# Mark scheme - Redox

| Question | | | Answer/Indicative content | Marks | Guidance |
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| 1 | | | Element **oxidised:** Oxygen/O<br>Change from: –2 to 0 ✓<br><br>Element **reduced:** Nitrogen/N<br>Change from +5 to +4 ✓ | 2(AO2.2×2) | **MAX 1 mark** if no '+' sign for oxidation number<br><br>**ALLOW** 2–<br><br>**ALLOW** 5+ **AND** 4+<br><br>**ALLOW** $O_2$ for oxygen<br><br>**ALLOW** 1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around<br><br>**IGNORE** numbers around equation<br>*i.e. treat as rough working*<br><br>**<u>Examiner's Comments</u>**<br><br>Less than half the candidates answered this question correctly. This may be because they are not used to assigning oxidation numbers within formulae that contain brackets. |
| | | | **Total** | **2** | |
| 2 | | i | Oxidised<br>**AND**<br>(Mg) transfers/loses/donates **2** electrons ✓<br><br>**2** essential | **1** | **ALLOW** Mg loses 6 electrons: *3 Mg in equation*<br>**ALLOW** $Mg \rightarrow Mg^{2+} + 2e^-$<br><br>**IGNORE** oxidation numbers (even if wrong)<br><br>**<u>Examiner's Comments</u>**<br><br>Despite the question clearly asking for a response in terms of the number of electrons transferred, most candidates answered in terms of oxidation number changes. Candidates are recommended to read the question and to answer in terms of its requirements. Underlining 'number of electrons' may have helped candidates to answer the question that had been set. |
| | | ii | **FIRST CHECK ANSWER ON THE ANSWER LINE**<br>**IF answer = 2.26 (3 SF) award 3 marks**<br>---------------------------------------------------<br>$n(H_3PO_4) = \frac{1.24 \times 50.0}{1000} = 0.062(0)$ (mol) ✓ | **3** | At least **3SF** needed throughout **BUT ALLOW** no trailing zeroes (e.g. 0.062 for |

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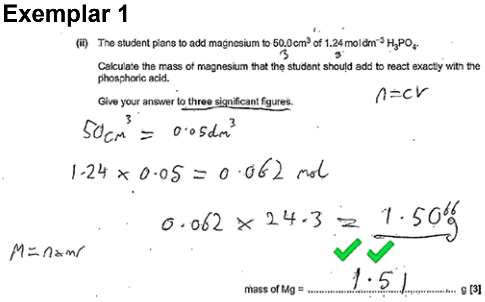
| | | | $n$(Mg) $= \frac{3}{2} \times 0.062(0) = 0.093(0)$ (mol) ✓<br><br>**mass of Mg** = 0.0930 × 24.3 = 2.26 (g) ✓<br><br>**3 SF required** | | 0.0620)<br><br>**ALLOW ECF** from $n$(H3PO4)<br><br>**ALLOW ECF** from $n$(Mg)<br><br>**---------------------------------------------**<br>**COMMON ERRORS for 2 marks**<br>**3:2 ratio omitted** → $n$(Mg) = 0.062(0) → 1.51 (g)<br>**Inverted 2:3 ratio** → $n$(Mg) = 0.0413 → 1.00 (g)<br><br>**<u>Examiner's Comments</u>**<br><br>Most candidates are competent at answering questions based on the mole. Almost all candidates were able to calculate the amount of H3PO4 as 0.062 mol. Candidates then needed to use the 2:3 mole stoichiometric ratio to show that 0.093 mol of Mg reacts, which has a mass of 2.26 g to the required 3 significant figures. The commonest errors were use of the inverse 3:2 ratio to obtain 1.00 g Mg, or to omit the ratio to obtain 1.51 g Mg, as shown in the exemplar. Candidates are advised to show clear working so that credit can be awarded for such responses by applying error carried forward.<br><br>**Exemplar 1**<br> |
| | | iii | **Separation of solid**<br><br>Filter to obtain solid/precipitate ✓<br>*Requires realisation that solid is filtered off.*<br>*Solid may be stated within in 'removal of water'*<br>**Removal of water**<br><br>Dry (solid)<br>**OR** Evaporate (water/solution/liquid) ✓ | **2** | **ALLOW**<br>**Removal of water**<br><br>Evaporate/ distil water/solution/liquid ✓<br>**IGNORE** 'distil' if product **OR** $H_2$ is distilled<br>**Collection of remaining solid** ✓<br><br>*Requires realisation that solid remains*<br>**IGNORE** 'Leave to crystallise' *(already solid)*<br><br>**<u>Examiner's Comments</u>**<br><br>Candidates often struggle with questions |

