Advanced Subsidiary GCE Subject Chemistry B (Salters)

Unit F332: Chemistry of Natural Resources - High 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.

1(a) Chlorine, Cl_2, can be used as a disinfectant for water. Chlorine is transported in pressurised containers.

Explain, in terms of intermolecular bonds, why chlorine is a gas at room temperature and pressure.

In your answer you should use appropriate technical terms, spelt correctly. [2]

Candidate style answer	*Examiner's commentary*
There are instantanious dipole-induced dipole bonds between the molecules. These are weak and do not require much energy to break	The chemistry is correct, but the word 'instantaneous' is mis-spelt and thus the technical term has not been spelt correctly. So only the second mark is scored here.

(b) In the event of an accident when chlorine is being transported, people living near the accident site are evacuated. Give <u>two</u> properties of chlorine that make this necessary. [2]

Candidate style answer	*Examiner's commentary*
it is a toxic gas	Quite correct. Toxic scores the first mark and gas the second.

(c) **A student bubbled some chlorine through water. The chlorine reacted with the water as shown below.**

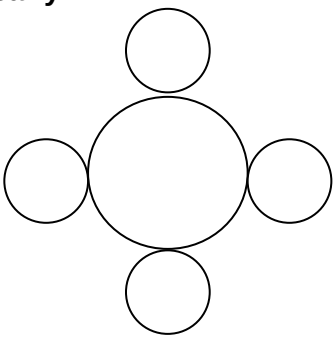
Cl_2 (aq) + H_2O (l) $\rightleftharpoons$ H^+ (aq) + Cl^- (aq) + HClO (aq) ***equation 1.1***

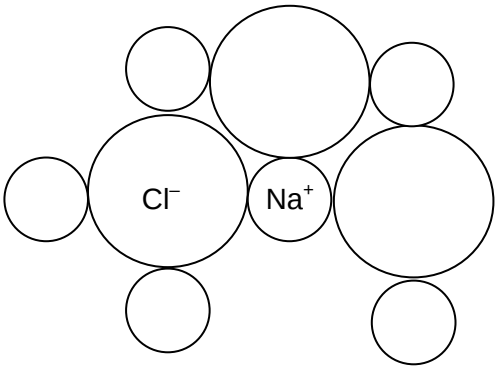
(i) **The student added some solid sodium chloride to the solution of chlorine in water. Use Le Chatelier's principle to describe and predict what would happen to the concentration of Cl_2(aq).** **[3]**

Candidate style answer	*Examiner's commentary*
the amount of chloride would increase, so the equilibrium would move to the left and the concentration of chlorine would increase.	The answer to part **(i)** is not quite detailed enough to score all the marks. It is not the amount of chloride that is important, it is its *concentration*. This must be stated for the first mark.

(ii) **The diagram below shows part of a layer of a sodium chloride lattice.**

Label each type of particle and complete the diagram with enough particles to show the structure of the layer clearly. **[2]**



Candidate style answer	*Examiner's commentary*
	Then two other marks are scored for the equilibrium moving and the increase in chlorine concentration. In part **(ii)**, the candidate scores one out of two. The labelling is sufficient but each sodium ion must have four chloride ions round it, which is not shown.

(iii) Sodium, like other elements in Group I, readily forms 1+ ions. Explain why this is so and why sodium is unlikely to form compounds containing Na^{2+} ions. [2]	
Candidate style answer	*Examiner's commentary*
sodium has a low first ionisation energy but a very high second ionisation energy, as this involves breaking into a full shell	Part **(iii)** is completely correct and scores two out of two.

(d)(i) Give the oxidation states of chlorine in Cl_2 and HC*l*O. [2]	
Candidate style answer	*Examiner's commentary*
0 +1	
(ii) Give the name of the process in which Cl_2 is changed into HC*l*O. [1]	
Candidate style answer	*Examiner's commentary*
oxidation	
(iii) Explain your choice of answer in (ii). [1]	
Candidate style answer	*Examiner's commentary*
the oxidation state has gone up	
(iv) Write a <u>half-equation</u> that shows what happens to the chlorine molecules in <u>equation 1.1</u> that are converted into chloride ions. [1]	
Candidate style answer	*Examiner's commentary*
$Cl_2 + 2e^- \rightarrow 2Cl^-$	All these parts are correct and score full marks.

