GCSE (9-1)

Exemplar Candidate Work

GATEWAY SCIENCE
COMBINED SCIENCE A

J250
For first teaching in 2016

J250/09 Summer 2018
examination series

Version 1
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Introduction

These exemplar answers have been chosen from the summer 2018 examination series.

OCR is open to a wide variety of approaches and all answers are considered on their merits. These exemplars, therefore, should not be seen as the only way to answer questions but do illustrate how the mark scheme has been applied.

Please always refer to the specification https://www.ocr.org.uk/qualifications/gcse/gateway-science-suite-combined-science-a-j250-from-2016/ for full details of the assessment for this qualification. These exemplar answers should also be read in conjunction with the sample assessment materials and the June 2018 Examiners’ report or Report to Centres available from Interchange https://interchange.ocr.org.uk/Home.mvc/Index

The question paper, mark scheme and any resource booklet(s) will be available on the OCR website from summer 2019. Until then, they are available on OCR Interchange (school exams officers will have a login for this and are able to set up teachers with specific logins – see the following link for further information http://www.ocr.org.uk/administration/support-and-tools/interchange/managing-user-accounts/).

It is important to note that approaches to question setting and marking will remain consistent. At the same time OCR reviews all its qualifications annually and may make small adjustments to improve the performance of its assessments. We will let you know of any substantive changes.
Question 2

Exemplar 1 1 mark

2 Which statement about phosphorus is correct?

Use the Periodic Table to help you answer this question.

A A phosphorus atom has 15 protons and 16 electrons. ✓
B The phosphorus-31 isotope has 16 neutrons.
C Phosphorus is a metal. ✗
D The symbol for phosphorus is Po. ✗

Your answer [1]

Examiner commentary

Candidates often gave the incorrect response of A, which actually refers to the number of 'electrons' in an atom being different to the number of protons. This is incorrect. An isotope has a different number of neutrons, hence the correct response is B. This answer is a good example of a candidate eliminating the incorrect answers so arriving at the correct answer.

Question 3

Exemplar 1 1 mark

3 The element astatine, At, is below iodine in Group 7.

Which prediction about astatine is correct?

A Astatine is a gas.
B Astatine is more reactive than iodine.
C Astatine is white.
D Astatine reacts with sodium to form NaAt.

Your answer [1]

Examiner commentary

This question required candidates to recall their knowledge about the periodic table, in particular group 7. They should know the trends of the group. The elements melting and boiling points increase as you go down the group so you would expect Astatine to be a solid (not a gas). The reactivity of the group increases as you go up not down the group so Astatine would be less reactive than iodine. The elements become darker as you go down the group so white is not a feasible colour to expect of Astatine. Group 7 do react with group 1 to form salts so D is the correct response.
Question 5

Exemplar 1

5. What is meant by an alloy?
   A. A compound substance
   B. A metal used in car wheels
   C. A mixture of metals
   D. An element

Your answer: C

Examiner commentary

Alloys is perhaps an area of the specification that has not been well covered in the classroom. Candidates should know the definition of an alloy to be 'a mixture of metals'.

Question 10

Exemplar 1

10. The relative formula mass of NaOH is 40.

   What mass of sodium hydroxide, NaOH, is found in 100 cm³ of a 0.5 mol/dm³ solution of NaOH?

   A. 0.2 g
   B. 0.4 g
   C. 2.0 g
   D. 4.0 g

Your answer: C

Examiner commentary

Candidates need to be able to perform simple calculations in multiple choice questions. The mass of the substance can be found by multiplying the volume in dm³ by the concentration and the relative formula mass. This gives 2.0 grams, response C.
Question 11 (a)

Exemplar 1  

2 marks

11 Carbon nanotubes are a new material.

The diagrams show how a graphene sheet can form a nanotube.

(a) Nanotubes are more than 100 times stronger than iron.

Explain why nanotubes are so strong. Use ideas about bonding.

A carbon atom has four electrons in its outer shell. In a nanotube, it uses these electrons in covalent bonds with other carbon atoms. These bonds are stronger than the metallic bonds in iron. Also, graphene is naturally 207 times stronger than iron.

Examiner commentary

The high level response shows a clear understanding of the relative strengths of bond with covalent bonds being described as stronger than the metallic bonds in iron. The type of bonding in the nanotube was correctly identified and the comparative statement of strength given.

Exemplar 2  

0 marks

(a) Nanotubes are more than 100 times stronger than iron.

Explain why nanotubes are so strong. Use ideas about bonding.

