Question number	Answer	Marks	Guidance
1	Ca : N : O = 30.35/40.1 : 21.20/14.0 : 48.45/16.0 = 0.7569 : 1.5286 : 3.028 Formula = CaN_2O_4	B1 B1	
2 (a)	$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$	B1	
2 (b)	4.50×10^{-3} mol	B1	
2 (c)	$n(KClO_3) = 3.0 \times 10^{-3}$ mol $M(KClO_3) = 122.6\ g\ mol^{-1}$ mass of $KClO_3$ = 0.3678 g	B1 B1 B1	
3	$M(ZnSO_4) = 161.5\ g\ mol^{-1}$ $n(ZnSO_4) = 6.57 \times 10^{-3}$ mol $n(H_2O) = (1.893 - 1.061)/18 = 4.62 \times 10^{-2}$ mol $x = n(H_2O)/n(ZnSO_4) = 7$ Formula = $ZnSO_4 \bullet 7H_2O$	B1 B1 B1 B1	
4	$M(Na_2CO_3) = 106.0\ g\ mol^{-1}$ Actual $n(Na_2CO_3)$ = 0.0234 mol Theoretical $n(Na_2CO_3) = 0.0234 \times 100/65$ = 0.0360 mol Theoretical $n(NaHCO_3)$ = 0.0720 mol Mass of $NaHCO_3 = 0.0720 \times 84.0 = 6.05$ g	B1 B1 B1 B1 B1	
5 (a)	$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$	B1	
5 (b)	$M(Fe_2O_3) = 159.6\ g\ mol^{-1}$ $n(Fe_2O_3) = (10\,000 \times 10^6)159.6 = 6.266 \times 10^7$ mol $n(Fe) = 1.253 \times 10^8$ mol $= 6.992 \times 10^9$ g (6992 tonne)	B1 B1 B1	
6 (a)	Na : N : O = 27.1/23.0 : 16.5/14.0 : 56.4/16.0 = 1.178 : 1.179 : 3.525 Formula = $NaNO_3$	B1 B1	
6 (b)	$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$	B1	

Question number	Answer	Marks	Guidance
6 (c)	$M(NaNO_3)$ = 85.0 g mol^{-1} $n(NaNO_3)$ = 0.04 mol $n(O_2)$ = 0.02 mol Volume of O_2 = 0.0200 × 24 000 = 480 cm^3	B1 B1 B1 B1	
7 (a)	0.0250 × 23.0 = 0.575 g	B1	
7 (b)	$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$	B1	
7 (c)	$n(H_2)$ = 0.0125 mol Volume H_2 = 0.0125 × 24 000 = 300 cm^3	B1 B1	
7 (d) (i)	n(NaOH) = n(Na) = 0.0250 = c × 50/1000 c = 0.500 mol dm^{-3}	B1	
7 (d) (ii)	c = 0.500 × 40.0 = 20.0 g dm^{-3}	B1	
8 (a)	58.5 g	B1	
8 (b)	$n(Cl_2) = (2.5 \times 10^9)/24 = 1.04 \times 10^8$ mol $n(NaOH) = 2 \times 1.04 \times 10^8 = 2.08 \times 10^8$ mol $2.08 \times 10^8 = 4.00 \times V$ (in dm^3) $\therefore V = 5.2 \times 10^7$ dm^3	B1 B1 B1	
9 (a) (i)	C : H = 54.55/12.0 : 9.09/1.0 : 36.36/16.0 = 4.55 : 9.09 : 2.27 Empirical formula = C_2H_4O	B1 B1	
9 (a) (ii)	$pV = nRT$ $n = \frac{(103 \times 10^3) \times (72.0 \times 10^{-6})}{8.314 \times 373}$ = 0.002 39 mol $M = \frac{0.2103}{0.00239}$ = 88.0	B1 B1 B1 B1	
9 (a) (iii)	Molecular formula = C_2H_4O × 88/44 = $C_4H_8O_2$	B1	
10 (a) (i)	Al^{3+} SO_4^{2-}	B1 B1	

Question number	Answer	Marks	Guidance
10 (a) (ii)	$Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2O$ 1 Mark for the species and a balanced Equation 1 Mark for state symbols	B1 * 2	**ALLOW** multiples
10 (a) (iii)	water of crystallisation	B1	**IGNORE** hydrated **OR** hydrous **OR** 'contains water'
10 (a) (iv)	$n(Al_2(SO_4)_3 = 6.846/342.3 = 0.0200$ mol $n(H_2O) = (12.606 – 6.848) /18.0 = 0.320$ mol $n(H_2O)/n(Al_2(SO_4)_3) = 16$	B1 B1 B1	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** as ECF from 12.606/342.3 = 0.0368(273) **AND** 0.32/0.0368(273) To give *x* = 9 for two marks **ALLOW** calculator value or rounding to 2 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. **ALLOW ECF** for calculation of correctly rounded whole number value of H_2O from incorrect mol of H_2O and / or incorrect mol of $Al_2(SO_4)_3$ **BUT** *x* must be a whole number **ALLOW** alternative method Mol of $Al_2(SO_4)_3$: 6.846 / 342.3 = 0.02(00) mol (first mark) Molar mass of $Al_2(SO_4)_3{\bullet}xH_2O$: 12.606 / 0.02(00) = 630.3 g mol^{-1} (second mark) Mass of water per mol = 630.3 – 342.3 = 288 **AND** 288/18 to give *x* = 16 (third mark)