(e) When a solution of chlorine in water behaves as a disinfectant, the active chemical is HC*l*O.

The disinfecting power decreases when the solution is exposed to sunlight because HC*l*O decomposes to form oxygen and a solution of hydrochloric acid.

Complete the balanced chemical equation for this reaction below. [2]

HClO $\rightarrow$

Candidate style answer	*Examiner's commentary*
$2HClO \rightarrow 2HCl + O_2$	This is correct and scores both marks

2 There is considerable concern over rising carbon dioxide levels that most scientists think are causing global warming. This concern has prompted the British Government to charge less in road fund tax for cars that produce less carbon dioxide.

(a) Cars are now more fuel efficient than they used to be and so they produce less carbon dioxide. Suggest one design feature that has made cars more fuel efficient. [1]

Candidate style answer	*Examiner's commentary*
more efficient engine design so that more of the fuel is burnt	This is one of many correct answers

(b) Greenhouse gases like carbon dioxide absorb infrared radiation in the troposphere. Explain the source of this infrared radiation and suggest what happens to a molecule of carbon dioxide when it absorbs this radiation. [5]

✎In your answer you should make it clear how your explanation links with the chemical theory.

Candidate style answer	*Examiner's commentary*
The Earth emits IR which causes the bonds in the carbon dioxide to vibrate more.	The candidate has not read the question carefully. The source of the radiation has not been given – uv (from the Sun) warming the Earth. So a mark is lost here and also the 'quality of written communication' mark which was partly for the *warm* Earth emitting ir. The rest is correct, so three marks out of five are scored.

(c) The Earth's oceans act in a way that regulates the increase in carbon dioxide levels in the troposphere. An equilibrium is set up between gaseous and aqueous carbon dioxide.

(i) Suggest and explain why the balance between gaseous and aqueous carbon dioxide is not a true equilibrium. [1]

Candidate style answer	*Examiner's commentary*
it is not a closed system	A mark is scored for part **(i)**, even though it is always dangerous to start an answer with 'it'.

(ii) Suggest two possible methods that could be used for the capture and storage of carbon dioxide, to prevent its build-up in the atmosphere. [2]

Candidate style answer	*Examiner's commentary*
burn less fossil fuels; pump it on to the Ocean floor	In part **(ii)**, the candidate has not read the question carefully. It asks for methods of *removal* of carbon dioxide, not ways of producing less. So 'burning fewer fuels' does not score, while the second point does.

(iii) For <u>one</u> of your methods in (ii) suggest an environmental impact that could arise from its use. [1]

Candidate style answer	*Examiner's commentary*
the pH of the Oceans might change, affecting the ecosystem of marine organisms	Part **(iii)** is a good answer and scores the mark available.

3 The polymer commonly known as PVC exists in two forms. Plasticised PVC is used where flexibility is required. Unplasticised PVC, uPVC, is rigid at room temperature and is used to make things such as guttering for houses.

(a) Suggest <u>one</u> other use for uPVC in the construction of a house. [1]

Candidate style answer	*Examiner's commentary*
drainpipes	Quite correct. This scores the mark

(b) PVC is manufactured by polymerising chloroethene. Chloroethene is produced in a two stage synthesis as outlined below.

stage 1 $CH_2 = CH_2 + Cl_2 \xrightarrow{FeCl_3} ClCH_2CH_2Cl$

stage 2 $ClCH_2CH_2Cl \xrightarrow{heat} CH_2 = CHCl + HCl$

(i) Underline two of the following words to describe the reaction in <u>stage 1</u>. [2]

addition electrophilic elimination nucleophilic radical substitution

Candidate style answer	*Examiner's commentary*
electrophilic addition	

(ii) Select <u>one</u> word from the list to describe the reaction in <u>stage 2</u>. [1]

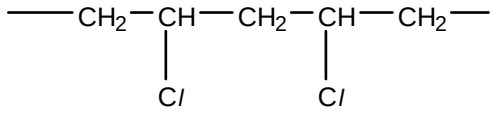
Candidate style answer	*Examiner's commentary*
elimination	Both of these parts are correct and score the marks.

