OCR
Oxford Cambridge and RSA

Accredited

A Level Chemistry B (Salters)
H433/02 Scientific literacy in chemistry
Sample Question Paper

Date – Morning/Afternoon
Time allowed: 2 hours 15 minutes

You must have:
- the Advance Notice (inserted)
- the Data Sheet for Chemistry B (Salters)

You may use:
- a scientific or graphical calculator

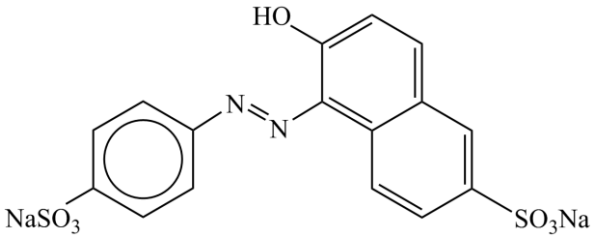
First name	
Last name	
Centre number	
Candidate number	

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **24** pages.

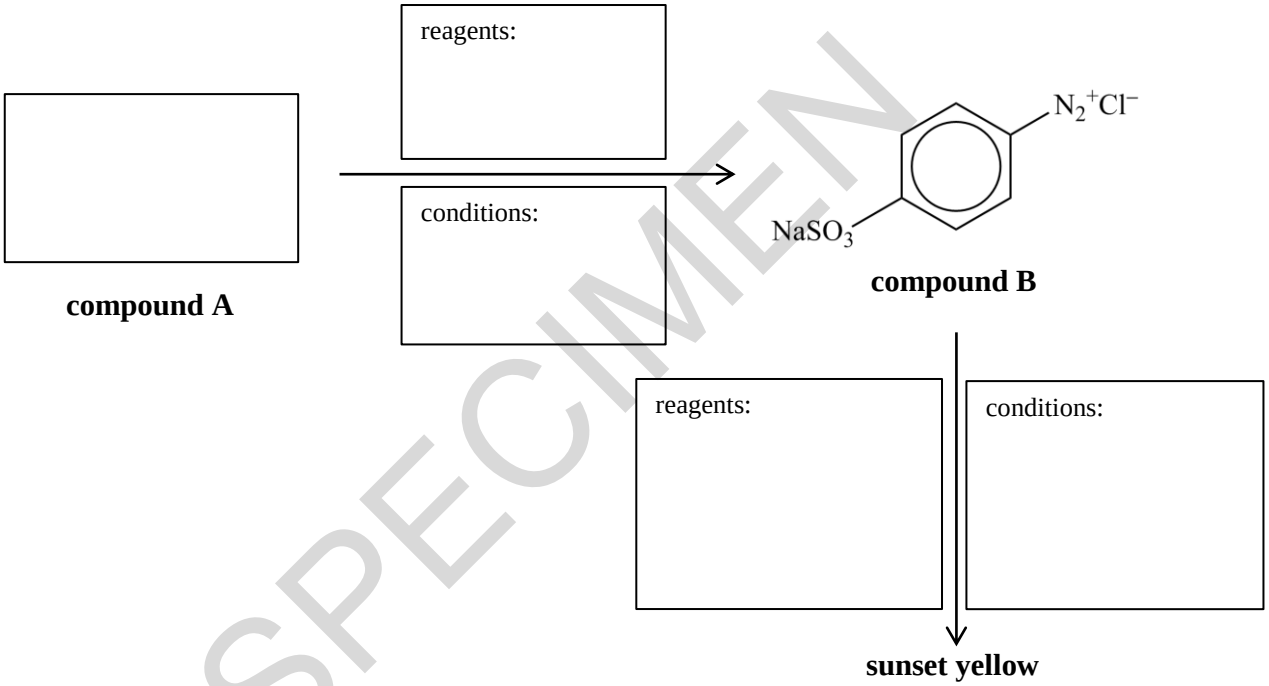
Answer **all** the questions.

1 The azo dye 'sunset yellow' is a food colouring, though its use is being phased out.



sunset yellow

(a) This dye can be made by a synthetic route that is shown, in outline, below.



Complete the diagram by drawing the structure of compound **A**, and giving the reagents and conditions for the reactions. **[5]**

(b) The groups shown as 'SO_3Na' aid the solubility of the dye.

Explain how the SO_3Na groups do this, in terms of bonds broken and made.

……

……

……

……

…… **[4]**

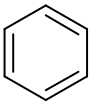
(c) Sunset yellow absorbs blue light of wavelength 450 nm.

Calculate the energy change of this absorption in kJ mol^{-1}.

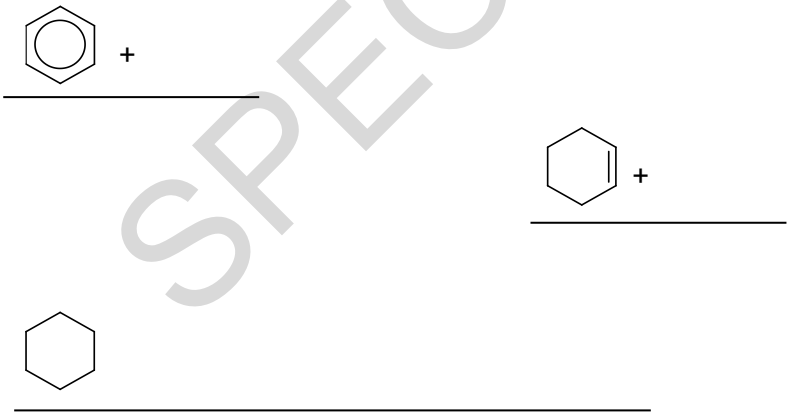
Show **all** your working.

energy change = **……** kJ mol^{-1} **[3]**

(d) Enthalpy changes of hydrogenation show that benzene is **not** best represented as:



Complete and explain the energy level diagram below to show why this is so.



