Advanced Subsidiary GCE Chemistry B (Salters)

Unit F331 Chemistry for Life - 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 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	*Examiners commentary*
	Most of this is right but there are places where the candidate has not been careful enough in answering the question.

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

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

Candidate style answer	*Examiners commentary*
they are the same element but have different number of neutrons	Part **(ii)**, however, is not full enough; 'same element' is too vague. 'Same atomic number' or 'same number of protons' is required here.

(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	*lead*
Deflection by electric field	*low*	large

Examiners commentary

Part **(iii)** scores all the marks, though 'low' is not in the list (but was accepted by the mark-scheme). Also, 'aluminium' is a better answer than 'lead' as lead stops all radiations. Again, lead was accepted as the answer.

(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	*Examiners commentary*
iodine is a mixture of isotopes and 126.9 is their average mass	The answer to part **(iv)** is correct.

(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	*Examiners commentary*
it is used in small doses, so the exposure is not great	Correct answer.

(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	*Examiners commentary*
8 days = 8000; 16 days = 4000; 24 days = 2000; 32 days = 1000; 40 days = 500 *40 days*	Both these answers are correct. There are neater ways of working out the time in part (ii) but this method is methodical and gives the right answer.

(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	*Examiners commentary*
The particles hit the nuclei and were deflected by large amounts (by the positive charge on the protons)	This is not enough for three marks. The fact that few particles were deflected has been well explained and scores two marks. The large numbers passing though unchanged has not been dealt with however. The third mark was for saying that the rest of the atom contained very low density electrons which did not deflect the particles.

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	*Examiners 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	*Examiners commentary*
CaO(s) + H2O(l) → Ca(OH)2(aq)	This is the correct equation and the correct state symbols have been given.

(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]

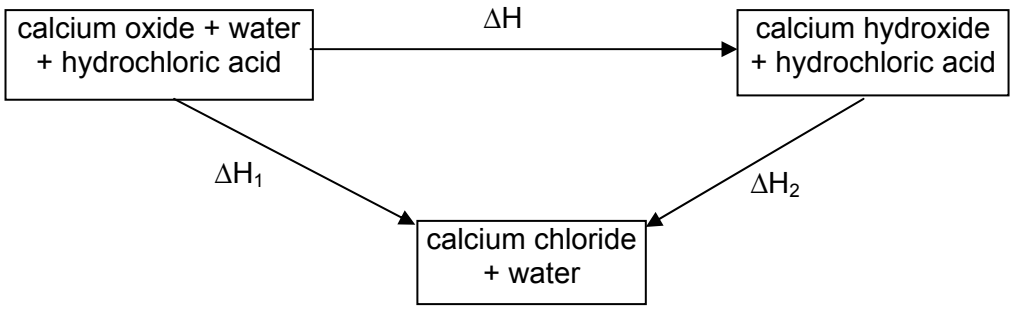
Candidate style answer	*Examiners commentary*
specific heat capacity of water = 4.2 kJ K^{-1} kg^{-1} ; density of water = 1.0 g cm^{-3} *M_r CaO = 56.1 Moles CaO = 10/56.1 = 0.18* *Heat = 250 x 4.2 x 50 = 53 kJ* *Thus, heat per mole = 53/0.18 = 290 kJ (2sf)*	This calculation is correct and the answer is to two significant figures. The candidate should be wary, however, of rounding the answers to two significant figures as they arise. It is better to leave at least three significant figures 'in play' until the end.

(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	*Examiners commentary*
some calcium hydroxide will dissolve	Correct answer

(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	*Examiners commentary*
$\Delta H = \Delta H_1 - \Delta H_2$	Part (i) is correct. Part (ii) is incomplete. As well as the equation, it is necessary to say that the enthalpy change does not vary with the route taken.

(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	*Examiners commentary*
magnesium is in the same group as calcium; however it is less reactive than calcium, so not so much heat will be given out.	The first mark is scored. Then the candidate veers off course. There is no requirement to discuss the relative merits of MgO and CaO and the answer given is not necessarily correct. The order of reactivity of the elements does not always indicate the order of reactivity of their compounds. The answer required is that compounds of elements in the same group have similar reactions.

