11.3 Nitrogen and fertilisers

01. 0620_m21_qp_42 Q: 3

This question is about ammonia.

(a) Nitrogen reacts with hydrogen to form ammonia in an industrial process.

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

(i) Name this industrial process.

..... [1]

(ii) State the meaning of the symbol $\rightleftharpoons$.

..... [1]

(iii) State the conditions used in this industrial process. Include units.

temperature .....

pressure .....

[2]

(iv) Name the catalyst used in this industrial process.

..... [1]

(v) If the pressure is increased, the yield of ammonia increases.

Explain why, in terms of equilibrium.

.....

.....

..... [2]

(vi) If the temperature is increased, the rate of reaction increases.

Explain why, in terms of particles.

.....

.....

.....

.....

..... [3]

(b) Ammonia reacts with sulfuric acid to make a compound which is used as a fertiliser.

Write the chemical equation for the reaction between ammonia and sulfuric acid.

..... [2]

[Total: 12]

02. 0620_w21_qp_42 Q: 5

Iron is a transition element. Potassium is a Group I element.

(a) Iron and potassium have the same type of bonding.

Name and describe the type of bonding in these two elements.

name .....

description .....

.....

.....

.....
[4]

(b) Transition elements and Group I elements have some similar physical properties.

They can both:

- be hammered into a shape
- conduct electricity
- be stretched into wires.

(i) Name the term used to describe the ability of elements to be hammered into a shape.

..... [1]

(ii) Describe what happens to the particles in iron when it is hammered into a shape.

.....

..... [1]

(iii) Suggest why copper, rather than other transition elements, is used for wires which conduct electricity.

..... [1]

(c) Transition elements are harder and stronger than Group I elements.

Describe how **two** other **physical** properties of transition elements are different from those of Group I elements.

1 .....

2 .....
[2]

(d) Chemical properties of some Group I elements are shown in the table.

element	reaction with cold water	reaction with oxygen	flame test colour
lithium	• steadily effervesces • forms a colourless solution	very slowly forms an oxide layer	red
sodium	• strongly effervesces • forms a colourless solution	slowly forms an oxide layer	
potassium	• very strongly effervesces • forms a colourless solution	quickly forms an oxide layer	
rubidium			ruby red

(i) Add to the table:

- the flame test colours for sodium and potassium
- the predicted reactions of rubidium with water and with oxygen.

[4]

(ii) Name the gas produced when Group I elements react with water.

..... [1]

(iii) Name the solution formed when potassium reacts with water.

..... [1]

(iv) Predict the pH of the colourless solution formed when potassium reacts with water.

..... [1]

(v) Write the chemical equation for the reaction of sodium with oxygen.

..... [2]

(e) Iron is a typical transition element. It is the catalyst used in the Haber process.

(i) Write the equation for the reaction that occurs in the Haber process.

..... [2]

(ii) State the temperature and pressure used in the Haber process. Include units.

temperature .....

pressure .....

[2]

[Total: 22]

03. 0620_s20_qp_42 Q: 1

(a) Give the name of the process that:

(i) occurs when a gas turns into a liquid

..... [1]

(ii) occurs when a solid turns into a gas without first forming a liquid

..... [1]

(iii) is used to separate a mixture of liquids with different boiling points

..... [1]

(iv) is used to extract aluminium from aluminium oxide

..... [1]

(v) is used to separate a mixture of amino acids.

..... [1]

(b) The symbols of the elements in Period 2 of the Periodic Table are shown.

Li Be B C N O F Ne

For each of the following, give the symbol of an element from Period 2 which matches the description.

Each element may be used once, more than once or not at all.

Which element:

(i) combines with hydrogen to produce ammonia

..... [1]

(ii) makes up approximately 21% of clean, dry air

..... [1]

(iii) has atoms with only two electrons in the outer shell

..... [1]

(iv) has atoms with only seven protons

..... [1]

(v) is a monoatomic gas

..... [1]

(vi) is a soft metal stored in oil?

..... [1]

[Total: 11]

04. 0620_s20_qp_43 Q: 2
Ammonia is manufactured by the Haber process.

(a) The equation for the reaction is shown.

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

(i) State what is meant by the symbol $\rightleftharpoons$.

..... [1]

(ii) State **one** source of hydrogen used in the manufacture of ammonia.

..... [1]

(b) The table shows some data for the production of ammonia.

pressure / atm	temperature / °C	percentage yield of ammonia
250	350	58
100	450	28
400	450	42
250	550	20

Deduce the effect on the percentage yield of ammonia of:

- increasing the pressure of the reaction

.....

- increasing the temperature of the reaction.

.....
[2]

(c) Explain, in terms of particles, what happens to the rate of this reaction when the temperature is increased.

.....

.....

.....

.....

.....

..... [3]

(d) Ammonia, NH_3, is used to produce nitric acid, HNO_3. This happens in a three-stage process.

Stage 1 is a redox reaction.

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

(i) Identify what is oxidised in **stage 1**.

Give a reason for your answer.

substance oxidised .....

reason .....

.....

[2]

(ii) In this reaction the predicted yield of NO is 512 g. The actual yield is 384 g.

Calculate the percentage yield of NO in this reaction.

percentage yield of NO = ... [1]

(iii) The equation for the reaction in **stage 2** is shown.

$$2NO + O_2 \rightarrow 2NO_2$$

Which major environmental problem does NO_2 cause if it is released into the atmosphere?

.....

..... [1]

(iv) The equation for the reaction in **stage 3** is shown.

$$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$$

Calculate the volume of O_2 gas, at room temperature and pressure (r.t.p.), needed to produce 1260 g of HNO_3.
Use the following steps.

- Calculate the number of moles of HNO_3.

moles of HNO_3 = ...

- Deduce the number of moles of O_2 that reacted.

moles of O_2 = ...

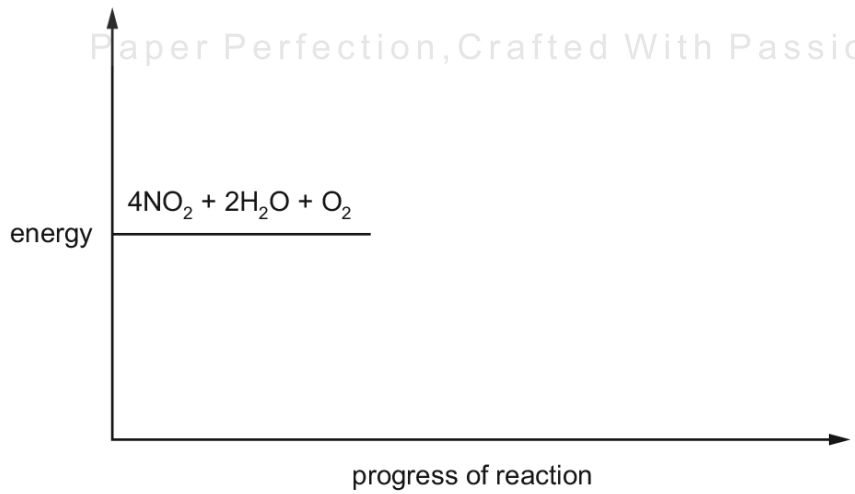
- Calculate the volume of O_2 gas that reacts at room temperature and pressure (r.t.p.).

volume of O_2 gas = ... dm^3
[4]

(e) The reaction in **stage 3** is exothermic.

$$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$$

Complete the energy level diagram for this reaction. Include an arrow that clearly shows the energy change during the reaction.