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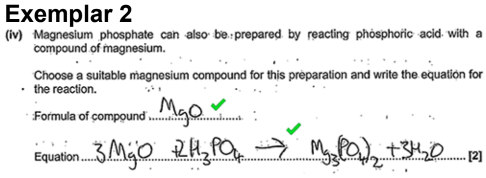
| | | | | | based on practical work. There were many random responses to this question, with relatively few candidates identifying that solid magnesium phosphate could be obtained by filtration, followed by drying. |
| | | iv | **Formula**<br><br>$MgO$ **OR** $Mg(OH)_2$ **OR** $MgCO_3$ **OR** soluble Mg salt ✓<br><br>**Equation**<br><br>$3MgO + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3H_2O$<br>**OR**<br>$3Mg(OH)_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6H_2O$<br>**OR**<br>$3MgCO_3 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3CO_2 + 3H_2O$ | **2** | **In equation:**<br>**NO ECF** from incorrect formula<br>**ALLOW** multiples<br>**IGNORE** state symbols (even if incorrect)<br><br>**Soluble Mg salts** include<br>$MgCl_2$, $MgSO_4$, $Mg(NO_3)_2$, $MgBr_2$, $MgI_2$<br>If unsure, check with TL<br>e.g. $3MgCl_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6HCl$<br><br>**<u>Examiner's Comments</u>**<br><br>Candidates were expected to identify a suitable reagent for this reaction, with most choosing magnesium oxide, hydroxide or carbonate. Credit was also given for using a soluble magnesium salt such as its sulfate, chloride or nitrate. The correct equation often followed, but errors sometimes appeared in the form of incorrect formulae, such as MgOH for magnesium hydroxide. The exemplar shows a good clear response, using MgO as the reagent.<br><br>**Exemplar 2**<br> |
| | | | **Total** | **8** | |
| 3 | | i | **Disproportionation**<br>Oxidation **AND** reduction of same element/iodine<br><br>**OR**<br>Iodine has been **oxidised** and Iodine has been **reduced** ✓<br><br>**Oxidation**<br>from **0** to **+1** in H**IO** ✓<br><br>**Reduction**<br>from **0** to **−1** in **HI** ✓ | 3 | **ALLOW** I or $I_2$ for iodine<br>**IGNORE** numbers around equation for oxidation states<br><br>**ALLOW** 1− for −1 **AND** 1+ for +1<br><br>**NOTE** (for iodine/$I_2$) **from 0** only needs to be seen once, does not need to be stated twice<br><br>**ALLOW** 1 mark for 3 ox nos correct but no mention of words **oxidation/reduction**:<br>0 in $I_2$ **AND** −1 in HI **AND** +1 in HIO |

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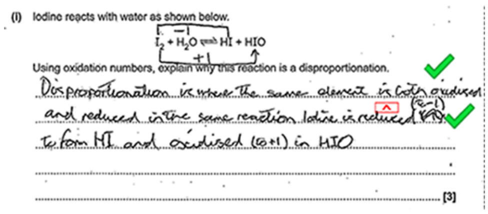
| | | | | | **ALLOW** 1 mark for species missing:<br>Iodine oxidised (from 0) to +1<br>**AND** iodine reduced (from 0) to −1<br><br>**<u>Examiner's Comments</u>**<br><br>Most candidates were aware of disproportionation but lost marks by not stating the species or whether the process was oxidation or reduction.<br><br>**Exemplar 2**<br><br><br><br>Here the candidate has lost a mark for not stating the initial oxidation number of elemental iodine as 0. |
| | | ii | Chlorine is toxic/poisonous<br>**OR**<br>forms halogenated hydrocarbons<br>**OR**<br>forms carcinogens/toxic compounds ✓ | 1 | **ALLOW** (reacts with hydrocarbons to) form carcinogens/toxic compounds<br><br>**IGNORE**<br><br>• chlorine causes cancer<br>• harmful/dangerous<br>• chlorine causes breathing problems<br><br>**<u>Examiner's Comments</u>**<br><br>The majority of candidates stated that chlorine is toxic or forms carcinogens, although some stated that chlorine is a carcinogen which was not credited. 12 |
| | | | **Total** | **4** | |
| 4 | | i | **2** Al(s) + **6** $CH_3COOH$Caq) → **2** ($CH_3COO_3Al$(aq) + **3** $H_2$(g) ✓ | **1** | **ALLOW** multiples, e.g.<br><br>Al(s) + **3**$CH_3COOH$(aq) → ($CH_3COO)_3A1$(aq) + **1**½$H_2$(g)<br><br>**Examiner's Comments**<br>The majority of candidates were able to balance this equation using whole numbers or half multiples. Where there was an error, it was invariably for the balancing number of $H_2$. |

