

Contents

	<i>Page no.</i>
C6 Chemical synthesis – Foundation Workbook answers	C6-F2
C6 Chemical synthesis – Higher Workbook answers	C6-F6

C6 Chemical synthesis – Foundation Workbook answers

1	a	Crude oil																							
	b	Examples from C2, e.g. ethene																							
	c	Any kind of pesticide (see C3): insecticide, herbicide, fungicide																							
	d	These products made with fine/speciality chemicals have much higher value than products from bulk chemicals.																							
	e	Nitrogen N ₂ , oxygen O ₂ , hydrogen H ₂																							
	f	10.4% 24.9% (100 – 10.4 – 37.7 – 27.0)																							
2	a	<table border="1"> <thead> <tr> <th>Name of acidic compound</th> <th>Formula of acidic compound</th> <th>State of the pure compound at room temperature</th> </tr> </thead> <tbody> <tr> <td>citric acid</td> <td>C₆H₈O₇</td> <td>solid</td> </tr> <tr> <td>tartaric acid</td> <td>C₄H₆O₆</td> <td>solid</td> </tr> <tr> <td>sulfuric acid</td> <td>H₂SO₄</td> <td>liquid</td> </tr> <tr> <td>nitric acid</td> <td>HNO₃</td> <td>liquid</td> </tr> <tr> <td>ethanoic acid</td> <td>CH₃COOH</td> <td>liquid</td> </tr> <tr> <td>hydrogen chloride</td> <td>HCl</td> <td>gas</td> </tr> </tbody> </table>			Name of acidic compound	Formula of acidic compound	State of the pure compound at room temperature	citric acid	C ₆ H ₈ O ₇	solid	tartaric acid	C ₄ H ₆ O ₆	solid	sulfuric acid	H ₂ SO ₄	liquid	nitric acid	HNO ₃	liquid	ethanoic acid	CH ₃ COOH	liquid	hydrogen chloride	HCl	gas
Name of acidic compound	Formula of acidic compound	State of the pure compound at room temperature																							
citric acid	C ₆ H ₈ O ₇	solid																							
tartaric acid	C ₄ H ₆ O ₆	solid																							
sulfuric acid	H ₂ SO ₄	liquid																							
nitric acid	HNO ₃	liquid																							
ethanoic acid	CH ₃ COOH	liquid																							
hydrogen chloride	HCl	gas																							
	b	<table border="1"> <thead> <tr> <th>Name of alkaline compound</th> <th>Formula of alkaline compound</th> <th>State of the pure compound at room temperature</th> </tr> </thead> <tbody> <tr> <td>sodium hydroxide</td> <td>NaOH</td> <td>solid</td> </tr> <tr> <td>potassium hydroxide</td> <td>KOH</td> <td>solid</td> </tr> <tr> <td>calcium hydroxide</td> <td>Ca(OH)₂</td> <td>solid</td> </tr> </tbody> </table>			Name of alkaline compound	Formula of alkaline compound	State of the pure compound at room temperature	sodium hydroxide	NaOH	solid	potassium hydroxide	KOH	solid	calcium hydroxide	Ca(OH) ₂	solid									
Name of alkaline compound	Formula of alkaline compound	State of the pure compound at room temperature																							
sodium hydroxide	NaOH	solid																							
potassium hydroxide	KOH	solid																							
calcium hydroxide	Ca(OH) ₂	solid																							
	c	<ul style="list-style-type: none"> • Pure water – pH 7 • Dilute hydrochloric acid – pH 1 • Dilute sodium hydroxide solution – pH 14 • Vinegar – pH 3 • Limewater – pH 12 																							

