

# Advanced Subsidiary GCE Subject Chemistry B (Salters)

## Unit F335: Chemistry by Design - Medium banded Candidate style answer

### Introduction

OCR has produced these candidate style answers to support teachers in interpreting the assessment criteria for the new GCE specifications and to bridge the gap between new specification release and availability of exemplar candidate work.

This content has been produced by senior OCR examiners, with the input of Chairs of Examiners, to illustrate how the sample assessment questions might be answered and provide some commentary on what factors contribute to an overall grading. The candidate style answers are not written in a way that is intended to replicate student work but to demonstrate what a “good” or “excellent” response might include, supported by examiner commentary and conclusions.

As these responses have not been through full moderation and do not replicate student work, they have not been graded and are instead, banded “medium” or “high” to give an indication of the level of each response.

Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

<b>1 Hydrogen is used to make ammonia, an important agricultural chemical.</b> $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ <b>equation 1.1</b> <b>Ammonia is used to make fertilisers.</b> <b>(a)(i) Suggest the cheapest source for the nitrogen gas used in equation 1.1. [1]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
the air	This candidate has made a good start. Parts (i), (ii) and (iv) are correct.
<b>(ii) Ammonium nitrate, NH<sub>4</sub>NO<sub>3</sub>, is a fertiliser made from ammonia. [2]</b> <b>Calculate the percentage by mass of nitrogen in NH<sub>4</sub>NO<sub>3</sub>.</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
$28 \times 100/80 = 35\%$	
<b>(iii) Ammonium sulfate is another fertiliser. [1]</b> <b>Write the formula of ammonium sulfate.</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
NH <sub>4</sub> SO <sub>4</sub>	The formula in part (iii) is wrong. Sulfate is SO <sub>4</sub> <sup>2-</sup> so the formula is (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> . Learn the charges on ions!

<b>(iv) Explain <u>one</u> advantage and <u>one</u> disadvantage of adding ammonium salts to the soil.</b> [2]	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
advantage: they provide nutrients for plants disadvantage: they get washed away causing pollution	

<b>(b) Hydrogen is produced industrially from methane by steam reforming as shown below.</b>									
<b>CH<sub>4</sub>(g) + H<sub>2</sub>O(g) ⇌ CO(g) + 3H<sub>2</sub>(g) <span style="float: right;"><i>equation 1.2</i></span></b>									
<b>(i) Write an expression for K<sub>c</sub> for the reaction in <i>equation 1.2</i>.</b> [2]									
<i>Candidate style answer</i>	<i>Examiner's commentary</i>								
K <sub>c</sub> = [CO][H <sub>2</sub> ] <sup>3</sup> / [CH <sub>4</sub> ][H <sub>2</sub> O]	The statement of K <sub>c</sub> is fine.								
<b>(ii) At the temperature of the reaction, K<sub>p</sub> = 292 mol<sup>2</sup> dm<sup>-6</sup>. The concentrations of some of the gases present in an equilibrium mixture at this temperature were measured and are given in the table.</b>									
<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>gas</th> <th>concentration/ mol dm<sup>-3</sup></th> </tr> </thead> <tbody> <tr> <td>CH<sub>4</sub></td> <td>5.00</td> </tr> <tr> <td>H<sub>2</sub>O</td> <td>5.00</td> </tr> <tr> <td>H<sub>2</sub></td> <td>12.0</td> </tr> </tbody> </table>		gas	concentration/ mol dm <sup>-3</sup>	CH <sub>4</sub>	5.00	H <sub>2</sub> O	5.00	H <sub>2</sub>	12.0
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CH <sub>4</sub>	5.00								
H <sub>2</sub> O	5.00								
H <sub>2</sub>	12.0								
<b>Calculate the concentration of carbon monoxide under these conditions. Give your answer to a <u>suitable</u> number of significant figures.</b> [3]									
<i>Candidate style answer</i>	<i>Examiner's commentary</i>								
$[\text{CO}] = K_c \frac{[\text{CH}_4][\text{H}_2\text{O}]}{[\text{H}_2]^3}$ $= 292 \times 5 \times 5 / 36 = 202.8 \text{ mol dm}^{-3}$	The rearranged formula at the start of part (ii) is correct, so 1 mark is scored. However 12 <sup>3</sup> is not 36, so the second mark is lost. If the candidate had put the answer to three significant figures - 203 (as the data) the third mark would have been scored, even though the answer is wrong. However, an incorrect four significant figures was decided upon.								

<b>(c)(i) Use le Chatelier's principle to predict the effect of <u>decreasing</u> the pressure on the yield of hydrogen in <i>equation 1.2</i></b> [3]	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
The reaction moves in the direction of more moles. So a lower yield.	In part (i), it is vital to talk about the equilibrium position moving, not the reaction. So the candidate loses the marks for 'the equilibrium position moves to the right' but also for 'more moles on the right' since this is not made clear. One mark is scored for 'higher yield'.

<b>(ii) Suggest a reason why a pressure of around 30 atm is actually used for the process.</b> [1]	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
To increase the yield without costing too much.	In part (ii), the candidate has jumped to conclusions and scores nothing. For this reaction, the lowest pressure is needed to get the best yield and a higher pressure will make the reaction go faster. That, then, is the compromise.