……

…… [2]

(e) A compound similar to compound **B** decomposes in dilute aqueous solution.

$$C_6H_5N_2Cl + H_2O \rightarrow N_2 + HCl + C_6H_5OH$$

Some chemists investigate the rate of this decomposition. They collect the nitrogen gas in a graduated syringe at different initial concentrations of the $C_6H_5N_2Cl$ solution. They time how long it takes for 50 cm^3 of nitrogen to be collected. The volume of solution used in each experiment is 100 cm^3.

(i) Two of the chemists' results are given in the table below.

Initial concentration / mol dm^{-3}	0.020	0.040
Initial rate / mol dm^{-3} s^{-1}	8.70×10^{-7}	1.74×10^{-6}

Use these data to calculate the rate constant for the reaction. Include units in your answer.

Assume that the reaction is zero order with respect to water.

Show **all** your working.

rate = …… units …… **[3]**

(ii) The chemists could have measured the time to produce a much larger volume of nitrogen.

Suggest why it would have been inappropriate to measure the time to collect larger volumes of gas, particularly in the experiments with lower concentrations of $C_6H_5N_2Cl$.

……

……

……

…… **[2]**

(iii) The progress of the reaction can also be followed with a pH meter.

What is the pH of the solution once 50 cm^3 of nitrogen have been collected?

Give your answer to **two** decimal places.

pH = **……** **[2]**

(iv) Besides gas collection and measuring pH, suggest **one** other method with which the chemists could measure the progress of the reaction.

……

…… **[1]**

QUESTION 1 CONTINUES ON PAGE 6

(v) The chemists carried out the reaction at several temperatures and obtained the results in the left-hand two columns of **Table 1.1**.

Table 1.1

Temperature, *T* / K	**rate constant, *k* / s^{-1}**	**1/*T* / K^{-1}**	**ln *k***
278	1.5×10^{-6}	3.60×10^{-3}	–13.41
298	4.1×10^{-5}		–10.10
308	2.0×10^{-4}	3.25×10^{-3}	
323	1.4×10^{-3}	3.10×10^{-3}	–6.57

Calculate the missing values in **Table 1.1** and plot a graph of ln *k* against 1/*T* on the graph paper below.

Use your graph to calculate a value for the activation enthalpy of the reaction.

activation enthalpy = ... kJ mol^{-1}

[5]

2 Concrete contains calcium hydroxide, $Ca(OH)_2$, and is alkaline when damp. The steel reinforcements in concrete do **not** corrode in an alkaline environment. When the calcium hydroxide reacts with carbon dioxide from the air to form calcium carbonate, 'carbonatation' occurs and the pH falls. The increased acidity can cause the steel to corrode.

(a) (i) Write the equation for carbonatation.

[1]

(ii) Calculate the mass of calcium carbonate that is formed when 15 cm^3 of carbon dioxide (measured at room temperature and pressure) react with excess calcium hydroxide.

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

mass = **……** g **[2]**

(b) Carbonatation produces calcium carbonate. The carbonate ion is alkaline in aqueous solution.

(i) Write an equation for the reaction that occurs between the carbonate ion and water.

[1]

(ii) Explain how the carbonatation reaction in **(a)(i)** accounts for the fall in pH.

……

……

…… **[2]**

(c) **(i)** Calculate the pH of a 0.0020 mol dm^{-3} solution of calcium hydroxide.

Show **all** your working.

pH = **……** **[3]**

(ii) Calculate the pH of a 0.0010 mol dm^{-3} solution of carbon dioxide.

$K_a = 4.5 \times 10^{-7}$ mol dm^{-3}

pH = **……** **[2]**

(iii) Explain the approximation that is made in performing the calculation in **(ii)** when $[H^+]$ is low.

……

……

…… **[2]**

(d) The rusting of steel reinforcements can affect the strength of the structure.

(i) Write the half-equations (as equilibria) for the formation of hydroxide ions and Fe^{2+} ions in the first stage of rusting.

[2]

(ii) $Fe(OH)_2$ is oxidised by O_2 to give rust, Fe_2O_3.

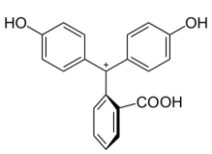
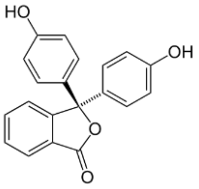
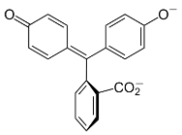
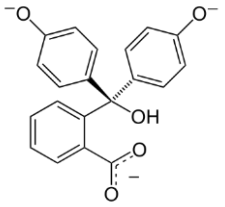
Use this information and your answer from part **(i)** to suggest why iron is less likely to rust in alkaline conditions.

……

……

…… **[3]**

(e) The indicator phenolphthalein can be used to detect carbonatation in concrete.
Phenolphthalein has a variety of related structures, depending on the pH.

Species	**C**	**D**	**E**	**F**
Structure				
pH	<0	0−8.2	8.2−12.0	>12.0
Conditions	strongly acidic	acidic or near-neutral	alkaline	strongly alkaline
Colour	orange	colourless	pink	colourless

(i) Give the colours of phenolphthalein for normal concrete and for concrete that has undergone carbonatation.

normal: ……

carbonatation: …….. **[1]**

(ii) An acid is titrated with a strong alkali using phenolphthalein until the pink colour just persists. If the solution is then allowed to stand in the titration flask it slowly goes colourless.

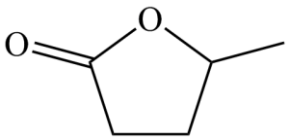
Explain what is happening.

……

……

…… **[2]**

3 The compound 'GMV' is a potential 'green fuel' as it can be made from glucose and can be blended with petrol.



GMV

(a) (i) Write an equation, using molecular formulae, for the complete combustion of GMV to carbon dioxide and water.

[2]

(ii) Calculate the ratio of the masses of carbon dioxide produced by burning equal masses of GMV and hexane.

Show **all** your working.

ratio = **……** **[3]**

(iii) A scientist says that the result in **(ii)** is an indication of the relative effects on the environment when GMV and hexane are used as vehicle fuels.

Discuss this statement.

