# Mark scheme

| Question | | | Answer/Indicative content | Marks | Guidance |
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| 1 | | i | The lower the melting point, the further the sample can stretch (before breaking) / **ORA** ✓ | 1 (AO 3.1a) | **ALLOW** the lower the melting point the higher the distance (stretched before breaking)<br><br>**Examiner's Comments**<br><br>The relationship was described by many candidates. Some described them as being harder or easier to stretch or discussed boiling point. |
| | | ii | $C_2H_2O$ ✓ | 1 (AO 2.2) | **ALLOW** $C_2H_2O_1$<br>**ALLOW** any order of symbols<br><br>**DO NOT ALLOW** $C^2H^2O$ / C2H2O<br><br>**Examiner's Comments**<br><br>Empirical formula was understood by the same candidates. Common incorrect responses included CHO, $C_5H_5O$ and $C_{10}H_{10}O_5$. A large number omitted the question.<br><br>**Misconception**<br><br>Many candidates thought the empirical formula was either the molecular formula or the atoms in the molecule (e.g. CHO) rather than it being the simplest whole number ratio of the atoms in a molecule. |
| | | | **Total** | **2** | |
| 2 | | | B ✓ | 1 (AO 1.2) | |
| | | | **Total** | **1** | |
| 3 | | | B ✓ | 1 (AO 1.1) | **Examiner's Comments**<br><br>The majority of candidates thought a formulation to be a compound hence A and C were the more popular responses. Of those who appreciated |

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| | | | | | that a formulation is a mixture (D), was the more popular response. |
| | | | **Total** | **1** | |
| 4 | | i | $C_4H_9$ ✓ | 1 (AO 2.2) | **DO NOT ALLOW** superscripts<br><br>**Examiner's Comments**<br><br>Popular responses included $C_8H_{18}$, $C_4H_8$ and $CH_2$.<br><br>**Misconception**<br><br>Many candidates thought the empirical formula was the molecular formula rather than it being the simplest whole number ratio of the atoms in a molecule. |
| | | ii | **First check the answer on answer line**<br>**If answer = 114 award 3 marks**<br><br>(Mass of carbon =) 8 × 12 = 96 ✓<br>(Mass of hydrogen =) 18 × 1 = 18 ✓<br>96 + 18 = 114 ✓ | 3 (AO 3 x 2.1) | **ALLOW ECF** on the mass of carbon and the mass of hydrogen<br><br>**Examiner's Comments**<br><br>Higher scoring candidates calculated the relative formula mass correctly. 12 + 1 = 13 and the relative formula mass of the empirical formula were popular responses. |
| | | | **Total** | **4** | |
| 5 | | i | A metal alloy has different sized atoms **ORA** ✓<br><br>The atoms/ions/particles of the same size can slide over each other more easily **ORA** ✓ | 2 (AO 2 x 1.1) | **ALLOW** different sized particles/ions<br>**IGNORE** has large/giant particles<br>**DO NOT ALLOW** molecules for M1 only<br>**DO NOT ALLOW** different sized elements for M1 only<br><br>**ALLOW** different sized atoms/ions/particles makes it harder for layers/atoms/ions/particles to slide<br><br>**Examiner's Comments**<br><br>Higher scoring candidates appreciated that the alloy contains |