Further guidance

3		Name of chemical	Formula of chemical	Type of chemical
		chlorine	Cl ₂	non-metal element
		calcium carbonate	CaCO ₃	metal carbonate, salt
		calcium chloride	CaCl ₂	salt
		copper	Cu	metal element
		hydrogen gas	H ₂	non-metal element
		hydrochloric acid	HCl(aq)	acid
		magnesium	Mg	metal element
		magnesium carbonate	MgCO ₃	metal carbonate, salt
		magnesium oxide	MgO	metal oxide
		magnesium hydroxide	Mg(OH) ₂	metal hydroxide, alkali
		magnesium sulfate	MgSO ₄	salt
		nitric acid	HNO ₃	acid
		nitrogen gas	N ₂	non-metal element
		oxygen	O ₂	non-metal element
		potassium chloride	KCl	salt
		sodium carbonate	Na ₂ CO ₃	metal carbonate, salt
		sodium chloride	NaCl	salt
	sodium hydroxide	NaOH	metal hydroxide, alkali	
	sulfuric acid	H ₂ SO ₄	acid	
4	a	acid + metal → salt + hydrogen hydrochloric acid + magnesium → magnesium chloride + hydrogen $2\text{HCl(aq)} + \text{Mg(s)} \rightarrow \text{MgCl}_2\text{(s)} + \text{H}_2\text{(g)}$		
	b	acid + metal oxide → salt + water sulfuric acid + copper oxide → copper sulfate + water $\text{H}_2\text{SO}_4\text{(aq)} + \text{CuO(s)} \rightarrow \text{CuSO}_4\text{(aq)} + \text{H}_2\text{O(l)}$		
	c	acid + metal carbonate → salt + carbon dioxide + water hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water $2\text{HCl(aq)} + \text{CaCO}_3\text{(s)} \rightarrow \text{CaCl}_2\text{(aq)} + \text{CO}_2\text{(g)} + \text{H}_2\text{O(l)}$		
5	a	Correctly labelled diagram		

Further guidance

	b	$T = 22.40 - 3.30 = 19.10 \text{ cm}^3$ purity = $19.10 \times 0.025 \times 100 / 0.48 = 99.5\%$
	c	Citric acid is used in foods and medicines, so it is important that possibly harmful impurities are not added along with the citric acid.
6	a	<ul style="list-style-type: none"> The top curve is for smaller chips, and the bottom curve is for larger chips. For both curves, the reaction is fastest at the start of the reaction. The reaction with smaller chips starts to slow down after about 100 seconds, and with larger chips after about 200 seconds. The reaction stops when the curves level off to horizontal, at about 500 seconds.
	b	Marble chips are calcium carbonate, and give off carbon dioxide gas when reacted with acid. This gas escapes from the flask, reducing the final weight of the flask and its contents.
	c	The same amount of reactants were used in both reactions so, regardless of the rate of reaction, the same mass of product will be formed and the same amount of carbon dioxide gas will be given off.
	d	Smaller chips have a larger surface area available to react with the acid than the same mass of larger chips, so the reaction is faster.
7	a	Solid sulfur is produced in the reaction, which is suspended in the solution (as a precipitate) and makes the solution cloudy.
	b	To make a fair comparison of the rates of reaction with different concentrations of thiosulfate solution (any differences cannot be due to the concentration of the acid).
	c	The more concentrated the thiosulfate solution, the less time it takes for the cross to be hidden, so the faster the reaction.
8		Correctly plotted graph. As temperature increases, the time taken for the cross to disappear decreases. This means that the higher the temperature, the faster the reaction.
9		<ul style="list-style-type: none"> Halving the concentration of the acid – slower rate of reaction at the start, half the volume of gas produced when the reaction stops. The curve on the graph is below the printed curve, with a less steep gradient at the start and levelling off to half the volume. Carrying out the reaction at 30°C – faster rate of reaction at the start, no effect on the overall volume of gas produced. The curve starts off steeper than the printed curve, but levels off at the same volume. Using the same mass of zinc but in larger pieces – slower rate of reaction at the start, but same overall amount of gas produced. The graph is less steep at the start but rises and levels off to the same level as the printed curve.
10	a	Milk going sour: change of temperature. Refrigerating the milk slows the reaction down. If you leave milk out on a warm day it goes sour quicker.
	b	Methane gas burning in the air: the reaction is so slow at room temperature that there is no reaction, heating the mixture of gases with a spark or flame starts the methane burning.
	c	Iron rusting: painting (and other means) reduces the surface area of iron in contact with air and water; this stops or slows the reaction

