GCSE (9–1)

Candidate Style Answers

GATEWAY SCIENCE
CHEMISTRY A

J248
For first teaching in 2016

Candidate style answers
Practical activity questions

Version 1

www.ocr.org.uk/chemistry
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Introduction

The following resource has been developed to support teachers in understanding how examiners apply the marking criteria and what they are looking for in candidate responses. There are sample responses for a selection of questions from the Sample assessments, with accompanying commentary.

The sample responses and commentaries should be read alongside the Specification for GCSE Gateway Suite – Chemistry A (9–1) which is available from the website. OCR will update these materials as appropriate.

Centres may wish to use these support materials in a number of ways:
- teacher training in interpretation of the marking criteria
- departmental standardisation meetings
- exemplars for candidates to review.

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.

Whilst a senior examiner has provided a possible mark/level when marking these answers, in a live series the mark a response would get depends on the whole process of standardisation, which considers the big picture of the year's scripts. Therefore the mark/level awarded here should be considered to be only an estimation of what would be awarded. How levels and marks correspond to grade boundaries depends on the Awarding process that happens after all/most of the scripts are marked and depends on a number of factors, including candidate performance across the board.

Details of this process can be found here: http://www.ocr.org.uk/Images/142042-marking-and-grading-assuring-ocr-s-accuracy.pdf
Phil investigates some exothermic and endothermic reactions. He measures the temperature changes during some chemical reactions. Look at the table. It shows his results.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Temperature at start (°C)</th>
<th>Temperature at end (°C)</th>
<th>Temperature change (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>25</td>
<td>+10</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>18</td>
<td>15</td>
<td>-3</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>20</td>
<td>+5</td>
</tr>
</tbody>
</table>

(a) What can you conclude about the type of energy change in each reaction? Explain your answer. [4]

- A is exothermic as the temperature increases (1)
- B is neither exothermic nor endothermic as the temperature stays the same (1)
- C is endothermic as the temperature drops (1)
- D is exothermic as the temperature increases (1)

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 (a)</td>
<td>A</td>
<td>4</td>
<td>1.2</td>
<td>ALLOW no energy change</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td>3 x 3.2b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question 16(a), sample answer 1

A and D are exothermic whilst C is endothermic. B is neither.

0 marks

Commentary
Although, the reactions have been correctly identified no marks are awarded because there are no explanations.
**Question 16(a), sample answer 2**

```
A\textsuperscript{1} this is an exothermic reaction because the......
temperature increases. Because there is an.............
overall transfer of energy to the surroundings.
C\textsuperscript{1} is endothermic because the temperature......
decreases as the energy transfers from the......
surroundings. B\rightarrow \text{ has no reaction} \& \text{ the......}
temperature doesn't change. 
```

4 marks

**Commentary**

The answer correctly identifies the types of reactions with explanations.

---

**Question 16(a), sample answer 3**

```
Reaction A\rightarrow and D\rightarrow showed an exothermic reaction because the temperature increased.
Reaction C\rightarrow showed an endothermic reaction because the temperature decreased. Reaction
B\rightarrow showed neither an exothermic or endothermic reaction because the temperature stayed the same.
```

4 marks

**Commentary**

The answer correctly identifies the types of reactions with explanations.
16(b) Look at how Phil does the experiment.

1. He measures the temperature of one of the reactants at the start.
2. He then adds the second reactant and stirs the mixture.
3. He removes the thermometer from the beaker and then reads it to take the temperature at the end of the reaction.

How should Phil improve his method? Explain your answer. [2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>16(b)</td>
<td>Idea that thermometer should remain in reaction mixture for temperature at end (1) otherwise temperature at end will be inaccurate (1)</td>
<td>2</td>
<td>3.3b</td>
<td>ALLOW do not stir with thermometer (1) as it is fragile (1) ALLOW lag the beaker (1) to reduce energy loss (1)</td>
</tr>
</tbody>
</table>

Question 16(b), sample answer 1

Phil should put some thermal insulation around the beaker to prevent heat loss. [2]

Commentary

A correct improvement and the effect of that is clearly in this answer.
Question 16(b), sample answer 2

*shown’t take the thermometer out of the beaker as it may change the temperature...
*repeat the experiment for all the reactants.

2 marks

Commentary
The answer correctly identifies an improvement with explanation.

Question 16(b), sample answer 3

He could read the temperature shown by the thermometer before removing it from the beaker.

1 mark

Commentary
The answer correctly identifies an improvement but with no explanation.
16(c) When Phil adds water to calcium oxide, a vigorous exothermic reaction takes place forming calcium hydroxide.
Calcium hydroxide has the formula Ca(OH)$_2$.
Show that the relative formula mass, $M_r$, of calcium hydroxide is 74.1.  

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 (c)</td>
<td>$(1 \times 40.1) + [(16.0 + 1.0) \times 2]$ Correct use of number of atoms (1) Correct use of $A_r$ (1)</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examiners comments

Proof incomplete.

Question 16(c), sample answer 1

0 marks

Examiners comments

This answer demonstrates a neat clear proof, so both marks awarded.
Examiners comments

This answer demonstrates a neat clear proof, so both marks awarded.
17(a) Look at the diagram.

It shows the apparatus used for the electrolysis of some molten compounds.

The table shows what is made at each electrode during the electrolysis of some molten compounds.

<table>
<thead>
<tr>
<th>Molten electrolyte</th>
<th>Formula</th>
<th>Product at negative electrode (cathode)</th>
<th>Product at positive electrode (anode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium chloride</td>
<td>NaCl</td>
<td>...........................................</td>
<td>chlorine</td>
</tr>
<tr>
<td>lead bromide</td>
<td>PbBr₂</td>
<td>lead</td>
<td>...........................................</td>
</tr>
</tbody>
</table>

Complete the table. [2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 (a)</td>
<td></td>
<td>2</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Molten electrolyte</th>
<th>Formula</th>
<th>Product at negative electrode (cathode)</th>
<th>Product at positive electrode (anode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium chloride</td>
<td>NaCl</td>
<td>...........................................</td>
<td>chlorine</td>
</tr>
<tr>
<td>lead bromide</td>
<td>PbBr₂</td>
<td>lead</td>
<td>...........................................</td>
</tr>
</tbody>
</table>

DO NOT ALLOW bromide.
Question 17(a), sample answer 1

<table>
<thead>
<tr>
<th>Molten Electrolyte</th>
<th>Formula</th>
<th>Product at Negative Electrode (Cathode)</th>
<th>Product at Positive Electrode (Anode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium chloride</td>
<td>NaCl</td>
<td>sodium</td>
<td>chlorine</td>
</tr>
<tr>
<td>lead bromide</td>
<td>PbBr₂</td>
<td>lead</td>
<td>bromine</td>
</tr>
</tbody>
</table>

Commentary
Both boxes filled in correctly.

2 marks

Question 17(a), sample answer 2

<table>
<thead>
<tr>
<th>Molten Electrolyte</th>
<th>Formula</th>
<th>Product at Negative Electrode (Cathode)</th>
<th>Product at Positive Electrode (Anode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium chloride</td>
<td>NaCl</td>
<td>sodium</td>
<td>chlorine</td>
</tr>
<tr>
<td>lead bromide</td>
<td>PbBr₂</td>
<td>lead</td>
<td>bromine</td>
</tr>
</tbody>
</table>

Commentary
Both boxes filled in correctly.

2 marks
17(b) Copper sulfate solution can be electrolysed using non-inert copper electrodes. Describe what happens at the negative copper electrode and the positive copper electrode.

[2]

Mark scheme

| 17 | (b) | negative electrode / cathode – copper deposited (1) |  | 2 |
|    |     | positive electrode / anode – anode dissolves / copper ions formed (1) |   | 1.2 |

Question 17(b), sample answer 1

```
negative copper electrode mass increases and positive copper electrode mass decreases. [2]
```

1 mark

Commentary

Although this answer does not talk about copper being deposited and dissolved, it does show that the electrodes increase in mass and decrease in mass showing that something is deposited at the negative electrode and that the positive electrode is dissolving because it is losing mass, so 1 mark awarded as what causes the loss or gain of mass is not mentioned.

Question 17(b), sample answer 2

```
the mass of the anode increases and the mass of the cathode decreases. [2]
```

0 marks

Commentary

This answer muddles up the anode and cathode. The cathode (negative electrode) increases in mass because copper is deposited and the anode (positive electrode) decreases in mass because copper ions form.
17(c) Javier is electrolysing a solution of sodium chloride, NaCl, in water, H₂O. Complete the list of ions present in sodium chloride solution.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>(c)</td>
<td>Positive ions (cations)</td>
<td>Negative ions (anions)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Na⁺</td>
<td>Cl⁻ (1)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H⁺ (1)</td>
<td>OH⁻</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Question 17(c), sample answer 1

2 marks

Commentary
Both ions correctly identified.

Question 17(c), sample answer 2

2 marks

Commentary
Both ions correctly identified.
17(d) Here is a diagram of a sodium chloride crystal.

