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| 1.1 | hydrogen <b>or</b> H <sub>2</sub> | allow hydrogen gas<br>ignore H without the 2 subscript | 1 | AO1<br>5.4.2.1 |
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| 2.1 | a mixture designed as a useful product |  | 1 | AO1<br>5.8.1.2 |
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| 3.1 | $\text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$<br>balancing: <b>2</b> (HCl) | products in any order                      | 1 | AO2                             |
|     |                                                                                 | dependent on correct formulae for products | 1 | 5.1.1.1<br>5.6.1.2<br>5.10.2.11 |

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| 4.1 | <u>damp / moist</u> litmus paper<br><br>bleaches / goes white | ignore colour of litmus paper | 1<br><br>1 | AO1<br>5.8.2.4 |
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| 5.1 | start line drawn in ink                                        | allow start line should have been drawn in pencil                                    | 1 | AO3<br>4.8.1.3 |
|     | (so) ink dissolves<br><b>or</b><br>ink runs in solvent / water | (as) pencil does not dissolve<br><b>or</b><br>pencil does not run in solvent / water | 1 |                |
|     | water used (as solvent)<br><b>or</b><br>water in beaker        | allow ethanol not used                                                               | 1 |                |
|     | (so) colours will not dissolve / move                          |                                                                                      | 1 |                |

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| 5.2 | <p>any <b>two</b> from:</p> <ul style="list-style-type: none"><li>the flowers have no colours in common</li><li>A / B contain one colour</li><li>C contains two colours</li><li>(the colour in) B is most soluble</li></ul> | <p>allow the flowers are not the same colour</p> <p>allow C is a mixture of colours</p> <p>allow (the colour in) B has the highest <math>R_f</math> value</p> <p>allow one of the colours in C is the least soluble</p> | 2 | AO3<br>4.8.1.3 |
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| 5.3 | $(\text{distance moved}) = \frac{3.2}{0.65}$ $(\text{distance moved}) = 4.9 \text{ (cm)}$ | an answer of 4.9 (cm) scores <b>2</b> marks<br><br>allow 4.923076923 (cm) correctly rounded | 1<br><br>1 | AO2<br>4.8.1.3 |
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| 6.1 |                  | allow boils at 100 °C for <b>2</b> marks                                                                                                                                                 |   | AO2<br>5.8.1.1 | E |
|     | boil (water)     | ignore heat<br>do <b>not</b> accept filter<br>do <b>not</b> accept incorrect test                                                                                                        | 1 |                |   |
|     | (boils) at 100°C | <b>alternative approach</b><br>freeze (water) (1)<br><br>(freezes) at 0°C (1)<br><br>if no other mark awarded, allow<br>1 mark for evaporate or distil<br>water <b>and</b> no solid left | 1 |                |   |

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| 7.1 | a mixture designed as a useful product |  | 1 | AO1<br>5.8.1.2 |
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| 7.2 | dyes distributed differently between the stationary and mobile phase | allow dyes have different solubilities<br>allow dyes have different forces of attraction for stationary phase<br>allow dyes have different forces of attraction for mobile phase<br><br>allow dyes have different forces of attraction to the paper<br>allow dyes have different forces of attraction to the solvent<br>ignore density | 1 | AO1<br><br>5.8.1.3 |
|     | (so dyes) move up the paper at different speeds / rates              | allow (so dyes) move different distances up the paper<br>ignore references to time                                                                                                                                                                                                                                                     | 1 |                    |

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| 7.3 | (because chromatogram has)<br>different dots / colours<br><br>in a (vertical) column | allow above the (original) spot | 1<br><br>1 | AO2<br>5.8.1.3 |
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| 7.4 | run known dyes and food colouring (as a chromatogram)                                                                                                   |                                                                                                                                                                            | 1 | AO2            |
|     | compare distances moved<br><b>or</b><br>compare $R_f$ values                                                                                            |                                                                                                                                                                            | 1 | AO2            |
|     | (so) can identify those that move the same distance as known dyes<br><b>or</b><br>(so) can identify those that have the same $R_f$ values as known dyes | allow (so) can identify those that move different distances as unknown dyes<br><b>or</b><br>allow (so) can identify those that have different $R_f$ values as unknown dyes | 1 | AO2<br>5.8.1.3 |

