M1.(a) 36 cm^3

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 6 or 7 of the points are correct*

2 best fit lines drawn

must not deviate towards anomalous point

2

*allow **1** mark if 1 line correct*

(c) The bung was not pushed in firmly enough.

1

The measuring cylinder was not completely over the delivery tube.

1

(d) as mass of lithium carbonate increases volume of gas produced increases

1

linear / (directly) proportional

1

(e) A gas / carbon dioxide is produced.

allow because the air in the tube expands

1

(f) any **one** from:

- Potassium carbonate does not decompose to produce carbon dioxide / a gas.
- Potassium carbonate does not decompose at the temperature of the Bunsen burner **or** the Bunsen burner is not hot enough to decompose potassium carbonate.
- When potassium carbonate decomposes a gas is not formed.

1

[11]

M2.(a) cotton wool

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 5 or 6 of the points are correct*

best fit line

must not deviate towards anomalous point

1

(c) (mass)
2.1 (g)

allow ecf from drawn best fit line

1

(time)
100 (s)

1

(d) a gas is produced

1

which escapes from the flask

1

(e) $\frac{9.85}{150} = 0.0656$

1

0.07 (g / s)

allow ecf answer correctly calculated to 2 decimal places

1

(f) collect the gas in a gas syringe

1

measured the volume of gas

allow carbon dioxide for gas

1

*allow for **1** mark*

collected gas

or

counted bubbles

(g) The particles have more energy

1

The particles move faster

1

[14]

M3.(a) (i) oxygen, sulfur trioxide

both needed for mark

1

(ii) compound

1

(b) increases

accept (goes) higher / (goes) up / (is) faster) / (are) more frequent

1

(c) activation

1

(d) catalyst **or** increase temperature

1

[5]

M4.(a) heat / energy

1

given out / transfers to surroundings

the mark for given out / transfers to cannot be awarded without heat / energy

allow given off

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

M5.(a) (i) In suntan creams

1

(ii) Much smaller

1

(b) (i) have a high surface area to volume ratio

1

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration <u>at the surface</u>'
ignore absorption

1

(that has) <u>lower</u> <u>activation energy</u>

allow weakens bonds

allow idea of increased successful collisions

*max **1** mark for incorrect chemistry eg increased energy of particles*

1

[5]

M6. (a) (i) 10

1

(ii) OH^-

1

(b) (i) air

1

(ii) particles move faster

1

particles collide more often

1

(iii) catalyst(s)

1

(c) liquid

1

[7]

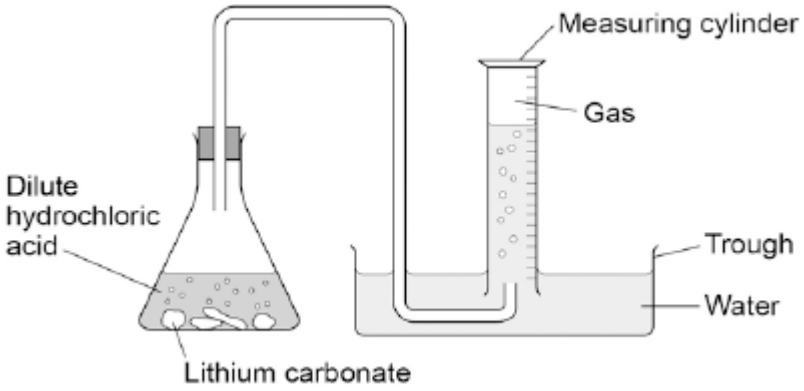
Q1. Lithium carbonate reacts with dilute hydrochloric acid.

A group of students investigated the volume of gas produced.

This is the method used.

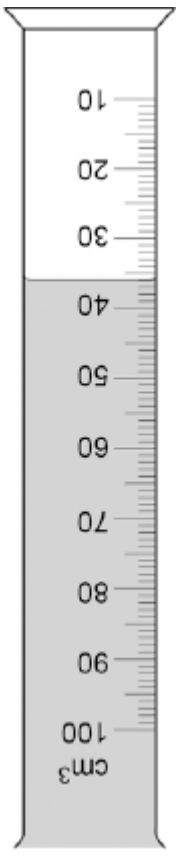
1. Place a known mass of lithium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas as shown in **Figure 1**.

Figure 1



(a) **Figure 2** shows the measuring cylinder.

Figure 2



What volume of gas has been collected?

Volume = ... cm^3

(1)

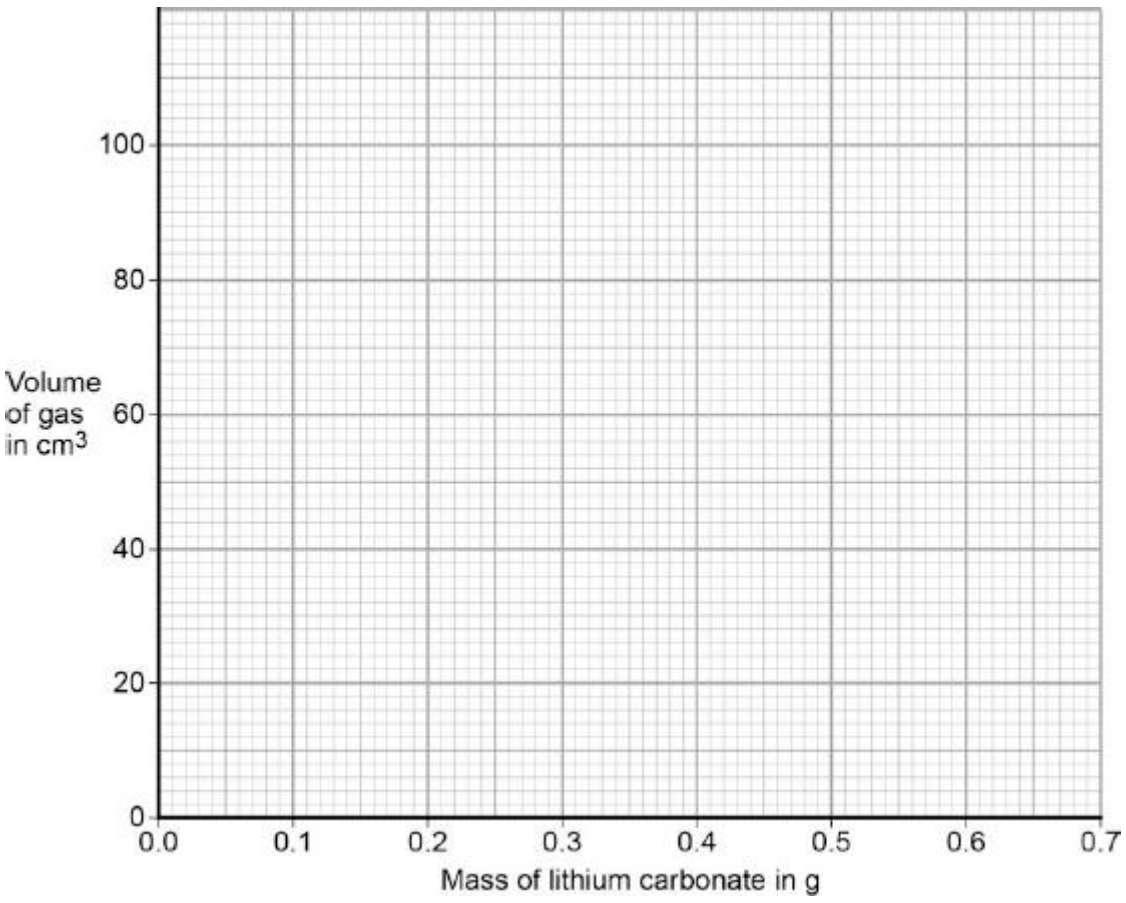
(b) The table below shows the students' results.

Mass of lithium carbonate in g	**Volume of gas in cm^3**
0.0	0
0.1	22
0.2	44
0.3	50
0.4	88
0.5	96
0.6	96
0.7	96

On **Figure 3**:

- Plot these results on the grid.
- Complete the graph by drawing **two** straight lines of best fit.

Figure 3



(4)

(c) What are **two** possible reasons for the anomalous result?

Tick **two** boxes.

Too much lithium carbonate was added. ☐

The bung was not pushed in firmly enough. ☐

There was too much water in the trough. ☐

The measuring cylinder was not completely over the delivery ☐

The conical flask was too small. ☐

(2)

(d) Describe the pattern the graph shows up to 0.4 g of lithium carbonate added.

.....

.....

.....

.....

(2)

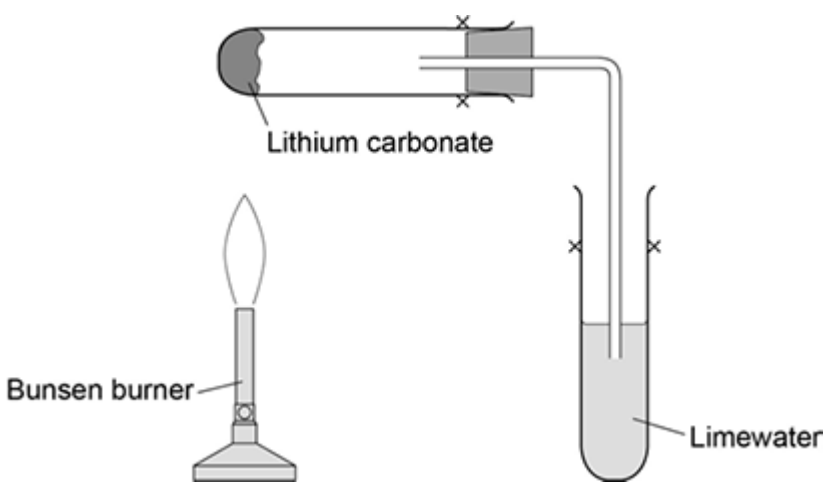
(e) Lithium carbonate decomposes when heated.

The equation shows the decomposition of lithium carbonate.

Li_2CO_3 (s) → Li_2O (s) + CO_2 (g)

Figure 4 shows the apparatus a student used to decompose lithium carbonate.

Figure 4



Why does the limewater bubble?

.....

.....

(1)

(f) The student repeated the experiment with potassium carbonate.
The limewater did not bubble.

Suggest why there were **no** bubbles in the limewater.

.....

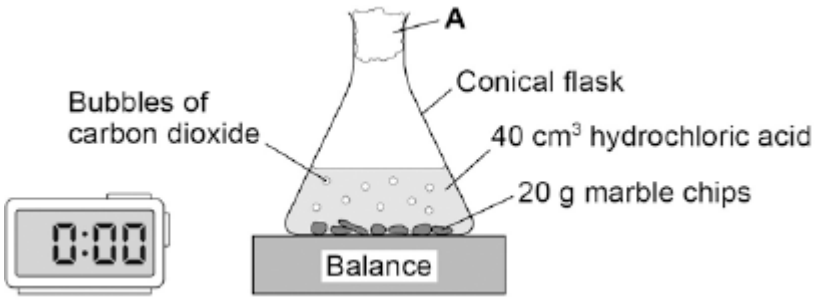
.....

(1)
(Total 11 marks)

Q2.A student investigated the rate of reaction between marble chips and hydrochloric acid.

Figure 1 shows the apparatus the student used.

Figure 1



(a) What is **A**?

Tick **one** box.

cotton wool ☐

limestone ☐

poly(ethene) ☐

rubber bung ☐

(1)

(b) **Table 1** shows the student's results for one investigation.

Table 1

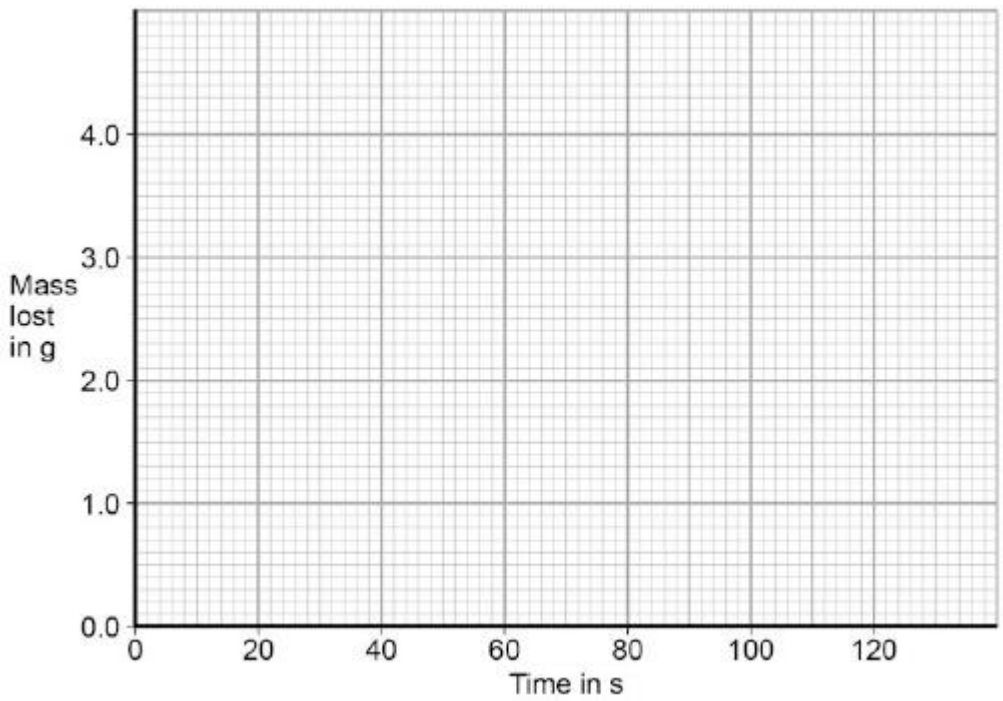
Time in s	Mass lost in g
0	0.0
20	1.6
40	2.6
60	2.9

80	3.7
100	4.0
120	4.0

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(3)

(c) Use **Figure 2** to complete **Table 2**.

Table 2

Mass lost after 0.5 minutes	..... g
Time taken to complete the reaction	..... s

(2)

(d) The equation for the reaction is:

$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

Explain why there is a loss in mass in this investigation.

.....

.....

.....

.....

(2)

(e) Another student investigated the rate of a different reaction.

Table 3 shows the results from the different reaction.

Table 3

Mass lost when the reaction was complete	9.85 g
Time taken to complete the reaction	2 minutes 30 seconds

Calculate the mean rate of the reaction using **Table 3** and the equation:

$$\text{mean rate of reaction} = \frac{\text{mass lost in g}}{\text{time taken in s}}$$

Give your answer to two decimal places.

.....

.....

Mean rate of reaction = ... g / s

(2)

(f) The student measured the change in mass of the reactants.

Describe another method, other than measuring the change in mass of the reactions, that the student could have used to find the rate of the reaction between marble chips and

hydrochloric acid.

.....

.....

.....

.....

(2)

(g) Another student planned to investigate the effect of temperature on the rate of reaction. The student predicted that the rate of reaction would increase as the temperature was increased.

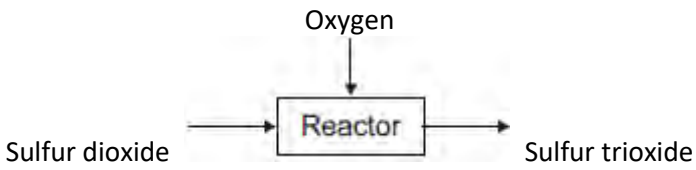
Give **two** reasons why the student's prediction is correct.

Tick **two** boxes.

The particles are more concentrated.	☐
The particles have a greater mass.	☐
The particles have a larger surface area.	☐
The particles have more energy.	☐
The particles move faster.	☐

(2)
(Total 14 marks)

Q3.(a) The figure below represents the reaction of sulfur dioxide with oxygen.



(i) Complete the word equation for the reaction of sulfur dioxide with oxygen.

sulfur dioxide + ... ⟶ .....

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

Sulfur dioxide (SO_2) is

- a compound.
- an element.
- a mixture.

(1)

(b) The reactants are gases.

When the pressure of the gases is increased, the reaction gets faster.

Complete the sentence.

When the pressure of the gases is increased,

the frequency of the collisions ..... .

(1)

(c) The particles need energy to react.

Complete the sentence.

The minimum amount of energy that particles need to react is called

the ..... energy.

(1)

(d) Give **one** way of increasing the rate of the reaction other than changing the pressure.

.....

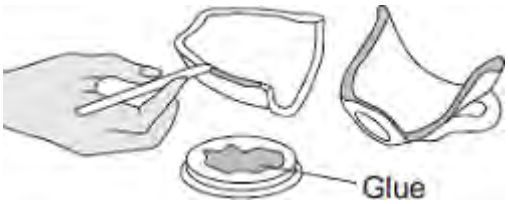
.....

(1)
(Total 5 marks)

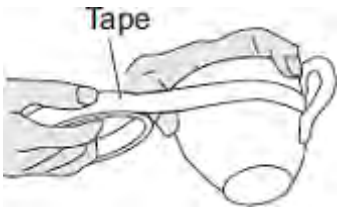
Q4. The following steps show how to use a type of glue.

Step 1 Measure out equal amounts of the liquids from tubes **A** and **B**.

Step 2 Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.



Step 3 Put the pieces together and hold them with tape.



Step 4 Leave the glue to set.

(a) When liquids **A** and **B** are mixed a chemical reaction takes place.

This reaction is *exothermic*.

What does *exothermic* mean?

.....

.....

.....

.....

(2)

(b) The time taken for the glue to set at different temperatures is given in the table below.

Temperature in°C	Time taken for the glue to set
20	3 days
60	6 hours
90	1 hour

(i) Use the correct answer from the box to complete each sentence.

decreases	increases	stays the same

When the temperature is increased the time taken for the glue to set

.....

When the temperature is increased the rate of the setting reaction

.....

(2)

(ii) Tick (✓) **two** reasons why an increase in temperature affects the rate of reaction.

Reason	Tick (✓)
It gives the particles more energy	
It increases the concentration of the particles	

It increases the surface area of the particles	
It makes the particles move faster	

(2)
(Total 6 marks)

Q5. Nanoparticles have many uses.

(a) (i) Tick (✔) **one** use of nanoparticles.

In the extraction of iron	☐
In suntan creams	☐
In the test for oxygen	☐

(1)

(ii) How is the size of nanoparticles different from normal-sized particles?

Draw a ring around the correct answer.

much smaller **same size** **much larger**

(1)

(b) Very small amounts of cerium oxide nanoparticles can be added to diesel fuel.

The cerium oxide is a catalyst.

(i) Draw a ring around the correct answer to complete the sentence.

Only a very small amount of cerium oxide nanoparticles is needed because

the nanoparticles

- are elements.
- are very reactive.
- have a high surface area to volume ratio.

(1)

(ii) Explain how a catalyst increases the rate of a reaction.

.....

.....

.....

.....

.....

(2)
(Total 5 marks)

Q6. (a) Ammonia solution is used in cleaning products to remove grease from kitchen surfaces.

Ammonia solution is alkaline.

(i) Draw a ring around the number most likely to be the pH of ammonia solution.

