Advanced Subsidiary GCE Chemistry B (Salters)

Unit F331 Chemistry for Life - 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.

1 In April 1986, the nuclear reactor at Chernobyl in the Soviet Union exploded, releasing a mixture of radioactive isotopes into the atmosphere.
One of the main isotopes released was $^{131}_{53}$I.

(a)(i) In the following table, write the number of protons, electrons and neutrons in an atom of $^{131}_{53}$I. [1]

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

	number of particles
protons	*53*
neutrons	*78*
electrons	*53*

(ii) What is meant by the term *isotopes*? [2]

Candidate style answer	*Examiner's commentary*
same protons but different number of neutrons	Part **(ii)** is correct.

(iii) Radioactive isotopes are unstable and many decay by emitting either α-particles or β-particles.
The table below summarises some of the properties of α- and β-particles.
Complete the table by choosing words or numbers from the following list: [2]

small; large; nil; paper; aluminium foil; lead; 0; -1; +2; +1;

Candidate style answer

Property	α-particle	β-particle
Relative charge	*+2*	*–1*
Relative mass	4	negligible
Stopped by	paper	*Al foil*
Deflection by electric field	*nil*	large

Examiner's commentary

In part **(iii)** the 'nil' is incorrect. Though they are much heavier than electrons, alpha particles are charged, so their deflection by an electric field is small, not zero. Thus the left-hand column does not score, though the right-hand is correct and so this answer would score some marks.

(iv) The relative atomic mass of iodine is given in the Periodic Table as 126.9.
Explain why this value is not a whole number. [1]

Candidate style answer	*Examiner's commentary*
iodine is a mixture of isotopes	In part **(iv),** more needs to be said. The number 126.9 is the average (mean) of the isotopic masses and this needs to be said to score the mark.

(b)(i) Radioactive isotopes such as $^{131}_{53}I$ can cause cancers.

However, $^{131}_{53}I$ can be used as a radioactive tracer for investigating patients suffering from a possible deficiency of iodine.

Suggest how it can be explained to a patient that it is relatively safe to use a dangerous radioactive substance as a tracer in their bodies. [2]

Candidate style answer	*Examiner's commentary*
it is only used in small doses	To gain a higher mark it is necessary to say something to the effect that the exposure is thus small

(ii) The half-life of $^{131}_{53}I$ is 8 days. A sample manufactured for use in hospitals has an original count rate of 16 000 counts per minute. It can be used as a tracer as long as its count rate is at or above 500 counts per minute.

For how long after manufacture can it be used as a tracer? [2]

Candidate style answer	*Examiner's commentary*
16000/500 = 32. This is 16 half-lives which lasts 640 days	In part **(ii)**, the candidate has divided 32 by 2, instead of working out to what power 2 has to be raised to get 32 (the answer is 5). Because the working (and therefore the error) is clear. A basic mark could be awarded.

(c) In 1911, Geiger and Marsden fired alpha-particles at gold foil and found that most passed through unchanged, while just a few were deflected by large amounts. This was evidence for the nuclear model of the atom.

Explain the results of the Geiger and Marsden experiments using a nuclear model of the atom. [3]

Candidate style answer	*Examiner's commentary*
The particles hit the nuclei and were deflected by large amounts. Many particles passed through the empty space of the rest of the atom and were not deflected.	Basic answer. For higher marks more detail required as to how the nuclei deflect the alpha particles. Eg it is the positively charged protons in the nuclei that do this.

2 Cans of 'self-heating' coffee were available until recently.

Inside the can, in separate compartments, were calcium oxide and water. When a button was pressed these reacted together to give enough heat to warm up the coffee.

(a) What term is used to describe a reaction that gives out heat? [1]

Candidate style answer	*Examiner's commentary*
exothermic	This is correct.

(b) The reaction between calcium oxide, (CaO), and excess water forms calcium hydroxide solution.

Write a balanced equation for the reaction below. Include the state symbols. [2]

Candidate style answer	*Examiner's commentary*
$CaO(s) + H_2O(l) \rightarrow CaOH_2(aq)$	This formula for calcium hydroxide is wrong, it should be $Ca(OH)_2$. Thus the equation mark is not scored. The mark for the state symbols is, however, scored.