<b>CH<sub>4</sub>(g) + H<sub>2</sub>O(g) ⇌ CO(g) + 3H<sub>2</sub>(g)</b> <span style="float: right;"><b>equation 1.2</b></span>	
<b>(d) The mixture of gases from the reaction in equation 1.2 is mixed with more steam and passed over a hot iron catalyst. The carbon monoxide is converted to carbon dioxide.</b>	
<b>(i) Write an equation for the reaction of carbon monoxide with steam.</b> [1]	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
CO + H <sub>2</sub> O → CO <sub>2</sub> + H <sub>2</sub>	The equation is correct.
<b>(ii) Suggest <u>two</u> reasons why the carbon monoxide is <u>not</u> released into the atmosphere.</b> [2]	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
It is harmful to humans and causes pollution	In part (ii), the candidate scores for 'harmful to humans' but 'pollution' is far too vague to score.

<b>(e)(i) Predict the sign of ΔS<sub>sys</sub> for the forward reaction in equation 1.2. Explain your reasoning.</b> [1]											
<i>Candidate style answer</i>	<i>Examiner's commentary</i>										
It will be +, since there are more molecules on the right	The candidate has got part (i) correct.										
<b>(ii) Use the entropy data given in the table below to calculate the value of ΔS<sub>sys</sub> (with the correct sign) for the forward reaction in equation 1.2.</b> [3]											
<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>compound</th> <th>S / J K<sup>-1</sup> mol<sup>-1</sup></th> </tr> </thead> <tbody> <tr> <td>CH<sub>4</sub>(g)</td> <td>+186</td> </tr> <tr> <td>H<sub>2</sub>O(g)</td> <td>+189</td> </tr> <tr> <td>CO(g)</td> <td>+198</td> </tr> <tr> <td>H<sub>2</sub>(g)</td> <td>+131</td> </tr> </tbody> </table>		compound	S / J K <sup>-1</sup> mol <sup>-1</sup>	CH <sub>4</sub> (g)	+186	H <sub>2</sub> O(g)	+189	CO(g)	+198	H <sub>2</sub> (g)	+131
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<i>Candidate style answer</i>	<i>Examiner's commentary</i>										
131 + 198 - 189 - 186 = -46 J K <sup>-1</sup> mol <sup>-1</sup>	In part (ii), the fact that there are 3H <sub>2</sub> has been forgotten, thus 131 should have been multiplied by 3. Since the method and the answer with sign (with 'error carried forward') are correct, the candidate scores two out of three.										

<p>(iii) At 500 K the value of <math>\Delta S_{\text{tot}}</math> for the forward reaction is <math>-1784</math>.          Calculate the value of <math>\Delta S_{\text{tot}}</math> at 1000 K.          Assume that <math>\Delta S_{\text{sys}}</math> does not change with temperature. [2]</p>	
<p><i>Candidate style answer</i></p> <p><math>-1784 = +216 - \Delta H/500</math>  <math>\Delta S = +1216 \text{ J K}^{-1} \text{ mol}^{-1}</math></p>	<p><i>Examiner's commentary</i></p> <p>In part (iii), full working is not shown. The first expression is correct but the first mark required the evaluation of <math>\Delta H</math>. Then the candidate misapplies the formula but does not show the working and so scores nothing.</p>

<p>2 The pigment chrome yellow consists of lead chromate(VI), <math>\text{PbCrO}_4</math>. It is made by precipitation when solutions of lead nitrate and sodium chromate(VI) are mixed.</p>	
<p>(a) Explain why (VI) is used to describe the <math>\text{CrO}_4^{2-}</math> ion. [1]</p>	
<p><i>Candidate style answer</i></p> <p>Chromium has an oxidation state of +6</p>	<p><i>Examiner's commentary</i></p> <p>The right answer.</p>

<p>(b) Write an <u>ionic</u> equation for the precipitation of lead chromate(VI), showing state symbols. [2]</p>	
<p><i>Candidate style answer</i></p> <p><math>\text{Pb}^{+}(\text{aq}) + \text{CrO}_4^{-}(\text{aq}) \rightarrow \text{PbCrO}_4(\text{s})</math></p>	<p><i>Examiner's commentary</i></p> <p>Here the charges on the ions are wrong. The charge on the chromate ion is given in part (a) – keep your eyes open for such useful pieces of information. One mark would have been awarded for the state symbols.</p>

<p>(c) Pigments can be identified by their visible reflectance spectra. The spectra of three pigments are shown below, lettered A, B and C.</p>	
<p>The figure contains three separate graphs, each with 'reflectance (%)' on the vertical axis and 'wavelength/nm' on the horizontal axis. The horizontal axis for all graphs is marked with values 400, 500, 600, and 700. Graph A shows a curve that starts at a high reflectance value at 400 nm and gradually decreases as the wavelength increases, reaching a very low reflectance value at 700 nm. Graph B shows a curve that starts at a low reflectance value at 400 nm and increases steadily as the wavelength increases, reaching a high reflectance value at 700 nm. Graph C shows a curve that remains at a low, constant reflectance level until about 500 nm, then rises to a sharp peak at approximately 580 nm, before falling back to the low, constant reflectance level by 700 nm.</p>	
<p>State, with a reason, which is the reflectance spectrum of chrome yellow. [2]</p>	
<p><i>Candidate style answer</i></p> <p>C because it reflects around 600</p>	<p><i>Examiner's commentary</i></p> <p>Yes, this is enough to score both marks.</p>

(d) The diagram below helps to explain the yellow colour of the chromate ion.

