GCSE (9-1)

Exemplar Candidate Work

GATEWAY SCIENCE
COMBINED SCIENCE A

J250
For first teaching in 2016

J250/03 Summer 2018
examination series

Version 1

www.ocr.org.uk/combinedsciencea
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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/]

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

2. A metal carbonate reacts with an acid.

What products are made?

A. Salt and carbon dioxide
B. Salt and water
C. Salt, carbon dioxide and water
D. Salt, hydrogen and carbon dioxide

Your answer [ ] [1]

Examiner commentary

This candidate has forgotten that carbon dioxide is formed as well as a salt and water, so they have wrongly selected B instead of C. Many candidates forgot that water was produced and chose A.

Question 3

Exemplar 1

3. Ethanoic acid is a weak acid.

What is the pH of ethanoic acid?

A. 1
B. 5
C. 7
D. 12

Your answer [ ] [1]

Examiner commentary

This candidate has interpreted the pH values and correctly identified B. Some candidates knew that pH1 and pH5 were acids but could not distinguish between the pH of weak and strong acids so chose A. Candidates should be reminded to write the correct letter in the box, rather than the pH number.
Question 6

Exemplar 1


Which of Dalton’s ideas is now known to be incorrect?

A. A chemical reaction is a rearrangement of atoms.
B. All matter consists of atoms.
C. Atoms cannot be subdivided.
D. When elements react, their atoms combine in simple, whole-number ratios.

Your answer: D

Examiner commentary

This answer is a common misconception, as D is a correct statement. Many candidates did not realise that since atoms contain protons, neutrons and electrons this means that they can be subdivided making C the correct answer.

Question 7

Exemplar 1

7. An element has a relative atomic mass of 19.0.

Find this element on the Periodic Table.

How many protons does this element contain?

A. 9
B. 10
C. 19
D. 28

Your answer: A

Examiner commentary

This candidate has correctly interpreted the data on the Periodic Table, but a few thought that the relative atomic mass indicated the number of protons so they chose C.
Question 8

Exemplar 1

0 marks

8 An atom is the smallest particle of an element.

What is the approximate size of a single atom? \(1 \times 10^{-10}\) m

A 0.0001 \(\times 10^{-6}\) m
B 0.0001 \(\times 10^{-10}\) m
C 0.01 \(\times 10^{-10}\) m
D 0.1 \(\times 10^{-12}\) m

Your answer C [1]

Examiner commentary

This candidate knew that the size of an atom was \(1 \times 10^{-10}\) m. They were unable to convert the supplied data into standard form in order to deduce that the correct answer was A. The most common wrong answer was B, but C and D were often chosen.

Question 9

Exemplar 1

0 marks

9 Graphite is used in pencils.

Why can graphite make marks on paper?

A All the bonds in graphite are weak.
B Atoms in graphite are in layers:
C Forces between layers in graphite are strong.
D Every atom in graphite is strongly bonded to four others.

Your answer D [1]

Examiner commentary

This candidate appears to have confused the bonding in graphite with that in diamond. Few candidates had a clear enough understanding of the structure and bonding in graphite to allow them to explain its properties and select the correct answer B. All the incorrect options were popular.
Question 10

Exemplar 1

10 The diagram shows a reaction profile.

What is the energy change of the reaction?

A. +40 kJ/mol
B. −100 kJ/mol
C. +140 kJ/mol
D. −140 kJ/mol

Your answer: A [1]

Examiner commentary

This candidate has selected the activation energy, A, instead of the energy change B. The most common incorrect answers were C and D, with candidates being unsure whether the reaction was exothermic or endothermic.
Question 11 (a)

Exemplar 1

11 Look at the pictures of some common laboratory equipment.
(a) A student wants to **accurately** measure the melting point of ice.

Describe an experiment that she could do.

You may draw a **labelled** diagram to help your answer.

Use some of the equipment from the pictures on page 6.

---

the student should set up the apparatus as shown. put the ice in the beaker, heat up with a bunsen burner until ice melts. stop the stopwatch when it has then get the readings off the thermometer at the result time.