(c) A group of students set out to determine the enthalpy change of this reaction by placing a known mass of calcium oxide into 250 cm^3 of water in an insulated flask and measuring the temperature rise.

The group of students recorded the measurements shown in the table.

mass of calcium oxide used	**10 g**
volume of water used	**250 cm^3**
temperature rise	**50 °C**

Calculate the heat transferred to the water (in kJ) by the reaction of 1.0 mol of CaO(s).

Give your answer to two significant figures. [4]

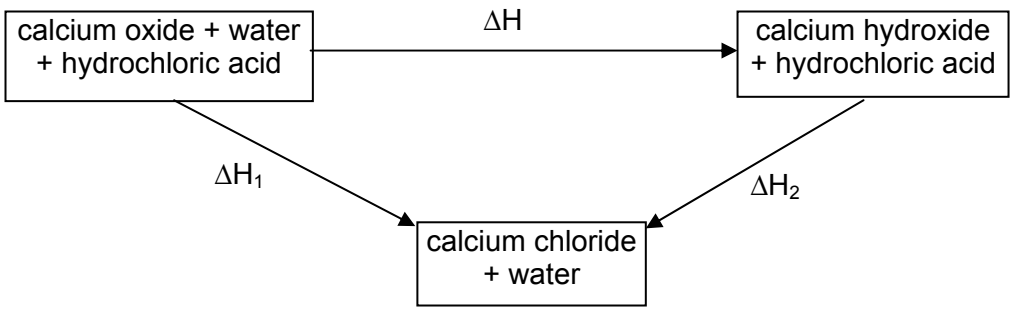
Candidate style answer	*Examiner's commentary*
specific heat capacity of water = 4.2 kJ K^{-1} kg^{-1} ; density of water = 1.0 g cm^{-3} *Moles CaO = 10/56 = 0.179* *Heat = 10 x 4.2 x 50 = 2.1 kJ* *Thus, heat per mole = 2.1/0.179 = 11.73 kJ*	The moles are calculated correctly. However, the heat is not. The mass of the calcium oxide has been used, not the mass of the water (250g), so the second mark is lost. The candidate then gets back on track by dividing by the moles and evaluating the result correctly. The answer has been expressed to two decimal places, not two significant figures (12 is the answer to two significant figures). This is an intermediate answer.

(d) The reaction will produce solid calcium hydroxide if the exact molar ratio of water to calcium oxide is used, as represented by the balanced equation.

(i) Suggest one reason why it is very difficult to measure this enthalpy change directly. [1]

Candidate style answer	*Examiner's commentary*
the thermometer is not very accurate	Part (i) is incorrect. The answer is that some calcium hydroxide will dissolve.

(ii) This enthalpy change can, however, be measured indirectly using an enthalpy cycle as shown below.



Explain how the cycle can be used to calculate the enthalpy change ΔH. [2]

Candidate style answer	*Examiner's commentary*
Hess' Law can be used	Part (ii) is incomplete. As well as the mention of Hess' Law, the equation $\Delta H = \Delta H_1 - \Delta H_2$ is needed, for a higher mark.

(e) Magnesium oxide is a possible alternative substance to use in the self-heating cans.

Use your knowledge of the Periodic Table to suggest why magnesium oxide might be considered a possible alternative to calcium oxide. [2]

Candidate style answer	*Examiner's commentary*
magnesium is in the same group as calcium and thus its oxide will behave in the same way.	Correct answer.

3 Environmental issues are an important consideration in chemistry, with the idea of 'green chemistry' becoming more and more vital.

In the left hand column below are some of the pollutants emitted from car exhausts.

For each pollutant, briefly explain in the right hand column how the pollutants are formed.

The first has been done for you. **[3]**

Candidate style answer

pollutant	how the pollutants in the exhaust gases are formed
oxides of nitrogen	from the reaction of nitrogen and oxygen gas in the air, at the high temperatures of the combustion chamber
carbon monoxide	*incomplete combustion of the fuel*
oxides of sulfur	*combustion of sulfur in the air*
hydrocarbons	*leakage of fuel from the petrol tank during refuelling*

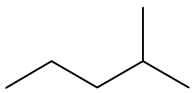
Examiner's commentary

The carbon monoxide answer is correct. The oxides of sulfur answer is incorrect as it is ambiguous as to where the sulfur comes from. In fact it comes from sulfur compounds in the fuel and this needs to be stated. The answer fcor 'hydrocarbons' is a correct source of hydrocarbons in the atmosphere, but it does not answer the question which is about vehicle exhausts. Unburnt hydrocarbons are produced in the exhaust.

