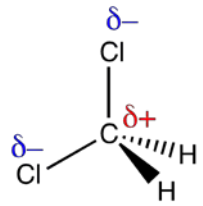
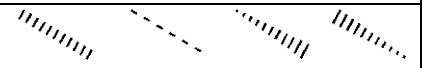
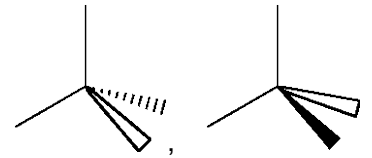
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th>Particle</th><th>Relative charge</th><th>Number of particles present in a $^{140}Ce^{2+}$ ion.</th></tr>
<tr><td>Protons</td><td>+1</td><td>58</td></tr>
<tr><td>Neutrons</td><td>Nil (or 0)</td><td>82</td></tr>
<tr><td>Electrons</td><td>–1</td><td>56</td></tr>
</table>
One mark per column ✓ ✓
</td><td>2</td><td>DO NOT ALLOW ‘+’ or ‘-‘ without ‘1’
DO NOT ALLOW 1 without charge
ALLOW 1+ AND 1–
IGNORE ‘–‘ (ie a dash) for relative charge of a neutron</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Hydrogen ✓</td><td>1</td><td>ALLOW H_2
IGNORE ‘H’</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$Ce_2(SO_4)_3$ ✓

(Cerium) loses three electrons (to form 3+ ion) ✓</td><td>2</td><td>ALLOW alternative phrases for ‘loses’ eg ‘gives away’, ‘donates’
IGNORE ‘3 electrons transferred’ unless a correct direction is given eg ALLOW (Ce) transfers 3 electrons to … OR (Ce) transfers 3 electrons forming Ce^{3+}
IGNORE references to sulfate gaining electrons
IGNORE references to reduction and oxidation</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>A hydrogen ion (of an acid) has been replaced by a metal ion ✓</td><td>1</td><td>For hydrogen ion:
ALLOW ‘H^+’ OR ‘proton’
but DO NOT ALLOW ‘H’ OR ‘hydrogen’ without ‘ion’
For metal ion:
ALLOW ‘cerium ion’ OR ‘Ce^{3+}’ OR ‘Ce^{2+}’ OR ‘Ce ion’
But DO NOT ALLOW ‘Ce’ without ‘ion’ OR ‘cerium’ without ‘ion’
IGNORE ‘ammonium ion’</td></tr>
</table>

Question			Answer	Mark	Guidance
	(c)		**Check the answer line.** **If answer = 1080 cm^3 award 2 marks** Amount of Eu = 9.12/ 152.0 = 0.06(00) mol ✓ Amount of O_2 = 0.0600 x 3/4 = 0.045(0) mol **and** Volume of O_2 = 0.0450 x 24000 = 1080 cm^3 ✓	2	**If there is an alternative answer, check to see if there is any ECF credit possible using working below.** **ALLOW** calculator value or rounding to 2 significant figures or more but **IGNORE** 'trailing zeroes' eg 0.200 is allowed as 0.2. **ALLOW** incorrectly calculated *amount* of Eu x 3/4 and x 24000 correctly calculated for 2nd mark Eg 2605.7 would come from (9.12/63) x 3/4 x 24000 (note: a mass of Eu x 3/4 and x 24000 would not score M2)
1	(d)	(i)	The simplest **whole** number ratio of **atoms** (of each element) present in a compound ✓	1	**ALLOW** smallest **OR** lowest for simplest **ALLOW** molecule for compound
		(ii)	**Check the answer line.** **If answer = $O_{12}S_3Tm_2$ award 2 marks** O = 30.7/ 16.0 S 15.4/32.1 Tm = 53.9 / 168.9 **OR** 1.9(2) mol 0.480 mol 0.319 mol ✓ $O_{12}S_3Tm_2$ ✓	2	**ALLOW** 0.479 OR 0.48 for mol of S **ALLOW** 0.32 for mol of Tm **DO NOT ALLOW** $Tm_2(SO_4)_3$ as empirical formula **IGNORE** $Tm_2(SO_4)_3$ if seen in working.
	(e)	(i)	32 ✓	1	
		(ii)	9 ✓	1	
			Total	**13**	