The Cl-Na-Cl length in a crystal of sodium chloride is 0.564 nm.
What is the volume of this cube in nm$^3$? Give your answer to 3 significant figures.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 (d)</td>
<td>Volume = 0.564$^3$ (1) = 0.179406144 (1) to 3 significant figures = 0.179 (1)</td>
<td>3</td>
<td>1.2</td>
<td>ALLOW 3 marks for 0.179 without any working out</td>
</tr>
</tbody>
</table>

Question 17(d), sample answer 1

\[0.564 \times 0.564 \times 0.564 = \text{volume} \]
\[0.564^3 = 0.179 \text{ nm}^3 \]
\[\text{volume} = 0.179 \text{ nm}^3 \]

3 marks

Commentary

Answer on answer line correct.
Question 17(d), sample answer 2

\[ \text{volume} = 0.564 \times 0.564 \times 0.564 = 0.179406144 \]

\[ \text{volume} = 0.179 \text{ nm}^3 \]

3 marks

Commentary

Answer on answer line correct.
J248/01: Foundation paper – Tier 1  – Question 18

18(a) A student is separating a mixture of three solid substances, A, B and C.

Look at the table. It gives information about these substances.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Colour</th>
<th>Is it magnetic?</th>
<th>Melting point (°C)</th>
<th>Is it soluble in water?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>grey</td>
<td>yes</td>
<td>1535</td>
<td>no</td>
</tr>
<tr>
<td>B</td>
<td>white</td>
<td>no</td>
<td>801</td>
<td>yes</td>
</tr>
<tr>
<td>C</td>
<td>yellow</td>
<td>no</td>
<td>1427</td>
<td>no</td>
</tr>
</tbody>
</table>

Suggest how the student can separate the mixture to get pure, dry samples of substances A, B and C.

Explain why your methods work.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 18       | Please refer to the marking instructions on page 4 of the mark scheme for guidance on how to mark this question.  
Level 3 (5–6 marks)  
Suggestion would enable pure dry samples of all three components to be obtained in the correct sequence with clear explanations of why the methods work.  
There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.  
Level 2 (3–4 marks)  
Suggestion would enable pure dry samples of two of the components of the mixture to be obtained with an attempt at an explanation.  
There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.  
Level 1 (1–2 marks)  
Suggestion would enable a pure sample of one of the components to be obtained.  
The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.  
0 marks  
No response or no response worthy of credit. | 6 | AO3.3a: Analyse information in the table to develop experimental procedures  
• Wash solid C with water and allow to dry.  
• Evaporate solution of B to obtain solid crystals.  
• Using a magnet will separate A from other two.  
• Add water to mixture of B and C.  
• Filter mixture of B and C.  
• Rinse and dry solid C.  
• Evaporate solution of B.  
AO2.2: Apply knowledge of purification techniques  
• A is magnetic or B and C are not magnetic.  
• A can be removed from the mixture as it will stick to the magnet.  
• B will dissolve but C will not.  
• Solid C will be left after filtering. |
Question 18, sample answer 1

Explain why your methods work.

A can be separated from B and C using a magnetic device. Pour water onto B and C and stir, then pour it onto filter paper, leave it to dry and then C is a pure, dry substance. BS is put over a burner to evaporate the water off.

Commentary
The answer details methods that will separate out each substance and produce a pure sample. The method does not mention drying and washing C to produce a pure, dry sample of C so this puts the answer as a good level 2 almost level 3 so 4 marks awarded.

Question 18, sample answer 2

Commentary
This answer uses the correct methods to separate the substances to produce pure dry samples but with little or no explanation of why the methods work, so 3 marks awarded.
J248/01: Foundation paper – Tier 1
– Question 20

20(a) Paul and Orla want to make some solid zinc sulfate. They make some predictions.

Paul says

You can react sulfuric acid with zinc metal or zinc carbonate to make zinc sulfate. Both reactions make hydrogen.

Orla says

You can react hydrochloric acid with zinc metal or zinc carbonate to make zinc sulfate. The reaction with zinc metal makes hydrogen and the reaction with zinc carbonate makes carbon dioxide.

Comment on how correct both statements are. [4]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 20 (a)   | Correct - Any two from:  
sulfuric acid reacts with zinc and/or zinc carbonate to make zinc sulfate (1)  
zinc reacts with acid to make hydrogen (1)  
zinc carbonate reacts with acid to make carbon dioxide (1)  
Incorrect - Any two from:  
Both reactions do not make hydrogen (1)  
zinc and/or zinc carbonate will not react with hydrochloric acid to make zinc sulfate (1)  
zinc carbonate does not make hydrogen when it reacts with acid (1) | 4 | 2 x 2.1 | 2 x 3.1a |
Question 20(a), sample answer 1

Reactions between sulphuric acid and zinc metal/zinc carbonate do make zinc sulfate, however they do not make hydrogen. You cannot react hydrochloric acid with zinc metal/zinc carbonate to make zinc sulfate, however the reaction with zinc metal does make hydrogen and the reaction with zinc carbonate makes carbon dioxide.

3 marks

Commentary
This answer identifies that reaction of zinc metal and zinc carbonate with sulphuric acid makes zinc sulfate for one mark and that reaction with hydrochloric acid does not make zinc sulfate for the second mark. The second sentence in the answer has missed out the word ‘both’ so it is incorrect so no mark awarded. There is one more mark for a correct statement so only one of ‘zinc metal reacts to make hydrogen’ and ‘zinc carbonate reacts to make carbon dioxide’ can be awarded a mark, so overall, 3 marks awarded.

Question 20(a), sample answer 2

On Paul’s company the first sentence is correct and the second statement is false. Incorrect as only sulphuric acid with zinc metal makes hydrogen. Orla’s first sentence is incorrect as it makes zinc chloride. The second statement is true correct.

4 marks

Commentary
This answer has correctly identified the correct statements from Paul and Orla and correctly identified the false statements saying why they are false and how to correct them, so 4 marks awarded.
20(b)(i) Zinc nitrate, Zn(NO$_3$)$_2$, can be made by reacting zinc oxide, ZnO, with nitric acid, HNO$_3$.
Water, H$_2$O, is also made.
Write a balanced symbol equation for this reaction.  [2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 20(b)(i) | ZnO + 2HNO$_3$ $\rightarrow$ Zn(NO$_3$)$_2$ + H$_2$O | 2 | 2.1, 2.2 | balancing mark is conditional on correct formulae
ALLOW any correct multiple e.g. 2ZnO + 4HNO$_3$ $\rightarrow$ 2Zn(NO$_3$)$_2$ + 2H$_2$O (2)
ALLOW $\Rightarrow$ or $\rightarrow$ or $\Rightarrow$ for arrow
DO NOT ALLOW ‘and’ or ‘&’ for +
ALLOW one mark for correct balanced equation with minor errors in case, subscript and superscript e.g. ZnO + 2HNO$_3$ $\rightarrow$ Zn(NO$_3$)$_2$ + H$_2$O |

Question 20(b)(i), sample answer 1

ZnO + 2HNO$_3$ $\rightarrow$ Zn(NO$_3$)$_2$ + H$_2$O  [2]

2 marks

Commentary
This answer shows a correct balanced symbol equation.

Question 20(b)(i), sample answer 2

ZnO + HNO$_3$ $\rightarrow$ Zn(NO$_3$)$_2$ + H$_2$O  [2]

1 mark

Commentary
The formulae are in the correct positions but the equation is not correctly balanced, so 1 mark awarded.
Look at the data about some hydrocarbons.

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of carbon atoms in molecule</th>
<th>Molecular formula</th>
<th>Boiling point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethane</td>
<td>2</td>
<td>C₂H₆</td>
<td>-88</td>
</tr>
<tr>
<td>propane</td>
<td>3</td>
<td>C₃H₈</td>
<td>-42</td>
</tr>
<tr>
<td>pentane</td>
<td>5</td>
<td>C₅H₁₂</td>
<td>36</td>
</tr>
<tr>
<td>hexane</td>
<td>6</td>
<td>C₆H₁₄</td>
<td>69</td>
</tr>
</tbody>
</table>

(a) Butane contains 4 carbon atoms.

Use the table to suggest the molecular formula of butane.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>C₄H₁₀</td>
<td>1</td>
<td>2.1</td>
<td>DO NOT ALLOW C₄H₁₀ / H₁₀C₄ / C₄H₁₀ / H₁₀C₄</td>
</tr>
</tbody>
</table>

Commentary

Answer correct.

Question 21(a), sample answer 1

1 mark

Question 21(a), sample answer 2

1 mark

Commentary

Answer correct.
21(b) The data for ethane and propane have been plotted on the grid.

(i) Plot the data for pentane and hexane on the grid.

Draw the line of best fit.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>21(b)</td>
<td>(i)</td>
<td>2</td>
<td>2.1</td>
<td></td>
</tr>
</tbody>
</table>
Commentary
Plotting correct, straight line of best fit correct.
Question 21(b)(i), sample answer 2

Commentary
Plotting not evident, straight line of best fit is correct.
21(b)(ii) Use your graph to estimate the boiling point of butane.

answer: .............

[1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>(b) (ii)</td>
<td>-4 to -10°C dependent on line of best fit (1)</td>
<td>1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Question 21(b)(ii), sample answer 1

0 marks

Commentary
Graph incorrectly read, the boiling point is more like -4°C.