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| 8.1 | glowing splint<br><br>relights |  | 1<br><br>1 | AO1<br>5.8.2.2 |
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| 9.1 | formulation(s) |  | 1 | AO1<br>4.8.1.2 |
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| 10.1 | glowing splint   | do <b>not</b> accept burning splint                   | 1 | AO1<br>4.8.2.2 |
|      | (which) relights | dependent on correct test in MP1<br>ignore with a pop | 1 |                |

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| 11.1 | (bubble gas through) lime water<br><br>turns milky / cloudy / white<br><b>or</b><br>white precipitate forms | MP2 is dependent upon correct response in MP1<br><br>allow (bubble gas through) calcium hydroxide (solution) | 1<br><br>1 | AO1.2<br>5.8.2.3 |
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| 11.2 | burning / lit splint             | MP2 is dependent upon correct response in MP1<br><br>allow flame<br>do <b>not</b> accept glowing splint | 1 | AO1<br>5.8.2.1 |
|      | burns with a (squeaky) pop sound | allow pops                                                                                              | 1 |                |

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| 12.1 | $0.60 = \frac{5.7}{\text{distance moved by solvent}}$ <p>(distance moved by solvent =)</p> $\frac{5.7}{0.60}$ $= 9.5 \text{ (cm)}$ |  | 1<br><br>1<br><br>1 | AO2<br>4.8.1.3<br>RPA6 |
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| 12.2 | some of the compounds are colourless (in solution)<br><br><b>or</b><br><br>dyes / compounds have the same $R_f$ values | allow there are only two compounds that are coloured (in solution) | 1 | AO3<br>4.8.1.3<br>RPA6 |
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| 12.3 | allow the solvent front to travel further |  | 1 | AO3<br>4.8.1.3<br>RPA6 |
|      | use a different solvent                   |  | 1 |                        |

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| 12.4 | so that the (shade of) green is the same | allow because the green ink is a formulation | 1 | AO3<br>4.8.1.2 |
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| 12.5 | the dye is less soluble in the new solvent and more attracted to the new paper |  | 1 | AO3<br>4.8.1.3 |
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| 13.1 | mass (of flask and contents) decreases        |   | 1 | AO1                |
|      | (because) carbon dioxide is produced          | } | 1 | AO2                |
|      | (and) carbon dioxide escapes (from the flask) |   | 1 | AO2                |
|      |                                               |   |   | 4.3.1.3<br>4.7.2.4 |

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| 14.1 | <b>test:</b> (use a) glowing splint | do <b>not</b> accept burning splint                   | 1 | AO1                |
|      | <b>result:</b> relights             | dependent on correct test in MP1<br>ignore with a pop | 1 | 4.8.2.2<br>4.9.1.3 |

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| 15.1 | a single element or compound | allow an element or compound<br>not (mixed) with any other<br>substance<br><br>ignore only one type of<br>substance | 1 | AO1<br>5.8.1.1 |
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| 16.1 | use limewater<br><b>or</b><br>use calcium hydroxide solution |                                | 1 | AO2<br>5.8.2.3 |
|      | (which) does not turn milky /<br>cloudy                      | allow (which) stays colourless | 1 |                |

