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AS LEVEL

Examiners' report

CHEMISTRY B (SALTERS)

H033
For first teaching in 2015

H033/02 Summer 2019 series

Version 1

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.

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space. The additional answer space will be clearly labelled as additional, and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of conciseness in their answers. Please follow this link to our SIU (https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/)

Paper 2 series overview

H033/02 (Chemistry in Depth) is one of the two examination components for the AS Level examination for GCE Chemistry B (Salters'), comprising 50% of the total AS Level. This component assesses content from across all teaching modules. Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions including Level of Response type. To do well on this paper, candidates need to be both familiar with the detail of the AS material and comfortable applying their knowledge and understanding to unfamiliar contexts. They also needed to be familiar with a range of practical techniques.

Candidate performance

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

- Performed unstructured calculations, paying attention to the required rubric (e.g. clear working, units, significant figures): 1(f) the use of pV = nRT to calculate V in dm3; 2(c)(i) the use of iodine-thiosulfate titration results and two linked equations to calculate the concentration of chlorine in a solution; 2(f)(ii) percentage yield; 3(c) the percentage abundance of two isotopes given isotopic masses and the relative atomic mass of an element; 4(b) molecular formula from percentage composition; 4(c) use of $E = h\nu$ to calculate a bond enthalpy
- Produced clear and concise responses for Level of Response Questions: 1(h) and 4(d)
- Drew a precise curly arrow mechanism for an organic reaction: 2(a)
- Constructed and balanced both full, ionic half and nuclear equations for both familiar and unfamiliar reactions: 1(a)(i), 2(a), 3(a)
- Applied knowledge and understanding of chemical ideas to questions set in both familiar and unfamiliar contexts: 1(d), 2(c)(ii), 3(b), 3(e), 4(a)(i) and 4(a)(ii).

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

- Found it difficult to apply what they had learnt in familiar but particularly in unfamiliar situations: 1(d), 2(c)(ii), 3(b), 3(e), 4(a)(i) and 4(a)(ii)
- Produced responses that lacked depth and detail, and were often rambling and peripheral to what had been asked, especially in the Level of Response: 1(h) and 4(d), but also in 1(b), 2(c)(ii), 3(b), 3(e), 4(a)(i) and 4(a)(ii)
- Did not set out unstructured calculations clearly: 1(f), 2(c)(i), 2f(ii), 3(c), 4(b), 4(c)
- Showed gaps in understanding and/or unclear presentation of organic reaction mechanisms: 2(a)
- Struggled with balancing various equations: 1(a)(i), 2(a), 3(a).

Question 1 (a) (i)

1 Catalytic cracking of hydrocarbons is carried out in the petrochemical industry.
Hot vaporised hydrocarbons and a powdered catalyst are fed into the bottom of a tube and forced upwards by steam.

(a) (i) Decane, $C_{10}H_{22}$, can be cracked to give an **alkene** with four carbon atoms and another alkane.

Write a chemical equation for this reaction using **molecular** formulae.

[1]

Many candidates were familiar with writing this type of equation but sometimes lost the mark by misreading which was the alkene and which the alkane or by using something other than the molecular formulae. The words in bold type are important.

Question 1 (a) (ii)

(ii) 2,2,3-Trimethylheptane is an isomer of decane.

Draw the **skeletal formula** of 2,2,3-trimethylheptane.

[1]

Many candidates were familiar with skeletal formulae but sometimes lost the mark by not having seven carbon atoms in the longest chain or by incorrectly showing CH_3 on the branches as if it were a functional group like OH.

Question 1 (b)

(b) A student wishes to crack a sample of liquid decane in the laboratory and collect the gaseous products.

Fig. 1.1 shows the apparatus that a student drew before doing this.

What modifications would be required for this apparatus to work?

Explain your answers.

