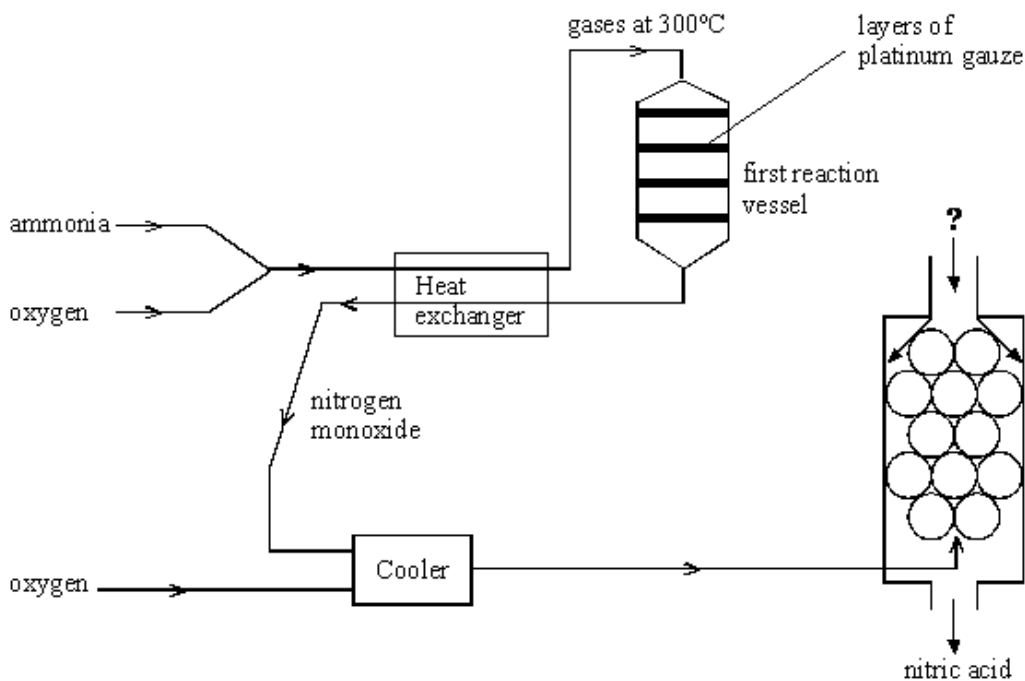**Q1.**   The chart shows the processes involved in the manufacture of nitric acid from ammonia.

(a)   Complete the word equation for the reaction that takes place in the first reaction vessel.

ammonia + ... ➤ nitrogen monoxide + water

(1)

(b)   (i)   What is the use of the platinum gauze in the reaction vessel?

....

(1)

(ii)   At first, the platinum gauze is electrically heated. However, as the reaction continues, no further heating is necessary.
Explain why.

....

(1)

(c)   Explain why the heat exchanger is used.

....

....

....

....

(2)

(d)   To convert nitrogen monoxide into nitric acid, **two** further reactants are needed.
What are they?

.... and ....

(1)

(e)   In an old method, nitrogen monoxide was produced from nitrogen instead of ammonia.

$$N_{2(g)} + O_{2(g)} \longrightarrow 2NO_{(g)}$$

184 kJ of energy is taken in from the surroundings for each formula mass (mole) of reactants.

The reaction was carried out at a high temperature (3000°C).
Suggest **two** reasons for this.

1 ....

2 ....

(2)

(f)   Complete the word equation below, to show how to make the fertiliser, ammonium nitrate.

.... + ... ⟶ ammonium nitrate + water

(2)
(Total 10 marks)

Q2.   (a)   Iron powder is used in the manufacture of ammonia. Why is it used?

....

....

(1)

(b)   Ammonia is manufactured from nitrogen and hydrogen. The equation for the reaction between them is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$
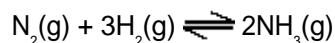
(i)   Which **two** raw materials are used to make the hydrogen?

.... and ....

(1)

(ii)   Why does increasing the pressure increase the chance of molecules of nitrogen reacting with molecules of hydrogen?

....

....

(1)

(iii) Calculate the mass, in tonnes, of ammonia which could be produced from 560 tonnes of nitrogen.

