Question Number	Acceptable Answers	Reject	Mark
1 (a)	**Pale / light and green / yellow** Allow (virtually) colourless	clear yellow green any other colour	**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(b)(i)**	Red/brown (solution) Allow yellow Ignore (From….) to….	Purple (or in combination with red or brown) Pale yellow Orange (or in combination with red or brown) Reject any other colours alone or in combination Grey/black (or any other colour alone or in combination) solid	**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(b)(ii)**	$Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)/(s)$ Entities **(1)** Balancing **and** all four state symbols Dependent on correct entities **(1)** $Cl_2(aq) + 2KI(aq) \rightarrow 2KCl(aq) + I_2(aq)/(s)$ 1 max $K^+(aq)$ on both sides of otherwise correct equation 1 max		**2**

Question Number	Acceptable Answers	Reject	Mark
1 **(c)(i)**	Starch **(1)** Blue/black to colourless Dependent on starch indicator **(1)** Accept: no indicator needed **(1)** Yellow to colourless **(1)** Blank for indicator and yellow to colourless 1max	Any other indicator e.g. methyl orange/ phenolphthalein = 0/2 Colourless to blue/black Blue/black to clear Any mention of purple	**2**

Question Number	Acceptable Answers	Reject	Mark
1 **(c)(ii)**	(ii) – (vi) General comme Allow correct answers with no working in all parts N.B. Mark each part to mark scheme answer first then allow TE from earlier parts. Minimum correct to 2SF. Penalise SF for 1SF once only. But incorrect rounding e.g. 4.525 to 4.52 is penalised once separately as well. Penalise wrong units once only as well. (Mean titre = 9.05) $\frac{9.05 \times 0.01}{1000}$ $= 9.05 \times 10^{-5}$ /0.0000905(mol) Allow 9.1×10^{-5}/0.000091(mol)	$9.(0) \times 10^{-5}$ / 0.00009(0)	**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(c)(iii)**	$(I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow)$ $\mathbf{2I^-}((aq)) + \mathbf{S_4O_6^{2-}}((aq))$ **(1)** **(1)** Marks stand alone for entities with balancing Either of these on their own scores 1 mark regardless of anything else that is written Multiples/fractions of equation allowed Ignore state symbols even if incorrect		**2**

Question Number	Acceptable Answers	Reject	Mark
1 **(c)(iv)**	$\frac{9.05 \times 10^{-5}}{2}$ $= 4.525 \times 10^{-5}$ /0.00004525(mol) Allow 4.53×10^{-5} /0.0000453 etc Allow TE $\frac{\text{ans (ii)}}{2}$ Accept TE from (iii) if you see it		**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(c)(v)**	4.525×10^{-5} /0.00004525 (mol) Allow TE = ans (iv) [Allow 'ans (iv)' with no numbers for this part only]		**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(c)(vi)**	$4.525 \times 10^{-5} \times \frac{1000}{10} =$ $4.525/4.53 \times 10^{-3}$ /0.004525/0.00453 (mol dm^{-3}) Accept TE ans (v) x 100 [a calculated number must be given]		**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(d)(i)**	Lilac Allow (light) purple or mauve	Violet Reject any other colours alone or in combination	**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(d)(ii)**	$2K + Cl_2 \rightarrow 2KCl$ Accept multiples/fractions Ignore state symbols even if incorrect Ignore correct charges on ions in KCl	K_2 and/or KCl_2 Charges on reactants K and/or Cl_2	**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(e)(i)**	Hydrogen chloride This may be accompanied by HCl	Hydrochloric acid HCl /HCl(g)/HCl (gas) alone SO_2 H_2S Anything else	**1**