[3]

[Total: 18]

05. 0620_s20_qp_43 Q: 6

(a) An endothermic reaction occurs when calcium nitrate is heated.

(i) Balance the equation for this reaction.

$$.....Ca(NO_3)_2 \rightarrow .....CaO + ...NO_2 + ...O_2$$ [1]

(ii) State the type of reaction shown by the equation.

..... [1]

(b) Describe the test for a nitrate ion.

test .....

.....

result .....

.....

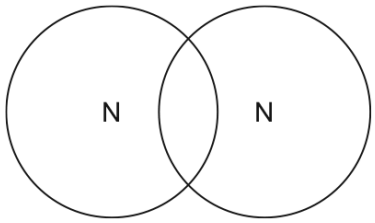
[3]

[Total: 5]

06. 0620_w20_qp_43 Q: 3

This question is about nitrogen and some of its compounds.

(a) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of nitrogen, N_2.
Show the outer shell electrons only.



[2]

(b) Nitrogen can be converted into ammonia by the Haber process.

(i) Describe how nitrogen is obtained for the Haber process.

.....

..... [2]

(ii) Give the essential reaction conditions and write a chemical equation for the reaction occurring in the Haber process.

chemical equation: .....

.....

reaction conditions: .....

.....

.....

.....

.....

[5]

(c) Some of the ammonia made by the Haber process is converted into nitric acid.

The first stage of this process is the oxidation of ammonia to make nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The process is carried out at 900 °C and a pressure of 5 atmospheres using an alloy of platinum and rhodium as a catalyst.

The forward reaction is exothermic.

(i) State the meaning of the term *catalyst*.

.....

..... [2]

(ii) State the meaning of the term *oxidation*.

..... [1]

(iii) Complete the table using the words **increase**, **decrease** or **no change**.

	effect on the rate of the forward reaction	effect on the equilibrium yield of NO(g)
increasing the temperature		
increasing the pressure		

[4]

(d) Nitrogen monoxide, NO, is converted into nitrogen dioxide, NO_2.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The nitrogen dioxide reacts with oxygen and water to produce nitric acid as the only product.

Write a chemical equation for this reaction.

..... [2]

(e) Ammonium nitrate, NH_4NO_3, is a fertiliser.

Calculate the percentage by mass of nitrogen in ammonium nitrate.

..... % [2]

[Total: 20]

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07. 0620_w19_qp_41 Q: 1

This question is about ions and ionic compounds.

(a) Choose from the following list of ions to answer the questions.

Br^-	Ca^{2+}	Cl^-	Cr^{3+}	Cu^{2+}
K^+	Li^+	Na^+	SO_3^{2-}	SO_4^{2-}

Each ion may be used once, more than once or not at all.

State which ion:

(i) gives a lilac colour in a flame test ..... [1]

(ii) forms a grey-green precipitate with aqueous ammonia ..... [1]

(iii) forms a white precipitate with aqueous sodium hydroxide ..... [1]

(iv) forms a cream precipitate with acidified aqueous silver nitrate ..... [1]

(v) forms a white precipitate with acidified aqueous barium nitrate. ..... [1]

(b) Describe how to do a flame test on a sample of a salt.

.....

.....

.....

..... [2]

(c) Magnesium phosphate contains magnesium ions, Mg^{2+}, and phosphate ions, PO_4^{3-}.

Deduce the formula of magnesium phosphate.

..... [1]

[Total: 8]

08. 0620_w19_qp_43 Q: 4

This question is about phosphorus and compounds of phosphorus.

(a) A phosphorus molecule contains four phosphorus atoms **only**.

What is the formula of a phosphorus molecule?

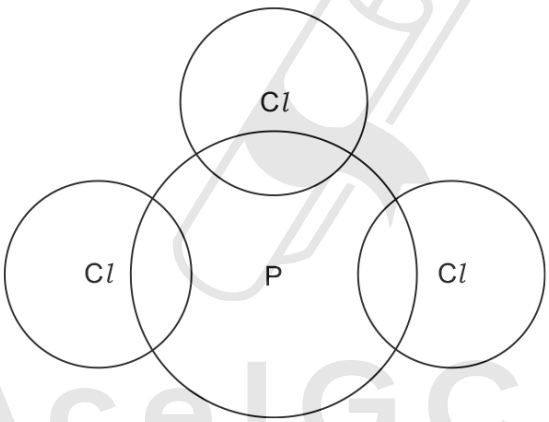
..... [1]

(b) Phosphorus reacts with chlorine gas to produce phosphorus(III) chloride, PCl_3.

(i) Write a chemical equation for the reaction between phosphorus and chlorine to produce phosphorus(III) chloride, PCl_3.

..... [2]

(ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphorus(III) chloride, PCl_3. Show outer shell electrons only.

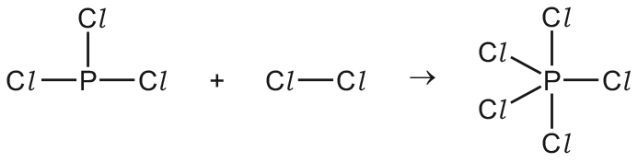


[2]

(c) Gaseous phosphorus(III) chloride, PCl_3, reacts with gaseous chlorine to form gaseous phosphorus(V) chloride, PCl_5.

$$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$$

The chemical equation for this reaction can be represented as shown.



(i) Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

bond	bond energy in kJ/mol
P–Cl	326
Cl–Cl	243

- Energy needed to break bonds.

..... kJ

- Energy released when bonds are formed.

..... kJ

- Energy change of reaction.

energy change = ... kJ/mol
[3]

(ii) Deduce whether the energy change for this reaction is exothermic or endothermic. Explain your answer.

.....

..... [1]

(d) Under certain conditions the reaction reaches equilibrium.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

State and explain the effect, if any, on the **position of equilibrium** if the pressure is increased. All other conditions are unchanged.

.....

.....

..... [2]

(e) Phosphine, PH_3, is produced by the reaction between water and calcium phosphide, Ca_3P_2.

Balance the chemical equation for this reaction.

$$Ca_3P_2 + ...H_2O \rightarrow .....Ca(OH)_2 + ...PH_3$$ [2]

(f) The phosphonium ion, PH_4^+, is similar to the ammonium ion.

(i) State the formula of the ammonium ion. ..... [1]

(ii) Suggest the formula of phosphonium iodide. ..... [1]

(g) Calcium phosphate contains the phosphate ion, PO_4^{3-}.

What is the formula of calcium phosphate?

..... [1]

(h) Phosphorus forms another compound with hydrogen with the following composition by mass: P, 93.94%; H, 6.06%.

(i) Calculate the empirical formula of the compound.

empirical formula = ... [2]

(ii) The compound has a relative molecular mass of 66.

Deduce the molecular formula of the compound.

molecular formula = ... [1]

[Total: 19]

09. 0620_m17_qp_42 Q: 2

Silver dichromate, $Ag_2Cr_2O_7$, is a red insoluble salt.

Silver dichromate can be made by reacting silver nitrate solution with ammonium dichromate solution. The chemical equation for the reaction is shown.

$$2AgNO_3(aq) + (NH_4)_2Cr_2O_7(aq) \rightarrow 2NH_4NO_3(aq) + Ag_2Cr_2O_7(s)$$

(a) Describe how you could obtain pure dry solid silver dichromate after mixing silver nitrate solution and ammonium dichromate solution.

.....

.....

.....

..... [3]

(b) (i) The charge on a silver ion is +1.

Deduce the charge on the dichromate ion in $Ag_2Cr_2O_7$.