As the nanotubes have a covalent bond, which gives it a stronger intermolecular force.

Examiner commentary

This response shows a lack of understanding of covalent bonding and intermolecular forces, as well as melting of a giant covalent structure and metals. The use of the phrase ‘intermolecular forces’ is a contradiction therefore zero marks.
Question 11 (b)

Exemplar 1 2 marks

(b) Carbon is a non-metal.
   Carbon nanotubes conduct electricity.
   Explain why carbon nanotubes conduct electricity.
   carbon nanotubes can conduct electricity
   as they have delocalised electrons that
   can get free enough to

Examiner commentary
This response has identified the delocalised electrons and the idea of movement of electrons to generate an electric current.

Exemplar 2 0 marks

(b) Carbon is a non-metal.
   Carbon nanotubes conduct electricity.
   Explain why carbon nanotubes conduct electricity.
   carbon nanotubes conduct electricity as they have delocalised electrons which can carry an electric current as they are free to

Examiner commentary
The word ‘transferable’ is not equivalent to delocalised or free, so the first marking point is not given. The candidate has then gone on to talk about ‘carrying a current’. A current is the movement of electrons. This candidate has described ‘carrying’ rather than ‘moving’ electrons so no mark can be given.
**Question 11 (ci)**

**Exemplar 1**

2 marks

(c) Carbon nanotubes and iron have very similar electrical conductivities.

Look at some other properties of carbon nanotubes and iron.

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (g/cm³)</th>
<th>Melting point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon nanotubes</td>
<td>1.6</td>
<td>3500</td>
</tr>
<tr>
<td>Iron</td>
<td>7.9</td>
<td>1538</td>
</tr>
</tbody>
</table>

(i) Calculate how many times more dense iron is than carbon nanotubes.

\[
\frac{7.9}{1.6} = 4.9
\]

Answer = 4.9 \[2\]

**Examiner commentary**

From the table of data provided 7.9 divided by 1.6 gives a ratio of 4.9 as the number of times the density of iron compared to carbon nanotubes. Candidates may have rounded this up to 5. It is preferred that the calculation be seen.

**Question 11 (cii)**

**Exemplar 1**

1 mark

(ii) Explain why iron is more dense than carbon nanotubes.

iron is a metal atom and so is very dense whilst a nanotube is hollow and a non-metal atom and so is less dense \[1\]

**Examiner commentary**

Candidates could describe the packing of the atoms of iron in a solid being closer together or describe in comparison, the hollow structure of the carbon nanotubes.
Examiner commentary

Candidates were expected to compare the strength of covalent bonds to metallic bonds. This comparison should have led them to describe the strength of covalent bonds as being stronger than metallics bonds. It was essential that a comparative statement was given to gain the mark in this question and not just that covalent bonds are ‘strong’. This answer did not gain the mark because they talked about intermolecular metallic bonds not just metallic bonds so showing confusion about the bonds within the metal.

Examiner commentary

Using the table of information provided, the candidates were expected to pick out the correct ions for aluminium and oxide. They were then expected to put them together using the correct terminology to provide the chemical formula for aluminium oxide. Several candidates left the charges on the ions rather than removing these when constructing the formula.
Exemplar Candidate Work

Question 12 (b)

Exemplar 1 1 mark

(b) A teacher wrote the formula for magnesium nitrate as:

\[
\text{MgNO}_3\text{.}
\]

A student says that the formula is incorrect.

Who is right? Explain your answer.

The student is correct. The formula should be \[\text{Mg(NO}_3\text{)}_2\].

Examiner commentary

Many candidates struggled to express their ideas clearly in this question. The formula they were given was not correctly written. The difficulty seemed to arise in expressing how to fix the problem with the formula. The correct formula was actually \[\text{Mg(NO}_3\text{)}_2\] showing there should have been two \[\text{NO}_3^-\] ions present to balance the \[\text{Mg}^{2+}\] ion rather than the one \[\text{NO}_3^-\] ion given in the original formula. The candidates could have explained this in several ways which referred to the charges not balancing so the overall charge was zero for the compound. There was no recognition for the comment alone about the teacher being incorrect or the student being correct.

Question 12 (ci)

Exemplar 1 1 mark

(c) Aluminium sulfide reacts with dilute hydrochloric acid.