---

[2]
Examiner commentary

This candidate gained their first mark for choosing appropriate equipment; a beaker (containing ice) with a thermometer are shown in a labelled diagram. It was not necessary to include the ice, and as an alternative to the beaker a (conical) flask, (evaporating) basin/ bowl or (test/boiling) tube were accepted.

The second mark was for a suitable suggestion for the method and was given here for the idea of heating with a bunsen burner. A labelled diagram of a bunsen burner would also have scored the mark. Other answers that were credited included stirring, crushing the ice or heating more slowly e.g. by leaving it at room temperature or using a water bath.

Most candidates attempted to draw a diagram but generally used the pictures from the question rather than the diagrams they have been taught. Unlabelled diagrams were common and gained no credit. Only a few candidates knew the names of common apparatus and most did not realise that a beaker was most appropriate. Many used evaporating basins, often just labelled as a ‘bowl’, conical flasks or sometimes measuring cylinders to heat their ice in. Many candidates thought the stop clock was the key instrument, and in many cases missed out the thermometer.

**Question 11 (b)**

**Exemplar 1**  
1 mark

1. **(b) Suggest one thing the student could do to improve the experiment.**

   - use a digital thermometer for more accurate readings.

   ...…………………………………………………………………………………………………………………………………………[1]

**Examiner commentary**

The candidate has scored the mark for the use of a more sensitive thermometer, in this case digital thermometer was suggested – which we can assume would measure to at least one decimal place. This was an uncommon answer, with most candidates gaining the mark for the idea of repeating the experiment. The idea of using computer controlled equipment was rarely seen, but would gain the mark.

Other answers that could be credited (provided they had not already been used in the answer to 11(a) included stirring, crushing the ice, heating more slowly e.g. by leaving it at room temperature or using a water bath. Some candidates thought that using more or less ice, or different sizes of ice cubes would improve the experiment.
Question 12 (a) (i)

Exemplar 1 0 marks

12 (a) This question is about atomic structure.

(i) What is meant by relative atomic mass?

He total number of Protons and neutrons in an atom. [1]

Examiner commentary

This is a common misconception where relative atomic mass has been confused with mass number. Almost no candidates could recall the correct definition which needs to mention the mean mass of an atom compared to (1/12th the mass of) an atom Carbon-12. The mass of an atom is insufficient.

Question 12 (a) (ii)

Exemplar 1 2 marks

(ii) What two things can you work out from the atomic number of an element?

1. The number of Protons in an element. ☑

2. The number of Electrons in an element. ☑ [2]

Examiner commentary

This clear answer scored one mark each for the number of protons and the number of electrons.

Most candidates scored at least one mark for stating the number of protons. However, many candidates confused atomic number and mass number and referred to the number of neutrons. A few candidates put more than two answers which resulted in a loss of credit e.g. 1. Number of electrons (1 mark), 2. Number of protons and neutrons (no mark). Some just wrote ‘protons’ rather than ‘number of protons’, but were credited with the mark.

Some candidates interpreted the question differently and stated things they could deduce e.g. the number of electrons in the outer shell, number of electron shells, period number. They did gain credit for this, although it was not what the question had intended.
Question 12 (b)

Exemplar 1

3 marks

(b) Look at the table about the particles in an atom.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Relative Charge</th>
<th>Relative Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton</td>
<td>+1</td>
<td>1</td>
</tr>
<tr>
<td>Neutron</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Electron</td>
<td>-1</td>
<td>Almost 0</td>
</tr>
</tbody>
</table>

Complete the table.

Examiner commentary

All three answers are correct. A common error was to give the relative mass of the electron instead of the relative charge.

Question 13 (a) (i)

Exemplar 1

2 marks

13 (a) Look at the diagram of an electrolysis experiment.

(i) Complete the labels on the diagram.

Examiner commentary

The correct technical language was required in this question. One mark has been scored for the correct labelling of the anode and cathode. The second mark was for 'electrolyte', but the candidate has gained this mark by giving a correct example of an electrolyte instead. Answers that did not gain credit included positive/negative rod, water and solution. A few thought the dashes in the beaker were electrons.
**Question 13 (a) (ii)**

**Exemplar 1**

(ii) Sodium chloride is an **ionic compound**.