(i) Which electron sub-shell is shown in the diagram? [1]

<i>Candidate style answer</i>	<i>Examiner's commentary</i>
3d	Part (i) is correct.

(ii) What causes the splitting of the orbitals within the sub-shell? [1]

<i>Candidate style answer</i>	<i>Examiner's commentary</i>
the complex ions	In part (ii) it is the ligands that cause the splitting of the orbitals and this must be stated.

(e) A painting is being analysed. Four yellow pigments it might contain are shown below.

- barium yellow, BaCrO<sub>4</sub>;
- cadmium yellow, CdS;
- orpiment, As<sub>2</sub>S<sub>3</sub>;
- yellow ochre, containing Fe<sub>2</sub>O<sub>3</sub>.

(i) Give the systematic name of the compound contained in yellow ochre. [1]

<i>Candidate style answer</i>	<i>Examiner's commentary</i>
iron oxide	Part (i) is not full enough to score. Iron(III) oxide is needed;

(ii) One method of identifying pigments is to use atomic emission spectroscopy. Part of a simplified atomic emission spectrum of the pigment is shown below.

Explain why the emissions occur at specific frequencies.  
 Include a diagram in your answer.  
 In your answer, you should make clear how the observed effect depends on the explanation. [4]

<i>Candidate style answer</i>	<i>Examiner's commentary</i>
<div style="display: flex; align-items: center;"> <div style="flex: 1;"> </div> <div style="flex: 2; padding-left: 20px;"> <p>electron falling energy levels emits light. The frequency depends on the energy level</p> </div> </div>	In part (ii), marks are scored for the electron falling and the lines being described as energy levels.

(iii) Use the data in the table below to identify the element and hence the systematic name of the pigment. [2]

element	certain characteristic emissions/nm
Ba	233.5
Cd	228.8 226.5
As	228.8 235.0
Fe	238.2 239.7

Candidate style answer	Examiner's commentary
cadmium    cadmium sulfate	Part (iii) scores a mark for cadmium, but it is cadmium sulfide not sulfate.

(f) Lead chromate(VI) is insoluble because it has an enthalpy change of solution of +17 kJ mol<sup>-1</sup>. An estimate of the lattice enthalpy of lead chromate is -1000 kJ mol<sup>-1</sup>.  
 (i) Complete the diagram to illustrate this by drawing and labelling suitable enthalpy levels and inserting the given values. [3]

Candidate style answer	Examiner's commentary
<p>The diagram shows an upward-pointing arrow on the left labeled 'enthalpy'. Three horizontal lines represent energy levels. The top line is labeled <math>Pb^{2+}(g) + SO_4^{2-}(g)</math>. The middle line is labeled <math>PbCrO_4(s)</math>. The bottom line is labeled <math>PbSO_4(aq)</math>. A downward-pointing arrow connects the top line to the middle line, with the value <math>-1000</math> next to it. An upward-pointing arrow connects the middle line to the bottom line, with the value <math>+17</math> next to it.</p>	<p>The energy level diagram is wrong in that the level for the aqueous ions ought to be above that for the solid. Also the arrow for the enthalpy change of solution is in the wrong direction. Thus only one mark is scored here for the gaseous ion level. The sum of the enthalpy changes of hydration is also wrong</p>

(ii) Use your diagram to calculate the sum of the enthalpy changes of hydration of the lead and chromate ions. [1]

Candidate style answer	Examiner's commentary
-1017 kJ mol <sup>-1</sup>	'Error carried forward' is allowed from the diagram, so the mark is scored in part (ii).

(iii) Name the bonds and intermolecular bonds that would be made and broken if lead chromate were to dissolve.  
 Explain, in terms of bonds broken and made, the endothermic nature of this dissolving process.  
 In your answer, you should use appropriate technical terms, spelt correctly. [4]

Candidate style answer	Examiner's commentary
The bonds broken are hydrogen bonds between water molecules. The bonds formed are hydrogen bonds between the lead and chromate ions and water. More energy is required to break bonds than to make them.	In part (iii), there is a lot more to it than hydrogen bonds. Ionic bonds are broken in the lattice and ion-dipole bonds are made, not hydrogen bonds. Hydrogen bonds are broken in water, however, some marks are scored.

3 The compound benzophenone is used in cosmetics and as a sunscreen. It can be prepared in the laboratory by the following reaction in the presence of an aluminium chloride catalyst.

benzene
benzoyl chloride
benzophenone

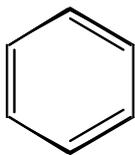
(a)(i) Draw the full structural formula for the acyl chloride group in benzoyl chloride. [1]

Candidate style answer	Examiner's commentary
	Part (i) is correct.