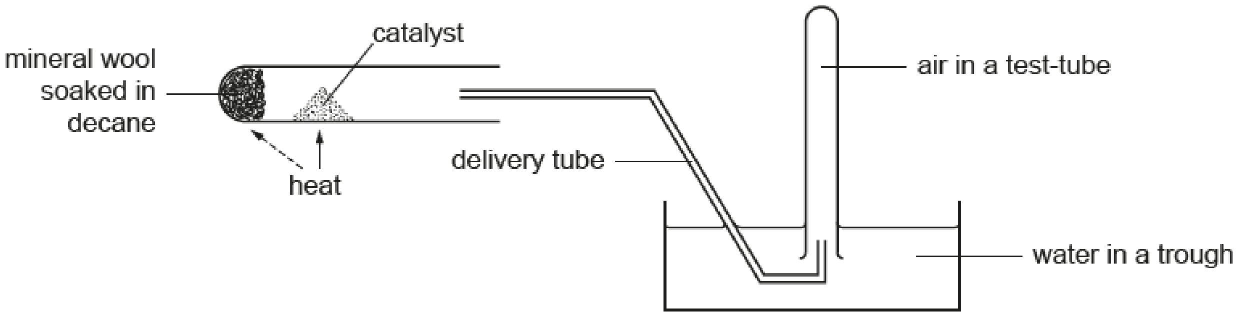


Fig. 1.1

....

....

.... **[4]**

There were some completely correct answers to this question but a significant number of candidates found it more demanding to clearly express the modifications. For example, many suggesting simply 'put a bung in the test-tube to prevent loss of gas' without specifying that it was the heated tube to which reference was being made. Even when the correct tube was identified many did not specify that the bung would require a hole for the delivery tube. Some simply stated 'seal the heated tube to prevent gas loss'.

The need to prevent gas loss from the heated tube was often stated but the means of achieving this was less well described. The drawing and labelling of an appropriate modification on the diagram would have been a very effective way of doing this, though very few candidates chose to do so. The need for the gas collecting tube to be full of water was usually recognised but the reason that without water the gaseous products would escape was less well known. A significant number of candidates also thought that the gas collecting tube needed to be replaced by a measuring cylinder so that the volume of gas collected could be measured.

Question 1 (c)

(c) Small alkenes produced in cracking can be used for making polymers.

The structure of a polymer chain is shown in **Fig. 1.2**.

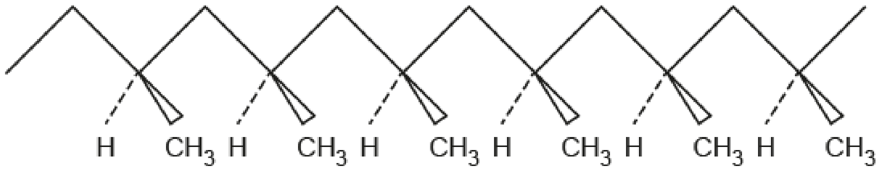


Fig. 1.2

Give the **name** of the monomer that forms the polymer in **Fig. 1.2**.

.... **[1]**

This question proved to be problematic for many candidates. It appeared that this dash and wedge notation for representing the 3-D structure of the polymer was not too familiar.

Question 1 (d)

(d) Another alkene that can be polymerised is but-2-ene, $CH_3CH{=}CHCH_3$.

Explain why stereoisomerism can occur in but-2-ene.

....

....

....

.... **[2]**

Many candidates recognised the lack of free rotation about the carbon-carbon double bond but there was less familiarity with the requirement to have different groups on each carbon atom of the double bond. It was not uncommon to simply have a description of the arrangement of E/Z isomers.

Question 1 (e)

(e) When but-1-ene, $CH_3CH_2CH{=}CH_2$, reacts with ICl the main product is 1-iodo-2-chlorobutane, $CH_3CH_2CHClCH_2I$.