Further guidance

	d	Pollutants turning into less harmful chemicals in a car exhaust: this is speeded up with the use of a catalysts in a catalytic converter; the reactions only start when the converter has warmed up.
	e	Food breaking down during digestion: chewing breaks up the food and increases the surface area, digestive enzymes speed up the rate of reaction, these enzymes are most effective at body temperature.
	f	Calcium carbonate reacting with hydrochloric acid: concentration of the acid, surface area of the calcium carbonate and temperature affect the rate of reaction.
	g	Protein stains being removed from clothes during washing: biological washing powders have enzymes to speed up the reaction; these work best at optimum temperatures (if too hot, the enzymes are destroyed). For non-biological washing powders, the concentration of powder and temperature affect rate of reaction.
11	a	Correctly labelled diagram (the liquid in the beaker is dilute sulfuric acid, the powder on the spatula is magnesium oxide, the liquid being poured into the funnel is the filtrate, the residue in the filter paper is unreacted magnesium oxide, the liquid in the evaporating basin is a solution of salt, and the crystals formed in the evaporating basin are magnesium sulfate.)
	b	<ul style="list-style-type: none"> • Dilute sulfuric acid is heated as this will speed up the rate of reaction. • Magnesium oxide is added to the acid and the contents of the beaker stirred (to speed up the rate at which the magnesium oxide dissolves and reacts). Magnesium oxide is added in excess to ensure that all the acid is used up. • The solution is heated to the desired temperature (to speed up the reaction). • The resulting solution is filtered to separate unreacted (excess) magnesium oxide solid from the magnesium sulfate solution. • The filtrate is heated to evaporate off most of the water from the salt solution. • It is then heated gently over a water bath to evaporate off the remaining water and to leave behind magnesium sulfate crystals.
12	a	Zinc metal is more expensive as a starting material, because it has to be extracted from ore. Powdered zinc carbonate reacts very fast and the gas (carbon dioxide) makes a froth which may bubble out of the beaker.
	b	Adding the zinc oxide bit by bit to the acid until no more will dissolve. All the acid is used up when there is excess solid.
	c	<ul style="list-style-type: none"> • Warm 25 cm³ of dilute sulfuric acid in a beaker over a Bunsen flame. • Remove from the heat then add zinc oxide powder little by little with a spatula, stirring continuously with a rod until no more powder will dissolve.
	d	<ul style="list-style-type: none"> • Filter the solution into an evaporating dish to remove any unreacted zinc oxide. • Heat the solution over a Bunsen flame until most of the water has evaporated, then heat over a water bath to dry out the zinc sulfate crystals.
	e	Any traces of impurities may be harmful to the body.
13	a	<ul style="list-style-type: none"> • $\text{MgCO}_3 \rightarrow \text{MgO} + \text{CO}_2$ • % yield = $7.2 / 8.0 \times 100 = 90\%$ • For example: loss of chemicals as they are transferred from one container to another, not all the magnesium carbonate reacted, there were other by-products from impurities in the reactants.

Further guidance

	b	<ul style="list-style-type: none"> • $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ • To ensure that all the acid is used up in the reaction. • $\text{CaCO}_3 = 40 + 12 + (16 \times 3) = 100$ $\text{CaCl}_2 = 40 + (35.5 \times 2) = 111$ • $\% \text{ yield} = 9.9 / 1.1 \times 100 = 90\%$ • Any impurities could damage the patients kidneys or harm the patient in other ways.
14	a	<ul style="list-style-type: none"> • The salt formed when sodium hydroxide reacts with sulfuric acid – sodium sulfate • The salt formed when potassium hydroxide reacts with citric acid – potassium citrate • The acid which reacts with calcium hydroxide to form calcium nitrate – HNO_3 • The alkali which reacts with acetic acid to form sodium acetate – NaOH • A set of compounds that are alkalis in water – soluble metal hydroxides • The type of reaction that occurs when an acid and an alkali form a salt – neutralization
	b	<ul style="list-style-type: none"> • 25 cm^3 – because this is the point at which pH 7 was achieved (when the reaction occurred). • Colours on the graph: red up to about pH 3, orange for pH 4 and 5, yellow pH 6, green pH 7, blue-green pH 8 and 9, blue-purple pH 10 and above.
15	a	<p>Missing words and symbols:</p> <ul style="list-style-type: none"> • hydrogen, ions, $\text{H}^+(\text{aq})$ • sodium, hydroxide, $\text{OH}^-(\text{aq})$ • salt, $\text{K}^+(\text{aq})$, $\text{NO}_3^-(\text{aq})$, $\text{H}_2\text{O}(\text{l})$ • acid, alkali, molecules, $\text{H}_2\text{O}(\text{l})$
	b	<p>Missing words: sodium chloride</p> <p>Diagram completed by writing the symbols in the ions/atoms on the right: O, H and H in the atoms of the water molecules, Cl^- in the large circles and Na^+ in the small circles.</p>

