Name: _____

Class: _____

Date: _____

Using Resources part 3 AQA Triple Chemistry

Time: **81 minutes**

Marks: **76 marks**

Comments:

1. This question is about fertilisers.

Compounds of nitrogen (N), phosphorus (P) and potassium (K) are used as fertilisers to improve agricultural productivity.

The table below shows information about three compounds, **A**, **B** and **C**, that can be used as fertilisers.

	Compound A	**Compound B**	**Compound C**
Name	potassium chloride	ammonium nitrate	diammonium hydrogen phosphate
Formula	KCl	NH_4NO_3	$(NH_4)_2HPO_4$
Percentage (%) of N, P and K by mass	**K**: 52%	**N**: 35%	**N**: 21% **P**: 23%
Cost in £/kg	0.24	0.23	0.35

(a) A scientist analysed the percentages of nitrogen, phosphorus and potassium in a soil.

The percentages of nitrogen and of potassium in the soil were lower than the percentages needed for high agricultural productivity.

There was sufficient phosphorus in the soil for high agricultural productivity.

Evaluate the use of the compounds in the table above to improve the agricultural productivity of this soil.

(4)

(b) How is potassium chloride (compound **A**) obtained from the Earth?

_____

_____

(1)

(c) Name **one** other compound that could be used instead of potassium chloride (compound **A**) to give a similar improvement in agricultural productivity.

_____

(1)

(d) Nitric acid is needed to produce ammonium nitrate (compound **B**).

Name a compound needed to produce nitric acid.

_____

(1)

(e) Phosphate rock contains phosphorus compounds.

Plants absorb phosphorus from compounds dissolved in rainwater.

Suggest why phosphate rock **cannot** be used directly as a fertiliser.

_____

_____

(1)

(f) Phosphate rock can be treated with different acids to produce salts useful as fertilisers.

Name the salts which are produced by treating phosphate rock with:

- sulfuric acid
- phosphoric acid.

Sulfuric acid _____

Phosphoric acid _____

(2)

(Total 10 marks)

2. Ammonia is produced in the Haber process.

The raw materials for the Haber process are nitrogen and hydrogen.

(a) Draw **one** line from each raw material to the source of that raw material.

Raw material	Source of raw material
	Air
Nitrogen	Clay
	Limestone
Hydrogen	Natural gas
	Sand

(2)

(b) What are the states of nitrogen and of hydrogen when used in the Haber process?

Tick (✓) **one** box.

State of nitrogen	State of hydrogen	
Gas	Gas	☐
Gas	Liquid	☐
Liquid	Gas	☐
Liquid	Liquid	☐

(1)

(c) The word equation for the production of ammonia is:

nitrogen + hydrogen ⇌ ammonia

The atom economy of the reaction is 100%.

How does the word equation show that the atom economy is 100%?

Tick (✓) **one** box.