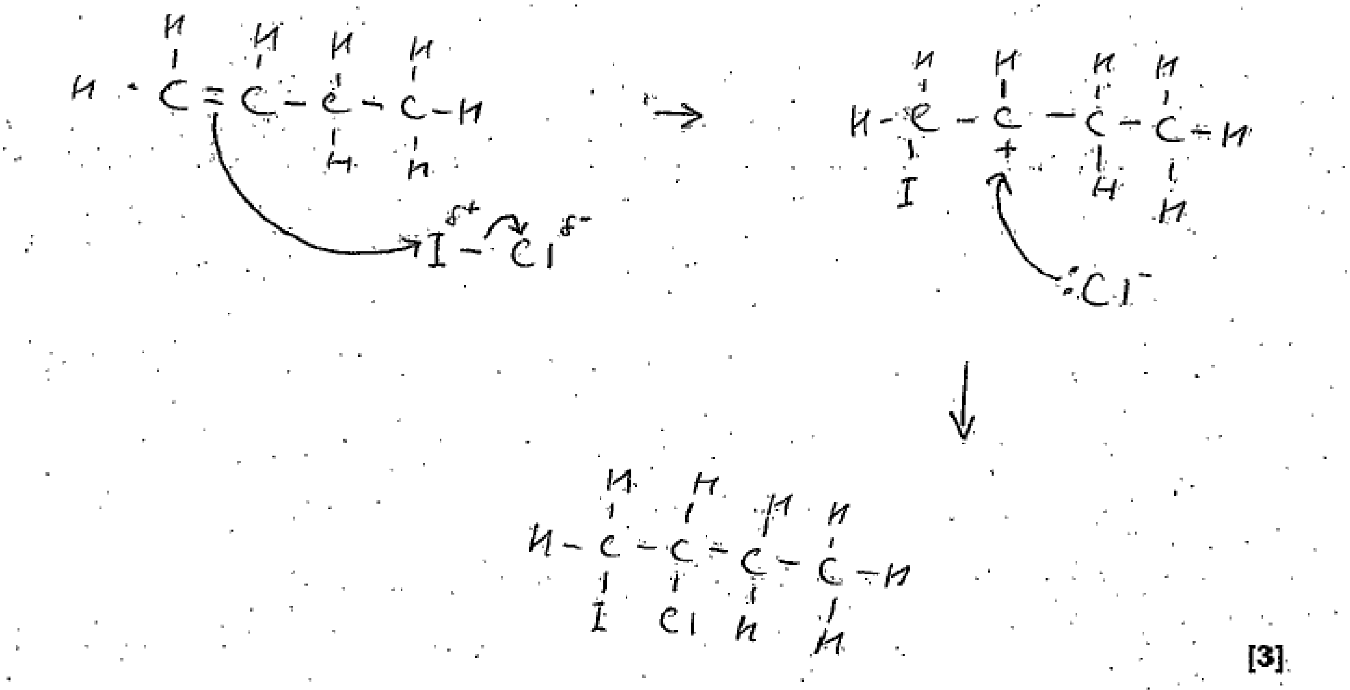
Suggest a mechanism for this reaction.

Show full and partial charges and 'curly arrows'.

[3]

Many candidates did not find this question particularly straightforward. The correct use of 'curly arrows' is an area for further development. It is particularly important to note that the 'curly arrow' must begin (when projected back if this is necessary) on a bond or an electron pair and end (when projected forward if necessary) on the atom with which the new bond is to be formed. The arrow head must be full to show the movement of an electron pair since a half arrow head shows the movement of a single electron. The exemplar shows these points very clearly.

Exemplar 1



[3]

This exemplar response scores 3 marks as it fully satisfies the points made above, especially relating to the start and end of 'curly arrows'.

Question 1 (f)

(f) Petrol contains hydrocarbons like octane, C_8H_{18}.

Equation 1.1 shows the complete combustion of octane.

$C_8H_{18}(g) + 12½O_2(g) \rightarrow 8CO_2(g) + 9H_2O(g)$ **Equation 1.1**

3.42 g of octane are burned per second in a vehicle engine.
The exhaust gases are produced at a temperature of 550 °C and a pressure of 1.50×10^5 Pa.