Question Number	Acceptable Answers	Reject	Mark
1 **(e)(ii)**	Dissolves in moisture/water/water vapour (in the air) **Or** reacts with moisture/water/water vapour (in the air)	HCl condenses	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (e)(iii)	NH_4Cl / Ammonium chloride/ $ClNH_4$ $NH_4^+Cl^-$ / $H_4N^+Cl^-$/ $Cl^-NH_4^+$ Ignore any states even if incorrect	Ammonia chloride / NH_3Cl	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (f)(i)	Any one of: Phosphorus(V) chloride/pentachloride Phosphorus(III) chloride/trichloride Allow (III/V) anywhere **Conc**entrated hydrochloric acid Hydrogen chloride (gas) Sodium/potassium chloride and **conc**entrated sulfuric acid Thionyl chloride Allow correct formula(e) for all above But note: **conc** HCl /**conc** H_2SO_4	Phosphorus chloride Hydrochloric acid/HCl/ HCl(aq) Chlorine	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (f)(ii)	Be generous here Horizontal test tube with ceramic fibre/ any sort of wool except iron **(1)** soaked in 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture… …with **heat** (or any diagram of a heat source or the word heat) **(1)** OR Round bottom/pear shaped flask/sloping test/boiling tube and **heat** (or any diagram of a heat source or the word heat) **(1)** containing 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture **(1)** Ignore: any use of aluminium oxide/pumice reflux/distillation set up Gas collection over water **(1)** Ignore Bunsen valves Allow: Collection in a gas syringe Note: This does not constitute a sealed apparatus	Sealed apparatus but ignore inadvertent closures owing to poor cross-sectional drawings (-1) Poor diagram e.g. clear air gaps at intermediate joints in the apparatus(-1) Solution/substances alone An arrow on its own Conical/flat bottomed flask N.B. contradiction between drawing and any label Solution/substances alone A poor diagram mark (which can be the second) should be deducted for the delivery tube through the side of trough and/or the delivery tube missing the collection tube.	**3**

Question Number	Acceptable Answers	Reject	Mark
2 (a)	**Mark independently** **From:** colourless **(1)** **To:** pink / (pale) red **(1)** If colour change wrong way round **max (1)**	**From:** clear **To:** magenta / purple / cerise	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b	(Titres 2, 3 and 4) are concordant / within 0.2 (cm^3) / within 0.1 (cm^3) / consistent **OR** Titre 1 is rough / trial / a rangefinder / too far out / overshot *ALLOW* Titre 1 is an outlier / is anomalous	**Just** "very similar" / within 0.05 / within 0.5 Titre 1 "very different" **Just** "not accurate" "Titration 1 is a control experiment"	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)	28.00 (cm^3) / 28.0 (cm^3) / 28 (cm^3)	28.14 (cm^3) / 28.1 (cm^3) / 28.13 (cm^3)	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(i)	$\frac{0.100 \times 28.00}{1000}$ = **0.0028 / 2.8 x 10^{-3}** (mol) *ALLOW* TE from (c) *IGNORE* sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(ii)	**0.0028 / 2.8 x 10^{-3}** (mol) OR **Same answer** to (d)(i) if TE applied *IGNORE* sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(iii)	$\frac{0.0028}{0.025}$ = **0.112** (mol dm^{-3}) OR **Answer** to $\frac{\text{(d)(ii)}}{0.025}$ if TE applied from (d)(ii) *IGNORE* sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(iv)	10 x 0.112 = **1.12** (mol dm^{-3}) OR **Answer** to (d)(iii) x 10 if TE applied from (d)(iii) *IGNORE* sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(v)	1.12 x 60 = **67.2** (g dm^{-3}) OR **Answer** to (d)(iv) x 60 if TE applied from (d)(iv) *IGNORE* sf except one sf	67.1	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (e)	*NOTE*: answer must refer to making up the diluted solution and not the titration *NOTE:* the Reason mark must be correctly linked to the Improvement **Improvement:** Use a pipette / burette to measure acid (solution) **(1)** **Reason:** Pipette / burette more accurate (than a measuring cylinder) **(1)** *ALLOW* "more precise" **OR** **Improvement:** Shake / invert **the volumetric flask** (thoroughly) **(1)** **Reason:** To ensure a uniform concentration **(1)** **OR** **Improvement:** Rinse out measuring cylinder (and transfer washings to the volumetric flask) **(1)** **Reason:** To ensure **all** the acid is transferred (to the volumetric flask) **(1)** **OR** **Improvement:** Use a (teat) pipette to make up to the mark (in volumetric flask) **(1)** **Reason:** To ensure volume of solution accurately measured **(1)**	Use of volumetric flask for **initial** measurement of volume of vinegar solution "more reliable" swirl (the flask) to ensure "fully dissolved" **just** "rinse out apparatus" Any suggested improvements relating to the titration part of this experiment	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (f)(i)	**Z *I*** between 27.85 and 28.05 (cm^3) *ALLOW* 27.95 ±0.10 (cm^3)		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (f)(ii)	Any **one** of the following / a statement equivalent to: • overshoots/misses end-point • water left in burette / pipette • air lock below tap in burette / air in pipette • burette not vertical • alkali not at stated concentration • leaking tap • not reading meniscus at eye-level • funnel left in top of burette • not reading level against a white background • not reading meniscus correctly • washing pipette between titres • washing the flask with the solution that will go in it • not swirling flask / mixture *IGNORE* "errors in calculation"	"water left in conical flask" **just** "measurements may be inaccurate" "there could be uncertainty with other equipment" "contamination of the vinegar"	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a) (i)	$2Al(s) + 2OH^-(aq) + 2H_2O(l) \rightarrow 2AlO_2^-(aq) + 3H_2(g)$	$2O_2^{2-}(aq)$	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	$\left(\frac{2 \times 10}{1000} = 0.02 / 2 \times 10^{-2}\right)$ Ignore trailing zeroes		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	$0.02 / 2 \times 10^{-2}$ Accept TE answer to (ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iv)	$0.02 \times 27.0 = 0.54 / 5.4 \times 10^{-1}$ (g) TE answer to (iii) OR (ii) x 27.0 Ignore sf except 1	Other unit	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(v)	$(1.1 \times 0.54) = 0.59(4) / 5.9(4) \times 10^{-1}$(g) TE answer to (iv) x 1.1 Ignore sf except 1 Only penalise sf once		**1**