Question			Answer	Mark	Guidance
2	(a)		Cl (has been oxidised) from Cl = –1 to Cl = 0 ✓ Mn (has been reduced) from Mn = +4 to Mn = +2 ✓	2	**ALLOW** 4+ **OR** 4 **OR** 2+ **OR** 2 **ALLOW** oxidation numbers written above the equation but **IGNORE** these if oxidation numbers are given in the text **ALLOW** one mark for Cl is oxidised because the oxidation number increased by 1 **AND** Mn is reduced because the oxidation number decreased by 2 **ALLOW** one mark if all oxidation numbers are correct but redox is incorrect. **IGNORE** HCl is oxidised **AND** MnO_2 is reduced **IGNORE** correct references to electron loss/gain **DO NOT ALLOW** incorrect references to electron loss/gain
	(b)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$ ✓	1	**ALLOW** $4s^2\ 3d^5$ **IGNORE** $1s^2$ seen twice
	(c)		$Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O$ ✓	1	**ALLOW** multiples **IGNORE** state symbols **ALLOW** OH^- and ClO^-, i.e. $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$ **ALLOW** NaOCl
2	(d)	(i)	(The solution would turn) yellow **OR** orange **OR** brown ✓	1	**ALLOW** shades and colours (eg dark yellow, yellow-orange) **DO NOT ALLOW** 'purple'
	(d)	(ii)	Cl_2 (g) + $2I^-$ (aq) → I_2 (aq) + $2Cl^-$ (aq) ✓	1	**ALLOW** multiples State symbols required **ALLOW** Cl_2(aq)
	(e)	(i)	The ability of an atom to attract electrons ✓ (Electron pair) in a (covalent) bond ✓	2	**ALLOW** 'Measure' for ability **ALLOW** 'attraction' for 'ability to attract' **ALLOW** 'The ability of an atom to attract a shared pair of electrons' for two marks

Question			Answer	Mark	Guidance
2	(e)	(ii)	 Correct orientation of 3-D tetrahedral arrangement of bonds around C atom ✓ δ+ on C atom **AND** δ– on both Cl atoms ✓	2	For a 3D structure, For bond in the plane of paper, a solid line is expected:  For bond out of plane of paper, a solid wedge is expected:  For bond into plane of paper, **ALLOW**:  **ALLOW** a hollow wedge for 'in bond' **OR** an 'out bond', provided it is different from the other in or out wedge e.g.:  **ALLOW** any 3D representation with a minimum of one bond into the plane of paper **AND** minimum of one out of plane of paper **ALLOW** 2 lines in the plane + 2 different bonds for M1 **IGNORE** dipole charges on H
		(iii)	The dipoles do not cancel out **OR** Because the molecule is non-symmetrical ✓	1	**ALLOW** partial charges do not cancel **IGNORE** charges do not cancel **ALLOW** (the more) electronegative atoms are on one side of the molecule
	(f)		55% ✓	1	
			Total	**12**	