..... [1]

(ii) Write the ionic equation for the formation of silver dichromate in this reaction.
State symbols are **not** required.

..... [1]

(c) Dilute aqueous sodium hydroxide was added to the ammonium nitrate solution made in the reaction. The mixture was then warmed and damp Universal Indicator paper was held above the mixture.

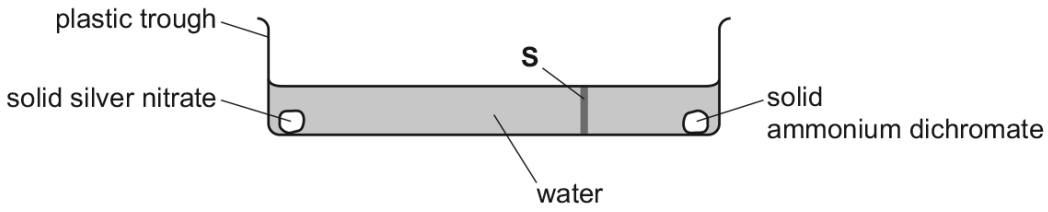
State and explain what would happen to the Universal Indicator paper.

.....

.....

..... [2]

(d) The apparatus shown was set up.



After five minutes, a red solid appeared along the line marked **S** on the diagram.

(i) Explain why a red solid appeared along the line marked **S**.

.....

.....

.....

..... [3]

(ii) The experiment was repeated at a higher temperature.

What effect, if any, would this have on the time taken for the red solid to appear? Explain your answer.

.....

..... [2]

(e) Ammonium dichromate, $(NH_4)_2Cr_2O_7$, undergoes thermal decomposition.
The products are chromium(III) oxide, nitrogen and water.

(i) What is meant by *thermal decomposition*?

.....

..... [2]

(ii) Write a chemical equation for the thermal decomposition of ammonium dichromate.

..... [2]

[Total: 16]

10. 0620_s17_qp_42 Q: 3

This question is about nitrogen and some of its compounds.

(a) Nitrogen in the air can be converted into ammonia by the Haber process. The chemical equation for the reaction is shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(i) State the temperature and pressure used in the Haber process.

temperature .....

pressure .....

[2]

(ii) Name the catalyst used in the Haber process.

..... [1]

(b) The ammonia produced in the Haber process can be oxidised to nitrogen(II) oxide at 900 °C. The reaction is exothermic.

(i) Balance the chemical equation for this reaction.

$$4NH_3 + ...O_2 \rightleftharpoons .....NO + ...H_2O$$

[2]

(ii) Suggest a reason, other than cost, why a temperature greater than 900 °C is **not** used.

..... [1]

(iii) Suggest a reason why a temperature less than 900 °C is **not** used.

..... [1]

(c) Nitrogen(II) oxide can be reacted with oxygen and water to produce nitric acid as the only product.

Write a chemical equation for this reaction.

..... [2]

(d) Describe how you would prepare a pure dry sample of copper(II) nitrate crystals in the laboratory using dilute nitric acid and solid copper(II) carbonate.
Include a series of key steps in your answer.
You should include a chemical equation for the reaction.

.....

.....

.....

.....

.....

.....

.....

..... [6]

[Total: 15]

11. 0620_m16_qp_42 Q: 5

This question is about compounds of nitrogen.

(a) (i) Describe the Haber Process giving reaction conditions and a chemical equation. Reference to rate and yield is not required.

.....

.....

.....

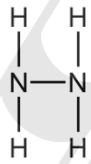
.....

..... [5]

(ii) Give **one** use of ammonia.

..... [1]

(b) The diagram shows the structure of a hydrazine molecule.



Draw the electron arrangement of a hydrazine molecule. Show the outer shell electrons only.

[2]

(c) Hydrazine is a base.

(i) Define the term *base*.

..... [1]

(ii) Complete the chemical equation to show that hydrazine acts as a base when added to water.

$N_2H_4 + H_2O \rightarrow$ ..... + ... [1]

(d) Nitrogen dioxide is an atmospheric pollutant.

(i) State **one** environmental problem caused by nitrogen dioxide.

..... [1]

(ii) Explain how oxides of nitrogen, such as nitrogen dioxide, are formed in car engines.

.....

..... [2]

[Total: 13]

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12. 0620_w16_qp_41 Q: 4

(a) Ammonia, NH_3, is made by reacting nitrogen with hydrogen in the Haber process.

(i) Write a chemical equation for the formation of ammonia in the Haber process.

..... [2]

(ii) Name the raw materials from which nitrogen and hydrogen are obtained.

nitrogen .....

hydrogen .....

[2]

(iii) State the temperature and pressure used in the Haber process. Include the units.

temperature .....

pressure .....

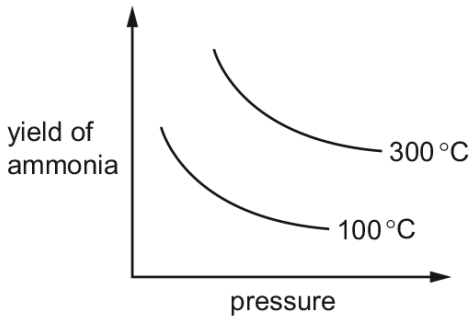
[2]

(b) Ammonia is also made when ammonium carbonate decomposes.

$$(NH_4)_2CO_3(s) \rightleftharpoons 2NH_3(g) + H_2O(g) + CO_2(g)$$

The reaction is reversible and can reach a position of equilibrium.

The graph shows how the yield of ammonia at equilibrium changes with temperature and pressure.



(i) What is meant by the term *equilibrium* for a reversible reaction?

.....

.....

..... [2]

(ii) Using information from the graph, explain whether the reaction is endothermic or exothermic.

.....

..... [1]

(iii) State and explain the effect of increasing the pressure on the yield of ammonia in this reaction.

.....

.....

.....

.....

..... [3]

[Total: 12]

13. 0620_m15_qp_32 Q: 3

Ammonia is manufactured by the Haber process. Nitrogen and hydrogen are passed over a catalyst at a temperature of 450 °C and a pressure of 200 atmospheres.

The equation for the reaction is as follows.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The forward reaction is exothermic.

(a) State **one** use of ammonia.

..... [1]

(b) What is the meaning of the symbol $\rightleftharpoons$?

..... [1]

(c) What are the sources of nitrogen and hydrogen used in the Haber process?

nitrogen .....

hydrogen .....

[2]

(d) Name the catalyst in the Haber process.

..... [1]

(e) **(i)** If a temperature higher than 450 °C was used in the Haber process, what would happen to the **rate** of the reaction? Give a reason for your answer.

.....

.....

..... [2]

(ii) If a temperature higher than 450 °C was used in the Haber process, what would happen to the **yield** of ammonia? Give a reason for your answer.

.....

.....

..... [2]

(f) **(i)** If a pressure higher than 200 atmospheres was used in the Haber process, what would happen to the **yield** of ammonia? Give a reason for your answer.

.....

.....

..... [2]

(ii) Explain why the rate of reaction would be faster if the pressure was greater than 200 atmospheres.

.....

..... [1]

(iii) Suggest **one** reason why a pressure higher than 200 atmospheres is not used in the Haber process.

.....

..... [1]

(g) Draw a dot-and-cross diagram to show the arrangement of the outer (valency) electrons in one molecule of ammonia.

[2]

(h) Ammonia acts as a base when it reacts with sulfuric acid.

(i) What is a base?

..... [1]

(ii) Write a balanced equation for the reaction between ammonia and sulfuric acid.