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*
oxides of sulfur	*combustion of sulphur in the petrol*
hydrocarbons	*incomplete combustion of the hydrocarbon*

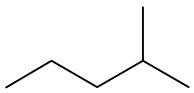
Examiners commentary

These are very short answers and thus some are too brief. (The model answer gives a clue as to how much detail is needed) The carbon monoxide answer scores a mark, though it would have been safer to add 'of the hydrocarbon fuel' or alternatives. The second answer does not score. This answer could be taken to imply that the element sulfur was present in the fuel, so 'sulfur compounds' should have been stated. Notice the internationally accepted way of spelling 'sulfur', though the word 'sulphur' would not have been penalised. The third answer is sufficient.

(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				✓

Examiners commentary

These are all correct.

(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	*Examiners commentary*
products are absorbed by the catalyst surface, bonds re-arrange and then the products diffuse away. Coke blocks the surface.	Another very brief answer to a question worth five marks with lots of lines. It loses the first mark as it says 'absorbed' rather than 'adsorbed' (incorrect spelling of a technical term). The next point is too vague, the bonds breaking in the reactants and then new bonds forming in the products need to be specifically mentioned. A mark is scored for the products diffusing away and also for the coke blocking the surface, though another mark would have been scored for saying that the coke bonds to the surface.

(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	*Examiners commentary*
they are renewable	Correct answer.

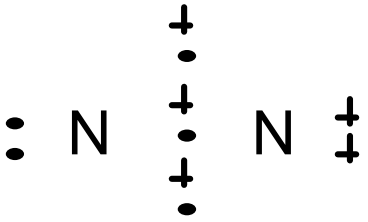
(ii) Biodiesel can be used on its own or blended with ordinary diesel.
Describe and explain what happens to the entropy of the system when this blending (or mixing) occurs, compared with the unblended compounds. [3]

Candidate style answer	*Examiners commentary*
the entropy is greater as there are more ways of arranging the molecules in the mixture	Correct answer.

(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	*Examiners commentary*
oxygenates	Correct answer.

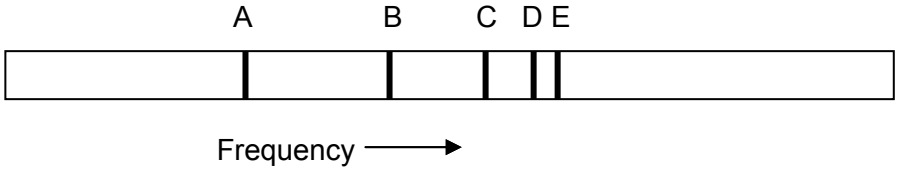
(iv) Emissions of most pollutants are reduced when biodiesel is used instead of petroleum diesel, with one exception.
The exception is that levels of oxides of nitrogen oxides (NO_x) increase in the exhaust.
A reason for this might be that the temperature at which biodiesel burns in the engine is higher 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	*Examiners commentary*
 *dot-cross diagram for nitrogen molecule* *the bond needs a lot of energy to break*	Parts (i) and (iii) are completely correct. In part (ii) there are three marks available and the candidate has not looked hard enough for the third, which is for the comparison '...more ways of arranging molecules in the mixture than in the compounds when separate'. The 'dot and cross' diagram is correct in part (iv) but the candidate has failed to point out that the strong bond is a triple bond.

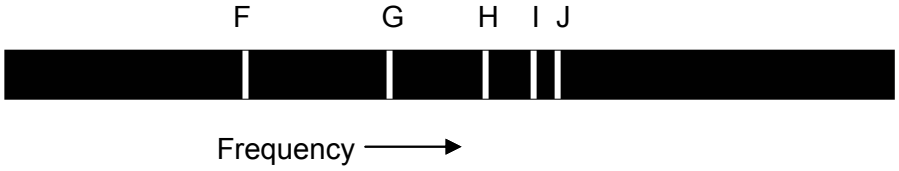
4 Most of the chemical elements found on Earth were produced in stars.

(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]

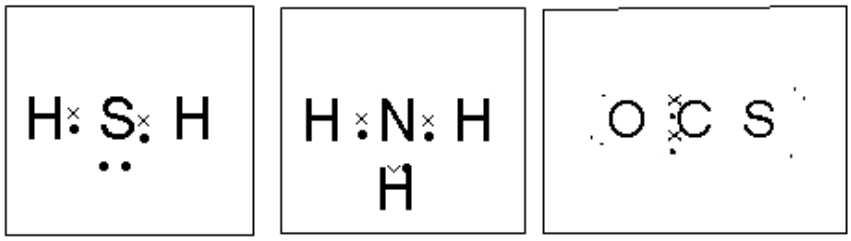
Candidate style answer	*Examiners commentary*
F, E	Correct answer.