Calculate the volume of exhaust gases, in dm^3, produced per second.

Assume that carbon dioxide and water vapour are the only gases present in the exhaust.

volume of exhaust gases = ... dm^3 **[4]**

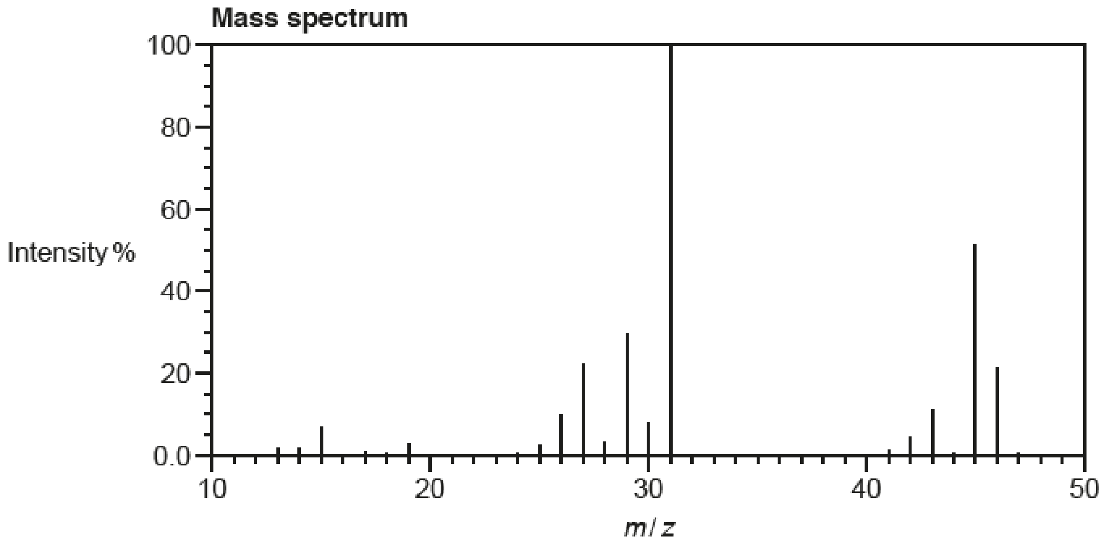
Many completely correct answers to this question were seen. One of the most common mistakes was to follow a correct calculation of the amount of octane (3.42/114 = 0.03 mol), with a failure to recognise that upon complete combustion the amount of gaseous products will be (17x0.03 =) 0.51 mol (8 mol CO_2 + 9 mol H_2O). Another error, but less common was not to convert 550 °C into 823 K. The final common error was to fail to realise that using $V = nRT/p$ with the values in the question will give an answer in m^3 which needs to be converted into dm^3 for the final answer by multiplying by 1000.

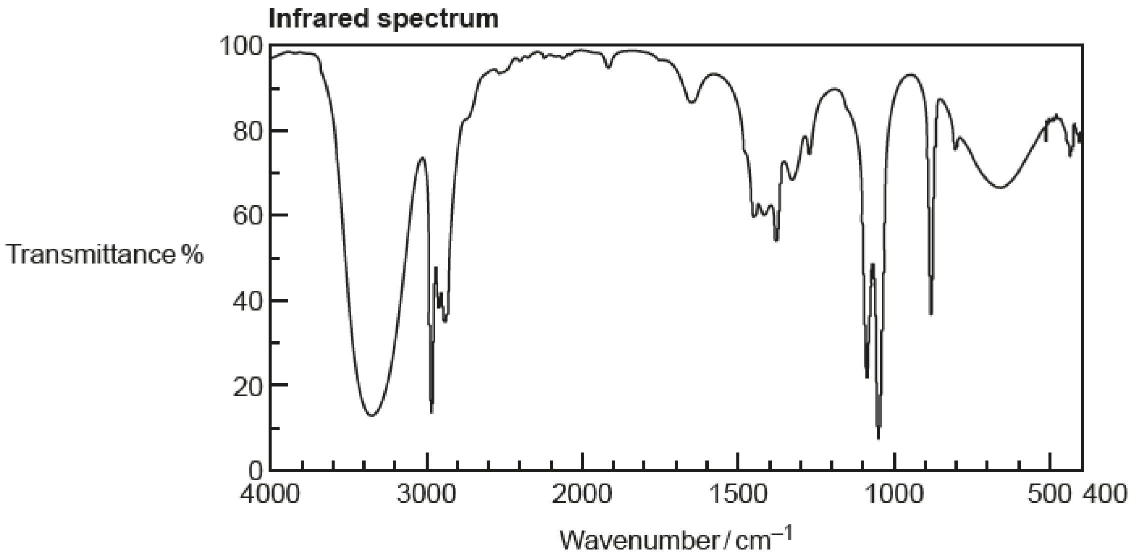
Question 1 (g)