Question 21(b)(ii), sample answer 2

1 mark

Commentary
Estimate correct for line of best fit.
**21(b)(iii)** Describe the relationship between the number of carbon atoms in the molecule and its boiling point. 
Use ideas about forces between molecules to explain your answer.

[2]

**Mark scheme**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>21(b)(iii)</td>
<td>as the number of carbon atoms increases the boiling point increases (1) idea that larger molecules have greater intermolecular forces (1)</td>
<td>2</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>

**Question 21(b)(iii), sample answer 1**

The more carbon molecules the higher the boiling point

1 mark

**Commentary**
The answer describes the relationship but does not explain why, so 1 mark awarded.

**Question 21(b)(iii), sample answer 2**

As the number of carbon increases the higher the boiling point. And the molecular forces between them increase so the boiling point.

2 marks

**Commentary**
The answer describes the relationship and explains why, so 2 mark awarded.
21(c) **Propane** burns in oxygen, \(O_2\).
Carbon dioxide and water are made.
Write a **balanced symbol** equation for this reaction

[2]

**Mark scheme**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 21 (c)   | \(C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O\) (2) correct formulae (1) balancing (1) | 2 | 2.1 | balancing mark is conditional on correct formulae
ALLOW any correct multiple e.g. 
\(2ZnO + 4HNO_3 \rightarrow 2Zn(NO_3)_2 + 2H_2O\) 
ALLOW \(=\) or \(\Rightarrow\) or \(\rightarrow\) for arrow 
DO NOT ALLOW 'and' or for + 
ALLOW one mark for correct balanced equation with minor errors in case, subscript and superscript e.g. \(C^+H^+ + 5O_2 \rightarrow 3CO_2 + 4H_2O\) (2) |

**Question 21(c), sample answer 1**

\[ C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \]

2 marks

**Commentary**

Balanced symbol equation correct.

**Question 21(c), sample answer 2**

\[ C_3H_8 + 2O_2 \rightarrow CO_2 + \text{gas}H_2O \]

1 mark

**Commentary**

Symbols correct but balancing incorrect, so 1 mark awarded.
21(d) Propane gives out 50 000 J/g when it reacts with oxygen.

A propane burner is used to boil water to make a cup of tea.

63 000 J of energy are required to boil the water.

There is only 3 g of propane in the burner.

Do a calculation to find out if there is enough propane in the burner to boil the water.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 (d)</td>
<td>Mass of fuel needed to boil water (g) = energy needed to boil water (J) / energy per gram = 63000 / 50000 (1) = 1.2 g (1) Since 3 g in burner, this is enough propane / AW (1)</td>
<td>3</td>
<td>2.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Question 21(d), sample answer 1

50 000 x 3

0 marks

Commentary
Calculation incorrect and incomplete.

Question 21(d), sample answer 2

3g x 50000 J/g = 150000 J/g

Yes.

2 marks

Commentary
The answer correctly works out the maximum energy given out by 3g of propane and correctly concludes there is enough fuel but the calculation is not quite complete as it needs to say 150 000 > 63 000 so there is enough fuel. So 2 marks awarded.
J248/01: Foundation paper – Tier 1 – Question 23

23 Methane has the formula, CH₄.
Look at the representations of methane

Describe the limitations of a displayed formula. [2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>idea that does not show arrangement in space / is 2-dimensional only (1) bond angles are incorrect (1)</td>
<td>2</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>

Question 23, sample answer 1

We cannot see how big it is also it is not 3D.

1 mark

Commentary

Only one limitation correctly identified, ‘not 3D’, so one mark awarded.

Question 23, sample answer 2

It does not show the scale of the bonds or nucleus.

1 mark

Commentary

Only one limitation correctly identified, ‘scale of the bonds’, so one mark awarded.
16 Chemical tests are used to identify gases, anions and cations.
(a) Draw straight lines to match the **gas** to the correct **chemical test** used in analysis.

<table>
<thead>
<tr>
<th>gas</th>
<th>chemical test</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon dioxide</td>
<td>relights a glowing splint</td>
</tr>
<tr>
<td>chlorine</td>
<td>turns moist blue litmus blue</td>
</tr>
<tr>
<td>ammonia</td>
<td>turns moist blue litmus red and then white</td>
</tr>
<tr>
<td>hydrogen</td>
<td>turns lime water milky</td>
</tr>
<tr>
<td>oxygen</td>
<td>burns with a squeaky pop</td>
</tr>
<tr>
<td></td>
<td>turns moist pH paper green</td>
</tr>
</tbody>
</table>

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 (a)</td>
<td>gas</td>
<td>5</td>
<td>1.2</td>
<td>Each link = 1 mark</td>
</tr>
</tbody>
</table>
Question 16(a), sample answer 1

3 marks

Commentary
The answers for chlorine and ammonia are incorrect so 2 marks lost.

Question 16(a), sample answer 2

5 marks

Commentary
This is a high level answer with all lines correct.
16(b) Fahmida uses the flame test to identify the cations in a solid.
Describe how Fahmida should do a flame test

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 16 (b)   | Use a flame test wire (1)  
Moisten wire and dip into sample (1)  
Introduce sample into blue flame of Bunsen burner (1) | 3 | 1.2 | ALLOW use a wooden splint  
ALLOW spray bottle  
ALLOW moisten wooden splint and dip into sample  
ALLOW have ions dissolved in the spray bottle |

Question 16(b), sample answer 1

She would get a wire in a cork.  
She would put the wire in the solid and then put it in the flame.  
If it goes yellow it is sodium.

1 mark

Commentary
The mark was awarded for saying use a ‘wire in a cork’. The answer does say ‘put the wire in the solid’ but moistening the wire is not mentioned, so no mark given. Also the answer mentioning putting the wire in the flame but was not specific about which part of the flame so the mark cannot be awarded.

Question 16(b), sample answer 2

She should clean a wire in acid and then put the solid in a blue Bunsen flame. The colour of the flame tells her what cation is there.

1 mark

Commentary
This answer is not very coherent but it does match putting the solid in the blue part of the flame so 1 mark awarded.
16(c) Fahmida does three chemical tests on an unknown solution.

Look at her results.

<table>
<thead>
<tr>
<th>Chemical test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH probe</td>
<td>pH value is 3</td>
</tr>
<tr>
<td>dilute hydrochloric acid followed by barium chloride solution</td>
<td>white precipitate</td>
</tr>
<tr>
<td>dilute nitric acid followed by silver nitrate solution</td>
<td>white precipitate</td>
</tr>
</tbody>
</table>

Which ions are present in the solution?

Choose from:

- calcium
- hydrogen
- iron(II)
- chloride
- sulfate

Explain your answer.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>16(c)</td>
<td>Hydrogen, chloride and sulfate are present (1) Hydrogen ions because pH is 3 (1) Sulfate because white precipitate with barium chloride (1) Chloride because white precipitate with silver nitrate (1)</td>
<td>4</td>
<td>3.1a 3.2b 3.2b</td>
<td>ALLOW H⁺, Cl⁻ and SO₄²⁻ ALLOW (1) for the three correct ions ALLOW (1) for each correct explanation (must be linked to correct ion)</td>
</tr>
</tbody>
</table>

Question 16(c), sample answer 1

It contains hydrogen ions because it is an acid.

It contains chloride ions because it gives a white precipitate.

2 marks

Commentary

This answer has identified the hydrogen and chloride ions but not the sulfate ion so has failed to gain the first mark. The answer does explain why the solution contains hydrogen and chloride ions so a mark is gained for each explanation.
Question 16(c), sample answer 2

3 marks

Commentary
This answer almost scores 4 marks but fails to actually mention the hydrogen ions found in acid so cannot gain the first mark.
17 Sarah does three titrations with dilute hydrochloric acid and potassium hydroxide solution. Look at the apparatus she uses.

(a) Sarah uses a pipette to measure out the 25.0 cm³ of potassium hydroxide solution.

Describe and explain one safety precaution Sarah uses with the pipette.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 (a)</td>
<td>Use a pipette filler (1) Potassium hydroxide is caustic / potassium hydroxide can burn skin (1)</td>
<td>2</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>
Question 17(a), sample answer 1

She uses a filler thing to suck up the solution. She wears safety glasses in case the glass breaks

1 mark

Commentary
The answer mentions 'a filler thing' that sucks up the solution but not the reason why it is used so one mark awarded. It would be a better answer if the correct name was used 'a pipette filler'.

Question 17(a), sample answer 2

She must be careful with the glass so she doesn’t get cut and use a suction pump to suck the solution up

0 marks

Commentary
This is a low level answer worth 0 marks because they have failed to name the pipette filler and why it is used.
17(b) In her first titration Sarah measures the initial volume of hydrochloric acid in the burette.
She slowly adds the acid until the potassium hydroxide is just neutralised.
She then measures the volume of the hydrochloric acid again.
Describe how Sarah can tell when the potassium hydroxide solution is just neutralised.