The reaction is reversible. ☐

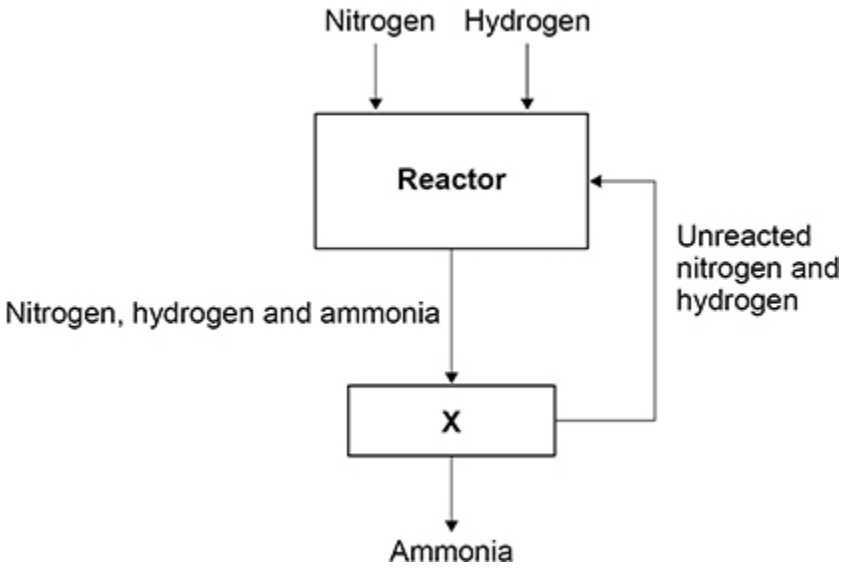
There are two reactants. ☐

There is one product. ☐

(1)

(d) **Figure 1** represents the Haber process.

Figure 1



A mixture of nitrogen, hydrogen and ammonia enters **X**.

Complete the sentences.

Choose answers from the box.

evaporated	**filtered**	**liquefied**	**recycled**

In **X**, the mixture is cooled.

The ammonia can be removed from **X** because the ammonia is

_____.

The unreacted nitrogen and hydrogen are

_____.

(2)

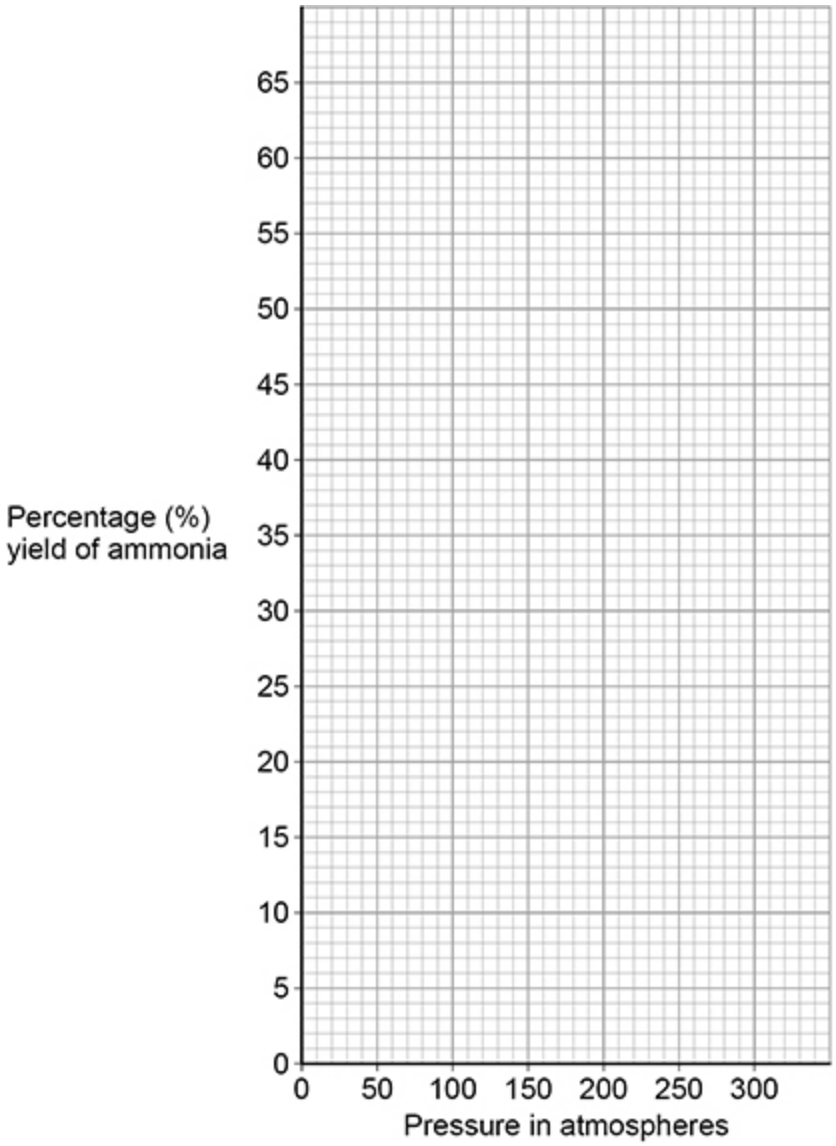
The table below shows the percentage yield of ammonia at different pressures.