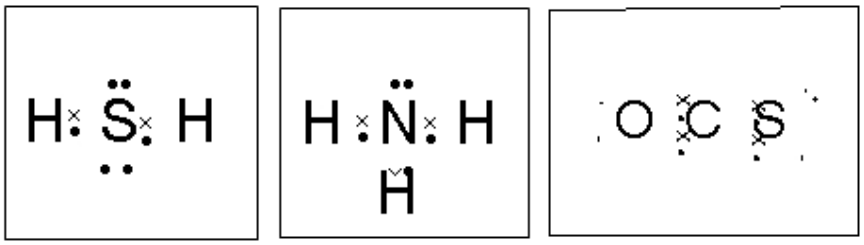
(ii) The emission and absorption spectra shown are for the same element. What evidence is there from the two spectra that this is the case? [1]

Candidate style answer	*Examiners commentary*
the lines are in the same places	These are all correct

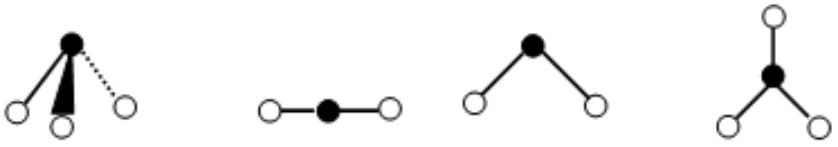
(b) Elements react together to form molecules in the dense clouds in interstellar space. These molecules can be detected by the characteristic radiowaves they emit.
Molecules of H_2S, NH_3 and OCS (similar to CO_2) have been discovered.

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



Candidate style answer	*Examiners commentary*
	

(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	*Examiners commentary*
 NH_3 OCS, H_2S	Correct answer.

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

Candidate style answer	*Examiners commentary*
they indicate bonds going into and out of the paper	Part **(i)** is completely correct. In part **(ii)**, two marks are scored for the correct shapes of NH_3 and OCS. However, H_2S has the same 'bent' shape as water, so H_2S should be under the third diagram from the left. 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.

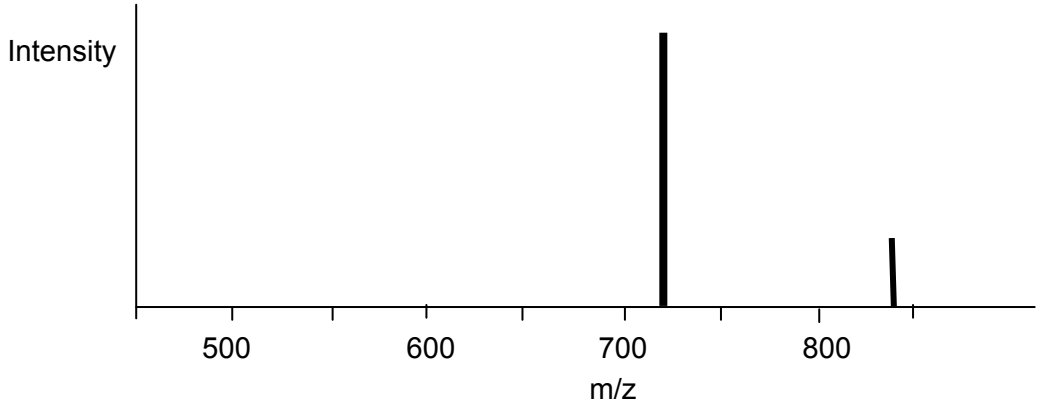
In the 1980s Professor Harry Kroto and other workers were investigating these chains. Professor Kroto was trying to recreate, in the laboratory, conditions that might account for the presence of carbon chains.

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	*Examiners commentary*
they are accelerated by an electric field and they take different times since they have different masses	Correct answer.

(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	*Examiners commentary*
the peak at 720 indicates C_{60} since 12x60 = 720	Correct answer.

(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	✓

Examiners commentary

All these answers are correct.

Overall banding: High

This candidate has scored in many of the most difficult parts, for example the calculations. There are, however, a lot of brief answers, sometimes too vague, that do not score as many marks as they should. The candidate needs to concentrate on getting full marks here by writing fuller answers.