[2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 (b)</td>
<td>When one drop makes the litmus change colour (1)</td>
<td>2</td>
<td>1.2</td>
<td>ALLOW use a pH probe = 1 mark</td>
</tr>
<tr>
<td></td>
<td>Correct colour change blue to red (1)</td>
<td></td>
<td></td>
<td>ALLOW gives a pH value of 7 when neutral = 1 mark</td>
</tr>
</tbody>
</table>

Question 17(b), sample answer 1

She puts in an indicator and it changes colour

1 mark

Commentary

1 mark awarded for recognising that the indicator changes colour to red at the neutralisation point. The second mark is not gained as the answer does not fully describe how Sarah can tell it is just neutralised.

Question 17(b), sample answer 2

The indicator changes colour to red.

1 mark

Commentary

1 mark awarded for recognising that the indicator changes colour to red at the neutralisation point. The second mark is not gained as the answer does not fully describe how Sarah can tell it is just neutralised.
17(c) Look at the diagrams. They show parts of the burette during the first titration.

Here is Sarah’s results table.

<table>
<thead>
<tr>
<th>Titration number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>final reading in cm³</td>
<td>37.5</td>
<td>32.1</td>
<td></td>
</tr>
<tr>
<td>initial reading in cm³</td>
<td>20.4</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>titre (volume of acid added) in cm³</td>
<td>17.1</td>
<td>17.1</td>
<td></td>
</tr>
</tbody>
</table>

(i) **Complete** the table by reading the burette readings from the diagrams.

**Mark scheme**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>(c)</td>
<td>(i)</td>
<td>2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Titration number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>final reading in cm³</td>
<td>17.8</td>
<td>37.5</td>
<td>32.1</td>
</tr>
<tr>
<td>initial reading in cm³</td>
<td>0.0</td>
<td>20.4</td>
<td>15.0</td>
</tr>
<tr>
<td>titre (volume of acid added) in cm³</td>
<td>17.8</td>
<td>17.1</td>
<td>17.1</td>
</tr>
</tbody>
</table>

Correct burette readings = 1 mark
Correct titre = 1 mark
DO NOT ALLOW 0
Question 17(c)(i), sample answer 1

<table>
<thead>
<tr>
<th>Titration number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final reading in cm³</td>
<td>18.2</td>
<td>37.5</td>
<td>32.1</td>
</tr>
<tr>
<td>Initial reading in cm³</td>
<td>0.0</td>
<td>20.4</td>
<td>15.0</td>
</tr>
<tr>
<td>Titre (volume of acid added) in cm³</td>
<td>18.2</td>
<td>17.1</td>
<td>17.1</td>
</tr>
</tbody>
</table>

0 marks

Commentary
Initial and final reading have been read and recorded incorrectly because they have not recognised that the scale on the burette starts with 0 at the top of the burette.

Question 17(c)(i), sample answer 2

<table>
<thead>
<tr>
<th>Titration number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final reading in cm³</td>
<td>17.8</td>
<td>37.5</td>
<td>32.1</td>
</tr>
<tr>
<td>Initial reading in cm³</td>
<td>0.0</td>
<td>20.4</td>
<td>15.0</td>
</tr>
<tr>
<td>Titre (volume of acid added) in cm³</td>
<td>17.8</td>
<td>17.1</td>
<td>17.1</td>
</tr>
</tbody>
</table>

2 marks

Commentary
Initial and final reading correctly read and recorded, the titre is correctly calculated.
17(c)(ii) Sarah thinks the mean titre is 17.1 cm³.

Is she correct?

Explain your answer.

[1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 (c) (ii)</td>
<td>Yes \nTitration 1 is a rough estimate / titration 1 is an outlier / titrations 2 and 3 are identical (1)</td>
<td>1</td>
<td>3.2a</td>
<td></td>
</tr>
</tbody>
</table>

**Question 17(c)(ii), sample answer 1**

Yes
The results for 2 and 3 are the same

1 mark

**Commentary**

The first mark is awarded for the equation being remembered and used correctly but the second mark has not been awarded as the rounding is incorrect for the answer.

**Question 17(c)(ii), sample answer 2**

Yes she is correct - because the first reading is a practice and is much bigger than 2 and 3

1 mark

**Commentary**

The answer recognises that the first titre is a practice (rough estimate).
17(d) Sarah does another titration to make a fertiliser called potassium nitrate, KNO₃.

Look at the equation for the reaction she uses.

$$\text{KOH} + \text{HNO}_3 \rightarrow \text{KNO}_3 + \text{H}_2\text{O}$$

The relative formula masses, $M_r$, of each compound are shown in the table.

<table>
<thead>
<tr>
<th>compound</th>
<th>formula</th>
<th>$M_r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>potassium hydroxide</td>
<td>KOH</td>
<td>56.1</td>
</tr>
<tr>
<td>nitric acid</td>
<td>HNO₃</td>
<td>63.0</td>
</tr>
<tr>
<td>potassium nitrate</td>
<td>KNO₃</td>
<td>101.1</td>
</tr>
<tr>
<td>water</td>
<td>H₂O</td>
<td>18.0</td>
</tr>
</tbody>
</table>

What is the atom economy for the reaction to make potassium nitrate?
Assume that water is a waste product.

Atom economy = ……………………% [2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 17(d)    | Atom economy = ($M_r$ of desired products / sum of $M_r$ of all products) x 100  
= (101.1 + 119.1) x 100 (1)  
= 84.9 (9) (1) | 2 | 2.2 | |

Question 17(d), sample answer 1

Commentary

Although the total mass of the reactants has been used and the mark scheme says total mass of the product, since these terms are equivalent in value and interchangeable depending on the version of the equation the student has been taught, the mark has been gained.

Final answer is not rounded correctly but full marks are given as the number of decimal places for the answer is not asked for.
Question 17(d), sample answer 2

Atom economy = \frac{101.1}{101.1 + 18} \times 100

Atom economy = 84.88\% \quad [2]

2 marks

Commentary

The answer is correct but the rounding is incorrect but this would still gain the mark as the number of decimal places are not stated so rounding is not being tested.
18 Crude oil is used as a source of fuels. It is separated into many fractions by fractional distillation. The diagram below shows a fractionating column.

(a) Crude oil contains a mixture of hydrocarbons that boil at different temperatures. Describe how crude oil can be separated using a fractionating column.

---

**Mark scheme**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (a)</td>
<td>Tall column with condensers coming off at different heights (1)</td>
<td>4</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Column heated at the bottom so hot at the bottom and cool at the top (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Substances with high boiling points condense at the bottom (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Substances with low boiling points condense at the top (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Question 18(a), sample answer 1**

"The oil is pumped in hot at the bottom and goes up the column. The different parts of oil have different boiling temperatures so go out at different levels."
Commentary

1 mark scored for the fact that hot oil is pumped into the bottom of the column. 1 mark for recognising that parts of the oil have different boiling point and condense at different levels.

The other 2 marks could be scored for a more detailed description of where the substances with different boiling points condense and run off the column.

Question 18(a), sample answer 2

Commentary

1 mark awarded for correctly mentioning that the heated oil goes in the bottom of the column.

The description lacks detail to gain other marks.
18(b) The alkane, $C_{15}H_{32}$, is cracked to make an alkene, $C_6H_{12}$ and an alkane, $C_3H_8$.

Construct the **balanced symbol** equation for this reaction.

![Equation](image)

**Mark scheme**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (b)</td>
<td>$C_{15}H_{32} \rightarrow 2C_6H_{12} + C_3H_8$ (1)</td>
<td>1</td>
<td>2.1</td>
<td>ALLOW any correct multiple</td>
</tr>
</tbody>
</table>

**Question 18(b), sample answer 1**

![Answer 1](image)

0 marks

**Commentary**

The equation has not been balanced.

**Question 18(b), sample answer 2**

![Answer 2](image)

1 mark

**Commentary**

Equation correctly written and balanced.
18(c) The polymer is used to make clothes such as socks and jumpers. Suggest one property of the polymer that makes it suitable for these uses.

[1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (c)</td>
<td>Can be made into fibres / waterproof / insoluble in water / flexible / soft (1)</td>
<td>1</td>
<td>2.1</td>
<td></td>
</tr>
</tbody>
</table>

Question 18(c), sample answer 1

It can be made into long fibres.

1 mark

Commentary
Correct property stated.

Question 18(c), sample answer 2

It can be dyed different colours.

0 marks

Commentary
The question asks for a property that makes the polymer suitable for socks and jumpers. They should be thinking about the fibres, the flexibility and comfort to score the marks.
19 The reversible reaction between carbon dioxide and hydrogen makes methane and water.

\[
\text{carbon dioxide} + \text{hydrogen} \rightleftharpoons \text{methane} + \text{water}
\]

(a) In a sealed container this reversible reaction forms a **dynamic equilibrium**.

What is meant by the term dynamic equilibrium?

Refer to both concentration and rate of reaction in your answer.

[2 marks]

**Mark scheme**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 19 (a)   | Rate of forward reaction equals the rate of the backward reaction (1)  
Concentration of reactants and products do not change (1) | 2 | 1.1 | DO NOT ALLOW concentration of reactant and products are the same  
ALLOW concentration of reactants and products stay the same |

**Question 19(a), sample answer 1**

The concentrations of all the chemicals don't change, and the rate of the reaction in both directions is the same.