1 **3** **7** **10**

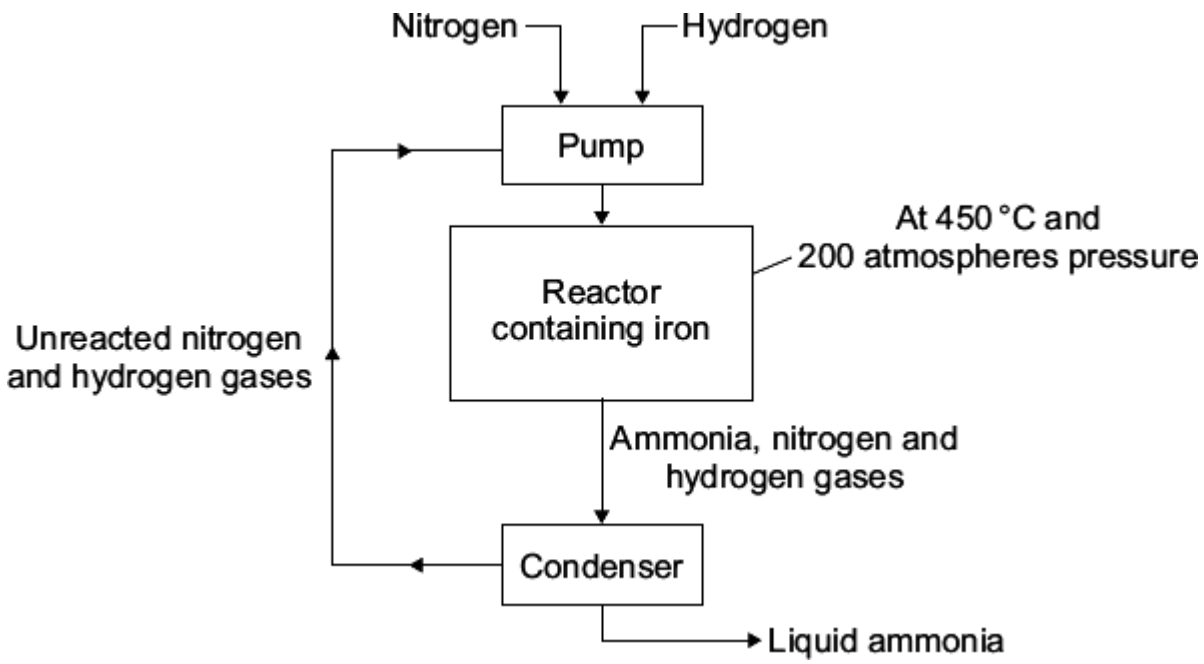
(1)

(ii) Draw a ring around the ion in ammonia solution which makes it alkaline.

Cl^- **H^+** **Na^+** **OH^-**

(1)

(b) Ammonia is made using the Haber process.



(i) Where does the nitrogen used in the Haber process come from?

Draw a ring around your answer.

air **natural gas** **water**

(1)

(ii) A high temperature of 450 °C is used in the reactor.

Tick (✓) **two** reasons in the table which explain why high temperatures make reactions faster.

Reasons	**Tick (✓)**
Particles move faster	
Particles are closer together	
Particles collide more often	
Particles have less energy	

(2)

(iii) The iron in the reactor speeds up the reaction but is not used up.

What is the name given to substances that speed up the chemical reaction but which are not used up during the reaction?

.....

(1)

(c) Complete the sentence.

The condenser separates the ammonia from the unreacted nitrogen and hydrogen by

turning the ammonia into a .....

(1)

(Total 7 marks)

M1.(a) sulfur / sulphur / S / S(s)

1

(b) as the temperature increases, the rate of reaction increases

allow two correct values for rate quoted (from graph) at different temperatures

1

the rate of increase increases **or** there is an exponential relationship

*accept the rate of reaction increases slowly (from 20 °C to 50 °C) then increases more rapidly for **2** marks*

answer MUST be based on rate / speed of reaction

1

(c) (i) any **two** from:

- temperature (of the reactants)
- concentration of hydrochloric acid
- volume of hydrochloric acid
- volume of sodium thiosulfate
- the (size / darkness / thickness of the) cross
- total volume of solution.

*if no other marks gained, allow **1** mark for:*

rate of stirring

OR

amount of hydrochloric acid / sodium thiosulfate

OR

volume of solution

2

(ii) (because as the concentration increases) the number of particles per unit volume increases **or** particles are closer together.

idea of more particles in a given space is required for the first mark.

ignore references to area.

1

(therefore) the frequency of (successful) collisions increases

allow increased chance / probability of collisions

number of collisions increases is insufficient here.

***must** mention per unit time or frequency.*

ignore speed of collisions.

if reference to space and time missing from M1 and M2 but they are otherwise correct, then award 1 mark.

1

so the number of particles (per unit volume) doubles **or** (the frequency of) collisions doubles.

*students can score **2** marks for a qualitative explanation; the third mark is for a quantitative explanation.*

1

[8]

M2.(a) (i) the higher the temperature, the greater the rate

or

at 40 °C rate is faster than at 20 °C

accept the higher the temperature, the faster the reaction

1

(ii) 40 °C curve is steeper

accept the 40 °C line becomes horizontal sooner

accept at higher temperatures the reaction finishes sooner

accept reaction finishes sooner at 40 °C

accept at higher temperatures the gas is produced faster

or

correct comparison of data from the graph

1

(iii) 2

1

(b) (i) Concentration of acid

Mass of marble chips

2

(ii) increases rate

*incorrect reference to energy = max **1***

1

(because of) more frequent collisions (between particles)

accept particles are more likely to collide

ignore more collisions

ignore more successful collisions

1

(c) any **one** from:

- increases rate of reaction
- reduces energy required
- lower temperature can be used
- catalyst is not used up.

1

[8]

M3.(a) (i) precipitation

1

(ii) (aq) on left hand side

1

(s) on right hand side

1

(iii) potassium iodide

1

potassium nitrate

1

(iv) filtration

1

(b) (i) diffusion

1

(ii) iodide ions move / diffuse faster than lead ions **or** travel further in the same time

Must be a comparison

Accept converse

1

because the lead iodide forms much closer to the lead nitrate (or **X**) than the potassium iodide (or **Y**).

allow because iodide ions are smaller than lead ions

allow references to potassium iodide and lead nitrate

1

(iii) the particles / ions move / diffuse faster

ignore which particles / ions the student refers to

1

because they have more energy **or** will collide / meet sooner

ignore reference to frequency of collisions

1

[11]

M4.(a) time from when the heating is started until

1

the limewater turns cloudy / milky

1

(b) (i) the temperature was not high enough

accept the copper carbonate had not started to decompose / react

accept it takes time to heat up the copper carbonate

1

the bubbles of gas were air

accept no carbon dioxide produced

1

(ii) the copper carbonate was decomposing / reacting

accept the temperature was high enough to cause decomposition / a reaction

1

so carbon dioxide was produced

allow correct word / symbol equation

1

(iii) copper oxide was produced

allow correct word / symbol equation

1

because the copper carbonate had <u>completely</u> decomposed / reacted

ignore all of the carbon dioxide had been given off

1

[8]

M5.(a) because sulfur / S forms

1

which is insoluble / a solid / a precipitate

1

(b) (i) 32

*correct answer with or without working gains **2** marks*

*accept evidence of 31 + 33 / 2 for **1** mark*

*allow 35 for **1** mark*

2

(ii) reaction rate increases

*if incorrect reference to energy = max **2***

1

because of more particles (per unit volume)

allow because particles are closer together

1

and because there is an increase in frequency of collisions

*accept because particles are more likely to collide **or** higher chance of collision*

ignore more (successful) collisions

1

[7]

M6.(a) (i) a continuous <u>straight line</u> missing anomalous point

allow a line which does not start at zero / origin

1

(ii) any **two** sensible errors eg

*ignore systematic / zero error / weighing error **or** error unqualified*

- timing errors and / or example
- measurement errors and / or example
- apparatus errors and / or example
- human / experimental / reading / random error and / or example

or 'did not do it right'

*could be two from **same** category*
eg two timing errors – watch not started at the same time plus difficulty in deciding when the cross has disappeared.

- temperature fluctuation
- anomalous point

accept outlier / wrong result

- results not recorded correctly
- plotting error
- rate calculated incorrectly

ignore 'not repeated'

2

(b) (i) <u>straight line</u>

*allow as concentration increases the rate goes up **or** converse*
allow numerical example
allow positive correlation
allow same gradient
ignore 'most points near / on line of best fit'

1

(ii) because of an increase in <u>frequency</u> of collisions

*max **1** if incorrect reference to energy **or** if subatomic particle specified*

accept because particles are more likely to collide or higher chance of collision

ignore more (successful) collisions

1

because there are more particles (per unit volume)

allow because particles are closer together

1

[6]

M7. (a) gives out energy **or** heat

1

(b) (i) *accept qualified answers in terms of volume of gas related to time*

fast initially

1

slows down

1

reaction stops

accept reaction is now very slow

1

(b) (ii) 21

1

(iii) 84

*correct answer with or without working = **2** marks*
*allow ecf from (b)(ii) correctly calculated for **2** marks*
*allow evidence of 21/25 **or** (b)(ii)/25 for **1** mark*

2

(c) because they / particles have more energy / move faster

ignore particles move more / vibrate

1

(and so) particles collide more often / more frequently **or** particles more likely to collide

ignore collide faster
ignore more collisions

1

(and) more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy

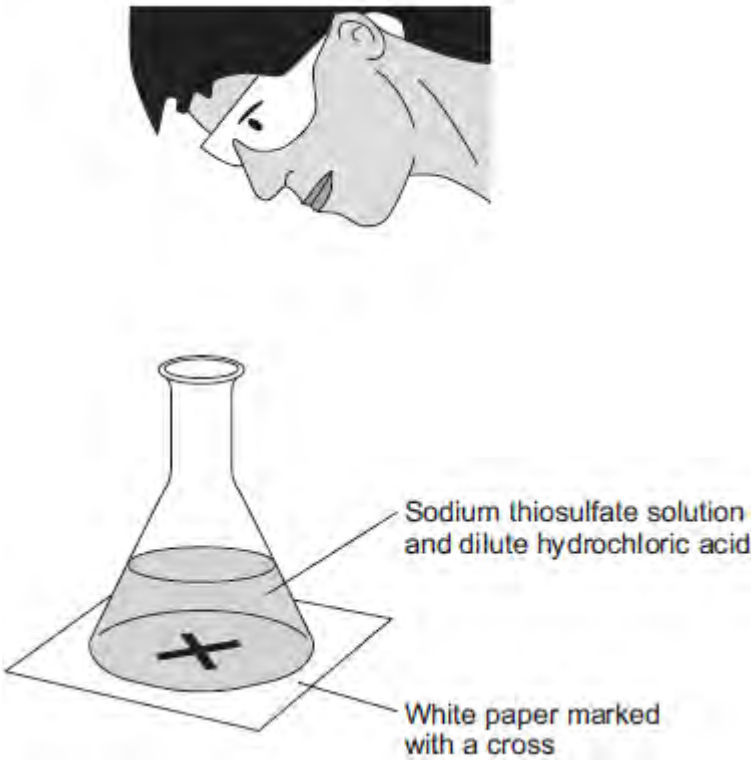
accept more successful collisions

1

[10]

Q1. A student investigated the rate of reaction between sodium thiosulfate solution and dilute hydrochloric acid, as shown in **Figure 1**.

Figure 1



The reaction produced a precipitate, which made the mixture turn cloudy.

The student timed how long it took until she could no longer see the cross.

She calculated the rate of the reaction.

(a) The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\ HCl(aq) \longrightarrow 2\ NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

Name the product that made the mixture go cloudy.

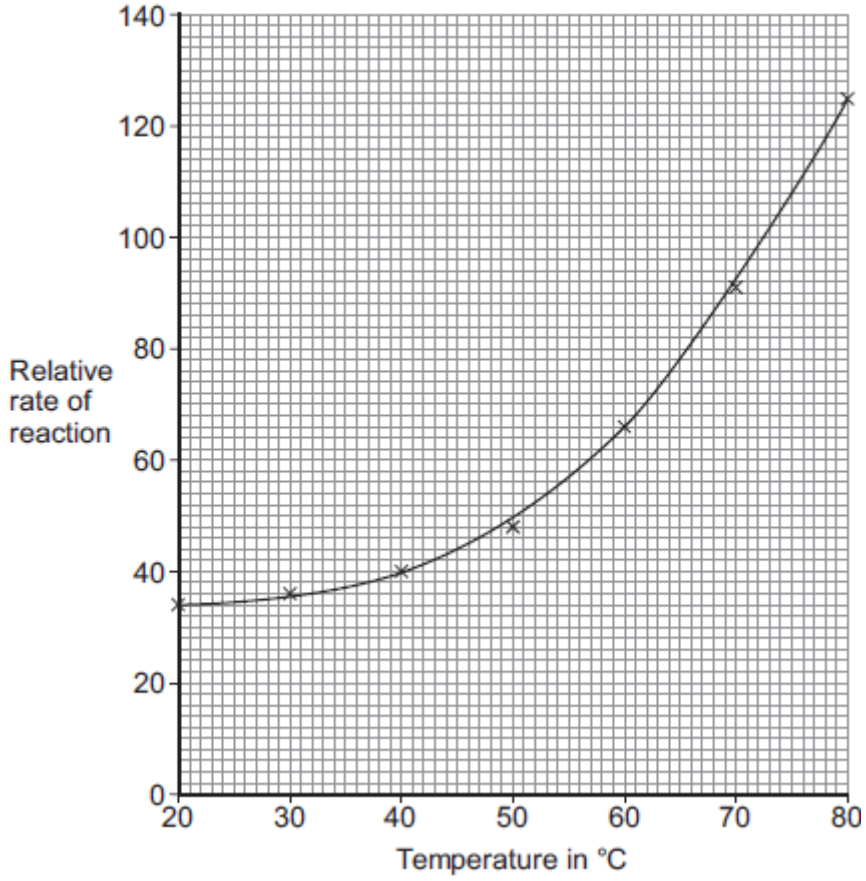
.....

(1)

(b) The student investigated the effect of changing the temperature of the sodium thiosulfate solution on the rate of reaction.

She plotted her results on a graph, as shown in **Figure 2**.

Figure 2



Describe the trends shown in the student's results.

.....

.....

.....

.....

.....

(2)

(c) The student then investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction.

(i) Suggest **two** variables the student would need to control to make sure that her results were valid.

.....

.....

.....

.....

(2)

(ii) From this investigation the student correctly concluded:

'As the concentration of sodium thiosulfate solution doubles, the rate of reaction doubles.'

Explain the student's conclusion in terms of particles.

.....

.....

.....

.....

.....

.....

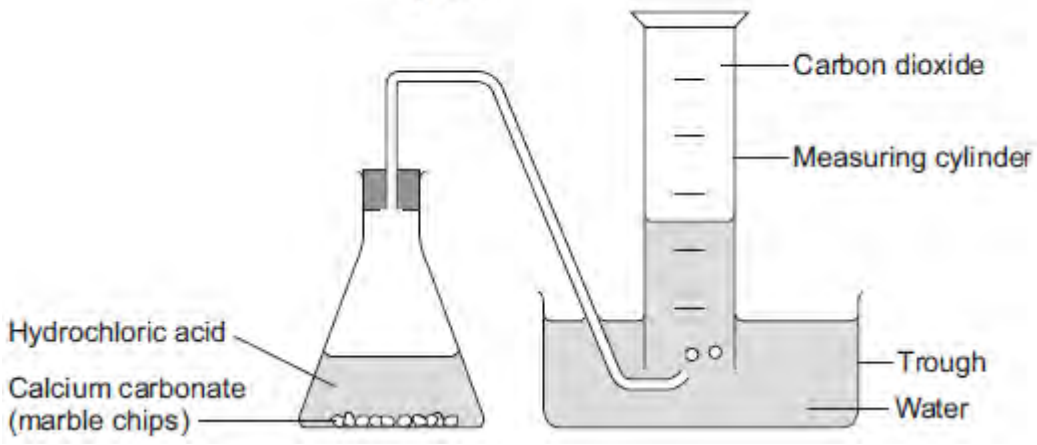
.....

(3)
(Total 8 marks)

Q2. A student investigated the rate of reaction between calcium carbonate (marble chips) and hydrochloric acid.

The student used the apparatus shown in **Figure 1**.

Figure 1



The student:

- recorded the volume of gas collected every 5 seconds
- repeated the experiment using hydrochloric acid at different temperatures.

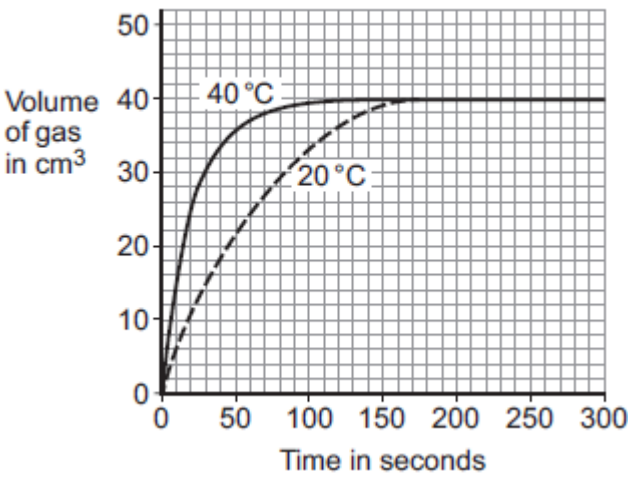
The equation for the reaction is:

$$CaCO_3(s) + 2\,HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a) The student plotted results for the hydrochloric acid at 20 °C and 40 °C on a graph.

Figure 2 shows the student's graph.

Figure 2



Use information from **Figure 2** to answer these questions.

(i) State **one** conclusion the student could make about the effect of temperature on the rate of the reaction.

.....

.....

(1)

(ii) Give **one** reason why the student could make this conclusion.

.....

.....

(1)

(iii) For the hydrochloric acid at 60 °C the student had collected 30 cm^3 after 15 seconds.

Calculate the average rate of reaction from 0 to 15 seconds.

.....

.....

Rate of reaction = ... cm^3 per second

(1)

(b) The student then investigated how the surface area of marble chips affected the rate of reaction.

(i) Which **two** variables should the student keep constant?

Tick (✓) **two** boxes.

Amount of water in the trough ☐

Concentration of acid ☐

Mass of marble chips ☐

Size of marble chips

Volume of measuring cylinder

(2)

(ii) Explain, in terms of particles and collisions, the effect that increasing the surface area of the marble chips has on the rate of reaction.

.....

.....

.....

.....

(2)

(c) Calcium carbonate is a catalyst for the industrial production of biodiesel.

Give **one** reason why using a catalyst reduces costs.

.....

.....

(1)
(Total 8 marks)

Q3. Lead nitrate solution reacts with potassium iodide solution.

The reaction produces a solid.

Figure 1 shows the reaction occurring.

