1(a). Ammonium sulfate, $(NH_4)_2SO_4$, is a fertiliser.

Ammonium sulfate can be manufactured from ammonia and sulfuric acid.

The Haber Process is used to manufacture ammonia. Scientists think that the Haber Process is one of the most important chemical reactions.

Explain the importance of the Haber Process in agriculture.

---[2]

(b). Ammonium sulfate is a salt.

It is made using the reaction between the alkali ammonia and sulfuric acid.

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

(i) Describe how a sample of solid ammonium sulfate is prepared in a laboratory.

Explain why this method is not suitable to be used industrially.

---[4]

(ii) Predict the maximum mass of ammonium sulfate that can be made from 51 tonnes of ammonia.

Maximum mass = _____ tonnes [2]

2(a). Farmers use fertilisers to improve crop yield.

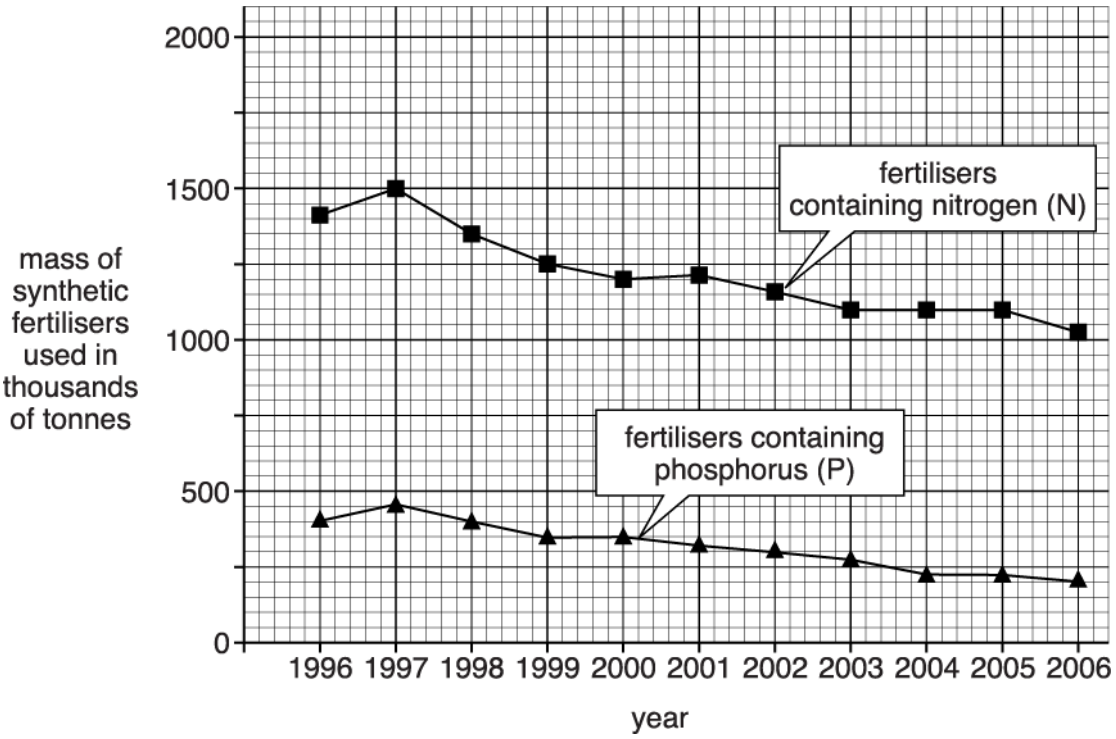
Fertilisers contain one or more of the three essential elements.

These essential elements are nitrogen, phosphorus and potassium.

Fertilisers made in factories are called **synthetic** fertilisers.

Look at the graph.

It shows the use of some synthetic fertilisers in the UK between 1996 and 2006.



(i) What mass of fertilisers containing **nitrogen** was used in 1997?

_____ thousands of tonnes

[1]

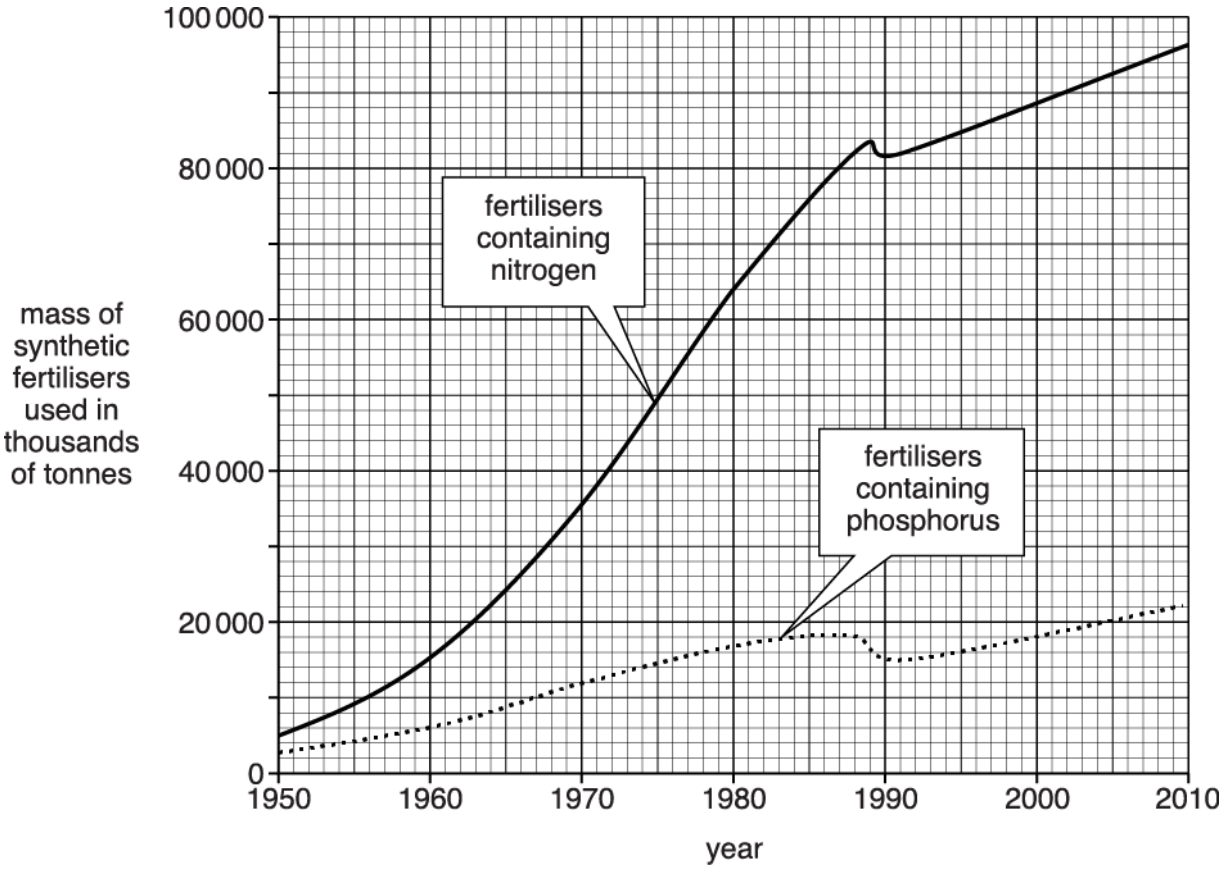
(ii) Describe the general trend in the use of these synthetic fertilisers in the UK from 1996 to 2006.

_____

_____ **[1]**

(b). Look at the graph.

It shows the use of synthetic fertilisers in the world between the years 1950 and 2010.



Use the graphs in **(a)** and **(b)** to **compare** the use of synthetic fertilisers in the UK and the world.

---

[3]

3(a). Aluminium is extracted from its ore using electrolysis.

Copper is extracted from its ore by heating with carbon.

Explain why different methods are used to extract aluminium and copper.

---

[2]

(b). Molten aluminium oxide contains Al^{3+} and O^{2-} ions.

The electrolysis of molten aluminium oxide makes aluminium and oxygen.

(i) Write the **balanced symbol** equation for the electrode reaction that happens at the cathode.

Use the symbol e^- to represent an electron.

---

[1]

(ii) Solid aluminium oxide cannot be electrolysed.

Explain why.

---

[1]

4(a). Farmers also use **pesticides** to increase crop yield.

Pesticides kill pests such as insects which eat the crops.

Look at the table. It shows the use of synthetic fertilisers and pesticides in some countries.

Country	Mass of synthetic fertilisers used in 1 km^2 in kg	Mass of pesticides used in 1 km^2 in kg
A	39000	5100
B	59000	200
C	45000	900
D	8000	500
E	6000	200

(i) Some people want to buy organic vegetables.

Organic vegetables must be grown **without** the use of synthetic fertilisers and pesticides.

From the information in the table, suggest a country, **A, B, C, D** or **E** which grows lots of organic vegetables.

Explain your answer.

---

[2]

(ii) The land area of country **B** is 7 000 000 km^2.

Calculate the mass of **pesticides** used in country **B**.

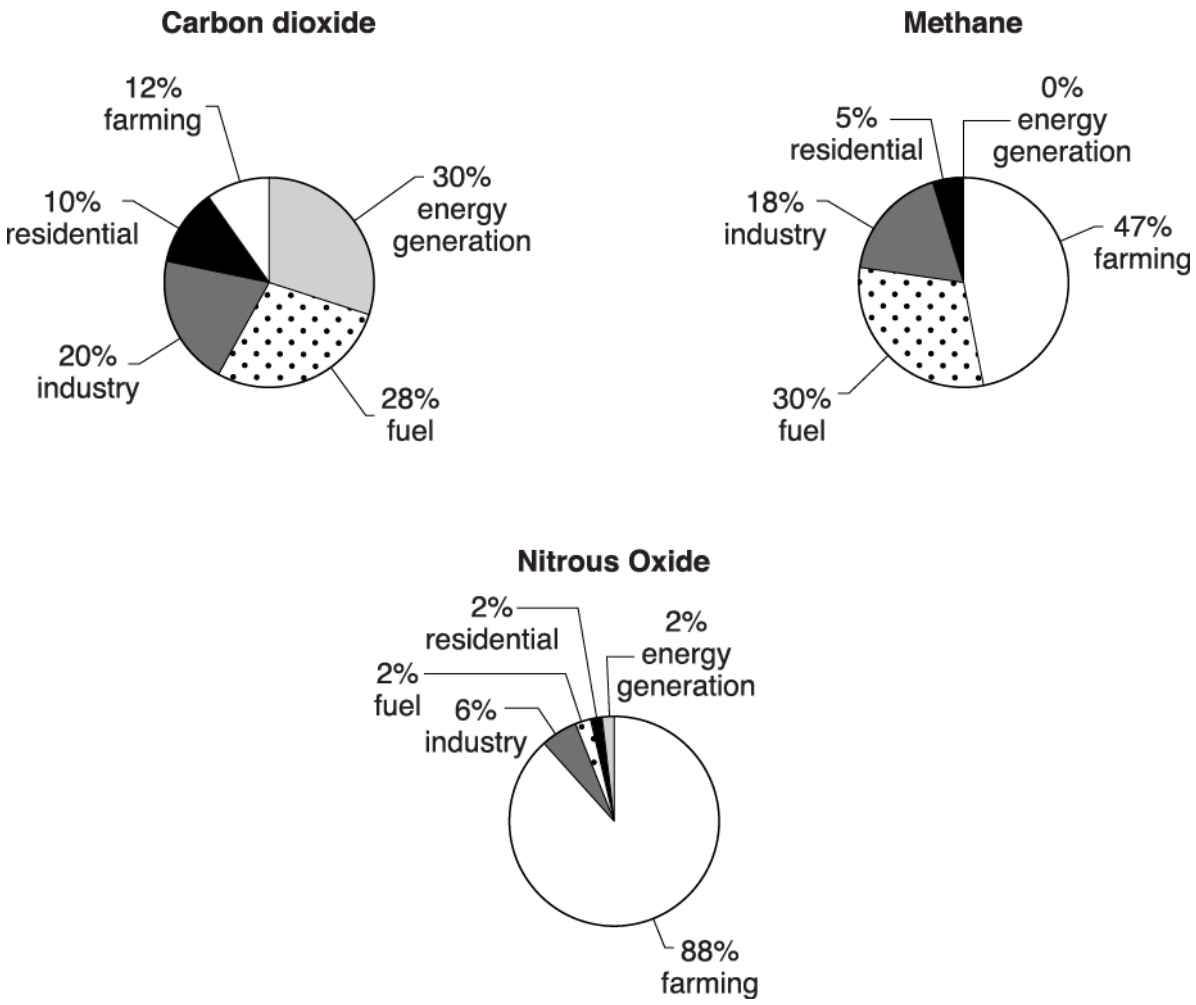
---

mass of pesticides = _____ kg **[1]**

(b). The use of synthetic fertilisers also contributes towards the greenhouse effect.