[2 marks]

**Commentary**

Both marks are awarded for a good description of a dynamic equilibrium.
Question 19(a), sample answer 2

\[
\frac{\text{rate of the forward reaction}}{\text{rate of the backward reaction}}
\]

1 mark

Commentary

This answer correctly identifies the rate of reaction in a dynamic equilibrium but does not describe the concentrations of the reactants and products so only 1 mark scored. Students must make sure they take notice of the prompts in the questions to gain all the marks.
19(b) Kayvan investigates this reaction.
He predicts that 11.0 g of carbon dioxide should make 4.0 g of methane.
In an experiment, he finds that 11.0 g of carbon dioxide makes 2.2 g of methane.
Calculate the percentage yield of methane.

Percentage yield = %

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 (b)</td>
<td>Percentage yield = ( \frac{\text{actual yield}}{\text{predicted yield}} \times 100 ) or ( \frac{2.2}{4.0} \times 100 ) (1)</td>
<td>2</td>
<td>2.1</td>
<td>ALLOW full marks for answer with no working out</td>
</tr>
</tbody>
</table>

Question 19(b), sample answer 1

2 marks

Commentary
Calculation of % yield correct.

Question 19(b), sample answer 2

2 marks

Commentary
Calculation of % yield correct.
19(c)* Kayvan investigates the effect of changing the pressure and changing the temperature on this reaction.

\[
\text{carbon dioxide } + \text{ hydrogen } \rightleftharpoons \text{ methane } + \text{ water}
\]

The table shows the percentage yield of methane in the equilibrium mixture under different conditions.

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Pressure in atmospheres</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>100, 200, 300, 400</td>
</tr>
<tr>
<td>600</td>
<td>35%, 52%, 65%, 80%</td>
</tr>
<tr>
<td>900</td>
<td>30%, 46%, 58%, 74%</td>
</tr>
<tr>
<td>1200</td>
<td>23%, 37%, 47%, 62%</td>
</tr>
<tr>
<td></td>
<td>14%, 25%, 36%, 48%</td>
</tr>
</tbody>
</table>

Describe what happens to the percentage yield as the pressure and temperature change and explain the effect of increasing the pressure on the rate of reaction.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 (c)*</td>
<td>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</td>
<td>6</td>
<td>4 x 1.1</td>
<td>AO1.1: Knowledge of pressure on rate of reaction</td>
</tr>
<tr>
<td></td>
<td>Level 3 (5–6 marks)</td>
<td></td>
<td>2 x 3.1a</td>
<td>• Increasing the pressure increases the rate of reaction.</td>
</tr>
<tr>
<td></td>
<td>Describes the effect of changing the temperature and pressure on the percentage yield from the table and includes clear explanations on the effect of increasing the pressure on the rate of reaction</td>
<td></td>
<td></td>
<td>• Increasing the pressure means particles are closer together.</td>
</tr>
<tr>
<td></td>
<td>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</td>
<td></td>
<td></td>
<td>• Increasing the pressure means more crowded particles / more particles in the same space.</td>
</tr>
<tr>
<td></td>
<td>Level 2 (3–4 marks)</td>
<td></td>
<td></td>
<td>• More collisions the quicker the reaction.</td>
</tr>
<tr>
<td></td>
<td>Describes the effect of changing the temperature and pressure on the percentage yield from the table and either describes the effect of increasing the pressure on the rate of reaction or explains the effect increasing the pressure on the rate of reaction</td>
<td></td>
<td></td>
<td>• More collisions more percentage yield.</td>
</tr>
<tr>
<td></td>
<td>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</td>
<td></td>
<td></td>
<td>AO3.1a: Analyse information in the table to interpret percentage yield</td>
</tr>
<tr>
<td></td>
<td>Level 1 (1–2 marks)</td>
<td></td>
<td></td>
<td>• As temperature increases the percentage yield decreases.</td>
</tr>
<tr>
<td></td>
<td>Describes the effect of changing the temperature and pressure on the percentage yield from the table or describes the effect of increasing the pressure on the rate of reaction</td>
<td></td>
<td></td>
<td>• As pressure increases the percentage yield increases.</td>
</tr>
<tr>
<td></td>
<td>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</td>
<td>0</td>
<td></td>
<td>• The highest yield is when the temperature is low and the pressure is high.</td>
</tr>
<tr>
<td></td>
<td>0 marks</td>
<td></td>
<td></td>
<td>No response or no response worthy of credit.</td>
</tr>
</tbody>
</table>
Question 19(c), sample answer 1

6 marks

Commentary
This is a high level answer where the effect of temperature and pressure on % yield is clearly described and clear explanation of how pressure affects rate is seen.

Question 19(c), sample answer 2

2 marks

Commentary
This answer only describes the effect on % yield of temperature and pressure. The answer has failed to answer the second part of the question about the rate of reaction so is limited to a maximum of 2 marks.
20 Ammonium sulfate, \((\text{NH}_4)_2\text{SO}_4\), is a fertiliser.

Ammonium sulfate can be manufactured from ammonia and sulfuric acid.

(a) Sulfuric acid is manufactured in a series of steps.

Step 1:
Sulfur is burnt in oxygen to produce sulfur dioxide.

Step 2, The Contact Process:
Sulfur dioxide is reacted with oxygen to produce sulfur trioxide. This takes place in the presence of vanadium(V) oxide at a pressure of 2 atmospheres and at about 450°C.

Step 3:
Sulfur trioxide is reacted with water to produce sulfuric acid.

Write balanced symbol equations for each stage of this process.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (a)</td>
<td></td>
<td>4</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

Mark scheme

Question 20(a), sample answer 1

3 marks

Commentary

All equations correctly balanced and correct symbols used but the answer has failed to recognise that the second reaction is reversible; a clue to this is given in the stem in the conditions used.
Commentary

Although, the correct symbols are used the second equation is not balanced. The answer also has failed to recognise that the second reaction is reversible; a clue to this is given in the stem in the conditions used.
20(b) Ammonium sulfate is a salt. It is manufactured using the reaction between the alkali ammonia and sulfuric acid.

$$2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4$$

What type of reaction is this?

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (b)</td>
<td>Neutralisation (1)</td>
<td>1</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>

Question 20(b), sample answer 1

1 mark

Commentary

The type of reaction is correctly identified as acid neutralising an alkali.

Question 20(b), sample answer 2

0 marks

Commentary

It is important that students learn to use technical terms correctly. Here only a partial term has been used so no mark awarded.
20(c) A sample containing 17.0 g of ammonia completely reacts with sulfuric acid. A mass of 66.0 g of ammonium sulfate is made. Show that the maximum mass of ammonium sulfate that can be made from 51.0 g of ammonia is 198.0 g. [1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (c)</td>
<td>17 (g) of ammonia makes 66 (g) of ammonium sulfate</td>
<td>1</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>So 51 g makes 198 g of ammonium sulfate (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question 20(c), sample answer 1

![Sample Answer 1](image1)

1 mark

Commentary
This answer shows a correct calculation using ratios to show that 198g of ammonium sulfate can be made from 51g of ammonia.

Question 20(c), sample answer 2

![Sample Answer 2](image2)

1 mark

Commentary
This answer shows a correct calculation using ratios to show that 198g of ammonium sulfate can be made from 51g of ammonia.
20(d) A student has a solution of ammonium sulfate.

Describe how he can obtain a pure dry sample of ammonium sulfate.

[1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Slow evaporation of solution / heat solution over a steam bath</td>
<td>1</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

Question 20(d), sample answer 1

0 marks

Commentary

Although this answer mentions evaporation of the water from the solution, because the question is only worth 1 mark, to gain the marks students should be aware that the process of evaporation needs to be performed slowly so as not to decompose the ammonium sulfate.

Question 20(d), sample answer 2

0 mark

Commentary

Although this answer mentions evaporation of the water from the solution, because the question is only worth 1 mark, to gain the marks students should be aware that the process of evaporation needs to be performed slowly so as not to decompose the ammonium sulfate.
Iron rusts when it gets wet.

(a) The word equation for rusting is

iron + water + oxygen $\rightarrow$ rust (hydrated iron(III) oxide)

Balance the symbol equation for the formation of rust.

$\text{..Fe(s) + 6H}_2\text{O(l) + \ldots O}_2(g) \rightarrow 2 \text{Fe}_2\text{O}_3.\text{3H}_2\text{O(s)}$
22(b)(i) Calculate the percentage by mass of iron in rust.

Give your answer to 2 decimal places.

Relative formula mass of rust = 213.6

[2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>22(b)(i)</td>
<td>(\frac{2 \times 55.8}{213.6} \times 100) (1)</td>
<td>2</td>
<td>2.1</td>
<td></td>
</tr>
</tbody>
</table>

| Question 22(b)(i), sample answer 1 |

\[
\begin{align*}
4 \times 55.8 &= 223.2 \\
\text{Rust is } 2 \times 213.6 &= 427.2 \\
52.25 \text{ } \% \\
\text{So } \frac{223.2}{427.2} \times 100 &= 52.24719
\end{align*}
\]

2 marks

Commentary

The calculation is correct and the answer recorded to 2 decimal places, so 2 marks awarded.

| Question 22(b)(i), sample answer 2 |

\[
\begin{align*}
2 \times 55.8 &= 111.6 \\
\frac{111.6}{213.6} &= 0.5224719101 \times 100 \\
52.2 \text{ } \% \\
\end{align*}
\]

1 mark

Commentary

Although the calculation is correct, the answer is not given to 2 decimal places so only 1 mark can be awarded. Because the workings were shown clearly, the mark was able to be awarded.
22(b)(ii) An iron bar is left outside in the rain to rust.