Figure 1

Lead Iodide By Der Kreole (own work) (CC-BY-3.0) via Wikimedia Commons

(a) (i) Give the name of this type of reaction.

Tick (✓) **one** box.

Combustion ☐

Neutralisation ☐

Precipitation ☐

(1)

(ii) Write the missing state symbols in the chemical equation.

$$Pb(NO_3)_2(aq) + 2KI(.....) \longrightarrow PbI_2(.....) + 2KNO_3(aq)$$

(2)

(iii) Complete the word equation for the reaction.

lead nitrate + ... ⟶ lead iodide + ...

(2)

(iv) How is solid lead iodide separated from the solution?

Draw a ring around the correct answer.

Distillation **Electrolysis** **Filtration**

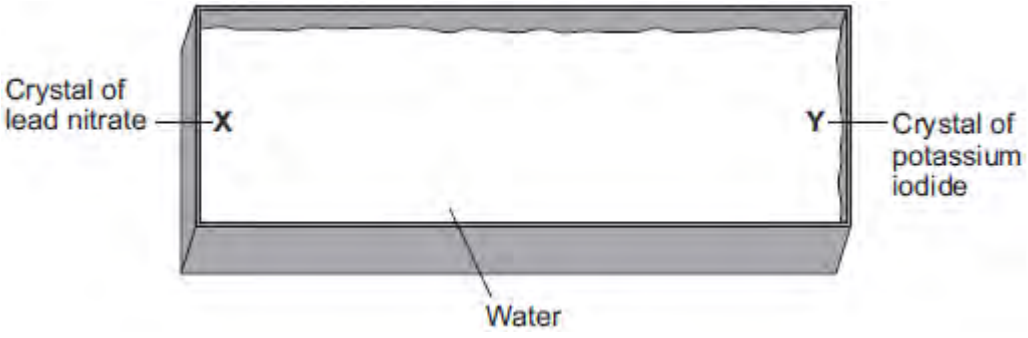
(1)

(b) A group of students investigated the movement of particles.

The students filled a container with water.

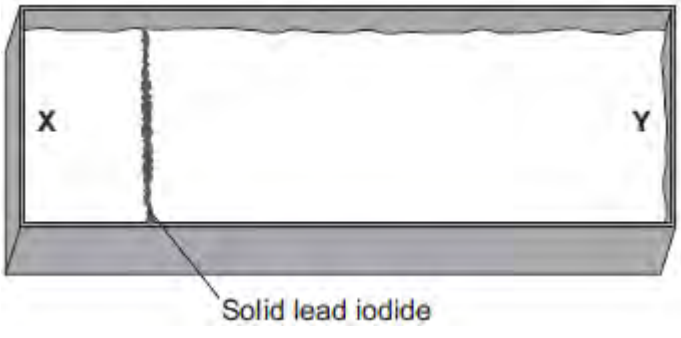
The students added a crystal of lead nitrate at position **X** and a crystal of potassium iodide at position **Y**, as shown in **Figure 2**.

Figure 2 – view from above



After 3 minutes solid lead iodide started to form at the position shown in **Figure 3**.

Figure 3 – view from above



(i) Tick (✓) the correct box to complete the sentence.

Lead ions and iodide ions move through the water by

diffusion. ☐

evaporation. ☐

neutralisation. ☐

(1)

(ii) What conclusion can you make about the speed of movement of lead ions compared with iodide ions?

Give a reason for your answer.

.....

.....

.....

.....

(2)

(iii) The students repeated the experiment at a higher temperature.

The solid lead iodide formed after a shorter period of time.

Explain why, in terms of particles.

.....

.....

.....

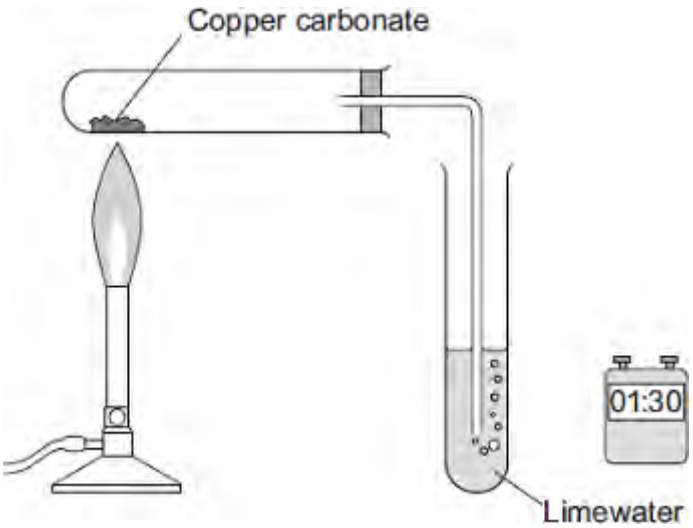
.....

(2)

(Total 11 marks)

Q4. Carbon dioxide is produced when copper carbonate is heated.

A student investigated heating copper carbonate.
The student used the apparatus to measure how long it took for carbon dioxide to be produced.
The student also noted what happened during each minute for three minutes.



(a) The student used changes to the limewater to measure how long it took for carbon dioxide to be produced.

Describe how.

.....

.....

.....

.....

(2)

(b) The student wrote down her observations.

Time interval in minutes	**Observations**
Between 0 and 1	A slow release of gas bubbles. The limewater did not change. The solid in the test tube was green.
Between 1 and 2	A fast release of gas bubbles.

	The limewater changed at 1 minute 10 seconds.
Between 2 and 3	No release of gas bubbles. The solid in the test tube was black.

(i) Suggest the reason for the student's observations between 0 and 1 minute.

.....

.....

.....

.....

.....

(2)

(ii) Explain the student's observations between 1 and 2 minutes.

.....

.....

.....

.....

(2)

(iii) Explain the student's observations between 2 and 3 minutes.

.....

.....

.....

.....

(2)

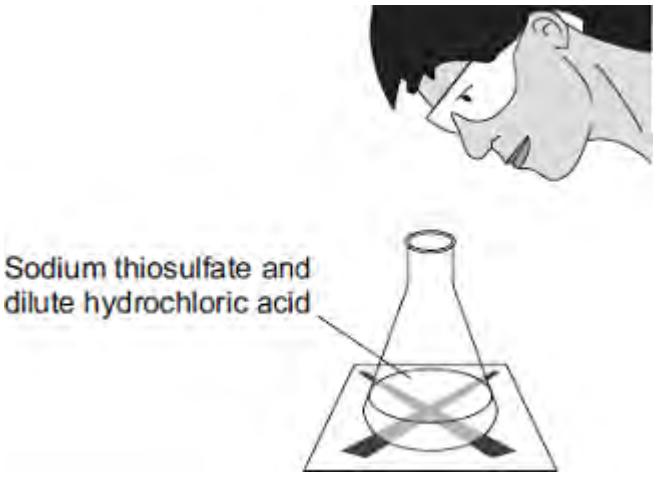
Q5.A student investigated the rate of reaction between sodium thiosulfate and dilute hydrochloric acid.

The student placed a conical flask over a cross on a piece of paper.

The student mixed the solutions in the flask.

The solution slowly went cloudy.

The student timed how long it took until the cross could not be seen.



The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$$

sodium thiosulfate + hydrochloric acid → sodium chloride + water + sulfur dioxide + sulfur

(a) Explain why the solution goes cloudy.

.....

.....

.....

.....

(2)

(b) The student repeated the experiment with different concentrations of sodium thiosulfate.

Concentration of	**Time taken until the cross could not be**

sodium thiosulfate in moles per dm^3	seen in seconds			
	Trial 1	**Trial 2**	**Trial 3**	**Mean**
0.040	71	67	69	69
0.060	42	45	45	44
0.080	31	41	33	

(i) Calculate the mean time for 0.080 moles per dm^3 of sodium thiosulfate.

.....

.....

.....

Mean = ... seconds

(2)

(ii) Describe and explain, in terms of particles and collisions, the effect that increasing the concentration of sodium thiosulfate has on the rate of the reaction.

.....

.....

.....

.....

.....

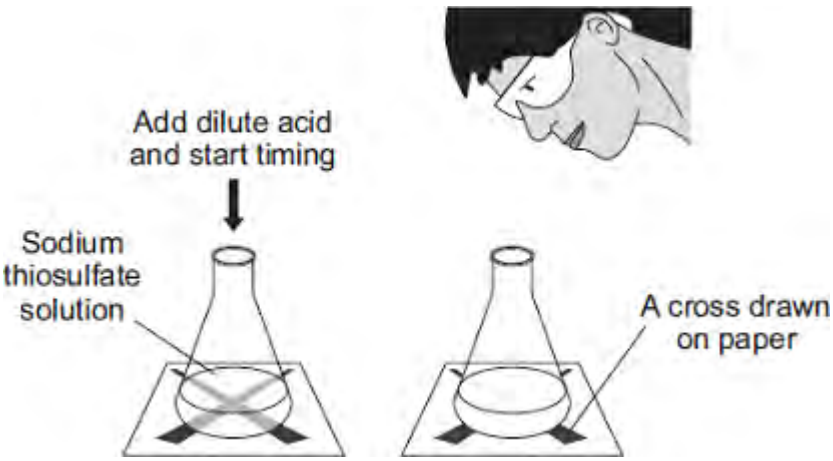
.....

(3)

(Total 7 marks)

Q6. Sodium thiosulfate solution reacts with hydrochloric acid. As the reaction takes place the solution slowly turns cloudy.

The diagram shows a method of measuring the rate of this reaction.



A student used this method to study how changing the concentration of the sodium thiosulfate solution alters the rate of this reaction.

The student used different concentrations of sodium thiosulfate solution. All the other variables were kept the same.

The results of the experiments are shown on the graph below.

(a) (i) Draw a line of best fit on the graph.

(1)

(ii) Suggest **two** reasons why all of the points do not lie on the line of best fit.

.....

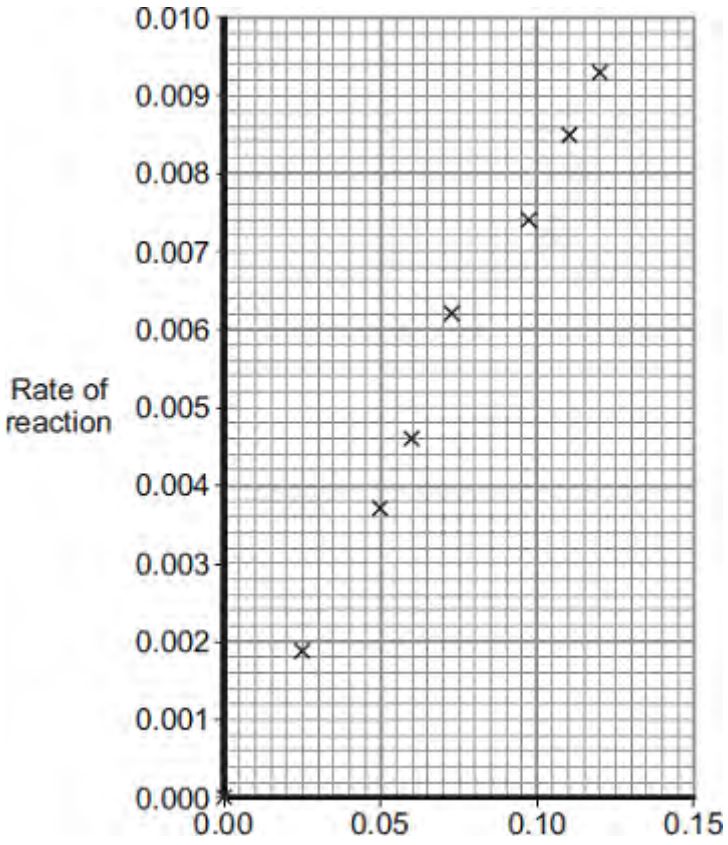
.....

.....

.....

.....

(2)



(b) (i) In a conclusion to the experiment the student stated that:

'The rate of this reaction is directly proportional to the concentration of the sodium thiosulfate.'

How does the graph support this conclusion?

.....

.....

(1)

(ii) Explain, in terms of particles, why the rate of reaction increases when the concentration of sodium thiosulfate is increased.

.....

.....

.....

.....

(2)
(Total 6 marks)

Q7. The symbol equation for the decomposition of hydrogen peroxide is:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) This reaction is *exothermic*.

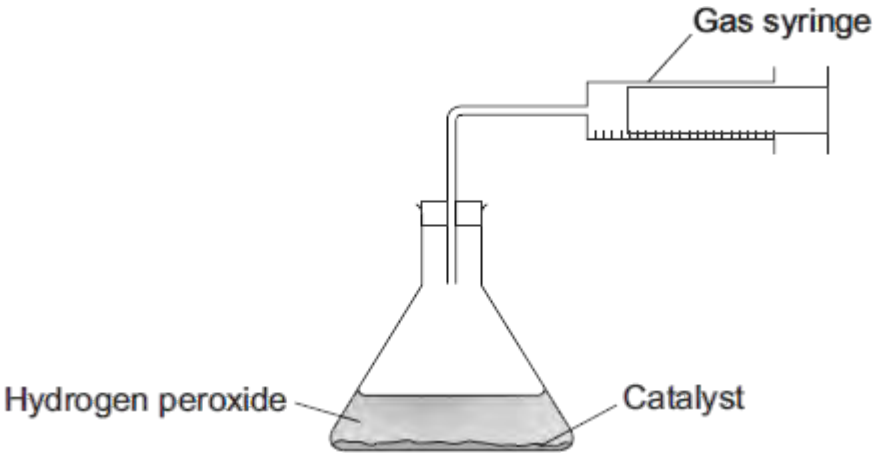
What is an *exothermic* reaction?

.....

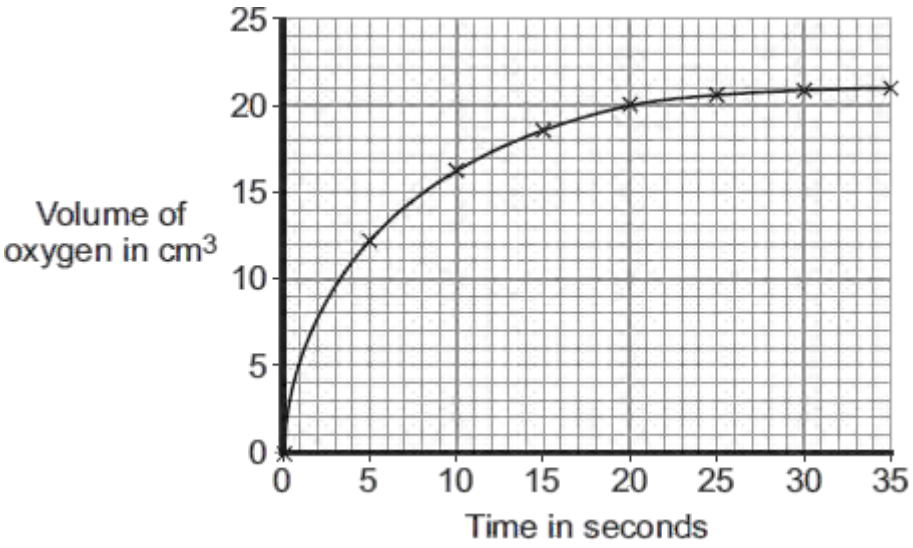
.....

(1)

(b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



(i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

.....

.....

.....

.....

.....

.....

(3)

(ii) What was the total volume of oxygen gas collected?

..... cm^3

(1)

(iii) The student had calculated that the hydrogen peroxide used should produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

.....

.....

.....

Answer = ... %

(2)

(c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

.....

.....

.....

.....

.....

.....

(3)

(Total 10 marks)

M1.(a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

2

*allow **1** mark for correct formulae*

(b) sensible scales, using at least half the grid for the points

1

all points correct

± ½ small square

*allow **1** mark if 8 or 9 of the points are correct*

2

best fit line

1

(c) steeper line to left of original

1

line finishes at same overall volume of gas collected

1

(d) acid particles used up

allow marble / reactant used up

1

so concentration decreases

allow surface area of marble decreases

1

so less frequent collisions / fewer collisions per second

*do **not** accept fewer collisions unqualified*

1

so rate decreases / reaction slows down

1

(e) mass lost of 2.2 (g)

1

time taken of
270 s

allow values in range 265 − 270

1

$$\frac{2.2}{270} = 0.00814814$$

allow ecf for values given for mass and time

1

0.00815 (g / s)

or

8.15×10^{-3}

*allow **1** mark for correct calculation of value to 3 sig figs*
*accept 0.00815 or 8.15×10^{-3} with no working shown for **4** marks*

1

(f) correct tangent

1

eg 0.35 / 50

1

0.007

allow values in range of 0.0065 − 0.0075

1

7×10^{-3}

1

*accept 7×10^{-3} with no working shown for **4** marks*

[20]

M2.(a) (s) (aq) (aq) (g)

must be in this order

2 *marks if all four correct*

1 *mark if 2 or 3 correct*

2

(b) (i) 55

ignore units

1

(ii) 54

allow ecf from ***(b)(i)***

1

(iii) 0.92

correct answer with or without working gains ***2*** *marks*

ecf from volume in ***(b)(i)***

accept 2 d.p. up to calculator value

if answer incorrect, allow rate = (b)(i) / 60 for ***1*** *mark*

2

(c) (i) circle round point at (48,22)

1

(ii) problem (1) and explanation (1)

explanation ***must*** *give lower volume of gas or slower reaction*

ignore human error unless qualified

problem with bung

e.g. bung not placed in firmly / quickly enough

so gas lost

or

problem with reagent

e.g. acid was diluted **or** acid not replaced

so reaction slower

or

problem with temperature

e.g. temperature was lower than recorded temperature

so reaction slower

or

problem with measurement

e.g. length of magnesium less than 8 cm **or** timed for less than a minute

so less gas produced

2

(d) repeat the experiment (several times)

1

because anomalous results could be excluded

1

and then the mean can be determined / calculated

*accept suggestion of alteration to method, which is explained as to why it would reduce the error, for **3** marks (e.g. place the magnesium in a container within the flask (1) so it can be tipped into the acid once the bung is in place (1). This will prevent anomalous results or gas loss (1))*

ignore idea of more accurate gas syringe
ignore shorter time intervals

1

(e) (i) use clean magnesium **or** use magnesium without oxide coating

1

compare results

1

(ii) **either**

measure the temperature of the acid before (adding magnesium)

1

and after adding magnesium

or

place the conical flask in a water bath (at 40 °C) (1)

compare results (1)

1

[16]

M3. (a) 118

1

(b) it loses / transfers electrons

it = Au / gold atom

1

three electrons

*sharing / covalency = max **1** mark*

1

(c) (i) O_2

1

2 CO and **2** CO_2

or

correct balancing of equation from O

accept correct multiples / fractions throughout

1

(ii) *reference to incorrect bonding = **1** mark max*

because carbon dioxide is simple molecular / small molecules

1

there are *intermolecular* forces (between the molecules)

allow intermolecular bonds

1

so a small amount of energy needed (to separate molecules) **or** (*intermolecular forces*) are weak

1

(d) any **three** from:

- gold is the only catalyst for some reactions
- catalysts are not used up
- improves speed of reaction

  reduces amount of energy **or** process needs low(er) temperature

  *if no mark awarded, allow catalyst reduce costs (of the process) for **1** mark*

- only small quantities (of catalyst) needed

3

[11]

M4. (a) same number of (gaseous) molecules / moles / volume on both sides of the equation

allow particles for molecules

*do **not** accept atoms*

ignore amount

1

(b) (forward) reaction is exothermic

accept reverse answer

1

(c) any **three** from:

- particles gain energy
- particles move faster

  allow particles collide faster / quicker

  ignore move more / vibrate more
- particles collide more **or** more collisions
- more of the collisions are successful **or**
  more of the particles have the activation energy **or**
  particles collide with more force / energy

3

(d) any **two** from:

- more product (obtained in shorter time)

  accept better yield (of product)
- less fuel needed

  accept less energy / heat / electricity needed

  or

  lower fuel costs

  ignore cheaper unqualified
- less pollution caused by burning fuels

or

less specified type of pollution caused by producing heat / burning fuels

*allow correct specified pollutants caused by burning fossil fuels eg CO_2 / greenhouse gases **or** correct effect of burning fossil fuels eg global warming*

accept thermal / heat pollution

- using less fuel conserves resources

  accept sustainable

  accept fossil fuels are non-renewable

2

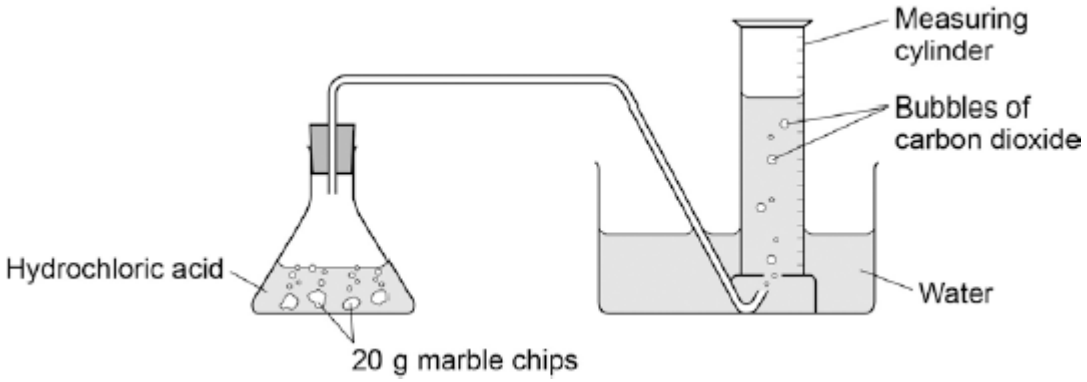
[7]

Q1. Marble chips are mainly calcium carbonate ($CaCO_3$).