(i) Balance the equation for this reaction.

\[\text{Al}_2\text{S}_3 + \ldots \ldots \text{HCl} \rightarrow \ldots 2\ldots \text{AlCl}_3 + 3\ldots \ldots \text{H}_2\text{S}\]

Examiner commentary

The correct balancing was 6 HCl, 2 AlCl\text{\textsubscript{3}} and 3 H\text{\textsubscript{2}}S. This answer shows the correct balancing.
Question 12 (cii)

Exemplar 1

1 mark

(ii) The table shows the melting point and boiling point of $\text{H}_2\text{S}$.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting point</td>
<td>$-85.5^\circ\text{C}$</td>
</tr>
<tr>
<td>Boiling point</td>
<td>$-80.7^\circ\text{C}$</td>
</tr>
</tbody>
</table>

What state does $\text{H}_2\text{S}$ exist in at room temperature?

A Gaseous State, it is a gas. [1]

Examiner commentary

Candidates were expected to use the table of data to understand that at a room temperature of approximately $25^\circ\text{C}$ the compound had surpassed both its melting and boiling points to become a gas.
Examiner commentary

This is a perfect answer as the arrows are carefully drawn to within one small square and the direction of the arrows are correct, up for A and down for E.
Question 13 (ai/aii)

Exemplar 2

Examiner commentary

This candidate has correctly identified the regions of the graph that represent the activation energy and the energy change, however the labels have been applied incorrectly so no mark was scored. The arrows are also double headed rather than just at the top for A and at the bottom for E.
Examiner commentary

This was a popular response, unfortunately showing a lack of understanding of the detail needed to use the graph to identify the activation energy and the energy change. A simple arrow towards the label of reactants, products or the peak of the graph were commonly seen.
Question 13 (b)

Exemplar 1 1 mark

(b) The reaction in the graph is exothermic.

Explain why. Use ideas about bonds.

Because the reaction creates more energy than it requires to break the bonds... so it gives out heat. [2]

Examiner commentary

This candidate has demonstrated an understanding of an exothermic reaction in terms of bonding but has not fully described the energy given out at the end of a reaction. The candidate needed to describe an exothermic reaction is due to the energy needed to break the existing bonds is less than the energy released when new bonds form. They have described the endothermic process of energy needed to break bonds but not the exothermic process of releasing energy when new bonds form. The mark is given for the idea that an exothermic reaction gives out energy or heat.

Exemplar 2 1 mark

(b) The reaction in the graph is exothermic.

Explain why. Use ideas about bonds.

The energy needed to form new bonds are less than the energy needed to break them... exothermic gives heat to the environment... causing a rise in temperature.

Examiner commentary

This candidate has scored 1 mark for the idea that energy or heat is released in an exothermic reaction. They have not correctly described the exothermic process of forming new bonds. Energy is not ‘needed’ when new bonds form. The other misconception frequently seen was the poor communication when describing the endothermic process of breaking bonds.
**Question 13 (c)**

**Exemplar 1**

2 marks

(c) Hydrogen burns in oxygen to form water.

Look at the equation for the reaction.

\[2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}\]

<table>
<thead>
<tr>
<th>Bond</th>
<th>Average bond energy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H – H</td>
<td>436</td>
</tr>
<tr>
<td>H – O</td>
<td>464</td>
</tr>
<tr>
<td>O = O</td>
<td>498</td>
</tr>
</tbody>
</table>

Calculate the energy change for this reaction.

\[
\begin{align*}
1 \cdot (498) &= 498 \\
1 \cdot (436) &= 436 \\
1 \cdot (1856) &= 1856 \\
-1 \cdot (1370) &= -1370 \\
\end{align*}
\]

\[
\frac{1856 - 1370}{498 - 436} = 48.6 \text{ kJ/mol}
\]

Examiner commentary

This candidate has correctly calculated the energy needed to break the bonds and the energy released when new bonds form. They have even gone on to correctly calculate the total energy released. Unfortunately, they have removed the negative sign on the answer line that would have scored the full 3 marks. Candidates need to calculate energies and apply the correct sign to gain full marks in such questions.

**Question 14 (a)**

**Exemplar 1**

1 mark

14 A student reacts an acid with a metal carbonate.

(a) Complete the word equation for the reaction.

\[\text{Acid + Metal Carbonate} \rightarrow \text{Salt} + \text{Water} + \text{Carbon dioxide}\]

Examiner commentary

This is the correct answer but a wide variety of incorrect responses were seen here, with metal hydroxide, hydrogen and bubbles being some of the more common incorrect responses. Centres should encourage candidates to learn the general equations.
Examiner commentary

The use of universal indicator is to test the pH of a substance. It should be noted that other substances can be used to show if the chemical is an acid or alkali and this type of broad statement should be avoided by candidates wherever possible. This answer although not ideal was allowed so gained the mark.