..... [2]

[Total: 18]

14. 0620_s15_qp_32 Q: 4

Ammonia is made by the Haber process.

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

The forward reaction is exothermic.

Typical reaction conditions are:

- finely divided iron catalyst,
- temperature 450 °C,
- pressure 200 atmospheres.

(a) Explain why the catalyst is used as a very fine powder and larger pieces of iron are not used.

.....

.....

..... [2]

(b) Using the above conditions, the equilibrium mixture contains about 15% ammonia.

State two changes to the reaction conditions which would increase the percentage of ammonia at equilibrium.

.....

.....

..... [2]

(c) Suggest why the changes you have described in **(b)** are **not** used in practice.

.....

.....

..... [2]

[Total: 6]

15. 0620_s15_qp_32 Q: 6

The Atacama desert in Chile has deposits of the salt sodium nitrate. Very large amounts of this salt were exported to Europe for use as a fertiliser. After the introduction of the Haber process in 1913, this trade rapidly diminished.

(a) (i) Explain why the introduction of the Haber process reduced the demand for sodium nitrate.

.....

..... [2]

(ii) Suggest why surface deposits of sodium nitrate only occur in areas with very low rainfall such as desert areas.

..... [1]

(iii) The desert has smaller surface deposits of potassium nitrate.

Suggest why potassium nitrate is a better fertiliser than the sodium salt.

..... [1]

(b) All nitrates decompose when heated. The extent to which a nitrate decomposes is determined by the metal in the salt.

(i) Sodium nitrate decomposes to form sodium nitrite, $NaNO_2$.

Write the equation for decomposition of sodium nitrate.

..... [2]

(ii) Sodium nitrite is a reducing agent.

What would be observed if an excess of sodium nitrite solution was added to a solution of acidified potassium manganate(VII)?

..... [2]

(iii) Copper(II) nitrate decomposes to form copper(II) oxide, nitrogen dioxide and oxygen.

What is the relationship between the extent of decomposition and the reactivity of the metal in the nitrate?

.....

..... [1]

(c) The equation for the decomposition of copper(II) nitrate is given below.

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

(i) Predict what you would observe when copper(II) nitrate is heated.

.....

.....

..... [3]

(ii) Copper(II) nitrate forms a series of hydrates with the formula $Cu(NO_3)_2.xH_2O$.
All these hydrates decompose to form copper(II) oxide.
1 mole of $Cu(NO_3)_2.xH_2O$ forms 1 mole of CuO.

What is meant by 1 mole of a substance?

.....

..... [2]

(iii) 7.26 g of a hydrate, $Cu(NO_3)_2.xH_2O$, formed 2.4 g copper(II) oxide.

number of moles of CuO formed = ...

number of moles of $Cu(NO_3)_2.xH_2O$ in 7.26 g = ...

mass of 1 mole of $Cu(NO_3)_2.xH_2O$ = ... g

mass of 1 mole of $Cu(NO_3)_2$ is 188 g

the value of *x* in this hydrate = ...

[4]

[Total: 18]

16. 0620_s14_qp_32 Q: 3

Plant growth is improved by the availability of essential elements, such as nitrogen, and by the soil having a suitable pH.

(a) Nitrogen-based fertilisers are made from ammonia. Ammonia is manufactured by the Haber process.

(i) Describe the Haber process giving reaction conditions and a balanced equation.
(Do not discuss reaction rate and yield.)

.....

.....

.....

.....

..... [5]

(ii) Fertilisers contain nitrogen.
Name the other **two** elements essential for plant growth commonly found in fertilisers.

..... [2]

(b) Crops do not grow well if the soil is too acidic.

(i) One cause of acidity in soil is acid rain. Explain how acid rain is formed.

.....

.....

.....

..... [3]

(ii) Name **two** bases which are used to increase the pH of acidic soils.

..... [2]

[Total: 12]

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17. 0620_s14_qp_33 Q: 5

Ammonia is made by the Haber process.

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

The forward reaction is exothermic.
The conditions in the reaction chamber are:

- a pressure of 200 atmospheres,
- a catalyst of finely divided iron,
- a temperature of 400 to 450 °C.

(a) What are the **two** advantages of using a high pressure? Give a reason for both.

advantage 1 .....

reason .....

.....

advantage 2 .....

reason .....

.....

[4]

(b) A higher temperature would give a faster reaction rate.
Why is a higher temperature **not** used?

.....

.....

..... [3]

(c) **(i)** Why is the iron catalyst used as a fine powder?

.....

..... [1]

(ii) Give **two** reasons why a catalyst is used.

.....

.....

.....

..... [2]

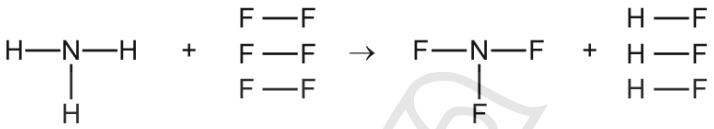
(d) The equilibrium mixture leaving the reaction chamber contains 15% ammonia. Suggest how the ammonia could be separated from the mixture.

	boiling point / °C
hydrogen	–253
nitrogen	–196
ammonia	–33

.....

..... [2]

(e) Ammonia is used to make nitrogen trifluoride, NF_3.
Nitrogen trifluoride is essential to the electronics industry. It is made by the following reaction.



Determine if the above reaction is exothermic or endothermic using the following bond energies and by completing the following table. The first line has been done as an example.
Bond energy is the amount of energy, in kJ / mole, needed to break or make one mole of the bond.

bond	bond energy in kJ / mole
N – H	390
F – F	155
N – F	280
H – F	565

bond	energy change / kJ
N – H	(3 × 390) = 1170
F – F	
N – F	
H – F	

.....

..... [4]

[Total: 16]

18. 0620_w14_qp_31 Q: 7

Nitrogen can form ionic compounds with reactive metals and covalent compounds with non-metals.

(a) Nitrogen reacts with lithium to form the ionic compound lithium nitride, Li_3N.

(i) Write the equation for the reaction between lithium and nitrogen.

..... [2]

(ii) Lithium nitride is an ionic compound. Draw a diagram which shows its formula, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x for an electron from a lithium atom.
Use o for an electron from a nitrogen atom.

[2]

(b) Nitrogen fluoride is a covalent compound.

(i) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound nitrogen trifluoride, NF_3.

Use x for an electron from a nitrogen atom.
Use o for an electron from a fluorine atom.

[2]

(ii) Lithium nitride has a high melting point, 813 °C. Nitrogen trifluoride has a low melting point, –207 °C.
Explain why the melting points are different.

.....

.....

..... [2]

[Total: 8]

19. 0620_s13_qp_31 Q: 6

Ammonia is a compound which only contains the elements nitrogen and hydrogen. It is a weak base.

(a) (i) Define the term *base*.

..... [1]

(ii) Given aqueous solutions of ammonia and sodium hydroxide, both having a concentration of 0.1 mol / dm^3, how could you show that ammonia is the weaker base?

.....

.....

..... [2]

(b) Ammonia is manufactured by the Haber Process. The economics of this process require that as much ammonia as possible is made as quickly as possible.
Explain how this can be done using the following information.

The conditions for the following reversible reaction are:

- 450 °C
- 200 atmospheres pressure
- iron catalyst

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \text{the reaction is exothermic}$$

.....

.....

.....

.....

.....

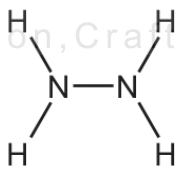
..... [5]

(c) Another compound which contains only nitrogen and hydrogen is hydrazine, N_2H_4.