C6 Chemical synthesis – Higher Workbook answers

1	a	Crude oil																					
	b	Examples from C2, e.g. ethene																					
	c	Any kind of pesticide (see C3): insecticide, herbicide, fungicide																					
	d	These products made with fine/speciality chemicals have much higher value than products from bulk chemicals.																					
	e	Nitrogen N ₂ , oxygen O ₂ , hydrogen H ₂																					
	f	10.4% 24.9% (100 – 10.4 – 37.7 – 27.0)																					
2	a	<table border="1"> <thead> <tr> <th>Name of acidic compound</th> <th>Formula of acidic compound</th> <th>State of the pure compound at room temperature</th> </tr> </thead> <tbody> <tr> <td>citric acid</td> <td>C₆H₈O₇</td> <td>solid</td> </tr> <tr> <td>tartaric acid</td> <td>C₄H₆O₆</td> <td>solid</td> </tr> <tr> <td>sulfuric acid</td> <td>H₂SO₄</td> <td>liquid</td> </tr> <tr> <td>nitric acid</td> <td>HNO₃</td> <td>liquid</td> </tr> <tr> <td>ethanoic acid</td> <td>CH₃COOH</td> <td>liquid</td> </tr> <tr> <td>hydrogen chloride</td> <td>HCl</td> <td>gas</td> </tr> </tbody> </table>	Name of acidic compound	Formula of acidic compound	State of the pure compound at room temperature	citric acid	C ₆ H ₈ O ₇	solid	tartaric acid	C ₄ H ₆ O ₆	solid	sulfuric acid	H ₂ SO ₄	liquid	nitric acid	HNO ₃	liquid	ethanoic acid	CH ₃ COOH	liquid	hydrogen chloride	HCl	gas
Name of acidic compound	Formula of acidic compound	State of the pure compound at room temperature																					
citric acid	C ₆ H ₈ O ₇	solid																					
tartaric acid	C ₄ H ₆ O ₆	solid																					
sulfuric acid	H ₂ SO ₄	liquid																					
nitric acid	HNO ₃	liquid																					
ethanoic acid	CH ₃ COOH	liquid																					
hydrogen chloride	HCl	gas																					
	b	<table border="1"> <thead> <tr> <th>Name of alkaline compound</th> <th>Formula of alkaline compound</th> <th>State of the pure compound at room temperature</th> </tr> </thead> <tbody> <tr> <td>sodium hydroxide</td> <td>NaOH</td> <td>solid</td> </tr> <tr> <td>potassium hydroxide</td> <td>KOH</td> <td>solid</td> </tr> <tr> <td>calcium hydroxide</td> <td>Ca(OH)₂</td> <td>solid</td> </tr> </tbody> </table>	Name of alkaline compound	Formula of alkaline compound	State of the pure compound at room temperature	sodium hydroxide	NaOH	solid	potassium hydroxide	KOH	solid	calcium hydroxide	Ca(OH) ₂	solid									
Name of alkaline compound	Formula of alkaline compound	State of the pure compound at room temperature																					
sodium hydroxide	NaOH	solid																					
potassium hydroxide	KOH	solid																					
calcium hydroxide	Ca(OH) ₂	solid																					
	c	<ul style="list-style-type: none"> • Pure water – pH 7 • Dilute hydrochloric acid – pH 1 • Dilute sodium hydroxide solution – pH 14 • Vinegar – pH 3 • Limewater – pH 12 																					
3	a	<p>acid + metal → salt + hydrogen</p> <p>hydrochloric acid + magnesium → magnesium chloride + hydrogen</p> $2\text{HCl}(\text{aq}) + \text{Mg}(\text{s}) \rightarrow \text{MgCl}_2(\text{s}) + \text{H}_2(\text{g})$																					