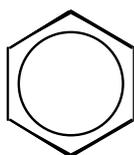
(ii) Name the reaction mechanism by which benzene reacts in *equation 3.1*. [2]

Candidate style answer	Examiner's commentary
electrophilic	Part (ii) scores one out of two since the full answer is electrophilic substitution.

(b) An alternative way of representing the structure of benzene is shown as representation 1 below.



representation 1



representation 2

Give reasons why representation 2 is sometimes preferred. Give one reason in terms of the shape of the molecule and one reason in terms of its chemical properties. [2]

<i>Candidate style answer</i>	<i>Examiner's commentary</i>
shape: representation 1 would not be a regular hexagon since double and single bonds are of different lengths chemical properties: both react with bromine, though representation 1 would react faster	The shape answer is correct and scores one mark. The chemical property is correct but does not answer the question. Reference needs to be made to the double bonds in representation 1 implying reaction with bromine water, for example.

(c) Sunscreens absorb ultraviolet radiation.

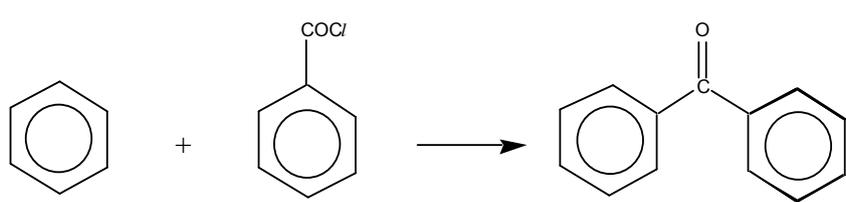
Explain, in terms of electronic energy levels, why a substance such as benzophenone absorbs in the ultraviolet but is not coloured.

In your answer, you should make it clear how your explanation links with what is observed. [5]

<i>Candidate style answer</i>	<i>Examiner's commentary</i>
Benzophenone absorbs ultraviolet light when electrons get excited. The energy absorbed depends on the energy levels. When the electrons drop back, they do not emit visible light, so no colour is seen.	One mark is scored for excited electrons. Another would have been scored for the relation between energy and energy levels if the gap between the levels had been mentioned. The last sentence is correct but it does not add anything. However, it looks as though the candidate thinks that coloured object emit coloured light, rather than absorbing the complementary colour.

<p>(d) The most effective way of removing the aluminium chloride at the end of the reaction is to hydrolyse it with water and to run it to waste.</p> <p><math>\text{AlCl}_3(\text{s}) + 3\text{H}_2\text{O}(\text{l}) \rightarrow \text{Al}(\text{OH})_3(\text{s}) + 3\text{HCl}(\text{aq})</math></p> <p>In the 1980s, benzophenone was made industrially by this method. Suggest and explain <u>two</u> reasons why this could lead to environmental hazards. [4]</p>
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Candidate style answer	Examiner's commentary
Aluminium and hydrochloric acid are toxic	This does actually score marks, but the candidate would have been wise to expand the answer as much as possible and, if possibly, say why they are both toxic.

 <p>benzene                      benzoyl chloride                      benzophenone                      + HCl                      <i>equation 3.1</i></p>	
<p>(e) More recently, another metal catalyst has been used and a solvent that is an ionic liquid. A very high percentage yield is achieved and the catalyst and the solvent can be recycled.</p> <p>(i) Explain the meaning of the term ionic liquid. [1]</p>	

Candidate style answer	Examiner's commentary
an ionic substance that melts above room temperature	Part (i) is correct.

<p>(ii) If the percentage yield were 100%, calculate the maximum mass of benzophenone that could be produced from 10 kg of <u>benzene</u>. [2]</p>
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Candidate style answer	Examiner's commentary
$182 \times 10 / (2 \times 78) = 11.7\text{kg}$	In part (ii), the candidate seems to think that two moles of benzene are needed for every benzophenone. Luckily the working is shown, so the first mark (for the two $M_r$ values) can be scored, even though the second is not. The atom economy is fine for two marks.

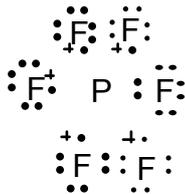
<p>(iii) Calculate the atom economy of the reaction in <i>equation 3.1</i>. [3]</p>
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Candidate style answer	Examiner's commentary
$182 \times 100 / 218.5 = 83\%$	Correct answer.

