Pearson
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Mark Scheme (Results)

January 2022

Pearson International Advanced Subsidiary Level
In Chemistry (WCH13)
Paper 01: Practical Skills in Chemistry I

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the mark scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit. ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

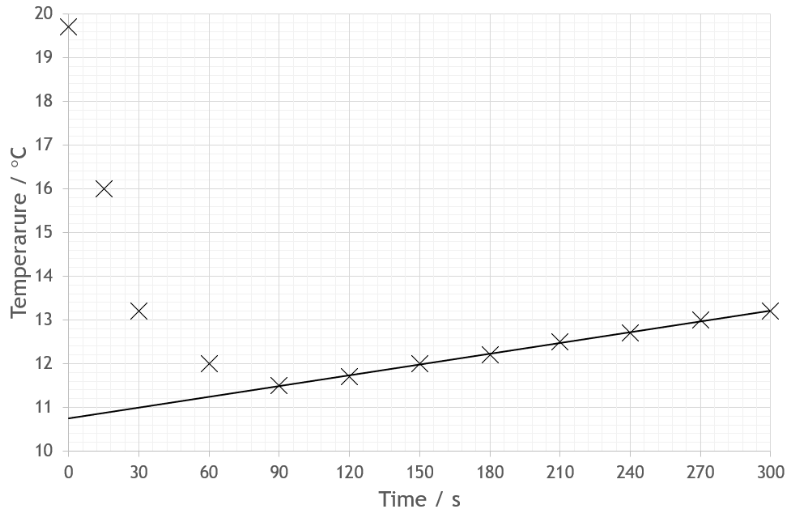
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer. ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Question Number	Answer	Additional guidance	Mark
1(a)(i)	An answer that makes reference to the following point: • white precipitate	Allow solid / ppt(e) / crystals for solid Ignore just white Ignore any references to colourless solutions Do not award any mention of cream, eg creamy-white Do not award colourless precipitate Do not award any reference to bubbles / effervescence Do not award any reference to fumes / smoke	**(1)**

Question Number	Answer	Additional guidance	Mark
1(a)(ii)	An answer that makes reference to the following points: • (add aqueous) sodium hydroxide / NaOH **and** warm (1) • (gas evolved) turns (damp red) litmus (paper) blue **or** (gives) white smoke with hydrogen chloride / HCl (1)	Allow heat **M2 dependent on hydroxide as test reagent** Allow turns universal indicator (paper) blue Do not award if indicator (paper) added to solution Allow white smoke with concentrated hydrochloric acid Ignore white / steamy fumes for white smoke Allow pungent / choking smell (as description of ammonia) Ignore just forms ammonia / NH_3 Ignore any reference to effervescence / fizzing Do not award any reference to formation of a precipitate	**(2)**

Question Number	**Answer**	**Additional guidance**	**Mark**
1(b)(i)	An answer which that makes reference to the following points: • so that the ammonium chloride / solid dissolves (1) • to ensure a uniform temperature (1)	Allow any reference to helping the solid dissolve Ignore any reference to mixing Ignore any reference to reaction / reactants Allow to ensure a constant temperature Allow to give an accurate temperature reading Allow (so solution is) evenly cooled / heated	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>1(b)(ii)</td><td>An answer that makes reference to the following points:</td><td>Example of extrapolation and calculation:

</td><td>(2)</td></tr>
<tr><td></td><td>• (data ≥ 90 s extrapolated back and) minimum temperature at $t = 0$ (1)</td><td>Accept minimum temperature in range of 10.7 ± 0.2 (°C)</td><td></td></tr>
<tr><td></td><td>• calculation showing maximum temperature change, ΔT (1)</td><td>ΔT = 19.7 – minimum temperature = 19.7 – 10.7 = 9(.0 °C)
TE on 19.7 – minimum temperature, provided ≤ 11.5 (°C)
Allow negative ΔT values from minimum minus initial temperatures</td><td></td></tr>
</table>