Look at the pie charts about three greenhouse gases.

They show where these greenhouse gases come from.



Suggest which gas is most likely to be made from the use of synthetic fertilisers.

Choose from carbon dioxide, methane or nitrous oxide.

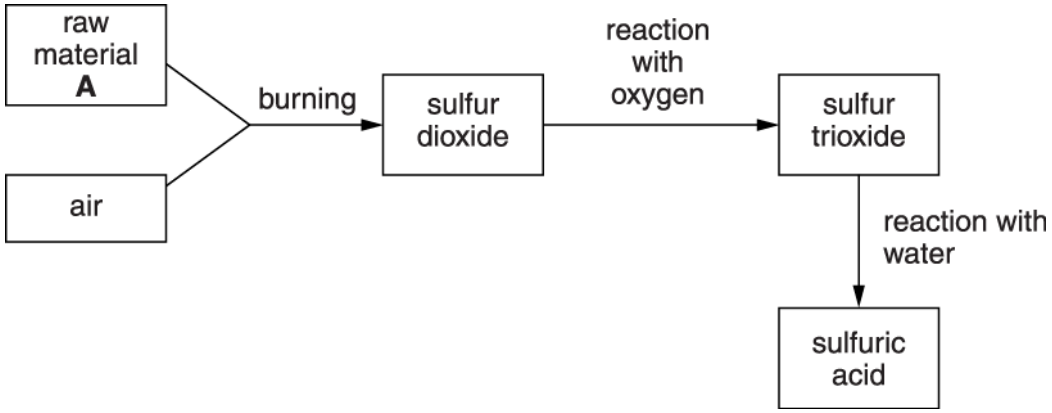
How can you tell?

---

[2]

5. This question is about the Contact Process used for the manufacture of sulfuric acid.

Look at the flow chart for the process.



What is the name of raw material **A**?

[1]

6. Farmers use fertilisers to improve crop yield.

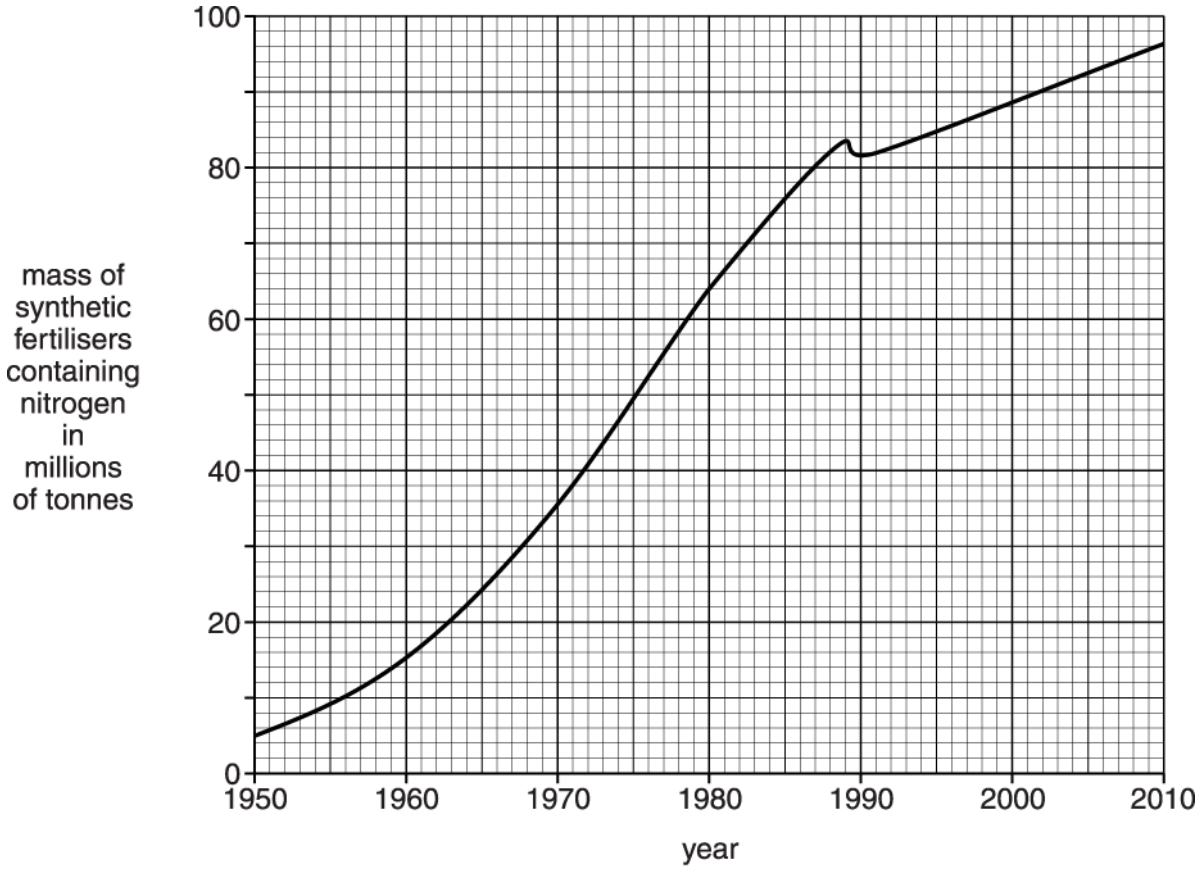
Fertilisers contain one or more of the three essential elements.

These essential elements are nitrogen, phosphorus and potassium.

Fertilisers made in factories are called **synthetic** fertilisers.

Look at **Graph 1**.

It shows the world use of synthetic fertilisers containing nitrogen between the years 1950 and 2010.



Graph 1

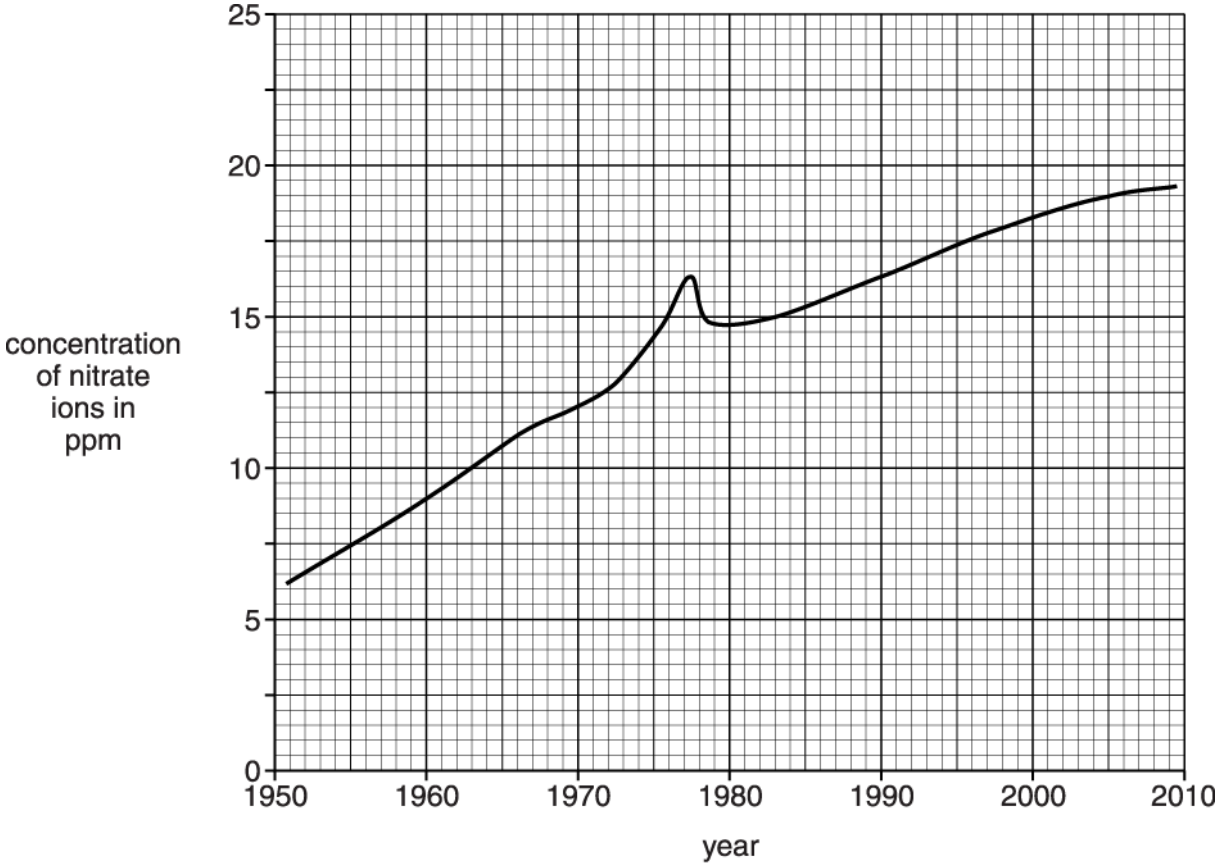
(i) What mass of fertilisers containing nitrogen was used in 1970?

mass = _____ millions of tonnes

[1]

(ii) Look at **Graph 2**.

It shows the concentration of nitrate ions, NO_3^-, from fertilisers in the River Rhine between the years 1950 and 2010.



Graph 2

Pollution controls were introduced for the River Rhine in 1977 to reduce nitrate, NO_3^-, concentrations.

What evidence is there from **Graph 2** that these controls have been effective?

---

[1]

7. Farmers use **pesticides** to increase crop yield.

Pesticides kill pests such as insects which eat the crops.

Look at the table. It shows the use of synthetic fertilisers and pesticides in some countries.

Country	Mass of synthetic fertilisers used in 1 km^2 of agricultural land in kg	Mass of pesticides used in 1 km^2 of agricultural land in kg	Percentage of land area available for agriculture (%)
A	26000	66	61
B	963000	128000	4
C	62000	1400	34
D	67000	740	34
E	330000	1000	18

(i) The agricultural land area of country **E** is 1 260 000 km^2.

Calculate the mass of **pesticides** used in country **E**.

---

mass of pesticides = _____ kg

[1]

(ii) Country **B** uses much more synthetic fertiliser and pesticides per km^2 than country A.

Suggest why. Use information from the table.

---

[2]

8. This question is about making ammonia by the Haber process.

Nitrogen and hydrogen react to make ammonia.

(i) The hydrogen gas used to make ammonia comes from natural gas.

Where does the **nitrogen gas** come from?

