow filter is appropriate as is complement colour to purple. Set colorimeter to zero (calibrate) using blank - hexane cuvette with no iodine dissolved. Fill each clean cuvette with sample from each standard solution and measure and record their percentage Absorbance using the colorimeter. Plot a calibration curve of percentage absorbance along the y axis and concentration (i.e. mass of iodine dissolved) along x-axis and join points with a line [6] of best fit to produce calibration curve.

Take sample of unknown iodine mass and place in cuvette and measure percentage absorbance. Read value along from the y-axis to the line of best fit and down to the corresponding concentration of iodine. From this, you can work out the moles of iodine $n = conc \times volume$ and then use the Mr to work out the mass of iodine in unknown hexane sample.

This candidate response avoided the trap of zeroing with water and explained how to transfer data from the graph in order to calculate the mass of iodine. A suggestion of the number of standard solutions appropriate to plot the graph would have been helpful, but overall this is a well explained and workable response.

Question 4 (a)(i)

4   This question refers to the **Practical Insert** that is provided as an insert to this paper.

(a)   The equation for the reaction producing phenyl benzoate is as follows:

$$C_6H_5COCl + C_6H_5OH \rightarrow C_6H_5COOC_6H_5 + HCl$$
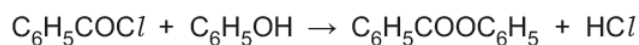
(i)   Draw a structural formula for phenyl benzoate, showing the bonding in the ester group.

[1]

Question 4 (a)(ii)

(ii)   Use the student results to calculate the percentage yield of phenyl benzoate obtained from the practical.

percentage yield = ... % [3]

This calculation could be approached either by using 'reacting masses' or moles and both methods were used in about equal measure. Some errors in the calculation of formula mass crept in but with error carried forwards still gained marks.

Question 4 (b)(iii)

(iii)   Describe the practical procedure used to measure the melting point of an organic solid. You **do not** need to discuss the type of melting point apparatus you use.

....

....

....

....

.... **[3]**

The response of many candidates did not describe the basic practical steps needed to get the sample into a suitable tube for determining the melting point of the solid (as described in the course text book). The most commonly scored marking point was for the identification of the range over which the solid melted.

Exemplar 3

This response succinctly describes the practical procedure when melting point capillary tubes are used to determine melting point, including how to get the solid to the bottom of the tube.

Question 4 (c)

(c) The students carry out thin layer chromatography of the phenyl benzoate formed.
One student states that this will enable them to assess the purity of their product.

Comment on the validity of this statement.
You should describe any possible observations to back up your comments.

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....

.... **[4]**

? **Misconception**

A significant number of candidates did not understand that Rf values did not address the requirement for describing what you would expect to see on a thin layer chromatography of the product mixture.

To address the description statement examiners were expecting to see comments on spotting patterns, for either a pure or impure product, on the chromatogram.

Exemplar 4

The Student is Correct, but this will only provide a ~~method~~ qualitative ✓ analysis, not a quantatative one ✓ If the Sample is ~~an~~ impure, then the phenyl benzoate spot would split ✓ into various different spots, with these other spots having R_f values equal to that of phenol or benzoyl chloride. If these spots appear then the Sample is impure and if they don't then the Sample is pure. However, these spots will appear no matter the concentrations ✓ of the impurities in the Same, so you wouldn't be able [4] to attain a percentage purity value from thin-layer chromatography. A titration would be needed to get that.

> A strong answer; the expected observations asked for in the stem of the question have been addressed as well as the broad idea of the method giving only a qualitative measure of the level of purity/impurity.

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