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]

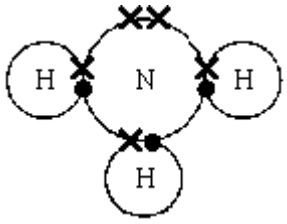
M2. (i) reversible (reaction)

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

<u>ammonia</u> removed as a liquid

*accept ammonia liquefies **or** condenses*

<u>nitrogen</u> and <u>hydrogen</u> are recycled

accept <u>nitrogen</u> and <u>hydrogen</u> 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) <u>2</u> $NO + O_2 \rightarrow$ <u>2</u>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]