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| | | | | | different sized atoms. Two elements, so stronger bonds was a common response, as was rewriting the question.<br><br>**Metals and alloys**<br><br>In pure metals the rows of atoms are able to slide. Alloys are stronger because the added atoms are a different size to the atoms of the pure metal and so they disrupt the regular pattern and the layers are no longer able to slide as well. |
| | | ii | Alloy 2 ✓<br><br>**Any two from:**<br><br>It is non-toxic ✓<br><br>It has a low/medium density ✓<br><br>It is strong ✓ | 3<br>(AO 3 x 3.2a) | **ALLOW** reverse arguments for why alloys 1 and 3 are not selected<br><br>**ALLOW** not too dense<br><br>**ALLOW** it has high tensile strength / doesn't break easily / can support more weight |
| | | | **Total** | **5** | |
| 6 | a | i | Idea that (a pure substance) is a single element or compound /<br><br>Idea that (a pure substance) only contains one element or compound ✓ | 1<br>(AO 1.1) | **IGNORE** has no other substance in it<br>**IGNORE** is not mixed with any other substance<br><br>**Examiner's Comments**<br><br>Higher attaining candidates appreciated that a pure substance would contain only one element or compound. Nothing mixed with it, only one substance or a discussion of the melting point being high or low were common responses. |
| | | ii | (The melting points) are sharp /<br>idea that (the painkillers) do not melt over a range of temperatures ✓ | 1<br>(AO 2.2) | **ALLOW** definite melting point/one melting point/set mpt / specific mpt / exact mpt<br>**IGNORE** look up data<br><br>**Examiner's Comments**<br><br>Candidates found this challenging. High melting point and low melting point were popular responses. |

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| | | | | | **Misconception**<br><br>The melting point of a pure substance was perceived to be either high or low rather than not being over a range of temperatures. |
| | b | | 2 ✓ | 1<br>(AO 2.2) | **Examiner's Comments**<br><br>Many candidates appreciated that 2 peaks would be seen. 3 and 33 were popular responses. |
| | c | i | **First check the answer on answer line**<br>**If answer = 0.69 ± 0.01 award 3 marks**<br><br>Rf = 5.5 (cm) / 8.0 (cm) ✓<br><br>Rf = 0.6875 ✓<br><br>**significant figures**<br>Rf = 0.69 ✓ | 3<br>(AO 3 x 2.2) | **ALLOW** distance moved by substance = 5.4 – 5.6 (cm)<br><br>**ALLOW ECF** for significant figure mark<br><br>**Examiner's Comments**<br><br>Higher achieving candidates measured the two distances carefully, calculated the value correctly and gave their answer to 2 decimal places. 2.6, 3.5 and 7.9 as measured lengths and the inversion of the division were popular. It was also common to give the unrounded answer,0.6875. |
| | | ii | Mobile phase ✓<br>Stationary phase ✓ | 2<br>(AO 2 x 1.2) | **ALLOW** paper<br><br>**Examiner's Comments**<br><br>Components were well known by the majority of candidates. Stationary phase and paper were quite often the two components ringed. |
| | d | | **Any two from:**<br><br>Idea that it could have more than two **spots** ✓<br><br>It depends on how many i**mpurities** are in the painkiller ✓<br><br>Could have one spot if $R_f$ of impurity has same $R_f$ as painkiller ✓ | 2<br>(AO 2 x 3.1b) | **ALLOW** may contain many spots<br><br>**ALLOW** may contain more than 2/many/multiple impurities / don't know how many impurities<br><br>**ALLOW** 2 or more spots can merge into one spot |