……

……

…… **[2]**

(b) GMV can be made in the laboratory by reacting a single organic compound with concentrated sulfuric acid.

Give the structure of this organic compound and state how it forms GMV.

……...

…… [2]

QUESTION 3 CONTINUES ON PAGE 14

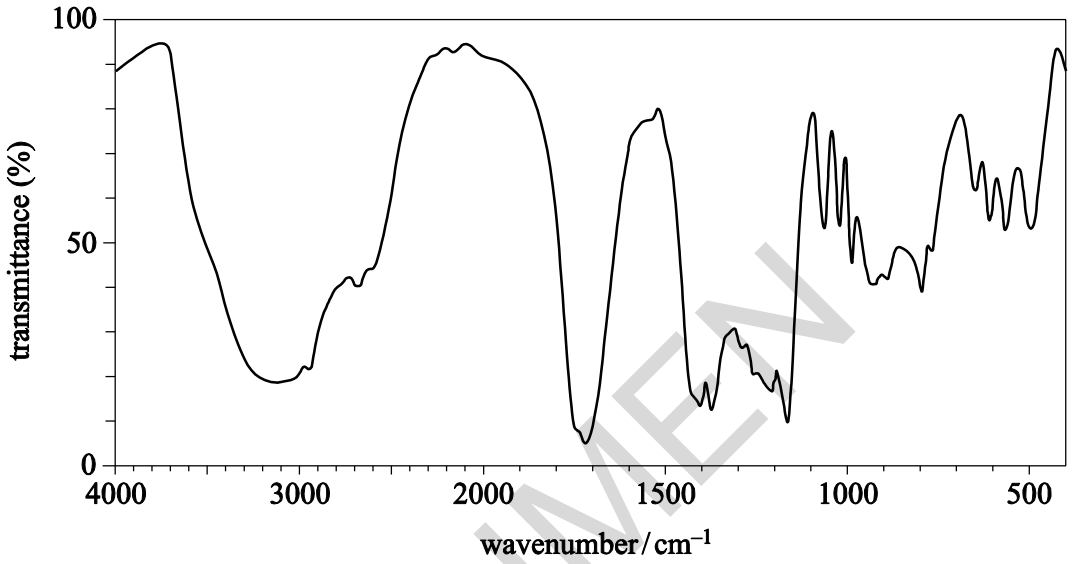
(c)* Compound **G** is an intermediate in the manufacture of GMV from glucose.

Compound **G** has the following composition by mass:

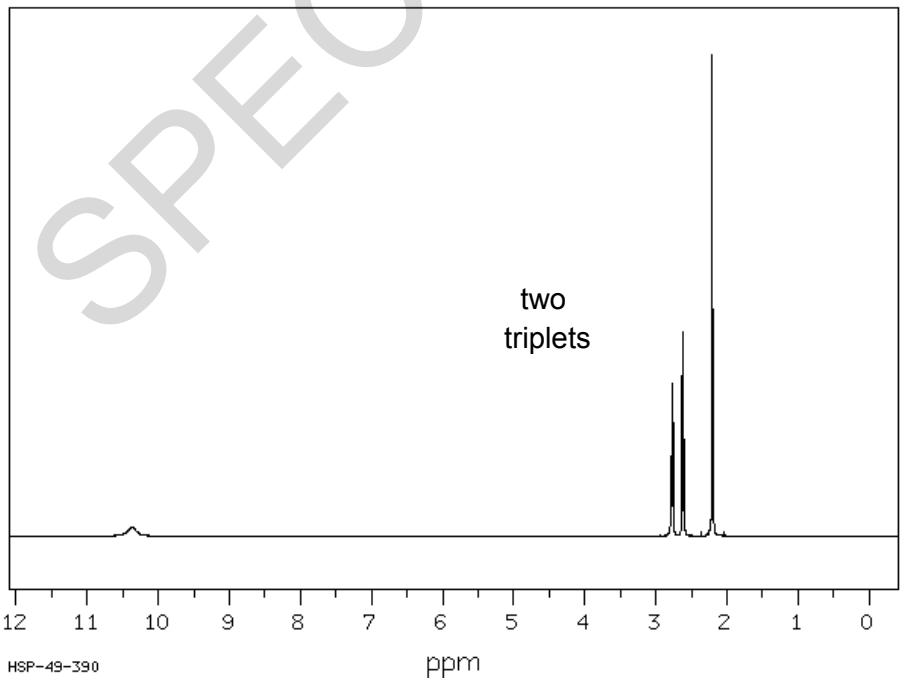
C, 51.72%; H, 6.90%; O, 41.38%

Compound **G** has IR and ^{1}H NMR spectra as shown below.

IR spectrum:



^{1}H NMR spectrum:



Use **all** this information to work out the structure of compound **G.**

In your answer give evidence to support your choice of structure.

……..

……..

……..

……..

……..

……..

……..

……..

……..

…… **[6]**

4 When brass objects are used in the presence of horses, the brass tends to corrode. This is because ammonia from horse urine reacts with copper in the brass to form the soluble compound $[Cu(NH_3)_4]SO_4$.

(a) Draw a diagram to show the square planar shape of the complex ion $[Cu(NH_3)_4]^{2+}$ and give the co-ordination number.

On your diagram name the type of bond joining atoms to the metal ion.

[2]

(b) This complex ion forms when ammonia solution is added to copper(II) sulfate solution.
The equation for the reaction can be represented as below.

$$Cu^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4]^{2+}(aq) \qquad \textbf{Equation 4.1}$$

(i) High concentrations of ammonia in horse's urine can be a sign of infection. Adding a fixed amount of copper(II) sulfate solution to a given volume of urine produces the deep blue/purple ion, $[Cu(NH_3)_4]^{2+}(aq)$ in **equation 4.1**.

Suggest how the production of this ion can be used as a measure of the ammonia content in the horse's urine.

……

…… **[2]**

(ii) Write an equation for the equilibrium constant, K_c, of the reaction in **equation 4.1**.