Pressure in atmospheres	Percentage (%) yield of ammonia
50	20
100	33
150	44
200	52
250	59
300	64

(e) Plot the data from the table above on **Figure 2**.

Draw a line of best fit.

Figure 2



(3)

(f) What is the effect of increasing the pressure on the percentage yield of ammonia?

Use the table above.

_____

_____

(1)

(Total 10 marks)

3. This question is about fertilisers.

Ammonium nitrate is a fertiliser containing nitrogen.

(a) Complete the sentence.

Choose the answer from the box.

hydrochloric acid	**nitric acid**	**sulfuric acid**

Ammonium nitrate is produced by reacting ammonia with

_____.

(1)

(b) Ammonium nitrate fertiliser is sold in 600 kg bags.

A farmer spreads 40 bags of ammonium nitrate fertiliser on land with an area of 800 000 m^2.

Calculate the mass of ammonium nitrate fertiliser spread per m^2 of land.

_____

_____

_____

Mass per m^2 = _____ kg/m^2

(2)

(c) A scientist works for a company which makes ammonium nitrate fertiliser.

The scientist investigates the effect of different fertilisers on crop growth.

The scientist concludes that the ammonium nitrate fertiliser improves crop growth more than other fertilisers.

Suggest **one** reason why this conclusion might **not** be valid.

_____

_____

(1)

A different fertiliser containing nitrogen has the formula $K_2NH_4PO_4$

(d) How many atoms of nitrogen are in the formula $K_2NH_4PO_4$?

_____

(1)

(e) Nitrogen and potassium in the fertiliser $K_2NH_4PO_4$ are important for good crop growth.

Which other element in the fertiliser $K_2NH_4PO_4$ is important for good crop growth?

Tick (✓) **one** box.

Hydrogen ☐

Oxygen ☐

Phosphorus ☐

(1)

(f) Some fertilisers are mixtures of different compounds in fixed proportions.

What name is given to a mixture of different compounds in fixed proportions?

_____

(1)

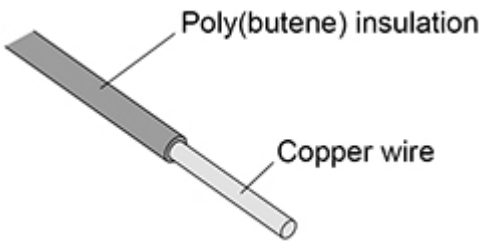
(Total 7 marks)

4. This question is about copper wire and copper compounds.

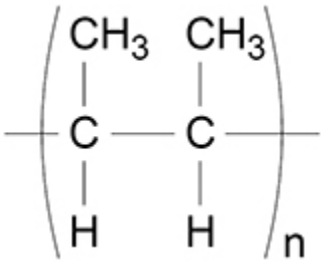
Copper is used to make electrical wires.

Figure 1 shows how copper electrical wire is insulated using an addition polymer called poly(butene).

Figure 1



(a) The addition polymer poly(butene) has the displayed structural formula:



Poly(butene) is produced from the monomer butene.

Complete **Figure 2** to show the displayed structural formula of butene.

Figure 2

(2)

Copper can be obtained by recycling scrap copper wire.

(b) Suggest why poly(butene) insulation must be removed from scrap copper wire before the copper is recycled.

_____

_____

(1)

(c) Describe how scrap copper wire can be recycled to make new copper water pipes.

_____

_____

_____

_____

(2)

(d) Suggest **two** reasons why recycling scrap copper is more sustainable than extracting copper from copper ores.