(iv) Explain the importance to society and the environment of using the modern method of making benzophenone. [4]

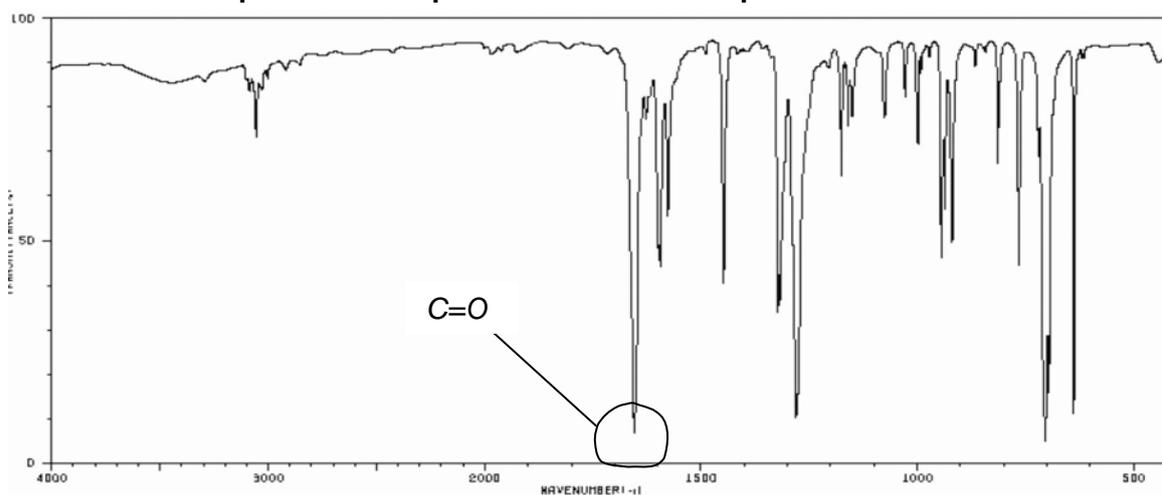
Candidate style answer	Examiner's commentary
it does not produce toxic products like the old method does.	Part (iv) is too vague. It scores one mark but, obviously, a lot more is needed for four marks. Comments on the renewable catalyst, the yield and the atom economy were all needed.

(v) The ionic liquid contains the PF<sub>6</sub><sup>-</sup> ion. Draw a 'dot-and-cross' diagram for this ion and give a word that describes its shape. [3]



Candidate style answer	Examiner's commentary
octahedral	The "dot-and-cross" diagram in part (v) is not quite correct as there is a single electron on the phosphorous where there should be a shared pair. The 'extra' electron from the negative charge on the ion could have been put here, or it could be put on a fluorine, with the resulting F <sup>-</sup> ion donating an electron pair to the P. The second mark, for the fluorine atoms, is scored here. Octahedral is correct in part (v).

(f) A chemist wished to confirm the identity of a sample of benzophenone by recording its infrared and proton NMR spectra. The infrared spectrum is shown below.

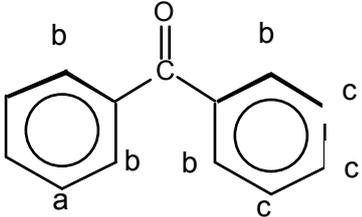


SDBSWeb : <http://www.aist.go.jp/RIODB/SDBS/> (National Institute of Advanced Industrial Science and Technology, 13/11/06)

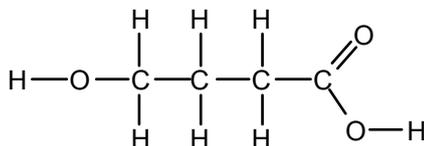
(i) Use the Data Sheet to select one absorption in the spectrum that is characteristic of benzophenone. Label this absorption with the bond that causes it. [1]

Candidate style answer	Examiner's commentary
	The bond indicated in part (i) is quite correct.

(ii) The proton NMR spectrum of benzophenone contains three signals in the ratio 2 : 2 : 1.  
 Mark on the structure below all the protons in each environment, lettering the environments a, b and c. [2]

Candidate style answer	Examiner's commentary
 <p>benzophenone</p>	<p>In part (ii), the candidate scores one mark for identifying the protons but the identical protons are not correctly identified for the second mark.</p>

4 The substance GHB was originally designed for use in sleeping pills. However, other drug-related uses were found for the substance and its sale was restricted in 2003. GHB stands for gamma-hydroxybutyric acid, an old name for the structure shown below.

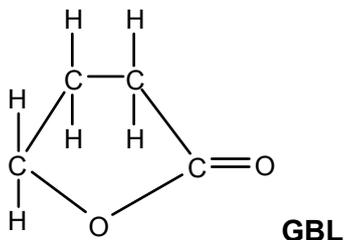


GHB

(a)(i) Name the two functional groups in GHB. [2]

Candidate style answer	Examiner's commentary
alcohol; carboxyl	Alcohol is correct but carboxyl should be carboxylic acid.
(ii) Give the systematic name for GHB. [2]	
Candidate style answer	Examiner's commentary
butanoic acid	There is no score in part (ii) as the name should be 4-hydroxybutanoic acid.

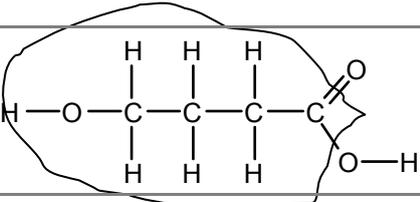
(b) A substance known as GBL is converted into GHB in the body. Its structure is shown below.



(i) Name the functional group in GBL. [1]

Candidate style answer	Examiner's commentary
ester	The functional group is correct.

<b>(ii) Name the <u>type</u> of reaction by which GBL forms GHB in the body. [1]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
condensation	In part (ii), however, the candidate has got things the wrong way round and described the reaction in which GBL is made from GHB not the other way round. The correct answer is hydrolysis.

