1(a). Matt finds out some information about the bonding in some compounds and the ions that they produce when they dissolve in water.
He dissolves the compounds in water and tests their pH values.

The table shows his results.

Compound	Bonding in compound	When dissolved in water		
		Positive ion	Negative ion	pH
sodium hydroxide	ionic	sodium	hydroxide	14
calcium bromide	ionic	calcium	bromide	7
ammonia	covalent	ammonium	hydroxide	9
hydrogen chloride	covalent	hydrogen	chloride	1
ethanoic acid	covalent	hydrogen	ethanoate	3
calcium hydroxide	ionic	calcium	hydroxide	12
citric acid	covalent	hydrogen	citrate	3

Which compounds in the table are acidic?
Put a tick (?) in the boxes next to each correct answer.

sodium hydroxide ☐

calcium bromide ☐

ammonia ☐

hydrogen chloride ☐

ethanoic acid ☐

calcium hydroxide ☐

citric acid ☐

[1]

(b). Matt looks at the information and puts forward this idea.

I can identify the alkalis from their pH values. I think all alkalis are ionic and one of the ions they produce is always the same.

Does the data support Matt's ideas?

Explain your reasoning.

---

[2]

(c). Draw straight lines to show the state of pure ethanoic acid and pure citric acid at room temperature.

ethanoic acid	solid
citric acid	liquid
	gas

[2]

2. A scientist works in a quality control laboratory for a chemical company.

The company makes acids for use in cleaning products.

The scientist tests some samples of another four dilute acids, **C**, **D**, **E** and **F**.

He uses the same volume of dilute acid each time.

He measures the pH and does titrations using sodium hydroxide solution.

He uses the same concentration of sodium hydroxide solution in each titration.

His results are shown in the table below.

Acid	pH	Mean volume of sodium hydroxide solution used in titration (cm^3)
C	5	12.0
D	1	18.5
E	4	25.0
F	1	12.0

The scientist looks at his results.

He wants to know whether each acid is a strong acid or a weak acid.

He wants to compare the concentrations of the acids.

What conclusions can you make from the results about the **strength** and **concentration** of each of the four acids, **C**, **D**, **E** and **F**?

The quality of written communication will be assessed in your answer.

---

[6]

3. Sodium hydroxide and sodium carbonate both neutralise acids to make salts.

Name the salts made when the following neutralisation reactions take place.

Acid	Alkali	Salt
sulfuric acid	sodium hydroxide	
nitric acid	sodium carbonate	

[2]

4. The acid in vinegar reacts with sodium hydroxide.

In the reaction, **hydrogen** ions react with **hydroxide ions**.

Complete the equation for this reaction by filling in the boxes.

Choose formulae from the list.

H_2 H^+ H_2^+ O^- OH^- H_2O O_2

[ ] + [ ] → [ ]

[2]

5. Alex adds dilute hydrochloric acid to solid calcium carbonate.

He sees that the reaction makes bubbles of gas.

Complete the word and symbol equations for the reaction by filling in the boxes.

calcium carbonate + hydrochloric acid → ☐ + ☐ + ☐

☐ + $2HCl$ → $CaCl_2$ + ☐ + ☐

[3]

6. Fred investigates the acid CH_3COOH.

(i) Which part of the formula shows you that CH_3COOH is a carboxylic acid?

Put a ring around the correct answer.

CH_3 CO OH COOH

[1]

(ii) The acid is a weak acid. What does this mean?

Put a tick (✓) in the box next to the correct answer.

Its formula contains carbon, hydrogen and oxygen. ☐

It is more dilute than acids such as hydrochloric acid. ☐

It is less reactive than acids such as hydrochloric acid. ☐

It is more runny than acids such as hydrochloric acid. ☐

[1]

(iii) Fred compares solutions of this weak acid with a strong acid of the same concentration.

How do the pH values of the two solutions compare?

Put a tick (✓) in the box next to the correct answer.

The weak acid has a higher pH. ☐

The weak acid has the same pH. ☐

The weak acid has a lower pH.

The weak acid has a much lower pH.

[1]

7(a). Acid rain contains a dilute solution of sulfuric acid.

Acid rain causes some lakes to become too acidic, killing fish and other wildlife.

Water companies can treat the lakes with calcium hydroxide to neutralise acidity.

Which ion causes the acidity in the lake?

Put a ring around the correct answer.

SO_4^{2-} H^+ OH^- O^{2-} SO_3^{2-}

[1]

(b). Which ion in calcium hydroxide reacts to neutralise the acidity in the lake?

Put a ring around the correct answer.

Ca^{2+} H^+ OH^- O^{2-} H^-

[1]

8(a). Eve has two beakers of dilute acid.

One contains dilute hydrochloric acid, one contains dilute sulfuric acid.

Complete the boxes to show which ions are in each acid.

Choose from this list. You may use each symbol once, more than once or not at all.

H_2 H^+ OH^- Cl^- ClO^- S^{2-} SO_4^{2-}

ions in dilute hydrochloric acid	ions in dilute sulfuric acid

[2]

(b). Eve does tests **A**, **B**, **C** and **D** on each acid .