[1]

(iii) A solution initially contains 0.10 mol dm^{-3} of Cu(II) ions and 0.40 mol dm^{-3} of ammonia. At equilibrium, the concentration of $[Cu(NH_3)_4]^{2+}$ formed is x.

Write an expression for the equilibrium constant K_c in terms of x.

[2]

(iv) Two students wanted to measure the concentration of ammonia in the complex solution at equilibrium. One suggested that they titrate samples of the complex solution with standard sulfuric(VI) acid. The other said the results would be inaccurate.

Comment on who is correct and give a reason for your answer.

……

……

…… **[2]**

(c) Copper(II) ions also form a complex with the bidentate ligand $NH_2–CH_2–CH_2–NH_2$.

Suggest the formula of the complex ion formed with this ligand and give the co-ordination number.

……

…… **[2]**

(d) Copper(II) ions react with iodide ions in aqueous solution to give CuI and I_2.

(i) Write an equation for the reaction.

[1]

(ii) Give the systematic name for CuI.

…… **[1]**

5 This question refers to the Article ***'Sniffing out an Explanation'*** which comes as an insert in this paper.

(a) (i) Draw, in the space below, the **skeletal formula** of the structure you would expect to obtain when ambrinol (**Fig. 2**) reacts with bromine.

[1]

(ii) How many peaks would you expect in the ^{13}C NMR spectrum of ambrinol?

…….. **[1]**

(iii) Give the number of chiral centres in ambrinol.

Explain how you arrived at your answer.

……..

…….. **[2]**

(iv) Discuss whether or not you would expect the enantiomers of ambrinol to smell the same.

…….

…….

…… **[2]**

(b) Describe chemical tests, resulting in colour changes, by which you could distinguish between vanillin, guaiacol and benzaldehyde (**Fig. 3**).

Include a positive reaction for each substance.

……

……

……

……

……

…… **[4]**

(c) Explain the significance of the graph (shown in **Fig. 3**) to Turin's theory.

Give the cause of the peak just above 3000 cm^{-1}.

……..

……..

……..

…….. **[3]**

(d) This part of the question explores Turin's use of isotopes to support his theory.

(i) State the meaning of the term *isotopes*, using the terms *atomic number* and *mass number*.

Give the number of neutrons in an atom of deuterium and an atom of ^{13}C.

meaning: ……..

……..

number of neutrons: ……

[2]

(ii) A sample of carbon dioxide contains 98.89% ^{12}C, the rest being ^{13}C.

Calculate the A_r value for the carbon in the carbon dioxide to **two** decimal places.

A_r = **……** **[1]**

(iii) Draw the **skeletal formula** of 'acetophenone'.

State the difference between this molecule and 'acetophenone-d_8' (**page 5**).

……..

……..

…… **[2]**

(iv)* Discuss examples from the article that support Turin's theory and **not** the 'lock and key' theory.

……..

……..

……..

……..

……..

……..

……..

……..

……..

…….. **[6]**

END OF QUESTION PAPER

BLANK PAGE

BLANK PAGE

OCR
Oxford Cambridge and RSA

Accredited

A Level Chemistry B (Salters)
H433/02 Scientific literacy in chemistry
Sample Advance Notice Article

For issue on or after: Date/Year

NOTES FOR GUIDANCE (CANDIDATES)

1. This leaflet contains an article which is needed in preparation for a question in the externally assessed examination H433/02 Scientific literacy in chemistry.
2. You will need to read the article carefully and also have covered the learning outcomes for A Level in Chemistry B (Salters). The examination paper will contain questions on the article. You will be expected to apply your knowledge and understanding of the work covered in A Level in Chemistry B (Salters) to answer this question. There are 20–25 marks available on the question paper for this question.
3. You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.
4. You will not be able to bring your copy of the article, or other materials, into the examination. The examination paper will contain a fresh copy of the article as an insert.
5. You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

This document consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Insert for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Sniffing out an explanation

By Josh Howgego from The Mole, Issue 6, November 2012.
Published by the Royal Society of Chemistry.

It's strange to think that no one knows exactly how smell works. Josh Howgego explains the chemistry behind the puzzle.

In laboratories up and down the country there are chemists who have the misfortune to work with thiols. Some of these whiffy molecules have a stench so pungent, so disgusting, that they have been known to empty entire buildings when a few drops are spilled in the wrong place.

But why do thiols smell so bad? It doesn't seem to make sense when you consider their structures (Fig. 1). Thiols are the sulfur analogues of alcohols – they look very similar, so what makes their odours different?

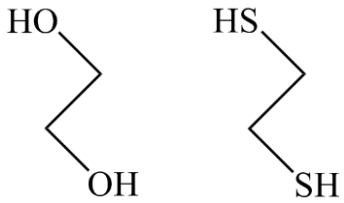


Fig. 1: Ethylene glycol (left) doesn't have much of a smell, but ethane dithiol (right) gives off one of the strongest and most unpleasant stenches known.

The answer is surprisingly complicated, and scientists are still arguing about it. It's strange to think that smell remains a mysterious process.

You would think that vision – which we understand quite well – would be a much more complicated sense than smell. But actually our eyes only have to detect one thing: photons (albeit with different wavelengths). Whereas our noses are chemical sensors: capable of identifying thousands of different molecules.

Smells of the past

Smell has an emotional power over us that the other senses can't emulate. The scent of cut grass on a sunny day can transport us back to memories of childhood, and we are beginning to understand why smell can be so evocative. The brain's olfactory bulb – the first port of call for impulses

from the nose – has a direct neural link to the limbic system, the region of the brain that processes memory and emotions. In contrast the major nerves from all the other senses are routed *via* the thalamus for pre-processing before the information is fully interpreted. That might be because humans have evolved to use mainly sight and touch for day to day activities (and so these inputs need careful attention). Leaving our sense of smell as a more instinctive and subtle guide.