A student investigated the rate of reaction between marble chips and hydrochloric acid (HCl).

Figure 1 shows the apparatus the student used.

Figure 1



(a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.

..... + ... → $CaCl_2$ + ... + ...

(2)

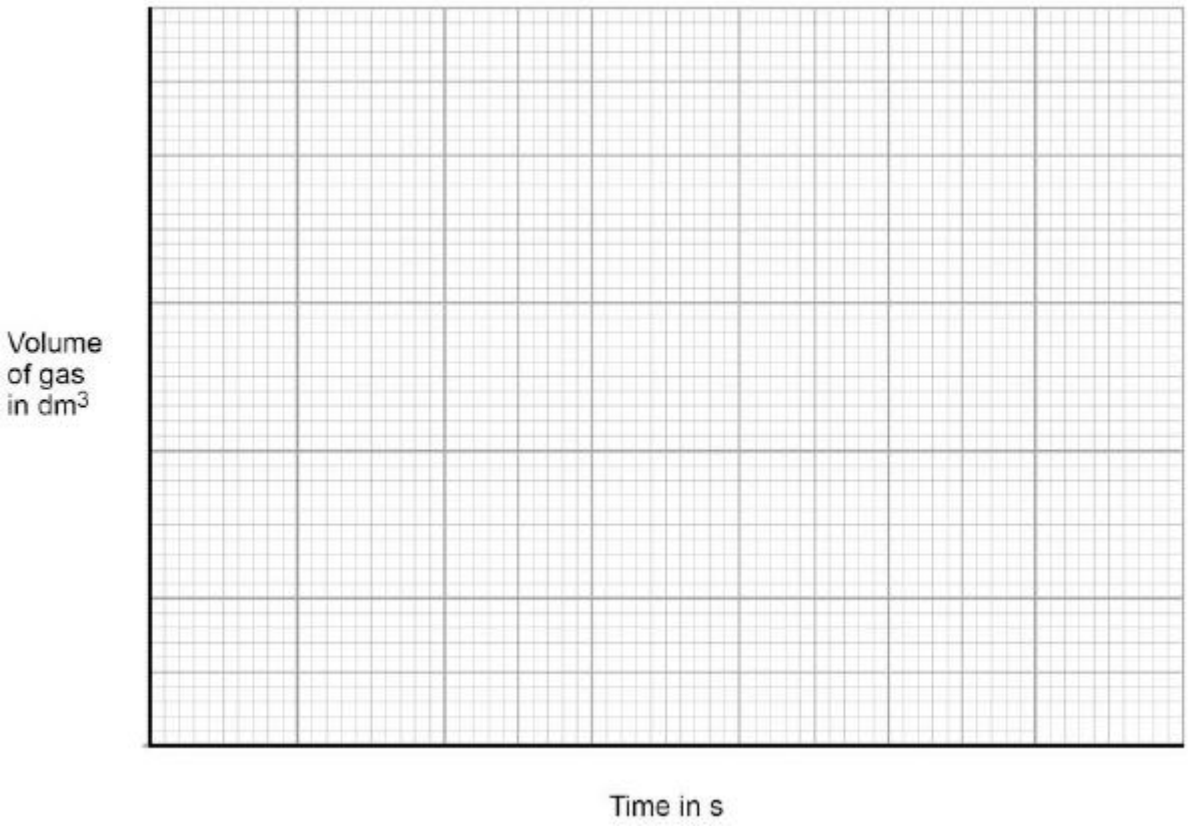
(b) The table below shows the student's results.

Time in s	Volume of gas in dm^3
0	0.000
30	0.030
60	0.046
90	0.052
120	0.065
150	0.070
180	0.076
210	0.079
240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

(c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

.....

.....

.....

.....

.....

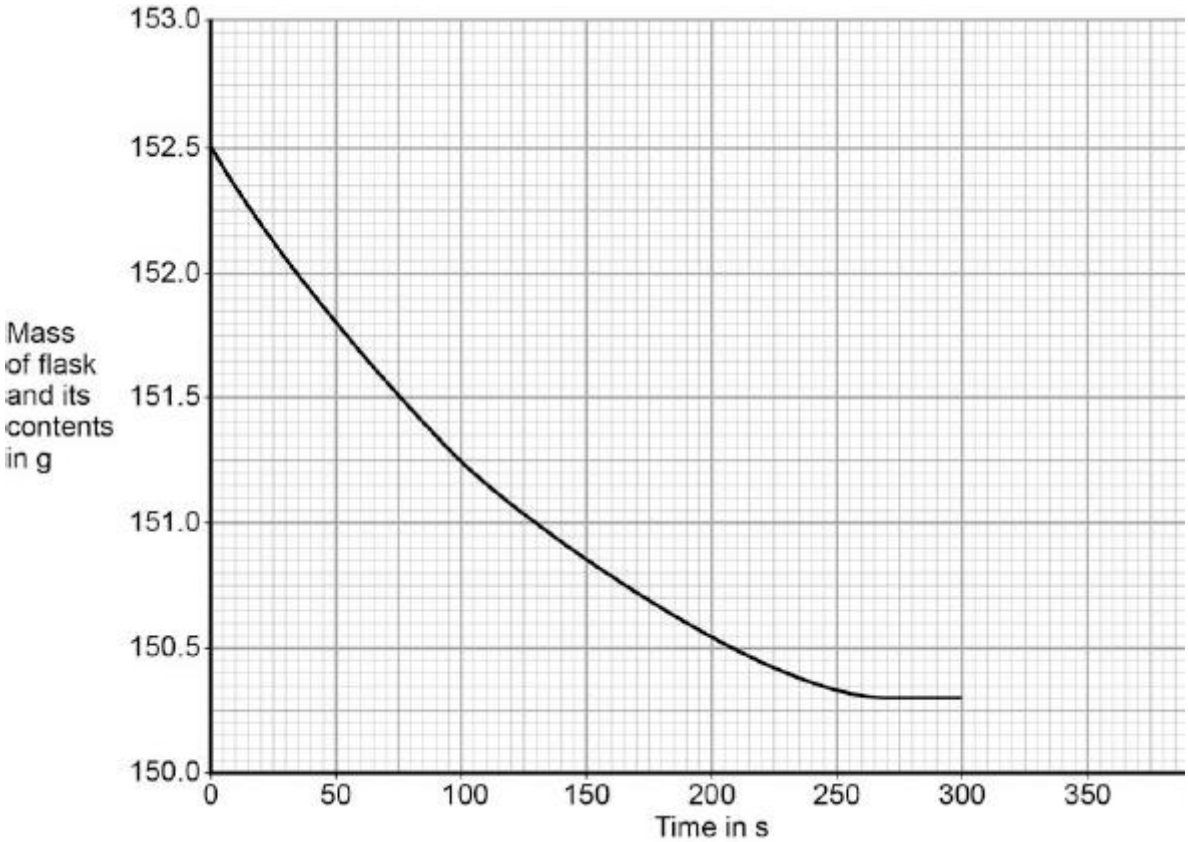
.....

(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

.....

.....

.....

.....

.....

.....

.....

.....

Mean rate of reaction = ... g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

.....

.....

.....

.....

.....

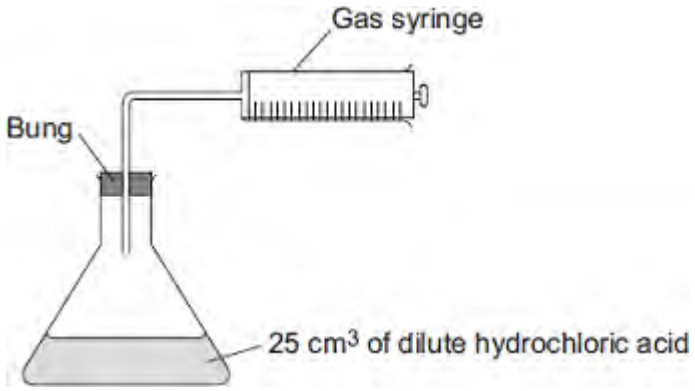
Rate of reaction at 150 s = ... g / s

(4)

(Total 20 marks)

Q2.A student investigated the reaction between magnesium metal and dilute hydrochloric acid.

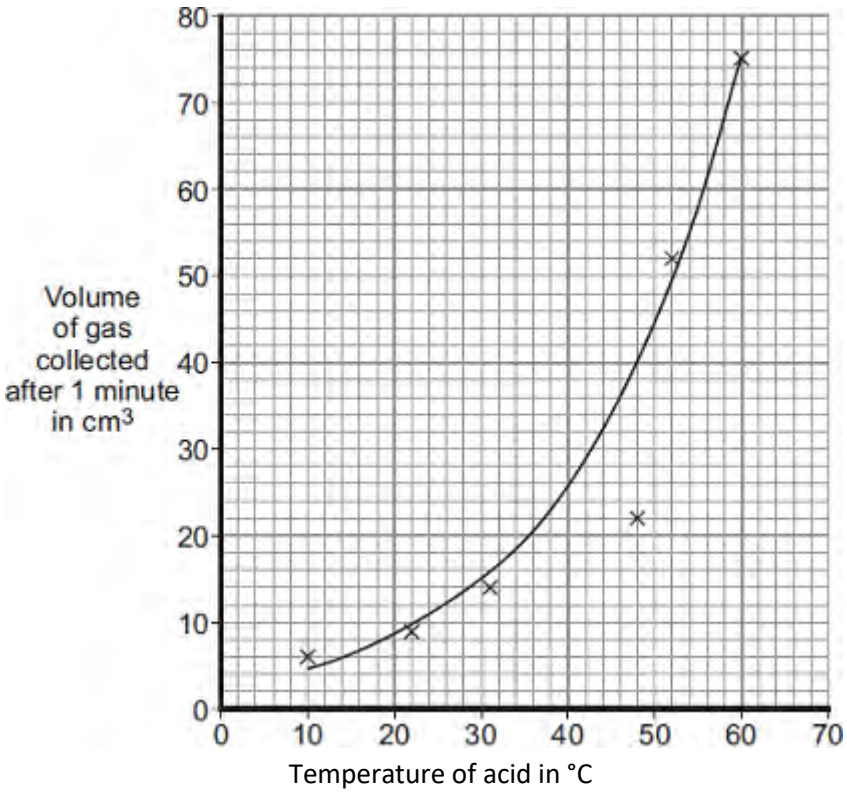
The student placed 25 cm^3 of dilute hydrochloric acid in a conical flask and set up the apparatus as shown in the diagram.



The student:

- took the bung out of the flask and added a single piece of magnesium ribbon 8 cm long
- put the bung back in the flask and started a stopwatch
- recorded the volume of gas collected after 1 minute
- repeated the experiment using different temperatures of acid.

The student plotted his results on a graph.



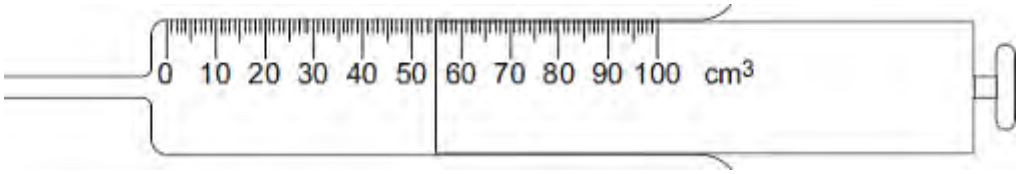
(a) Write the correct state symbols in the equation.

Choose from (s) for solid, (l) for liquid, (g) for gas and (aq) for aqueous.

$Mg(....) + 2HCl(....) \longrightarrow MgCl_2(....) + H_2(....)$

(2)

(b) The diagram shows a gas syringe after 1 minute.



(i) What volume of gas has been collected in the gas syringe after 1 minute?

Volume = ... cm^3

(1)

(ii) Use the graph to determine the temperature of the acid used in this experiment.

Temperature = ... °C

(1)

(iii) Calculate the average rate of reaction, in cm^3 of hydrogen made per second (cm^3/s), for this experiment.

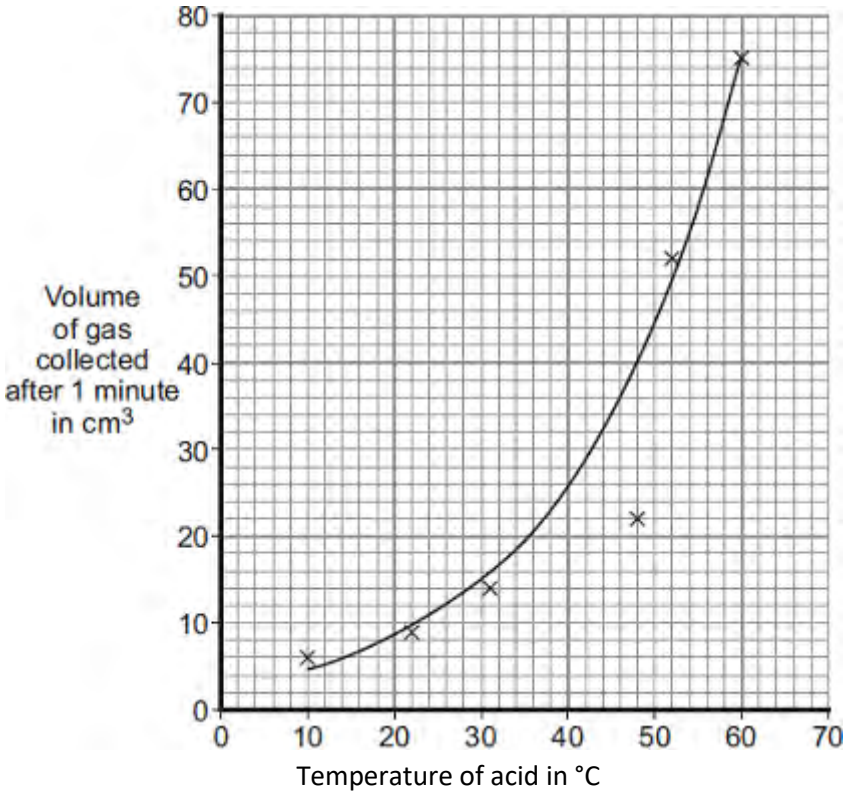
.....

.....

Rate of reaction = ... cm^3/s

(2)

(c) The student's graph has been reprinted to help you answer this question.



One of the results on the graph is anomalous.

(i) Draw a circle on the graph around the anomalous point.

(1)

(ii) Suggest what may have happened to cause this anomalous result.

Explain your answer.

.....

.....

.....

.....

.....

.....

(2)

(d) Explain how the student could improve the accuracy of the volume of gas recorded at each temperature.

.....

.....

.....

.....

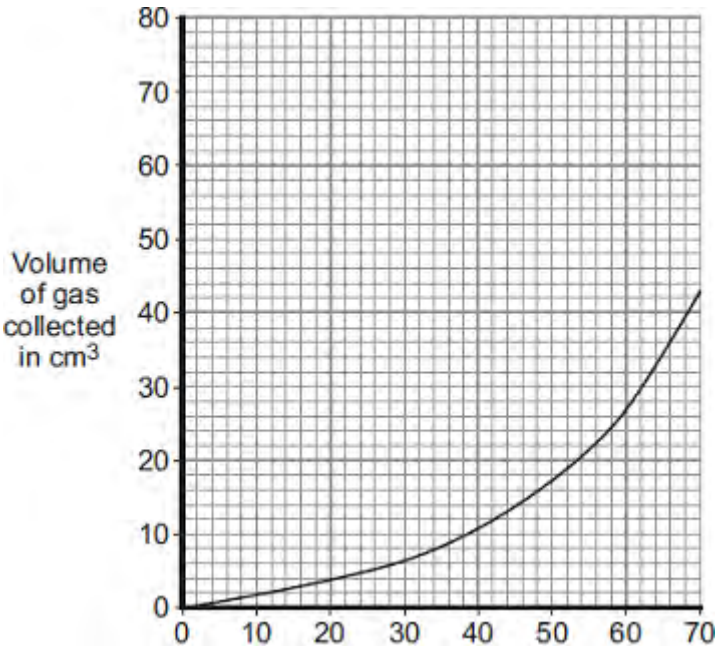
.....

.....

(3)

(e) The student then used the same apparatus to measure the volume of gas produced every 10 seconds at 40 °C.

The student's results are shown on the graph.



The rate at which the gas was produced got faster over the first 60 seconds.