Complete the equation for the preparation of hydrazine from ammonia.

$$.....NH_3 + NaCl O \rightarrow N_2H_4 + ... + H_2O$$ [2]

(d) The structural formula of hydrazine is given below.



Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound hydrazine.
Use x to represent an electron from a nitrogen atom.
Use o to represent an electron from a hydrogen atom.

[3]

(e) Hydrazine is a weak base and it removes dissolved oxygen from water. It is added to water in steel boilers to prevent rusting.

(i) One way it reduces the rate of rusting is by changing the pH of water.
What effect would hydrazine have on the pH of water?

..... [1]

(ii) Give a reason, other than pH, why hydrazine reduces the rate of rusting.

..... [1]

[Total: 15]

---

20. 0620_w13_qp_32 Q: 3

(a) Nitric acid is now made by the oxidation of ammonia. It used to be made from air and water. This process used very large amounts of electricity.

Air was blown through an electric arc and heated to 3000 °C.

$$N_2(g) + O_2(g) \rightleftharpoons \underset{\text{nitric oxide}}{2NO(g)} \qquad \textbf{equilibrium 1}$$

The equilibrium mixture leaving the arc contained 5 % of nitric oxide. This mixture was cooled rapidly. At lower temperatures, nitric oxide will react with oxygen to form nitrogen dioxide.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2 \qquad \textbf{equilibrium 2}$$

Nitrogen dioxide reacts with oxygen and water to form nitric acid.

(i) Suggest a reason why the yield of nitric oxide in **equilibrium 1** increases with temperature.

..... [1]

(ii) What effect, if any, would increasing the pressure have on the percentage of nitric oxide in **equilibrium 1**? Explain your answer.

.....

..... [2]

(iii) Deduce why **equilibrium 2** is only carried out at lower temperatures.

.....

..... [2]

(iv) Complete the equation for the reaction between nitrogen dioxide, water and oxygen to form nitric acid.

.....NO_2 + O_2 + ... → .....HNO_3 [2]

(v) Ammonia is more expensive than water and air. Suggest a reason why the ammonia-based process is preferred to the electric arc process.

..... [1]

(b) (i) Nitric acid is used to make the fertiliser ammonium nitrate, NH_4NO_3.
What advantage has this fertiliser over another common fertiliser, ammonium sulfate, $(NH_4)_2SO_4$?

..... [1]

(ii) Plants need nitrogen to make chlorophyll. Explain why chlorophyll is essential for plant growth.

.....

.....

.....

.....

..... [4]

[Total: 13]

21. 0620_s12_qp_32 Q: 8

Ethylamine, $CH_3–CH_2–NH_2$, is a base which has similar properties to ammonia.

(a) In aqueous ethylamine, there is the following equilibrium.

$$CH_3–CH_2–NH_2 + H_2O \rightleftharpoons CH_3–CH_2–NH_3^+ + OH^-$$

Explain why water is behaving as an acid in this reaction.

..... [1]

(b) Given aqueous solutions of ethylamine and sodium hydroxide, describe how you could show that ethylamine is a weak base like ammonia and not a strong base like sodium hydroxide.

.....

.....

..... [3]

(c) Ethylamine, like ammonia, reacts with acids to form salts.

$$CH_3–CH_2–NH_2 + HCl \rightarrow CH_3–CH_2–NH_3Cl$$

ethylammonium chloride

Suggest how you could displace ethylamine from the salt, ethylammonium chloride.

.....

..... [2]

(d) Explain the chemistry of the following reaction:

When aqueous ethylamine is added to aqueous iron(III) chloride, a brown precipitate is formed.

.....

..... [2]

[Total: 8]

22. 0620_w12_qp_33 Q: 7

Ammonia is made by the Haber process.

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

(a) State **one** major use of ammonia.

..... [1]

(b) Describe how hydrogen is obtained for the Haber process.

.....

.....

..... [3]

(c) This reaction is carried out at a high pressure, 200 atmospheres.
State, with an explanation for each, **two** advantages of using a high pressure.

.....

.....

.....

.....

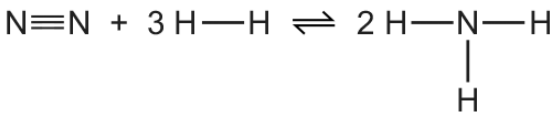
..... [5]

(d) **(i)** What is the difference between an endothermic and an exothermic reaction?

.....

..... [1]

(ii) Bond breaking is an endothermic process. Bond energy is the amount of energy needed to break or form one mole of the bond. Complete the table and explain why the forward reaction is exothermic.



bond	bond energy kJ / mol	energy change kJ	exothermic or endothermic
N≡N	944	+944	endothermic
H—H	436	3 × 436 = +1308	
N—H	388		

.....

..... [3]

[Total: 13]

01. 0620_m21_ms_42 Q: 3

Question	Answer	Marks
(a)(i)	Haber	1
(a)(ii)	reversible / equilibrium	1
(a)(iii)	450 °C (1) 200 atm (1)	2
(a)(iv)	iron / Fe	1
(a)(v)	equilibrium **shifts / moves** in forwards direction (1) fewer molecules / moles (of gas) on RHS (1)	2
(a)(vi)	particles have more energy (1) more collisions (between particles) occur per second / per unit time (1) a greater percentage / proportion / fraction of collisions (of particles) are successful / have energy above activation energy / have energy equal to activation energy (1)	3
(b)	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ $(NH_4)_2SO_4$ (1) correct equation (1)	2

02. 0620_w21_ms_42 Q: 5

Question	Answer	Marks
(a)	metallic (1) (lattice of) positive ions (1) sea of / delocalised / mobile electrons (1) attraction between positive ions and electrons (1)	4
(b)(i)	malleability / malleable	1
(b)(ii)	(particles) slide (over each other)	1
(b)(iii)	unreactive	1
(c)	high(er) density high(er) melting points	2
(d)(i)	Na – yellow (1) K – lilac (1) colourless solution (1) clear idea of increased reactivity in **both** reactions (1)	4

Question	Answer	Marks
(d)(ii)	hydrogen	1
(d)(iii)	potassium hydroxide	1
(d)(iv)	any number in the range $7 < pH \leqslant 14$	1
(d)(v)	$4Na + O_2 \rightarrow 2Na_2O$ Na_2O (1) correct equation (1)	2
(e)(i)	$N_2 + 3H_2 \rightarrow 2NH_3$ species (1) correct equation (1)	2
(e)(ii)	450 °C (1) 200 atm (1)	2

03. 0620_s20_ms_42 Q: 1

(a)(i)	condensation	1
(a)(ii)	sublimation	1
(a)(iii)	fractional distillation	1
(a)(iv)	electrolysis	1
(a)(v)	chromatography	1
(b)(i)	N	1
(b)(ii)	O	1
(b)(iii)	Be	1
(b)(iv)	N	1
(b)(v)	Ne	1
(b)(vi)	Li	1

04. 0620_s20_ms_43 Q: 2

(a)(i)	reversible reaction	1
(a)(ii)	hydrocarbons (reacting with steam)	1
(b)	[increasing pressure] increases yield [increasing temperature] decreases yield	2