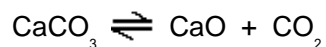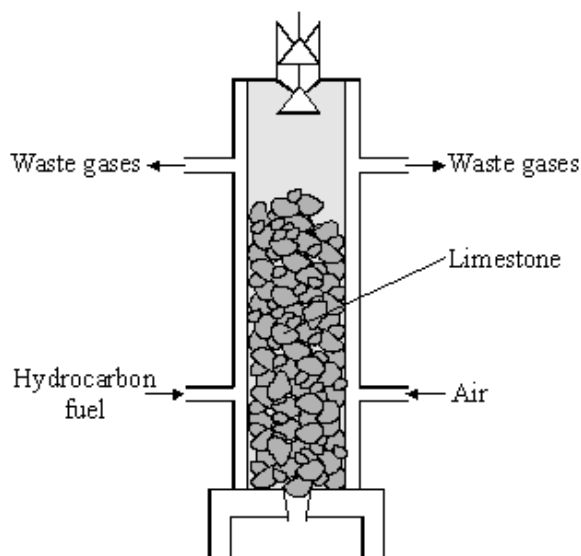The relative atomic masses are: H 1; N 14.

Show clearly how you get to your answer.

....

....

....

Mass of ammonia = ... tonnes

(3)
(Total 6 marks)

Q3. 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.
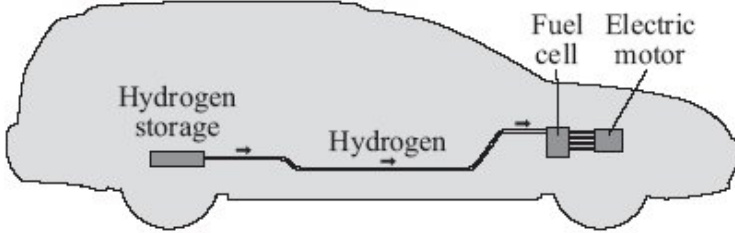
....

....

....

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....

Mass of lime = ... tonnes

(3)
(Total 5 marks)

Q4.   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.

$$.......... \, Li + N_2 \rightarrow .... \, Li_3N$$
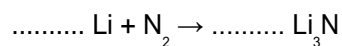
(1)

(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-}).

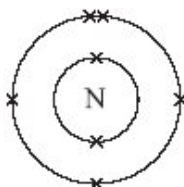(i)   The formation of a lithium ion from a lithium atom is an oxidation reaction.

Explain why.

....

....
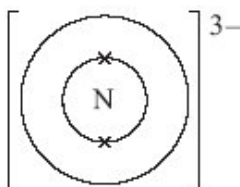
(1)

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

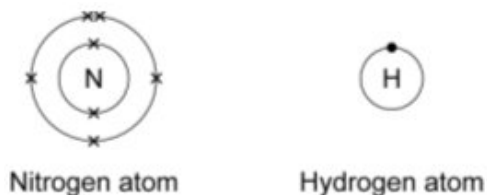Complete the diagram below to show the electronic structure of a nitride ion (N^{3-}).

(1)
(Total 8 marks)

Q5.   Ammonia has the formula NH_3

The diagrams show how electrons are arranged in nitrogen and hydrogen atoms.

Nitrogen atom   Hydrogen atom

(a)   Draw a diagram to show how the electrons are arranged in an ammonia molecule.

You need only show the electrons in the highest energy level.

(2)

(b)   Ammonia is a gas at room temperature.

Explain why ammonia has a low boiling point.

....

....

....

....

(2)

(c)   Ammonia dissolves in water to form a solution with a pH of about 10.

(i)   Name the ion in the ammonia solution that causes the pH of 10.

.... ion

(1)

(ii)   Ammonium nitrate is made by reacting ammonia with an acid.

Name the acid.

.... acid

(1)

(d)   Instant cold packs are used to treat sports injuries.

One type of cold pack has a plastic bag with water inside. Inside the bag is a smaller bag containing solid ammonium nitrate.

The outer bag is squeezed so that the inner bag bursts. The pack is shaken and quickly gets cold as the ammonium nitrate dissolves in the water.

Explain why the bag gets cold.

....

....

....

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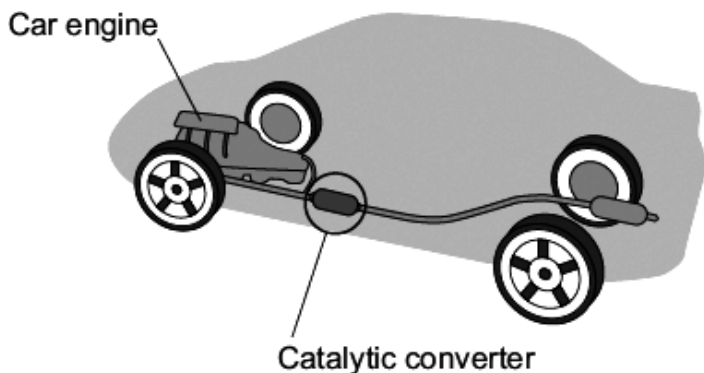
(2)
(Total 8 marks)

Q6. Read the information about car engines.

Burning petrol in air is an *exothermic* reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.

(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

....

....