Sodium chloride

- Will **not** conduct electricity when it is solid
- Will **conduct** electricity when it is dissolved in water.

Explain why.

Sodium chloride will not conduct electricity when solid because there are no free mobile ions, it will only conduct electricity when dissolved in water because then the ions... \[2\]

**Exemplar 2**

(ii) Sodium chloride is an **ionic compound**.

Sodium chloride

- Will **not** conduct electricity when it is solid
- Will **conduct** electricity when it is dissolved in water.

Explain why.

When it is a liquid, it mimics the sea of delocalised electrons in a metal, allowing the electricity to flow through, this is not possible when it is in a solid state... \[2\]

**Examiner commentary**

The first candidate has explained their answer very clearly. They have scored 1 mark each for the two ideas that the ions cannot move in NaCl solid but that they are free to move in NaCl solution.

The second response illustrates a common misconception that there are free/delocalised electrons instead of ions in the solution. Candidates frequently wrote about electricity/electrons having space to move through liquids but not solids. Some candidates confused NaCl solution with molten NaCl but they did gain credit if their answer was otherwise correct.
Exemplar 1 2 marks

(b) A scientist electrolyses three different compounds.

Complete the table below to show what products will be formed.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Product formed at negative electrode</th>
<th>Product formed at positive electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molten PbBr$_2$</td>
<td>Lead</td>
<td>Bromine</td>
</tr>
<tr>
<td>A solution of KBr</td>
<td>Hydrogen</td>
<td>Potassium</td>
</tr>
<tr>
<td>A solution of CuCl$_2$</td>
<td>Copper</td>
<td>Chlorine</td>
</tr>
</tbody>
</table>

Exemplar 2 0 marks

(b) A scientist electrolyses three different compounds.

Complete the table below to show what products will be formed.

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<td>Hydrogen</td>
<td>Potassium bromide</td>
</tr>
<tr>
<td>A solution of CuCl$_2$</td>
<td>Copper</td>
<td>Chloride</td>
</tr>
</tbody>
</table>

Examiner commentary

The first candidate has been given 1 mark each for bromine (for PbBr$_2$) and chlorine (for CuCl$_2$). The second candidate scored no marks as they wrote bromide/chloride instead of bromine/chlorine.

Candidates found the KBr solution question more difficult and common misconceptions were that it produced either potassium or hydrogen, rather than bromine. There were a wide range of incorrect responses given for all three compounds – not all were names of elements. Many candidates did not attempt this question.
Question 13 (c)

Exemplar 1 2 marks

(c) Electrolysis can also be used to **electroplate** one metal onto another.

Look at the diagram of this experiment:

The experiment shown in this diagram will **not work**.

Suggest **two** things that must be changed to make the experiment work.

- The **silver** needs to be **positively charged**.
- and the **ring** needs to touch **the anode** (**negative**). [2]

**Examiner commentary**

One mark was given for knowing that the silver needs to be the positive electrode, but could have been gained for the idea that the silver and ring (or the anode and cathode) are the wrong way round. The second mark was given for realising that the circuit is not complete because the ring is not attached to the wire (even though this candidate has incorrectly stated that the anode is negative). Candidates were also able to gain a mark by stating that water would not work but an alternative was to name a suitable electrolyte. Most could not do this and did not realise that metal ions were required in solution. Some candidates thought that there was no power source.
Question 14 (a)

Exemplar 1

14 Look at the molecule below:

\[ \text{H}_4\text{C}_2\text{O}_2 \]

(a) Write down the empirical formula for this molecule.

\[ \text{H}_2\text{CO} \]  

1 mark

Exemplar 2

14 Look at the molecule below:

\[ \text{H}_4\text{C}_2\text{O}_2 \]

(a) Write down the empirical formula for this molecule.

\[ 2:1:1 \]  

0 marks

Examiner commentary

Candidates were required to state the empirical formula \( \text{CH}_2\text{O} \). The first candidate has scored the mark as credit was given even if the elements were not written in the conventional order. The second candidate has deduced the correct ratio (based on their stated molecular formula of \( \text{H}_4\text{C}_2\text{O}_2 \)), but does not gain credit as they have not written the empirical formula.