1 _____

_____

2 _____

_____

(2)

Copper sulfate is a compound of copper.

Copper sulfate solution contains copper(II) ions and sulfate ions.

(e) A solution can be added to copper sulfate solution to show the presence of copper(II) ions.

Name the solution added.

Give the result of the test.

Name of solution added _____

_____

Result _____

_____

(2)

(f) Describe **one** test to show the presence of sulfate ions in copper sulfate solution.

Give the result of the test.

Test _____

_____

Result _____

_____

(2)

(Total 11 marks)

5. This question is about water.

(a) Sewage is waste water.

Sewage contains organic matter.

Describe how sewage is treated to remove organic matter.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

Sea water and ground water are treated to make them potable.

The table below shows information about the composition and treatment of sea water and of ground water.

	Sea water	**Ground water**
Concentration of sodium ions and chloride ions before **Process 1**	Na^+ : 0.5 mol/dm^3 Cl^- : 0.5 mol/dm^3	Na^+ : 0.001 mol/dm^3 Cl^- : 0.001 mol/dm^3
Process 1	Reverse osmosis	Filtration
Concentration of sodium ions and chloride ions after **Process 1**	**X**	Na^+ : 0.001 mol/dm^3 Cl^- : 0.001 mol/dm^3
Process 2	Add ozone	Expose to ultraviolet light

(b) Sea water is desalinated during **Process 1**.

Which pair of concentrations could represent **X** in the table above?

Tick (✓) **one** box.

Na^+ : 0.003 mol/dm^3	Cl^- : 0.003 mol/dm^3	☐
Na^+ : 0.003 mol/dm^3	Cl^- : 0.5 mol/dm^3	☐
Na^+ : 0.5 mol/dm^3	Cl^- : 0.003 mol/dm^3	☐
Na^+ : 0.5 mol/dm^3	Cl^- : 0.5 mol/dm^3	☐

(1)

(c) Explain why the concentrations of sodium ions and of chloride ions in the ground water in the table above are unchanged by **Process 1**.

_____

_____

_____

_____

(2)

(d) Explain why the ground water in the table above requires **Process 2** before the water is safe to drink.

_____

_____

_____

_____

(2)

(e) After treatment the ground water in the table above is sold by a company as pure water.

The ground water in above table is not chemically pure because the water contains sodium ions and chloride ions.

Suggest what the company means by 'pure'.

_____

_____

(1)

(f) Chlorine is also used to treat some ground water.

Describe the test for chlorine gas.

Give the result of the test.

Test _____

_____

Result _____

_____

(2)

(Total 12 marks)

6. Ammonia is produced in the Haber process.

The raw materials for the Haber process are nitrogen and hydrogen.

The equation for the reaction is:

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

(a) Give the sources of the nitrogen and of the hydrogen used in the Haber process.

Nitrogen _____

Hydrogen _____

(2)

(b) How does the equation for the reaction show that the atom economy of the forward reaction is 100%?