(g) Biofuels are increasingly providing alternatives to petrol.

One of the compounds in a biofuel has the following mass spectrum and infrared spectrum.

The biofuel contains carbon, hydrogen and oxygen only.





(i) Identify the biofuel given by the mass spectrum and infrared spectrum.

[1]

A common error here was to give a molecular formula, for example C_2H_6O, which does not specifically identify ethanol.

Question 1 (g) (ii)

(ii) Give **one** piece of evidence from the mass spectrum to support your answer to **(g)(i)**.

....

.... **[1]**

A number of candidates did not highlight the m/z value of 46.

Question 1 (g) (iii)

(iii) Give **one** piece of evidence from the infrared spectrum to support your answer to **(g)(i)**.

....

.... **[1]**

A common error here was to reference 'the absorption at about 3400 cm^{-1}' but not to link this to the O-H bond in an alcohol.

Question 1 (h)

(h)* Discuss the advantages and disadvantages of using biofuels as fuels for cars compared with fossil fuels. **[6]**

....

....

....

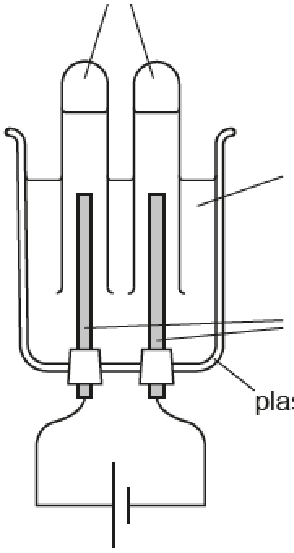
....

Candidates found this LOR question rather challenging. The main problem arose from rather lengthy and imprecise answers that did not address the question. The mark scheme gives ample indicative scientific points from which candidates could choose to exemplify both the advantages and disadvantages of biofuels for use as fuel for cars. There was often a lack of clarity and detail in the advantages and disadvantages suggested by candidates.

Question 2 (a)

2 Chlorine is obtained by the electrolysis of aqueous sodium chloride.

(a) A student investigates the electrolysis of aqueous sodium chloride in the laboratory using the apparatus shown below.



The student observes bubbles of gas at both the anode (+) and the cathode (–).

Write half-equations for the reactions occurring at each electrode.

Anode (+)

Cathode (–)

[2]

More candidates were successful with the anode equation than with the cathode equation. However, even with the anode equation incorrect answers such as $2Cl^- + 2e^- \rightarrow Cl_2$ were not uncommon. Candidates do need to check that what has been written makes sense with respect to balancing charge. With the cathode equation candidates that wrote the allowed answer of $2H^+ + 2e^- \rightarrow H_2$ seemed to be more successful than those that attempted the preferred answer of $2H_2O + 2e^- \rightarrow 2OH^- + H_2$.

Question 2 (b) (i)

(b) One use of chlorine is in water treatment.

