Mark schemes

Q1.

(a) ammonium phosphate

1

potassium nitrate

1

(b) (nitric acid) calcium nitrate

1

(phosphoric acid)
(calcium) triple superphosphate
or
calcium dihydrogenphosphate

1

(c) (industrial process)
(is) large(er) scale
allow converse for laboratory process
ignore references to cost / energy
ignore large mass produced

1

(is) quicker

1

(is a) continuous process
allow does not need to be repeated

1

reasoned judgement

1

[8]

Q2.

(a) (the reaction is) reversible
allow description of a reversible reaction

1

(b) iron

1

(c) activation energy with a catalyst

1

(d) bar to 22 (%) labelled phosphorus / P
allow a tolerance of ± ½ a small square

1

bar to 25 (%) labelled potassium / K

*if no other mark is awarded, allow **1** mark for two bars drawn to 22% and 25%*

1

(e) there are other elements in the fertiliser (besides phosphorus and potassium)

or

there is nitrogen in the fertiliser

allow there are other substances in the fertiliser (besides phosphorus and potassium)

1

(f) **B**

1

(g) **B**

1

[8]

Q3.

(a) (equation contains a) ⇌ (symbol)

allow description of arrow / symbol

1

(b) exothermic

1

(c) to reduce costs

1

to use less energy

1

(d) (the world production of ammonia) increased

1

(the increase was) not steady / linear

*do **not** accept decreases*
ignore levels off

1

(e) the demand for food changed

1

the world population changed

1

(f) **C** and **D**

1

(g) **D**

1

[10]

Q4.

(a)

an answer of 17.6470588 (%) correctly rounded to at least 2 significant figures scores 2 marks

$\frac{6}{34} \times 100$

1

= 17.6 (%)

allow 17.6470588 (%) correctly rounded to at least 2 significant figures

1

(b)

allow converse arguments in terms of higher pressure
ignore references to rate

higher yield (of hydrogen or carbon monoxide or product)

allow more hydrogen or more carbon monoxide or more product
allow equilibrium moves to the right
allow equilibrium moves in the forward direction

1

(because) fewer moles / molecules / particles on left hand side
or
(because) more moles / molecules / particles on right hand side

allow (because) the reverse reaction produces fewer moles / molecules / particles
or
allow (because) the forward reaction produces more moles / molecules / particles
*do **not** accept fewer / more atoms*

1

(c) no effect (on yield of hydrogen)

allow position of equilibrium unaffected by pressure
ignore references to rate of reaction

1

(d)

*an answer of 2.25 scores **3** marks*

350 (°C) and 285 (atmospheres) = 63 (%)
and
450 (°C) and 200 (atmospheres) = 28 (%)

allow a value between 62 (%) and 64 (%) inclusive

1

$\frac{63}{28}$

allow a correct expression using incorrectly determined value(s) for percentage yield

1

= 2.25 (times greater)

allow a correct calculation using incorrectly determined value(s) for percentage yield correctly evaluated and rounded to at least 2 significant figures

1

(e)

allow converse arguments in terms of low(er) pressure

any **one** from:

- the energy costs would be high(er)
  ignore energy / cost unqualified
- the equipment would need to be strong(er)
  allow the equipment would be (more) expensive (to build / maintain)
- high(er) pressures are (more) dangerous
  allow (more) dangerous because (greater) risk of explosion

1

(f) higher temperatures produce a lower (percentage) yield (of ammonia)

allow converse
allow correct reference to shift in equilibrium
ignore references to pressure

1

(g) world population has increased

1

any **one** from:

- demand for fertiliser has increased
  allow more food needed
- increased demand for other specified ammonia-based products e.g. nitric acid, drugs, dyes, explosives

1

[12]

Q5.

(a) hydrogen

allow H_2

1

(b) 450 °C

allow values in the range 400−500 °C

1

200 atm / atmospheres

allow values in the range 150−250 atm / atmospheres

*allow **1** mark if both values within range but no units given*

1

(c) ammonia has a higher boiling point

allow the other gases have lower boiling points

ignore references to melting point

1

(d) **Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

5–6

Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1–2

No relevant content

0

Indicative content

changes

- carbon dioxide has decreased
- oxygen has increased

processes

- volcanic activity released water vapour
- the water vapour condensed to form oceans
- carbon dioxide dissolved in oceans
- carbonates produce sediments
- carbon locked up in sedimentary rocks

- algae and plants evolved / appeared
- algae / plants absorbed carbon dioxide
- by photosynthesis
- which also released oxygen

- carbon locked up in fossil fuels

(e) any **one** from:

- occurred 4.6 billion years ago

  allow any indication of billions of years

  allow limited or no proof

- limited or no evidence

  ignore there was nobody there

1

[11]

Q6.

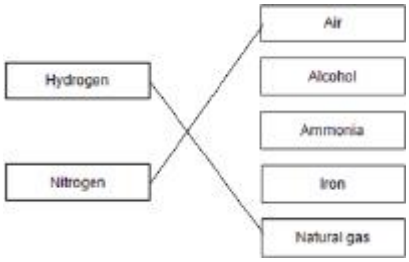
(a) 4

1

(b) reversible (reaction)

1

(c)



1
1

(d) −40 °C

1

(e) recycled to the reactor

1

(f) ionic

1

(g) nitrogen

1

phosphorus

1

(h) 0.24 × 50 × 5

allow £87.50

1

= £60

1

*an answer of £60 scores **2** marks*

(i) may need to use nitrogen, phosphorus and potassium

allow neither fertiliser has all the elements / nutrients needed.