Most candidates did not appear to understand what was meant by an empirical formula and attempted to write a molecular formula. Some wrote both molecular and empirical formulae so did not gain credit; some attempted to write a symbol equation instead.
Question 14 (b)

Exemplar 1

(b) Calculate the relative formula mass, \( M_r \), for this molecule.

\[ 4\text{CH}_2 + \text{CO}_2 + \text{H}_2\text{O} \Rightarrow 60 \]

Answer = \( 60 \) \[ \text{[1]} \]

Examiner commentary

This is a correct answer of 60, with clear working. Candidates should be encouraged to show their working. A common wrong answer was 30. Many candidates did not seem to know how to calculate the relative formula mass.

Question 14 (c)

Exemplar 1

(c) The displayed formula for the molecule does not show the exact length of the bonds.

Write down two other limitations of the displayed formula.

- Doesn’t show the approximate size of the elements
- Doesn’t show if that was what its structure would look like

Examiner commentary

This candidate scored 1 mark for the idea that the displayed formula does not show the sizes of the atoms, though the idea that the molecule was not to scale would also be accepted. To score the second mark candidates needed to explain that the formula shown is 2D whereas molecules are 3D. The idea that the shape was not shown would also have been credited.

Many candidates did not seem to understand what the term ‘limitation’ meant. They took it to mean ‘what is the mistake with it’ and started trying to correct the formula with comments such as there shouldn’t be two lines between the C and the O. Others talked about bond lengths/strengths, sometimes just repeating the stem of the question. Most marks were given for the idea of size, but the fact that it was the atoms that were different sizes was generally not clearly explained.
Question 15 (a)

Exemplar 1

15 This question is about electronic structure and bonding.

(a) The electronic structure of phosphorus is 2.8.5. = S

Use these three numbers to explain the position of phosphorus in the Periodic Table.

If phosphorus has three shells... so it is in the third period.

It has 5 electrons in the outer shell... so it is in Group 5.

If you add the electronic structure of (15) it gives you...

Examiner commentary

The first candidate has been given their first mark for explaining that phosphorus is in period 3 because it has three electron shells (it has three numbers' would have gained credit). The second mark was given for explaining that it is in group 5 because it has five electrons in the outer shell.

The second candidate has been given only 1 mark for explaining that it is in group 5 because it has five electrons in the outer shell. They have realised that it has two completely full shells of electrons but have incorrectly linked this to period 2; also they have not used the correct terminology.

There were a number of common errors. Some candidates wrote about 'columns' and 'rows' instead of 'groups' and 'periods'. Many realised it was in group 5 but could not link this to having five electrons in the outer shell. Fewer candidates could link the three shells of electrons to it being in period 3. The fact that it had 15 electrons led some to place it in group 15 without the correct reason. Some just looked up phosphorus on the periodic table and described its position.
Exemplar 1

2 marks

(b) Phosphorus bonds with hydrogen to form the toxic gas phosphine, PH₃.

- Draw a ‘dot and cross’ diagram to show the covalent bonding in PH₃.

Examiner commentary

The first mark was given for showing one shared pair of electrons between phosphorus and a hydrogen atom. The second mark was for completing the structure correctly. A total of three shared pairs of electrons between hydrogen atoms and phosphorus were required, plus two extra electrons on the outer shell of phosphorus (which did not have to be drawn together as lone pair). This candidate's diagram is messy as they have rubbed out their initial attempt; this has shown up when their exam paper was scanned.

Marks were given even if all dots, all crosses or a mixture of dots and crosses were used. It was only necessary to draw the outer shells, but if the inner two shells were shown they had to be correct in order to score the second mark. Some candidates incorrectly attempted an ionic structure (despite covalent being stated in the question) or a stick diagram.
Question 16 (a)

Exemplar 1

16 Sodium hydroxide reacts with hydrochloric acid.

Sodium chloride and water are made.