Question number	Answer	Marks	Guidance
11 (a)	$M(Na_2B_4O_7•10H_2O)$ = 381.2 g mol^{-1} $n(Na_2B_4O_7•10H_2O)$ = 0.0800 × 250/1000 = 0.02(00) mol mass = 0.0200 × 381.2 = 7.624 g OR ALTERNATIVE $M(Na_2B_4O_7•10H_2O)$ = 381.2 g mol^{-1} mass = 0.0800 × 381.2 = 30.496 g (for 1000 cm^3) mass = 30.496/4 = 7.624 g	B1 B1 B1 A1 A1 A1	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** 381 **DO NOT ALLOW** 380 **ALLOW** [incorrect amount of borax] x 381.2 OR [incorrect amount of borax] x [incorrect molar mass of borax] OR 0.02(00) x [incorrect molar mass of borax] correctly calculated for this mark **ALLOW** calculator value or rounding to three significant figures or more **IGNORE** (if seen) a second rounding error **OR** **ALLOW** 381 **DO NOT ALLOW** 380 **ALLOW** 0.0800 x [molar mass of borax] correctly calculated for 2nd mark (ie mass of borax in 1000 cm^3) **ALLOW** [mass of borax in 1000 cm^3] / 4 correctly calculated for 3rd mark **ALLOW** calculator value or rounding to three significant figures or more **IGNORE** (if seen) a second rounding error
11 (b) (i)	$n(Na_2B_4O_7•10H_2O)$ = 0.0800 × 22.5/1000 = 1.80 × 10^{-3} mol	B1	
11 (b) (ii)	$n(HCl)$ = 2 × 1.80 × 10^{-3} = 3.60 × 10^{-3} mol	B1	**ALLOW** [incorrect amount of borax] x 2 correctly calculated for the 2nd mark. **ALLOW** calculator value or rounding to 3 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2

Question number	Answer	Marks	Guidance
11 (b) (iii)	$c = 3.60 \times 10^{-3} \times 1000/25.00 = 0.144\ mol\ dm^{-3}$	B1	**ALLOW** [incorrect amount of HCl] / (25/1000) correctly calculated for the 3rd mark given to 3 SF
12 (a)	Bubbles Solid dissolves	B1 B1	
12 (b)	0.500 mol HCl is dissolved in each 1 dm^3 of solution	B1	
12 (c) (i)	$M(Li_2CO_3) = 73.8\ g\ mol^{-1}$ $n(Li_2CO_3) = 0.025\ mol$ $n(HCl) = 0.500 \times 125/1000 = 0.0625\ mol$	B1 B1 B1	
12 (c) (ii)	0.025 mol Li_2CO_3 reacts with 0.050 mol HCl HCl is in excess by 0.0625 – 0.0500 = 0.0125 mol	B1 B1	
12 (d) (i)	$n(CO_2) = n(Li_2CO_3) = 0.025\ mol$ Volume of $CO_2 = 0.025 \times 24000 = 600\ cm^3$	B1	
12 (d) (ii)	CO_2 is slightly soluble in water.	B1	
12 (e)	$n(HCl) = 0.0500\ mol$ $c = 0.0500 \times 1000/125 = 0.400\ mol\ dm^{-3}$	B1	
13 (a) (i)	(26.0/100.1) × 100 = 26.0%	B1 B1	First mark for 100.1 **OR** (64.1 + 36.0) **OR** (74.1 + 26.0) at bottom of fraction with or without × 100 **ALLOW** full marks for 26.0 or 26% with no working out **ALLOW** from two significant figures up to calculator value **ALLOW** 25.97 / 26% **NO ECF** for this part from incorrect numbers in first expression
13 (a) (ii)	$n(CaC_2) = 1.00 \times 10^6/64.1 = 15\,600\ mol$	B1	**ALLOW** calculator value of 15 600.624 02 and any rounded value to a minimum of three significant figures
13 (a) (iii)	$n(C_2H_2) = 3.60 \times 10^5/24.0 = 15\,000\ mol$	B1	**ALLOW** 1.50 × 104 etc.

Question number	Answer	Marks	Guidance
13 (a) (iv)	% yield = 15000/15600 × 100 = 96.2%	B1	**ALLOW** ECF from **(iii)** ÷ **(ii)** **ALLOW** calculator value 96.153 8461 and any rounded value to a minimum of two significant figures **ALLOW** 96.147 682 84 if 15 601 is used **ALLOW** any value between 88 to 89 if answer to **(iii)** was calculated by dividing by 26
13 (a) (v)	Any two from: low atom economy gives a poor sustainability OR low atom economy means lots of waste a use for the aqueous calcium hydroxide needs to be developed to increase atom economy alternative process needs to be developed with high atom economy	B1 * 2	**ANNOTATE WITH TICKS AND CROSSES** **IGNORE** comments about percentage yield **ALLOW ECF** from (i) e.g. high atom economy will have good sustainability **ALLOW** find a use for the waste to increase atom economy