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| | | ii | Element oxidised: aluminium/Al 0 to +3 ✓<br>Element reduced: hydrogen/H +1 to 0 ✓ | **2** | **ALLOW** 3+ for +3 and 1+ for +1<br><br>**ALLOW** $H_2$ for hydrogen<br><br>**ALLOW** 1 mark for elements **AND** all oxidation numbers correct, but H in oxidised line and Al in reduced line<br><br>'+' is required in +3 and +1 oxidation numbers<br><br>**IGNORE** numbers around equation *(treat as rough working)*<br><br>**Examiner's Comments**<br>This question was not answered as well as expected. It was pleasing to see that almost all candidates recognised the importance of writing oxidation numbers correctly including a '+' or '−' sign where needed. Common mistakes included giving the total contribution from an element as opposed to the oxidation state of each atom of the element. |
| | | | **Total** | **3** | |
| 5 | | | Element oxidised: aluminium/Al 0 to +3 ✓<br>Element reduced: hydrogen/H/$H^+$ +1 to 0 ✓ | 2 | **MAX 1 mark** if no '+' sign for oxidation number<br><br>**ALLOW** 3+<br><br>**ALLOW** 1+<br><br>**ALLOW** $H_2$ for hydrogen<br><br>**ALLOW** 1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around<br><br>**IGNORE** numbers around equation *i.e. treat as rough working*<br><br>**Examiner's Comments**<br><br>A good proportion of candidates were able to achieve the 2 marks here. A minority correctly identified the elements, but not the oxidation numbers. Aluminium was credited more often than hydrogen, perhaps as only some of the hydrogen atoms are reduced. Some amazing oxidation states were claimed for S, O, Al and H with more electrons lost than the atoms had. Very few candidates assigned the oxidation and reduction incorrectly. |

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| | | | **Total** | **2** | |
| 6 | | i | Magnesium (atoms) has been oxidised<br>**AND**<br>Because it has lost **two** electrons ✓<br><br>Copper (ions) has been reduced<br>**AND**<br>Because it has gained **two** electrons ✓ | 2 | **IGNORE** use of oxidation numbers if electron gain/loss is mentioned.<br>Electrons gain/loss could be in half equations<br>In the absence of text look for evidence on the equation<br>**ALLOW** 'donated' for 'lost'<br><br>Assume 'Cu' refers to copper in '$CuSO_4$'<br>**ALLOW** one mark **two** electrons gained and lost for each species but oxidation/reduction is incorrect or is omitted<br><br>**ALLOW** one mark for correct oxidation and reduction if electron transfer is **omitted** and correct changes of oxidation state are shown (ie Mg 0 --> (+)2 **AND** Cu (+)2 to 0)<br><br>**ALLOW** '**two** electrons transferred from magnesium to copper<br><br>**Examiner's Comments**<br><br>This type of question in the past has proved difficult but the current cohort found little difficulty. By far, the most common error was to use changes in oxidation numbers as the basis of the redox rather than using the number of electrons gained and lost for the explanation of the redox process. |
| 6 | | ii | $Mg(s) + 2H_2O(l)$ ◊$Mg(OH)_2(aq) + H_2(g)$<br>Correct reactants and products ✓<br>Balance and state symbols ✓ | 2 | **ALLOW** multiples<br>**ALLOW** $Mg(OH)_2(s)$<br>**ALLOW** $Mg(s) + H_2O(g)$ **OR** $H_2O(l)$ $MgO(s) + H_2(g)$ including state symbols for **one** mark<br><br>**Examiner's Comments**<br><br>The equation for the reaction between magnesium and water was well known – but many erroneously assumed MgO was formed. |
| | | | **Total** | **4** | |
| 7 | | i | $N_2O_3$ = +3<br>NO = +2<br><br>$NO_2$ = +4 ✓ | 1 | **ALLOW** '3' **OR** '3+' etc<br><br>**ALLOW** oxidation numbers written over the equation but<br><br>**IGNORE** if oxidation numbers are given on the answer lines |