Many animals use smell as a means of communication too. The chemicals that animals secrete as messages are called pheromones. They can be warnings of danger, or even hints that the

sender is on the lookout for a mate. There is little evidence to suggest that humans use pheromones but scientists think our ancestors may have done because there are parts of our nose which are no longer connected up to the brain. These may once have been part of the vomeronasal organ (the part of the nose which detects pheromones), but we have lost the use of it during evolution.

Getting a whiff of the truth

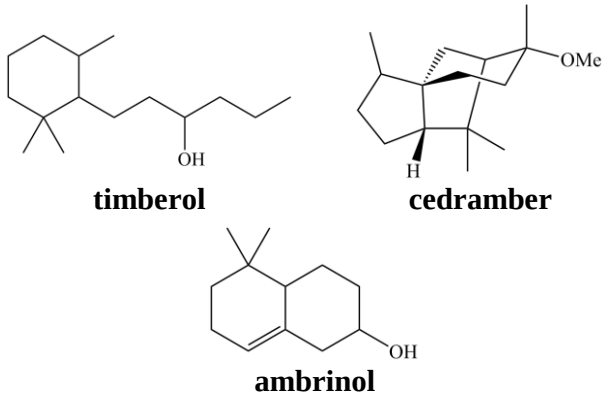
But how do our noses detect chemicals anyway? Early in the 20th century scientists thought that olfactory receptors worked much like any other enzyme or protein: they have a well-defined three-dimensional structure and a specifically shaped cleft in the middle. Only molecules with a complementary shape are able to fit inside the cleft, and so the idea became known as the 'lock and key' theory, because of the shape-dependent way the receptor and small molecule fit together.

You can imagine the nose like a dungeon with hundreds of locked doors leading to the brain (an analogy that works quite well, given the dark and slimy nasal environment). When a molecule wafts into the chamber it can only unlock a specific door, and the passage it activates tells the brain the identity of the intruder.

But alas, the concept of olfactory receptors being like locks has seemed over-simplified for decades. Molecules that have similar shapes would be expected to open the same locks, but as we've already seen (Fig. 1), structurally related molecules can smell utterly different. On the other hand, it's not clear how timberol, cedramber and ambrinol (Fig. 2) could unlock the same smell receptors when they have such dissimilar structures, yet all three smell very alike.

Shaking possible answers out

Luca Turin, a Lebanon-born biophysicist fascinated with the mechanisms of smell, came up with an innovative theory to explain all this in 1996. It's not just the molecule's shape that's important, according to Turin, but also how it vibrates once inside the receptor's binding pocket. If it oscillates in just the right way it encourages an electron to 'jump' from one part of the receptor



timberol **cedramber** **ambrinol**

Fig. 2: Three structurally different molecules which all smell very similar

protein to another (in a process called quantum tunnelling), and this sets off a nerve impulse.

Turin's theory can potentially explain the different scents of molecules with the same shape but different atoms. The vibrations of any given bond are decided not only by geometry, but also by the mass of the atoms at either end. Sulfur and oxygen are different sizes, so thiol and alcohol functional groups have different vibrational signatures.

Like all good theories, Turin's made some predictions about smell that could be tested. One was that even subtle differences in atomic mass in similar molecules should result in odour variations. He stated, for example, that acetophenone and its deuterated analogue (acetophenone-d_8) smell a little different (see 'Subtle vibrations').

In 2001 scientists from Canada set out to check if this 'isotopes smell different' rule would hold for a similar compound, benzaldehyde. They found that trained noses could distinguish regular and deuterated benzaldehyde quite easily. The two compounds smell similar (like 'bitter almonds'), but not quite the same.

Interestingly, when they tried varying the isotope of carbon in the molecule (from regular ^{12}C to ^{13}C) people could detect a difference less often. That adds up, because the percentage mass difference between ^{12}C and ^{13}C is small, and would understandably affect the overall vibrations of the molecule less than the doubling of mass incurred when ^{1}H is substituted with ^{2}H. The results seemed to support Turin's theory nicely.

But unfortunately this was not to be a case where the scientists all happily agreed with one another. In 2004 another team of scientists looked at Turin's claim about acetophenone and acetophenone-d_8, and disagreed with him: finding that, in general, their test subjects couldn't distinguish the two molecules.

Adding up to a big stink

They also looked at another prediction of Turin's theory – that molecules can add up to produce smells which none of the individual molecules give off in isolation. The classic example is a 1:1 mixture of benzaldehyde and guaiacol. Looking at these molecules (Fig. 3), it is obvious that a mixture would contain the same functional groups as vanillin overall (aldehyde, methyl ether and phenol), but they wouldn't add together to make something the same shape as vanillin (it would be nearly twice as big). Turin says that the 1:1 mixture does smell of vanilla though, adding that 'the illusion is not perfect, but it is striking, because the vanilla character is absent from the components'.

The scientists then set out to test Turin's reports themselves. They asked a group of test subjects to rate vials containing guaiacol, benzaldehyde, and a 1:1 mixture of the two on a scale from 1 (no vanilla character) to 13 (extremely vanilla). They tried the test at various concentrations, but at no point did the subjects find the 1:1 mixture more vanilla-like than either of the separate components. This apparently disproved another of Turin's findings. The team ended their report of the study saying that 'molecular vibrations alone cannot explain the perceived smell of an odorous chemical'.

Vanillin is extracted from vanilla pods – but can its smell be recreated from a mix of two other compounds?

To date, scientists still don't agree on why similarly shaped molecules can smell so different, but we are certainly closer to the answer than we were before Turin's hypothesis. His ideas may not be fully correct, but they have prompted people to ask some interesting questions that may eventually lead us to the answers.