Choose from the list.

air

limestone

salt

water

---------- [1]

(ii) Nitrogen and hydrogen react to make ammonia.

Not all of the nitrogen and hydrogen reacts.

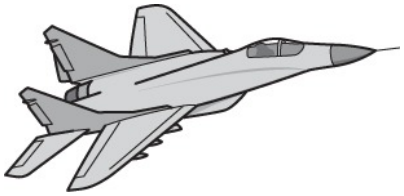
What happens to the unreacted nitrogen and hydrogen?

---------- [1]

9. Look at the table. It gives information about the properties of some metals.

Metal	Melting point in °C	Density in g/cm^3	Relative strength (1 = weak, 10 = strong)	Relative heat conductivity (1 = low, 10 = high)	Cost per tonne in £
A	1660	4.5	6.4	8.6	5000
B	420	7.1	4.3	9.0	870
C	1535	7.9	8.2	7.3	400

Look at the picture of a military aircraft. Only small numbers of these aircraft are made.



Evaluate the advantages and disadvantages of each metal for making the **body** and **wings** of this military aircraft. Which metal, **A**, **B** or **C**, would you choose and why?

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

[6]

10. One cost in making ethanol is the cost of heating the equipment to 300 °C and generating a pressure of 70 atmospheres.

Write about the **other** costs involved.

---

[2]

11. Many fertilisers are made by neutralisation.

Write about one **benefit** and one **problem** caused by using fertilisers.

---

[2]

12. Ethanol is also made by fermentation of sugars in a batch process.

The table compares making ethanol by hydration and by fermentation.

	Hydration	Fermentation
Raw materials	ethene from crude oil	sugar from plants
Type of process	continuous	batch
Rate of reaction	fast	slow
Conditions used	high temperature, 300 °C, high pressure, 60 atm, and a catalyst	low temperature, 40 °C, atmospheric pressure and an enzyme in yeast acts as a catalyst
Purity of product	pure	impure
Atom economy	100%	51%

Evaluate the advantages and disadvantages of each method.

Which method do you think is the best for manufacturing ethanol in the UK?

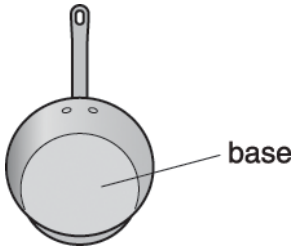
Explain why.

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

---

[6]

13. Kylie is choosing a metal to make a base for a saucepan.



Look at the information about some metals.

Metal	Melting point in °C	Relative electrical conductivity (1 = low, 10 = high)	Relative conductivity of heat (1 = low, 25 = high)	Density in g / cm^3
A	1535	1	4.2	7.9
B	98	2	7.8	1.0
C	1083	6	22.3	8.9
D	660	4	11.8	2.7

Which metal should Kylie choose to make a base for a saucepan?

_____

Explain your answer.

_____

_____

_____ [2]

14(a) This question is about the rusting of iron.

.

Which **two** substances are needed for iron to rust?

_____ and _____ [2]

(b). Write about **two** methods that can be used to stop iron from rusting.

Explain how **one** of the methods works.

---

[3]

15. This question is about metals.

Phil wants to buy a new bicycle.

He uses the internet to research which metal is the most suitable for making the bicycle frame.

Look at the table.

It shows the information he finds out.

Metal	Density in g/cm^3	Relative strength (1= low, 10 = high)	Resistance to corrosion	Cost per tonne in ☐
aluminium	2.7	0.9	very good	2220
copper	8.9	2.1	good	5550
stainless steel	7.8	7.3	very good	900
titanium	4.5	10	very good	17000

Which metal is the most suitable for making Phil's bicycle frame?

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Explain your answer using information from the table.

---[3]

16. Ammonium sulfate is made by reacting an acid with an alkali.

Name the acid and alkali needed.

Describe how the acid and alkali are used to make a sample of ammonium sulfate.

---[3]

17. This question is about fertilisers.

Amy and Chris decide to make **some solid ammonium sulfate** by neutralisation.

They use an acid and an alkali.

Name the acid and alkali they use and describe the experimental method they use.

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

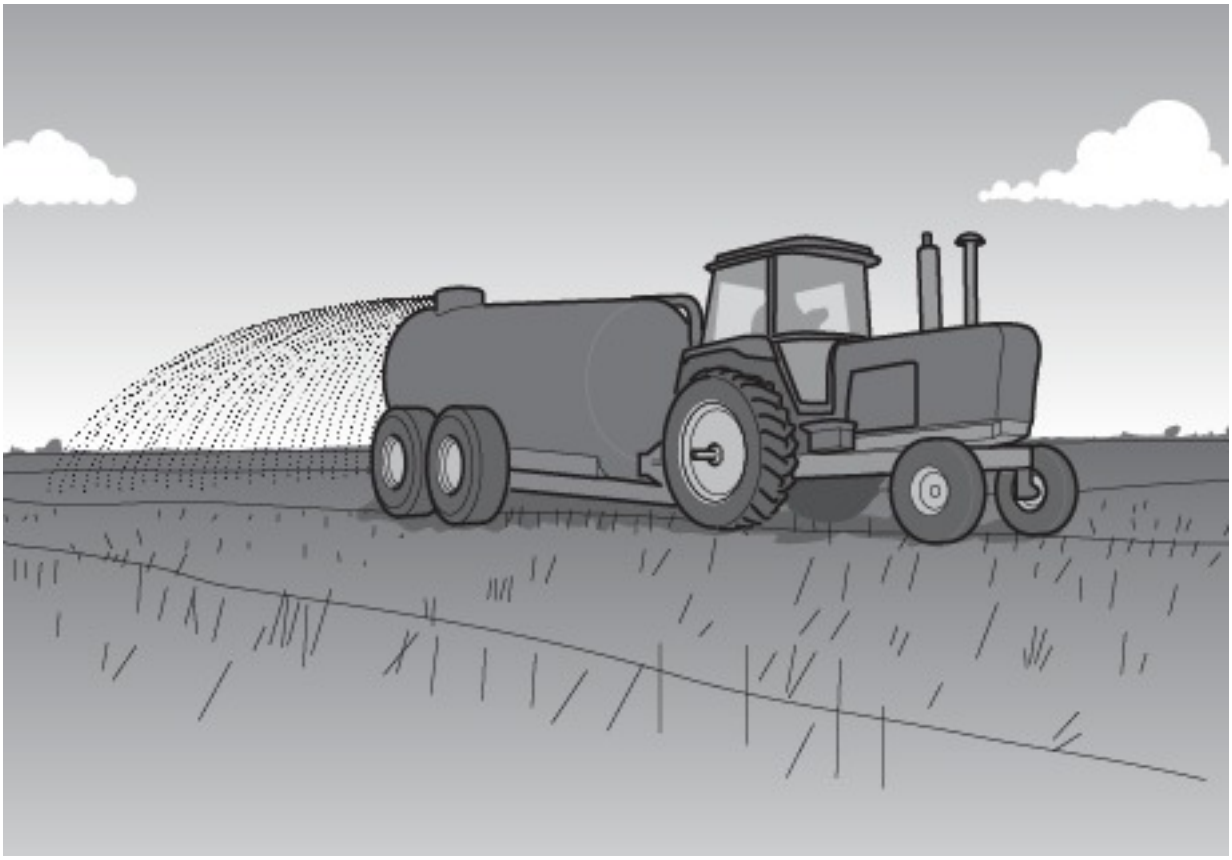
---

[6]

18(a) This question is about fertilisers.

.

Farmers add fertilisers to the soil.



What part of a plant absorbs the minerals from the fertilisers?

---------- [1]

(b). Ammonium phosphate, $(NH_4)_3PO_4$, is a fertiliser.

(i) Complete the table to show the number of each **type of atom** in the formula $(NH_4)_3PO_4$.

Atom	Number
N	_____
H	_____
P	_____
O	_____

[2]

(ii) Write down the **names** of the **two** essential elements in ammonium phosphate.

_____

_____ **[2]**

(c). Ammonium phosphate solution is made by reacting an acid with an alkali in a neutralisation reaction.

Write down the name of the **acid** and the **alkali** needed to make ammonium phosphate.

Describe how an indicator can be used to check the **pH** of the solution made.

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

---

[6]

19. Martin investigates the corrosion of different metals.

He places strips of metals in some damp gases.

Look at his results.

Metal	Appearance at start	Appearance after two weeks in damp ...		
		... oxygen	... acidic air	... nitrogen
copper	shiny pink	small patches of green on surface	thick green layer on surface	shiny pink
iron	shiny silver	small patches of brown on surface	lots of brown flakes on surface	shiny silver
lead	shiny silver	dull silver	black layer on surface	shiny silver

Martin concludes that:

- oxygen is needed for corrosion
- more corrosion happens in acidic air than in any of the other conditions.

Is he correct? _____

How can you tell? Write down evidence from the table in your answer.

_____

_____

_____

_____ [2]

20. **Recycling** copper is cheaper than extracting copper from its ore.

Explain why.

_____

_____

_____ [2]

21. There are many costs in making ammonia.

One of these is the cost of energy (gas and electricity).

Write about some of the other **costs** of making ammonia.

---

[3]

22. Stowmarket Synthetics make a polymer that is used to make bottles for fizzy drinks.

The polymer used to make the bottles is **non-biodegradable**.

Some scientists want the polymer to be **biodegradable**.

What is a **biodegradable** polymer?

Write about the advantages and disadvantages of using a **biodegradable** polymer to make these bottles.

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

---

[6]

23. Concrete is a building material.

Concrete is made stronger using a steel support.

This is called **reinforced concrete**.

Look at the table.

It gives some information about three types of steel.

Type of steel	Iron alloyed with	Relative strength	Other properties
A	about 0.25% carbon	386	easily shaped
B	up to 2.5% carbon	414	hard, more difficult to shape
C	chromium and nickel	515	easily shaped, resistant to corrosion

(i) Steel **C** is the best choice for reinforcing concrete.

Use information from the table to give **two** reasons why.

---

[2]

(ii) The three types of steel in the table are **alloys**.

What is meant by an alloy?

---

[1]

24. This question is about metals.

Look at the table. It shows some properties of three metals.

	Density in g/cm^3	Relative electrical conductivity (0 = low, 100 = high)	Relative strength (0 = weak, 1000 = very strong)	Corrosion in moist air	Cost per tonne in £
Aluminium	2.7	40	300	does not corrode	770
Copper	8.9	64	400	corrodes slowly	5900
Iron	7.9	11	600	corrodes	200

Look at the picture. It shows overhead power cables used by electric trains.

Suggest what **properties** are needed by a metal used to make the overhead power cables.

Which metal in the table would you use and why?

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

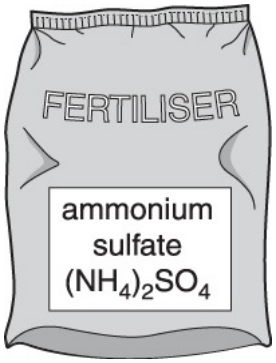
---

[6]

25(a) This question is about fertilisers.

.

Ammonium sulfate is used as a fertiliser.



The formula for ammonium sulfate is $(NH_4)_2SO_4$.

(i) Write down the number of **different elements** in ammonium sulfate.

answer _____

[1]

(ii) Write down the number of **atoms** in this formula.

answer _____

[1]

(b). Chloe makes some ammonium sulfate.

The alkali she uses is ammonia solution.

Which **acid** does she use?

_____ **[1]**

(c). Write about one **benefit** and one **problem** of using fertilisers.

---[2]

26. Different polymers have different properties.

The uses of a polymer depend on its properties.

Look at the table. It compares the properties of three polymers, **A**, **B** and **C**.