<b>(c) A molecule that has the same effect on the body as GHB is called 'GHB alcohol'. Its structure is shown below, together with the structure of GHB. [1]</b>	
$  \begin{array}{cccc}  & \text{H} & \text{H} & \text{H} \\  &   &   &   \\  \text{H}-\text{O}- & \text{C} & -\text{C} & -\text{C} & -\text{C} \\  &   &   &   & // \\  & \text{H} & \text{H} & \text{H} & \text{O} \\  & & & & \backslash \\  & & & & \text{O}-\text{H}  \end{array}  $ <p><b>GHB</b></p>	$  \begin{array}{cccc}  & \text{H} & \text{H} & \text{H} & \text{H} \\  &   &   &   &   \\  \text{H}-\text{O}- & \text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{O}-\text{H} \\  &   &   &   &   \\  & \text{H} & \text{H} & \text{H} & \text{H}  \end{array}  $ <p><b>GHB alcohol</b></p>
<b>(i) On the molecule of GHB above, draw a ring round the largest part of the molecule that could be the pharmacophore. [1]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
	
<b>(ii) Suggest why both of these molecules are able to bind to the same receptor site in the body. Name the intermolecular bonds involved. [3]</b>	

<i>Candidate style answer</i>	<i>Examiner's commentary</i>
They have the same shape so they both fit the receptor	The pharmacophore does not score, as the second OH group should be included. In part (ii), there is one mark for both fitting the receptor. However, mention should also be made of OH groups and the fact that they hydrogen bond to the receptor.

<b>(d) Chemists are constantly seeking new medicines, starting from known pharmacophores. [1]</b>	
<b>(i) Name a modern technique that allows chemists to view the possible ways in which a molecule can bind on to a receptor site. [1]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
computer graphics	Correct answer.

<b>(ii) Suggest how chemists might justify continuing to manufacture GHB when it has been implicated as a “date-rape” drug. [2]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
its a good sleeping pill and there are very few others	The answer to part <b>(ii)</b> is too vague and scores zero. There are other sleeping pills. The comment about it being a good sleeping pill would have scored if followed by a better possible reason – for example, few side effects.

<b>(e) GHB is a weak acid. Weak acids can be represented as HA. [1]</b>	
<b>(i) Write an equation to show how a weak acid HA behaves when dissolved in water. 1]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
$\text{HA} \rightleftharpoons \text{H}^+ + \text{A}^-$	Part <b>(i)</b> is correct.
<b>(ii) Use ions and molecules from this equation to explain the meaning of the term conjugate base. [2]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
HA and A <sup>-</sup> are conjugate	Part <b>(ii)</b> is too brief and does not score. It does not mention which is the acid and which the base, nor does it mention proton transfer
<b>(iii) Write an expression for the acidity constant K<sub>a</sub> of an acid HA. 1]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$	Part <b>(iii)</b> is correct.
<b>(iv) A 0.10 mol dm<sup>-3</sup> solution of GHB has a pH of 2.9. Calculate the value of K<sub>a</sub> for GHB and give its units. [4]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
$[\text{H}^+] = 1.26 \times 10^{-3}$ $K_a = (1.26 \times 10^{-3})^2 = 1.59 \times 10^{-5}$	Part <b>(iv)</b> is also correct but the candidate has left off the units, thus missing out a mark.
<b>(v) State one simplifying assumption that you made when carrying out your calculation in (iii). [1]</b>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
$[\text{H}^+] = [\text{A}^-]$	Part <b>(v)</b> is correct.

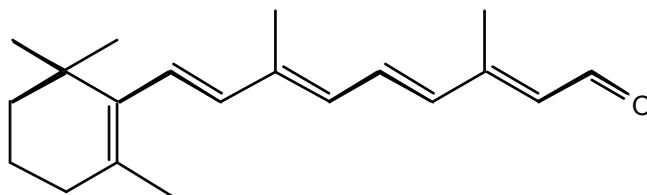
<p><b>(f) A mixture of GHB and its sodium salt acts as a buffer solution.</b></p> <p><b>(i) Explain the meaning of the term buffer solution and explain why buffer solutions are found in our bodies.</b> [5]</p>
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<i>Candidate style answer</i>	<i>Examiner's commentary</i>
<p>Buffer solutions maintain their pH when small amounts of acid or alkali is added. Our bodies need to be at constant pH which is why we contain buffers</p>	<p>This is a good answer to the first part of part (i) and scores some marks. However, the second part is vague and does not score.</p>

