1.

(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]

2.

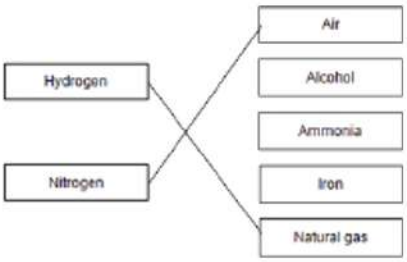
(a) 4

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]

3. (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]

4. (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]

5. (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

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]

6. (a) reversible

1

(b) catalyst

1

(c) recycled

allow re-used **1**

(d) (Q) S R P

*allow **1**mark if one letter in correct place.*

2

[5]