(a) Write a word equation for this reaction.

\[ \text{Sodium hydroxide + hydrochloric acid} \rightarrow \text{Sodium chloride + water} \]

Examiner commentary

A clear word equation with the + signs and arrow positioned correctly. Some candidates were unable to copy the names of the chemicals from the stem of the question accurately. Some used different chemicals to those shown in the question. Some attempted a symbol equation but this rarely gained credit, even though it did not have to be balanced.

Question 16 (b) (i)

Exemplar 1

16 Sodium hydroxide reacts with hydrochloric acid.

Sodium chloride and water are made.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Volume of HCl (cm³)</th>
<th>Volume of NaOH (cm³)</th>
<th>Highest temperature reached during reaction (°C)</th>
<th>pH at the end of the reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>10</td>
<td>50</td>
<td>29.3</td>
<td>30.6</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td>40</td>
<td>34.5</td>
<td>35.3</td>
</tr>
<tr>
<td>C</td>
<td>30</td>
<td>30</td>
<td>37.3</td>
<td>37.8</td>
</tr>
<tr>
<td>D</td>
<td>40</td>
<td>20</td>
<td>34.3</td>
<td>35.5</td>
</tr>
</tbody>
</table>

(i) Calculate the mean temperature for experiment D.

Answer = \[ \frac{34.8}{3} \] °C [1]

Examiner commentary

The mean has been calculated correctly and written on the answer line, although the mark would have been given if it had been written the table instead. Some candidates added the three numbers but forgot to divide by three, others made one of a variety of different errors.
Question 16 (b) (ii)

Exemplar 1

1 mark

(ii) Describe the pattern of the highest temperature reached for experiments A to C.

...As the volume of HCl increases, so does the temperature. [1]

Examiner commentary

This mark could be gained for just stating that the temperature increased. This candidate has qualified their answer correctly but others lost the mark with incorrect comments such as ‘the temperature increased as the volume of hydrochloric acid and sodium hydroxide increased’.

Some candidates were confused because there were three repeats in the table and they tried to describe the pattern within these. A few misread the question and described the pattern from A to D rather than A to C.

Question 16 (b) (iii)

Exemplar 1

0 marks

(iii) Describe the pattern of pH at the end of the reaction for experiments A to D.

...The pH decreases as the more volume of HCl decreases and NaOH increases. They go from an alkali substance to neutral to weak acid... [1]

Examiner commentary

This candidate has correctly realised that the pH decreases. If they had stopped writing here they would have scored the mark. However, they have qualified their answer incorrectly and lost the mark. The pH decreases as the volume of HCl increases and the volume of NaOH decreases – they could have given either one of these as a correct qualification.
Exemplar Candidate Work

Question 16 (b) (iv)

Exemplar 1

1 mark

(iv) How could the student measure the pH?

[1 mark]

Examiner commentary

This candidate has correctly realised that the pH decreases. If they had stopped writing here they would have scored the mark. However, they have qualified their answer incorrectly and lost the mark. The pH decreases as the volume of HCl increases and the volume of NaOH decreases – they could have given either one of these as a correct qualification.

Question 16 (c)

Exemplar 1

1 mark

(c) What conclusion can you draw from the student’s experiments?

[1 mark]

Examiner commentary

This excellent conclusion gained the mark.

Candidates could score the mark for a wide variety of valid conclusions, or any pattern, drawn from the table of data. However, a lot of candidates did not seem to understand what a conclusion was, so just gave an observation or quoted data from the table. It was insufficient to just state that HCl was an acid and/or NaOH was an alkali. Many gained credit by just repeating the answer they had given in questions 16(b)(ii) or (iii). A common wrong answer was that as temperature increased pH decreased, as candidates had not spotted that temperature had dropped at D. Some candidates thought that a conclusion meant that a graph or diagram should be drawn.
Exemplar 1

Question 17

17* A student wants to find out which pigments are in a plant.

She does a chromatography experiment on a sample from the plant.

Look at her results.

The $R_f$ values for some pigments are shown in the table.