<p><b>(ii) Calculate the pH of a buffer solution containing equal amounts of GHB and its sodium salt.</b> [2]</p>
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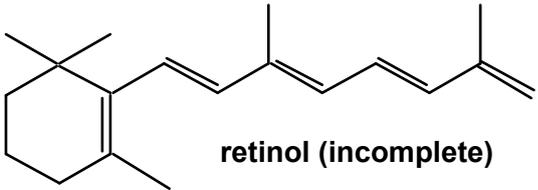
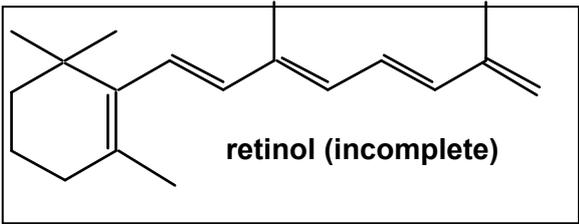
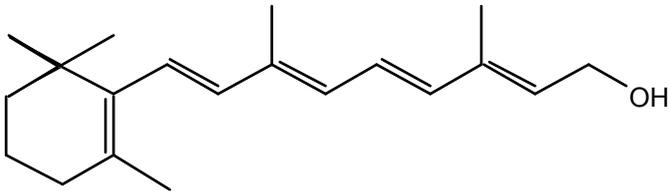
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
<p><math>\text{pH} = -\log(1.59 \times 10^{-5}) = 4.8</math></p>	<p>The mark-scheme requires mention of enzymes and their need for a narrow pH range. Part (ii) is correct.</p>

<p><b>5 The rod cells in the retina at the back of the eye contain an alcohol called retinol which is responsible for their sensitivity to light. Retinol is oxidised by an enzyme-catalysed reaction to the aldehyde retinal.</b></p>
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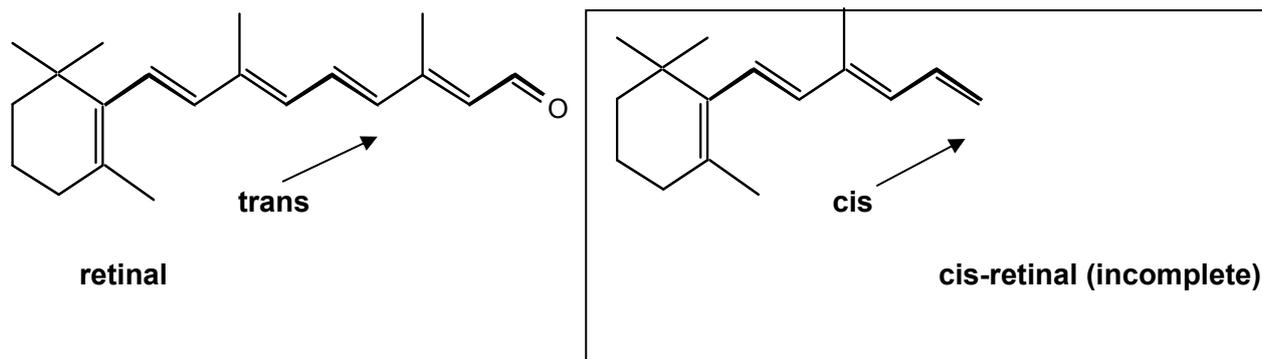
<p><b>(a)(i) Deduce the molecular formula of <u>retinal</u> from its skeletal formula above.</b> [1]</p>
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<i>Candidate style answer</i>	<i>Examiner's commentary</i>
<p>C<sub>20</sub>H<sub>28</sub>O</p>	<p>Correct answer.</p>

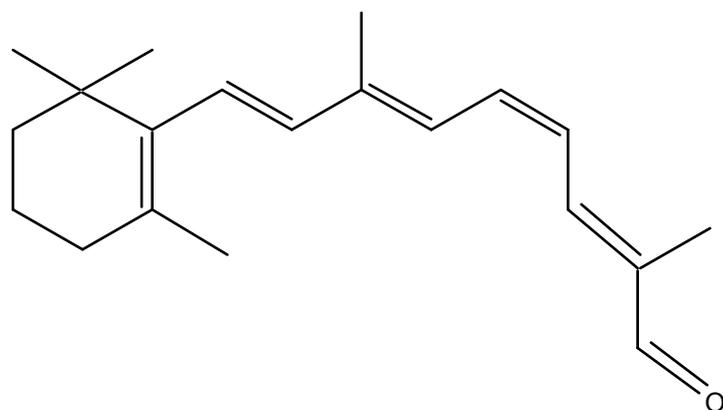
<p>(ii) Suggest the structure of the alcohol <u>retinol</u> by completing the skeletal formula below. [2]</p>	
 <p style="text-align: center;">retinol (incomplete)</p>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
 <p style="text-align: center;">retinol (incomplete)</p> 	<p>Correct answer.</p>
<p>(iii) Name a functional group which is present in <u>both</u> retinol and retinal. [1]</p>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
alkene	Correct answer.
<p>(b)(i) What reagents and conditions could be used to convert an alcohol to an aldehyde <u>in a laboratory</u>? [3]</p>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
heat with acidified dichromate	The candidate scores two out of three for acidified dichromate. The mixture should be specifically distilled (not just heated) to get the aldehyde (rather than the carboxylic acid) for the third mark.
<p>(ii) How many moles of hydrogen molecules would you expect to react with one mole of <u>retinol</u>? [1]</p>	
<i>Candidate style answer</i>	<i>Examiner's commentary</i>
10	In part (ii), the candidate has mistaken moles of hydrogen atoms and moles of hydrogen molecules. 'Molecules' was requested and so the answer is five, not ten.