The student's teacher gave two possible explanations of why the reaction got faster.

Explanation 1
There was a layer of magnesium oxide on the surface of the magnesium.
The layer of magnesium oxide prevented the magnesium reacting with the acid.
As the magnesium oxide reacted slowly with the acid, the magnesium was exposed to the acid and hydrogen gas was produced.

Explanation 2
The reaction is exothermic, and so the temperature of the acid increased during the reaction.

(i) Describe further experimental work the student could do to see if **Explanation 1** is correct.

.....

.....

.....

.....

.....

(2)

(ii) Describe further experimental work the student could do to see if **Explanation 2** is correct.

.....

.....

.....

.....

.....

(2)
(Total 16 marks)

Q3. This question is about gold (Au).

(a) An atom of gold is represented as:

$$^{197}_{79}\mathrm{Au}$$

How many neutrons are in this atom of gold? .....

(1)

(b) Gold ions are used as a catalyst.

How does a gold atom (Au) become a gold ion (Au^{3+})?

.....

.....

.....

.....

(2)

(c) A gold catalyst can be used when carbon monoxide reacts with oxygen to make carbon dioxide.

(i) Complete and balance the equation for this reaction.

.... CO + ... → ..... CO_2

(2)

(ii) Carbon dioxide has a very low boiling point.

Explain why.

.....

.....

.....

.....

.....

.....

(3)

(d) Gold is used as a catalyst in industrial processes. Gold is rare and increasingly expensive.

Suggest **three** reasons why gold is still used in industrial processes.

.....

.....

.....

.....

.....

.....

(3)
(Total 11 marks)

Q4. The equation for a reaction to produce hydrogen is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

(a) Explain why changing the pressure does **not** affect the yield of hydrogen at equilibrium.

.....

.....

(1)

(b) Suggest why the best yield of hydrogen at equilibrium is obtained at **low** temperatures.

.....

.....

(1)

(c) The temperature used in industry needs to be high enough for the reaction to take place quickly. Explain, in terms of particles, why the rate of reaction increases when the temperature is increased.

.....

.....

.....

.....

.....

.....

(3)

(d) Scientists have developed catalysts which allow the reaction to take place quickly at lower temperatures. How could this be good for the manufacturer and for the environment?

.....

.....

.....

.....

(2)
(Total 7 marks)

M1.(a) reversible

allow equilibrium

1

(b) The colour changed from blue to pink

1

(c) 8.3 (°C)

1

(d) endothermic

allow dehydration

ignore reversible

1

[4]

M2.(a) natural gas

allow correct answer shown in box if answer line blank

1

(b) (i) 450

allow correct answer shown in box if answer line blank

1

(ii) iron

allow correct answer shown in box if answer line blank

1

(iii) The catalyst lowers the activation energy.

1

(c) (the gases are) cooled

1

ammonia condenses

allow ammonia liquefies

1

nitrogen and hydrogen are recycled

*if no other mark awarded allow ammonia is separated for **1** mark*

1

[7]

M3. (a) reversible

1

(b) (from blue) to pink

*do **not** accept*

incorrect initial colour

1

(c) sensible answers such as:

- stop water reaching papers

  accept stop entry of moisture / wet / dampness / condensation

- water (vapour) in air

  ignore references to toxicity of cobalt chloride

1

[3]

M4. (a) (i) 10

1

(ii) OH^-

1

(b) (i) air

1

(ii) particles move faster

1

particles collide more often

1

(iii) catalyst(s)

1

(c) liquid

1

[7]

M5. (a) 22

1

(b) (i) exothermic

1

(ii) C

1

gives out most heat energy

accept has largest temperature change / increase

*allow has highest (final) temperature **or** hottest*

1

(c) (i) increases

1

(ii) blue

ignore pale / dark etc

1

(iii) reversible (reaction)

*allow goes both ways **or** two / either way*

1

(iv) <u>anhydrous</u> copper sulfate

1

[8]

M6. (a) gases

1

white

1

solid

1

ammonium chloride

1

(b) reversible

allow phonetic spelling

allow goes both / two / either way(s)

1

[5]

M7. (a) increases

1

(b) the reaction is reversible

1

(c) A liquid

1

(d) recycled / reused (owtte)

accept returned to pump / start

1

[4]

M8. (a) white to blue

accept colourless to blue

1

(b) reversible

1

[2]

M9. (a) water

*accept H_2O **or** $5H_2O$*

2 must be below halfway

1

(b) the cold water / ice / cubes (owtte)

*accept 'cooled down' **or** references to cold*

1

(c) reversible reaction

1

(d) (i) 0.87g

1

(ii) the student made errors in weighing during the experiments

1

the student did not heat the copper sulfate for long enough in one of the experiments

1

(e) white

1

blue

*allow **1** mark for blue to white*

1

[8]

M10. (a) (i) nitrogen + hydrogen → ammonia

accept full correct balanced equation

1

(ii) reversible (reaction) (owtte)

*do **not** allow just 'backwards' (unqualified)*

1

(iii) catalyst / speed up reaction

accept to lower activation energy

1

(iv) boiling point

1

(v) recycled (owtte)

1

(b) (i) used to make explosives (owtte) used to make medicines (owtte)

1

(ii) used to make fertilisers (owtte)

1

(c) (i) sensible answers such as

provides workers (owtte)

good transport links

ignore reference to raw materials

1

(ii) sensible idea

1

linked reason

idea

linked reason

eg escape of chemicals /fumes /waste gases / pollution

harmful to health / environmental damage owtte

*do **not** allow harmful / damage / smell (unqualified)*

risk of explosion

because of high pressures / may endanger local people / dangerous

risk of fire

because of high temperatures / may endanger local people

noise

*any detrimental effect on quality of life **or** night and day*

lorries / traffic

danger / noise / pollution etc

unsightly

detrimental effect on quality of life / house prices / reduced tourism

uses a lot of land

loss of habitats

1

[10]

Q1. The word equation shows the reaction between anhydrous cobalt chloride and water.

anhydrous cobalt chloride (blue) + water ⇌ hydrated cobalt chloride (pink)

(a) Name the type of reaction shown by the sign ⇌

.....

(1)

(b) When the student added water to anhydrous cobalt chloride what happened?

.....

(1)

(c) A student measured the temperature rise when anhydrous cobalt chloride was added to water.

The student's results are shown in the table below.

	Trial 1	**Trial 2**	**Trial 3**
Temperature rise in °C	8.5	8.2	8.2

Calculate the mean temperature rise.

.....

Temperature = ... °C

(1)

(d) When water was added to anhydrous cobalt chloride an exothermic reaction took place.

Name the type of reaction when hydrated cobalt chloride reacts to form anhydrous cobalt chloride and water.

.....

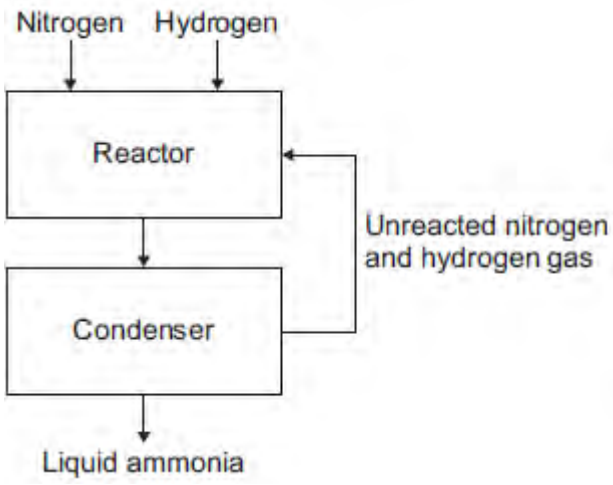
.....

(1)

(Total 4 marks)

Q2.A flow diagram of the Haber process is shown below.

The Haber process produces ammonia from nitrogen and hydrogen.



(a) Use the correct answer from the box to complete the sentence.

air	**limestone**	**natural gas**

Hydrogen is obtained from ..... .

(1)

(b) In the reactor, nitrogen and hydrogen at a high pressure are heated and passed over a catalyst.

(i) Use the correct answer from the box to complete the sentence.

25	**100**	**450**

The temperature in the reactor is ..... °C

(1)

(ii) Use the correct answer from the box to complete the sentence.

copper	iron	nickel

The catalyst used in the reactor is ..... .

(1)

(iii) How does a catalyst speed up a reaction?

Tick (✓) **one** box.

The catalyst lowers the activation energy. ☐

The catalyst gives the reactants extra energy. ☐

The catalyst increases the pressure in the reactor. ☐

(1)

(c) A mixture of gases leaves the reactor.

The mixture contains ammonia, nitrogen and hydrogen.

Describe what happens to this mixture of gases in the condenser.

Use the flow diagram to help you.

.....

.....

.....

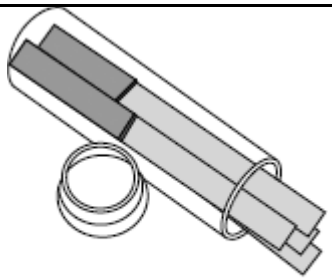
.....

.....

.....

(3)
(Total 7 marks)

Q3. Read the information and then answer the questions.



Cobalt chloride paper can be used to test for water.

The paper contains anhydrous cobalt chloride.

The jar containing the papers must be kept closed when not being used.

The equation shows the reaction between anhydrous cobalt chloride and water.

$$CoCl_2 + 6\,H_2O \rightleftharpoons CoCl_2.6H_2O$$

anhydrous cobalt chloride (blue) — hydrated cobalt chloride (pink)

(a) Choose **one** word from the box to complete the sentence.

endothermic	**exothermic**	**reversible**

The symbol $\rightleftharpoons$ means that the reaction is .....

(1)

(b) Describe the colour change when water is added to the cobalt chloride paper.

.....

.....

(1)

(c) Suggest why the jar containing the unused cobalt chloride papers must be kept closed.

.....

.....

(1)
(Total 3 marks)

Q4. (a) Ammonia solution is used in cleaning products to remove grease from kitchen surfaces.

Ammonia solution is alkaline.

(i) Draw a ring around the number most likely to be the pH of ammonia solution.

1 **3** **7** **10**

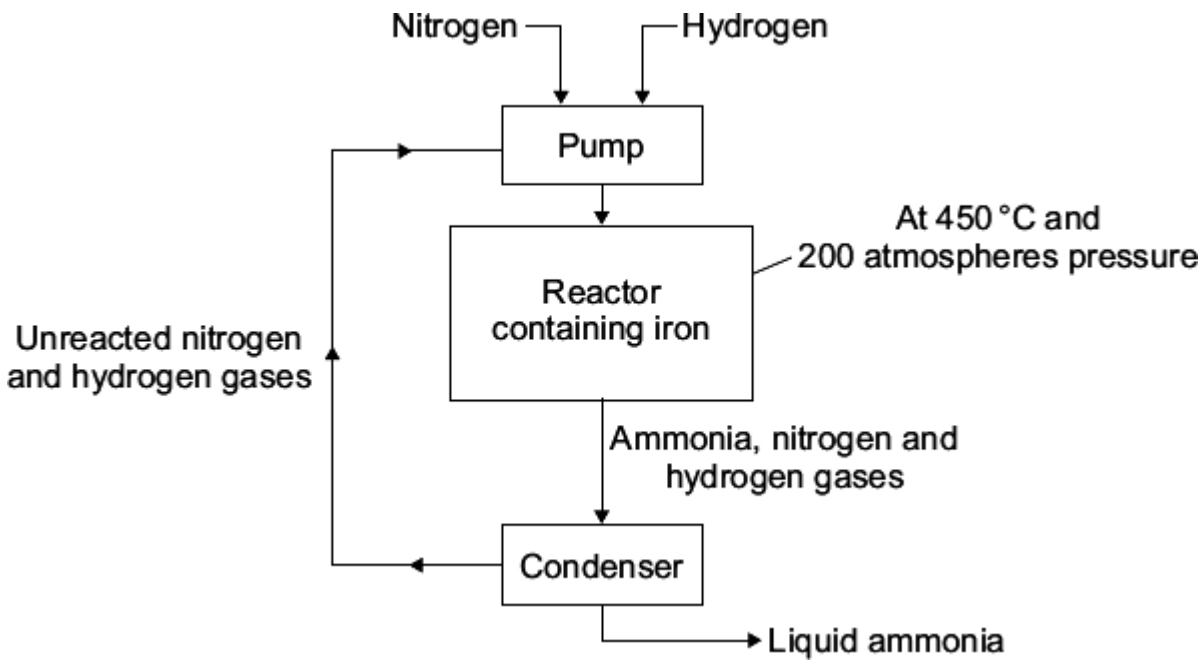
(1)

(ii) Draw a ring around the ion in ammonia solution which makes it alkaline.

Cl^- **H^+** **Na^+** **OH^-**

(1)

(b) Ammonia is made using the Haber process.



(i) Where does the nitrogen used in the Haber process come from?

Draw a ring around your answer.

air **natural gas** **water**

(1)

(ii) A high temperature of 450 °C is used in the reactor.

Tick (✓) **two** reasons in the table which explain why high temperatures make reactions faster.

Reasons	**Tick (✓)**
Particles move faster	
Particles are closer together	
Particles collide more often	
Particles have less energy	

(2)

(iii) The iron in the reactor speeds up the reaction but is not used up.

What is the name given to substances that speed up the chemical reaction but which are not used up during the reaction?

.....

(1)

(c) Complete the sentence.

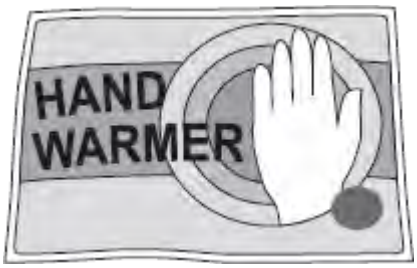
The condenser separates the ammonia from the unreacted nitrogen and hydrogen by

turning the ammonia into a .....

(1)

(Total 7 marks)

Q5. Hand warmers use chemical reactions.



(a) The table shows temperature changes for chemical reactions **A**, **B** and **C**.

Reaction	Starting temperature in °C	Final temperature in °C	Change in temperature in °C
A	18	25	+ 7
B	17	.....	+ 5
C	18	27	+ 9

What is the final temperature for reaction **B**? Write your answer in the table.

(1)

(b) (i) What name is given to reactions that heat the surroundings? .....

(1)

(ii) Which reaction, **A**, **B** or **C**, would be best to use in a hand warmer?

Reaction ☐

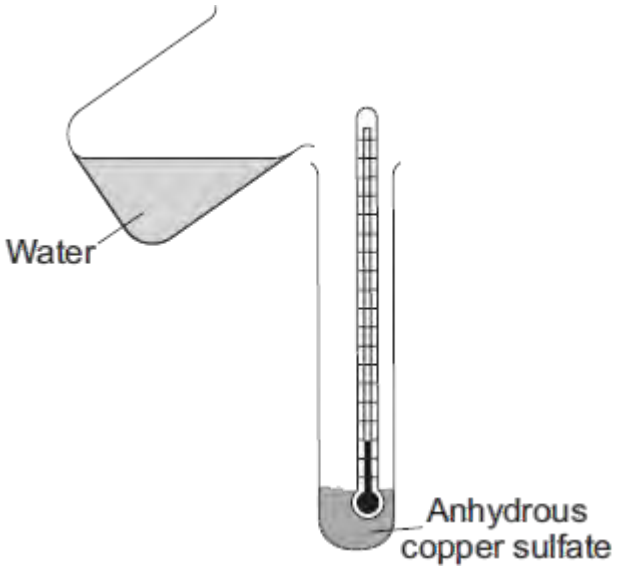
Give a reason why you chose this reaction.

.....

.....

(2)

(c) A student added water to some anhydrous copper sulfate.



The equation for the reaction is shown.

anhydrous copper sulfate + water ⇌ hydrated copper sulfate

$CuSO_4$ + 5 H_2O ⇌ $CuSO_4.5H_2O$

The student measured the temperature before and after the reaction.

(i) The measurements showed that this reaction can be used for a hand warmer.

Draw a ring around the correct answer to complete the sentence.

When water is added to anhydrous copper sulfate the temperature

of the mixture

increases.
decreases.
stays the same.

(1)

(ii) Anhydrous copper sulfate is white.

What colour is seen after water is added to the anhydrous copper sulfate?

.....

(1)

(iii) What does the symbol ⇌ mean?

.....

(1)

(iv) The student heated a tube containing hydrated copper sulfate.

Name the solid substance produced.

.....

(1)

(Total 8 marks)

Q6. Stage smoke is used for special effects at pop concerts.

By Sam Cockman [CC BY 2.0], via Flickr

Ammonium chloride can be used to make stage smoke.
Ammonium chloride is a white solid.
When heated, ammonium chloride produces white smoke which can be blown onto the stage.

The equation shows what happens when ammonium chloride is heated and cooled.

$NH_4Cl(s)$ $\underset{\text{cooled}}{\overset{\text{heated}}{\rightleftharpoons}}$ $NH_3(g)$ + $HCl(g)$

ammonium chloride (white)	ammonia (colourless)	hydrogen chloride (colourless)

(a) The sentences explain how the smoke is made.

Draw a ring around the correct answer in each box to complete each sentence.

Use the information and the equation to help you.

When heated, ammonium chloride makes two colourless | solids. / liquids. / gases. |

These are blown into the air where they cool and make a | colourless / black | solid. / liquid. |

	white	gas.

which is

ammonia.
ammonium chloride.
hydrogen chloride.

(4)

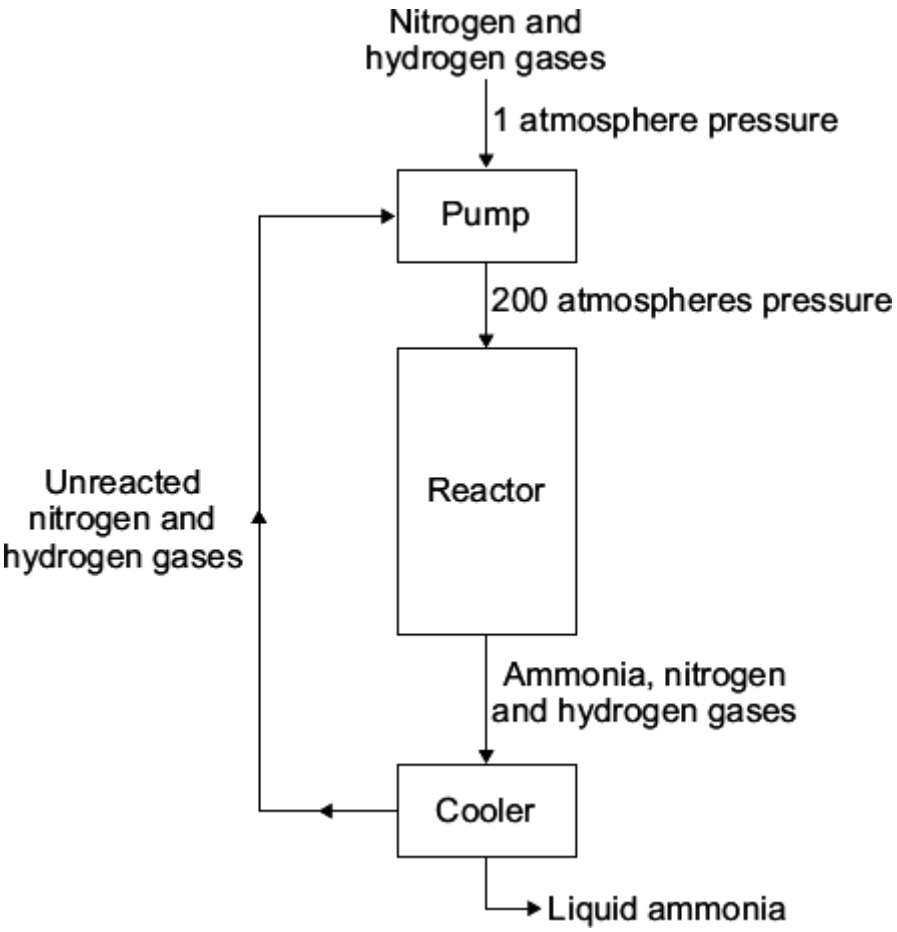
(b) Complete the sentence.