	Density in g/cm^3	Maximum useable temperature in °C	Strength in MPa (1 = weak, 10 = strong)	Relative flexibility
polymer **A**	0.92	85	1	flexible
polymer **B**	0.95	120	9	stiff
polymer **C**	0.89	25	2	stiff

Which polymer would you choose to make outdoor garden furniture?

polymer _____

Explain your choice.

---

[3]

27. Ammonium phosphate, $(NH_4)_3PO_4$, is a fertiliser.

(i) Complete the table to show the number of each **type of atom** in the formula $(NH_4)_3PO_4$.

Atom	Number
N	----------
H	----------
P	----------
O	----------

[2]

(ii) Ammonium phosphate solution is made by reacting an acid with an alkali in a **neutralisation** reaction.

Describe how pure, dry crystals of ammonium phosphate can be made, including the names of the **acid** and **alkali** needed.

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

---

[6]

28. Martin investigates the corrosion of different metals and alloys.

He places pieces of the metals or alloys in different concentrations of sulfuric acid.

He does his experiment at three different temperatures.

Look at his results.

Temperature in °C	Sulfuric acid concentration in %	Resistance to corrosion		
		Niobium	Zirconium	Hastelloy
20	10	excellent	excellent	poor
	40	excellent	excellent	good
	70	excellent	excellent	excellent
	90	good	poor	excellent
40	10	poor	excellent	poor
	40	poor	excellent	poor
	70	poor	excellent	poor
	90	poor	poor	poor
60	10	poor	excellent	poor
	40	poor	excellent	poor
	70	poor	good	poor
	90	poor	poor	poor

Martin concludes that:

- all three metals or alloys are more resistant to corrosion at lower concentrations of sulfuric acid
- all three metals or alloys are more resistant to corrosion at lower temperatures.

Is he correct?

Use information from the table to explain your answer.

---

[2]

29. Concrete is a construction material.

Concrete is quite strong.

It is reinforced using a mesh of steel rods.

This is called **reinforced concrete**.

(i) Reinforced concrete is a better construction material for making bridges than non-reinforced concrete.

Explain why.

---

[2]

(ii) Look at the table.

It gives some information about three types of steel used to reinforce concrete.

Type of steel	Relative strength	Density in g / cm^3	Cost of 1 m × 2 m mesh	Resistance to corrosion	Other properties
A	386	7.85	£26.99	limited	easily shaped
B	414	7.90	£40.35	limited	hard, more difficult to shape
C	515	7.80	£50.52	very good	easily shaped

Which type of steel would be best to reinforce concrete?

Use information from the table to suggest why.

---

[2]

30. Trevor needs to store these four chemicals.

Trevor investigates different metals, **A**, **B**, **C** and **D**.

Look at the results of his investigation.

	Rate of corrosion of metal by chemical (1 = very slow, 3 = fast)			
	Metal A	**Metal B**	**Metal C**	**Metal D**
chlorine gas	1	2	3	3
hydrogen gas	1	1	1	1
sodium chloride	3	1	1	2
sodium hydroxide	1	3	1	2

Trevor concludes that he **cannot** use the same metal to make the container for each chemical.

Do you think that Trevor has made the correct conclusion? _____

Explain your answer using the evidence in the table.

---

[2]

31(a) Ammonium sulfate is another fertiliser.

.

Ammonium sulfate is made by reacting an acid with an alkali.

Write down the name of the **acid** used to make ammonium sulfate.

---

[1]

(b). Fertilisers can be **beneficial** but may also cause **problems**.

Write about the benefits and problems of using fertilisers.

---

[2]

(c). Nitric acid is used to make fertilisers.

Ammonia and oxygen are used to manufacture nitric acid.

Water is the other product.

Write the **word equation** for this process and describe **costs** of making nitric acid.

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

---

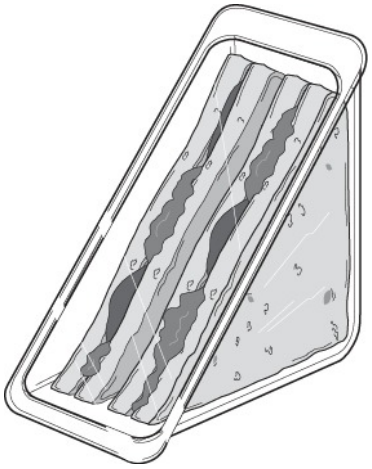
[6]

32(a) Anna buys sandwiches from a shop.

.

The sandwiches are in plastic packaging.

The plastic is made from a polymer called poly(propene).



Two properties of poly(propene) are:

- it is non-biodegradable
- it is insoluble in water.

Explain why these two properties make poly(propene) suitable for making the packaging and suggest, with a reason, one **other** suitable property needed by poly(propene).

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

[6]

(b). Anna finishes her sandwiches.

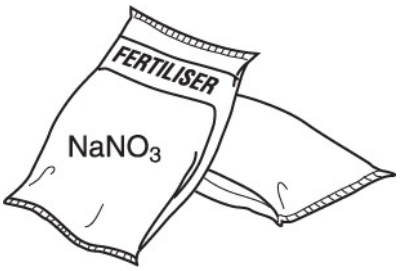
She throws the packaging into a dustbin.

Write about **two** ways the waste plastic from the dustbin is disposed of.

[2]

33. This question is about fertilisers.

Fertilisers are chemicals that provide plants with **essential elements**.



Sodium nitrate, $NaNO_3$, is a fertiliser.

Write down the **name** of the essential element for plant growth found in sodium nitrate.

[1]

34. Most metals have these physical properties.

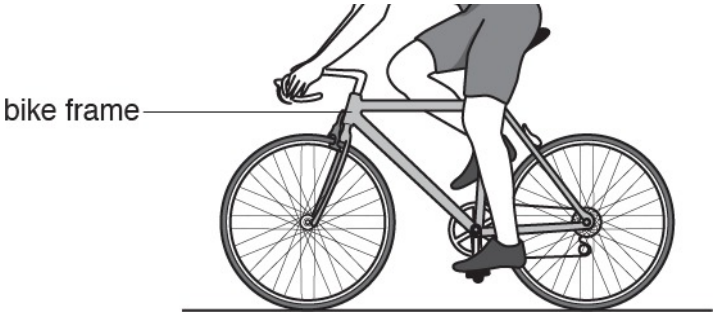
shiny

high melting point

high boiling point

Kevin builds a lightweight racing bike.

He chooses a suitable metal for the bike frame.



Suggest **three** properties, other than cost, needed by the metal he chooses.

---

[3]

35. The table shows the main stages in the life-cycle assessment of a manufactured product.

Stage	Process
1	Manufacturing the product
2	Obtaining raw materials
3	Disposing of the product
4	Using the product

What is the correct order for the stages?

A 1, 2, 3, 4
B 1, 2, 4, 3
C 2, 1, 4, 3
D 2, 4, 1, 3

Your answer ☐ **[1]**

36. The Haber process is used to make ammonia, NH_3.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

What is the raw material for the **nitrogen**?

A Air
B Hydrochloric acid
C Natural gas
D Seawater

Your answer ☐ **[1]**

37(a) This question is about the corrosion of metals.

.

A student investigates the rusting of iron.

Fig. 16.1 shows the experiments she sets up.

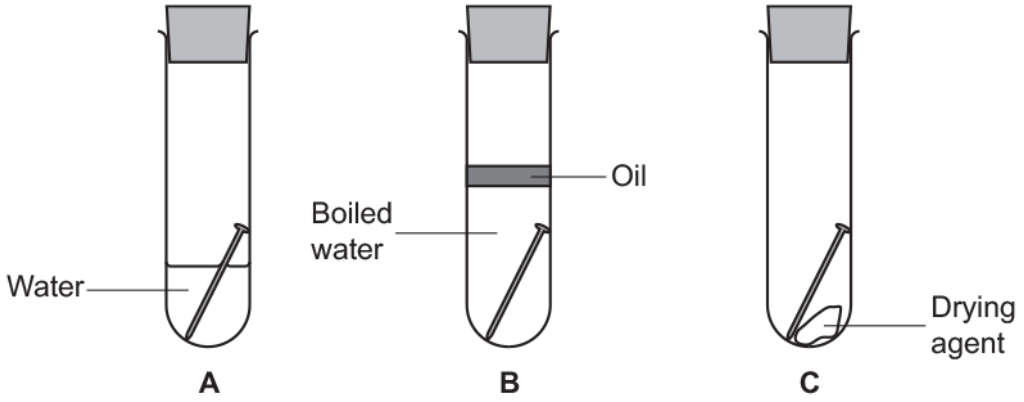


Fig. 16.1

Write about what the student would observe in each tube after one week.

Explain the observations.

Tube **A** ----------

Tube **B** ----------

Tube **C** ----------

---

[3]

(b). A galvanised iron bucket is made of iron coated with a layer of zinc.

After years of use, the zinc coating has become scratched.

The iron below the zinc has been exposed but the iron has not rusted.

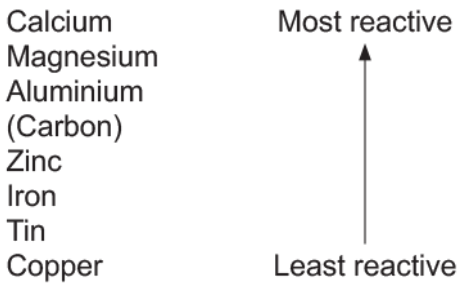
Explain why the iron has not rusted.

---

[2]

38(a) Look at the reactivity series of some metals. Carbon is also included.

.



(i) Zinc is usually extracted from zinc oxide by **heating zinc oxide with carbon**.

Explain why. Use the reactivity series to help you.

[1]

(ii) Aluminium is extracted from aluminium oxide by **electrolysis**.

Explain why. Use the reactivity series to help you.

[1]

(b). The table shows some information about aluminium and zinc.

Metal	Cost of 1 kg (£)	Amount in Earth's crust (%)
Aluminium	1.31	8.1
Zinc	2.51	0.0078

Suggest **two** reasons why it could be more important to recycle zinc than aluminium.

Use information from the table to help you.

1 ---

---

2 ---

---

[2]

(c). Aluminium alloys are often used to build aircraft.

A sample of an aluminium alloy contains 1.28 g of magnesium and 43.70 g of aluminium only.

Calculate the **percentage of magnesium** in this alloy.

Give your answer to **3** significant figures.

Percentage of magnesium = ... % **[4]**

39. Ammonia is used to make fertilisers.

Fertilisers usually contain nitrogen.

Name the **two** other elements that fertilisers usually contain.

---------- and ---------- [2]

40. A student buys a new bicycle. The bicycle chain is made of iron.

The student decides to oil the chain to prevent it from rusting, as shown in **Fig. 16.2**.

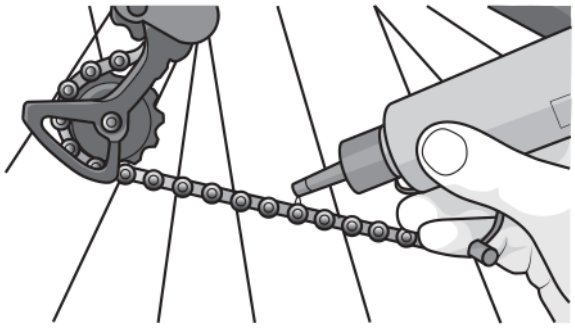


Fig. 16.2

Explain why oiling the chain will prevent the iron from rusting.