(b) Reforming is a process which converts straight-chain alkanes into new compounds which burn more effectively in the engine, reducing pollution. These new compounds include branched alkanes, cycloalkanes and arenes.

Classify the molecules in the table by ticking the appropriate boxes. **[2]**

Candidate style answer

hydrocarbon	straight chain	branched chain	cycloalkane	arene
		✓		
				✓
$CH_3(CH_2)_5CH_3$	✓			
C_6H_6				✓

Examiner's commentary

The second row is incorrect. The structure represents cyclo-octane, a cycloalkane, so it is not an arene.

(c) Heterogeneous catalysts are often used in the reforming process. The process is called 'platforming' when the catalyst is platinum metal. Coke (from side reactions in the process) reduces the efficiency of the catalyst.

Describe the stages involved in heterogeneous catalysis and explain why the formation of coke can cause the platinum to become ineffective. [5]

✎In your answer you should use appropriate technical terms, spelt correctly

Candidate style answer	*Examiner's commentary*
products diffuse on to the catalyst surface, bonds in reactants weaken and are broken. Then bonds are made and the products diffuse away.	The technical term 'adsorb' is required for a higher mark. The candidate correctly mentions bonds breaking and diffusing away. However the section about bonds being made is not full enough to score as it is necessary to make clear that these are the bonds in the products. Note that the candidate has ignored the second part of the question about why the formation of coke can cause the platinum to become ineffective. This is easy to do in a long question. Some method such as highlighting the second part or underlining it is recommended

(d) Another approach towards greener cars is to change the fuel.
One possible alternative fuel is 'biodiesel'. This can be manufactured from soya beans.

(i) Suggest one possible advantage of a fuel manufactured from soya beans. [1]

Candidate style answer	*Examiner's commentary*
it is biodegradable should any be spilt	Part **(i)** is correct.

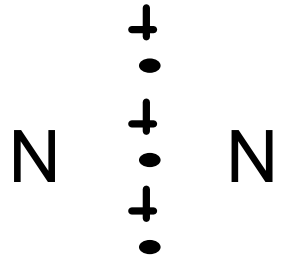
(ii) Biodiesel can be used on its own or blended with ordinary diesel.
Describe and explain what happens to the entropy of the system when this blending (or mixing) occurs, compared with the unblended compounds. [3]

Candidate style answer	*Examiner's commentary*
entropy inc oxidising agents reases as there are more molecules	Basic marks awarded in part **(ii)** for the entropy increasing but the reason given is describing something else. The correct reason here is that there are more ways of arranging the molecules in the mixture than in the two substances separately.

(iii) Biodiesel molecules contain oxygen atoms. What general name is given to such molecules that can be added to fuels to improve performance? [1]

Candidate style answer	*Examiner's commentary*
oxidising agents	In part (iii) the answer is 'oxygenate' not 'oxidising agent'.

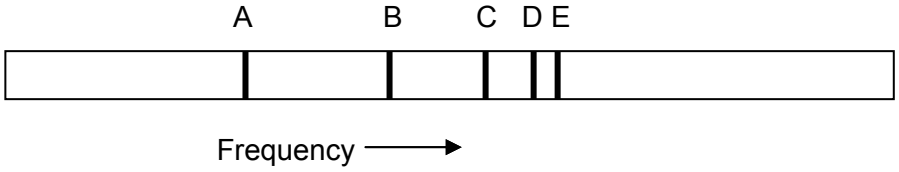
(iv) Emissions of most pollutants are reduced when biodiesel is used instead of petroleum diesel, with one exception.
The exception is that levels of oxides of nitrogen oxides (NO_x) increase in the exhaust.
A reason for this might be that the temperature at which biodiesel burns in the engine is higher than for petroleum diesel.
Draw a *'dot-and-cross'* diagram for the nitrogen molecule. Use it to explain why a large amount of energy will be needed to break up the molecule. [4]

Candidate style answer	*Examiner's commentary*
 *dot-cross diagram for nitrogen molecule* *the triple bond is very strong*	In part (iv), the *'dot-and-cross'* diagram omits the lone pairs on the nitrogen atoms, losing one mark. The description is correct, however, so some marks out of four are scored.