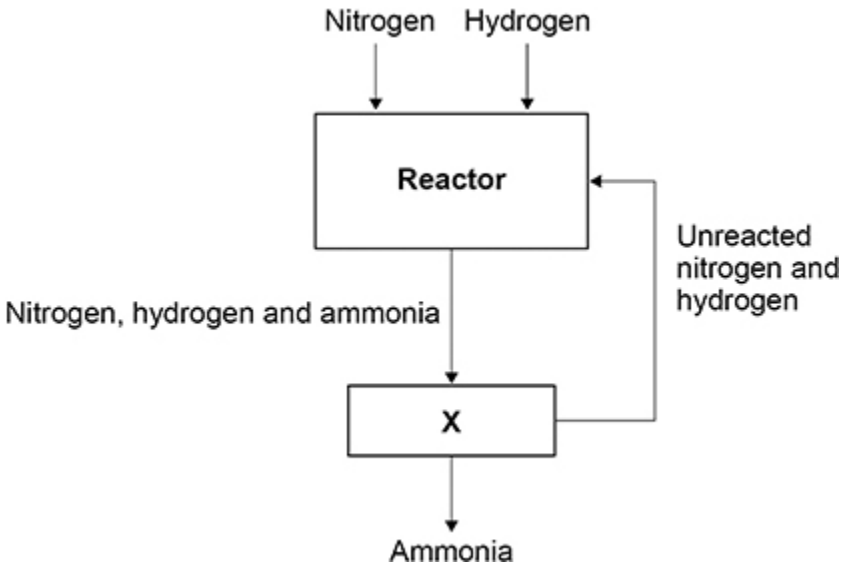
_____

_____

(1)

(c) **Figure 1** represents the Haber process.

Figure 1



Explain how the ammonia produced is separated from the unreacted nitrogen and hydrogen in **X**.

_____

_____

_____

_____

(2)

The Haber process uses a temperature of 450 °C and a pressure of 200 atmospheres.

The table below shows the percentage yield of ammonia produced at 450 °C using different pressures.

Pressure in atmospheres	Percentage (%) yield of ammonia
60	9
120	18
180	25
240	31
300	36
360	40
420	43

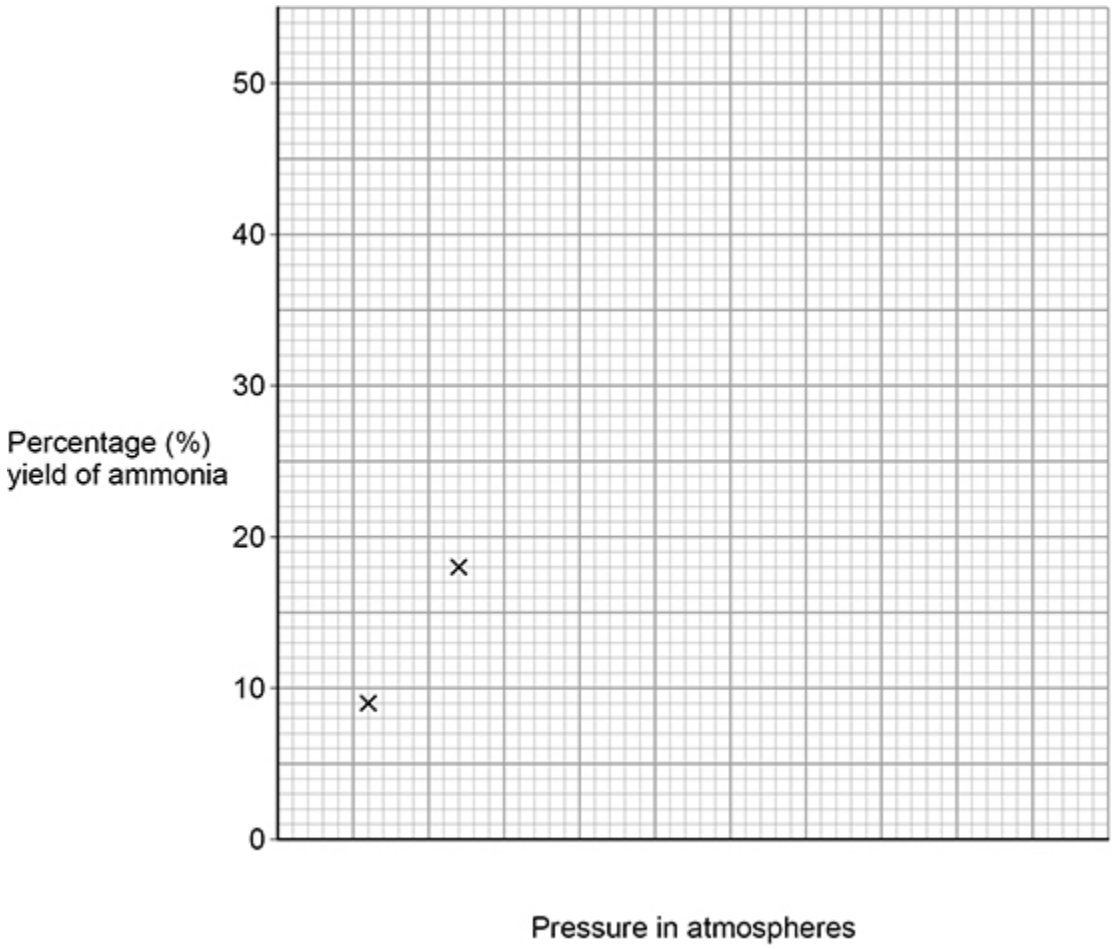
(d) Complete **Figure 2**.