<table>
<thead>
<tr>
<th>Pigment</th>
<th>$R_f$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.95</td>
</tr>
<tr>
<td>B</td>
<td>0.45</td>
</tr>
<tr>
<td>C</td>
<td>0.32</td>
</tr>
<tr>
<td>D</td>
<td>0.26</td>
</tr>
<tr>
<td>E</td>
<td>0.16</td>
</tr>
</tbody>
</table>
Calculate the $R_f$ value for each spot.

Describe and explain which pigments are in the sample from the plant and suggest why further analysis of the plant pigments is needed.

Spot 1: $1.1/3.2 = 0.125 \rightarrow \text{pigment E}

\text{but may be different}

Spot 2: $2.8/8.8 = 0.318 \rightarrow \text{pigment C}$

Spot 3: $5.7/8.8 = 0.647 \rightarrow \text{unknown, this pigment has not been identified}$

Spot 4: $8.0/8.8 = 0.954 \rightarrow \text{pigment A}$

Only 2, possibly 3, pigments have been identified. Pigment spot 3 is made of an unknown pigment as spot 1 shows similarity to pigment E, although it could be different. Further analysis is needed.

Examiner commentary

This candidate has clearly shown how to use the $R_f$ formula and calculated all four $R_f$ values. Their answers for spots 3 and 4 have not been rounded correctly (they should be 0.65/0.648/0.6477 and 0.95/0.955/0.9545 respectively), but in this instance it has not been penalised as higher level science is present. They have correctly analysed the results to match spot 2 to pigment C and spot 4 to pigment A (Level 2).

The best match for this candidate’s answer is Level 3, as they have analysed the results to identify improvements that could be made. They have realised that spot 1 could be pigment E (but that it might not be) and that spot 3 has not been matched to any of the known pigments so 5 marks have been given. To achieve 6 marks the candidate needed to improve the level of their communication by suggesting that they should look up $R_f$ values of other pigments or test other known pigments in order to identify spots 1 and 3.
A student wants to find out which pigments are in a plant.

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<tr>
<td>C</td>
<td>0.32</td>
</tr>
<tr>
<td>D</td>
<td>0.25</td>
</tr>
<tr>
<td>E</td>
<td>0.15</td>
</tr>
</tbody>
</table>

$\text{Spot 2} = \text{pigment C}$  
$\text{Spot 4} = \text{pigment A}$
Examiner commentary

This candidate has not stated the formula for $R_f$, but has demonstrated that they know it as they have calculated all four $R_f$ values correctly. They have also correctly analysed the results and assigned two spots to pigments. In the answer space they state that pigments A and C are in the sample from the plant. However, when we look on the page where the data was provided they have also clearly matched spot 2 to pigment C and spot 4 to pigment A. Candidates should ensure that all of their answer is written in the space provided. Level 2 with 4 marks has been given.

To achieve Level 3 the candidate needed to point out that spot 3 did not match any of the pigments and that the identification of spot 1 was in doubt as it did not match the $R_f$ value for pigment E exactly. They should suggest looking up $R_f$ values of other pigments or testing other known pigments in order to attempt to identify spots 1 and 3.
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<tr>
<th>Pigment</th>
<th>$R_f$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.95</td>
</tr>
<tr>
<td>B</td>
<td>0.45</td>
</tr>
<tr>
<td>C</td>
<td>0.32</td>
</tr>
<tr>
<td>D</td>
<td>0.25</td>
</tr>
<tr>
<td>E</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Calculate the $R_f$ value for each spot.

Describe and explain which pigments are in the sample from the plant and suggest why further analysis of the plant pigments is needed.

\[
\begin{align*}
R_f &= 1.1 \div 9 = 0.12, \\
2.8 &\div 9 = 0.31, \\
5.7 &\div 9 = 0.63, \\
8.4 &\div 9 = 0.93. \\
\end{align*}
\]

The exact $R_f$ value of the spots is not the same as those some of the pigments already know. To make valid and reasonable conclusions more analysis is needed to see if the pigments are similar to each other or if they are very different. Another pigment C could be in the sample plant as pigment C's $R_f$ value is 0.32 and the spot 2's $R_f$ value is 0.31. To see whether they are the same pigment further analysis is needed. This analysis is needed for all the spots as they all have similar $R_f$ values to each pigment.