It has a mass of 1.0 kg.

A student predicts that the mass of the bar will increase by no more than 0.8 kg if it completely turns to rust.

Do a calculation to work out the mass of rust produced, if the bar completely turns to rust, to see if the student is correct.

Give your answer to the nearest gram.

Mass of rust = …………………………… g

Is the student’s prediction correct and why? [3]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 22(b)(ii)| 52.25% of rust is iron
For a 1.0 kg Fe bar, total mass of rust produced
= (1.0 kg) / 52.25% x 100% (1)
= 1.914 kg (1)
Therefore increase is 914 g which is greater than 800 g so student is incorrect (1) | 3     | 2.1        | 2.1      |
|          |                                                                        |       | 2.1        | 3.2a     |

Question 22(b)(ii), sample answer 1

1 mark

Commentary

The student has failed to understand that the iron is part of the rust so although the calculation is correct only 1 mark is awarded due to this lack of understanding. This lack of understanding shows also in the assessment of the prediction, the mark is not awarded as although the conclusion made is correct, the explanation is not correct as it is expressed. A more accurate explanation is needed.
Question 22(b)(ii), sample answer 2

![Chemical equation]

Mass of rust = 1914 g

Is the student’s prediction correct and why?

No, rust weighs more.

2 marks

Commentary

The calculation is correct so 2 marks awarded. The answer does not gain a mark for the explanation as to whether the prediction is correct because there is little explanation.
23 Zinc and dilute sulfuric acid react to make hydrogen.

\[ \text{Zn(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{H}_2(\text{g}) \]

Inga measures the rate of this reaction by measuring the loss in mass of the reaction mixture. She finds that the change in mass is very small and difficult to measure.

(a) Draw a labelled diagram to show a better way of measuring the rate of this reaction. [3]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 (a)</td>
<td>Suitable container for the reactants e.g. flask, boiling tube or test tube (1) Use of a gas syringe / upturned burette with water in trough of water / upturned measuring cylinder with water in trough of water (1) The method actually works (1)</td>
<td>3</td>
<td>3.3b</td>
<td></td>
</tr>
</tbody>
</table>

Question 23(a), sample answer 1

3 marks

Commentary

This is a clearly drawn and labelled diagram but there is no label or graduation on the measuring cylinder, so 2 marks awarded. The setup would collect the gas but measuring it would be more difficult so 3rd mark cannot be awarded.
Question 23(a), sample answer 2

![Diagram](image)

1 mark

Commentary

The setup is mainly correct and labelled but the measuring cylinder is not labelled and no graduations are drawn. Also the tube is not hooked round into the ‘measuring cylinder’ so the gas may not collect. So only 1 mark awarded.
23(b) The reaction between zinc and dilute sulfuric acid is slow.

Inga decides to try and find a catalyst for this reaction.

She tests four possible substances.

Each time she adds 0.5 g of the substance to 1.0 g of zinc and 25 cm³ of dilute sulfuric acid.

Look at her table of results.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Colour of substance at start</th>
<th>Colour of substance at end</th>
<th>Relative rate of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>no substance</td>
<td>white</td>
<td>white</td>
<td>1</td>
</tr>
<tr>
<td>calcium sulfate powder</td>
<td>white</td>
<td>white</td>
<td>1</td>
</tr>
<tr>
<td>copper powder</td>
<td>pink</td>
<td>pink</td>
<td>10</td>
</tr>
<tr>
<td>copper(II) sulfate powder</td>
<td>blue</td>
<td>pink</td>
<td>30</td>
</tr>
<tr>
<td>manganese(IV) oxide powder</td>
<td>black</td>
<td>black</td>
<td>1</td>
</tr>
</tbody>
</table>

(i) It is important to do the reaction with only zinc and dilute sulfuric acid.

Explain why. [1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23(b)(i)</td>
<td>To allow a comparison between with and without the added substance (1)</td>
<td>1</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>

Question 23(b)(i), sample answer 1

So there is something to compare it with.

1 mark

Commentary

Correct answer.

Question 23(b)(i), sample answer 2

It is a control

0 marks

Commentary

The answer does not go far enough in explaining why.
23(b)(ii) It is important to do all of the reactions with the same concentration of acid.

Explain why. [1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>(b)(ii) Idea that the rate of reaction will change if concentration is changed (1)</td>
<td>1</td>
<td>2.2</td>
<td>It is a fair test is not sufficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ALLOW if concentration is increased the rate of reaction is increased</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ALLOW to ensure there are the same number of acid particles present /</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>same number of acid particles per unit volume</td>
</tr>
</tbody>
</table>

Question 23(b)(ii), sample answer 1

[Handwritten answer]

1 mark

Commentary

Good explanation.

Question 23(b)(ii), sample answer 2

[Handwritten answer]

0 marks

Commentary

This answer is not an explanation of why the concentration should be kept constant.
23(b)(iii) Which of the substances could be a catalyst for the reaction between zinc and dilute sulfuric acid?

Explain your answer. [2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23(b)(iii)</td>
<td>Copper</td>
<td>2</td>
<td>3.2b</td>
<td>No marks for copper on its own. If substance other than copper given then 0 marks for the question.</td>
</tr>
<tr>
<td></td>
<td>Because the reaction is faster (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>There is no change in appearance (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question 23(b)(iii), sample answer 1

![Handwritten answer]

2 marks

Commentary

The right option is chosen with the correct reasons.

Question 23(b)(iii), sample answer 2

![Handwritten answer]

2 marks

Commentary

The right option is chosen with the correct reasons.
23(b)(iv) There is not enough evidence to confirm which substance is a catalyst.

Suggest an extra piece of experimental evidence that could be collected to confirm which substance is a catalyst.

[1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 (b) (iv)</td>
<td>Measure mass of catalyst before and after (1)</td>
<td>1</td>
<td>3.3b</td>
<td></td>
</tr>
</tbody>
</table>

Question 23(b)(iv), sample answer 1

[1]

0 marks

Commentary

Although what is suggested is correct the question asks for an extra piece of experimental evidence and the answer does give the way to check whether the copper is used up.

Question 23(b)(iv), sample answer 2

[1]

1 mark

Commentary

A good answer giving a piece of experimental data that could be collected.
23(b)(v) Inga does the experiment with copper, zinc and dilute sulfuric acid again.

This time she uses a lump of copper rather than copper powder.

Predict, with reasons, the relative rate of reaction.

[2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 (b) (v)</td>
<td>(Relative rate) between above 1 and below 10 because of smaller surface area / less exposed particles / less collisions (2)</td>
<td>2</td>
<td>2.2</td>
<td>No marks for the prediction on its own No marks for whole question if prediction incorrect</td>
</tr>
</tbody>
</table>

Question 23(b)(v), sample answer 1

1 mark

Commentary

The answer does not predict the relative rate of reaction in numbers as the question asked so only 1 mark awarded.

Question 23(b)(v), sample answer 2

1 mark

Commentary

The answer does not predict the relative rate of reaction in numbers as the question asked so only 1 mark awarded for the explanation.
### J248/03: Higher paper – Higher Tier – Question 23

18. Look at the energy profile for a reaction.

![](energy_profile.png)

(a) What can you deduce about this reaction? Include the quantities $A$ and $B$ and a full explanation.

**Mark scheme**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (a)</td>
<td>any four from: reaction is exothermic (1) as reactants have more energy than products (1) $A$ is the activation energy (1) activation energy is the amount of energy supplied to get the reaction started (1) $B$ is the energy change for the reaction (1) the value of $B$ is negative (1)</td>
<td>4</td>
<td>2 x 1.1</td>
<td>2 x 3.2b</td>
</tr>
</tbody>
</table>

**Question 18(a), sample answer 1**

It is... an exothermic reaction meaning... [4] it transfers energy... to the surrounding area... It gets better... It means... this reaction takes... less energy... to break the bonds... then... is transferred... to make... them... Arrow $A$ signifies... [4] the activation energy Arrow $B$ shows the energy change.

4 marks
Commentary

Although this answer does not say that the reactants have more energy than the products this is implied in the statement that energy is transferred to the surroundings, so a mark is awarded.

Question 18(a), sample answer 2

Commentary

This is a high level answer; the statements made about the reaction are correct.
18(b) Look at the equation.

The table shows the bond energies of the bonds involved.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond energy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–H</td>
<td>435</td>
</tr>
<tr>
<td>O=O</td>
<td>498</td>
</tr>
<tr>
<td>C=O</td>
<td>805</td>
</tr>
<tr>
<td>O–H</td>
<td>464</td>
</tr>
</tbody>
</table>

(i) What type of energy change happens when bonds are broken and when bonds are made?