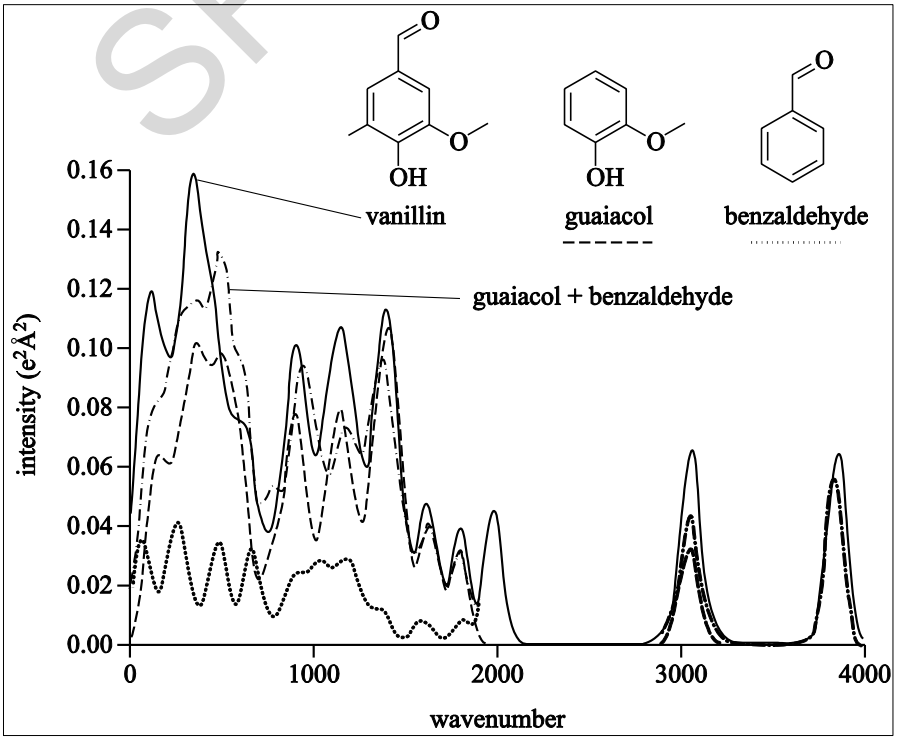
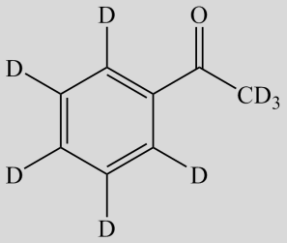


Fig. 3

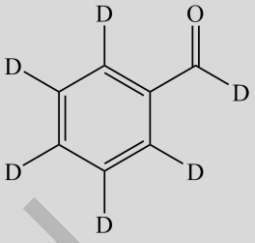
Subtle vibrations

The mass of the two atoms at either end of a chemical bond helps determine the frequency at which it vibrates. It's a little like a guitar string; if the atoms are heavier, they pull the 'string' taut and the vibration occurs at a higher pitch.

An easy way to change the mass of atoms without changing the shape of the parent molecule is to use isotopes; atoms which have the same number of protons but a different number of neutrons. Turin stated in the 1990s that acetophenone-d_8, which has all its protons (^1H) replaced with deuterium (^2H), smells slightly different from the natural, all-hydrogen analogue.



acetophenone-d_8



benzaldehyde-d_6

END OF ADVANCE NOTICE ARTICLE

BLANK PAGE

BLANK PAGE

OCR
Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

This document consists of 20 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

Once the level is located, award the higher or lower mark.

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

- **The science content determines the level.**
- **The communication statement determines the mark within a level.**

Level of response questions on this paper are **3(c) and 5(d)(iv)**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument
✓	Marking point

12. **Subject-specific Marking Instructions**

INTRODUCTION

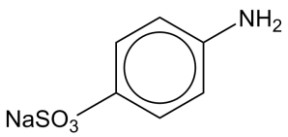
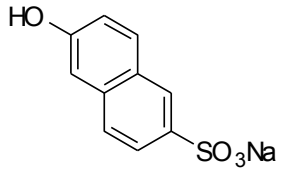
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

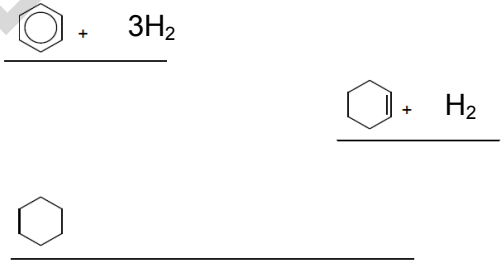
- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	Guidance
1	(a)		Compound **A**:  ✓ *First reaction:* *Reagents:* HC*l*/H^+ and $NaNO_2$ **OR** HNO_2 ✓ *Condition:* below 5 °C ✓ *Second reaction:* *Reagents/conditions:*  ✓ NaOH ✓	5	**ALLOW** names (including 'nitrite', 'nitrous acid') **ALLOW** $–O^–$ for –OH **ALLOW** NaOH as reagent or condition **IGNORE** temperature for second reaction
	(b)		$–SO_3^–$ groups (formed by dissociation of $NaSO_3$) ✓ form ion–dipole bonds with water ✓ energy released by bond formation greater than required for bonds broken (**AW**) ✓ (these are) hydrogen bonds between water molecules **OR** ionic bonds between ions ✓	4	

Question			Answer	Marks	Guidance
	(c)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** Energy change = 266 (kJ mol^{-1}) award 3 marks ΔE for absorption by 1 atom = hc/λ ΔE for absorption in kJ mol^{-1} = $hcN_A/1000\lambda$ ✓ $= \frac{6.63\times10^{-34}\times3.00\times10^{8}\times6.02\times10^{23}}{10^{3}\times450\times10^{-9}}$ ✓ = 266 (kJ mol^{-1}) ✓	3	**First and second marks can be scored by correctly substituted figures into the expressions.**
	(d)		$3H_2$ on top left line and H_2 on top right line ✓ indication that left-hand side is less than 3 × right-hand side **OR** that gap between benzene and cyclohexene is less than three times value for cyclohexene ✓	2	
	(e)	(i)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** rate =4.35×10^{-5} award 2 marks rate =4.35×10^{-5} **AND** units = s^{-1} award 3 marks rate doubles with concentration so reaction 1st order to $C_6H_5N_2Cl$ rate = $k[C_6H_5N_2Cl]$ ✓ k = rate / $[C_6H_5N_2Cl]$ = 4.35×10^{-5} ✓ s^{-1} ✓	3	Answer can be calculated using either data set.
		(ii)	only know concentration at start/initial concentration ✓ (therefore) collecting larger volumes would not give initial rate ✓	2	**IGNORE** references to actual percentages