(c) When light shines on the rod cells an enzyme-catalysed reaction occurs. This changes the arrangement around the double bond from *trans* to *cis*, as indicated in the structure below.

(i) Suggest the structure of *cis*-retinal by completing the skeletal formula below. [2]



*Candidate style answer*



*Examiner's commentary*

In part (i), the candidate has the idea of *cis* as opposed to *trans* and so scores one. However, the methyl group is on the wrong carbon on the right-hand side of the molecule, so the second mark is not scored.

(ii) Why are the *cis* and *trans* isomers of a compound not identical? [1]

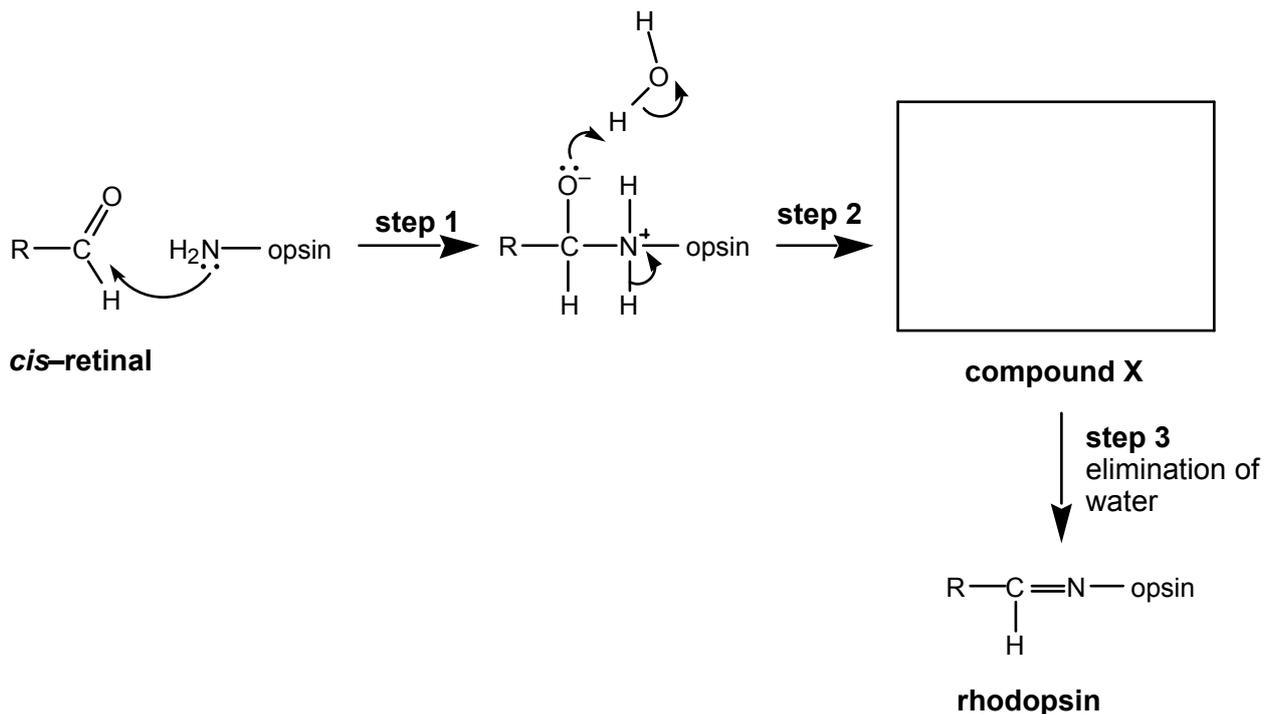
*Candidate style answer*

because of the lack of free rotation about the C=C bond

*Examiner's commentary*

The answer to part (ii) is correct.

(d) The *cis*-retinal binds to the protein opsin to form rhodopsin. Part of the mechanism of this reaction is shown below.



(i) Name the functional group on opsin which is reacting with the aldehyde group on *cis* retinal. [1]

*Candidate style answer*

amine

*Examiner's commentary*

Parts (i) and (ii) are completely correct.

(ii) Name the type of reaction mechanism which starts in step 1 and is completed in step 2. [2]

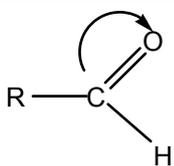
*Candidate style answer*

nucleophilic addition

*Examiner's commentary*

(iii) Draw a 'curly arrow' on the *cis*-retinal molecule to complete the electron movements that occur in step 1. [1]

*Candidate style answer*

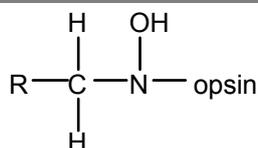


*Examiner's commentary*

In part (iii), the curly arrow, however, does not start on the bond that is broken but on the carbon. This is incorrect and does not score.

(iv) Deduce a structure for compound X and draw it in the box above. [1]

*Candidate style answer*



*Examiner's commentary*

Part (iv) is also incorrect. The OH should be on the carbon and the H on the nitrogen.

## Overall banding: Medium

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This candidate has got a lot of answers right. Quite a few calculations, however, were wrong and there were some very vague answers to some of the descriptive parts.