Bonds broken ........................................

Bonds made ...........................................

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>18(b)(i)</td>
<td>bonds broken – endothermic (1) bonds made – exothermic (1)</td>
<td>2</td>
<td>1.1</td>
<td>both required</td>
</tr>
</tbody>
</table>

Question 18(b)(i), sample answer 1

![Handwritten answer: Bonds broken endothermic; Bonds made exothermic]

2 marks

Commentary

Correct answer.
Commentary
The answers are the wrong way round.
18(b)(ii) Calculate the energy change for this reaction.

Energy change = ......................... kJ/mol

[3]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>(b) (ii)</td>
<td></td>
<td>2.1</td>
<td>Correct answer scores 3 if no working is shown</td>
</tr>
<tr>
<td>18 (b)</td>
<td>energy needed to break bonds = 2736 (kJ) (1)</td>
<td></td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>energy released when new bonds form = 3466 (kJ) (1)</td>
<td></td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>energy change for a reaction = 730 (kJ) given out / - 730 (kJ) (1)</td>
<td></td>
<td>2.1</td>
<td></td>
</tr>
</tbody>
</table>

Question 18(b)(ii), sample answer 1

3 marks

Commentary

This is a high level answer. Although a minus is not present on the answer line, there is a minus sign in the working so 3 marks awarded. Candidates should be careful when they are transferring answers from their workings to the answer line. In this case, the working was clear so the mark could be awarded.
Question 18(b)(ii), sample answer 2

3 marks

Commentary
This is a high level answer. The working is clear and the answer correct with the correct sign.
18(c) When propane reacts with oxygen, energy is given out.

Propane gives out 50 kJ/g.

A propane burner is used to boil 200 g of water to make a cup of tea.

The initial temperature of the water is 15°C.

How many grams of propane are needed to heat this water?

Use the following equation:

\[
\text{Energy transferred in J} = 4.2 \text{ J/g°C} \times \text{mass of water in g} \times \text{temperature change in °C}
\]

Amount of propane = ……………………………… g

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 18 (c)   | energy transferred = 4.2 \times 200 \times (100 - 15) \text{ J} \ (1)  
           = 71400 \text{ J} \ (1)  
           Mass of fuel needed to boil water (g) = energy needed to boil water (J) / energy per gram 
           50 \text{ kJ} = 50000 \text{ J} \ (1) 
           = 71400 / 50000 \ (1) 
           = 1.43 g \ (1)  | 5 | 2.2 | ALLOW 1.428 g instead of 1.43 (1) |

Question 18(c), sample answer 1

When propane reacts with oxygen, energy is given out.

Propane gives out 50 kJ/g. → 50,000 J/g

A propane burner is used to boil 200 g of water to make a cup of tea.

The initial temperature of the water is 15°C.

How many grams of propane are needed to heat this water?

Use the following equation:

\[
\text{Energy transferred in J} = 4.2 \text{ J/g°C} \times \text{mass of water in g} \times \text{temperature change in °C}
\]

\[
71400 / 50000 = 1.43 \text{ g}
\]

Amount of propane = 1.428 g

5 marks
Commentary
This is a high level answer with clear working and a correct answer.

Question 18(c), sample answer 2

When propane reacts with oxygen, energy is given out.
Propane gives out 50 kJ/g.
A propane burner is used to boil 200 g of water to make a cup of tea.
The initial temperature of the water is 15°C.
How many grams of propane are needed to heat this water?
Use the following equation:
Energy transferred in J = 4.2 J/g°C x mass of water in g x temperature change in °C

\[ \text{Energy} = 4.2 \times 200 \times 85 = 71,400 \]

\[ \frac{71,400}{1000} = 71.4 \text{ kJ} \]

Amount of propane = \[ \frac{71.4}{50} \text{ g} = 1.428 \text{ g} \]

3 marks

Commentary
This calculation is incomplete as it stops after the calculation of the number of kilojoules needed to boil the water. But because the working is clear and logical, 3 marks can be awarded even though the calculation of the amount of propane has not been reached.
Irenka reacts an element, X, with oxygen, O₂.

There is one product. It is the oxide of X i.e. X \text{oxide}.

4.86 g of X reacts with 3.20 g of oxygen to make 8.06 g of X \text{oxide}.

(a)(i) Calculate the number of moles of X, oxygen and X oxide involved in the reaction.

(The relative atomic mass of X is 24.3 and the relative formula mass of oxygen, O₂, is 32.0 and of X oxide is 40.3.)

Number of moles of X = ..........................

Number of moles of O₂ = ..........................

Number of moles of X \text{oxide} = ..........................

Mark scheme

<table>
<thead>
<tr>
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<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>(a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>no of moles of X = 0.2 (1)</td>
<td>3</td>
<td>3.1a</td>
<td>Number of moles of X, O₂ and X \text{oxide} calculated correctly so 3 marks scored.</td>
</tr>
<tr>
<td></td>
<td>no of moles of oxygen = 0.1 (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>no of moles of X oxide = 0.2 (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
19(a)(ii) Use your answers to write the balanced symbol equation for the reaction between X and oxygen to make X oxide.

[2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 (a)</td>
<td>(ii)</td>
<td>2</td>
<td>2.2</td>
<td>balancing is conditional on correct formulae</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.1a</td>
<td>ALLOW ecf from calculations of numbers of moles</td>
</tr>
</tbody>
</table>

Question 19(a)(ii), sample answer

2X + O₂ → 2XO

2 marks

Commentary

Balanced symbol equation correctly written.
Look at the equation.

It shows the reaction between sodium hydroxide and dilute sulfuric acid.

\[
2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}
\]

Sodium + sulfuric acid \rightarrow sodium sulfate + water

Calculate the mass of sodium hydroxide needed to make 30.0 g of sodium sulfate.

Give your answer to three significant figures.

Mass of sodium hydroxide = ………………………….. g

[3]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
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</tr>
</thead>
<tbody>
<tr>
<td>19 (b)</td>
<td>16.9 (g) scores (3) but if answer incorrect then RFM of NaOH = 40.0 and RFM of Na\textsubscript{2}SO\textsubscript{4} = 142.1 (1) idea that 2 moles of NaOH react to produce 1 mole of Na\textsubscript{2}SO\textsubscript{4} (1)</td>
<td>3, 1.1, 2 x 2.1</td>
<td>ALLOW 16.89 (2) ALLOW ccf from incorrect RFMs</td>
<td></td>
</tr>
</tbody>
</table>

Question 19(b), sample answer 1

46 + 32 + 2 = 80 = sodium hydroxide
2 \times 46 + 32 + 64 = 142.1 = sodium sulfate
80 g sodium hydroxide = 142.1 g sodium sulfate
80 ÷ 142.1 = 0.56 2983 = 30

Mass of sodium hydroxide = 16.9 ………………… g

3 marks

Commentary

Answer correct and to three significant figures so 3 marks awarded.
Question 19(b), sample answer 2

3 marks

Commentary
Although there is no answer on the answer line, the working is clear so an answer of 16.9 is clearly seen so 3 marks awarded.
A student is separating a mixture of three substances, A, B and C.

Look at the table. It gives information about these substances.

<table>
<thead>
<tr>
<th>Substance</th>
<th>State at room temperature</th>
<th>Melting point (°C)</th>
<th>Boiling point (°C)</th>
<th>Solubility in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>liquid</td>
<td>0</td>
<td>100</td>
<td>soluble</td>
</tr>
<tr>
<td>B</td>
<td>liquid</td>
<td>-117</td>
<td>78</td>
<td>soluble</td>
</tr>
<tr>
<td>C</td>
<td>solid</td>
<td>1535</td>
<td>2750</td>
<td>insoluble</td>
</tr>
</tbody>
</table>

A and B mix together completely.

(a)* Suggest how the student can separate the mixture to get pure samples of substances A, B and C.

Explain in detail how each method works.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (a)</td>
<td>Please refer to the marking instructions on page 4 of the mark scheme for guidance on how to mark this question.</td>
<td>6</td>
<td>AO1.2: Knowledge of process of fractional distillation</td>
<td>AO1.2: Knowledge of process of fractional distillation • Use fractional distillation to separate substance A from substance B. • Substance B will come off first as it has lowest boiling point. • Stronger forces between molecules in substance A.</td>
</tr>
<tr>
<td></td>
<td>Level 3 (5–6 marks) Suggestion would enable pure samples of all three components to be obtained in the correct sequence with clear explanations of why the methods work. There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</td>
<td></td>
<td></td>
<td>AO2.2: Apply knowledge of process of fractional distillation • Fractional distillation works as substances A and B have different boiling points. • As substance C is insoluble in water. • Because there are differing forces of attraction between the molecules.</td>
</tr>
<tr>
<td></td>
<td>Level 2 (3–4 marks) Suggestion would enable pure samples of two of the components of the mixture to be obtained with an attempt at an explanation. There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</td>
<td></td>
<td></td>
<td>AO3.3a: Analyse information in the table to develop experimental procedure • Heat mixture to boil off substances A and B leaving pure C. • Filter mixture to remove substance C. • Substance C can be washed with water and dried.</td>
</tr>
<tr>
<td></td>
<td>Level 1 (1–2 marks) Suggestion would enable a pure sample of one of the components to be obtained. The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 marks No response or no response worthy of credit.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question 20(a), sample answer 1

3 marks – Level 2

Commentary
This answer identifies the methods of separation and attempts at explanation but the explanation is limited to a description of how the equipment works. That is that C is insoluble in water and one of the liquids is likely to be water as it boils at 100°C so it is likely that C is un-dissolved so can be filtered off and washed with water and dried. From this answer only the liquids may be obtained as pure samples. The explanations are attempted but incomplete as the difference in boiling point is only eluded to, so the answer is sufficient for 4 marks.
Question 20(a), sample answer 2

To separate substance A & B from C you would have to filter it, this is because A & B are liquids and C is a solid, so if you add it to the filter paper the substance C would become the residue and substances A & B will become the filtrate. Then to separate A & B, as they are both liquids you would have to use fractional distillation which separates two or more substances. You would do this by heating the mixture in a fractional column at 78°C so that substance B will evaporate and then the vapour will pass into a test tube therefore leaving you with three pure substances.