The symbol $\rightleftharpoons$ means that the reaction is .....

(1)

(Total 5 marks)

Q7. The flow diagram shows how ammonia is made.



(a) What effect, if any, does the **pump** have on the pressure of the nitrogen and hydrogen?

Draw a ring around the correct answer to complete the sentence.

The pump | decreases / has no effect on / increases | the pressure.

(1)

(b) The word equation for making ammonia is:

nitrogen + hydrogen $\rightleftharpoons$ ammonia

In the **reactor** only a small amount of the nitrogen and hydrogen is changed into ammonia.

Tick (✓) the reason why.

Reason why	Tick (✓)
Ammonia is formed from two elements.	
Nitrogen and hydrogen are gases.	
The reaction is reversible.	

(1)

(c) In the **cooler** the mixture of gases is cooled.

Draw a ring around the correct answer to complete the sentence.

The cooler turns the ammonia into

a liquid.

a solid.

an element.

(1)

(d) What happens to the unreacted nitrogen and hydrogen from the **reactor**?

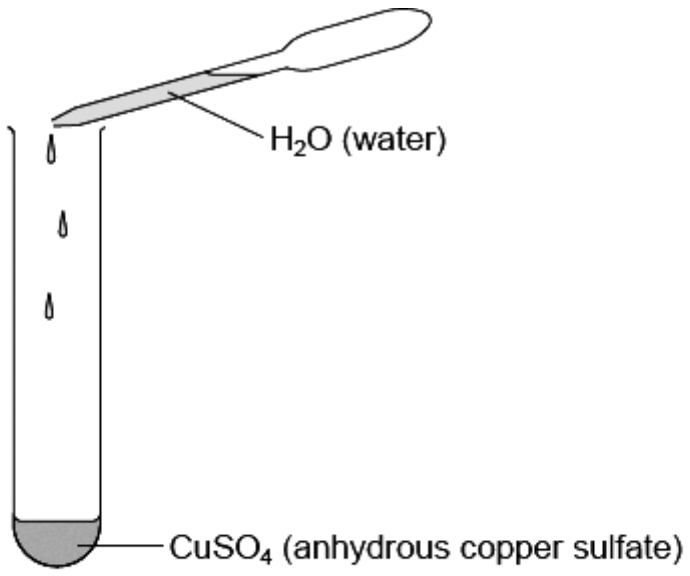
.....

.....

(1)

(Total 4 marks)

Q8. The diagram shows how anhydrous copper sulfate can be used to test for water.



$$\underset{\text{white}}{CuSO_4} + \underset{\text{colourless}}{5H_2O} \rightleftharpoons \underset{\text{blue}}{CuSO_4.\,5H_2O}$$

(a) What colour change will you see when water is added to the $CuSO_4$?

Colour changes from ..... to .....

(1)

(b) Draw a ring around the meaning of the symbol $\rightleftharpoons$

endothermic exothermic **reversible**

(1)

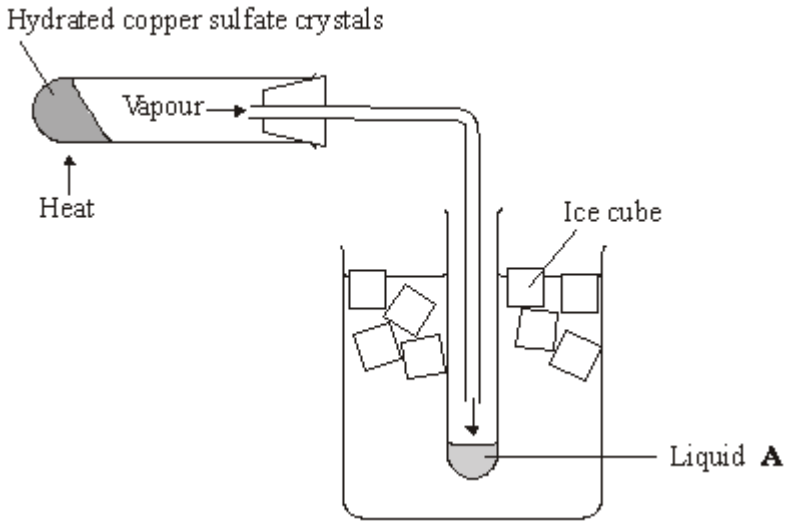
(Total 2 marks)

Q9. A student heated some hydrated copper sulfate crystals.
The equation for this reaction is shown below.

$$CuSO_4.5H_2O(s) \rightleftharpoons CuSO_4(s) + 5H_2O(1)$$

hydrated copper sulfate crystals — anhydrous copper sulfate — water

The diagram shows the apparatus used.



(a) Name liquid **A** .....

(1)

(b) What helped the vapour to condense into liquid **A**?

.....

.....

(1)

(c) Put a tick (✓) next to the correct meaning of the symbol $\rightleftharpoons$

Meaning	(✓)
equal amounts of reactants and products	
exothermic reaction	
reversible reaction	

(1)

(d) The student weighed the copper sulfate before and after it was heated.
The experiment was repeated and the two sets of results are shown in the table.

Mass of copper sulfate before heating in grams	Mass of copper sulfate after heating in grams	Mass lost in grams
2.50	1.65	0.85
2.50	1.61	0.89

(i) Draw a ring around the **average** mass lost for these two sets of results.

0.85 g **0.87 g** **0.89 g**

(1)

(ii) The student used the same mass of copper sulfate each time but the mass lost was different.

Put a tick (✓) next to the **two** reasons which could explain why the mass lost is different.

Reason	(✓)
The student used different test tubes for the two experiments.	
The student made errors in weighing during the experiments.	
The student used more ice in one of the experiments.	
The student did not heat the copper sulfate for long enough in one of the experiments.	

(2)

(e) Anhydrous copper sulfate is used to test for water.

Use words from the box to complete the sentence.

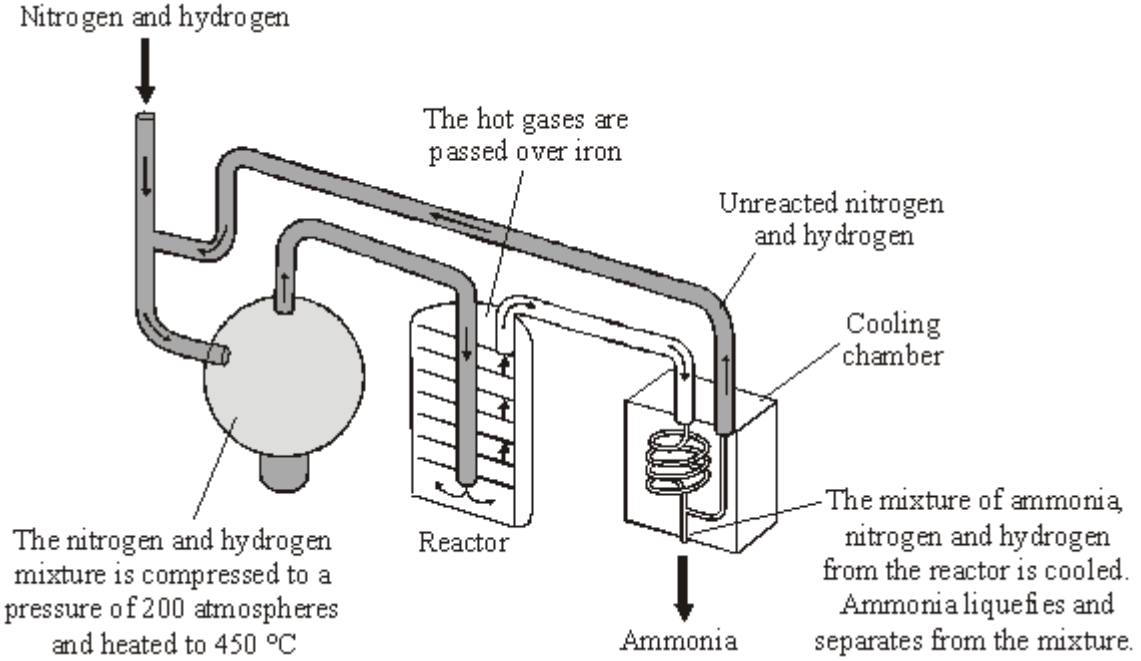
blue	**green**	**red**	**white**

Water changes the colour of anhydrous copper sulfate from .....

to ..... .

(2)
(Total 8 marks)

Q10. The Haber process is named after the German chemist, Fritz Haber.
The diagram shows the main stages in the Haber process.



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(a) Use the diagram to help you to answer these questions.

(i) Complete the word equation for the reaction that takes place in the reactor.

nitrogen + ... ⇌ .....

(1)

(ii) What does the symbol ⇌ mean?

.....

(1)

(iii) What is the purpose of the iron in the reactor?

.....

(1)

(iv) Ammonia is separated from unreacted nitrogen and hydrogen.

Draw a ring around the physical property that allows this separation to take place.

boiling point **density** **melting point**

(1)

(v) What is done with the unreacted nitrogen and hydrogen?

.....

(1)

(b) Some of the products that can be made from ammonia are:

- fertilisers
- dyes
- explosives
- medicines
- plastics

(i) The Haber process was invented a few years before the start of the First World War. It is thought that the First World War would have finished earlier if the Germans had **not** invented the Haber process.

Suggest why.

.....

.....

(1)

(ii) The Haber process has helped to increase food production.

Explain why.

.....

.....

(1)

(c) Factories that make ammonia are very large and operate night and day.

(i) Ammonia factories are often near towns.

Suggest why.

.....

(1)

(ii) Suggest and explain **one** reason why local people might not want an ammonia factory near their town.

.....

.....

.....

.....

(2)

(Total 10 marks)

M1. (a) to speed up the reaction **or** it is a catalyst

allow higher level answers such as to reduce the activation energy

ignore cost or yield

1

(b) (i) reaction is exothermic

*accept reverse reaction is endothermic **or** high temperature causes decomposition of ammonia*

ignore reference to rate

1

(ii) more (gaseous) reactant molecules than (gaseous) product molecules

accept 4 volumes / moles of reactant and 2 volumes / moles of product

*accept lower volume of products **or** volume lower on right hand side*

accept 'favours the reaction which produces fewer molecules'

ignore incorrect number of moles

ignore reference to 'amount' of product / reactant

ignore references to rate

1

(c) (rate is) too slow / slower owtte

allow catalyst would not work

accept at higher temperature the rate is quicker

*accept at lower temperatures particles do not collide as often **or** fewer particles have the activation energy **or** particles do not have the activation energy*

ignore reaction would not work

ignore optimum / compromise type answers

1

(d) cooled

*allow ammonia / it is turned into a liquid **or** is condensed*

ignore references to boiling point

1

[5]

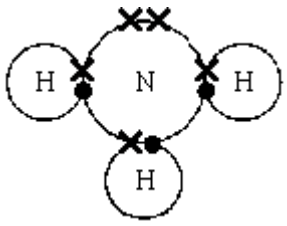
M2. (i) reversible (reaction)

1

(ii) (yield of ammonia) increases

1

(iii)



1

[3]

M3. (i) A = air
B = natural gas
for 1 mark each

2

(ii) nitrogen
both for 1 mark

1

(iii) catalyst / speed up reaction
for 1 mark

1

(iv) recycle unreacted gases / save money
for 1 mark

1

[5]

M4. (a) as a catalyst

accept to speed up the reaction (equilibrium)

1

(b) nitrogen + hydrogen ⇌ ammonia

$N_2 + H_2 \rightleftharpoons NH_3$

accept mixed formula / word equations
ignore balancing

1

(c) (i) the reaction is reversible / an equilibrium

accept that ammonia can break down again into nitrogen and hydrogen
accept reaction goes both ways
*do **not** accept some nitrogen and hydrogen do not react*

1

(ii) (the gases are cooled)

no marks as given in the diagram
accept correct formulae NH_3, N_2 H_2

1

ammonia removed as a liquid

*accept ammonia liquefies **or** condenses*

nitrogen and hydrogen are recycled

accept nitrogen and hydrogen are put back through the converter
accept 'other gases' only if ammonia identified for first mark

1

[5]

M5. (a) endothermic (reaction)

accept thermal decomposition

1

(b) gives out heat (energy)

accept exothermic (reaction)

1

turns blue

accept goes to hydrated copper sulphate

1

[3]

M6. (a) (i) gas

accept they are all gases

1

(ii) reversible (reaction)

accept can go either way
accept ammonia can be decomposed (to nitrogen and hydrogen)
accept could be (an) equilibrium
do not credit just 'equilibrium'

1

(iii) (liquid) air **or** atmosphere

1

(iv) same number **or** amount **or** weight (of atoms) on each side (of the equation)

accept "sums" for each side

accept same amounts of elements on each side
*do not credit molecules **or** compounds*
do not credit both sides are the same unless explained

1

of the same type

***or** gives a correct example 'e.g. six hydrogen atoms' (on each side)*

1

(b) (i) nitrate **or** sulphate **or** phosphate

if first left blank, second may be awarded

do not credit chloride

nitric **or** sulphuric **or** phosphoric

1

(only if correct above, exception is for ammonium chloride followed by hydrochloric acid (1 mark))

as appropriate if only the formula is given this should be credited
only if it is correct in every detail i.e. NH_4NO_3 HNO_3 $(NH_4)_2SO_4$ H_2SO_4
accept correct name with an incorrect version of the formula
do not credit a correct formula with an incorrect version of the name e.g. 'nitrate/sulphite' etc

1

any **one** of

* (solution) can be sprayed (on the fields **or** crops)

accept more even distribution

* dissolves in <u>soil</u> water **or** rain (water)

accept soaks into soil (because soaks implies water)

* can be taken up by (plant) roots

do not credit can be added to water to "feed" the plants

1

(c) (i) elements **or** <u>different</u> atoms are bonded or joined **or** combined **or** reacted

do not credit just 'atoms'

*do not credit added **or** mixed*

1

(ii) (pairs of) electrons are shared

do not credit <u>an</u> electron is shared

1

[10]

M7. (a) (i) ammonia and hydrogen chloride

both required either order
accept formulae if correct in every detail

1

(ii) ammonium chloride / NH_4Cl

do not credit ammonia chloride

1

(iii) the fumes / gases / are poisonous / toxic

***or** ammonia and hydrogen chloride are poisonous / toxic / lethal*
accept just ammonia is poisonous / toxic
accept just hydrogen chloride is poisonous / toxic
accept vapour is poisonous / toxic
*do not credit just fumes are dangerous **or** harmful*

1

(iv) nitrogen

do not credit N/N_2

1

hydrogen

do not credit H/H_2

1

molecule

*do not credit compound **or** mole*

1

covalent

accept single / molecular

1

(b) (i) proton

neutron

electron

***either** all three correct*

or *one or two correct*

however do not credit a response which is repeated

2

(ii) protons and neutrons

both required in either order

1

[10]

M8. (a) (i) *idea that it is*

a reaction in which the products can themselves react to reform the original substance or a reaction that can go in either direction

(allow explanation in terms of the specific reaction in the question)

for 1 mark

1

(ii) nitrogen, hydrogen and ammonia

(allow formulae)

for 1 mark

1

(b) (i) high pressure/400 atm

low temperature/100 °C

for 1 mark each

2

(ii) higher rate of <u>reaction</u>

good rate of <u>production</u>

or *idea* that more economic (ally viable)

(allow catalyst more effective at higher temperature)

for 1 mark each

2

(c) (i) *ideas that it involves*

use of catalyst

gains 1 mark

but use of platinum catalyst

gains 2 marks

2

high temperature/900 °C

for 1 mark

1

(ii) $\underline{2}\ NO + O_2 \rightarrow \underline{2}NO_2$

for 1 mark each

1

(iii) $\underline{3}\ NO_2 + H_2O \rightarrow \underline{2H}NO_3 + NO$

for 1 mark each

1

(d) (i) references to

- transport reductions
- economic savings
- saves time
- guaranteed consumer/supplier

for 1 mark each

2

(ii)
- selection of site
- design of plant
- safe disposal of waste
- make gas emissions safe(r)
- monitoring/safety checks
- reduction of waste gas emissions
- research into more efficient processes
- research into energy savings/use of cooling water
- training of staff re: emergency procedures
- warning/evacuation procedures for the community

(or any two sensible suggestions)

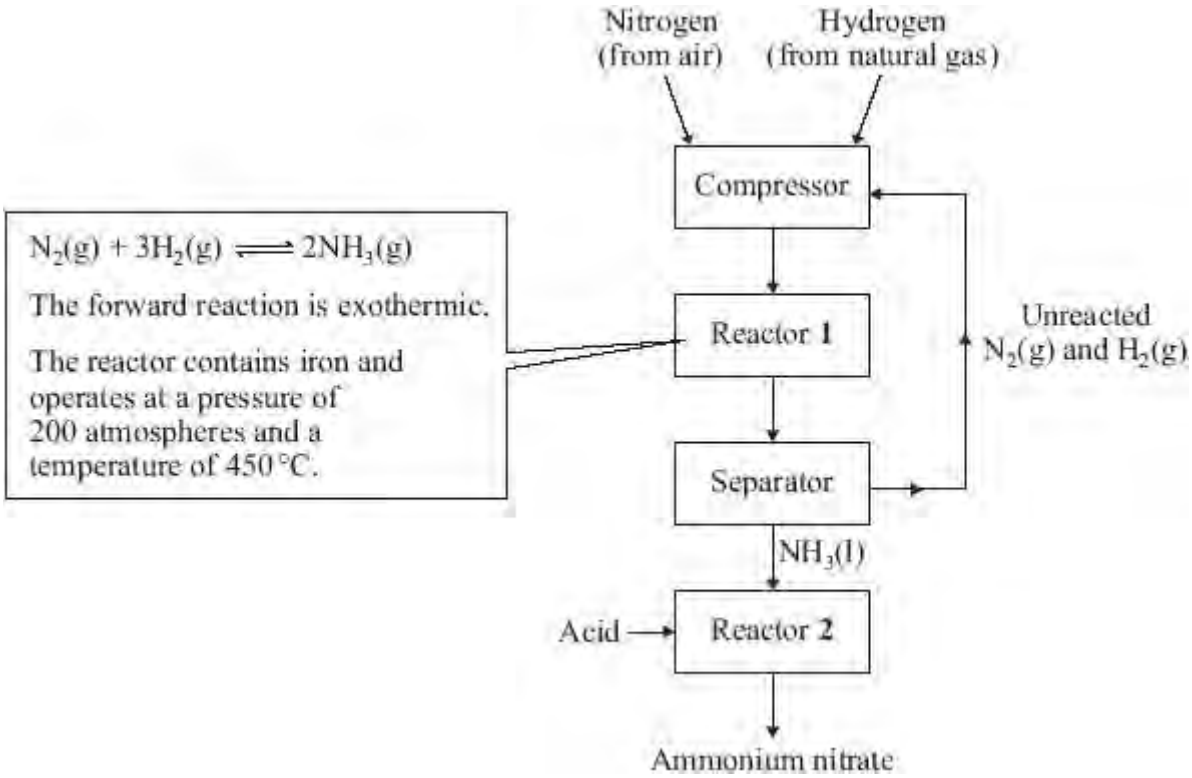
any two for 1 mark each

2

[15]

Q1. Ammonium nitrate is an important chemical. The diagram shows the main stages in the manufacture of ammonium nitrate.