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| 17.1 | <b>Level 3:</b> The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 5–6 | AO1<br>4.8.1.3<br>RPA6 |
|      | <b>Level 2:</b> The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 3–4 |                        |
|      | <b>Level 1:</b> The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1–2 |                        |
|      | <b>No relevant content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0   |                        |
|      | <b>Indicative content</b><br><br><b>Method</b> <ul style="list-style-type: none"> <li>• draw (pencil) start line on (chromatography) paper</li> <li>• place spot of food colouring on start line</li> <li>• use of suitable solvent</li> <li>• place solvent in beaker / container</li> <li>• place (chromatography) paper in beaker / container</li> <li>• so (chromatography) paper is in solvent</li> <li>• but solvent is below start line</li> <li>• use a lid</li> <li>• wait for solvent to travel up the (chromatography) paper (until near top)</li> <li>• mark solvent front</li> <li>• dry the (chromatography) paper</li> </ul> <b>Measurements</b> <ul style="list-style-type: none"> <li>• measure distance between start line and centre of spot</li> <li>• measure distance between start line and solvent front</li> <li>• use of measurements to determine <math>R_f</math> value</li> </ul> |     |                        |

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| 17.2 | different solvent used |  | 1 | AO3<br>4.8.1.3<br>RPA6 |
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| 17.3 | paper |  | 1 | AO1<br>4.8.1.3<br>RPA6 |
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| 18.1 | <p>any <b>two</b> pairs from:</p> <p>(start) line drawn in ink (1)<br/>(so ink) will mix with solvent (1)</p> <p>the solvent is above the (start) line (1)<br/>(so) colours / ink will dissolve (1)</p> <p>no lid on tank (1)<br/>(so) solvent will evaporate (1)</p> | <p>allow (start) line should be drawn in pencil<br/>allow the ink will move up the paper</p> <p>allow the solvent should be below the (start) line</p> | 4 | AO3<br>5.8.1.3<br>RPA12 |
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| 18.2 | <p>any <b>two</b> from:</p> <ul style="list-style-type: none"><li>• (the brown ink) contains the blue, yellow and red (colours)</li><li>• (the brown ink) contains an unknown colour</li><li>• (the brown ink) does not contain green ink</li><li>• blue (colour) is the most soluble<br/><b>or</b><br/>red (colour) is the least soluble</li></ul> | <p>allow blue (colour) has the highest <math>R_f</math> value</p> <p>allow red (colour) has the lowest <math>R_f</math> value</p> <p>ignore green colour is insoluble</p> | 2 | AO3<br>5.8.1.3<br>RPA12 |
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| 18.3 | the green colour was insoluble in the solvent |  | 1 | AO2<br>5.8.1.3<br>RPA12 |
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| 18.4 | $0.24 = \frac{1.8}{\text{distance moved by solvent}}$<br><br>$\begin{array}{l} \text{(distance moved by solvent =)} \\ \frac{1.8}{0.24} \\ \\ = 7.5 \text{ (cm)} \end{array}$ |  | 1<br><br><br>1<br><br><br>1 | AO2<br>5.8.1.3<br>RPA12 |
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| 19.1 | (use) damp litmus paper                                         | MP2 is dependent upon MP1 | 1 | AO1<br>4.8.2.4 |
|      | (the paper) is bleached<br><b>or</b><br>(the paper) turns white | ignore paper turns red    | 1 |                |

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| 20.1 | stationary phase |  | 1 | AO1<br>5.8.1.3<br>RPA12 |
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| 20.2 | <p>any <b>one</b> from:<br/>(the substances)</p> <ul style="list-style-type: none"><li>• move at different speeds</li><li>• have different solubilities</li><li>• have different attractions for the (chromatography) paper</li></ul> |  | 1 | AO2<br>5.8.1.3<br>RPA12 |
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| 20.3 | 1 |  | 1 | AO1<br>5.8.1.3<br>RPA12 |
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| 20.4 | $\begin{array}{r} (R_f = ) \\ 4.77 \\ \hline 5.30 \\ \\ = 0.9 \end{array}$ |  | <div>1</div> <div>1</div> | AO2<br>5.8.1.3<br>RPA12 |
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| 20.5 | <b>Level 3:</b> The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5–6 | AO1<br>5.8.1.3 |
|      | <b>Level 2:</b> The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3–4 |                |
|      | <b>Level 1:</b> The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1–2 |                |
|      | <b>No relevant content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0   |                |
|      | <b>Indicative content</b> <ul style="list-style-type: none"> <li>• <b>draw a pencil line</b></li> <li>• near the bottom edge of the (chromatography) paper</li> <li>• <b>put a small dot of black ink on the pencil line</b></li> <li>• put a small volume of water / solvent in a beaker</li> <li>• <b>place the (chromatography) paper in the solvent</b></li> <li>• the dots of ink should be above the level of the water / solvent</li> <li>• support the paper in this position</li> <li>• put a lid on the beaker</li> <li>• <b>leave to run</b></li> <li>• mark position of solvent front</li> <li>• remove from beaker and leave to dry</li> <li>• <b>determine <math>R_f</math> values</b></li> <li>• measure distance of all dots from start line</li> <li>• measure distance of solvent front from start line</li> <li>• calculate <math>R_f</math> values for all dots</li> <li>• compare with known <math>R_f</math> values</li> </ul> |     |                |