Examiner commentary

There was a significant number of candidates that could correctly quote the concentration of hydrogen ions as either 0.1 or 1x10⁻¹.
Question 14 (di)

Exemplar 1

1 mark

(d) A student has two different acids and one alkali.

- She adds 25 cm\(^3\) of the alkali to Acid A.
- She records the maximum temperature rise for the reaction using the equipment below.
- She repeats the experiment with Acid A several times to get 6 results in total.
- She repeats the whole experiment using Acid B.

Look at the student’s results.

<table>
<thead>
<tr>
<th></th>
<th>Maximum temperature rise (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Acid A</td>
<td>12.2</td>
</tr>
<tr>
<td>Acid B</td>
<td>4.1</td>
</tr>
</tbody>
</table>

(i) What is the range of the results for Acid A?

\[ \text{Answer} = 12.6 - 8.9 \]

Examiner commentary

This candidate has correctly identified the range as being 3.7 and has also shown the highest and lowest values which would have also gained the mark.

If the anomalous result (8.9) was taken into consideration and the range was therefore identified as the difference between 11.0 and 12.6. This gave an answer of 1.6. This answer was also allowed.
Question 14 (dii)

Exemplar 1

Evaluate the quality of the student's results.

The student's results are relatively close, except for result 6, which can be ignored as an anomaly. She tested her results appropriately and the experiment is easily repeatable. The results are of a high quality therefore.

Examiner commentary

The candidate was expected to identify that both results in the sixth column were anomalies. Both of the second results were a little on the low side. This would have been creditworthy if it had been mentioned. Results 1, 3, 4 and 5 are pretty close together and so the results are of good quality.
**Examiner commentary**

This candidate has given a comprehensive explanation and comparison of the strong cross links in polymer C and weak intermolecular forces in polymer A. Such a clear explanation was missing from the majority of responses. Instead most candidates ignored this part of the question and only discussed the properties listed in the table and related them to the ability of the box to do the job required. This candidate has given a less detailed description of how this relates to the properties of the material to make it a good storage box.
Question 15

Exemplar 2

2 marks

15* The table gives information about three polymers A, B and C.

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Melting Point (°C)</th>
<th>Relative Flexibility</th>
<th>Density (g/cm³)</th>
<th>Relative Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>70</td>
<td>Flexible</td>
<td>0.91</td>
<td>11.7</td>
</tr>
<tr>
<td>B</td>
<td>150</td>
<td>Rigid</td>
<td>1.32</td>
<td>12.1</td>
</tr>
<tr>
<td>C</td>
<td>230</td>
<td>Rigid</td>
<td>0.98</td>
<td>25.2</td>
</tr>
</tbody>
</table>

Explain which polymer would be best to make a plastic storage box.

Relate the relative flexibility of polymers A, B and C to a simple model of their structures.

Polymer A has a melting point of 70°C which would be too low and it is really flexible so wouldn’t make a good box. Polymer B is better with a melting point of 150°C and is rigid, however it is very dense at 1.32 and its strength is only 12:1. The best polymer would be C because its melting point is high and at 230°C and is rigid. It also is quite low density at 0.98 and its strength is best at 25.2.

Examiner commentary

This candidate has identified that polymer C will be the best for the job but has simply quoted data from the table rather than use the data to relate it to everyday properties of a good box. For example if they had discussed the relative strength and then explained that this meant it was hard to break or would hold its shape, or the relatively low density meant it was lightweight then a higher level would be accessible. Likewise there is no discussion of the structure and how this relates to the properties.
Question 16 (a)

Exemplar 1 1 mark

16 The molecule below has a simple molecular structure. It has a boiling point of 36.1 °C.

(a) Explain why the molecule has a low boiling point.

Examiner commentary

This answer has identified that the boiling point is relatively low as the molecule has weak intermolecular forces holding the molecules together so gaining one mark. ‘Easy to overcome them’ was insufficient for the second mark. To gain the second mark the answer needs to talk about the small amount of energy needed to break these intermolecular forces leading to a low boiling point.
Question 16 (b)

Exemplar 1

2 marks

(b) Look at the displayed formula of carbon dioxide.

O = C = O

The bonds between the carbon atom and the oxygen atoms are covalent bonds.

Draw a “dot and cross” diagram to show the bonding in carbon dioxide.

Only draw the outer shell electrons.