Question			Answer	Marks	Guidance
		(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** pH = 1.68 (2 d.p.) award 2 marks $n(N_2)$ = 0.050 / 24.0 = 0.00208 mol concentration HCl = 0.00208 × 10 = 0.0208 mol dm^{-3} ✓ pH = 1.68 (2 d.p.) ✓	**2**	
		(iv)	*One from* ✓ (Measure) loss of mass Titrate HCl	**1**	
		(v)	two missing values: 3.36 × 10^{-3} and –8.52 ✓ axes drawn, labels correct *x*-axis: 1/*T* / K^{-1} *y*-axis: ln *k* scales that use over half of each axis ✓ all points plotted correctly with best straight line drawn through points ✓ measurement of slope (1.33 ± 0.05 × 10^4) ✓ multiplication by 8.314, division by 10^3 and change of sign to give E_a in kJ units [+111 (kJ mol^{-1})] ✓	**5**	units of 1/*T* can be missing **ALLOW** no sign but not minus sign for last mark **ALLOW** 2 or more sig figs **ALLOW** any answer rounding to 106–115 (calculated correctly from slope)
			Total	**27**	

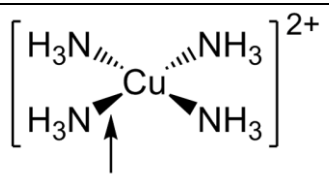
Question			Answer	Marks	Guidance
2	(a)	(i)	$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$ ✓	1	**IGNORE** state symbols
		(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** mass = 0.0625 award 1 mark mass = 0.063 g to 2 sig figs award 2 marks moles CO_2 = 15/24000 **OR** 6.25×10^{-4} ✓ mass $CaCO_3$ = ($6.25 \times 10^{-4} \times 100$) = 0.063 g to 2 sig figs ✓	2	**ALLOW ECF** from first marking point
	(b)	(i)	$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-$ **OR** $CO_3^{2-} + H_2O \rightarrow CO_2 + 2OH^-$ ✓	1	**ALLOW** equilibrium signs **IGNORE** state symbols
		(ii)	$CaCO_3$ is less soluble/weaker base than $Ca(OH)_2$ ✓ so fewer $OH^-(aq)$ ions are present (as $Ca(OH)_2$ reacts / $CaCO_3$ forms) ✓	2	
	(c)	(i)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** pH = 11.6 award 3 marks $[OH^-] = 2 \times 0.002 = 0.004$ (mol dm^{-3}) ✓ $[H^+] = (1 \times 10^{-14}/4 \times 10^{-3} =) 2.5 \times 10^{-12}$ (mol dm^{-3}) ✓ pH = 11.6 ✓	3	**ALLOW ECF** on third marking point from a given $[H^+]$, provided pH is between 10 and 13
		(ii)	$[H^+] = 2.1 \times 10^{-5}$ (mol dm^{-3}) ✓ pH = 4.7 ✓	2	
		(iii)	contribution of $[H^+]$ from water ✓ 1×10^{-7} insignificant compared to (**AW**) 2×10^{-5} ✓	2	

Question			Answer	Marks	Guidance
	(d)	(i)	$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$ ✓ $Fe \rightleftharpoons Fe^{2+} + 2e^-$ ✓	2	**ALLOW** 'e' without minus **IGNORE** state symbols **ALLOW** ½ or ¼ equation for OH^-
		(ii)	high $[OH^-]$ pushes first equilibrium to left (**AW**) ✓ electrons (formed) push second equilibrium to left ✓ so less Fe^{2+} (and hence rust) formed ✓	3	
	(e)	(i)	(normal) pink; (after carbonatation) colourless ✓	1	both answers required for mark
		(ii)	CO_2 from air is reacting with water to form H^+ ✓ turning (the structure of phenolphthalein) from **E** to **D** ✓	2	
			Total	21	

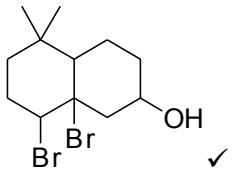
Question			Answer	Marks	Guidance
3	(a)	(i)	$C_5H_8O_2 + 6O_2 \rightarrow 5CO_2 + 4H_2O$ Correct molecular formula of GMV ✓ Balanced equation (with **ECF**) ✓	2	**IGNORE** state symbols
		(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** ratio = 1 : 1.4 or more sig figs (1.395….) award 3 marks mass CO_2 per mole GMV = 5 × 44 = 220 g mass CO_2 per mole hexane = 6 × 44 = 264 g ✓ M_r values GMV 100; hexane 86 ✓ ratio (220/100) : (264/86) = 1 : 1.40 ✓	3	**OR** moles CO_2 per mole fuel **ALLOW ECF** from first marking point
		(iii)	Comparison of CO_2 is important as it is a greenhouse gas/contributes to global warming ✓ Should be CO_2 per kJ released on burning (**AW**) ✓	2	
	(b)		$CH_3CH(OH)CH_2CH_2COOH$ ✓ internal ester formation (**AW**) ✓	2	**ALLOW** any unambiguous representation of structure

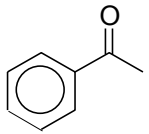
Question	Answer	Marks	Guidance
(c)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Candidate identifies the structure of the compound correctly, the evidence for this identification uses information from composition by mass **AND** IR spectrum **AND** proton NMR spectrum. *The identification is clear and logically structured. The evidence selected is relevant and fully supports the identification.* **Level 2 (3–4 marks)** Candidate identifies the compound as a keto-acid, the evidence for this identification uses information from composition by mass **AND EITHER** IR spectrum (both points) **OR** proton NMR spectrum **OR** using information from IR spectrum **AND** proton NMR spectrum. *The identification has a logical structure. The evidence selected is in the most-part relevant and supports the identification.* **Level 1 (1–2 marks)** Candidate makes an attempt at identifying the compound and the evidence to support this identification uses **EITHER** information from composition by mass **OR** IR spectrum **OR** proton NMR spectrum. *The identification is basic and communicated in an unstructured way. The evidence selected is limited and the relationship to the identification may not be clear.*	**6**	**Indicative scientific points may include:** Compound is $CH_3COCH_2CH_2COOH$ **Composition by mass**: • $C_5H_8O_3$ calculated. **IR spectrum:** • COOH from IR at 3200–3600 (• no OH at 3200–3600/3640). **Proton NMR: (any 3)** • 4 proton environments • peak at 10.5 indicates COOH • peaks at 2.2–2.7 indicate (three) Cs next to (a single) C=O • singlet at 2.2 indicates C with no Hs on adjacent carbons **AND** triplets at 2.6 and 2.8 indicate Cs with one adjacent CH_2.

