

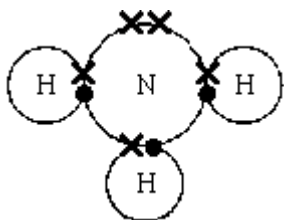
- M1.** (a) to speed up the reaction **or** it is a catalyst
allow higher level answers such as to reduce the activation energy
ignore cost or yield 1
- (b) (i) reaction is exothermic
*accept reverse reaction is endothermic **or** high temperature causes decomposition of ammonia*
ignore reference to 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 \rightleftharpoons 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 soil 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** different 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 an 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/N₂ 1
- hydrogen
do not credit H/H₂ 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

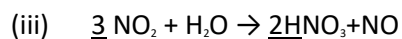
1

[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 reaction
 good rate of production
 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) $2 \text{ NO} + \text{O}_2 \rightarrow 2 \text{ NO}_2$

for 1 mark each

1



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]