Question Number	Answer	Additional guidance	Mark
1(b)(iii)	An explanation that makes reference to the following points: • minimum temperature would be lower (1) • temperature would increase at a slower rate (> 90 s) (1) • less heat (from the surroundings) would enter the solution (1)	**All marks are standalone** Ignore any reference to endothermic / exothermic / ΔH Allow temperature (values) would be lower Allow temperature change would be greater Ignore minimum temperature reached sooner Do not award temperature values would be higher Do not award less heat loss Allow temperature would remain constant / rise more slowly (> 90 s) Allow slope of graph would be less steep (> 90 s) Allow heat would not enter Allow polystyrene cup is (better) insulated Allow glass beaker (better) conducts heat Ignore polystyrene cup absorbs more heat	**(3)**

Question Number	Answer	Additional guidance	Mark
1(c)(i)	An answer that refers to any **two** of the following points: • solution has a density of 1 g cm^{-3} (1) • mass of ammonium chloride / solid is ignored (1) • (specific) heat capacity of the solution is the same as water (1)	Ignore reference to purity of NH_4Cl Ignore any reference to heat transfer Ignore any reference to endothermic / exothermic Ignore any reference to instantaneous reaction Ignore any reference to standard / nonstandard conditions Ignore any attempt at justification, including calculation Allow mass of solution is same as its volume Allow the density of the solution is the same as water Allow mass of solution is 50 g Allow mass of ammonium chloride / solid is negligible Allow heat capacity of the solution is 4.18 / 4.2 (J g^{-1} $°C^{-1}$) Allow heat capacity of beaker / apparatus can be ignored / is negligible	**(2)**

Question Number	Answer	Additional guidance	Mark
1(c)(ii)	An answer that makes reference to the following points: **Method 1** • calculation of uncertainty in experimental value (1) • indication that experimental value is consistent with data book value (1) **Method 2** • calculation of percentage change from experimental to data book value (1) • indication that percentage change is less than experimental uncertainty (1)	Example of calculation: Ignore SF except 1SF Ignore truncation of values in intermediate working, eg 0.37 for 0.377 uncertainty = 2.6 ÷ 100 × 14.5 (= 0.377 kJ mol^{-1}) Do not award the use of 14.8 instead of 14.5 14.5 + 0.377 = 14.877 (kJ mol^{-1}) Accept 14.8 – 0.377 = 14.423 (kJ mol^{-1}) Accept 0.3 < 0.377 14.5 × 1.026 = 14.877 / 14.88 / 14.9 (kJ mol^{-1}) scores (2) Award 1 mark for TE on use of 14.8 in M1: 14.5 + 0.3848 = 14.8848 (kJ mol^{-1}) Allow 14.8 – 0.3848 = 14.4152 (kJ mol^{-1}) 0.3 < 0.3848 percentage change = (14.8 – 14.5) ÷ 14.5 × 100 (= 2.06897 %) Allow 14.8 ÷ 14.5 × 100 (= 102.6897 %) Do not award division by 14.8 instead of 14.5 2.06897 < 2.6 Award 1 mark for TE on division by 14.8 in M1: 2.02703 < 2.6	**(2)**

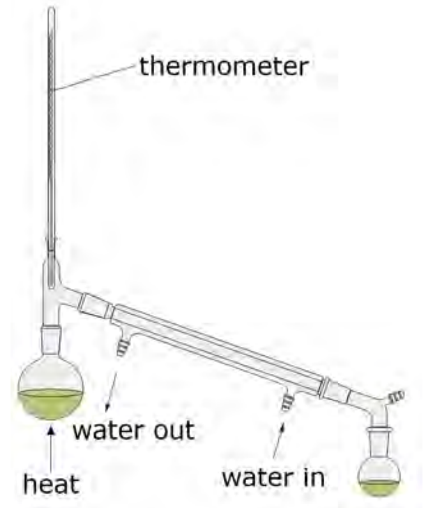
(Total for Question 1 = 14 marks)