Chlorine reacts with water to form chloric(I) acid, $HClO$, as in **equation 2.1**.

The $HClO$ kills the bacteria that can cause diseases like cholera.

$Cl_2(aq) + H_2O(l) \rightarrow HCl(aq) + HClO(aq)$ **Equation 2.1**

(i) Explain what is meant by the (I) in chloric(I) acid.

.... **[1]**

It was not uncommon for candidates to simply refer to the (I) as being the oxidation state without specifically referring to the chlorine. Incorrect reference to charge was also not uncommon.

Question 2 (b) (ii)

(ii) Chloric(I) acid can also be produced by adding solid calcium chlorate(I) to water.

Suggest a reason why it may be preferable to use calcium chlorate(I) rather than chlorine for treating drinking water.

....

.... **[2]**

It was very uncommon to see both marks obtained here. Candidates did not seem to make the connection between the solid state of calcium chlorate(I) compared with the gaseous state of chlorine, and therefore the greater ease of transport, storage, handling or the lesser toxicity.

Question 2 (c) (i)

(c) (i) Chlorine is also used to sterilise swimming pool water.

An analytical chemist uses a titration to find out the amount of chlorine in a sample of swimming pool water.

The chemist takes a 25.0 cm^3 sample of water and treats it with an excess of potassium iodide solution. The equation for this reaction is shown in **equation 2.2**.

$Cl_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$ **Equation 2.2**

The chemist then titrates the treated sample with 0.000100 mol dm^{-3} sodium thiosulfate solution to find out how much iodine has formed. The equation for this reaction is shown in **equation 2.3**.

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$ **Equation 2.3**

The chemist obtains a mean titre of 12.4 cm^3.

Use this information to calculate the concentration of Cl_2, in mol dm^{-3}, in the sample of swimming pool water.

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

Assume Cl_2 is the only substance in the water that oxidises iodide ions.

concentration of Cl_2 = ... mol dm^{-3} **[4]**

Correct numerical answers to an appropriate number of significant figures (three) were quite common. However, even among such answers the setting out of the working was often unclear. It was not uncommon to see simply numerical working with no explanation of what was being worked out and little organisation of the calculation. If the final answer is incorrect then marks can be given for working out but these can be difficult to award if the working is not clear.

Question 2 (c) (ii)

(ii) A student is asked to write a detailed plan for the titration carried out by the chemist. The student writes:

1. Use a measuring cylinder to transfer 25 cm^3 of swimming pool water to a 250 cm^3 conical flask.
2. Rinse out a burette with de-ionised water and fill it with the 0.000100 $mol\,dm^{-3}$ solution of sodium thiosulfate, and ensure that the space below the tap is filled.
3. Record the initial burette reading to the nearest 0.1 cm^3.
4. Add excess potassium iodide solution to the solution in the conical flask.
5. Add a few drops of starch indicator.
6. Titrate until the blue-black colour of the starch indicator just disappears.
7. Repeat until titres agree within 0.1 cm^3.

Identify and correct the mistakes that the student has made.

....

....

....

....

....

.... **[3]**

A significant number of candidates realised that a (volumetric/measuring/graduated) pipette would need to be used instead of a measuring cylinder, and although not requested in the question, many explained the reason why.

The need to rinse out the burette with the sodium thiosulfate solution was also recognised by many, again with a reason often given. However, many also thought incorrectly that the space below the tap of the burette should not be filled. This seemed to suggest that for some candidates the correct filling and use of a burette is not a familiar practical procedure.

The need to record burette readings to 0.05 cm^3 rather than 0.1 cm^3 was also quite well known. However, a number of candidates also seemed to wish to identify and correct mistakes by omission, for example many referred to the need for a trial titration. While not incorrect in itself it does not answer the question set.