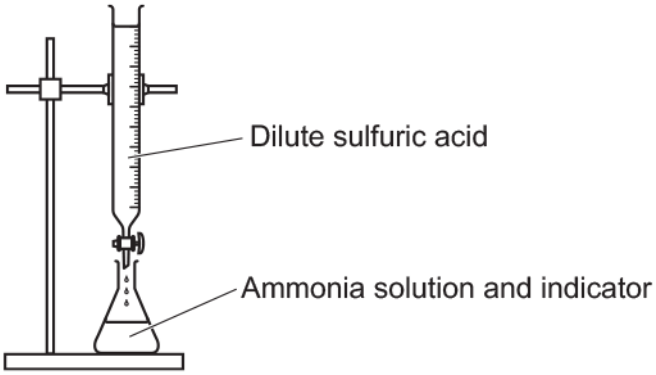
---

[2]

41. Ammonium sulfate is a salt used as a fertiliser.

Ammonium sulfate can be made in a laboratory in a batch process.

Ammonia solution is titrated with dilute sulfuric acid to make a solution of ammonium sulfate, as shown in the diagram.



Describe how you would make **dry crystals** of ammonium sulfate from ammonium sulfate solution.

---

[2]

42. This question is about properties of materials.

Police bullet-resistant vests could be made from steel or Kevlar®.

The table shows some information about steel and Kevlar®.

	Steel	Kevlar®
Density (g / cm^3)	7.85	1.44
Relative strength	1	5
Flexibility	low	high
Resistance to corrosion	low	high

Describe and explain **two** reasons why bullet-resistant vests are made from Kevlar® instead of steel.

1 ----------

---

2 ----------

---

[4]

43. Phytoextraction is one way to extract copper from low-grade ores.

The table shows the main stages involved in phytoextraction.

Stage	Process
1	Copper ions accumulate in the roots, shoots and leaves of plants.
2	Copper is extracted from ash with a high concentration of copper compounds.
3	Plants absorb dissolved copper ions through their roots.
4	A crop is planted in soil containing low-grade copper ore.
5	Plants are harvested and burned.

What is the correct order for the stages?

A 1, 3, 4, 5, 2
B 4, 1, 3, 2, 5
C 4, 3, 1, 5, 2
D 1, 4, 3, 5, 2

Your answer [ ] [1]

44. This question is about properties of materials.

Police bullet-resistant vests could be made from steel or Kevlar®.

The table shows some information about steel and Kevlar®.

	Steel	Kevlar®
Density (g / cm^3)	7.85	1.44
Relative strength	1	5
Flexibility	low	High
Resistance to corrosion	low	High

Describe and explain **two** reasons why bullet-resistant vests are made from Kevlar® instead of steel.

1 ---

---

2 ---

---

[4]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		Endless supply of starting materials / no need to use solid raw materials to make fertilisers (1) Ammonia used to make fertilisers which increase crop yield (1)	2	**ALLOW** Haber Process used to convert atmospheric nitrogen into ammonia / Haber process involves the chemical fixation of ammonia (1)
	b	i	Titrate ammonia against sulfuric acid to obtain volumes needed for complete neutralisation (1) Add these volumes without the use of indicator (1) Slow evaporation of reaction mixture / heat reaction mixture over a steam bath (1) Burette and other chemical apparatus not suitable for using large quantities / very difficult to use a steam bath in the large scale (1)	4	**ALLOW** heat neutral mixture with carbon or charcoal and then filter off carbon **ALLOW** Slow evaporation of filtrate / heat filtrate over a steam bath if method involving carbon is used
		ii	34 (g or tonnes) of ammonia makes 132.1 (g or tonnes) of ammonium sulfate / 17 (g or tonnes) of ammonia makes 66 (g or tonnes) of ammonium sulfate (1) So 51 tonnes makes 198.1 tonnes of ammonium sulfate (1)	2	**ALLOW** one mark for correct calculation of M_r for ammonia **AND** ammonium sulfate **IGNORE** units for the first marking point **ALLOW** one mark for 2 moles of ammonia makes 1 mole of ammonium sulfate
			Total	**8**	
2	a	i	1500 (1)	1	units **not** needed **Examiner's Comments** Most candidates correctly interpreted the graph and scored the marks.
		ii	decreases / gets smaller / gets less (1)	1	**allow** goes up to start with and then goes down / AW (1) **Examiner's Comments** Most candidates correctly interpreted the graph and scored the marks.
	b		**any three from:**	3	

Question			Answer/Indicative content	Marks	Guidance
			(UK decreases but) world is increasing (1) world uses more fertilisers than UK / AW (1) both UK and world use less phosphorus than nitrogen / ora (1) idea that 'blip' on graph for UK in 1997 not shown in the world / AW (1)		**allow** graph (a) for UK and graph (b) for world **Examiner's Comments** Good responses described that world use of fertilisers is increasing and that both the UK and the world use less phosphorus containing fertilisers than nitrogen containing fertilisers.
			Total	**5**	
3	a		Aluminium is above carbon in the reactivity series so cannot be obtained by reaction of oxide with carbon (1) Copper is below carbon in the reactivity series (1)	2	
	b	i	$Al^{3+} + 3e^- \rightarrow Al$ (1)	1	**ALLOW** any correct multiple **ALLOW** = instead of → **DO NOT ALLOW** & or and instead of +
		ii	Ions cannot move (1)	1	**IGNORE** electrons cannot move
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
4	a	i		2	**No marks for E, marks are for explanation**
		i	**?E** ?because idea that uses smallest amount of pesticides (1)		**allow** cannot tell because the figures give are mean values and so other countries may use lots of fertilisers and pesticides on
		i	idea that uses smallest amount of fertilisers (1)		**allow** other countries with correct justification **Examiner's Comments** Most candidates scored for correctly identifying that country **E** uses the smallest amount of fertilisers and pesticides.
		ii	1.4×10^9 / 1 400 000 000 (1)	1	unit **not** needed **Examiner's Comments** Examiners saw a wide range of incorrect values calculated.
	b		nitrous oxide (1) largest source from farming (1)	2	N_2O (1) it is 88% is **not** sufficient but **allow** 88% from farming (1) **allow** fertilisers contain nitrogen and this gas contains nitrogen (1) **ignore** just quoting numbers **Examiner's Comments** Most candidates correctly chose nitrous oxide and explained their choice because it is the largest source from farming.
			Total	**5**	
5			sulfur (1)	1	**allow** S (1) **Examiner's Comments** Sulfur was usually correct.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
6		i	34 - 36 (1)	1	units **not** needed Examiner's Comments This question assessed evaluation and analysis skills and was focused on the use of fertilisers. Most candidates could interpret the graph and give a value between 36 and 35 millions of tonnes.
		ii	Controls effective because gradient is less (than it would have been) after 1977 / controls effective since the use of fertilisers has grown at a much greater rate than the pollution / controls effective because of the sudden decrease at 1977 (1)	1	**allow** controls effective since concentration of nitrate less after 1977 **allow** figures quoted from graph to show decrease of nitrate concentration **allow** not (very) effective since little change in the gradient of graph before and after 1977 Examiner's Comments This question assessed evaluation and analysis skills and was focused on the use of fertilisers. Candidates usually referred to the decrease in the concentration of nitrate ions after 1977 although some did mention the difference in gradient of the line before and after 1977.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
7		i	1 260 000 000 (1)	1	unit **not** needed **allow** 1.26×10^9 or 1.3×10^9 Examiner's Comments This question assessed evaluation and analysis skills and was focused on the use of fertilisers. candidates had to interpret a table of data. Many could calculate the mass of pesticides used in county **E**. Only a small number of candidates gave the answer in standard form which avoided writing so many zeros. A small proportion of candidates divided the number by 1000 instead of multiplying it by 1000
		ii	(percentage of) land available (for agriculture) is (much) less (1) so need to get very high crop yield from the land (1)	2	assume answers apply to country **B** but **allow** ora for **A** if specified **ignore** country small / 4% used for agriculture / 4% available unlike (another quoted value) **allow B** has lots of pests (1) Examiner's Comments This question assessed evaluation and analysis skills and was focused on the use of fertilisers. Candidates often appreciated that the land available for agriculture was much less than in country **A** but were less likely to link this to the need to improve crop yield. Some candidates referred to country **B** having a large number of pests and this was also given credit in the mark scheme.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
8		i	air (1)	1	**allow** other ways of indicating answer e.g. tick or circle but the answer on the answer line takes precedence Examiner's Comments This question was about the manufacture of ammonia by the Haber process. Many candidates recognised that air was the source for nitrogen.
		ii	recycled (1)	1	**allow** sent round again / it is reacted together (again) Examiner's Comments This question was about the manufacture of ammonia by the Haber process. Some candidates thought that unreacted nitrogen and hydrogen was recycled but others stated it was vented into the air.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
9			[Level 3] All three metals are comprehensively evaluated AND metal A is chosen and justified. Quality of written communication does not impede communication of science at this level. (5–6 marks) [Level 2] An attempt is made to evaluate the strengths and weaknesses of at least two metals AND metal A or C is chosen with an attempt at a justification. Quality of written communication partly impedes communication of science at this level. (3–4 marks) [Level 1] An attempt is made to evaluate both the strengths or weaknesses of one metal. Quality of written communication impedes communication of 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: • metal A has the lowest density and a high strength but is expensive • metal B has a high density, reasonable strength but is cheap • metal C has a high density but is cheap and is the strongest • metal A is the best choice • because it has the lowest density and good strength • metal A is expensive but not many aircraft will be made. • metal B has a low melting point as a disadvantage Use the L1, L2, L3 annotations in scoris. Do not use ticks. Examiner's Comments Candidates could often use the data in the table, but some candidates were confused over strengths and weaknesses — high density was often perceived as strength. Other candidates did not write about each of the metals but focused on the metal of their choice. C was the most common choice but some mixed choices for the wings and body were given.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
10			**any two from:** cost of ethene (1) labour costs (1) equipment costs (1) cost of catalyst (1) research costs (1) cost of testing (1) rent or rates or taxes (1) pollution controls (1) storage (1)	2	**allow** extra qualification of costs (1) **allow** safety costs or safety equipment (1) **allow** maintenance costs (1) **ignore** references to energy costs / electricity / gas **ignore** packaging **ignore** transporting ethanol **ignore** marketing **Examiner's Comments** Most candidates scored 1 mark and a number both marks. Labour costs and the cost of ethene were common correct answers.
			Total	**2**	
11			**benefits – any one from:** increased crop yield (1) crops grow faster (1) increased food supply (1) provides essential elements / provides nitrogen or phosphorus or potassium (1) **problem – any one from:** runs off into rivers and lakes (1) idea of algal bloom (1) causes death of water organisms (1) eutrophication (1)	2	**allow** bigger crops (1) **ignore** better crops **ignore** to help crops grow (healthy) **allow** blue baby syndrome (1) **ignore** just ‘causes pollution’ **allow** correct description of eutrophication (1) **Examiner's Comments** The words ‘formula’ and ‘product’ were both emboldened in the question. In spite of this there were a number of names rather than formulae given and only a minority of candidates understood what was meant by a product.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
12			Level 3 (5–6 marks) Discusses at least one advantage and at least one disadvantage of each process AND identifies the better process fully justifying their choice. Quality of written communication does not impede communication of the science at this level. Level 2 (3–4 marks) EITHER Discusses at least one advantage and at least one disadvantage of each process OR Gives two comments (either advantages or disadvantages) about each process AND identifies the better process and gives a reason for that choice Quality of written communication partly impedes communication of the science at this level. Level 1 (1–2 marks) Gives two comments (either advantages or disadvantages) about each process OR identifies the better process and gives a reason for that choice Quality of written communication impedes communication of the science at this level. Level 0 (0 marks) Insufficient or irrelevant science. Answer not worthy of credit	6	This question is targeted at grades up to A/A* Indicative scientific points may include: Relevant points include for hydration process: advantages • making ethanol from ethene is a much quicker process • ethanol can be produced 24/7 from ethene • pure ethanol made so it does not need to be purified • making ethanol from ethene does not produce any waste products as the atom economy is 100% • UK has access to North sea oil. • made by a continuous process disadvantages • ethene has to be manufactured from crude oil • crude oil (ethene) is a non renewable source • uses a lot of energy. Relevant points include for fermentation process: advantages • making ethanol from sugar is greener as the raw sugar is renewable / can be grown • energy costs are cheaper because a lower atmospheric pressure and a lower temperature than hydration is used • catalyst used is not corrosive since it is an enzyme found in yeast disadvantages • ethanol has to be purified • takes a long time to make