Question			Answer	Mark	Guidance
3	(a)	(i)	Mol of H_2SO_4 = 0.100 x 18.00/1000 = 1.80 x 10^{-3} mol ✓	1	**ALLOW** calculator value or rounding to 2 significant figures or more but **IGNORE** 'trailing zeroes' throughout Q4. eg 0.200 is allowed as 0.2
		(ii)	Mol of NaOH in = 1.80 x 10^{-3} x 2 x 1000/25.0 = 0.144 mol dm^{-3} ✓	1	**ALLOW** ECF for (a)(i) x 2 x 1000/25
	(b)	(i)	**Check the answer line.** **If answer = 0.0184 mol award 2 marks** Mol of $NaHCO_3$ in 25.0 cm^3 = [0.100 x 11.50/1000] x 2 = 0.00230 mol ✓ Mol of $NaHCO_3$ in 200 cm^3 = 0.00230 x 200/25.0 = 0.0184 mol ✓	2	**If there is an alternative answer, check to see if there is any ECF credit possible using working below.** **ALLOW** for an alternative method for M1 Total mol of H_2SO_4 used = [0.100 x 29.50/1000] = 0.00295 mol Mol of H_2SO_4 reacting with $NaHCO_3$ = 0.00295 – answer to (a)(i) Expected answer = .00295 – 0.00180 = 0.00115 mol Mol of $NaHCO_3$ in 25.0 cm^3 = 0.00115 x 2 = 0.00230 mol **ALLOW** ECF for **mol** of $NaHCO_3$ x 200/25.0 For ECF in M2 titration values of 11.50 or 29.50 must have been used in M1 Second marking point is for scaling up number of mol of $NaHCO_3$ by 200/25.0 (Usually seen as '8')
		(ii)	Mass of $NaHCO_3$ = 0.0184 x 84.0 = 1.55 g ✓ **(must be three significant figures)**	1	**ALLOW** ECF for **(b)(i)** x 84.0 correctly calculated and rounded to three significant figures.
			Total	**5**	

Question			Answer	Mark	Guidance
4	(a)	(i)	$2Ca + O_2 \rightarrow 2CaO$ ✓	1	**ALLOW** multiples e.g. $Ca + ½O_2 \rightarrow CaO$ **IGNORE** state symbols
		(ii)	Thermal decomposition ✓	1	
	(b)		Base: A substance which readily accepts H^+ ions (from an acid) ✓ Alkali: releases OH^- ions into (aqueous) solution ✓	2	**ALLOW** proton acceptor **ALLOW** Is soluble and releases OH^- ions (into aqueous solution)
	(c)		Effervescence **OR** fizzing **OR** bubbling **OR** gas produced **AND** The solid **OR** calcium **OR** the metal would dissolve **OR** disappear **OR** a (colourless) solution forms ✓ $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ ✓	2	**IGNORE** 'hydrogen produced' but **ALLOW** 'hydrogen gas produced' **DO NOT ALLOW** an incorrectly named gas (eg CO_2) produced **ALLOW** multiples **IGNORE** state symbols
	(d)		Nitric acid **OR** HNO_3 ✓ $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$ ✓	2	**ALLOW** reagent mark if no response is seen but HNO_3 is seen in the equation **IGNORE** calcium carbonate on reagent line **ALLOW** multiples **IGNORE** state symbols **DO NOT ALLOW** H_2CO_3 for $H_2O + CO_2$
			Total	**8**	

Question			Answer	Mark	Guidance
5	(a)		period = 5 **AND** block = p ✓	1	
5	(b)	(i)	**Atom(s)** of an element **AND** with different numbers of neutrons (and with different masses) ✓	1	**ALLOW** for '**atoms** of an element': **Atoms** of the same element **OR** **Atoms** with the same number of protons **OR** **Atoms** with the same atomic number **IGNORE** different relative atomic masses **IGNORE** different mass number **IGNORE** same number of electrons **DO NOT ALLOW** different number of electrons **DO NOT ALLOW** 'atoms of elements' for 'atoms of an element' **DO NOT ALLOW** 'an element with different numbers of neutrons) (ie atom(s) is essential)
5	(b)	(ii)	same number of electrons in outer shell **OR** same electron configuration **OR** electron structure ✓	1	**IGNORE** same number of protons **IGNORE** same number of electrons **IGNORE** they are the same element
5	(b)	(iii)	51p 70n 51e ✓	1	