[12]

Q7.

(a) cool

1

to −34 °C

allow temperatures below −34 °C but above −196 °C

1

(b) recycled (to the reactor)

1

(c) $825 \times \frac{2}{3}$

1

= 550 (dm^3)

1

*an answer of 550 (dm^3) scores **2** marks*

(d) a lower pressure would decrease the equilibrium yield

1

a lower temperature would make the reaction too slow

1

(e) nitrogen / N

1

(f) **B** and **C**

1

contain nitrogen, phosphorus and potassium

1

(g) (**B**)

any **two** from:
- more stages
- uses more energy
- uses more raw materials
- takes longer

*allow converse for **C***

2

[12]

Q8.

(a) $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

1

(b) catalyst

1

(c) as pressure increases percentage yield increases

1

(d) 32−23

both readings correct

1

= 9 (%)

1

[5]

Q9.

(a) ammonia **and** nitric acid

allow NH_4OH

allow $NH_3(aq)$

1

(b) shows fertilisers are formulations

allow gives percentage / proportion of nitrogen, phosphorus and potassium in the fertiliser

1

(so) farmers can choose fertiliser with required properties

1

(c) as world population increases, ammonia production increases

1

ammonia is used to produce fertilisers

1

so increasing need for fertilisers as more food required for increased population

allow as more food produced less mortality

1

[6]

Q10.

(a) endothermic

1

(b) 82 (%)

*correct answer with working gains **3** marks*

*if 17 or 34 not shown in working **max 2** marks*

accept 82.4

accept 82.35 to full calculator display (82.35294...) correctly rounded to at least 2 sf

if no answer or incorrect answer, then

*(M_r =) 17 gains **1** mark **or***

*14/17 gains **2** marks*

OR

*($2M_r$ =) 34 gains **1** mark **or***

*28/34 gains **2** marks*

OR

*14/their M_r shown gains **1** mark **or***

*correct calculation of 14/their M_r gains **2** marks*

3

(c) (i) 7 / seven

1

(ii) $H^+ + OH^- \rightarrow H_2O$

1

(iii) ammonium chloride

allow NH_4Cl

1

ignore an incorrect formula

(d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
Suggestion with reasons from all three graphs, and linking of ideas which may explain a compromise.

Level 2 (3 – 4 marks):
Suggestion with reasons referring to more than one graph.

Level 1 (1 – 2 marks):
Suggestion with a reference to a graph.

0 marks:
No relevant content.

Examples of chemistry points made in response:
A reasonable suggested amount of fertiliser would be in the region of 200 kg (per ha).
Accept any suggestion from about 180 kg (per ha) to 500 kg (per ha).

Yield:
- Using fertiliser improves yield.
- Yield improved most up to about 200 kg (per ha) of fertiliser.
- Yield only increased slightly above about 200 kg (per ha).

Profit:
- About 200 kg of fertiliser gives the most profit.
- Above about 200 kg (per ha) of fertiliser profit declines.

Run off:
- Run off is at low levels until about 300 kg (per ha) of fertiliser.
- Above about 300 kg (per ha) of fertiliser, run off increases.

Examples of linking of ideas:
- Overall 200 kg gives high crop yield and most profit.
- In conclusion 200 kg gives high crop yield and low run off.
- 200 kg gives most profit and low run off.

Examples of compromise:

- Profits go down after about 200 kg (per ha) of fertiliser because cost of fertiliser is not covered by increased yield.
- 200 kg gives the highest profit although it is not the highest yield.
- 500 kg gives the best yield but has the most runoff.

6

[13]

Q11.

(a) (i) nitrogen: air

1

hydrogen: natural gas

1

(ii) as a catalyst

1

so the reaction speeds up

allow lowers activation energy or so a lower temperature can be used

1

(iii) cooled

1

ammonia condenses / liquefies

*allow nitrogen **and** hydrogen remain in the gaseous state*

1

(iv) recycled

allow reused or returned to the reactor

1

(b) reversible arrows

1

hydrogen **and** ammonia

1

[9]

Q12.

(a) (i) natural gas

allow fossil fuels / biogas generator

1

(ii) air contains oxygen

1

this would react with / oxidise the hydrogen

allow this would react with / oxidise the iron

ignore nitrogen

1

(iii) cooled

1

ammonia condenses / liquefies (so can be separated)

1

nitrogen and hydrogen (remain as gases and) are returned to the reactor

allow recycled

1

(b) (i) 200 °C **and** 1000 atmospheres

1

(ii) the reaction is reversible

allow stated as equilibrium or forward / backward reaction anywhere in answer

1

forward reaction is exothermic so increased temperature lowers the yield of ammonia

allow converse

1

a lower temperature would decrease rate of reaction

allow converse

1

a higher pressure would increase the yield of ammonia because the forward reaction produces the least number of (gaseous) molecules / moles

allow converse

1

higher pressures would involve high cost / energy

1

ignore risk / explosion

[12]