Question			Answer/Indicative content	Marks	Guidance
					• climate not suitable • uses large areas of arable land. • atom economy not 100% (if carbon dioxide not used) • made in a batch process Use the L1, L2, L3 annotations in Scoris; do not use ticks Examiner's Comments In this six mark question candidates often gave a comprehensive discussion of the advantages and disadvantages of hydration and fermentation. A significant proportion of the candidates needed to use additional pages to complete their answers. Sometimes candidates forgot to make a choice at the end of their answer which limited the mark to level 2 and four marks. Either choice of hydration or fermentation was accepted in themark scheme provided the answer was justified. The best organised answers put their information in a table of advantages and disadvantages.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
13			C high(est) heat conductivity (1) high melting point (1)	2	no mark for choice **allow** a (very) good heat conductor **allow** will not melt when heated on a stove / does not melt easily **allow A** due to a (fairly) high melting point (1) **allow D** due to good heat conductivity (1) and either high melting point or low density / lightweight (1) ignore light **ignore** other properties Examiner's Comments Many candidates could evaluate the data in the table and suggest, with reasons, the letter of a metal that could be used to make the base of a saucepan. There were no marks for the choice of metal; all the marks were awarded for the explanation. Most candidates appreciated the importance of both a high thermal conductivity and a high melting point.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
14	a		water (1) oxygen (1)	2	**allow** H_2O (1) **allow** O / O_2 / air (1) **allow** moist air or damp air (2) **ignore** iron **Examiner's Comments** Most candidates scored 2 marks on this question. A common incorrect substance was 'salt'.
	b		**any two from**: oil or grease (1) paint (1) galvanising (1) idea of sacrificial protection (1) alloying (1) tin plating (1) **then any one from**: oil or grease or paint or tin plating – act as a barrier (so they stop water and oxygen reaching the iron) (1) galvanising – coated with zinc / so acts as a barrier / zinc corrodes first (1) sacrificial protection uses a more reactive metal / magnesium reacts instead of iron / zinc reacts instead of iron (1)	3	 **allow** coat with zinc (1) **allow** put in contact with magnesium or zinc (1) **allow** coat in another metal (1) **allow** mix with another metal (1) **allow** use stainless steel (1) **allow** plastic coating (1) **allow** paint provides a protective layer (1) **Examiner's Comments** This question discriminated well across the ability range. Most candidates could state one or two methods of protecting iron from rusting. Painting, oiling and galvanising were common correct answers. Better candidates gave good explanations of how the methods worked. Weaker candidates suggested keeping the iron inside away from water.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
15			(copper because) good resistance to corrosion (1) **or** (aluminium because) good resistance to corrosion (1) low density (1) **or** (stainless steel because) good resistance to corrosion (1) strong (1) cheap(est) (1) **or** (titanium because) good resistance to corrosion (1) strong (1) low density (1)	3	**No mark for the metal – the mark is for the correct reason** **ignore** other properties **allow** copper does not rust (1) but **not** copper does not rust as easily **allow** aluminium does not rust (1) but **not** aluminium does not rust as easily **allow** lightweight (1), but **ignore** just light **allow** only £900 per tonne (1) **allow** titanium does not rust (1) but **not** titanium does not rust as easily **allow** lightweight (1), but **ignore** just light **Examiner's Comments** Most candidates were able to use the data in the question to suggest and explain which metal is the most suitable for making the bicycle. Candidates could gain full credit for justifying the choice of either stainless steel or titanium as the data presented suitable reasons for both.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
16			**names of reactants:** (acid is) sulfuric acid (1) (alkali is) ammonia / ammonium hydroxide / ammonium carbonate / ammonium hydrogencarbonate (1) **AND** **any one from:** acid is titrated with alkali using an indicator / idea of controlled addition of acid to alkali with use of indicator (1) (heat to) evaporate water / leave solution to crystallise (1)	3	**allow** correct formulae or mix of formula and name H_2SO_4 $NH_3/NH_4OH/(NH_4)_2CO_3/NH_4HCO_3$ **not** ammonium / NH_4 / ammonia hydroxide **allow** acid is added to alkali (or vice versa) until a neutral solution is obtained (1) **allow** idea of controlled addition of acid to alkali with use of pH meter or test with indicator paper (1) **Examiner's Comments** Good responses to this question correctly stated that sulphuric acid and ammonia / ammonium hydroxide are needed to make ammonium sulphate and described how the acid and alkali are used to make a neutral solution. It was not necessary to describe a titration method to gain full credit, but candidates did need to suggest the controlled addition of acid to alkali rather than merely adding the acid to the alkali.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
17			Level 3 (5–6 marks) Names both the reagents needed AND Describes a neutralisation experiment, including how both a neutral solution and solid ammonium sulfate is obtained. Quality of written communication does not impede communication of the science at this level. Level 2 (3–4 marks) Names both the reagents needed AND Attempts to describe a neutralisation experiment. Quality of written communication partly impedes communication of the science at this level. Level 1 (1–2 marks) Names one of the reagents needed OR Attempts to describe a neutralisation experiment. Quality of written communication impedes communication of the science at this level. Level 0 (0 marks) Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted at grades up to A*. Indicative scientific points may include: names of reagents • acid is sulfuric acid • alkali is (a solution of) ammonia or ammonium hydroxide or ammonium carbonate. method • sulfuric acid is added to ammonia solution until a neutral solution is formed • neutral solution obtained by use of pH meter / indicator solution / indicator paper / universal indicator solution • the neutral solution is evaporated until saturated • solution is allowed to stand and crystallise • crystals are filtered off and dried. **allow** idea of 'evaporation to dryness' as an alternative to crystallisation **N.B.** It is not necessary to describe a titration method to get Level 3. Use the L1, L2, L3 annotations in scoris; do not use ticks. Examiner's Comments This question was about fertilisers. The number of atoms in the formula was usually correct. Where candidates did not gain the mark it was often because they gave an answer of 132, being the relative formula mass of ammonium sulfate.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
18	a		(through their) roots (1)	1	**not** shoots / stems **ignore** leaves Examiner's Comments This question focused on the fertiliser ammonium phosphate. Most candidates could recall that plants absorb minerals through their roots.
	b	i	<table><tr><th>Atom</th><th>Number</th></tr><tr><td>N</td><td>3</td></tr><tr><td>H</td><td>12</td></tr><tr><td>P</td><td>1</td></tr><tr><td>O</td><td>4</td></tr></table> **all four** correct scores (2) **two** or **three** correct scores (1) one correct scores (0)	2	Examiner's Comments Some candidates could complete the table of information about the number of atoms in the formula. The most common errors involved the number of nitrogen and hydrogen atoms. A significant proportion of the candidates did not attempt. The names of the two essential elements in ammonium phosphate were given by some candidates
		ii	nitrogen (1) phosphorus (1)	2	**allow** N **not** N_2 **allow** P Examiner's Comments Often phosphate or ammonium was given instead.
	c		**Level 3 (5 – 6 marks)** **States the name of the acid and the alkali needed to make ammonium phosphate AND fully describes how an indicator can be used to check the pH of the solution made.** Quality of written communication does not impede communication of the science at this level. **Level 2 (3 – 4 marks)** **EITHER** **States the name of the acid and the alkali needed to make ammonium phosphate** **OR** **fully describes how an indicator can be**	6	**This question is targeted at grades up to C** **Indicative scientific points may include:** • acid needed is phosphoric acid / H_3PO_4 • alkali needed is ammonia / ammonium hydroxide / NH_3 / NH_4OH **To check the pH of the solution** • add universal (indicator) / pH paper / full range indicator **ignore** litmus / phenolphthalein / methyl orange

Question			Answer/Indicative content	Marks	Guidance
			used to check the pH of the solution made. Quality of written communication partly impedes communication of the science at this level. **Level 1 (1 – 2 marks)** **EITHER** **States the name of the acid needed to make ammonium phosphate** **OR** **states the name of the alkali needed to make ammonium phosphate** **OR** **attempts to describe how an indicator can be used to check the pH of the solution made.** Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.		• compare colour obtained against colour chart **allow** its colour tells you the pH **but** to see what colour it goes is **not** sufficient **allow** examples of colour matching with pH e.g. if it is green then it is pH 7 - the colour stated must match the pH, i.e. red, yellow, orange for a pH below 7 and blue-green, blue or purple for pH above 7 **Use the L1, L2, L3 annotations in Scoris. Do not use ticks.** Examiner's Comments This question also assessed quality of written communication and involved aspects of the preparation of ammonium phosphate. Most candidates were not able to give the names of either the alkali or the acid needed. A common error was phosphorus acid. The use of the colours obtained when indicators are added to solutions of different pH values was well known although candidates did not always give the name of Universal Indicator. A significant proportion of the candidates did not attempt this question.
			Total	**11**	

Question			Answer/Indicative content	Marks	Guidance
19			yes because none of the metals corrode in nitrogen / none of the metals corrode in the absence of oxygen or air (1) **all** of the metals show more change in acidic air (than moist clean air) (1)	2	If no then 0 marks for the question marks are for explanation rather than yes on its own **allow** for any given metal **allow** stays shiny instead of does not corrode **allow** no change instead of no corrosion **allow** for any given metal more corrosion is **not** sufficient for a mark Examiner's Comments This question was about the corrosion of metals. This question assessed the skill of evaluation. Candidates found this question demanding and rarely were awarded both marks for the question. Many candidates just repeated the conclusions and did not quote information from the table. The best answers appreciated that with nitrogen there was no corrosion and that with acidic air the metal was covered with more solid on the surface than with damp oxygen.
			Total	2	
20			any two from: reduces problems of disposing of copper (1) uses less energy (1) idea that copper ore needs lots of processing to make copper (1)	2	**allow** saves digging up copper ore / malachite / copper carbonate **allow** to extract copper from its ore is difficult and takes a lot of time / lot of equipment required to extract copper from its ore Examiner's Comments Few candidates scored 2 marks because they concentrated on how expensive it is to dig the ore up but forgot that recycling copper requires less energy.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
21			any three from: cost of starting materials (1) labour costs / wages (1) equipment (1) plant / cost of rent / cost of rates (1) cost of catalyst (1) transportation costs (1)	3	 **allow** cost of nitrogen / hydrogen **allow** cost of high pressure container **allow** research costs **allow** environmental costs Examiner's Comments This part was fairly well answered.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
22			**Level 3** **Defines biodegradable** **AND** **Evaluates the use of the polymer giving an advantage and a disadvantage** Quality of communication does not impede communication of science at this level. (5 – 6 marks) **Level 2** EITHER **Defines biodegradable AND evaluates the use of the polymer giving either an advantage or a disadvantage** OR **Evaluates the use of the polymer giving an advantage AND a disadvantage** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **Level 1** EITHER **Defines biodegradable** OR **Evaluates the use of the polymer giving either an advantage or a disadvantage** Quality of 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 C Indicative scientific points may include: **Definition of biodegradable** • does rot • does decay • does break down (naturally) • does break up (naturally) • is attacked by bacteria • will decompose **ignore** corrode / will not be around for ever **Evaluation** • advantage – when disposed of will not contribute to (long term) litter or pollution • advantage – no need to burn plastic in order to dispose of it / no need to use a disposal method that contributes to global warming • advantage – will not fill up land-fill sites • disadvantage – idea that it cannot have a long storage life • disadvantage – idea that it may start to degrade when still in use • disadvantage – not recyclable • disadvantage – polymer has a use by date **ignore** references to strength and flexibility Use the L1, L2, L3 annotations in Scoris, do not use ticks <u>Examiner's Comments</u> Many candidates did not understand the meaning of the term biodegradable and as a result found this six mark question quite challenging. Candidates often referred to biodegradable plastics being recyclable and not very strong. Some candidates gave disadvantages that were typical of