Question			Answer	Marks	Guidance
			0 marks No response or no response worthy of credit.		
			Total	**15**	

Question			Answer	Marks	Guidance
4	(a)		 Structure ✓ Bond name ✓	2	**IGNORE** 2+ **ALLOW** a flat structure, i.e. viewed from above
	(b)	**(i)**	intensity of colour **OR** absorbance of (suitable wavelength) light ✓ gives a measure of concentration (of complex/ammonia) **OR** (directly) proportional to concentration (of complex/ammonia) ✓	2	
		(ii)	= $\frac{[[Cu(NH_3)_4]^{2+}]}{[Cu^{2+}][NH_3]^4}$ ✓	1	
		(iii)	$\frac{x}{(0.1-x)(0.4-4x)^4}$ correct apart from a wrong value for $[NH_3]$ ✓ $(0.4 - 4x)$ for $[NH_3]$ ✓	2	**ALLOW ECF** from **(ii)**
		(iv)	Inaccurate / second student correct because Reaction of (OH^- in) ammonia solution with H_2SO_4 causes equilibrium to move so all the ammonia is neutralised (**AW**) **OR** equilibrium **4.1** shifts to the left as the acid reacts with the ammonia ✓ so titre / measured concentration will be too large ✓	2	

Question			Answer	Marks	Guidance
	(c)		$Cu(C_2H_8N_2)_2^{2+}$ ✓ 4 ✓	2	**ALLOW** a more structured formula for ethane diamine 2+ must be present **ALLOW** $Cu(C_2H_8N_2)_3^{2+}$ ✓ 6 ✓
	(d)	(i)	$Cu^{2+} + 2I^- \rightarrow CuI + ½ I_2$ **OR** doubled ✓	1	**IGNORE** state symbols
		(ii)	copper(I) iodide ✓	1	**ALLOW** a gap between 'copper' and '(I)'
			Total	13	

Question			Answer	Marks	Guidance
5	(a)	(i)	 ✓	1	**ALLOW** any unambiguous formula clearly displaying the structure of the compound.
		(ii)	11 ✓	1	
		(iii)	two ✓ (because ambrinol has two) asymmetric carbon atoms / carbon atoms surrounded by 4 different groups ✓	2	
		(iv)	yes, because same bonds ✓ hence same vibrations ✓	2	**ALLOW**: no, based on analogy with named compound ✓ (e.g. carvone) for which enantiomers smell different ✓
	(b)		vanillin and guaiacol are phenols ✓ purple colour with $FeCl_3$ ✓ benzaldehyde and vanillin are aldehydes ✓ acid dichromate goes green **OR** Tollens' reagent **OR** $AgNO_3$ and NH_3 ... give silver (mirror) **OR** Fehlings solution gives red precipitate ✓	4	
	(c)		IR spectrum that shows how bonds vibrate ✓ Shows similarity between spectra of vanillin and combination of guaiacol and benzaldehyde (**AW**) ✓ C–H in arenes ✓	3	

Question			Answer	Marks	Guidance
	(d)	(i)	(atoms with) same atomic number **AND** different mass number ✓ 1 and 7 ✓	2	must mention both terms
		(ii)	12.01 ✓	1	
		(iii)	 ✓ all hydrogen atoms replaced with deuterium atoms ✓	2	Correct **skeletal** formula required. **ALLOW** 'H'/'proton' for 'hydrogen atom' and 'D' for deuterium atom To score, answer must state that all the atoms are replaced.
		(iv)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Supporting evidence for Turin's theory **AND** evidence to discredit the lock and key theory have been correctly identified. There is a clear discussion related to both theories. *The evidence selected is relevant and substantiated. The discussion shows a well-developed line of reasoning for the choices of evidence, which is clear and logically structured.* *Candidate demonstrates a clear and confident knowledge of relevant technical language (names of compounds, 'deuterated', 'vibrate').* **Level 2 (3–4 marks)**	6	**Indicative scientific points may include:** **Statements to support Turin's theory** • deuterated acetophenone smells different (from non-deuterated form) • deuterated benzaldehyde smells different (from non-deuterated form) • because H and D have different masses and hence C–D and C–H vibrate differently • C^{12} and C^{13} exchange does not affect smell, since masses only differ slightly • structures of deuterated acetophenone and benzaldehyde given.

Question			Answer	Marks	Guidance
			Supporting evidence for Turin's theory **AND** evidence to discredit lock and key theory have been correctly identified although there is a limited attempt to discuss them. *The evidence selected is in the most-part relevant.* *The discussion has some structure but is limited in scope.* *Candidate demonstrates a sound grasp of technical language (one spelling error).* **Level 1 (1–2 marks)** Evidence for Turin's theory has been identified **OR** Evidence against lock and key theory *The information is supported by limited evidence and the relationship to the evidence may not be clear. The discussion is basic and communicated in an unstructured way.* *Candidate demonstrates a basic grasp of relevant technical language (several spelling errors).* **0 marks** No response or no response worthy of credit.		**Statements to discredit Lock and Key** • since structures are similar, lock and key theory would not predict difference (**AW**). • structurally related molecules can smell utterly different.
			Total	**24**	

BLANK PAGE