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| 21.1 | (crude oil is a mixture but) not a useful product | allow (crude oil is) not designed for a specific purpose | 1 | AO2<br>5.7.1.1<br>5.8.1.2 |
|      | (and) not mixed in carefully measured quantities  | allow not the same composition all the time              | 1 |                           |

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| 22.1 | <p>(test)<br/>determine the boiling point</p> <p>(result)<br/>(pure water) boils at 100 °C</p> <p><b>OR</b></p> <p>(test)<br/>determine the freezing point (1)</p> <p>(result)<br/>(pure water) freezes at 0 °C (1)</p> |  | <p>1</p> <p>1</p> | <p>AO2</p> <p>5.8.1.1</p> <p>5.9.2.2</p> |
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| 23.1 | (test)<br>glowing splint | MP2 is dependent upon MP1<br>being awarded<br><br>do <b>not</b> accept burning / lit splint | 1 | AO2            |
|      | (result)<br>relights     | allow glows more brightly                                                                   | 1 | AO1<br>5.8.2.2 |

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| 24.1 | (test)<br>burning / lit splint                  | MP2 is dependent upon MP1<br>being awarded<br><br>allow flame<br>do <b>not</b> accept glowing splint | 1 | AO1<br>4.8.2.1 |
|      | (result)<br>burns with a (squeaky) pop<br>sound | allow pops                                                                                           | 1 |                |

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| 25.1 | (limewater turns) milky / cloudy | allow white precipitate (formed)<br><br>allow calcium carbonate is produced | 1 | AO1<br>4.8.2.3 |
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| 26.1 | the start line is drawn in ink          | allow the start line should be drawn in pencil       | 1 | AO3<br>4.8.1.3<br>RPA6 |
|      | the start line is below the water level | allow the start line should be above the water level | 1 |                        |

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| 26.2 | $0.60 = \frac{\text{distance moved by dye}}{12.0}$<br><br>(distance moved by dye =)<br>$0.60 \times 12.0$<br><br>$= 7.2 \text{ (cm)}$ |  | 1<br><br><br>1<br><br><br>1 | AO2<br>4.8.1.3<br>RPA6 |
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| 26.3 |                                                                                                                    | allow converse                                                                                    |   |                 |
|      | the $R_f$ value is smaller for Paper <b>A</b>                                                                      |                                                                                                   | 1 | AO2             |
|      | (because the red dye) is more attracted to Paper <b>A</b> (than to Paper <b>B</b> )                                |                                                                                                   | 1 | AO3             |
|      | (so the red dye) spends a greater (proportion of the) time distributed in Paper <b>A</b> (than in Paper <b>B</b> ) |                                                                                                   | 1 | AO3             |
|      |                                                                                                                    | if no other mark awarded allow <b>1</b> mark for the dye has a different attraction to each paper |   | 4.8.1.3<br>RPA6 |

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| 26.4 | use a different solvent | allow use ethanol (as the solvent) | 1 | AO1<br>4.8.1.3<br>RPA6 |
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