The first two points have been plotted.

You should:

- use a suitable scale for the *x*-axis
- plot the remaining data from the table above
- draw a line of best fit.

Figure 2



(4)

(e) Determine the percentage yield of ammonia at 450 °C and 500 atmospheres.

Show your working on **Figure 2**.

Percentage yield = _____%

(2)

(f) The equation for the production of ammonia in the Haber process is:

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

The forward reaction is exothermic.

The conditions used are:

- a temperature of 450 °C
- a pressure of 200 atmospheres
- the presence of an iron catalyst.

Explain why these conditions are chosen for economical production of ammonia in the Haber process.

You should include references to the rate of reaction and the position of equilibrium.

(6)

(Total 17 marks)

7. This question is about life cycle assessments (LCAs).

(a) Milk bottles can be made from glass or from a polymer.

The table below shows information about milk bottles of equal volume.

	Glass	**Polymer**
Raw materials	Limestone Sand Sodium carbonate	Crude oil
Energy needed to process raw materials in kilojoules	6750	1710
Energy needed to manufacture bottle in kilojoules	750	90
Mass of bottle in grams	200	20
Mean number of times used during lifetime of bottle	25	1
One disposal method at end of useful life	Recycled to make different glass products	Recycled to make different polymer products

Evaluate the use of glass for milk bottles compared with the use of a polymer for milk bottles.

Use features of life cycle assessments (LCAs) in your answer.

Use the table above.

_____

(6)

(b) Milk is also sold in cardboard cartons.

A carton is made using 40 cm^3 of cardboard.

The density of the cardboard is 0.40 g/cm^3.

Calculate the mass of the carton.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

_____

_____

_____

_____

Mass = _____g

(3)

(Total 9 marks)

1.

(a) **Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

3-4

Level 2: Some logically linked reasons are given. There may also be a simple judgement.

1-2

No relevant content

0

Indicative content

reasons

- compound **A** (potassium chloride) only contains potassium
- compound **A** (potassium chloride) is the only source of potassium so is needed.

- compound **B** (ammonium nitrate) only contains nitrogen
- compound **B** (ammonium nitrate) contains more nitrogen than compound **C** (diammonium hydrogen phosphate) so is preferable
- compound **B** (ammonium nitrate) contains more nitrogen and is cheaper than compound **C** (diammonium hydrogen phosphate) and so is more cost effective

- compound **C** (diammonium hydrogen phosphate) contains phosphorus which is not needed

judgement

- none of the compounds contain both nitrogen and potassium so a mixture is needed
- (both) compound **A** (potassium chloride) and **B** (ammonium nitrate) should be used
- (both) compound **A** (potassium chloride) and **C** (diammonium phosphate) could be used