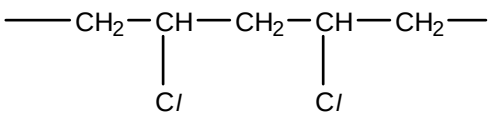
(c) PVC owes many of its properties to the intermolecular bonds between the polymer chains.

(i) Name the strongest type of intermolecular bond that is present in PVC. [1]

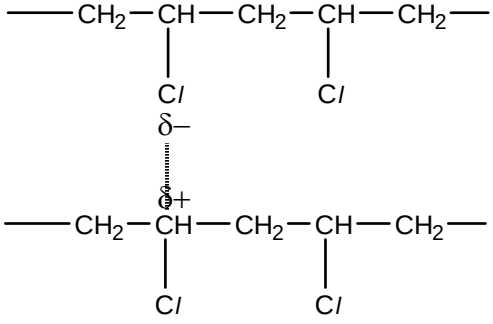
Candidate style answer	*Examiner's commentary*
permanent dipole bonds	In part **(i)**, the answer is not sufficient to score. 'Permanent dipole – permanent dipole' is required.

(ii) Use the diagram below to show how these intermolecular bonds hold the PVC chains together.





[2]

Candidate style answer	*Examiner's commentary*
	The diagram in part **(ii)** is correct and scores the two marks.

(d) Chloroethene will also undergo the following sequence of reactions.

$CH_2 = CHCl \longrightarrow CH_3CH_2Cl \longrightarrow CH_3CH_2OH \longrightarrow CH_3CHO$

chloroethene **chloroethane** **ethanol** **compound A**

(i) Name the reagent and conditions needed to turn <u>chloroethene</u> into <u>chloroethane</u>. [2]

Candidate style answer	*Examiner's commentary*
hydrogen with a hot nickel catalyst	Part **(i)** scores both marks, though it might have been safer to quote a temperature (450^oC is usually given for this).

(ii) Classify <u>ethanol</u> as primary, secondary or tertiary, giving a reason. [2]

Candidate style answer	*Examiner's commentary*
primary, since it is connected to one other carbon	Part **(ii)** scores for 'primary' but the candidate has not made it clear what 'it' means. The carbon connected to the –OH group is connected to just one other carbon. Only one mark is scored here.

(iii) Name the functional group in <u>compound A</u>. [1]

Candidate style answer	*Examiner's commentary*
aldehyde	Part **(iii)** is correct.

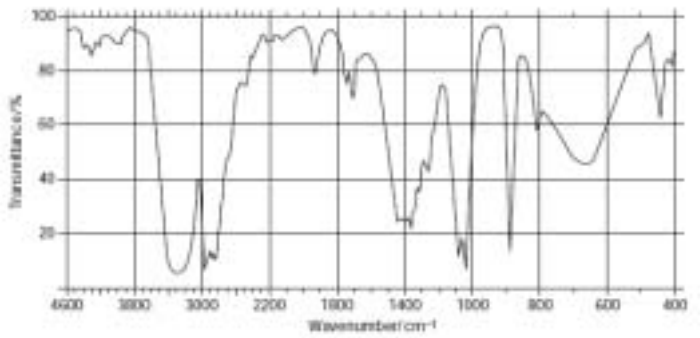
(iv) Give the reagents and conditions for the conversion of <u>ethanol</u> to <u>compound A</u> in the laboratory. [3]

Candidate style answer	*Examiner's commentary*
reflux with acidified potassium dichromate(VI)	Part **(iv)** scores two marks for 'acidified' and the reagent but *distillation* is needed here not reflux (which will tend to form the carboxylic acid).