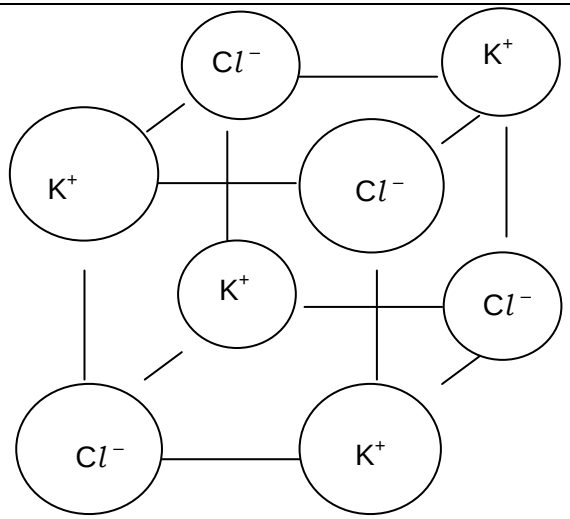
Question			Answer	Mark	Guidance
5	(c)	(i)	The (weighted) mean **mass** of an **atom** (of an element) **OR** The (weighted) average **mass** of an **atom** (of an element) ✓ compared with 1/12th (the mass) ✓ of (one atom of) carbon-12 ✓	3	**ALLOW** average atomic mass **DO NOT ALLOW** mean mass of an element **ALLOW** mean mass of isotope**s OR** average mass of isotope**s** **DO NOT ALLOW** the singular 'isotope' For second **AND** third marking points **ALLOW** compared with (the mass of) carbon-12 which is 12 For three marks; **ALLOW** mass of **one mole** of **atoms** compared to 1/12th (mass of) **one mole OR** 12**g** of carbon **OR** **ALLOW** $\frac{\text{mass of one mole of atoms}}{\text{1/12th mass of one mole OR 12g of carbon-12}}$
5	(c)	(ii)	123 ✓	1	**ALLOW** ^{123}Sb **OR** Sb-123 **OR** antimony-123 **ALLOW** 123.0 **IGNORE** working
5	(d)	(i)	(Trigonal) Pyramidal ✓ (Sb has) three bonding pairs **AND** one lone pair of electrons ✓ **Pairs** of electrons repel ✓	3	**ALLOW** alternative phrases/words to repel eg 'push apart' **ALLOW** lone pairs repel more than bonding pairs **ALLOW** bonds for bonded pairs **ALLOW** lp and bp **IGNORE** electrons repel **DO NOT ALLOW** atoms repel

Question			Answer	Mark	Guidance
5	(d)	(ii)	There is a difference in electronegativities (between Sb and C*l*) **OR** (Sb-Cl) bonds are polar **OR** have a dipole **OR** Dipoles seen on the diagram ✓ The molecule is not symmetrical **AND** dipoles do not cancel ✓	**2**	**ALLOW** Because C*l* is more electronegative (than Sb) OR Because Sb is more electronegative (than C*l*) **ALLOW** description that electrons are drawn along a covalent bond **IGNORE** single δ+ or single δ- for dipole **IGNORE** diagram if M1 awarded in text **ALLOW** partial charges do not cancel **IGNORE** references to lone pair causing dipoles
			Total	**13**	

Question			Answer	Mark	Guidance
6	(a)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = CH_4N_2O award 2 marks C H N O 20.00/12.0 6.67/1.0 46.67/14.0 26.66/16.0 **OR** 1.67 6.67 3.33 1.67 ratio of mol ✓ to give CH_4N_2O ✓	2	**ALLOW** 1.66 for C **OR** 1.66 for O **IGNORE** Significant figures beyond the 3rd significant figure. (eg **ALLOW** 3.3335 for N **OR** 1.666 for C) **ALLOW** ECF from incorrectly calculated ratio of mol, **DO NOT ALLOW** ECF from using an atomic number **OR** any original sums inverted (eg 12.00/20.00) **ALLOW** any order of atoms
6	(b)		NH_4^+ ✓ NO_3^- ✓	2	Mark incorrect ions first
6	(c)	(i)	H_3PO_4 ✓	1	**ALLOW** formula if seen as reactant in an equation **IGNORE** name
6	(c)	(ii)	Calcium oxide **OR** calcium hydroxide **OR** calcium carbonate ✓	1	**IGNORE** formulae **IGNORE** lime, quicklime and limestone
			Total	6	