(c)	(particles) have more energy OR (particles) move faster more collisions per second OR greater collision rate more (of the) particles OR collisions have sufficient energy / activation energy to react OR a greater percentage / proportion / fraction of collisions are successful	3
(d)(i)	N / NH_3 change in oxidation state of N from –3 to +2 / increase in oxidation number / gain in oxygen / loss of electrons	2
(d)(ii)	75	1
(d)(iii)	(it could react with rain water to) form nitric acid / acid rain	1
(d)(iv)	(M_r of HNO_3 =) 63 (1) 20 (1) 5 (1) 120 (dm^3) (1)	4
(e)	• horizontal product energy line at lower energy level than reactant • label of product • correct direction of vertical arrow – arrow must start level with reactant energy and finish level with product level and one arrow head ONLY	3

05. 0620_s20_ms_43 Q: 6

(a)(i)	2, 2, 4, 1	1
(a)(ii)	thermal decomposition	1
(b)	• add aqueous sodium hydroxide • then (reduction with) aluminium (foil) (and warm) • (ammonia gas produced which) turns damp red litmus blue	3

06. 0620_w20_ms_43 Q: 3

Question	Answer	Marks
(a)	triple bond (1) diagram completely correct (1)	2
(b)(i)	**METHOD 1** **liquid** air (1) **fractional** distillation (1) **METHOD 2** hydrogen burns in **air** (to remove the oxygen and then scrub out the carbon dioxide)	2
(b)(ii)	(pressure) 200 atmospheres (1) (temperature) 450 °C (1) iron **catalyst** (1) $N_2 + 3H_2 \rightarrow 2NH_3$ (1) equilibrium / reversible (1)	5
(c)(i)	substance that speeds up a reaction / increases rate (1) unchanged (chemically) at the end **OR** not used **up** **OR** lowers activation energy (1)	2
(c)(ii)	gain of oxygen / loss of hydrogen / electron loss / increase in oxidation state (oxidation number)	1

Question	Answer	Marks
(c)(iii)	<table><tr><th>effect on the rate of the forward reaction</th><th>effect on the equilibrium yield of NO(g)</th></tr><tr><td>increase (1)</td><td>decrease (1)</td></tr><tr><td>increase (1)</td><td>decrease (1)</td></tr></table>	4
(d)	$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ all formulae (1) equation fully correct(1)	2
(e)	(M_r of NH_4NO_3 =) 80 (1) 35% (1)	2

07. 0620_w19_ms_41 Q: 1

(a)(i)	K^+	1
(a)(ii)	Cr^{3+}	1
(a)(iii)	Ca^{2+}	1
(a)(iv)	Br^-	1
(a)(v)	SO_4^{2-}	1
(b)	(compound / salt) on wooden splint **or** (nichrome / platinum) wire (1) into (roaring) Bunsen flame (1)	2
(c)	$Mg_3(PO_4)_2$	1

08. 0620_w19_ms_43 Q: 4

(a)	P_4	1

(b)(i)	$P_4 + 6Cl_2 \rightarrow 4PCl_3$ formulae correct (1) equation balanced (1)	2
(b)(ii)	3 bonding pairs and 1 lone pair on P (1) six non-bonding electrons on 3 chlorine atoms (1)	2
(c)(i)	**method 1** □ (bond breaking) = 1221 or (326 □ 3) + 243 (1) □ (bond forming) = 1630 or (326 □ 5) (1) □ energy change = –409 kJ (1) negative sign essential **OR** **method 2** (ignoring 3 P–Cl bonds on both sides) □ bond breaking = 243 .(1) □ bond forming = 652 or 326 □ 2 (1) □ energy change = –409 kJ (1) negative sign essential	3
(c)(ii)	exothermic **AND** energy released when bonds form is greater than energy absorbed to break bonds **OR e**xothermic **AND** overall energy change has a negative sign	1
(d)	fewer **OR** less molecules **OR** moles + on right **OR** in product (1) ORA equilibrium shifts to the right (1)	2

(e)	any two numbers correct (1) equation fully balanced (1) $Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$	2
(f)(i)	NH_4^+	1
(f)(ii)	PH_4I	1
(g)	$Ca_3(PO_4)_2$	1
(h)(i)	93.94 / 31 and 6.06 / 1 **OR** 3.03 and 6.06 **OR** 1 : 2 ratio (1) PH_2 (1)	2
(h)(ii)	P_2H_4	1

09. 0620_m17_ms_42 Q: 2

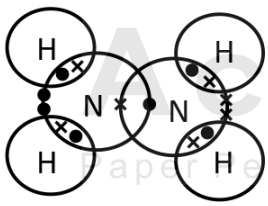
(a)	**M1** filter	1
	M2 wash (the residue) using water	1
	M3 dry the residue between filter papers / in a warm place	1
(b)(i)	2^-	1
(b)(ii)	$2Ag^+ + Cr_2O_7^{2-} \rightarrow Ag_2Cr_2O_7$	1
(c)	**M1** Universal Indicator turns blue	1
	M2 ammonia / NH_3 (is made)	1
(d)(i)	**M1** dichromate ions / particles are heavier (than silver ions)	1
	M2 so dichromate ions diffuse / move more slowly **ORA**	1
	M3 (where they meet they react and) silver dichromate is made	1
(d)(ii)	**M1** red solid forms in less than five minutes **or** red solid forms faster / sooner	1
	M2 particles / ions move faster	1
(e)(i)	**M1** breaking down	1
	M2 when heated	1

(e)(ii)	**M1** formula of chromium(III) oxide	1
	M2 rest of equation correct to give a fully correct equation ($(NH_4)_2Cr_2O_7 \rightarrow N_2 + Cr_2O_3 + 4H_2O$ scores [2])	1

10. 0620_s17_ms_42 Q: 3

(a)(i)	450 °C	1
	200 atmospheres	1
(a)(ii)	iron	1
(b)(i)	4(NO)	1
	5(O_2) **AND** 6(H_2O)	1
(b)(ii)	lower yield of NO / lower yield of nitric acid / lower yield of product / equilibrium shifts to left (at higher temperatures) / backward reaction favoured(at higher temperatures) **ORA**	1
(b)(iii)	too slow / rate decreases **ORA**	1
(c)	$4NO + 3O_2 + 2H_2O \rightarrow 4HNO_3$ **M1** all formulae correct **M2** balancing	2
(d)	add copper(II) carbonate (to acid) until it stops dissolving or no more effervescence / bubbling / fizzing	1
	filter (to remove copper(II) carbonate)	1
	evaporate / heat / warm / boil / leave in sun **AND** until most of the water has gone / some water is left / evaporate **some** of the water / until it is concentrated / saturation (point) / crystallisation point / crystals form on glass rod or microscope slide / crystals **start** to form	1
	(for any solution) leave / allow to cool / allow to crystallise **OR** (for any crystals) filter / wash / dry with filter paper / dry in warm place / dry in a **(low)** oven / leave to dry	1
	formula of $Cu(NO_3)_2$	1
	equation: $CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + CO_2 + H_2O$	1

11. 0620_m16_ms_42 Q: 5

(a)(i)	pressure in range 150–300 atmospheres / atm; temperature in range 370–470 °C; iron (catalyst); balanced equation: $N_2 + 3H_2 \rightarrow 2NH_3$; equilibrium / reversible;	5
(a)(ii)	manufacture of fertilisers / nylon / nitric acid / cleaning agent(allow oven cleaner) / hair dye / urea / refrigeration / explosives;	1
(b)	 **M1** all shared electrons correct (5 bonds); **M2** exactly two non-bonding electrons on each N and no additional non-bonding electrons;	2
(c)(i)	proton / H^+ acceptor;	1
(c)(ii)	$(N_2H_4 + H_2O) \rightarrow N_2H_5^+ + OH^-$; **or** $(N_2H_4) + 2H_2O \rightarrow N_2H_6^{2+} + 2OH^-$;	1
(d)(i)	acid rain / effect of acid rain / (photochemical) smog / (producing) low level ozone;	1
(d)(ii)	**M1** nitrogen and oxygen (from the air) react / combine or word equation; **M2** at high temperature / spark / very hot;	2