(e) In a laboratory experiment, 10g of chloroethene, CH_2CHCl, produced 1.5g of ethanol, CH_3CH_2OH.
Work out the percentage yield of the conversion of chloroethene to ethanol.
Give your answer to <u>two</u> significant figures. [5]

Candidate style answer	*Examiner's commentary*
10/62.5 mol chloroethene should produced 10/62.5 mol ethanol = 10 x 46/62.5g = 7.36g *% = 1.5/7.36 = 20.4%*	The calculation is well explained and correct. However, the candidate has forgotten the requirement about significant figures and gives the answer to three, not two significant figures. Thus the score is four out of five. A way of remembering to think about significant figures right at the end, is to highlight or underline it as you read through the question.

(f) Infrared spectroscopy was carried out on the product formed in the reaction of chloroethene to give ethanol. The spectrum that was produced is shown below.



(i) Use information from this spectrum to explain how it confirms that an alcohol had been produced. [1]

Candidate style answer	*Examiner's commentary*
There is a peak at 3300 which shows the presence of an O–H group.	

(ii) Suggest how you would be able to confirm, using infrared spectroscopy, that the product was ethanol. [2]

Candidate style answer	*Examiner's commentary*
The 'fingerprint region' below about 1400 cm^{-1} would be different for different alcohols.	The answer to part **(i)** is correct and scores the mark. In part **(ii)**, the candidate has not quite answered the question. In order to confirm ethanol, a spectrum of a known sample of ethanol would be needed, then the fingreprint regions can be confirmed. Thus only one mark out of two is scored

(g) Much of the ethanol is made industrially from ethene.

(i) Give the reagents and conditions by which ethanol is made from ethene in industry. [2]

Candidate style answer	*Examiner's commentary*
water with a catalyst at high temperature and pressure	

(ii) The reaction in which ethanol is produced from ethene involves attack by an electrophile. Explain what is meant by the term *electrophile*. [2]

Candidate style answer	*Examiner's commentary*
a reagent that is attracted to areas of high electron density	Parts **(i)** and **(iii)** are correct and score full marks.

(iii) Suggest a reason, other than cost, why ethanol is not manufactured from chloroethene. [1]

Candidate style answer	*Examiner's commentary*
the yield is low	Part **(ii)** is incomplete. An electrophile does attack a negative area but then it accepts a pair of electrons form it to form a bond. So this answer scores one out of two.

4 Hydrofluorocarbons, HFCs, have replaced CFCs for many of their uses. They are broken down in the troposphere before they have time to reach the stratosphere.

(a)(i) Give the formula of a CFC. [1]

Candidate style answer	*Examiner's commentary*
$CHCl_2F$	Part **(i)** is wrong because the molecule is a HCFC, it has hydrogen in it. CFCs contain carbon, fluorine and chlorine only.

(ii) CFCs were used as the refrigerant in domestic fridges. The presence of CFCs makes disposing of old fridges difficult. Give one property of CFCs that made them suitable as refrigerants. [1]

Candidate style answer	*Examiner's commentary*
they are suitably volatile	Part **(ii)** is correct and scores the mark.

(b) CFCs cause depletion of the ozone layer. Describe how they do this. [4]

Candidate style answer	*Examiner's commentary*
CFCs break down under the effect of uv light in the stratosphere to form Cl radicals that catalyse the breakdown of ozone	This answer misses one important point. The first marking point is for saying that this breakdown occurs in the stratosphere. The second is for saying that the uv there is of *high energy*. The last two marking points are scored for talking about chlorine *radicals* and for saying these *catalyse* the breakdown of ozone. So three out of four are scored.