4 marks – Level 2

Commentary

Again the washing and drying of the solid is missed and again there is an attempt at an explanation. The answer does have a line of reasoning with some structure and the information is relevant and supported by some evidence. So Level 2, 4 marks awarded.
20(b) The student has separated a pure sample of substance B from the mixture. Suggest how the student can check that the sample of substance B is pure.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (b)</td>
<td>measure its melting point or boiling point (1)</td>
<td>2</td>
<td>1.2</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>if pure melting point or boiling point will be sharp / if impure melting point is lowered / if impure boiling point is elevated (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question 20(b), sample answer 1

Freeze it then see if the melting point is exactly -117°C because if it is that means it's pure. [2]

2 marks

Commentary

Correct identification of using the melting point.

Question 20(b), sample answer 2

...you could measure its boiling point or use chromatography to see if you get the same... [2]

1 mark

Commentary

This answer mentions measuring the substances boiling point so gains 1 mark but does not say how the boiling point would show that the substance is pure so the second mark cannot be awarded.
21 Zinc nitrate can be made by reacting zinc oxide with nitric acid, HNO₃.

(a) Write a balanced symbol equation for this reaction. [2]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 (a)</td>
<td>ZnO + 2HNO₃ → Zn(NO₃)₂ + H₂O correct formulae (1) balancing (1)</td>
<td>2</td>
<td>2.2</td>
<td>balancing mark is conditional on correct formulae ALLOW any correct multiple e.g. 2ZnO + 4HNO₃ → 2Zn(NO₃)₂ + 2H₂O (2) ALLOW = or ⇄ or ⇆ for arrow DO NOT ALLOW 'and' or &amp; for + ALLOW one mark for correct balanced equation with minor errors in case, subscript and superscript e.g. ZnO + 2HNO₃ → Zn(NO₃)₂ + H₂O</td>
</tr>
</tbody>
</table>

Question 21(a), sample answer 1

[Image of the equation: ZnO + 2HNO₃ → Zn(NO₃)₂ + H₂O]

2 marks

Commentary

The symbols are all correct and the equation is correctly balanced so 2 marks awarded.

Question 21(a), sample answer 2

[Image of the equation: ZnO + 2HNO₃ → Zn(NO₃)₂ + H₂O]

2 marks

Commentary

The symbols are all correct and the equation is correctly balanced so 2 marks awarded.
21(b) Paul suggests this method for preparing zinc nitrate.

1. Measure 50 cm³ of dilute nitric acid into a beaker.
2. Add one spatulaful of zinc oxide.
3. Heat the mixture until crystals of zinc nitrate are made.

Paul's method will not make a pure dry sample of zinc nitrate.

What improvements should Paul make to the method to make sure that:

- the reaction is complete
- the zinc nitrate can be separated from the nitric acid and the zinc oxide?

Explain your answer.

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 21(b)    | Any four from:
          | idea that an excess of zinc oxide must be added (1)   |
          | so reaction is complete / all nitric acid is reacted (1) |
          | filter off excess zinc oxide (1)                        |
          | evaporate off some of the water (1)                      |
          | allow to crystallise (1)                                 |
|          | 4       | 3.3b   |            |          |

Question 21(b), sample answer 1

1 spatulaful may not be enough so you must keep adding more until it no longer reacts. Then you filter out the excess. You do not heat it until the crystals form as you want to. Leave some to evaporate slowly.

4 marks

Commentary

This answer clearly describes adding excess zinc oxide and why. It then describes how to remove the excess. It goes on to describe how you would let the crystals form slowly. So 4 marks awarded.
Question 21(b), sample answer 2

4 marks

Commentary
This answer clearly describes adding excess zinc oxide and why. It then describes how to remove the excess. It goes on to describe how you would let the crystals form slowly. So 4 marks awarded.
Magnesium burns in oxygen to make magnesium oxide.

The reaction involves both oxidation and reduction.

\[
2\text{Mg}(s) + \text{O}_2(g) \rightarrow 2\text{MgO}(s)
\]

magnesium + oxygen → magnesium oxide

(a) Complete the sentence.

During this reaction, the oxidising agent is ……………………… and the reducing agent is …………………….

[1]

Mark scheme

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 (a)</td>
<td>The oxidising agent is oxygen and the reducing agent is magnesium (1)</td>
<td>1</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

Question 22(a), sample answer 1

During this reaction, the oxidising agent is oxygen………... and the reducing agent is magnesium………... .

1 mark

Commentary

Oxidising agent and reducing agent identified correctly.

Question 22(a), sample answer 2

During this reaction, the oxidising agent is oxygen………... and the reducing agent is magnesium.

1 mark

Commentary

Oxidising agent and reducing agent identified correctly.
22(b) Magnesium has an atomic number of 12.

Calculate the mean mass of an atom of magnesium. Quote your answer to three significant figures.

(Avogadro constant = 6.022 x 10\(^{23}\) atoms per mole)

Mean mass …………………….. g

Mark scheme

<table>
<thead>
<tr>
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<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>(b)</td>
<td>2</td>
<td>2.1</td>
<td>1 mark for 4.03520425 x 10(^{-23}) or correctly rounded up but not to 3 significant figures.</td>
</tr>
</tbody>
</table>

Commentary

The calculation is correct and the answer rounded correctly but not quoted to 3 significant figures so only 1 mark awarded. Students need to know how to quote answers to a given number of significant figure or decimal places.
23 Meena electrolyses copper sulfate using copper electrodes.

Look at the diagram. It shows the apparatus she uses.

She investigates the change in mass at each electrode before and after the electrolysis.

Look at Meena’s method.

1. Using a balance, measure the mass of the copper cathode and copper anode.
2. Set up the apparatus and run the electrolysis for 30 seconds.
3. Remove the copper cathode and the copper anode and immediately place them on the balance and measure their masses again.

(a) What improvements could you make to Meena’s experiment?

Explain your answers.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 (a)</td>
<td>electrolysis needs to run for longer than 30 seconds (1)</td>
<td>2</td>
<td>3.2a</td>
<td>2 x 3.2a</td>
</tr>
<tr>
<td></td>
<td>otherwise insufficient change at electrodes (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>after electrolysis anode and cathode need to be washed (1) and then dried (1) before measuring the mass</td>
<td></td>
<td>3.3b</td>
<td>2 x 3.3b</td>
</tr>
</tbody>
</table>
Question 23(a), sample answer 1

Commentary
The two marks have been awarded for increasing the time of the electrolysis and for drying the electrodes. The explanation of why a longer time was an improvement is missing and the student has forgotten to wash the electrodes before drying them so the other 2 marks could not be awarded.

Question 23(a), sample answer 2

Commentary
The two marks have been awarded for increasing the time of the electrolysis and for drying the electrodes. The explanation of why a longer time was an improvement is missing and the student has forgotten to wash the electrodes before drying them so the other 2 marks could not be awarded.
23(b) Meena finds that

- the cathode gains mass
- the anode loses mass.

Explain these observations in terms of the reactions at each electrode. [2]

Mark scheme

<table>
<thead>
<tr>
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<th>Marks</th>
<th>AO element</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23(b)</td>
<td>copper is deposited at the cathode (1) copper anode dissolves / copper ions produced at anode (1)</td>
<td>2</td>
<td>1.2</td>
<td>ALLOW higher level answers in terms of half equations e.g. at cathode ( \text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu} ) (1) e.g. at anode ( \text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^- / \text{Cu} - 2\text{e}^- \rightarrow \text{Cu}^{2+} ) (1)</td>
</tr>
</tbody>
</table>

Question 23(b), sample answer 1

[Image of handwritten answer]

0 marks

Commentary

This answer does not show understanding that it is the copper ions in the solution that gain electrons from the electrodes so copper is deposited and the copper atoms that lose electrons at the anode and become copper ions and dissolve into the solution so copper is lost from the anode.

Question 23(b), sample answer 2

[Image of handwritten answer]

2 marks

Commentary

This answer has gone down the equation route showing correctly the reactions that happen at the cathode and anode so 2 marks awarded.
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