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| | | | | | **Examiner's Comments**<br><br>The highest achieving candidates appreciated that the number of spots would depend on the number of impurities and this could mean more than two spots. Impure containing just one spot was a common response. |
| | | | **Total** | **10** | |
| 7 | | | **C** | 1<br>(AO 2.1) | **Examiner's Comments**<br><br>Many candidates added the two relative atomic masses together and chose incorrect response A. |
| | | | **Total** | **1** | |
| 8 | | i | Neutralisation ✓ | 1<br>(AO 1.2) | |
| | | ii | **First check the answer on answer line**<br>If answer = 76 / 76.47 / 76.5 (%) award 3 marks<br><br>$M_r$ of NaC*l* = 58.5 and H2O = 18.0 ✓**OR** 58.5 and 76.5<br><br>atom economy = $\frac{58.5}{76.5} \times 100$ ✓<br><br>= 76.47 / 76.5 (%) ✓ | 3<br>(3 × AO 2.2) | **ALLOW ECF** from incorrect $M_r$<br><br>**ALLOW**<br>atom economy = $\frac{M_r \text{ of desired products}}{\text{sum of } M_r \text{ of all products}} \times 100$ ✓<br><br>**Examiner's Comments**<br><br>Most candidates seemed uncertain how to approach this calculation. Examiners were often able to award credit for working out suitable relative molar masses even if the rest of the calculation was flawed. |
| | | | **Total** | **4** | |
| 9 | a | | Stationary phase ✓<br><br>Pencil line ✓<br><br>Mobile phase ✓ | 3(3 × AO1.2) | **Examiner's Comments**<br><br>Pencil line was the most well known. Stationary phase was often labelled as solvent front, mobile phase was often labelled as stationary phase or water. |
| | b | i | **FIRST CHECK THE ANSWER ON ANSWER LINE**<br>**If answer = 0.85 award 2 marks** | 2(2 × AO2.2) | **ALLOW** $R_f = \frac{\text{distance moved by dye}}{\text{distance moved by solvent}}$<br><br>**ALLOW** ECF for sig fig mark |

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| | | | Rf = 55 × 65 = 0.846153… ✓<br><br>= 0.85 (2 significant figures) ✓ | | **Examiner's Comments**<br><br>More successful responses calculated the value correctly and quoted it to two significant figures; 0.8 was the common part correct response. A large number inverted the division and gave their final answer to three significant figures hence 1.18 was a common incorrect response. |
| | | ii | The Rf values are different ✓<br><br>Idea that if dye X was tartrazine, it would have the same $R_f$ value ✓ | 2(2 × AO3.2b) | **ALLOW** Rf tartrazine value is too low / Rf value for tartrazine would be higher /<br>$R_f$ dye X value is too high / Rf value for dye X would be lower<br>$R_f$ dye X is double/ Rf for tartrazine is half / the substances travel different distances<br><br>**Examiner's Comments**<br><br>More successful responses interpreted the values as being different and the most successful appreciated that if they were the same substance the values need to be the same. Many repeated the question stem with no interpretation and a large number omitted the question. |
| | | | **Total** | **7** | |
| 10 | | | **FIRST CHECK THE ANSWER ON ANSWER LINE**<br>**If answer = 3.0 / 3 (tonnes) award 3 marks**<br><br>$M_r$ of NO = 30.0 **OR** $N_2$ = 28.0 ✓<br><br>Mass of NO = $\frac{60.0}{28.0} \times 1.4$ ✓<br>= 3.0 (tonnes) ✓ | 3(AO2.2) | **ALLOW** ECF from incorrect $M_r$ values<br><br>**Examiner's Comments**<br><br>While very few candidates could work out how to calculate the mass of the nitrogen monoxide, those who attempted this question often picked up some marks for calculating relevant molar masses. |
| | | | **Total** | **3** | |
| 11 | | | **FIRST CHECK THE ANSWER ON ANSWER LINE**<br>**If answer = 7.62 (g) award 4 marks**<br><br>$M_r$ of HNO3 = 63.0 **OR** $NH_4NO_3$ = 80.0 ✓ | 4(AO2.2 × 3)(AO1.2) | **ALLOW** whole numbers at this stage<br><br>**Examiner's Comments**<br><br>Few candidates knew how to work out a theoretical yield, but were frequently able to gain intermediate marks for calculating the molar mass of |