Further guidance

	b	acid + metal oxide → salt + water nitric acid + copper oxide → copper nitrate + water $\text{HNO}_3(\text{aq}) + \text{CuO}(\text{s}) \rightarrow \text{Cu}(\text{NO}_3)_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$																																																												
	c	acid + metal hydroxide → salt + water sulfuric acid + sodium hydroxide → sodium sulfate + water $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})$																																																												
	d	acid + metal carbonate → salt + carbon dioxide + water hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water $2\text{HCl}(\text{aq}) + \text{CaCO}_3(\text{s}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$																																																												
4	a	<table border="1"> <thead> <tr> <th colspan="3">Positive ions</th> <th colspan="3">Negative ions</th> </tr> <tr> <th>Ion</th> <th>charge</th> <th>symbol</th> <th>Ion</th> <th>charge</th> <th>symbol</th> </tr> </thead> <tbody> <tr> <td>lithium</td> <td>1+</td> <td>Li+</td> <td>chloride</td> <td>1-</td> <td>Cl-</td> </tr> <tr> <td>sodium</td> <td>1+</td> <td>Na+</td> <td>bromide</td> <td>1-</td> <td>Br-</td> </tr> <tr> <td>potassium</td> <td>1+</td> <td>K+</td> <td>iodide</td> <td>1-</td> <td>I-</td> </tr> <tr> <td>magnesium</td> <td>2+</td> <td>Mg²⁺</td> <td>nitrate</td> <td>1-</td> <td>NO₃⁻</td> </tr> <tr> <td>calcium</td> <td>2+</td> <td>Ca²⁺</td> <td>hydroxide</td> <td>1-</td> <td>OH-</td> </tr> <tr> <td>barium</td> <td>2+</td> <td>Ba²⁺</td> <td>oxide</td> <td>2-</td> <td>O²⁻</td> </tr> <tr> <td>aluminium</td> <td>3+</td> <td>Al³⁺</td> <td>carbonate</td> <td>2-</td> <td>CO₃²⁻</td> </tr> <tr> <td></td> <td></td> <td></td> <td>sulfate</td> <td>2-</td> <td>SO₄²⁻</td> </tr> </tbody> </table>	Positive ions			Negative ions			Ion	charge	symbol	Ion	charge	symbol	lithium	1+	Li+	chloride	1-	Cl-	sodium	1+	Na+	bromide	1-	Br-	potassium	1+	K+	iodide	1-	I-	magnesium	2+	Mg ²⁺	nitrate	1-	NO ₃ ⁻	calcium	2+	Ca ²⁺	hydroxide	1-	OH-	barium	2+	Ba ²⁺	oxide	2-	O ²⁻	aluminium	3+	Al ³⁺	carbonate	2-	CO ₃ ²⁻				sulfate	2-	SO ₄ ²⁻
Positive ions			Negative ions																																																											
Ion	charge	symbol	Ion	charge	symbol																																																									
lithium	1+	Li+	chloride	1-	Cl-																																																									
sodium	1+	Na+	bromide	1-	Br-																																																									
potassium	1+	K+	iodide	1-	I-																																																									
magnesium	2+	Mg ²⁺	nitrate	1-	NO ₃ ⁻																																																									
calcium	2+	Ca ²⁺	hydroxide	1-	OH-																																																									
barium	2+	Ba ²⁺	oxide	2-	O ²⁻																																																									
aluminium	3+	Al ³⁺	carbonate	2-	CO ₃ ²⁻																																																									
			sulfate	2-	SO ₄ ²⁻																																																									
	b	NaOH MgCO ₃ NaCl MgSO ₄ NaNO ₃ CaCO ₃ Na ₂ CO ₃ CaCl ₂ KCl CaI ₂ MgBr ₂ Ca(NO ₃) ₂ MgO Al ₂ O ₃ Mg(OH) ₂ AlCl ₃																																																												
	c	S ²⁻ , Sr ²⁺ , PO ₄ ³⁻																																																												
5	a	Correctly labelled diagram																																																												
	b	T = 22.40 – 3.30 = 19.10 cm ³ purity = 19.10 x 0.025 x 100 / 0.48 = 99.5%																																																												
	c	Citric acid is used in foods and medicines, so it is important that possibly harmful impurities are not added along with the citric acid.																																																												