12. 0620_w16_ms_41 Q: 4

(a)(i)	$N_2 + 3H_2 \rightleftharpoons 2NH_3$ **M1** formulae **M2** balancing	**2**
(a)(ii)	(nitrogen) air / atmosphere (hydrogen) steam / water / hydrocarbons / natural gas	**1** **1**
(a)(iii)	(temperature) answer in range 370–470 °C (pressure) answer in range 150–300 atm	**1** **1**
(b)(i)	**M1** forward and reverse reactions (occur) **M2** amounts / moles / concentrations (of reagents and products) constant **OR** **M2** rate of forward and reverse reactions equal	**1** **1**
(b)(ii)	endothermic **AND** yield increases as temperature increases	**1**
(b)(iii)	**M1** yield decreases (as pressure increases) **M2** because more moles / molecules (of gas) on the right **M3** so position of equilibrium moves left	**1** **1** **1**

13. 0620_m15_ms_32 Q: 3

(a) (making) fertilisers / nitric acid / nylon / explosives / urea
(for) cleaning products (allow oven cleaner) / refrigeration [1]

(b) equilibrium / reversible [1]

(c) (nitrogen)air / atmosphere [1]

(hydrogen) methane / water / steam / alkane / named alkane / hydrocarbon / crude oil or petroleum / natural gas [1]

(d) iron [1]

(e) **(i)** rate increases / faster [1]

More (effective) collisions [1]

(ii) yield decreases [1]

(forward reaction) exothermic / reverse reaction endothermic / high temp favours endothermic reaction [1]

(f) **(i)** yield increases [1]

less / fewer molecules or moles or volume on RHS ORA / high pressure favours reaction which produces fewer molecules or moles or volume [1]

(ii) particles / molecules clos**er** / more particles per unit area or volume / more molecules per unit area or volume / more concentration / particles have less space between them **and** more collisions [1]

(iii) safety issues / higher cost [1]

(g) 3 bond pairs between N & H [1]

Lone pair on N [1]

(h) **(i)** proton / H^+ acceptor [1]

(ii) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ [2]

Formula of $(NH_4)_2SO_4$ (1)
The rest (1)

[Total:18]

14. 0620_s15_ms_32 Q: 4

(a)	large surface area / large area of contact / large surface; more (successful) collisions (between catalyst and gases or between reacting gases) **OR** more active sites **OR** faster reaction / increase rate / increase speed;	**2**	**I** activation energy Second mark must be comparative
(b)	decrease temperature / temperature below 450 °C / quoted temperature below 450 °C; increase pressure / pressure above 200 atm / quoted pressure above 200 atm;	**2**	**I** comments about concentration **I** low temperature and high pressure. Both answers must be comparative **I** explanations

(c)	decreased temperature would reduce rate / reaction slow**er** / too slow; increased pressure expensive / uneconomic / safety risks / leaks / explosions / yield **or** rate good enough at lower pressure / strong pipes needed / thick pipes needed / sturdy pipes needed / requires a lot of energy;	**2**	**A** takes long**er** **I** slow (unqualified) **I** answers that do not refer to decreased temperature and increased pressure e.g. it is too expensive unless this is linked with pressure

15. 0620_s15_ms_32 Q: 6

(a)(i)	(Haber process makes) ammonia / NH_3 ; (ammonia converted into) fertilisers / nitrates / ammonium salts or names or formulae of examples e.g. ammonium nitrate / NH_4NO_3 / ammonium sulfate / $(NH_4)_2SO_4$ / calcium nitrate / $Ca(NO_3)_2$ / urea / $CO(NH_2)_2$;	**2**	**A** 2 marks for 'ammonia is a fertiliser' **A** ammonia is used to make sodium nitrate Haber process used to make fertilisers gets second mark only
(a)(ii)	it (refers to sodium nitrate) / sodium nitrate would dissolve (in rain) / soluble (in water) / wash away / leach / drain off;	**1**	**A** reacts with water **I** reference to fertiliser **R** sodium reacts / dissolves **A** because they are not dissolved by rainfall (implication is in desert)
(a)(iii)	potassium (is required by plants as well as nitrogen) / NP**K**;	**1**	**R** comments about pH / better for soil / %N higher / reactivity of potassium **I** comments about what K does for plants e.g. combat disease
(b)(i)	$2NaNO_3 \rightarrow 2NaNO_2 + O_2$ species; balancing;	**2**	**A** multiples **I** state symbols / word equation

(b)(ii)	(colour changes) from pink / purple; to colourless / decolourised;	**2**	**I** clear / discoloured / effervescence **I** brown fumes / brown gas **NOTE:** stays pink or purple gets first mark but turns purple or pink is 0
(b)(iii)	the more reactive the metal the lower rate of decomposition / more difficult the decomposition / more stable the nitrate / more energy needed to decompose / decomposes at higher temperature ora;	**1**	**A** less (extent the) decomposition **A** reactive metals produce nitrates difficult to decompose ora i.e. comparatives not essential **A** the more reactive the metal the less it decomposes is acceptable because we can assume that *it* refers to the nitrate BOD **A** inverse relationship with further qualification **A** group 1 / reactive metals produce nitrite (and oxygen) **and** less reactive metals produce oxide (+ NO_2 + O_2) (both required for mark) **I** less products (unqualified) **R** less products / metals decompose
(c)(i)	(changes from) blue solid / blue crystals; black solid formed; brown gas / brown vapour / (pungent) smell;	**3**	**R** precipitate **A** one mark out of the first two for changes from blue to black (without solid or crystals) **I** red / melt **I** water / steam / condensation given off **I** reference to glowing / burning splints / colourless gas / effervescence **I** names / formulae

(c)(ii)	Avogadro('s) number / constant / 6.02×10^{23}; **COND** particles; **OR** (the number of particles which is equal to the number of atoms in) 12 g of carbon 12; **COND** atoms; **OR** the mass **in grams** which contains Avogadro('s) Number; **COND** particles; **OR** (the amount of substance which has a mass equal to) its relative formula mass / RFM / relative atomic mass / Ar / relative molecular mass / Mr / molar mass; **COND** in grams; **OR** (the amount of substance which has a volume equal to) 24 dm^3; **COND** of a gas **at** RTP;	**2**	**A** any values from 6 to 6.023×10^{23} **A** atoms / ions / molecules / electrons **A** one mark for reference to C12 **A** equivalent statement for any element **or** compound e.g. 32 grams of oxygen(1) **COND** molecules / O_2 (1) e.g. 16 grams of oxygen (1) **COND** atoms / O(1) **A** different volumes under different conditions e.g. 22.4 dm^3 at STP or volumes in different units e.g. 24 000 cm^3 at RTP
(c)(iii)	M1 (number of moles of CuO formed =) **0.03**; M2 (number of moles of $Cu(NO_3)_2.xH_2O$ in 7.26 g =) **0.03**; M3 (mass of 1 mole of $Cu(NO_3)_2.xH_2O$ 7.26 ÷ 0.03 =) **242** (g); (mass of 1 mole of $Cu(NO_3)_2$ is 188 g) M4 the value of x = **3**;	**4**	 ecf same as M1 ecf 7.26 ÷ M2 ecf M3 – 188 ÷ 18