Examiner commentary

This candidate has clearly shown the dot and cross symbols to score both marks. Inner electrons are not needed for the mark, neither is a linear shape (although it would be preferred).
Question 16 (c)

Exemplar 1

2 marks

(c) Some elements bond to form compounds by ionic bonding.

Describe what is meant by ionic bonding.

Ionic bonding occurs when an atom donates electrons to another atom so that they can both become ions and have full outer shells. They occur between a metal and a non-metal. The metal gives electrons away and loses electrons so becomes positively charged. The non-metal gains electrons so becomes negatively charged.

Examiner commentary

The movement of electrons was mentioned by the majority of candidates. Unfortunately the direction of the transfer of the electrons was not clarified. It was expected that the candidates would explain the metals would release the electrons that would then pass to the non-metals creating ions. Metals producing positive ions and non-metals producing negative ions. There is then an electrostatic attraction formed between the positive metal ion and the negative non-metal ion, which holds the ionic compound together.
Examiner commentary

Here candidates were expected to link the information on the diagram with their own knowledge of Rutherford’s experiment. The idea that most particles passed straight through led to a theory of the atom being mainly empty space. This candidate has described that link well. Whilst the mark scheme did not require a candidate to link points it did require them to describe the different amounts of particles that passed through and were deflected using phrases such as ‘very few’ to describe those that deflected greatly back towards the source.
17 The atomic model has changed over time.


Look at the diagram of the experiment they did.

- Undeflected particles
- Slightly deflected particles
- Greatly deflected particles
- Gold foil
- α particle ray tube

(a) What conclusions did Rutherford, Geiger and Marsden draw from the experiment?

Explain how their results supported their conclusions.

Rutherford thought the particles were going to only be slightly deflected however some were deflected a lot more which suggested the nucleus in the atom was small and dense but instead of the plum pudding model a atom had space in it. Just two small electrons.

Examiner commentary

Here the candidate appears to have repeated some key words from the diagram but hasn't clearly understood the number of particles that pass straight through or deflected. The comment 'some were deflected a lot' is not correct as only a very few were deflected greatly. The mark was given for the idea of a small dense nucleus (marking point 6).
Question 17 (b)

Exemplar 1

2 marks

(b) Rutherford, Geiger and Marsden published their results.

Why is it important that scientists publish their results?

...Scientists must publish results in order to share their discoveries with the world, and in order to get recognition for their work.[2]

Examiner commentary

The importance of publishing results can be for several reasons. These include checking or comparing their data, sharing their ideas so that further evidence can be collected and information can be passed to other organisations.

Question 17 (c)

Exemplar 1

1 mark

(c) What new idea did Bohr add to the model of the atom?

Bohr added electron shells to the atomic model.[1]

Examiner commentary

Most candidates could explain that Bohr was responsible for adding electron shells to the model of the atom.
Question 18

Exemplar 1

18 Ammonium carbonate reacts with nitric acid. Ammonium nitrate, water and carbon dioxide are made.

Look at the equation for the reaction.

\[(\text{NH}_4)_2\text{CO}_3 + 2\text{HNO}_3 \rightarrow 2\text{NH}_4\text{NO}_3 + \text{H}_2\text{O} + \text{CO}_2\]

Calculate the mass of ammonium nitrate, \(\text{NH}_4\text{NO}_3\), that can be made from 3.84g of ammonium carbonate, \((\text{NH}_4)_2\text{CO}_3\).

\[
\text{Moles of ammonium nitrate} = \frac{3.84}{80} = 0.04
\]

\[
\text{Mass} = \text{moles} \times \text{Mr} = 0.04 \times 80 = 3.2 \times 2 = 6.4
\]

Examiner commentary

Very few candidates gained marks on this question. It was expected that candidates would calculate the relative formula mass of compounds in the equation. They could then either calculate moles and hence the mass of ammonium nitrate or calculate the reacting ratios and scale accordingly. This candidate produced a correct answer with clear working.
Examiner commentary

This question was about the representations that scientists use to describe molecules. Diagram A was the simple representation of the covalent bonds between atoms within a molecule. Diagram B was a space filled molecule and diagram C was a ball and stick diagram. Candidates were expected to discuss the advantages and disadvantages of each type of diagram to display the number and types of atoms and bonds present and their overall shape. Most candidates gained at least 1 mark on this question. This answer missed the gaining the fourth mark as it only clearly describes one disadvantage that all these models do not show size of atoms. The disadvantages as well as the advantages should be clearly linked to each model in the answer.
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