A significant number of candidates also believed the excess of potassium iodide to be an error, seemingly not aware of the need to make sure that all of the chlorine in the pool water reacts. The addition of starch indicator before titrating was also recognised by many candidates with many of these being aware of the need to wait until the brown colour of the iodine had faded to a pale yellow colour. That said there were some candidates that did not seem to be aware of the use of starch indicator and incorrectly suggested an acid-base indicator instead.

Question 2 (d)

(d) Bromine can be extracted from seawater. One method of making bromine involves reacting chlorine gas with acidified seawater that contains bromide ions.

$Cl_2(aq) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$ **Equation 2.4**

The bromine that is produced is then reacted with sulfur dioxide and water. The reaction that occurs is a redox process.

$Br_2 + SO_2 + 2H_2O \rightarrow 2Br^- + SO_4^{2-} + 4H^+$ **Equation 2.5**

Give the formula of the reducing agent in the reaction shown in **equation 2.5**.

Explain your answer in terms of oxidation states.

Reducing agent ....

Explanation ....

[1]

Many candidates did not score this mark. Many simply incorrectly identified the reducing agent or identified it as sulfur. Even of those that did correctly identify it as sulfur dioxide many were not able to correctly relate that to oxidation states, either of the S in the SO_2 or of the Br in Br_2.

Question 2 (e)

(e) The solution containing bromide ions is then treated with chlorine and steam before the bromine produced is separated by fractional distillation.

Describe the state and appearance at room temperature of the bromine that is collected at the end of this process.

.... **[1]**

Most candidates scored this mark although the volatility of liquid bromine did cause some to incorrectly identify the state at room temperature as gaseous.

Question 3 (a)

3 Many of the chemical elements found on Earth were produced in nuclear fusion reactions in stars.

(a) Write a nuclear equation to show the fusion of the nuclei of two hydrogen-2 atoms to give a single atom.

[1]

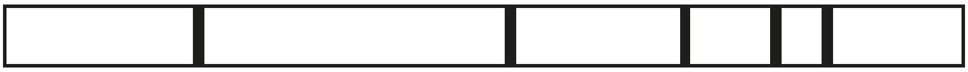
A common mistake in this question was the inversion of the mass number and atomic number.

Question 3 (b)

(b) The presence of different elements in stars is shown by absorption or emission atomic spectra.

The diagrams below represent parts of an absorption spectrum and an emission spectrum.

absorption spectrum



frequency →

emission spectrum

frequency →

A student says that the absorption and emission spectra are for the same element.

Discuss whether the student is correct, giving the chemical theory.

....

....

....

....

....

.... **[3]**

Whilst it appeared that candidates were generally aware of the origin of both absorption and emission atomic spectra for elements some simply described this without addressing the question. The crucial points here are that each element has unique energy levels and that when an electron moves between two given energy levels the energy that is either absorbed or emitted is the same. This will cause the absorption or emission lines to occur at the same frequency. Therefore in this case the student's statement is correct and, given the question, candidates must state that fact.

Question 3 (c)

(c) The element indium was discovered in 1863 from an emission spectrum.

Indium has two naturally occurring isotopes as shown in the table.

Isotope	Isotopic mass
^{113}In	112.90
^{115}In	114.90

The relative atomic mass, A_r, of indium is 114.82.

Calculate the percentage abundances of the two isotopes.

^{113}In .... %; ^{115}In .... % **[2]**

Although a substantial number of correct answers were seen many candidates, that showed working out, did find the algebra required to calculate an answer quite challenging.

Question 3 (d) (iii)

(iii) Indium forms an oxide that has a melting point of 1910 °C and conducts electricity in the molten state.

Explain this high melting point in terms of the structure and bonding in the compound.

....

.... **[1]**

A significant number of candidates appeared not to have read this question carefully enough, referring to metallic bonding although the substance in question was the oxide. It was therefore not uncommon to read about 'attraction between indium cations and the delocalised electrons'. A lot of candidates also referred to a giant covalent structure, apparently overlooking the statement about the oxide conducting electricity in the molten state.

Question 3 (e)

(e) A student is asked to predict and explain the shape of an InH_3 molecule.