Question Number	Answer	Additional guidance	Mark
2(a)(i)	An answer that makes reference to the following points: • mass / weight of each U-tube and their contents (1) • mass / weight before and after combustion / reaction (1)	Ignore any reference to amount / volume Ignore any reference to temperature / time Allow mass / weight of silica (gel) **and** soda lime Ignore reference to mass of X remaining Ignore mass of O_2 **M2 dependent on mention of U-tube / silica / soda lime** Allow initial mass / weight **and** final mass / weight Allow change in mass / weight If no other mark awarded, mass / weight of H_2O **and** CO_2 absorbed / produced scores (1)	**(2)**

Question Number	Answer	Additional guidance	Mark
2(a)(ii)	An answer that refers to any **two** of the following points: • to exclude water from the air (1) • to exclude carbon dioxide from the air (1) • for complete combustion (1)	Ignore any reference to unwanted side reactions Ignore any reference to air being a mixture Ignore air contains O_2 / N_2 / noble gases Ignore so mass of H_2O and CO_2 can be measured more accurately Ignore any reference to rate / efficiency / yield of combustion Allow because it is dry Allow air might be damp / contains H_2O Do not award air contains hydrogen / H_2 Allow air contains CO_2 Allow (to ensure X is) fully combusted Allow (to ensure) complete reaction Allow to prevent incomplete combustion in air	**(2)**

Question Number	Answer	Additional guidance	Mark
2(a)(iii)	An answer that makes reference to the following points: • mass of oxygen (1) • mols C, H and O (1) • mole ratio **and** empirical formula (1)	Example of calculation: Allow truncation of mass and mols in intermediate working, eg 0.05 for 0.0525 mass O = 1.33 – 0.14 – 0.63 = 0.56 (g) C : H : O $\frac{0.63}{12}$: $\frac{0.14}{1}$: $\frac{0.56}{16}$ 0.0525 : 0.14 : 0.035 TE on M1 **M3 dependent on use of mols** C : H : O 1.5 : 4 : 1 3 : 8 : 2 empirical formula is $C_3H_8O_2$ TE on M2 Correct answer with some working scores (3) Correct answer with no working scores (1)	**(3)**

Question Number	Answer	Additional guidance	Mark
2(b)	An answer that makes reference to the following point: • (X contains) O–H / hydroxyl (group)	Allow OH / –OH / hydroxy Allow "(X is) either alcohol or carboxylic acid" Ignore just alcohol / diol Ignore just carboxylic acid Do not award hydroxide / OH^-	**(1)**

Question Number	Answer	Additional guidance	Mark
2(c)	An answer that makes reference to the following points: • round-bottom / pear shaped flask **and** still head **and** thermometer (1) • (downward-sloping) Liebig condenser with inner tube **and** labelled water flow (1) • heat **and** unsealed collection vessel **and** left hand side of apparatus sealed (1)	Example of diagram:  Allow any form of heating Allow fractionating column (in place of still head) Allow omission of flask contents Do not award M1 for a one-piece apparatus Do not award M1 if thermometer bulb is in the liquid	**(3)**

Question Number	Answer	Additional guidance	Mark
2(d)	An explanation that makes reference to the following points: • (broad) peak at 3220 cm^{-1} **and** (indicates an) O–H (in a carboxylic acid) (1) • peak at 1720 cm^{-1} **and** (indicates) C=O (1)	Allow identification of peaks and bonds on annotated spectrum Allow any wavenumber or range of values within 3300–2500 Allow OH / –OH for O–H Do not award O–H in alcohol Ignore C–H Allow any wavenumber or range of values within 1740–1680 Ignore aldehyde / ketone Do not award C=C If no other mark awarded, award 1 mark if both peaks / ranges given but bonds missing Comment Allow transmittance for absorbance Ignore any reference to the fingerprint region	**(2)**