16. 0620_s14_ms_32 Q: 3

(a) (i) pressure 150–300 atmospheres / atm (1)

temperature **accept** in range 370 to 470 °C (1)

iron (catalyst) (1)

balanced equation $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (1)

equilibrium / reversible (1) [5]

(ii) potassium / K (1)

phosphorus / P (1) [2]

(b) (i) burn fossil fuels / burn fuels containing sulfur / burn compounds containing sulfur / burn ores containing sulfur / roast metal sulfides / burn metal sulfides (1)

sulfur dioxide / SO_2 (formed) (1)

(form) sulfuric / H_2SO_4 / sulfurous acid / H_2SO_3 (1)

OR

nitrogen and oxygen (in air) react at high temperatures / in jet engines / car engines / lightning. (1)

(form) oxides of nitrogen (1)

(form) nitric acid / HNO_3 / nitrous acid / HNO_2 (1) [3]

(ii) any **two** from:
calcium oxide / lime / quicklime / CaO (1)
calcium hydroxide / $Ca(OH)_2$ / lime / slaked lime / limewater (1)
calcium carbonate / $CaCO_3$ / limestone / chalk / marble (1) [2]
guidance: 'lime' can only be credited once.

[Total: 12]

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17. 0620_s14_ms_33 Q: 5

(a) faster reaction rate (1)
higher collision rate (1)
greater yield **or** favour RHS (1)
pressure favours products because it has lower volume / fewer product molecules (1) [4]

(b) higher temperature favour endothermic reaction (1)
this is the back reaction / left hand side / reactants (1)
reduce yield (1) [3]

(c) **(i)** greater surface area (1) [1]

(ii) increase reaction rate (1)
can use a lower temperature to have an economic rate (1)
and not decrease yield (by increasing temperature). [2]

(d) lower the temperature (1)
only ammonia will liquefy (1)
OR
add water (1)
only ammonia will dissolve (1)
OR
increase pressure (1)
only ammonia will liquefy (1) [2]

(e) second line $+3 \times 155 = +465$
third line $-3 \times 280 = (-)840$
fourth line $-3 \times 565 = (-)1695$
all **three** correct (2)
two correct (1)

1170 + 465 = 1635
840 + 1695 = 2535
both numerically correct (1)
exothermic reaction with some reasoning (1) [4]

[Total: 16]

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18. 0620_w14_ms_31 Q: 7

(a) (i) $6Li + N_2 = 2Li_3N$
species (1) balancing (1)

(ii) N^{3-} ion drawn correctly [1]

Charges correct (minimum 1 × Li ion and 1 nitride ion) [1]

(b) (i) 3 × shared pairs between N and 3 × F [1]

only 2 non-bonding electrons on N, 6 non-bonding electrons on each F
(COND on first point) [1]

(ii) Strong attractive forces/strong ionic bonds in lithium nitride [1]

weak (attractive) forces between molecules in NF_3 [1]

[Total: 8]

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19. 0620_s13_ms_31 Q: 6

(a) (i) proton or H^+ acceptor [1]

(ii) (measure) pH or (use) UI indicator [1]
note: can be implied need not be explicit
sodium hydroxide has higher pH / ammonia(aq) has lower pH [1]
(this sentence would score 2 marks)
or
appropriate colours with UI / appropriate numerical values [1]
ammonia is closer to green, blue-green, turquoise or lighter blue
sodium hydroxide is darker blue / purple / violet [1]
or
measure electrical conductivity [1]
can be implied need not be explicit
ammonia (aq) is the poorer conductor/ sodium hydroxide is the better conductor [1]

(b) any five from:

- high pressure favours lower volume side / movement to right / ammonia side, **or** high pressure increases the yield
- high pressure increases rate
- low temperature favours exothermic reaction / increases yield / favours the forward reaction
- low temperature gives low rate or vice versa
- catalyst increases rate or lowers activation energy
- 450 °C low enough to give an economic yield but with catalyst gives a fast enough rate
  note need whole concept to get this compromise temperature point [5]

(c) $2NH_3 + NaClO \rightarrow N_2H_4 + NaCl + H_2O$ [2]
not balanced only 1

(d) 4 hydrogen atoms 1 bonding pair each [1]
2 nitrogen atoms with 1 bonding pair between them [1]
one non-bonding pair on each N (need not be seen as a pair) [1]

(e) **(i)** pH increases [1]

(ii) oxygen needed for rusting / removes oxygen / reacts with oxygen [1]

[Total: 15]

20. 0620_w13_ms_32 Q: 3

(a) (i) the (forward) reaction is endothermic [1]

(ii) none [1]
volume of reactants and products the same [1]
ACCEPT: number of moles or molecules

(iii) the reaction (between oxygen and nitric oxide) is exothermic [1]
high temperatures push equilibrium to left / high temperatures decrease yield of products / low temperatures favour forward reaction [1]

(iv) $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ [2]
not balanced = (1) only

(v) (cost of) high amount of electricity / energy [1]

(b) (i) contains more nitrogen [1]

(ii) photosynthesis [1]
chlorophyll is catalyst / chlorophyll absorbs light [1]
carbon dioxide and water react [1]
to make glucose / carbohydrates / starch / sugar / named sugar [1]

[Total: 13]

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21. 0620_s12_ms_32 Q: 8

(a) proton donor; [1]

(b) equal concentrations of both (solutions); [1]
add Universal indicator / determine pH / pH paper; [1]
ethylamine has lower pH / ORA; [1]
or
equal concentration of both (solutions); [1]
measure conductivity of aqueous ethylamine and sodium hydroxide; [1]
ethylamine will have lower conductivity / sodium hydroxide will have higher conductivity; [1]

(c) add strong(er) base / NaOH / KOH; [1]
warm / heat; [1]

(d) (ethylamine forms) hydroxide ions / OH^- (in water); [1]
hydroxide ions / OH^- reacts with iron(III) ions / Fe^{3+};
or
iron(III) hydroxide / $Fe(OH)_3$ (forms as a brown precipitate); [1]
note: balanced or unbalanced ionic equation i.e. $Fe^{3+} + (3)OH^- \rightarrow Fe(OH)_3$ scores both marks

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22. 0620_w12_ms_33 Q: 7

(a) (making) fertilisers / nitric acid / nylon / refrigeration / explosives / cleaning products; [1]

(b) alkane / named alkane; [1]
water / steam; [1]
heat / catalyst; [1]

or electrolysis; [1]
suggest suitable electrolyte; (**allow:** water) [1]
hydrogen at cathode; [1]

or cracking; [1]
alkane / named alkane; [1]
heat or catalyst [1]

(c) any five from:
faster; (rate) [1]

more collisions / molecules closer together / more particles per unit volume; [1]

(collisions) more frequent / more often / more chance / more effective or successful collisions / more collisions with Ea / increase rate of collisions; [1]

higher yield / moves (equilibrium) to RHS / more ammonia / to side of products / high pressure favours the reaction with less moles; [1]

less moles / molecules / volume on RHS ORA (can be implied in previous comments) [1]

high pressure means lower temperature can be used to achieve comparable rate (thus saving energy); [1]

(d) **(i)** endothermic takes in / absorbs / uses / needs / gains energy / heat **and** exothermic gives out / loses energy / heat; [1]

(ii) 2328 (ignore + or –) / 6 × 388 (not evaluated); [1]

944 + 1308 / 2252 **and** endothermic and exothermic in table; [1]

2328>2252 or (–) 76 kJ; [1]

or energy of products / RHS > reactants / LHS
or energy needed to break bonds < energy given out on formation of bonds.

[Total: 13]