Question			Answer/Indicative content	Marks	Guidance
					non-biodegradable plastics such as problems of disposal in land-fill sites or incineration. Only the very best answers appreciated the problems of using a biodegradable polymer in terms of it breaking down before the plastic bottle was thrown away. Other candidates stated there would be less pollution but did not attempt to explain why. Many candidates struggled with the correct use of chemical terminology.
			Total	6	
23		i	strong**est** (1) **and any one from:** resistant to corrosion (1) easily shaped (1)	2	Examiner's Comments Many candidates could give two reasons but some did not include the importance of having the highest strength. Candidates often struggled to give a definition for the term alloy
		ii	a mixture containing a metal (1)	1	**allow** contains two metals / mixture containing a metal and a non-metal (1) **allow** a metal made from other metals (1) (limit of acceptability) **not** metals joined or metals combined or metals bonded **not** metal mixed with a compound Examiner's Comments Some candidates made reference to a material that does not corrode and others just a mixture of materials without referring to metals.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
24			Level 3 (5-6 marks) Candidates apply their knowledge and understanding of the link between properties and uses to suggest the important properties necessary for a metal to be used in construction of overhead power cables. AND Candidates analyse the data and explain why aluminium is the best choice of the metals. If copper is chosen as the metal with correct explanations a mark of 5 can be credited. Quality of written communication does not impede communication of the science at this level. Level 2 (3-4 marks) Candidates apply their knowledge and understanding of the link between properties and uses to suggest some properties necessary for a metal to be used in construction of overhead power cables AND choose a metal with a suitable reason for their choice. Quality of written communication partly impedes communication of the science at this level. Level 1 (1-2 marks) Candidates apply their knowledge and understanding of the link between properties and uses to suggest two properties a metal should have OR choose a metal with a suitable reason for their choice. Quality of written communication impedes communication of the science at this level Level 0 (0 marks) Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted at grades up to C. Indicative scientific points may include: general properties of metals needed for overhead power cable construction: • good electrical conductor • low density • strong • does not corrode • does not cost too much • flexible • able to be drawn into a wire / ductile. properties that make aluminium suitable from table: • good electrical conductor • low density • does not corrode. properties that make copper suitable: • good electrical conductor. properties that make iron suitable: • low cost • strong. Use the L1, L2, L3 annotations in scoris, do not use ticks. Examiner's Comments Credit was given to candidates who identified a metal then described and explained its properties although the question did ask for candidates to suggest what properties a metal should have to make overhead power lines before choosing an appropriate metal. This question was well answered.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
25	a	i	4 (1)	1	**Examiner's Comments** A number of candidates correctly gave the number of different elements in the fertiliser as 4 but far fewer could give the number of atoms. A number of candidates totaled the atomic masses of the atoms.
		ii	15 (1)	1	
	b		sulfuric acid / H_2SO_4 (1)	1	**Examiner's Comments** Was reasonably well answered.
	c		**benefits** increases crop yield / increase food supply (1) **problems** cause death of aquatic animals (1)	2	to score **two** marks answer must have **one** benefit and **one** problem **allow** helps crops grow faster **allow** eutrophication / pollution of water supplies / contaminates water supplies / blue baby syndrome **ignore** damages soil **Examiner's Comments** Was reasonably well answered.
			Total	**5**	
26			polymer **B** (1) it is stiff (1) it is strong(er) (than polymers **A** or **C**) (1)	3	**allow** maximum useable temperature (above summer temperatures) / high melting point so it won't melt in the summer / AW **Examiner's Comments** The best answered question on the paper.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
27		i	<table><tr><th>Atom</th><th>Number</th></tr><tr><td>N</td><td>3</td></tr><tr><td>H</td><td>12</td></tr><tr><td>P</td><td>1</td></tr><tr><td>O</td><td>4</td></tr></table> **all four** correct scores (2) **two** or **three** correct scores (1) **one** correct scores (0)	2	Examiner's Comments Most candidates were successful in deducing the number of each type of atom in the formula $(NH_4)_3PO_4$.
		ii	Level 3 **States the name of the acid and the alkali needed to make ammonium phosphate AND** **fully describes how ammonium phosphate can be made.** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) Level 2 **States the name of the acid and the alkali needed to make ammonium phosphate AND** **attempts to describe how ammonium phosphate can be made.** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 **States the name of the acid and the alkali needed to make ammonium phosphate OR** **attempts to describe how ammonium phosphate can be made.** 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:** **Acid** needed is phosphoric acid / H_3PO_4 **Alkali** needed is ammonia / ammonium hydroxide / NH_3 / NH_4OH **ignore** ammonia hydroxide **To make ammonium phosphate:** • titrate the acid with the alkali, using an indicator / add the acid to the alkali (or vice versa), using an indicator • repeat the titration until consistent results are obtained • use the titration result to add the correct amounts of acid and alkali together without the indicator / decolourise indicator with carbon • evaporate (most of) the solution • leave the remaining solution to crystallise **allow** add excess ammonia to phosphoric acid and then heat the mixture to drive off the excess ammonia **Use the L1, L2, L3 annotations in Scoris. Do not use ticks.** Examiner's Comments

Question			Answer/Indicative content	Marks	Guidance
					The 6 mark question focused on how ammonium phosphate can be made and was targeted up to grade A. At the simplest level, candidates who stated the name of the acid and the alkali needed to make ammonium phosphate, or who attempted to describe how ammonium phosphate can be made, scored Level 1. To gain Level 2 candidates needed to give the name of the acid and the alkali and attempt to describe the method. A complete description of the method, including the names of the acid and the alkali, was required to gain credit at level 3 (5 - 6 marks). Common errors were naming the acid as 'phosphorus acid' and the alkali as 'ammonium'. A significant number of candidates did not mention repeating the titration to obtain consistent results, or repeating the titration without the indicator. Some candidates described the Haber process for the procedure.
			Total	8	
28			(no because) **hastelloy** is more resistant to corrosion at **high(er) concentrations** of acid (at 20°C) / ora (1) but (yes because) all (three) metals are more resistant to corrosion at **low(er) temperatures** / ora (1)	2	**marks are for explanations** Examiner's Comments Good responses to this question displayed an ability to interpret the data and appreciate that hastelloy is actually more resistant to corrosion at higher concentrations of acid, but all three metals are indeed more resistant to corrosion at lower concentrations of acid. When candidates did not gain credit it was often because they did not focus on the conclusions separately and tried to link the trend between both temperature and concentration, particularly when interpreting how concentration affected the resistance to corrosion. Many candidates also focused on individual metals rather than looking for overall trends.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
29		i	**any two from:** steel is strong (under tension) (1) steel is (more) flexible (1) steel stops the concrete stretching / cracking / breaking (1) concrete is hard (1) concrete is strong **under compression** (1)	2	**Assume unqualified answers refer to reinforced concrete** **allow** steel gives concrete (more) strength (1) **allow** concrete cracks (without steel reinforcing) (1) **allow** combines the strength and flexibility of steel with the hardness of concrete (2) **ignore** reinforced concrete is a composite material **if no other mark awarded, allow** reinforced concrete is stronger or reinforced concrete is more flexible (1) Examiner's Comments Good responses explained why reinforced concrete is a better construction material than non-reinforced concrete in terms of the combination of the hardness of concrete and the strength and the flexibility of steel. Candidates who simply compared reinforced and non-reinforced concrete, stating that reinforced concrete is stronger, gained only 1 mark.
		ii	(C because) **any two from:** strong**est** (1) (very good) resistance to corrosion (1) easily shaped (1) low density (1) other properties more important than high cost (1)	2	**marks are for explanation** **if A or B chosen scores 0** **allow** doesn't corrode (1) **ignore** light, but **allow** lightweight (1) Examiner's Comments Most candidates were able to interpret the data and correctly chose steel C, with two reasons to support their choice.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
30			Yes (no mark) because no metal has four 1's (1) idea that if a metal corrodes fast it is not suitable to store the chemical / to be used the container should corrode very slowly (1)	2	No mark for yes if answer is no 0 marks for question **allow** each metal has at least one 3 (1) **allow** can only use a metal if it is 1 **allow** each metal will corrode fast with at least one chemical / there is no metal that corrodes slowly with every chemical (2) **Examiner's Comments** This question assessed the evaluative skills of the candidates. Many candidates found it difficult to express their answer clearly and often just referred to each metal having different properties. The best answers appreciated that the conclusion was correct and illustrated their answer by quoting which metal would be best for each substance to be stored. Candidates did not often state clearly that the metals could not be used if they corroded rapidly.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
31	a		sulfuric (acid) (1)	1	**allow** H_2SO_4 **Examiner's Comments** The acid needed to make ammonium sulfate was well known. Nitric acid and ammonia were two incorrect answers given by candidates. The most common misconception was to refer to sulfur acid rather than sulfuric acid.
	b		**any one benefit from:** idea of increasing food supply / bigger crop yield / produce bigger plants / plants grow faster (1) **and** **any one problem from:** harms or death of aquatic organisms / eutrophication / pollution of water supplies / produces an algal bloom (in rivers) (1)	2	**allow** replace essential elements / replace nitrogen / replace potassium / replace phosphorus / replace nutrients / replace minerals **allow** fertilisers contain nutrients / contain vital minerals **allow** to make more money **ignore** to make plants grow / to help plants grow / to produce better crops **ignore** makes plants healthier **not** kills weeds / kills pests **allow** contamination of water supplies effect organisms in river is **not** sufficient washed into rivers is **not** sufficient **Examiner's Comments** Many candidates were able to give a benefit and a disadvantage of using fertilisers. The idea that plants grow faster or give a greater crop yield was well known. Other candidates referred to the presence of extra plant nutrients. In terms of disadvantages candidates often used the term eutrophication or described some of the processes involved with eutrophication. It was not sufficient to describe that fertilisers could be washed away. A common misconception was that fertilisers kill other animals on the crop and act as pesticides.