Question Number	Answer	Additional guidance	Mark
2(e)(i)	An answer that makes reference to the following points: • molecular (ion) / $M^{(+)}$ peak at *m* / *z* = **88** **and** (relative molecular mass of) $C_3H_4O_3$ is 88	Allow peak to the far right / with the highest *m* / *z* is **88** Allow any indication of $M^{(+)}$ peak being **88** Ignore just peak at *m* / *z* is 88	**(1)**

Question Number	Answer	Additional guidance	Mark
2(e)(ii)	An answer that makes reference to the following point: • CH_3CO^+	Accept displayed/skeletal formula with charge Allow any position of charge, eg $^+CH_3CO$ Allow CH_2CHO^+ / CH_2COH^+ / $HC{=}CH(OH)^+$ / $CH_2{=}C(OH)^+$ Ignore just $C_2H_3O^+$ Do not award $C_3H_7^+$	**(1)**

Question Number	Answer	Additional guidance	Mark
2(f)	An answer that makes reference to the following points: • structure of **X** (1) • structure of **Y** (1)	Accept structural, displayed or skeletal formula or any correct combination of these If more than one type of formula given, all must be correct Ignore connectivity of vertical OH Penalise horizontal C–HO connectivity once only Ignore names even if incorrect Example of structure: $CH_3CH(OH)CH_2OH$ Example of structure: $CH_3COCOOH$ Allow $CH_2{=}C(OH)COOH$	**(2)**

(Total for Question 2 = 17 marks)

Question Number	Answer	Additional guidance	Mark
3(a)(i)	An answer that makes reference to the following points: • correct species **and** balancing **and** state symbols	Example of equation: $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ Ignore full equation as working Do not award uncancelled spectator ions	**(1)**

Question Number	Answer	Additional guidance	Mark
3(a)(ii)	An answer that makes reference to the following point: • (to remove) barium ions / Ba^{2+} (that would otherwise) form a precipitate with chromate((VI)) ions / CrO_4^{2-}	Allow to stop formation of barium chromate((VI)) / $BaCrO_4$ Allow to stop $Ba^{2+} + CrO_4^{2-} \rightarrow BaCrO_4$ Allow to stop barium ions reacting with the indicator / chromate((VI)) ions / CrO_4^{2-} Allow would otherwise make the end-point hard to determine	**(1)**

Question Number	Answer	Additional guidance	Mark
3(b)	An answer that makes reference to the following point: • silver chloride is (much) less soluble (than silver chromate((VI)))	Accept solubility product / K_{sp} of silver chloride is (much) smaller than that of silver chromate((VI)) Allow reverse arguments Ignore chloride ions are more reactive than chromate ions Ignore reaction with chloride ions is faster	**(1)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr>
<td>3(c)(i)</td>
<td>An answer that makes reference to the following points:

• three values correctly recorded in table (1)

• calculation of mean titre to 2DP from concordant results (1)</td>
<td>Example of completed table and calculation:
<table>
<tr><td>Titration number</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>Burette reading (final) / cm^3</td><td>16.15</td><td>32.05</td><td>48.30</td><td>47.40</td></tr>
<tr><td>Burette reading (initial) / cm^3</td><td>0.00</td><td>16.15</td><td>32.50</td><td>31.55</td></tr>
<tr><td>Titre / cm^3</td><td>16.15</td><td>15.9(0)</td><td>15.8(0)</td><td>15.85</td></tr>
</table>

mean titre = $\frac{(15.9(0) + 15.8(0) + 15.85)}{3}$
= 15.85 (cm^3)
TE on averaging of concordant results from incorrect subtraction in table