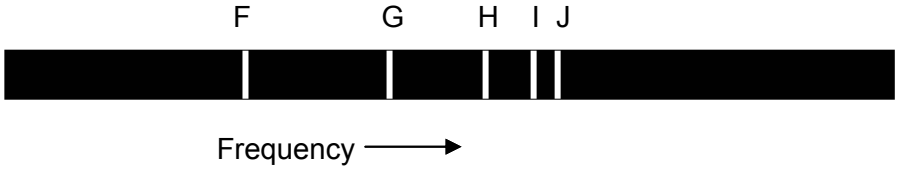
4 Most of the chemical elements found on Earth were produced in stars.

(a) Absorption and emission atomic spectra show the presence of elements in the stars. The wavelengths involved are in the u.v. or visible portion of the electromagnetic spectrum.

(i) The labelled diagrams below represent part of an atomic absorption spectrum and an atomic emission spectrum, drawn to the same scale.



Absorption spectrum



Emission spectrum

Using the letters, choose a line from the spectra which would correspond to:

1. the line of lowest frequency in the emission spectrum.

2. the line corresponding to the absorption of the largest amount of energy. [2]

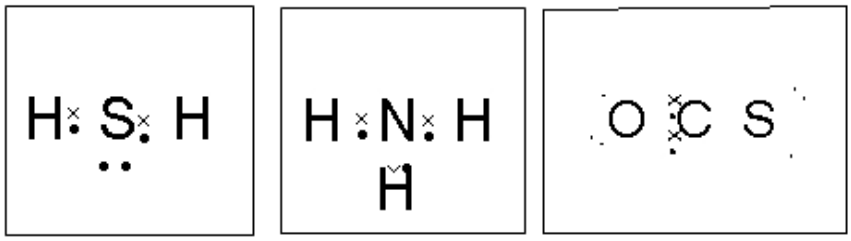
Candidate style answer	*Examiner's commentary*
F, A	In part **(i)**, F is correct but A should be J. The candidate has chosen the line of lowest frequency when it should be the highest frequency.

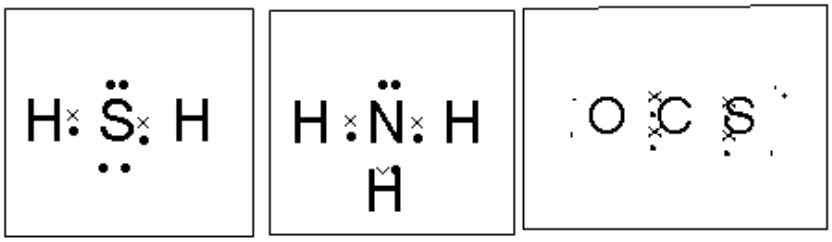
(ii) The emission and absorption spectra shown are for the same element.
What evidence is there from the two spectra that this is the case? [1]

Candidate style answer	*Examiner's commentary*
both spectra have a set of lines	Part **(ii)** is incorrect. The reason is that the lines in both spectra occur at the same frequencies

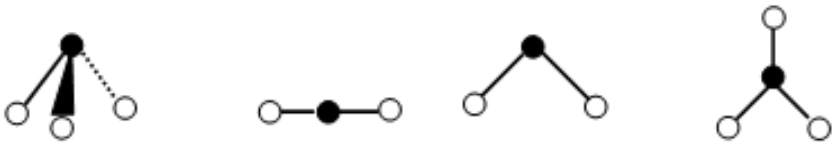
(b) Elements react together to form molecules in the dense clouds in interstellar space. These molecules can be detected by the characteristic radiowaves they emit.
Molecules of H_2S, NH_3 and OCS (similar to CO_2) have been discovered.

(i) Complete the *'dot-and-cross'* diagram for each molecule in the boxes below. [3]



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

(ii) Use the theory of electron pair repulsion to decide which of the possible shapes below represents the shape of each molecule.
Write the formula of each of the molecules H_2S, NH_3 and OCS underneath its shape. [3]

Candidate style answer	*Examiner's commentary*
 OCS, H_2S NH_3	In part **(ii)**, some marks are scored for the correct shapes of H_2S and OCS. However, NH_3 has a 'pyramidal' structure so NH_3 should be under the first diagram on the left.