Further guidance

6	a	<ul style="list-style-type: none"> The top curve is for smaller chips, and the bottom curve is for larger chips. For both curves, the reaction is fastest at the start of the reaction. The reaction with smaller chips starts to slow down after about 100 seconds, and with larger chips after about 200 seconds. The reaction stops when the curves level off to horizontal, at about 500 seconds. 												
	b	Marble chips are calcium carbonate, and give off carbon dioxide gas when reacted with acid. This gas escapes from the flask, reducing the final weight of the flask and its contents.												
	c	The same amount of reactants were used in both reactions so, regardless of the rate of reaction, the same mass of product will be formed and the same amount of carbon dioxide gas will be given off.												
	d	Smaller chips have a larger surface area available to react with the acid than the same mass of larger chips, so the reaction is faster.												
7	a	Solid sulfur is produced in the reaction, which is suspended in the solution (as a precipitate) and makes the solution cloudy.												
	b	To make a fair comparison of the rates of reaction with different concentrations of thiosulfate solution (any differences cannot be due to the concentration of the acid).												
	c	The more concentrated the thiosulfate solution, the less time it takes for the cross to be hidden, so the faster the reaction.												
8		<p>Note: Error in workbook. Table should be:</p> <table border="1"> <tbody> <tr> <td>Temperature (°C)</td> <td>20</td> <td>30</td> <td>40</td> <td>50</td> <td>60</td> </tr> <tr> <td>Time taken for the cross to disappear (s)</td> <td>280</td> <td>132</td> <td>59</td> <td>31</td> <td>17</td> </tr> </tbody> </table> <p>As temperature increases, the time taken for the cross to disappear decreases. This means that the higher the temperature, the faster the reaction.</p>	Temperature (°C)	20	30	40	50	60	Time taken for the cross to disappear (s)	280	132	59	31	17
Temperature (°C)	20	30	40	50	60									
Time taken for the cross to disappear (s)	280	132	59	31	17									
9		<ul style="list-style-type: none"> Halving the concentration of the acid – slower rate of reaction at the start, half the volume of gas produced when the reaction stops. The curve on the graph is below the printed curve, with a less steep gradient at the start and levelling off to half the volume. Carrying out the reaction at 30°C – faster rate of reaction at the start, no effect on the overall volume of gas produced. The curve starts off steeper than the printed curve, but levels off at the same volume. Using the same mass of zinc but in larger pieces – slower rate of reaction at the start, but same overall amount of gas produced. The graph is less steep at the start but rises and levels off to the same level as the printed curve. 												
10	a	Diagram completed with either a calibrated syringe attached to the open end of the glass tubing or a measuring cylinder full of water inverted in a trough of water. Labels to include: flask, bung, glass tubing, hydrogen peroxide and metal oxide mixture, syringe (or cylinder) to collect and measure oxygen gas												
	b	ZnO, CuO, MnO ₂ (least effective first)												
	c	So the results could be fairly compared												