Question			Answer/Indicative content	Marks	Guidance
	c		[Level 3] Answer describes costs of making nitric acid AND includes the word equation for the reaction. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Answer describes costs of making nitric acid OR includes the word equation for the reaction and a cost of making nitric acid. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Answer describes a cost of making nitric acid OR includes the word equation for the reaction. 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 E Indicative scientific points may include: Word equation ammonia + oxygen ? nitric acid + water **allow** correct formulae but equation does not need to balance e.g. $NH_3 + O_2$? $HNO_3 + H_2O$ **allow** mix of correct formulae and words Costs • energy / gas / electricity / heating / lighting / temperature / pressure • raw materials / starting materials / ammonia / oxygen / catalyst • labour / wages / salaries / staff / workers • equipment / plant / maintenance • marketing • taxes / rates / rent • safety / H&S • pollution control **ignore** R&D, distribution, transport, packaging, advertising , storage Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This question assessed the quality of written communication in the context of the cost of making nitric acid from ammonia. Answers were often well constructed and started with the word equation and then went on to describe different costs. Many candidates could construct the word equation but there were some errors in which water was also given as one of the reactants. The different costs of making chemicals were well known and sometimes

Question			Answer/Indicative content	Marks	Guidance
					candidates went beyond the mark scheme in terms of explaining how the process could be made cheaper. Typically the most common costs were that for maintaining the pressure and temperature, the raw materials, and labour costs. A small but significant proportion of the candidates did not attempt this question.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
32	a		Level 3 Answer applies knowledge and understanding of the properties of a plastic and its use. Explanation as to why the plastic used to make the sandwich box needs to be nonbiodegradable and insoluble in water. One other property needed by the plastic explained. Quality of communication does not impede communication of science at this level. (5–6 marks) Level 2 Answer applies knowledge and understanding of the properties of a plastic and its use. Two properties of the plastic needed are explained. OR One property of the plastic needed is explained and one extra property is given. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 Answer applies knowledge and understanding of the properties of a plastic and its use. One property of the plastic needed is explained. OR One extra property is given. Quality of 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 C Indicative scientific points may include: Explanations • Non-biodegradable so the plastic does not rot, decay, decompose or breakdown • Insoluble in water so it will not dissolve / so moist foods can be stored / idea that water cannot enter Extra properties • Non-toxic material (so it will not contaminate the food or make the food dangerous to eat) • Non-reactive (so will not react with chemicals in the food) • Ability to shape the plastic • Plastic must be air-tight to prevent entry by bacteria • Transparent / colourless / clear • Waterproof • Does not react with water • Cannot be crushed easily • Low density ignore references to can be coloured / is strong / is hard / tough / durable / melting point / boiling point / recycling ignore disadvantages Use the L1, L2, L3 annotations in Scoris, do not use ticks Examiner's Comments This question assessed quality of written communication in the context of the properties and uses of polymers. Candidates were often able to explain why the plastic was suitable for making the container for sandwiches. In terms of non-biodegradable candidates often referred to

Question			Answer/Indicative content	Marks	Guidance
					the plastic not rotting or decomposing. Candidates that referred to recycling were not given credit. Many candidates appreciated that if the polymer was insoluble in water then water could not enter or leave the container. Candidates could often explain an extra property the polymer would need but did not always identify the name of the property. For example candidates mentioned the sandwich box should not change shape easily without naming the actual property. Typical properties described were flexibility, permeability to air, and transparency.
	b		**any two from:** land-fill site (1) idea of recycling (1) incinerated / combusted / burned (1) cracked / broken down to form monomers (1)	2	**ignore** heated to make fossil fuels **Examiner's Comments** Most candidates were able to describe two ways of disposing polymers, typically recycling, land-fill or burning.
			Total	**8**	
33			nitrogen (1)	1	**allow** N **ignore** nitrate **Examiner's Comments** Many candidates recognised that the element nitrogen was present. The use of nitrate was not given a mark since it is not an element.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
34			strong (1) low density / lightweight (1) does not corrode (1)	3	**mark first three points but ignore irrelevant reasons e.g. hardwearing or durable** **allow** stays rigid (1) **ignore** so it doesn't fall apart **ignore** light **allow** does not rust (1) **allow** a property (1) and a linked explanation (1) for example strong (1) so the frame will not buckle (1) **ignore** references to cost **Examiner's Comments** This question was well answered. Candidates could identify the necessary properties andmany offered explanations for why the property was needed e.g. ystrong to carry hisweight'.
			Total	3	
35			C ✓	1(AO 1.1)	Examiner's Comments Most candidates successfully identified the correct order for the stages in a life cycle.
			Total	1	
36			A ✓	1(AO 1.1)	Examiner's Comments While higher ability candidates often knew that air is the raw material for nitrogen, the majority chose natural gas.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
37	a		Tube **A** (nail) will rust because water AND air/oxygen are present ✓ Tube **B** no rust/change as there is no air/oxygen present ✓ Tube **C** no rust/change as there is no water present ✓	3(AO 2.2)	**Observation AND explanation needed for each mark** **ALLOW** For Tube **A** idea of suitable colour change e.g. red / orange. **Allow** 'nothing happens' **ALLOW** 'because it's dry' as the reason **ALLOW** One mark for getting all three observations as a standalone mark Examiner's Comments Many candidates knew what would happen in the first and last tubes, and the higher ability remembered to explain their observations and so gained credit. The function of the oil above the boiled water was least well understood 'The oil can't get to the iron.' Some candidates misread the question and described what **should** be observed rather than what **would** be observed.

Question			Answer/Indicative content	Marks	Guidance
	b		(Iron has not rusted because) zinc is more reactive (than iron) / ora ✓ (so) zinc corrodes instead of iron / zinc acts as a sacrificial metal ✓	2(AO 1.1)	Marks are for explanation Examiner's Comments Almost all candidates knew and understood that the zinc plays an active role, and many recognised that it was the continuing presence of zinc that was responsible. 'There are still bits of zinc on the iron stopping it from rusting'. However, even the higher ability candidates had difficulty explaining this in terms of reactivity and sacrificial metals. A common misunderstanding was to state that zinc acts as a barrier, either without appreciating that the iron was no longer completely coated or accepting that the iron wasn't completely coated but not dealing with it as an issue, as in exemplar 2 which was not creditworthy. Some suggested that the zinc was no longer needed because it had permanently altered the iron in some way, for example 'the zinc has covered the iron for so long that the iron isn't vulnerable anymore'. This was sometimes explicitly explained as the zinc continuing to have an effect even though it was no longer there, for example 'because the agents of the zinc are still with the iron, even if the physical zinc isn't'. Exemplar 2 Because no moisture can get to the iron So the reaction for rust can't happen. Most of the iron is still covered. [2]
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
38	a	i	Carbon is more reactive (than zinc) ✓	1(AO 2.1)	**ALLOW** carbon displaces zinc from zinc oxide **ALLOW** carbon is higher (in the table) / above zinc **IGNORE** carbon is highly reactive Examiner's Comments The reactivity of carbon compared to zinc was well understood.
		ii	Idea that aluminium is more reactive (than carbon) ✓	1(AO 2.1)	**IGNORE** aluminium is reactive / quite reactive **ALLOW** aluminium is highly / too / very reactive **ALLOW** aluminium is higher (in the table) / above carbon Examiner's Comments The link between reactivity and the need for electrolysis was less well known than the previous part. Some candidates discussed other elements from the reactivity series rather than aluminium, giving answers such as 'because copper is less reactive' or 'magnesium is very reactive'.
	b		Zinc costs more than aluminium / ORA ✓ Amount of zinc in the Earth's crust is much less (than the amount of aluminium) / ORA ✓	2(AO 3.2a)	**'It' refers to zinc** **ALLOW** It's expensive **ALLOW** There's less of it **ALLOW** only a small amount of zinc (in Earth's crust) Examiner's Comments This question was very well attempted

Question			Answer/Indicative content	Marks	Guidance
	c		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.85 (%) award 4 marks 1.28 (g) + 43.70(g) = 44.98(g) ✓ $\frac{1.28}{44.98} \times 100$ ✓ = 2.8457 … ✓ = 2.85 (3 sig. figs) ✓	4(AO 3×2.2 1.2)	Candidates who divide by 43.70 instead of 44.98 are carrying out a very similar calculation, so can score the remaining three marks ie $\frac{1.28}{43.70} \times 100 = 2.92906$ = 2.93 (3 sig. figs) ✓✓✓ Allow the sig figs mark for any other incorrect calculation which leads to an answer that needs shortening. Examiner's Comments This question was well attempted. Most candidates had a good basic grasp of how to solve the problem, even if they made mistakes. Many candidates gained at least partial credit because they had shown their working. A common mistake was to divide 1.28 by 43.70 instead of 44.98. In such cases, the candidate could still gain three of the marks. Often marks were lost due to miscopying of numbers eg 43.70+1.24 instead of 1.28. Another problem occurred when candidates did not convert the number on their calculator screens from 2.8457 to 2.85. Again, these candidates could still gain the remaining three marks.
			Total	8	
39			Phosphorus ✓ Potassium ✓	2(AO 1.1)	ALLOW P, K ALLOW oxygen/O/sulfur/S IGNORE radicals eg sulfate/phosphate Examiner's Comments The most popular acceptable response was 'sulfur'. Incorrect responses of water, ammonia, carbon and hydrogen were also common.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
40			(Oil) prevents water (reaching the iron) ✓ (Oil) prevents air / oxygen (reaching the iron) ✓	2(AO 1.1)	IGNORE other detail which doesn't contradict the answer 'lubricates the chain so it doesn't absorb water' Examiner's Comments Most candidates knew that the oil acted as a barrier, although often didn't say against what, as in **exemplar 1,** which was not creditworthy. Higher ability candidates did state that this barrier was against both oxygen and water. It was interesting to see a language change on going from the laboratory example of rusting to a real-life application. 'Water' often became 'moisture' or 'rain', and 'oxygen' often became 'air'. For some, this practical application became totally dissociated from the preceding part, and their answers focused on the lubricating properties of oil with minimal mention of corrosion prevention. 'It loosens the chain and makes it more flexible which prevents it from rusting'. Exemplar 1 Because it is like a protection layer due to being slippy and thick.
			Total	2	
41			Heat the solution / to evaporate (most of the water) ✓ Dry in a warm oven / dry in air ✓	2(AO 2.2)	IGNORE allow to crystallise unless detail given (stem) IGNORE 'dry it'/ 'let it dry out' unless detail given Examiner's Comments Many candidates got a mark for heating the solution.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
42			**Any two from:** (Kevlar®) has a low(er) density / is (more) lightweight (than steel) ✓ so it is easier to wear or carry / more comfortable to wear ✓ **OR** (Kevlar®) is strong(er) ✓ so it is less likely to be penetrated (by a bullet) ✓ **OR** (Kevlar®) is (more) flexible ✓ so it is easier to wear / more comfortable to wear / idea that it allows movement more easily ✓ **OR** (Kevlar®) does not corrode / does not rust ✓ so it will last longer ✓	4(AO 3.2b)	**Explanation must be linked to description** **ALLOW** 'light / lighter' only if supported by comparative data **ALLOW** idea that person can move more easily or more quickly **ALLOW** idea that (Kevlar®) can withstand a greater impact / is less easily damaged / is more resistant to wear **IGNORE** just the idea that (Kevlar®) is better at keeping you safe **ALLOW** idea that the vest can be worn in all weathers Examiner's Comments The whole of this question is common with the Higher Tier paper. Part (a) was well answered.
			Total	**4**	
43			**C ✓**	1(AO 1.1)	
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
44			**Any two from:** (Kevlar®) has a low(er) density / is (more) lightweight (than steel) ✓ so it is easier to wear or carry / more comfortable to wear ✓ OR (Kevlar®) is strong(er) ✓ so it is less likely to be penetrated (by a bullet) ✓ OR (Kevlar®) is (more) flexible ✓ so it is easier to wear / more comfortable to wear / idea that it allows movement more easily ✓ OR (Kevlar®) does not corrode / does not rust ✓ so it will last longer ✓	4(AO 3.2b)	**Explanation must be linked to description** **ALLOW** 'light / lighter' only if supported by comparative data **ALLOW** idea that person can move more easily or more quickly **ALLOW** idea that (Kevlar®) can withstand a greater impact / is less easily damaged / is more resistant to wear **IGNORE** just the idea that (Kevlar®) is better at keeping you safe **ALLOW** idea that the vest can be worn in all weathers Examiner's Comments This question required candidates to use the data to compare steel and Kevlar®. Candidates who did not gain full credit often simply repeated the stem of the question, ie Kevlar® is stronger than steel so is better at resisting bullets. Vague explanations, such as 'Kevlar® gives better protection', did not gain credit. Misconception Lower ability candidates still tend to confuse 'low density' with 'light'.
			Total	**4**	