Examiner commentary

This candidate has not stated the formula for $R_f$ but has demonstrated that they know it as they have calculated all four $R_f$ values. However, they have measured the solvent front value incorrectly from the chromatogram (the correct value is 8.8 cm, not 9 cm). They have been given Level 1 with 2 marks as their calculation method is correct.

They have attempted to match their $R_f$ values to the known pigments and deduced that spot 2 could be pigment C. If they had also matched spot 4 to pigment A they would have been credited with Level 2 with 4 marks. If they had deduced that pigments A and C were present but not explained which spots they matched on the chromatogram they would be given Level 2 with only three marks due to poor communication.
17* A student wants to find out which pigments are in a plant.

She does a chromatography experiment on a sample from the plant.

Look at her results.

The \( R_f \) values for some pigments are shown in the table.

<table>
<thead>
<tr>
<th>Pigment</th>
<th>( R_f ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.95</td>
</tr>
<tr>
<td>B</td>
<td>0.45</td>
</tr>
<tr>
<td>C</td>
<td>0.32</td>
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<tr>
<td>D</td>
<td>0.25</td>
</tr>
<tr>
<td>E</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Examiner commentary

This response was not worthy of credit. The candidate did not state the $R_f$ formula and was unable to calculate the $R_f$ values for the spots. They do not appear to understand what is meant by a pigment and confused the $R_f$ values provided for the known pigments A – E with the distances travelled by spots 1 – 4 on the chromatogram.
**Question 18 (a)**

Exemplar 1 2 marks

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

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

- The bonds are joined together through covalent bonding. This is because they move with each other, allowing them to be stable.

Examiner commentary

Despite not being clearly expressed, this answer gained 2 marks. One mark was for the idea that carbon nanotubes had covalent bonds (minor mis-spellings were allowed). The second mark was for the idea that the bonds were strong; alternatives to this being either that there were many bonds, or that the bonds take lots of energy to break.

Mostly candidates scored 1 mark for the idea of strong bonds, although this was often not expressed clearly; few identified covalent bonds. Many candidates mentioned intermolecular forces which invalidated any otherwise correct answers.

**Question 18 (b)**

Exemplar 1 2 marks

(b) Carbon is a non-metals.

Carbon nanotubes conduct electricity.

Explain why carbon nanotubes conduct electricity.

Nanotubes are conduct electricity due to the delocalised electron that is free to move around the structure, allowing an electrical current.

Examiner commentary

This clear answer was given 1 mark each was given for the ideas that the carbon nanotubes contain delocalised or free electrons, and that these electrons can move. Candidates who just stated that electrons move freely gained only 1 mark, the idea of delocalised or free electrons was also required to gain both marks.

Candidates mostly gained just 1 mark by stating that electrons could move. Explanations involving delocalised electrons were rarely seen, with many writing about space for electricity to flow in nanotubes rather than about the electrons. Those who wrote about free or delocalised electrons often did not say that they moved. Many stated that carbon nanotubes conduct because carbon is a metal. Some thought they conduct because it’s a non-metal and non-metals are good conductors. A significant minority of incorrect responses mentioned inclusion of metals in the nanotubes as the reason for conductivity, or said that nanotubes had been designed so they conduct.
Question 18 (c) (i)

Exemplar 1

2 marks

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

\[
\frac{7.9}{1.6} = 4.9375
\]

\[
\approx 4.94
\]

Answer = \[4.94\] [2]

Examiner commentary

The answer of 4.9375 has been calculated and rounded correctly to two decimal places. 2 marks were given for any correctly rounded value (including 5). 1 mark was given for \(7.9 \div 1.6\).

Some candidates did not show their working so when they made an error, typically in rounding, they did not gain any credit. The most common error was to subtract the densities to give 6.3. A few candidates used the melting point data by mistake.

Question 18 (c) (ii)

Exemplar 1

1 mark

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

because there are more atoms packed into one single... 

space \[\text{BOD}\]

[1]

Examiner commentary

The mark has been given for the idea that the atoms (in iron) are more closely packed; although this has not been expressed very clearly, it has been given the benefit of doubt (BOD). Any one of three points could be stated in order to gain the mark: the atoms are packed closer in metals, carbon nanotubes have hollow spaces or that the relative atomic mass of iron is much bigger than that of carbon.