The student writes, 'Since the formula, InH_3, is similar to ammonia, NH_3, the shape must be the same, so it is trigonal pyramidal with bond angles of about 107°'.

Discuss the student's statements about InH_3.

Give the supporting chemistry.

....

.... **[3]**

Many candidates did not find the statement of the student easy to discuss. Drawing out dot/cross bonding diagrams for both InH_3 and NH_3 would have made the accompanying explanation in terms of the repulsion between the differing number/type of electron pairs and hence the different bond angles easier to explain.

Question 4 (a) (i)

4 Halons are halogenated organic compounds.

Halons have been particularly useful in aircraft fire extinguishers.

One halon is Halon–1211, $CBrClF_2$.

In the high temperature of a fire one of the bonds in $CBrClF_2$ breaks and radicals are formed.

(a) A student states that it is a C–F bond that breaks because C–F is the most polar of the three carbon-halogen bonds.

The student's statement is partially correct.

(i) Explain, chemically, the correct part of the statement.

....

....

....

.... **[2]**

Many candidates did seem to recognise the identification of the C-F bond being the most polar as correct. However, some did not pick up the second mark through slightly imprecise language; that is, by saying that 'fluorine is highly electronegative' rather than making the point that 'fluorine is the most electronegative'.

Question 4 (a) (ii)

(ii) Correct the incorrect part of the statement, giving a reason for the correction.

....

....

....

.... **[2]**

Many candidates simply stated that it was not the C-F bond that is broken whereas the question required a correction of the incorrect part, that is 'it is the C-Br bond that is broken' followed by the reason that 'the C-Br bond is the weakest'. Many candidates still answered this part by reference to electronegativity. Assessing the correctness or otherwise of a statement made by a student using appropriate chemical ideas is a type of question for which candidates appear to require more practice.

Question 4 (c)

(c) When halons get into the stratosphere, C–C*l* bonds can be broken by UV radiation from the Sun.

The minimum frequency of radiation needed to break one C–C*l* bond is 8.67×10^{14} Hz.

Calculate the bond enthalpy of the C–C*l* bond, in kJ mol^{-1}.

bond enthalpy = ... kJ mol^{-1} **[3]**

A significant number of candidates were successful with this calculation. Where the answer was incorrect the working out is crucial for the award of marks. The clearer this can be set out the better. There are essentially three steps required here, although this order is not essential.

There is the calculation of the energy needed to break just one C-Cl bond, using the Planck constant in $E = h\nu$, ($6.63 \times 10^{-34} \times 8.67 \times 10^{14} = 5.75 \times 10^{-19}$ J.

This then needs to be converted into the energy needed to break one mole of C-Cl bonds by multiplying by the Avogadro Number, ($5.75 \times 10^{-19} \times 6.02 \times 10^{23} = 346042$ J).

The J to kJ conversion is then required.

The clear setting out of the calculation is even more important where numbers in standard form are concerned. A number of candidates overlooked the unit conversion.

A number of candidates seemed to think that the speed of light was involved in the calculation, suggesting a possible confusion with the need to convert to frequency using $\nu = c/\lambda$ if wavelength had been involved.

Question 4 (d)

(d)* Ozone and nitrogen dioxide are present in both the troposphere and the stratosphere.

Describe the advantages and disadvantages of the presence of ozone and how it can be affected by the presence of nitrogen dioxide in the troposphere and stratosphere.

Give equations where appropriate. **[6]**

....

....

Candidates found this LOR question a little less demanding than 1(h) though again there was a tendency for responses to not clearly address what the question was asking for. Some candidates confused the two regions of the atmosphere and the catalytic cycle equations proved a problem for some. Some candidates, possibly not reading the question carefully enough, referred to the role of chlorine radicals in the breakdown of ozone. The role of NO_2 and O_3 in forming photochemical smog in the troposphere was also not well known, with some answers implying that nitrogen dioxide itself formed the smog.

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