Question			Answer	Mark	Guidance
7	(a)		Oxidised **AND** because aluminium has lost (three) electron**s** ✓	1	**ALLOW** 'donated' for 'lost' **IGNORE** where electrons are transferred to **IGNORE** Al → Al^{3+} + $3e^-$ **DO NOT ALLOW** 'an electron' or incorrect number of electrons
	(b)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2.88 dm^3 award 2 marks Mol of H_2 = 0.12 ✓ Volume of H_2 = 0.12 x 24.0 = 2.88 dm^3 ✓	2	 ALLOW ECF from incorrectly calculated moles of H_2 0.08 x 24 = 1.92 gets 1 mark
	(c)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 10.7 g award 2 marks Correctly calculates molar mass of $AlCl_3$ = 133.5 g ✓ Mass of $AlCl_3$ formed = 0.0800 x 133.5 = 10.7 (g) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for incorrect molar mass of $AlCl_3$ multiplied by 0.0800 and correctly rounded to 3 significant figures
	(d)		FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 200(.0) cm^3 award 2 marks Correctly calculates moles of HCl needed = 0.0800 x 3 = 0.24(0) mol ✓ Volume of HCl = 0.24(0) x 1000/1.2 = 200 cm^3 ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below **ALLOW** ECF for incorrect mol of HCl x 1000/1.20 **ALLOW** 66.7 (66.67 or 66.667 etc) for 1 mark **DO NOT ALLOW** 66.6 (66.66 or 66.666 etc)
			Total	7	

Question			Answer	Marks	Guidance
8	(a)	(i)	**Mass** of the **isotope** compared to 1/12th **OR** **mass** of the **atom** compared to 1/12th ✓ (the mass of an atom of) ^{12}C ✓	2	**ALLOW** for ^{12}C: carbon-12 **OR** C-12 **OR** C 12 **OR** 12C **ALLOW** mass of a **mole** of the isotope **OR** mass of a mole of atoms compared to 1/12th the mass of **mole** or 12 **g** of ^{12}C for two marks **ALLOW** mass of the isotope or mass of the atom compared to ^{12}C which has a mass of 12(.0) for two marks **ALLOW** one mark for responses which have individual atoms compared to one mole of 12C and vice versa eg mass of the isotope or mass of the atom compared to ^{12}C which has a mass of 12(.0) **g** eg mass of an atom compared to 1/12th mass of one mole of ^{12}C eg mass of one mole of atoms compared to 1/12th the mass of an atom of 12C **ALLOW** 2 marks for responses expressed as a fraction eg $\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of } ^{12}C}$ **IGNORE** (weighted) mean **OR** average **DO NOT ALLOW** mass of element or mass of ion
		(ii)	19p and 20n ✓ $^{41}K^+$ and 19p ✓	2	Mark by row **ALLOW** 41K+
	(b)		$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ ✓	1	**ALLOW** $1s^2$ repeated **ALLOW** subscripts **AND** upper case etc

Question			Answer	Marks	Guidance
8	(c)	(i)	**First check the answer on the answer line.** **If answer** = 3.01 x 10^{22} award 3 marks 170.1 ✓ (**ALLOW** in working shown as 28.1 + 35.5 x 4) Correctly calculates amount of molecules 8.505 / 170.1 = 0.05(00) mol ✓ Correctly calculates number of molecules 0.05 x 6.02 x 10^{23} = 3.01 x 10^{22} ✓	3	**ALLOW** 0.301 x 10^{23} for three marks If there is an alternative answer, check to see if there is any ECF credit possible using working below. **ALLOW** ECF from incorrect molar mass of $SiCl_4$ **ALLOW** 0.05(00) (mol) for two marks **ALLOW** ECF for incorrect number of mol of $SiCl_4$ **ALLOW** calculator value or rounding to 3 significant figures or more **BUT IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2. **DO NOT ALLOW** any marks for: 8.505 x 6.02 x 10^{23} = 5.12 x 10^{24}
		(ii)	 4 K and 4 Cl correctly arranged ✓ 4 K^+ and 4 Cl^- correctly arranged ✓	2	**ALLOW** the structure with **ALL** Cl^- and K^+ transposed **ALLOW** labels if seen outside circles but linked with an arrow eg K^+ → ○
			Total	**10**	