1 test pH using a pH meter
2 add magnesium ribbon
3 add a few drops of dilute silver nitrate (see data sheet page 2)
4 add a few drops of dilute barium chloride (see data sheet page 2)

(i) Two tests give the **same** result with both hydrochloric acid and sulfuric acid.

Which two tests give the same result?

What will she **see** when she does each of these tests?

test _____

result _____

---

test _____

result _____

_____

[3]

(ii) Two tests give a **different** result with hydrochloric acid and sulfuric acid.

Which two tests give a different result?

What will she **see** when she does each test?

test _____

result for each acid _____

_____

test _____

result for each acid _____

_____

[3]

(c). Both dilute hydrochloric acid and dilute sulfuric acid are neutralised when they react with dilute sodium hydroxide.

Complete the table to show the name and formula of the salt that is made from each acid.

Acid	Salt formed with dilute sodium hydroxide	
	Name	Formula
dilute hydrochloric acid		
dilute sulfuric acid		

[2]

9. What is the name of the salt that is made when zinc reacts with hydrochloric acid?

_____ [1]

10.

Sulfuric acid is used in car batteries.

Mia has a sample of car battery acid that is diluted to $\frac{1}{100}$ of its original concentration.

She measures the concentration of this acid by titration.

This equation shows what happens when pure sulfuric acid is mixed with water.

$H_2SO_4(l) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

Explain how this equation shows that sulfuric acid is a **strong** acid.

---

[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		Sodium hydroxide ☐ Calcium bromide ☐ Ammonia ☐ hydrogen chloride √ ethanoic acid √ calcium hydroxide ☐ citric acid √	1	Need all three (1) **Examiner's Comments** Most know which substances in the list were acidic.
	b		all (solutions of) alkalis have pH greater than 7 / all alkalis produce hydroxide ions (in solution); (dry) ammonia is covalent;	2	**Ignore** 'yes' or 'no', look at explanations **Accept** 'ammonia is not ionic' **Examiner's Comments** The main issue that caused candidates difficulties was that many thought that calcium bromide was an alkali. This led them to incorrectly answer that alkalis have a pH of '7 and over'. However, many correctly stated that ammonia is a covalently bonded alkali, whereas the others are ionic.
	c		☐ ethanoic acid ☐ citric acid solid liquid gas	2	**Examiner's Comments** The states of ethanoic and citric acid were not generally known. Few thought that either of them were solid.
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
2			[Level 3] Both strength and concentration correct for most of the acids. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Both strength **and** concentration correct for **some** of the acids. **OR** Makes correct statements about concentration for **most** acids **or** strength for **most** acids. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Makes correct statements about concentration **OR** strength for **some** acids; Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] **Insufficient** or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A* Indicative scientific points may include: Level 3 indicative points • Acid C is a weak acid AND has a low concentration. • Acid D is a strong acid and more concentrated than C • Acid E is a weak acid and high in concentration • Acid F is a strong acid AND has a low concentration. • Accept comments about dibasic acids Concentration • Acid C and acid F have the lowest concentration. • Acid C and acid F have the same concentration • Acid E has the highest concentration. • Acid D is more concentrated than C or F • Acid D is less concentrated than acid E Strength • Acid D is a strong acid • Acid F is a strong acid • Acid C is a weak acid • Acid E is a weak acid • Acid C is the weakest acid • Acid D and F are the strongest acids • Acid E is stronger than acid C Statements such as “Acid C&F have ***lowest*** concentration” OR “Acid D and F are the ***strongest*** acids” qualify as statements about MOST of the acids. If reasoning faulty, give the lower mark of the level Use the L1, L2, L3 annotations in RM Assessor; do not use ticks. Examiner's Comments