Do not award 15.85 from (15.90 + 15.80) ÷ 2</td>
<td>(2)</td>
</tr>
</table>

Question Number	Answer	Additional guidance	Mark
3(c)(ii)	An answer that makes reference to the following points: **Method 1** **First three marks:** • mols Ag^+ in mean titre (1) • mols Ba^{2+} in 10.0 cm^3 **or** mols Cl^- in 250 cm^3 (1) • mols Ba^{2+} in 250 cm^3 (1)	Example of calculation: Ignore SF except 1 SF throughout Allow truncation of mass and mols in intermediate working, eg 0.000513 for 0.0005135 mols Ag^+ = 0.0324 × 15.85 ÷ 1000 = 0.00051354 / 5.1354×10^{-4} TE on mean titre from (c)(i) mols Ba^{2+} in 10.0 cm^3 = 0.00051354 ÷ 2 = 0.00025677 / 2.5677×10^{-4} **or** mols Cl^- in 250.0 cm^3 = 0.00051354 × 250 ÷ 10.0 = 0.0128385 / 1.28385×10^{-2} TE on mols Ag^+ mols Ba^{2+} in 250 cm^3 = 0.00025677 × 250 ÷ 10.0 = 0.0064193 / 6.4193×10^{-3} **or** (from mols Cl^-) = 0.0128385 ÷ 2 = 0.0064193 / 6.4193×10^{-3} TE on mols Ba^{2+} in 10.0 cm^3 / mols Cl^- in 250.0 cm^3	**(5)**

	Final two marks: • molar mass $BaCl_2.\mathbf{x}H_2O$ (1)	 molar mass $BaCl_2.\mathbf{x}H_2O$ = 1.57 ÷ 0.0064193 = 244.58 (g mol^{-1}) TE on mols Ba^{2+} in 250 cm^3	
	• molar mass of $\mathbf{x}H_2O$ **and** value of **x** (1)	molar mass of $\mathbf{x}H_2O$ = 244.58 – 208.3 = 36.277 (g mol^{-1}) **and** value of **x** = 36.277 ÷ 18.0 = 2(.0154) (so formula is $BaCl_2.2H_2O$) TE on molar mass $BaCl_2.\mathbf{x}H_2O$	
	or		
	• mass H_2O in hydrated salt (1)	mass H_2O = 1.57 – (0.0064193 × 208.3) = 0.23287 (g) TE on mols Ba^{2+} in 250 cm^3	
	• mols H_2O in hydrated salt **and** value of **x** (1)	mols H_2O = 0.23287 ÷ 18.0 = 0.012937 (mol) **and** value of **x** = 0.012937 ÷ 0.0064193 = 2(.0154) (so formula is $BaCl_2.2H_2O$) Accept 1 SF TE on mass H_2O in hydrated salt	

	Method 2 **First three marks:** • mass $BaCl_2.\mathbf{x}H_2O$ in 10.0 cm^3 (1)	mass $BaCl_2.\mathbf{x}H_2O$ in 10.0 cm^3 = 1.57 × (10.0 ÷ 250.0) = 0.0628 (g)	
	• mols Ag^+ in mean titre (1)	mols Ag^+ = 0.0324 × 15.85 ÷ 1000 = 0.00051354 / 5.1354×10^{-4} TE on mean titre from (c)(i)	
	• mols Ba^{2+} in 10.0 cm^3 (1)	mols Ba^{2+} in 10.0 cm^3 = 0.00051354 ÷ 2 = 0.00025677 / 2.5677×10^{-4} TE on mols Ag^+	
	Final two marks: • molar mass $BaCl_2.\mathbf{x}H_2O$ (1)	molar mass $BaCl_2.\mathbf{x}H_2O$ = 0.0628 ÷ 0.00025677 = 244.58 (g mol^{-1}) TE on mass $BaCl_2.\mathbf{x}H_2O$ in 10.0 cm^3 TE on mols Ba^{2+} in 10.0 cm^3	
	• molar mass of $\mathbf{x}H_2O$ **and** value of **x** (1)	molar mass of $\mathbf{x}H_2O$ = 244.58 – 208.3 = 36.277 (g mol^{-1}) **and** value of **x** = 36.277 ÷ 18.0 = 2(.0154) (so formula is $BaCl_2.2H_2O$) Accept 1 SF TE on molar mass $BaCl_2.\mathbf{x}H_2O$	

	or • mass H_2O in 10.0 cm^3 hydrated salt (1) • mols H_2O in hydrated salt **and** value of **x** (1)	mass H_2O = 0.0628 – (0.00025677 × 208.3) = 0.0093148 (g) TE on mols Ba^{2+} in 10.0 cm^3 mols H_2O = 0.0093148 ÷ 18.0 = 0.00051749 (mol) **and** value of **x** = 0.00051749 ÷ 0.00025677 = 2(.0154) (so formula is $BaCl_2.2H_2O$) Accept 1 SF TE on mass H_2O in 10.0 cm^3 hydrated salt Just **x** = 2 with no working scores (0)	