(c) Initially, studies of changes in the Earth's atmosphere did not reveal the problem of ozone depletion. Explain why the information about ozone depletion was overlooked. [2]

Candidate style answer	*Examiner's commentary*
the readings were so low they were not believed	Well, that's part of it. The readings were very low, so that scores. They were overlooked because the computers had been programmed to ignore any data which was well out of the expected ranges. One mark out of two is scored here.

(d) Other atmospheric pollutants can contribute to a build-up in tropospheric ozone. For example, hydrocarbons can interfere with the normal reactions for the formation and breakdown of ozone. The reaction for the breakdown of ozone involves naturally occurring NO_2 and NO.

$NO_2 \xrightarrow{hv} NO + O$ **equation 4.1**

$NO + O_3 \rightarrow NO_2 + O_2$ **equation 4.2**

$O + O_2 \rightarrow O_3$ **equation 4.3**

(i) Combine two of these equations to show how ozone is broken down. [1]

Candidate style answer	*Examiner's commentary*
$O_3 \rightarrow O_2 + O$	Part **(i)** is correct and scores the mark.

(ii) Hydrocarbons lead to reactions in which NO is converted into NO_2. Explain how this leads to a build-up of ozone. [2]

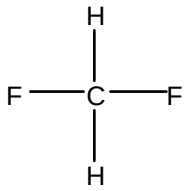
Candidate style answer	*Examiner's commentary*
less ozone is broken down	Part **(ii)** is incomplete. For two marks a reason is needed, which is that hydrocarbons provide an alternative to **equation 4.2**. Only one mark out of two is scored.

(iii) Suggest one disadvantage of a build-up of tropospheric ozone. [1]

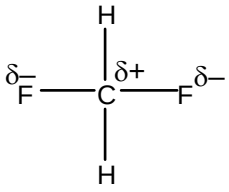
Candidate style answer	*Examiner's commentary*
photochemical smogs are formed	Part **(iii)** is correct and scores the mark.

(e) One example of an HFC is CH_2F_2. The C-F bond is polar.

(i) Mark partial charges on the C and F atoms in the structure below.



[1]

Candidate style answer	*Examiner's commentary*
	Part **(i)** is correct and scores the mark.

(ii) Explain what determines where the partial charges are placed on this molecule. [2]

Candidate style answer	*Examiner's commentary*
the electronegativity of the atoms	Part **(ii)** is an incomplete answer. It scores one mark for mentioning electronegativity but does not score the second mark for saying that fluorine is more electronegative than carbon.

(iii) Does the whole molecule have a dipole? Explain your answer. [2]

Candidate style answer	*Examiner's commentary*
yes, because when you look at the three-dimensional tetrahedral structure the two fluorine atoms are side by side and do not cancel out.	Part **(iii)** is a good answer and scores both marks.

(f) If molecules of CH_2F_2 reach the stratosphere, they do not break down to produce F radicals.

(i) Suggest why C-F bonds are not broken in the stratosphere. [2]

Candidate style answer	*Examiner's commentary*
they are too strong and not even broken by the high energy uv	The answer to part **(i)** scores both marks.

(ii) The bond enthalpy of the C-F bond is +467 KJ mol^{-1}.
Calculate the minimum energy (in joules) needed to break a single C–F bond. [2]

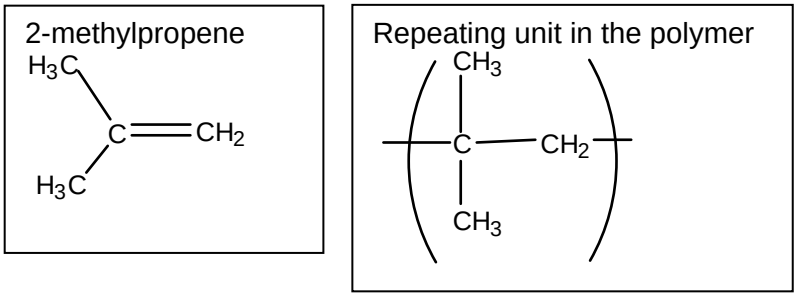
Candidate style answer	*Examiner's commentary*
Avogadro constant, N_A = 6.02 x 10^{23} mol^{-1} *467/N_A = 7.76 x 10^{-22}*	In part **(ii)**, the candidate does not realise the need to convert to J from kJ by multiplying by 1000 and so scores one out of two.