Question			Answer/Indicative content	Marks	Guidance
					The most able candidates showed an easy understanding of the relationship between acid strength and pH, and of concentration and the amount of sodium hydroxide used in a titration. Others had great difficulty in coping with the idea that an acid could be both strong *and* dilute, or weak *and* concentrated, and tried to combine them in some way. Answers such as "D and F are both strong acids because they have a pH of 1, but D is the stronger of the two because it uses more sodium hydroxide" were not uncommon. This question also exposed other misunderstandings. Many candidates suggested that the smaller the amount of alkali used, the *more* concentrated the acid would be. Also, and unsurprisingly, many felt that low pH numbers indicated weak acidity. In several cases examiners suspected that candidates understood the material, but that the candidates' expression was ambiguous to the point where examiners were not able to award the mark with confidence. This question asked candidates to differentiate between two very specific terms: acid strength and acid concentration. This meant that examiners had to focus carefully on the precise words that candidates used. A lack of precision in answering let some candidates down here, since very general statements such as 'it was the most/least acidic' were inadequate in this context – and had to be ignored.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
3			sodium sulfate (1) sodium nitrate (1)	2	**allow** correct formulae Na2SO4 NaNO3 **allow** sodium sulphate do not allow any other answers if name and formula given mark name only **Examiner's Comments** The majority of candidates had little idea of how to work out the names of these two salts. A wide variety of incorrect suggestions were made; common errors including nitric hydroxide, carbon nitrate, carbon sulphate sulfuric hydroxide and nitric carbonate. More able candidates fared better, with many gaining both marks.
			Total	2	
4			$H^+ + OH^-$ (1) ? H_2O (1)	2	**ignore** state symbols **Examiner's Comments** Most candidates knew water was formed. Fewer selected the correct ions for the left hand side of the equation. Sometimes careless errors in copying the formulae cost candidates marks.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
5			$CaCO_3$ (1) Calcium chloride (1) Correct formula and names: Carbon dioxide + water $CO_2 + H_2O$ (1)	3	If extra numbers are added to incorrectly balance the equation, **maximum of 2 marks** can be awarded. Formula must be unambiguous and fully correct with subscripts used correctly. Do not allow CO^2 etc. O in CO_2 must be at least half the size of C i.e. not Co_2 **Examiner's Comments** A full range of achievement was seen for this equation completion. Most candidates correctly gave the name of calcium chloride. Most knew that carbon dioxide was a product, but hydrogen was commonly given as the second blank product. The formula for calcium carbonate was less well known. CaC2 and CaCO2 were common incorrect answers. Some candidates lost marks for poorly writing the formulae of carbon dioxide and water. Answers such as Co2, H2o, h2o and CO2 were not given credit.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
6		i	COOH	1	**Examiner's Comments** Almost all candidates realised that the carboxylic acid group is –COOH.
		ii	its formula contains carbon, hydrogen and oxygen ☐ it is more dilute than acids such as hydrochloric ☐ it is less reactive than acids such as hydrochloric ✓ it is more runny than acids such as hydrochloric ☐	1	**Examiner's Comments** The majority of candidates knew that weak acids are less reactive than strong acids. The most common mistake was to suggest that weak acids are more dilute than strong acids.
		iii	a weak acid has a higher pH ✓ a weak acid has the same pH ☐ a weak acid has a lower pH ☐ a weak acid has a much lower pH ☐	1	**Examiner's Comments** Most candidates knew that weak acids have a higher pH than strong acids. The most common misconception was, unsurprisingly, that they have a lower pH.
			Total	**3**	
7	a		H^+	1	Examiner's Comments About a third of candidates knew that H^+ ions cause acidity.
	b		$OH^?$	1	Examiner's Comments About a third of candidates knew that OH^- ions neutralise acidity. These statistics imply that the ions in acids and alkalis are not well known by candidates.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
8	a		hydrochloric acid: H^+ and $Cl^?$ (1) sulfuric acid: H^+ and $SO_4^{2?}$ (1)	2	**ignore** $OH^?$ / HCl (in LHS box) / H_2SO_4 (in RHS box) **Examiner's Comments** About half of the candidate gained some marks. Usually, this was for correctly selecting the ions in hydrochloric acid. Common incorrect selections for sulphuric acid included H_2 and $S^{2?}$.
	b	i	Test A and B; (1) (both) give a low value for pH / pH below 7; (1) (both) react with magnesium ribbon / ribbon 'disappears' / fizz / see a gas; (1)	3	**Accept** 'hydrogen forms' **Examiner's Comments** Both parts were poorly answered. Candidates did not seem to know that the pH of all acids are similar or that they would both react with magnesium. Those who did select the correct tests in the correct places usually gained all three marks.
		ii	(Test C and D) because (test C silver nitrate) white precipitate (with HCl or chloride); (1) (test D barium chloride) white precipitate (with H_2SO_4 or sulfate); (1) no precipitate with 'other' acid stated for at least one of the tests / use of the word 'only'; (1)	3	e.g. 'test C gives white ppt with HCl only' = (2) **Examiner's Comments** For correctly describing the changes they would see. However, over 75% of candidates failed to score in both question parts.

Question			Answer/Indicative content	Marks	Guidance
	c		sodium chloride AND NaCl; sodium sulfate AND Na_2SO_4;	2	**Allow** (1) if both names correct OR if both formulae are correct **Examiner's Comments** Most candidates gained one mark, either for giving the correct name and formula for sodium chloride or for naming both salts correctly. The formula for sodium sulfate was less well known.
			Total	10	
9			zinc chloride	1	**Allow** $ZnCl_2$ **Ignore** incorrect formula if name is correct. **Allow** zinc chloride and hydrogen (1) **Do not allow** if other incorrect additional products are named. **Examiner's Comments** Almost all correctly identified zinc chloride.
			Total	1	
10			(The arrow shows that) the acid is fully dissociated/ionised / the reaction goes to completion AW / there is no equilibrium sign ✓	1 (AO 1.1)	Examiner's Comments Some candidates recognised the importance of complete dissociation linked to acid strength. The word 'strong' was misinterpreted, with many candidates focussing on the idea that sulfuric acid is dibasic and so produces more hydrogen ions per molecule.
			Total	1	