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| | | | | | **Examiner's Comments**<br><br>The correct answer was almost universally known. |
| | | ii | Disproportionation ✓ | 1 | QWC 'disproportionation' spelled correctly.<br><br>**Examiner's Comments**<br><br>The correct answer was almost universally known with just the rare misspelling of disproportionation seen. |
| | | | **Total** | **2** | |
| 8 | | i | $1s^22s^22p^63s^2$ ✓ | 1 | **ALLOW** upper case S and P, and subscripts, e.g. ......$2S_23P_6$<br><br>**Examiner's Comments**<br><br>This part was generally answered well showing a good understanding of electron configuration. Candidates frequently used subscripts rather than superscripts for denoting the number of electrons in a particular sub-shell and although this was still credited the correct use of notation should be emphasised in lessons. |
| | | ii | (Mg) loses / transfers / donates **two** electrons ✓ | 1 | **ALLOW** Mg loses the 3s electrons provided electronic configuration in **(i)** is $3_s^2$<br><br>**ALLOW** $Mg \rightarrow Mg^{2+} + 2e^-$<br><br>**IGNORE** reference to oxidation numbers / states<br><br>**Examiner's Comments**<br><br>Most candidates understood that oxidation resulted in the loss of electrons although some answers considered changes in oxidation number. A significant number of candidates did not specify how many electrons were lost when magnesium was oxidised preventing the award of the mark. |
| | | | **Total** | **2** | |
| 9 | | | Cl (has been oxidised) from Cl = –1 to Cl = 0 ✓<br>Mn (has been reduced) from Mn = +4 to Mn = +2 ✓ | 2 | **ALLOW** 4+ **OR** 4 **OR** 2+ **OR** 2<br>**ALLOW** oxidation numbers written above the equation but **IGNORE** these if oxidation numbers are given in the text<br><br>**ALLOW** one mark for Cl is oxidised because the oxidation number increased by 1 **AND** |

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| | | | | | Mn is reduced because the oxidation number decreased by 2<br>**ALLOW** one mark if all oxidation numbers are correct but redox is incorrect.<br>**IGNORE** HCl is oxidised **AND** $MnO_2$ is reduced<br>**IGNORE** correct references to electron loss / gain<br>**DO NOT ALLOW** incorrect references to electron loss / gain<br><br>**Examiner's Comments**<br><br>Overall the answer to this question could be determined by most candidates. Some were confused by the fact that Cl appeared in two oxidation states in the products and suggested that this was a type of disproportionation reaction with the Cl in $MnCl_2$ having a −2 oxidation state. |
| | | | **Total** | **2** | |
| 10 | | | Oxidised **AND** because aluminium has lost (three) electrons ✓ | 1 | **ALLOW** 'donated' for 'lost'<br>**IGNORE** where electrons are transferred to<br>**IGNORE** $Al \rightarrow Al^{3+} + 3e^-$<br>**DO NOT ALLOW** 'an electron' or incorrect number of electrons<br><br>**Examiner's Comments**<br><br>This question was very well answered. Where candidates did not gain the mark it was often because they forgot to discuss the oxidation of aluminium in terms of electron loss, but instead justified it in by using oxidation numbers. |
| | | | **Total** | **1** | |
| 11 | | | Element oxidised: zinc / Zn 0 to +2 (1)<br>Element reduced: carbon / C +4 to +2 (1) | 2 | **allow** 1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around<br><br>**max** 1 mark if missing '+' or 'if given as charges e.g. '2+' |
| | | | **Total** | **2** | |