(iii) Calculate the minimum frequency of radiation needed to break a C-F bond.
Give the appropriate units for your answer. [3]

Candidate style answer	*Examiner's commentary*
Planck constant, h = 6.63 x 10^{-34} J Hz^{-1}. *7.76 x 10^{-22} / h = 1.17 x 10^{12} Hz*	In part **(iii)** all three marks are scored by 'error carried forward' since the candidate has obtained the answer that follows from the error made in the previous part. Such an approach will always be used, provided the working can be seen to justify it.

5 This question is based on the article *Getting tyred with Chemistry* which is provided as an insert to this paper.

(a)(i) Draw the structural formula of 2-methylpropene and the formula of the repeating unit of the rubber formed from it (line 44) [3]

Candidate style answer	*Examiner's commentary*
	

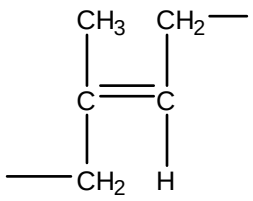
(ii) Suggest the formula of the repeating unit of the rubber formed from butadiene and styrene that has one double bond per butadiene remaining. (Fig 4). Include one unit of butadiene and one unit of styrene. [2]

Candidate style answer	*Examiner's commentary*
$-CH_2-CH=CH-CH_2-CH(C_6H_5)-CH_2-$	

(iii) Describe a simple chemical test that might enable you to distinguish between the rubbers in parts (i) **and** (ii)**. [3]**

Candidate style answer	*Examiner's commentary*
add bromine water and (ii) will go form brown to colourless	Parts **(i)** and **(ii)** are correct. In part **(iii)**, however, the candidate has given the correct test and how rubber **(ii)** performs, but not rubber **(i)**, and so scores two out of three.

(b) Draw the structure of the repeating unit of *trans* polyisoprene. (line 20). [1]

Candidate style answer	*Examiner's commentary*
	This is correct and scores the mark

(c) Explain why *trans* (polyisopropene) cannot be rotated to give *cis* (polyisopropene). [1]	
Candidate style answer	*Examiner's commentary*
lack of free rotation about C=C	Another correct answer which scores a mark.

(d) Explain the meaning of the term *thermoplastic* (line 29). [1]	
Candidate style answer	*Examiner's commentary*
softens easily	This is not sufficient for the mark – it must be 'softens on heating'.

(e) Suggest how ultraviolet light might affect rubber (line 62). [3]	
Candidate style answer	*Examiner's commentary*
it breaks the bonds and breaks down the structure	This is worth two marks out of three. It omits the point that it is the high energy of the uv that breaks the bonds.

(f) Vulcanisation improves the properties of rubber and accelerator molecules catalyse the process Use information from the article about polymer structures and your knowledge of catalysts to explain this. ✎ In your answer you should make it clear how your explanation links with the chemical theory. [6]	
Candidate style answer	*Examiner's commentary*
Vulcanisation causes strong –S-S- bonds to form between the rubber chains. This strengthens the rubber by stopping the chains sliding over one another. *Accelerator molecules are catalysts. They speed up a reaction by providing an alternative pathway of lower activation enthalpy.*	This answer starts well. It scores for the formation of –S-S- bonds and then explains why these are important. The 'cause and effect' mark for linking explanation and theory is also scored here. The catalyst part is not sufficiently detailed. The definition of a catalyst scores one mark but more detail is needed to score any further marks, for example that the catalysts contain sulfur and thus form intermediates with the rubber. Thus four marks out of six are scored here.

Overall standard: high

Overall comment The candidate clearly knows a lot of the chemical ideas associated with this unit. Too often, however, answers are rather brief and lack detail, the sort of detail that the candidate probably really knew.