Question Number	Acceptable Answers	Reject	Mark
3 **(a)(vi)**	**Potassium hydroxide / KOH** (solution) is corrosive / burns / caustic **OR** **KOH** damages / harms / is harmful to / dissolves / reacts with **skin / eye(s)** **(1)** **OR** **KOH** in **eye(s)** **(1)** **Ignore** Harmful, irritant, highly reactive alone **Hydrogen / H_2** is flammable / explodes / explosive **(1)** Allow mention of both potassium hydroxide and hydrogen alone scores **(1)** Allow Al foil can cut your skin **(1)** Correct answer with additional incorrect chemistry e.g. KOH is oxidising so corrosive scores **(0)**	Toxic, carcinogenic, alone or in combination with correct answer Burns alone Additional chemicals	**2**

Question Number	Acceptable Answers	Reject	Mark
3 **(b)(i)**	$KAlO_2(aq) + \mathbf{2}H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + \mathbf{2}H_2O(l)$ Allow multiples		**1**

Question Number	Acceptable Answers	Reject	Mark
3 **(b)(ii)**	$\frac{2 \times 1000 \times 0.02}{1} = 40\ (cm^3)$ Allow 0.04(0) **dm^3** TE answer to (a)(ii) x 2000 and TE from (b)(i)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 **(b)(iii)**	Litmus (paper / solution) **(1)** Red / pink (in acid) **(1)** OR any other named acid-base indicator including universal indicator **(1)** with a correct acidic colour **(1)** NB phenolphthalein must be spelt correctly to score **(1)** and no mark for colour Notice that other indicators only require recognisable spellings Red litmus turns blue scores for the indicator **(1)** OR pH meter / universal indicator **(1)** with value < 7 **(1)** NB measure pH alone (0) pH < 7 **(1)** OR add a (metal) carbonate / suitable metal eg Mg **(1)** bubbles / fizzing **(1)** Calculation of amounts / moles of **both** reactants (1 maximum)		**2**