(iii) What is the significance of the wedge( ) and the dotted line ( ) in the shape on the left? [1]

Candidate style answer	*Examiner's commentary*
they indicate the shape of the molecule	Part **(iii)** is too vague and does not score. The wedge bond comes out of the paper and the dotted bond goes in; both of these need to be said.

(c) Radio-astronomy also revealed the possible presence of long chains of carbon atoms in outer space.

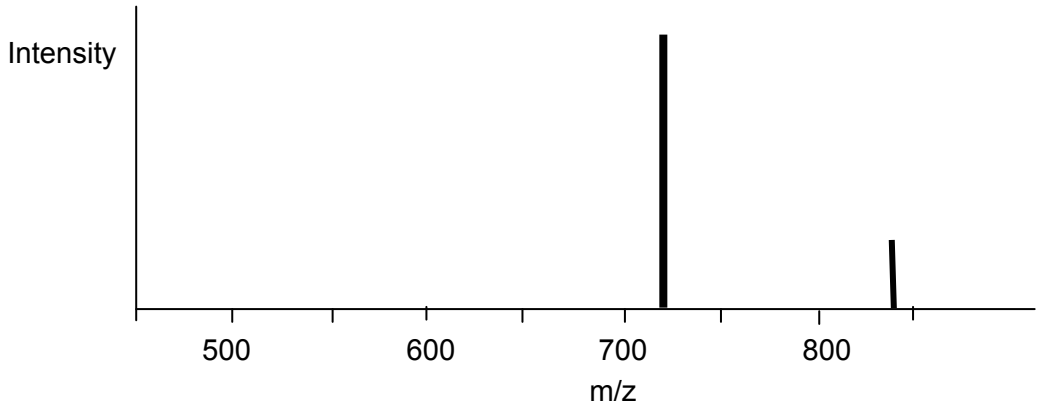
In the 1980s Professor Harry Kroto and other workers were investigating these chains. Professor Kroto was trying to recreate, in the laboratory, conditions that might account for the presence of carbon chains.

He tried vaporising carbon rods in an electric arc and he analysed the soot from the vaporised carbon in a mass spectrometer.

(i) In a time-of-flight mass spectrometer, how are the ions accelerated and why do they take different times to reach the detector? [2]

Candidate style answer	*Examiner's commentary*
They are accelerated when they are bombarded by electrons. *They take different times since they have different masses.*	In part **(i)**, the reason for the time is correct but the particles are *ionised* by electron bombardment, then accelerated by an electric field.

(ii) A simplified version of the mass spectrum is shown below. On the basis of this spectrum Professor Kroto suggested the presence of a C_{60} molecule.



Explain how the mass spectrum indicates the presence of a C_{60} molecule. [2]

Candidate style answer	*Examiner's commentary*
There are two peaks, so there are two isotopes; one is C_{60}	No marks are scored in part **(ii)**. It is the peak at 720 that indicates C_{60} (12 x 60 = 720). The candidate has confused the mass spectrum of an atom with that of a molecule.

(iii) **This C_{60} form of carbon (later named buckminsterfullerene) is unusual in that it is a simple molecule.**

Up until this discovery the only two forms of carbon thought to exist were the giant molecular structures of diamond and graphite.

Below is a table showing some physical and chemical properties of the three forms of carbon. Tick <u>two</u> boxes in the last column which corresponds to a property that supports <u>only</u> the simple molecular model for C_{60}. **[2]**

Candidate style answer

property	diamond	graphite	C_{60}	property supports simple molecular model
density/gcm^{-3}	3.52	1.9-2.3	1.69	✓
hardness scale (hardest 10 – softest 1)	10	1-2	1-2	
melting point/^{o}C	3550	3652-3697	sublimes around 800	✓
solubility	insoluble	insoluble	soluble in organic solvents	✓

Examiner's commentary

In part (iii), the density tells us relatively little about the structure, so it should not be ticked. The melting point and solubility are important. One basic mark is scored since both the correct ones are indicated plus one other wrong one.

Overall banding: Medium

This candidate has answered each part with reasonable detail and shown working for the calculations. Although there were some parts where the chemical ideas were not known or where the question was misunderstood, this is a respectable performance.