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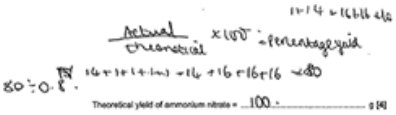
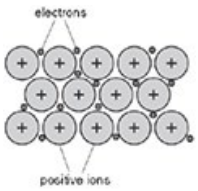
| | | | Mass of ammonium nitrate = $\frac{80.0 \times 6.00}{63.0}$ ✓<br>= 7.619 (g) ✓<br>To 3 sig figs = 7.62 (g) ✓ | | ammonium nitrate.<br><br>Exempar 2<br>  <br><br>The candidate gets a mark for calculating the molar mass of ammonium nitrate and a second mark, even though the calculation is incorrect, as the incorrect final response has been rounded to a number with 3 significant figures. |
| | | | **Total** | **4** | |
| 12 | | i | Positive (metal) ions ✓<br><br>Idea of the ions being surrounded by a sea of electrons ✓<br><br>Idea that there are strong forces of attraction between ions and electrons ✓ | 3(AO1.1) | **Any reference to ionic or covalent bonding or IMF scores 0**<br><br>**ALLOW** a labelled diagram<br>  <br><br>In a diagram there must be at least one electron in the body of the ions<br>Diagram must show **close packed** metal ions, in a regular arrangement<br>**ALLOW** - / e / e- / dots for electrons labelled<br>If e or e- are used they do not need labelling but just a dot or – unlabelled does not score<br><br>**ALLOW** circles with + or circles labelled positive ions<br>**IGNORE** free electrons<br><br>If M1 **and** M2 scored allow strong (metallic) bond for M3<br><br>**<u>Examiner's Comments</u>**<br><br>The most successful responses gave a labelled diagram and described the bonding. Diagrams were often missing or unlabelled and often diamond. Many discussed ionic or covalent bonding. A large number omitted the |

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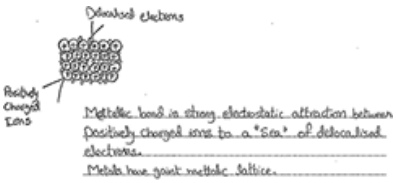
| | | | | | question.<br><br>Exemplar 1<br>  <br><br><br>Diagram has close packed regular positive ions and labelled, ions interspersed with delocalised electrons and labelled; text has strong attraction between positive ions and delocalised electrons. This response gained all 3 marks. |
| | | ii | Idea that layers or rows or sheets (of particles) slide over each other ✓ | 1(AO1.1) | **IGNORE** layers can bend<br>**IGNORE** IMF<br><br>**Examiner's Comments**<br><br>The most successful responses discussed layers. Many discussed weak bonding, delocalised electrons or forces between atoms and a large number omitted the question |
| | | iii | Has electrons ✓<br><br>(Electrons) that can move (through the metal) ✓<br><br>**OR**<br>Delocalised electrons scores ✓ ✓ | 2(2 × AO1.1) | **DO NOT ALLOW** free ions – scores 0<br><br>**IGNORE** free (electrons) for idea of movement<br>**IGNORE** carry charge<br><br>**Examiner's Comments**<br><br>More successful responses discussed electrons and the most successful described the electrons as moving. Popular responses included bonding, close packing of atoms allowing conduction and moving ions. |
| | | iv | **FIRST CHECK THE ANSWER ON ANSWER LINE**<br>**If answer = 3:2 award 2 marks**<br><br>(Lead:tin ratio in diagram =) 12:8 ✓<br><br>Divide by 4 to give smallest ratio = 3:2 ✓ | 2(2 × AO2.1) | **ALLOW** tin:lead in diagram = 8:12<br><br>**Examiner's Comments**<br><br>This was answered well, a small number of candidates gave 12:8, simplified to 6:4 or reversed the ratio. |
| | | v | As the silver content increases, the melting point decreases **ORA** ✓ | 1 (AO3.1a) | both variables must be comparative |

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| | | | | | **Examiner's Comments**<br><br>More successful candidates derived the link between silver content and melting point. Popular incorrect responses included high melting point, low melting point and the melting point increasing as silver content increases. |
| | | | **Total** | **9** | |
| 13 | | | C ✓ | 1(AO2.1) | |
| | | | **Total** | **1** | |
| 14 | | | B ✓ | 1(AO1.2) | |
| | | | **Total** | **1** | |