Question Number	Acceptable Answers	Reject	Mark
3 **(b)(iv)**	**Each point must be made in full** **The second and final scoring points, which are asterisked, can only be gained through these statements. Two further marks can be scored for any two of the other four points.** 1 Filter (to remove any aluminium / impurities) **(1)** NB This mark can only be awarded if it is the first action **and** the mixture is subsequently heated. 2 *Boil / heat / evaporate to reduce the volume of water **(1)** NB boil / heat to remove water only gets the mark if it is clear, subsequently, that some solution is left 3 Cool / set aside / leave to allow crystals to form **(1)** 4 Filter OR pick out / remove / take out crystals (to separate) **(1)** 5 Wash with a **little / cold** water **(1)** 6 *Place between filter papers / dab with paper towel / use dessicator (to dry) **(1)**	Leave in the sun If boiled to dry stop marking here Heat in oven	**4**

Question Number	Acceptable Answers	Reject	Mark
3 **(b)(v)**	White / colourless Ignore clear / transparent / cloudy / opaque e.g. accept clear and colourless	Any other colours with or without white	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(vi)	Cr^{3+}/ Fe^{3+}/ Sc^{3+} / Ga^{3+} Accept any feasible triply positive metal ion Allow B^{3+} Allow any name or symbol for a Group 3 element Allow named existing transition metal ions with (III) after the name (if they exist) Fully correct formula for an alum or intermediate starting entity Eg $KGa(SO_4)_2$ / $KGaO_2$	Al^{3+} and anything else Group 3 element with incorrect charge	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (a)	All have the same number of electrons / all have one (s) electron / same electron configuration **(1)** All have the same number of protons / all have one proton **(1)** The first has no neutrons, the second one neutron and the third two neutrons Allow deuterium has one more neutron, tritium two more neutrons **(1)** Ignore references to same atomic number and different mass numbers	All have one p electron Different number of neutrons alone	**3**

Question Number	Acceptable Answers	Reject	Mark
4 (b)	( +  →  +)  Numbers can be on either side or both sides		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(i)	**Molar mass / M(r) / 3+2 / 2+3** = 5 (g mol^{-1}) (1) Number of moles = 4/5 = 0.8 **(1)** O.8 with correct working, with wrong working, or with no working **(2)** Allow internal TE if Molar mass clearly indicated and incorrect eg Molar mass / M(r) = 6 (g mol^{-1}) **(0)** Number of moles = 4/6 = 0.67 **(1)**	Penalise incorrect units	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(ii)	24 000 x 0.8 = 19 200 (cm^3) Allow 19.2 **dm^3** Allow TE from (c)(i)	Incorrect units	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (d)	$\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{100}$ OR $\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{99.9850 + 0.0150}$ **(1)** Notice this working must be shown in full to score first mark. (= 1.007951) = 1.0080 **(1)** 1.008 max 1 with or without working Correct answer no working **(2)** Only give second mark for correct answer to 4 decimal places Ignore g mol^{-1}	Incorrect units e.g.	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (e)(i)	Single arrow **upwards** from lowest line to infinity line (allow above or very close below) Allow double headed arrow	More than one line	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (e)(ii)	Hydrogen $1s^1$ **and** Sodium $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(1)** Electron numbers may be on lines or subscript. Both have one (s) electron in the **outer** shell / orbital / sub shell OR same number of electrons / same electron(ic) configuration in **outer** shell / orbital / sub shell OR Both have an/one unpaired electron in their **outer** / **last** shell / orbital / sub shell **(1)** Second mark depends on one outer shell s electron shown for each electronic configuration	$1s^2\ 2s^1$ half filled s outer shell same electron(ic) configuration alone	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (f)	Helium **(1)** Any two from the following points: Electron removed is closest / close to the nucleus **(1)** Little shielding, allow no shielding **(1)** More protons / higher nuclear charge than hydrogen. Allow higher effective nuclear charge **(1)** **NB** second and third marks can be gained if **hydrogen** is given: Electron removed is close / closest to the nucleus **(1)** No shielding **(1)**	Any other elements	3