(b) mining

allow quarrying

1

(c) potassium sulfate

ignore potassium chloride

allow potassium nitrate

allow any other named potassium salt

1

(d) ammonia

allow water

1

(e) (phosphate rock is) insoluble (in water)

allow (phosphate rock) cannot be absorbed as a solid

1

(f) (sulfuric acid)
calcium sulfate

allow single superphosphate

allow calcium phosphate

1

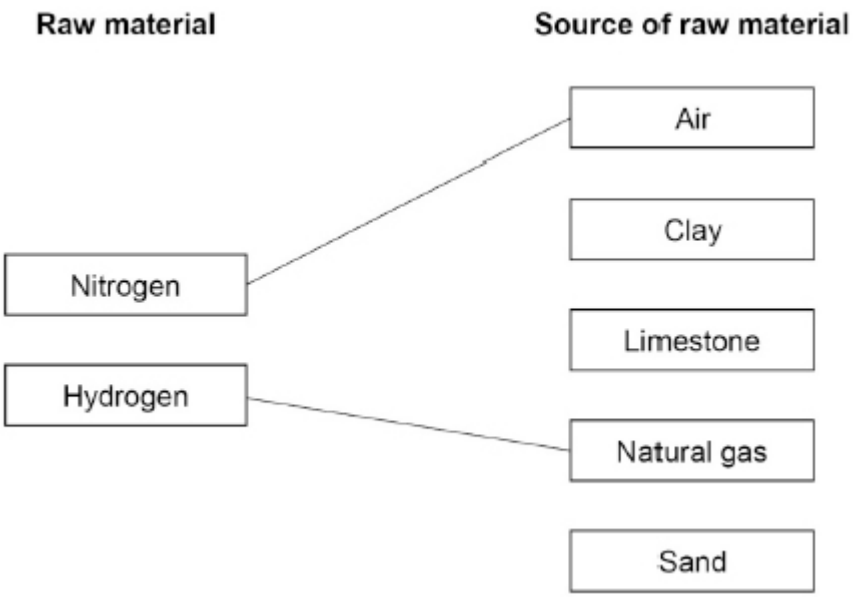
(phosphoric acid)
calcium phosphate

allow triple superphosphate

1

[10]

2. (a)



do not accept more than one line from a box on the left

2

(b) gas gas

1

(c) there is one product

1

(d) liquefied

1

recycled

1

must be in this order

(e) all six points plotted correctly

allow a tolerance of ± ½ a small square

*allow **1** mark for four / five points plotted correctly*

2

line of best fit

1

(f) (percentage yield) increases

1

[10]

3.

(a) nitric acid

1

(b) (mass =) $\frac{40 \times 600}{800\ 000}$

1

= 0.03 (kg/m^2)

1

(c) (the scientist might be) biased

or

(there was) no peer review

allow the investigation was not repeated (by others)

1

(d) one / 1

1

(e) phosphorus

1

(d) formulation

1

[7]

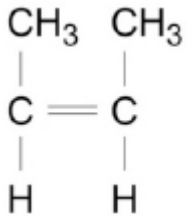
4.

(a) C=C bond

2 × C-H bonds **and** 2 × C-CH_3 bonds

*do **not** accept extra bonds*

an answer of



*scores **2** marks*

2

(b) any **one** from:

- (otherwise) the copper (produced) would be impure

  allow (otherwise) the copper (produced) would be contaminated
- (otherwise) the copper (produced) would be a mixture
- (otherwise) the insulation would burn / melt (during recycling)

  allow (otherwise) poly(butene) could produce toxic fumes
- copper and poly(butene) are recycled by different methods

1

(c) (wire heated until) copper melts

1

(re)cast / reformed (into pipes)

allow (re)shaped / extruded / (re)moulded

1

(d) any **two** from: (recycling scrap copper)

- uses less energy
- conserves copper (ore)
- (produces) less waste

  allow less landfill required
- specified environmental impact

  allow converse statements for extracting copper from ores

  ignore references to cost

2

(e) sodium hydroxide (solution)

allow NaOH for sodium hydroxide

1

blue precipitate

allow blue solid

1

MP2 dependent on MP1

(f) (add acidified) barium chloride (solution)

allow $BaCl_2$ for barium chloride

allow (add acidified) barium nitrate (solution)

*do **not** accept add sulfuric acid*

1

white precipitate

allow white solid

1

MP2 dependent on MP1

[11]