(1)

(b) The catalytic converter has two parts shown as **A** and **B** in the diagram.
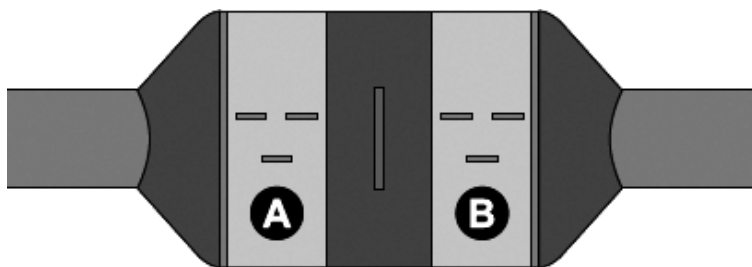
Part **A** contains a catalyst made from platinum and rhodium.

Part **B** contains a catalyst made from platinum and palladium.

(i) Why are catalysts used in chemical reactions?

....

....

(1)

(ii)   One reaction in part **A** is shown by this equation.

$$2NO \rightarrow N_2 + O_2$$

Suggest why this reaction helps the environment.

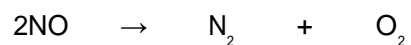...

....

(1)

(iii)   The equation for one of the reactions in part **B** is shown below.

Balance this equation.

$$....... CO + O_2 \rightarrow .... CO_2$$
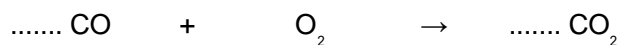
(1)

(iv)   The catalytic converter works for many years without replacing the catalyst.

Explain why the catalyst does not need to be replaced.

....

....

(1)

(v)   Suggest why different catalysts are used in parts **A** and **B**.

....

....

(1)

(c)   Modern catalytic converters contain nanosized particles of catalyst. Using nanosized particles reduces the cost of the catalytic converter.

Suggest and explain why the use of nanosized catalyst particles reduces the cost of the catalytic converter.

Your answer should include information about the size and surface area of the particles.

....

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....

....

(3)
(Total 9 marks)

Q7.   Kelp is a seaweed.

Kelp can be used in foods and as a renewable energy source.

© Ethan Daniels/Shutterstock

(a)   Scientific experiments, on their own, **cannot** fully answer one of the following questions. Which one?

Tick (✓) **one** box.

Questions	Tick (✓)
How much carbon dioxide is produced when 100 g of kelp is burned?	
Does kelp give out more heat energy than coal?	
Will kelp last longer than coal as an energy source?	
Which fuel, kelp or coal, produces the most ash when burned?	

(1)

(b)   Scientists cannot answer the question 'should people use kelp instead of coal as an energy source?'

Give **two** reasons why.

....

....

....

....

(2)

(c)   Sodium iodide can be produced from kelp.

(i)   How many electrons are in the outer shell of an iodine atom?

(1)

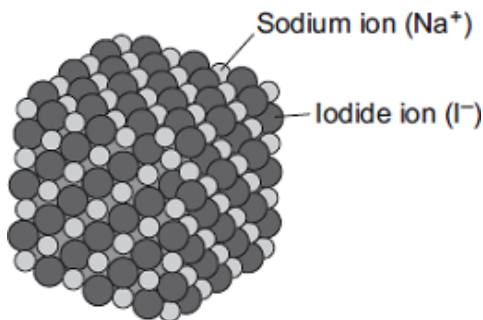(ii)   Sodium iodide contains sodium ions (Na^+) and iodide ions (I^-).

Describe, as fully as you can, what happens when sodium atoms react with iodine atoms to produce sodium iodide.

You may use a diagram in your answer

....

....

....

....

....

....

(3)

(iii)   The diagram shows the structure of sodium iodide.

Solid sodium iodide does not conduct electricity.

Why does sodium iodide solution conduct electricity?

....

....

(1)

(iv)   When sodium iodide solution is electrolysed, iodine is formed at the positive electrode.

Complete and balance the half equation for the formation of iodine.

$$..........I^- \rightarrow I_2 + ...e^-$$
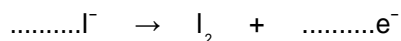
(1)

(v) What is formed at the negative electrode when sodium iodide solution is electrolysed?

Explain why.

....

....

....

....
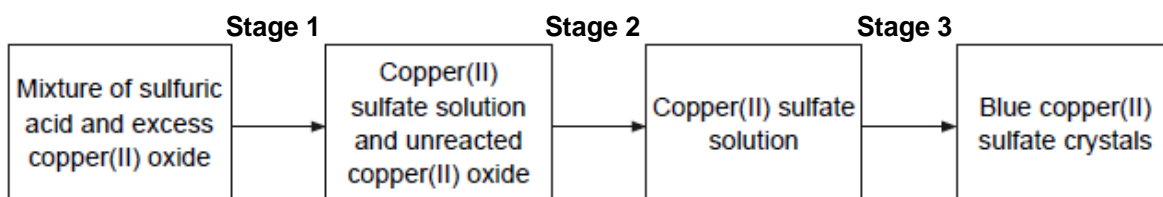
(2)
(Total 11 marks)

Q8.   This question is about compounds of copper.