Some candidates knew that iron atoms were tightly packed. However, they often did not give comparative answers so gained no credit e.g. iron atoms are close together. Some candidates said ‘they’ are hollow but did not make it clear that they were referring to carbon nanotubes. Another common error was to merely state that iron was heavier or had more mass, but failing to mention relative atomic mass. A variety of irrelevant answers were given including relating density to melting point and conductivity.
Question 18 (c) (iii)

Exemplar 1

1 mark

(iii) Suggest a reason why carbon nanotubes have a higher melting point than iron.

...Their... bonds... are... tightly... packed... together... [✓]

...and... require... more... energy... to... break... than... [✓]

Examiner commentary

This candidate has scored the mark for stating that the bonds (in carbon nanotubes) need more energy to break them. However, this is not because their bonds are tightly packed together; this part of their response is not relevant so has been ignored. An ideal answer should explain that the (covalent) bonds in the carbon nanotubes are stronger than the (metallic) bonds in iron.

Many candidates knew that carbon nanotubes had strong bonds but did not always make their answer comparative so did not score the mark. Many incorrect answers linked high melting point to high density, or just to the nanotubes being stronger. No marks were given if intermolecular forces were mentioned.

Question 19 (a)

Exemplar 1

0 marks

19 The table shows some common ions.

<table>
<thead>
<tr>
<th>Negative ions</th>
<th>Positive ions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate</td>
<td>NO₃⁻</td>
</tr>
<tr>
<td>Oxide</td>
<td>O²⁻</td>
</tr>
<tr>
<td>Aluminium</td>
<td>Al³⁺</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Mg²⁺</td>
</tr>
</tbody>
</table>

(a) Write the formula for aluminium oxide.

Al₃O₂

Examiner commentary

This candidate did not score the mark; they knew how a formula should be written but the numbers are the wrong way round. Only a very few candidates deduced that the correct formula for aluminium oxide was AlO³⁻. Most included charges on the ions, e.g. Al¹⁺+O²⁻. Some attempted to write a word or symbol equation.
Question 19 (b)

Exemplar 1

1 mark

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

\[ \text{MgNO}_3 \]

A student says that the formula is incorrect.

Who is right? Explain your answer.

The student is correct because you need 2 nitrate ions to bond with one magnesium ion → \( \text{Mg(NO}_3\text{)}_2 \) [1]

Examiner commentary

This candidate scored the mark by stating the correct formula of magnesium nitrate as \( \text{Mg(NO}_3\text{)}_2 \). They have attempted to explain, but their explanation without the formula would have been insufficient to score the mark.

Alternative ways to gain the mark would be either to state the ratio of \( \text{MgNO}_3 \) ions which is 1:2, or to explain that the charges in \( \text{MgNO}_3 \) would not balance as an \( \text{Mg}^{2+} \) ion is but an \( \text{NO}_3^- \) ion is \( 1^- \).

Question 19 (c) (i)

Exemplar 1

1 mark

(c) Aluminium sulfide reacts with dilute hydrochloric acid.

(i) Balance the equation for this reaction.

\[ \text{Al}_2\text{S}_3 + 6 \text{HCl} \rightarrow 2 \text{AlCl}_3 + 3 \text{H}_2\text{S} \] [1]

Examiner commentary

This candidate has deduced all three numbers correctly to gain the mark. Some candidates sensibly used the spare pages at the back of the exam paper for their working out.

Only higher ability candidates seemed to understand how to balance an equation, and few could do this correctly. A significant number of candidates had written new formulae or names of chemicals on the dotted lines. A large number of candidates did not attempt to answer.
**Question 19 (c) (ii)**

**Exemplar 1**

1 mark

---

**Examiner commentary**

Gas is the correct answer.

Some candidates did not appear to understand what was meant by the term 'state'. A significant number of candidates who didn’t score the mark here had written something that wasn’t a state of matter. Incorrect answers included numbers, formulae and 'boiling point'.
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