Study the diagram and then answer the question.



(a) What is the purpose of the iron in reactor **1**?

.....

.....

(1)

(b) Explain why the best yield of ammonia at equilibrium is obtained:

(i) at low temperature

.....

.....

(1)

(ii) at high pressure.

.....

.....

(1)

(c) The temperature used in reactor **1** is 450 °C.

Explain why a much lower temperature is **not** used.

.....

.....

(1)

(d) A mixture of ammonia, nitrogen and hydrogen leaves reactor **1**.

In the separator, what is done to the mixture to separate the ammonia from the other gases?

.....

.....

(1)
(Total 5 marks)

Q2. Transition metals are useful as catalysts. Iron is used as a catalyst in the manufacture of ammonia.

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

(i) What is meant by $\rightleftharpoons$ in the chemical equation?

.....

.....

(1)

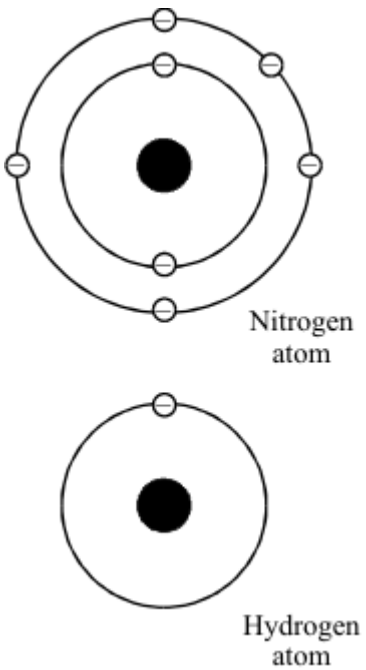
(ii) What would be the effect on the yield of ammonia if the pressure was increased?

.....

.....

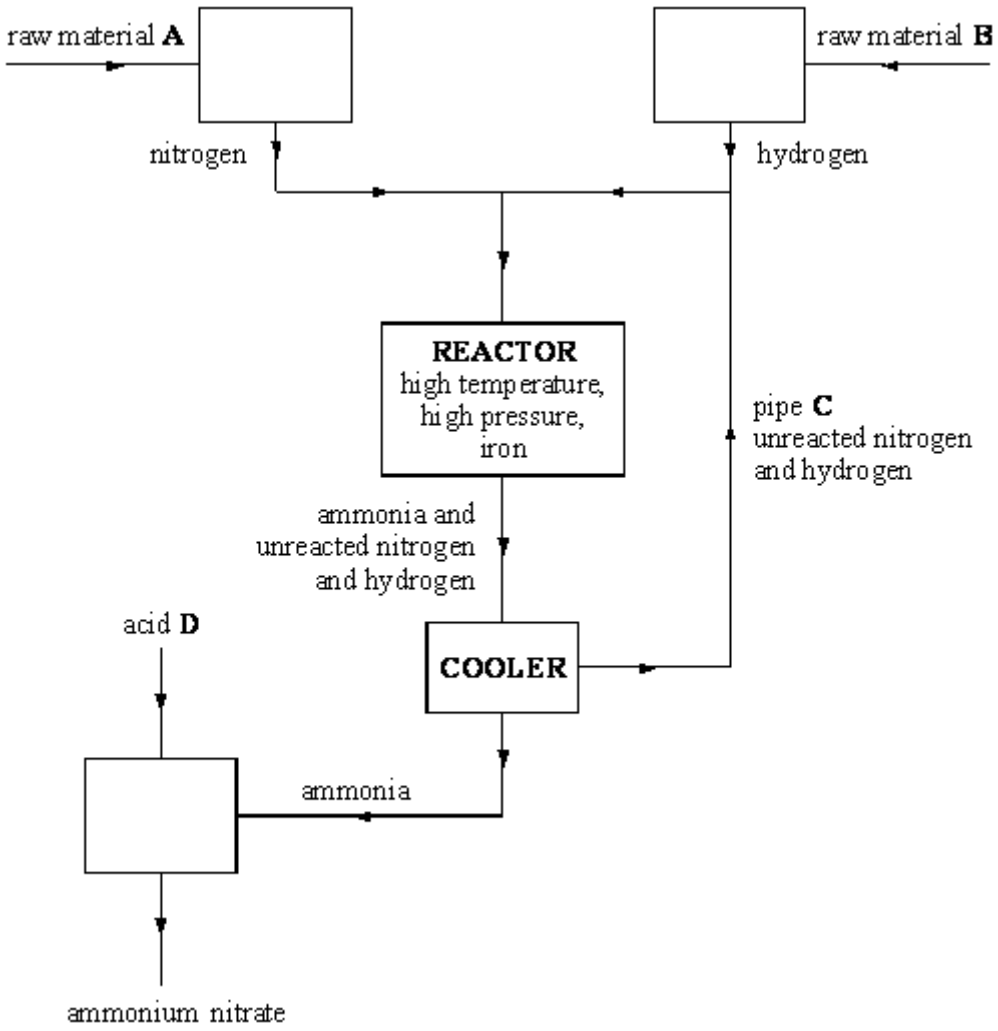
(1)

(iii) Draw a diagram to show the arrangement of the electrons in a molecule of ammonia. The electron arrangement of each atom is shown.



(1)
(Total 3 marks)

Q3. The flow chart below shows the main stages in the production of ammonium nitrate.



(i) Name the **two** raw materials shown in the flow chart as **A** and **B** by choosing words from the list.

air **coke** **limestone** **natural gas**

Raw material **A** .....

Raw material **B** .....

(2)

(ii) Complete the word equation for the reaction which makes ammonia.

..... + ... → ammonia

(1)

(iii) What is the purpose of the iron in the reactor?

.....

.....

(1)

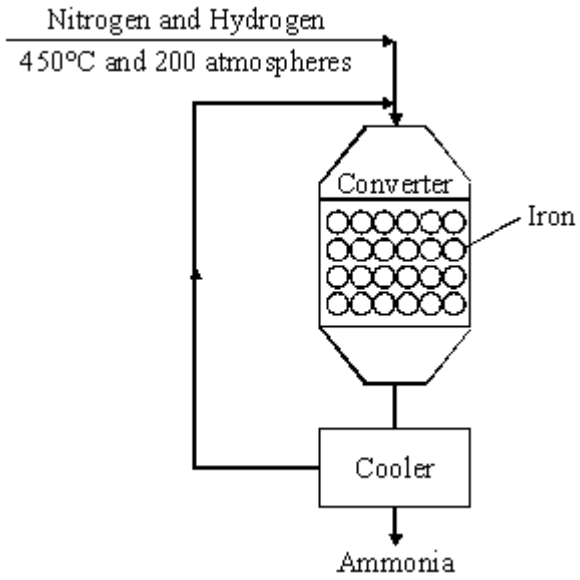
(iv) What is the purpose of pipe **C**?

.....

.....

(1)
(Total 5 marks)

Q4. The diagram shows the final stages in the manufacture of ammonia.



(a) Why is iron used in the converter?

.....

.....

(1)

(b) Write the word equation for the reaction in the converter.

..... + ... ⇌ .....

(1)

(c) The yield of ammonia is only about 15%.

(i) Why can the yield **not** be 100%?

.....

.....

(1)

(ii) Describe what happens to the mixture of gases after it leaves the converter.

.....

.....

.....

(2)
(Total 5 marks)

Q5. Hydrated copper sulphate is a blue solid. When it is heated, white solid anhydrous copper sulphate is made. This is a reversible reaction.

hydrated copper sulphate (blue) [+ heat energy] ⇌ anhydrous copper sulphate (white) + water

(a) To make the forward reaction work, the hydrated copper sulphate must be heated all the time.

What type of reaction is this?

.....

.....

(1)

(b) Anhydrous copper sulphate can be used in a test for water. What **two** things will happen when water is added to anhydrous copper sulphate?

1 .....

.....

2 .....

.....

(2)

(Total 3 marks)

Q6. (a) In industry ammonia is produced from nitrogen and hydrogen. The equation for the reaction is:

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

(i) What does the symbol (g) represent?

.....

(1)

(ii) What does the symbol $\rightleftharpoons$ represent?

.....

(1)

(iii) Nitrogen is used for the industrial production of ammonia. From what raw material does this nitrogen come?

.....

(1)

(iv) Hydrogen is used for the industrial production of ammonia. It is obtained from the reaction between methane and steam. The equation for this reaction is:

$CH_4 + H_2O \rightarrow 3H_2 + CO$

Explain how you can tell that this equation is balanced.

.....

.....

.....

.....

(2)

(b) Ammonia is used to make ammonium salts which can be used as fertilisers.

(i) Complete the names in the following sentence.

One example is ammonium ..... which is made by reacting ammonia with ..... acid.

(2)

(ii) All ammonium salts are soluble in water. Why is this a useful property of a fertiliser?

.....

.....

(1)

(c) Ammonia is a covalent, chemical compound.

(i) Complete the following sentence to describe a chemical compound.

In a chemical compound, two or more .....

.....

.....

(1)

(ii) What is a covalent bond?

.....

.....

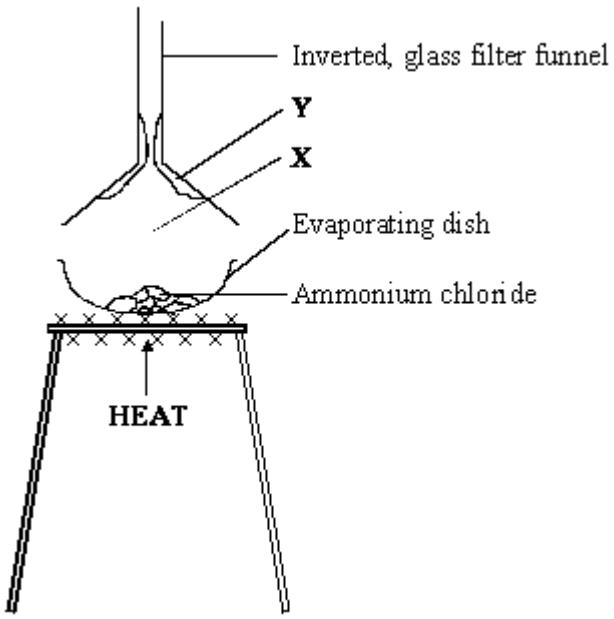
(1)

(Total 10 marks)

Q7. (a) The equation for the reaction that takes place when ammonium chloride is heated is:

$$\underset{\text{ammonium chloride}}{NH_4Cl(s)} \rightleftharpoons \underset{\text{ammonia}}{NH_3(g)} + \underset{\text{hydrogen chloride}}{HCl\ (g)}$$

The diagram shows how a teacher demonstrated this reaction. The demonstration was carried out in a fume cupboard.



(i) Apart from the gases normally in the atmosphere, which two gases would be at **X**?

..... and .....

(1)

(ii) Name the white solid that has formed at **Y**.

.....

(1)

(iii) Why was the demonstration carried out in a fume cupboard?

.....

.....

(1)

(iv) Complete the **four** spaces in the passage.

The chemical formula of ammonia is NH_3. This shows that there is one atom of ..... and three atoms of ..... in each ..... of ammonia. These atoms are joined by bonds that are formed by sharing pairs of electrons. This type of bond is called a ..... bond.

(4)

(b) Electrons, neutrons and protons are sub-atomic particles.

(i) Complete the **three** spaces in the table.

Name of sub-atomic particle	Relative mass	Relative charge
.....	1	+1
.....	1	0
.....	$\frac{1}{1840}$	–1

(2)

(ii) Which **two** sub-atomic particles are in the nucleus of an atom?

..... and .....

(1)

(Total 10 marks)

##

Ammonia is manufactured by the Haber Process, where nitrogen and hydrogen react together as follows:

$N_2 + 3H_2 \Leftrightarrow 2NH_3$

The reaction is reversible. A balance is eventually reached when ammonia is being formed at the same rate at which it is decomposing.

This point is called 'equilibrium'.

	PERCENTAGE OF AMMONIA AT EQUILIBRIUM		
PRESSURE (ATM)	100° C	300° C	500° C
25	91.7	27.4	2.9
100	96.7	52.5	10.6
400	99.4	79,7	31.9

(a) (i) What is meant by a 'reversible reaction'?

.....

.....

(1)

(ii) Which substances are present in the mixture at equilibrium?

.....

(1)

(b) (i) Under what conditions shown in the table is the maximum yield of ammonia obtained?

.....

.....

(2)

(ii) The Haber Process is usually carried out at a higher temperature than that which would produce the maximum yield. Suggest why.

.....

.....

.....

.....

(2)

(c) Ammonia can be converted into nitric acid in three stages:

Stage 1 Ammonia reacts with oxygen from the air to form nitrogen monoxide and water

$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

Stage 2 On cooling, nitrogen monoxide reacts with oxygen from the air to form nitrogen dioxide.

Stage 3 Nitrogen dioxide reacts with water to form nitric acid and nitrogen monoxide.

(i) Describe the conditions under which the reaction in Stage 1 takes place.

.....

.....

.....

.....

(3)

(ii) Balance the equation for the reaction at Stage 2.

$NO \quad + \quad O_2 \longrightarrow NO_2$

(1)

(iii) Balance the equation for the reaction at Stage 3.

$NO_2 \quad + \quad H_2O \longrightarrow HNO_3 \quad + \quad NO$

(1)

(d) The chemical plant for manufacturing ammonia is often on the same site as plants manufacturing nitric acid and fertilisers.

(i) What advantages will this have for the manufacturing company?

.....

.....

.....

.....

(2)

(ii) Briefly describe **two** important ways in which it is possible to reduce the environmental impact of such plants on the surrounding area.

1 .....

.....

2 .....

.....

(2)
(Total 15 marks)

M1.(a) both water <u>vapour</u> and ethanol will condense

allow steam for water vapour
allow they both become liquids
allow ethane condenses at a lower temperature
allow some of the steam hasn't reacted
allow it is a reversible reaction / equilibrium

1

(b) amount will decrease

1

because the equilibrium will move to the left

1

(c) more ethanol will be produced

1

because system moves to least / fewer molecules

1

[5]

M2. (a) (i) nitrogen - air

accept atmosphere

1

hydrogen - north sea gas / natural gas / methane / CH_4

accept water / (crude) oil / coal / hydrocarbons / brine

1

(ii) *allow converse throughout*

- high temperature gives a low yield

1

- because reaction is exothermic

must be linked to first bullet point

1

- but at low temperatures the rate is (too) slow

if no other marks awarded accept 450°C is a compromise between yield and rate

or

*450°C gives a reasonable yield in a reasonable time for **1** mark*

1

(iii) nitric (acid)

accept HNO_3

1

(b) Ammonia / Haber process can be used to make fertiliser

1

with a specified economical reason

eg raw materials for Haber process readily available
eg transport costs are lower or no need to import
eg Haber process is a continuous process

ignore employment / labour costs

1

[8]

M3. (a) same number of (gaseous) molecules / moles / volume on both sides of the equation

allow particles for molecules

*do **not** accept atoms*

ignore amount

1

(b) (forward) reaction is exothermic

accept reverse answer

1

(c) any **three** from:

- particles gain energy
- particles move faster

  allow particles collide faster / quicker

  ignore move more / vibrate more
- particles collide more **or** more collisions
- more of the collisions are successful **or**
  more of the particles have the activation energy **or**
  particles collide with more force / energy

3

(d) any **two** from:

- more product (obtained in shorter time)

  accept better yield (of product)
- less fuel needed

  accept less energy / heat / electricity needed

  or

  lower fuel costs

  ignore cheaper unqualified
- less pollution caused by burning fuels

or

less specified type of pollution caused by producing heat / burning fuels

*allow correct specified pollutants caused by burning fossil fuels eg CO_2 / greenhouse gases **or** correct effect of burning fossil fuels eg global warming*

accept thermal / heat pollution

- using less fuel conserves resources

  accept sustainable

  accept fossil fuels are non-renewable

2

[7]

M4. (a) fewer product molecules than reactant molecules (owtte) **or**

accept forward reaction produces fewer molecules

accept left hand side for reactants and right hand side for products

3 reactant molecules and 1 product
or 3 volumes of gas becomes 1 volume of gas

accept high pressure favours the side with fewer molecules

ignore references to reaction rate

1

(b) any **three** from:

- low temperature gives best yield

  *accept <u>add</u> heat as increased temperature **or** 'less' as poor yield*

  or high temperature gives poor yield

- because the reaction is exothermic

  accept reverse argument if clearly expressed

- reaction too slow at low temperature
  or reaction faster at high temperature

  accept <u>add</u> heat and reaction goes faster

- temperature used gives a reasonable yield
  at a fast rate / compromise explained

  allow get less product but it takes less time
  *for **2** marks*

3

[4]

M5. (a) (i) any **one** from:

- they are positive / cations
- they are H^+
- opposite charges attract

ignore atom

1

(ii) potassium is more reactive (or reverse)

assume 'it' refers to hydrogen

allow potassium reacts <u>with</u> water

*allow potassium is very reactive **or** most reactive metal / element*

allow hydrogen gains electrons more easily / is reduced more easily

accept potassium is higher up the reactivity series

1

(b) 6 **and** 2

accept correct multiples and fractions

1

(c) (i) the reaction / it is reversible **or** a description of a reversible reaction

allow 'it is an equilibrium'

allow reversible symbol drawn correctly

allow 'the reverse / back reaction'

1

(ii) **lithium nitride**

assume that 'it' or if they do not specify means lithium nitride

assume lithium / lithium nitrate refers to lithium nitride

- hydrogen is bonded / held / absorbed / has formed a compound / reacted with lithium nitride

1

plus **one** of:

- does not explode / cause a fire
- is not free / less hydrogen
- is not under pressure
- does not leak
- is only released slowly