5. (a) screening
or
grit removal
allow filtering to remove (large) solids
1

sedimentation (to produce sewage sludge and effluent)
1

anaerobic digestion of (solid sewage) sludge
1

aerobic biological treatment of (liquid) effluent
allow aerobic digestion of effluent
1

allow a description of each process

(b) Na^+ : 0.003 mol/dm^3 Cl^- : 0.003 mol/dm^3
1

(c) the ions pass through the filter
allow the ions are not trapped / removed by the filter
1

(because) the ions are in solution
allow (because) the ions are smaller than the filter pores
1

(d) (the ground water) contains microbes which are harmful (to health)
1

(so) the water is sterilised
or
(so) the microbes are destroyed
1

(e) (the water is) unadulterated
or
(the water is) in its natural state
allow nothing is added (to the water)
allow (the water) contains no microbes
1

(f) (use) damp litmus paper
1

(the paper) is bleached
or
(the paper) turns white
ignore paper turns red
1

MP2 is dependent upon MP1

[12]

6.

(a) (nitrogen) air

allow atmosphere

1

(hydrogen) natural gas

allow methane

allow water / steam

1

(b) there is only one product

1

(c) (mixture is) cooled

1

(so that only) ammonia liquefies

allow (so that only) ammonia condenses

1

(d) scale labelled at 100, 200, 300 and 400 (atm)

allow scale labelled at 50, 150, 250 and 350 (atm)

1

all five points plotted correctly

allow a tolerance of ± ½ a small square

*allow **1** mark for three / four points plotted correctly*

2

line of best fit

1

(e) **View with Figure 2**

extrapolation to 500 atmospheres

1

percentage value at 500 atmospheres

allow a tolerance of ± ½ a small square

1

(f) **Level 3**: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

5–6

Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1–2

No relevant content

0

Indicative content

rate
- higher temperature gives higher rate because of more frequent collisions
- higher temperature gives higher rate because more particles have the activation energy
- higher pressure gives higher rate because of more frequent collisions
- use of catalyst gives higher rate because the activation energy is lowered

equilibrium
- higher temperature shifts the position of equilibrium to the left because reaction is exothermic
- higher pressure shifts the position of equilibrium to the right because more molecules on left-hand side
- use of catalyst has no effect on the position of equilibrium

other factors
- higher temperature (than 450°C) uses more energy so increases costs
- higher pressure (than 200 atmospheres) uses more energy so increases costs
- higher pressure (than 200 atmospheres) requires stronger reaction vessels so increases costs
- use of a catalyst reduces energy costs

compromise
- the temperature chosen is a compromise between rate of reaction and position of equilibrium
- the temperature chosen is a compromise between rate and cost
- the pressure chosen is a compromise between yield / rate and cost

[17]

7. (a) **Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

5–6

Level 2: Some logically linked reasons are given. There may also be a simple judgement.

3–4

Level 1: Relevant points are made. They are not logically linked.

1–2

No relevant content

0

Indicative content

raw materials
- crude oil is finite
- quarrying / mining pollute the environment
- glass uses more energy to process raw materials

manufacturing
- glass uses more energy to make bottles
- glass is heavier so takes more energy to transport

use and operation

- glass bottles are reusable
- reuse of glass conserves (natural) resources
- reuse of glass consumes energy during washing
- reuse of glass consumes water during washing

disposal

- both glass and polymer bottles can be recycled
- recycling polymer conserves finite resources
- recycling glass and polymer uses less energy than making new glass and polymer
- both methods reduce use of landfill

other points

- energy needed may be derived from fossil fuels
- use of fossil fuels causes (specified) pollution
- total energy for glass (bottle) (7500 kJ) is greater than total energy for polymer (bottle) (1800 kJ)

reasoned judgement

(b) mass = density × volume

1

mass = 0.40 × 40

1

= 16 (g)

1

[9]