(Total for Question 3 = 10 marks)

Question Number	Answer	Additional guidance	Mark
4(a)(i)	An explanation that makes reference to the following points: • to absorb / remove water (1) • (as water) would otherwise react with aluminium chloride / the product (1)	Allow to absorb / remove moisture Allow drying agent / to dry the gas Ignore absorption of any other chemical, eg HCl Do not award dehydrating agent **M2 dependent on some mention of water / steam / drying** Allow (water) reacts with aluminium Allow (reaction with water) would decrease the yield Do not award any reference to rusting / corrosion	**(2)**

Question Number	Answer	Additional guidance	Mark
4(a)(ii)	An answer that makes reference to the following point: • to enable gases / chlorine / Cl_2 to pass through (easily)	Accept reverse argument Allow to prevent build-up of pressure / blocking tube Ignore granules stay in position / powder moves Do not award references to surface area / rate	**(1)**

Question Number	Answer	Additional guidance	Mark
4(b)(i)	An answer that makes reference to the following points: • toxic / poisonous (1) • (perform experiment in a) fume cupboard (1)	**Mark M1 and M2 separately** Ignore irritant / harmful / dangerous / corrosive / health hazard Do not award flammable Allow fume box / fume hood Ignore wear a gas mask Ignore use smaller amounts Ignore wear safety goggles / gloves	**(2)**

Question Number	Answer	Additional guidance	Mark
4(b)(ii)	An answer that makes reference to the following point: • to provide a steady stream of chlorine / gas **or** to prevent chlorine / gas being produced too quickly	Accept reverse arguments Allow to control the rate of reaction / production of chlorine Allow so that the reaction is slow / not too fast Allow to prevent vigorous reaction Ignore to prevent violent reaction / explosion / breaking flask Ignore build-up of pressure Ignore to prevent (acid) spray / boiling over Ignore exothermic reaction Ignore to ensure complete reaction Do not award any gas other than chlorine	**(1)**

Question Number	Answer	Additional guidance	Mark
4(c)	An answer that makes reference to one of the following: • to allow chlorine to displace air from the apparatus **or** to prevent oxygen reacting with the aluminium **or** to prevent the formation of aluminium oxide	Allow to fill the apparatus with chlorine (gas) Allow to remove all air from the apparatus Ignore so that the chlorine reaches the aluminium first Allow to prevent air from reacting with the aluminium Allow so only chlorine reacts with the aluminium	**(1)**

Question Number	Answer	Additional guidance	Mark
4(d)	An answer that makes reference to the following point: • (when the aluminium) stops glowing	Allow when all the aluminium / solid has turned white Allow when no more aluminium foil remains Ignore when aluminium foil is not as bright / starts to dim Ignore just when no further change is seen Ignore when no more product collects in the receiver bottle Ignore just when all reactants are used up Ignore any reference to mass of reactants / products	**(1)**

Question Number	Answer	Additional guidance	Mark
4(e)	An answer that makes reference to the following point: • to absorb (unreacted) chlorine / hydrogen chloride (gas)	Allow react with / remove / neutralise for absorb Allow to absorb acidic gases Allow to exclude water (from the air) Ignore to absorb hydrochloric acid Ignore just to absorb acid Ignore just to absorb excess gas Ignore to limit escape of toxic / harmful / dangerous gas Do not award to absorb carbon dioxide	**(1)**

(Total for Question 4 = 9 marks)

TOTAL FOR PAPER = 50 MARKS

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