1

- compound of hydrogen with lithium nitride / product is (more) stable / less reactive / less chance of a reaction

  accept converse for hydrogen as below

  assume that gas / hydrogen means gas in the cylinder

  - *hydrogen (in cylinder) / gas is not bonded / held absorbed / in a compound / reacted with lithium nitride*

1

*plus **one** of:*

- *can explode / cause a fire*
- *is free*
- *is under pressure*
- *can leak*
- *releases quickly*

1

(d) (i) loss of an electron **or** loses electrons

do not accept any ref. to oxygen

1

(ii) full outer shell of 8 electrons on circle

need not be paired

can be ×, dot or e

*do **not** accept if extra electrons added to inner shell*

1

[10]

M6. (a) (i) high temperature

accept temperature given if ≥ 400 °C
ignore value if "high" stated, unless silly value

1

endothermic or reaction takes in energy
or Δ H is +ve

independent marks

1

(ii) low pressure

or up to and including 10 atmospheres

1

(low pressure) favours a reaction in which more molecules are formed

2 moles → 4 moles
(2 molecules → 4 molecules)

independent marks

1

(iii) nickel **and** it is a transition / transitional element / metal (owtte) **or** nickel **and** variable oxidation state / number or it is similar to other named transition elements e.g. iron

1

(b) (i) (bonds broken =) 2005 (kJ)

1

(bonds formed =) 2046 (kJ)

1

energy change = 2005 – 2046 = (–)41

for correct subtraction ignore sign

1

(ii) (exothermic)

if in part (b)(i) answer is <u>not</u> 41
answer is consequential on endothermic or exothermic shown

*accept correct reasoning for **incorrect** answer from (b)(i)*

energy given out forming new bonds

*do **not** accept energy <u>needed</u> to form new bonds*

1

greater than energy put in to break old bonds

*accept exothermic **and** more energy given out than taken in for 1 mark*
*accept negative value for energy change **or** energy in products less than energy in reactants for 1 mark*

1

[10]

M7. (a) ***2** marks for comments related to temperature*

low / lower / lowest temperature (**or** 100 °C from graph)

ignore references to catalyst

1

any **one** from:

- (forward) reaction exothermic

  ***or** reverse reaction endothermic*

- if the temperature is increased the yield of product will decrease **or** reaction right to left

  *high temperature favours reverse reaction **or** reverse argument*

  *the lower the temperature the greater the yield = **2** marks*

  ***2** marks for comments related to pressure*

1

high / higher / highest pressure (or greater than 200 atm. from graph)

1

any **one** from:

- four reactant molecules but only two product molecules (owtte)

  reverse reaction goes from 2 molecules / moles / volumes to 4 molecules / moles / volumes

- increase in pressure favours the reaction which produces the least number of molecules

  decrease in pressure favours the back reaction because it produces the most molecules

1

(b) any **three** from:

- at low temperatures the reaction is too slow
- 450 °C gives a reasonable yield at a fast rate / compromise between yield and rate (*)
- 200 atm. gives a reasonable yield at a reasonable cost / safely / compromise between yield and cost / safety (*)

  *(*) or 450°C and 200 atm / these are compromise conditions for **1** mark*

- catalyst works better at higher temperature

- (very) high pressures could be dangerous (owtte)
  safety factor
- (very) high pressures are expensive (owtte)
- (yield is not too important because) unreacted gases can be recycled

3

[7]

M8. (i) a reaction in which the products can be changed back to reactants

*accept a reaction that can go forwards **or** backwards*

1

under certain conditions

1

(ii) M_r $CaCO_3$ = 100

1

M_r CaO = 56

1

mass of CaO = 140 (tonnes)

1

mark consequentially

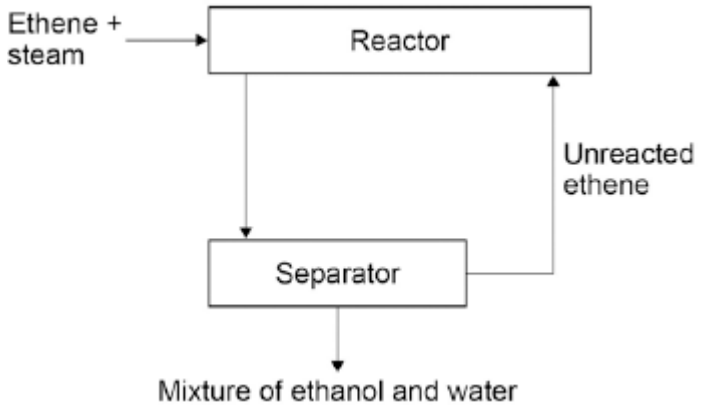
[5]

Q1. In industry ethanol is produced by the reaction of ethene and steam at 300°C and 60 atmospheres pressure using a catalyst.

The equation for the reaction is:

$$C_2H_4\ (g) + H_2O\ (g) \rightleftharpoons C_2H_5OH\ (g)$$

The figure below shows a flow diagram of the process.



(a) Why does the mixture from the separator contain ethanol and water?

.....

.....

(1)

(b) The forward reaction is exothermic.

Use Le Chatelier's Principle to predict the effect of increasing temperature on the amount of ethanol produced at equilibrium.

Give a reason for your prediction.

.....

.....

.....

.....

(2)

(c) Explain how increasing the pressure of the reactants will affect the amount of ethanol produced at equilibrium.

.....

.....

.....

.....

(2)
(Total 5 marks)

Q2. Humberstone was a town in the desert of Northern Chile in South America. It was built for the people who worked in the nearby sodium nitrate mines.

The sodium nitrate was used as a fertiliser.

The sodium nitrate was exported by ship to countries all around the world.

Today the mines have closed and nobody lives in Humberstone.

One of the reasons for the mines closing was the invention of the Haber process.

By Sznegra (Own work) [CC-BY-SA-3.0], via Wikimedia Commons

(a) The Haber process is used to make ammonia (NH_3).

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

The forward reaction is exothermic.

(i) Name the raw materials that are used to supply the nitrogen and hydrogen.

Nitrogen .....

Hydrogen .....

(2)

(ii) The Haber process uses a temperature of 450 °C.

Explain, as fully as you can, why a temperature of 450 °C is used rather than a much higher temperature or a much lower temperature.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(iii) Ammonia can be converted to ammonium nitrate by adding an acid.

Name this acid.

.....

(1)

(b) Suggest and explain why the invention of the Haber process caused the closure of the Humberstone mines in Chile.

.....

.....

.....

.....

.....

(2)
(Total 8 marks)

Q3. The equation for a reaction to produce hydrogen is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

(a) Explain why changing the pressure does **not** affect the yield of hydrogen at equilibrium.

.....

.....

(1)

(b) Suggest why the best yield of hydrogen at equilibrium is obtained at **low** temperatures.

.....

.....

(1)

(c) The temperature used in industry needs to be high enough for the reaction to take place quickly. Explain, in terms of particles, why the rate of reaction increases when the temperature is increased.

.....

.....

.....

.....

.....

.....

(3)

(d) Scientists have developed catalysts which allow the reaction to take place quickly at lower temperatures. How could this be good for the manufacturer and for the environment?

.....

.....

.....

.....

(2)
(Total 7 marks)

Q4. Methanol is a fuel that is used in some racing cars instead of petrol.

Methanol can be made from carbon monoxide and hydrogen. The equation for this reaction is shown below.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The forward reaction is exothermic.

(a) A high pressure (between 50 and 100 atmospheres) is used in this process.

Explain why the highest equilibrium yield of methanol is obtained at high pressure.

.....

.....

(1)

(b) The temperature used in this process is about 250 °C.

It has been stated that, 'the use of this temperature is a compromise between the equilibrium yield of product and the rate of reaction'.

Explain this statement.

.....

.....

.....

.....

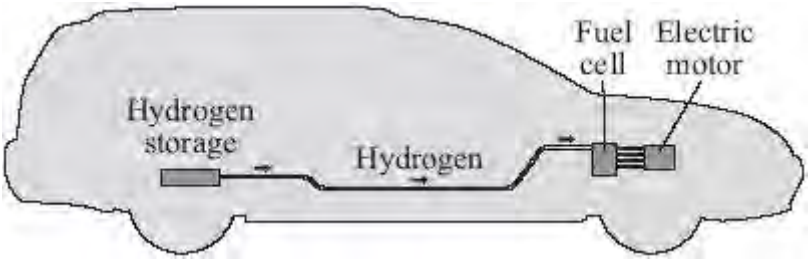
.....

.....

(3)
(Total 4 marks)

Q5. Read the article and then answer the questions that follow.

Hydrogen fuel for cars?



Hydrogen is an excellent fuel. It can be made by the electrolysis of potassium hydroxide solution.

Hydrogen gas can be stored under pressure in a cylinder but a leak of the gas could cause an explosion.

It has been found that lithium nitride can absorb and then release large volumes of hydrogen. A chemical reaction takes place between the hydrogen and the lithium nitride. The hydrogen is held in the resulting compounds by chemical bonds.

The problem is that the rate at which hydrogen is absorbed and then released from normal sized particles of lithium nitride is slow.

Recently scientists have made 'nanosized' particles of lithium nitride. These particles absorb hydrogen in the same way as normal sized lithium nitride particles. The 'nanosized' particles have the advantage that they absorb and release the hydrogen much faster when needed in the fuel cell.

It is hoped that 'nanosized' particles of lithium nitride may provide a safe method of storing hydrogen in the future.

(a) Hydrogen is produced at the negative electrode during the electrolysis of potassium hydroxide solution.

(i) Why are hydrogen ions attracted to the negative electrode?

.....

.....

.....

(1)

(ii) Potassium ions are also attracted to the negative electrode.

Explain why hydrogen gas is formed but not potassium.

.....

.....

.....

(1)

(b) Lithium nitride is made by reacting lithium with nitrogen.

Balance the equation for this reaction.

..... $Li + N_2 \rightarrow$ ..... Li_3N

(1)

(c) (i) The equation for the reaction of lithium nitride with hydrogen is:

$$Li_3N + 2H_2 \rightleftharpoons LiNH_2 + 2LiH$$

What feature of this reaction allows the hydrogen to be released?

.....

.....

(1)

(ii) Hydrogen stored in a fuel tank filled with lithium nitride would be safer in an accident than a cylinder full of hydrogen.

Suggest and explain why.

.....

.....

.....

.....

.....

(2)

(d) Lithium nitride is an ionic compound which contains lithium ions (Li^+) and nitride ions (N^{3-}).

(i) The formation of a lithium ion from a lithium atom is an oxidation reaction.

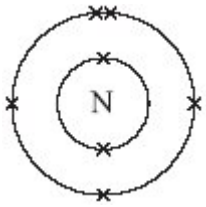
Explain why.

.....

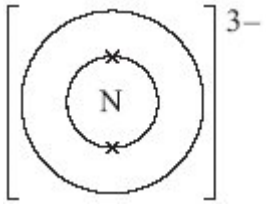
.....

(1)

(ii) The diagram shows the electronic structure of a nitrogen atom.



Complete the diagram below to show the electronic structure of a nitride ion (N^{3-}).



(1)
(Total 8 marks)

Q6. The reaction of methane with steam is used in industry to make hydrogen.

(a) One of the reactions in this process is represented by this equation.

CH_4 (g) + H_2O ⇌ CO (g) + $3H_2$ (g)

The forward reaction is endothermic.

State the conditions of temperature and pressure that would give the maximum yield of hydrogen.

Explain your answers.

(i) Temperature

.....

.....

.....

.....

(2)

(ii) Pressure

.....

.....

.....

.....

(2)

(iii) Which one of the following metals is most likely to be a catalyst for this process? Draw a ring around your answer.

aluminium **lead** **magnesium** **nickel** **sodium**

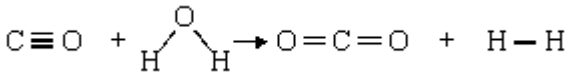
Give a reason for your choice.

.....

.....

(1)

(b) A second stage in this process is represented by this equation.



(i) Use the bond energies given in the table to help you to calculate the nett energy transfer (energy change) for this reaction.

Bond	Bond energy in kJ/mol
C ? O	1077
C = O	805
H – H	436
O – H	464

.....

.....

.....

.....

.....

.....

Nett energy transfer = ... kJ/mol

(3)

(ii) State whether this reaction is exothermic or endothermic. .....

Explain, by reference to your calculation, how you know.

.....

.....

.....

.....

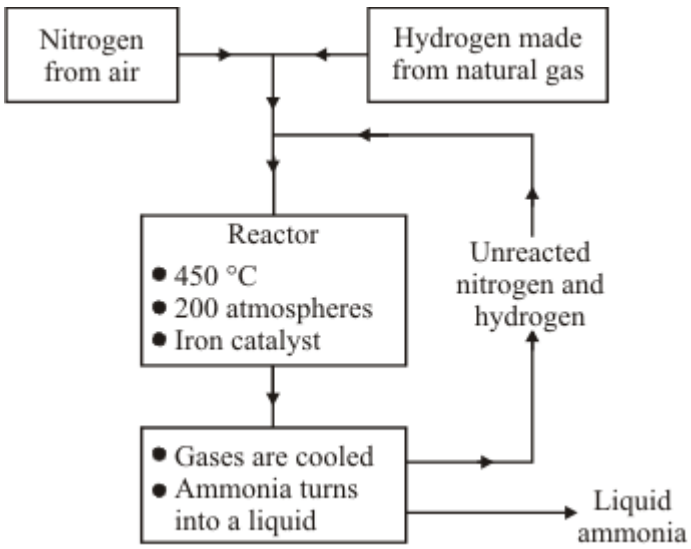
(2)

(Total 10 marks)

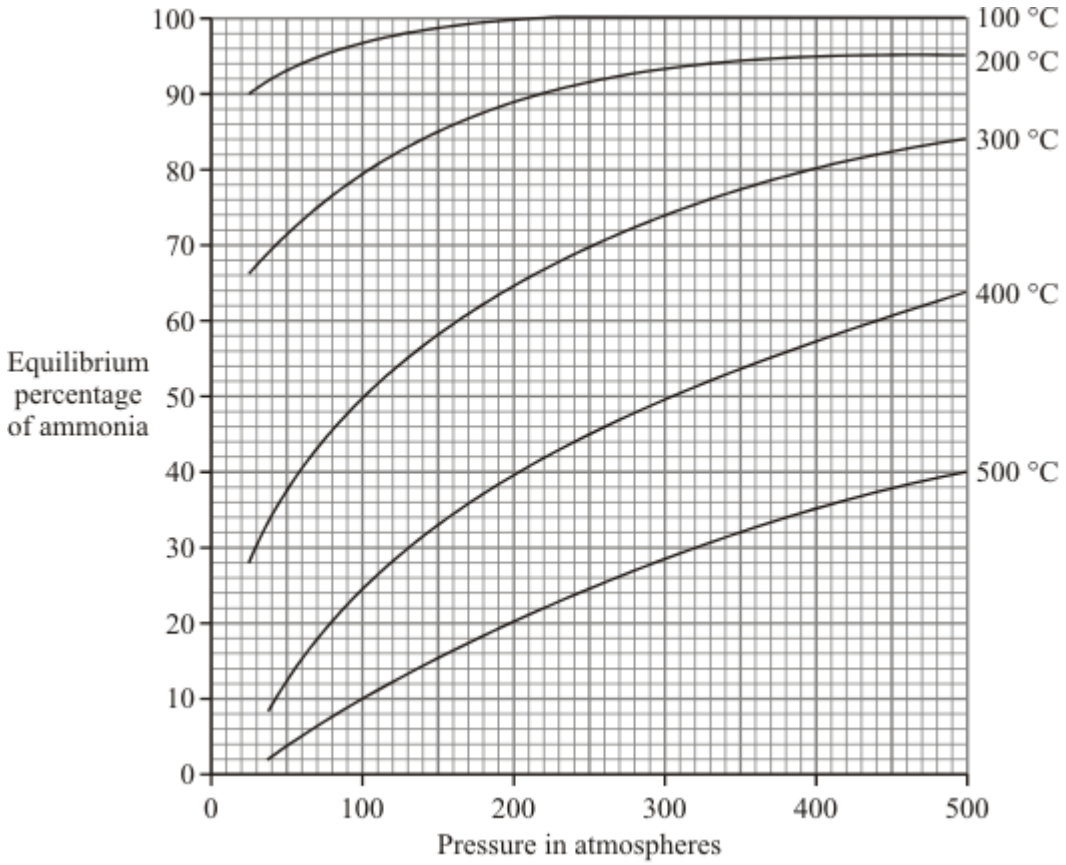
Q7. Ammonia is made from nitrogen and hydrogen in the Haber process.

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

Flow Chart for the Haber Process



Effect of temperature and pressure on the amount of ammonia at equilibrium



(a) Use the information given above and your knowledge of the Haber process and reversible reactions to help you to answer this question.

State which conditions of temperature and pressure would give the highest percentage of ammonia at equilibrium. Explain why.

.....

.....

.....

.....

.....

.....

.....

.....

(4)

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

Explain why these conditions are chosen.

.....

.....

.....

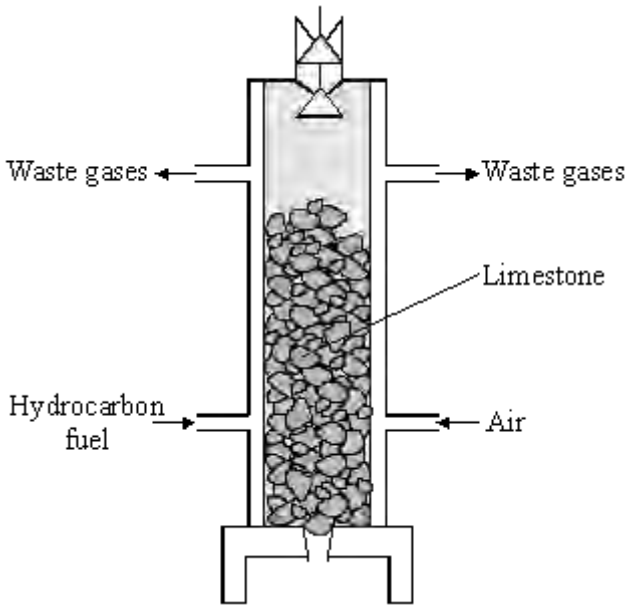
.....

.....

.....

(3)
(Total 7 marks)

Q8. Limestone is a useful mineral. Every day, large amounts of limestone are heated in limekilns to produce lime. Lime is used in the manufacture of iron, cement and glass and for neutralising acidic soils.



$$CaCO_3 \rightleftharpoons CaO + CO_2$$

(i) The decomposition of limestone is a *reversible* reaction. Explain what this means.

.....

.....

.....

.....

(2)

(ii) Calculate the mass of lime, CaO, that would be produced from 250 tonnes of limestone, $CaCO_3$.

Relative atomic masses: C 12; O 16; Ca 40.

.....

.....

.....

.....

.....

Mass of lime = ... tonnes

(3)

(Total 5 marks)