Further guidance

	d	A chemical that speeds up a reaction without being used up in the process
11	a	Molecules (and ions) are in constant motion in gases and liquids. They can only react if they bump into other molecules (or ions), so that bonds (in the reactants) can be broken and new bonds formed (to make products). More collisions mean more reaction. Increasing surface area and concentration increase the number of collisions. Increasing the temperature speeds up the movement of molecules, so they will collide more often and with greater energy.
	b	<ul style="list-style-type: none"> Diagrams coloured as in textbook page 167. Molecules have a greater chance of colliding in a more concentrated solution. More collisions mean more reaction. Reactions get faster if the reactants are more concentrated.
12		<p>Correctly labelled diagram (the liquid in the beaker is dilute sulfuric acid, the powder on the spatula is magnesium oxide, the liquid being poured into the funnel is the filtrate, the residue in the filter paper is unreacted magnesium oxide, the liquid in the evaporating basin is a solution of salt, and the crystals formed in the evaporating basin are magnesium sulfate.)</p> <ul style="list-style-type: none"> Dilute sulfuric acid is heated as this will speed up the rate of reaction. Magnesium oxide is added to the acid and the contents of the beaker stirred (to speed up the rate at which the magnesium oxide dissolves and reacts). Magnesium oxide is added in excess to ensure that all the acid is used up. The solution is heated to the desired temperature (to speed up the reaction). The resulting solution is filtered to separate unreacted (excess) magnesium oxide solid from the magnesium sulfate solution. The filtrate is heated to evaporate off most of the water from the salt solution. It is then heated gently over a water bath to evaporate off the remaining water and to leave behind magnesium sulfate crystals.
13	a	You want a reaction that will work, where the reactants are easily obtainable, that will produce the product you want, and that you can easily separate and purify.
	b	This avoids wasting reactants and helps you produce exactly the quantity of product that you need. Sometimes the amount needed can be calculated from the equation. In other examples the amounts to use can be found by experiment as in exercise 12.
	c	This ensures the reaction runs smoothly and safely, that no reactants or products are lost.
	d	The product cannot be used if it is mixed with other chemicals.
	e	This removes unwanted by-products which might have undesirable effects when the product is used.
	f	This tells you how efficient your method is.
14	a	<p>Step 1: $\text{H}_2\text{SO}_4 + \text{MgO} \rightarrow \text{MgSO}_4 + \text{H}_2\text{O}$</p> <p>Steps 2, 3, 4: $98 \text{ g} + 40 \text{ g} \rightarrow 120 \text{ g} + 18 \text{ g}$</p> <p>Step 5: $4.0 \text{ g MgO} = 40/10 \text{ g}$ $120/10 \text{ g MgSO}_4 = 12.0 \text{ g}$ So the theoretical yield of $\text{MgSO}_4 = 12.0 \text{ g}$</p>
	b	$10.0/12.0 \times 100 = 83 \%$
	c	<p>$\text{ZnCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{CO}_2 + \text{H}_2\text{O}$</p> <p>125 g \rightarrow 161g</p> <p>9.2 g $\rightarrow 161/125 \times 9.2 = 11.8 \text{ g theoretical yield}$</p>

Further guidance

	d	Percentage yield = $11.4/11.8 \times 100 = 97\%$
15	a	<ul style="list-style-type: none"> • The salt formed when sodium hydroxide reacts with sulfuric acid – sodium sulfate • The salt formed when potassium hydroxide reacts with citric acid – potassium citrate • The acid which reacts with calcium hydroxide to form calcium nitrate – HNO₃ • The alkali which reacts with acetic acid to form sodium acetate – NaOH • A set of compounds that are alkalis in water – soluble metal hydroxides • The type of reaction that occurs when an acid and an alkali form a salt – neutralization
	b	<ul style="list-style-type: none"> • 25 cm³ – because this is the point at which pH 7 was achieved (when the reaction occurred). • Colours on the graph: red up to about pH 3, orange for pH 4 and 5, yellow pH 6, green pH 7, blue-green pH 8 and 9, blue-purple pH 10 and above.
16	a	<p>Missing words and symbols:</p> <ul style="list-style-type: none"> • hydrogen, ions, H⁺(aq) • sodium, hydroxide, OH⁻(aq) • salt, K⁺(aq), NO₃⁻(aq), H₂O(l) • acid, alkali, molecules, H₂O(l)
	b	<p>Missing words: sodium chloride</p> <p>Diagram completed by writing the symbols in the ions/atoms on the right: O, H and H in the atoms of the water molecules, Cl⁻ in the large circles and Na⁺ in the small circles.</p>