(a)   A student made some copper(II) sulfate crystals.

The flow diagram shows the stages of the preparation of copper(II) sulfate crystals.

Stage 1	**Stage 2**	**Stage 3**
Mixture of sulfuric acid and excess copper(II) oxide	→ Copper(II) sulfate solution and unreacted copper(II) oxide	→ Copper(II) sulfate solution	→ Blue copper(II) sulfate crystals

(i)   The reaction mixture is heated in **Stage 1**.

Suggest why.

....

....

(1)

(ii)   Complete the equation for this reaction.

CuO + ... → $CuSO_4$ + ...
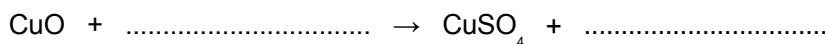
(2)

(iii)   How would the student remove the unreacted copper(II) oxide in **Stage 2**?

....

....

(1)

(iv)   How would the student obtain copper(II) sulfate crystals from the copper(II) sulfate solution in **Stage 3**?

....

(1)

(v)   The mass of crystals obtained was less than the student had calculated.

Suggest **one** reason why.

....

....
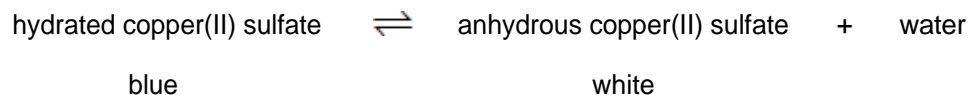
(1)

(b)   The student heated the blue copper(II) sulfate crystals.

The word equation for the reaction is shown below.

hydrated copper(II) sulfate $\rightleftharpoons$ anhydrous copper(II) sulfate   +   water

blue   white

(i)   What does the symbol $\rightleftharpoons$ mean ?

....

(1)

(ii)   300 J of energy are taken in when some blue copper(II) sulfate crystals are heated.

What is the energy change when an excess of water is added to the anhydrous copper(II) sulfate produced?

....

....

(2)

(c)   A sample of copper nitride contains 3.81 g of copper and 0.28 g of nitrogen.

Calculate the empirical formula.

You **must** show all your working to get full marks.

Relative atomic masses (A_r): N = 14; Cu = 63.5.
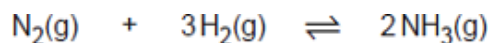
....

....

....

....

....

....

....

Empirical formula = ...

(4)
(Total 13 marks)

Q9. Ammonia is produced from nitrogen and hydrogen.

The equation for this reaction is:

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

(a) (i) A company wants to make 6.8 tonnes of ammonia.

Calculate the mass of nitrogen needed.

Relative atomic masses (A_r): H = 1; N = 14

....

....

....

....

....

Mass of nitrogen = ... tonnes

(3)

(ii) The company expected to make 6.8 tonnes of ammonia.

The yield of ammonia was only 4.2 tonnes.

Calculate the percentage yield of ammonia.

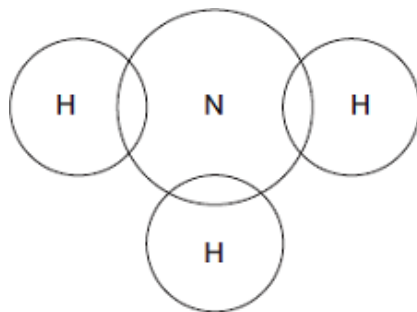...

....

Percentage yield of ammonia = ... %

(2)

(iii) Use the equation above to explain why the percentage yield of ammonia was less than expected.

....

....

(1)

(b) Complete the diagram to show the arrangement of the outer shell electrons of the nitrogen and hydrogen atoms in ammonia.

Use dots (●) and crosses (x) to represent the electrons.

(2)

(c) Ammonia dissolves in water to produce an alkaline solution.

(i) Which ion makes ammonia solution alkaline?

....

(1)

(ii) Name the type of reaction between aqueous ammonia solution and an acid.

....

(1)

(iii) Name the acid needed to produce ammonium nitrate.

....

(1)

(iv) The reaction of ammonia with sulfuric acid produces ammonium sulfate.

Use the formulae of the ions on the Chemistry Data Sheet.

Write the formula of ammonium sulfate.

....

(1)
(Total 12 marks)