Mark schemes

1

(a) reversible

allow equilibrium

1

(b) The colour changed from blue to pink

1

(c) 8.3 (°C)

1

(d) endothermic

allow dehydration

ignore reversible

1

[4]

2

(a) both water vapour and ethanol will condense

allow steam for water vapour

allow they both become liquids

allow ethane condenses at a lower temperature

allow some of the steam hasn't reacted

allow it is a reversible reaction / equilibrium

1

(b) amount will decrease

1

because the equilibrium will move to the left

1

(c) more ethanol will be produced

1

because system moves to least / fewer molecules

1

[5]

3

(a) (i) 25 °C

1

(ii) (fractional) distillation

1

(b) (i) (fertile) land is used to grow fuel crops **or** crops are grown for fuel **or** farmers get a better price for crops for fuel **or** crops for biofuels take up space

ignore biofuels are made from food or plants

1

less food grown **or** food prices rise **or** less (fertile) land to grow food

1

(ii) (crops / plants) take in carbon dioxide (while growing / during photosynthesis)

1

so the CO_2 given out was previously taken in

*do **not** accept burning biofuels does not release CO_2 or releases less CO_2 unqualified*

*if no other mark awarded, a statement of "carbon neutral" scores **1** mark*

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best–fit' approach to the marking.

0 marks
No relevant content

Level 1 (1−2 marks)
At least one statement about the effect of a condition on either rate **or** yield.

Level 2 (3−4 marks)
Correct statements about the effect of at least one condition on rate **and** yield.

Level 3 (5−6 marks)
Correct statements about the effect of at least one condition on rate and yield **and** at least one correct statement about compromise conditions.

Examples of the points made in the response

Temperature
- a higher temperature gives a lower yield
- a higher temperature gives a faster rate

Pressure
- a higher pressure gives a higher yield
- increase in yield gets less as pressure increases
- a higher pressure gives a faster rate
- increase in rate increases as pressure increases

Catalyst
- using a catalyst speeds up reaction
- catalysts allow a lower temperature to be used and so save energy / reduce energy costs

Compromise
- a higher pressure gives a greater yield but increases costs / (safety) risks
- a high pressure gives a faster rate but increases costs / risks
- a high temperature makes reaction faster but reduces yield
- a catalyst makes reaction faster so a lower temperature can be used which will increase the yield

6

[12]

4 (a) natural gas

allow correct answer shown in box if answer line blank

1

(b) (i) 450

allow correct answer shown in box if answer line blank

1

(ii) iron

allow correct answer shown in box if answer line blank

1

(iii) The catalyst lowers the activation energy.

1

(c) (the gases are) cooled

1

ammonia condenses

allow ammonia liquefies

1

nitrogen and hydrogen are recycled

*if no other mark awarded allow ammonia is separated for **1** mark*

1

[7]

5 (a) (i) nothing can enter **and** nothing can leave the reaction

allow sealed reaction vessel

1

(ii) forward and backward reactions have same rate

1

so there is no (overall) change in quantities of reactants and products

allow concentrations of reactants and products

1

(b) (i) natural gas

allow methane / CH_4

allow fossil fuels / hydrocarbons

allow water

1

(ii) provides an alternative reaction pathway

1

which has a lower activation energy

ignore references to collisions

1

(iii) the amount (of ammonia) increases

allow yield increases

1

the equilibrium moves to the side (of the equation) with fewer (gaseous) molecules / moles

allow it favours the forward reaction

1

(c) (i) vertical arrow from reactants to maximum

1

(ii) (energy of) products higher than (energy of) reactants

allow converse

1

(iii) amount of hydrogen iodide decreases

1

equilibrium moves in the direction of the endothermic reaction

allow it favours the forward reaction

1

[12]

6 (a) (i) covalent

1

(ii) increases the rate of reaction

1

(b) (i) the reaction is reversible

1

(ii) at lower pressure the molecules will be further apart

1

so there will be fewer collisions <u>per unit time</u>

accept frequency of collisions lower

1

(iii) as the temperature increases, the yield of the reaction increases

1

(iv) 2 molecules / volumes become 4 **or** more molecules / volumes **of** product than reactant

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
Candidate has written about some basic points from the table but has not added any extra knowledge. Candidate may have included advantages **or** disadvantages.

Level 2 (3 – 4 marks)
Candidate has attempted an evaluation using points from the table and their own knowledge. Candidate has included advantages **and** disadvantages.

Level 3 (5 – 6 marks)
Candidate has given an evaluation that includes both advantages and disadvantages. Candidate has clearly linked points from the table with their own knowledge and uses appropriate scientific terminology.

examples of the points made in the response

Advantages of using hydrogen:

- its combustion only produces water
- combustion of hydrogen does not produce carbon dioxide **or** does not contribute to climate change
- petrol requires much more oxygen to burn so partial combustion is possible producing carbon monoxide
- combustion of hydrogen does not produce any particulates **or** does not contribute to global dimming
- petrol comes from a non-renewable source **or** there are renewable ways of producing hydrogen, eg electrolysis of water.

Disadvantages of using hydrogen:

- hydrogen has to be stored at high pressure **or** risk of explosion or larger volume needed for storage.
- much less energy produced from the combustion of hydrogen **or** need to refuel more often
- most methods of producing hydrogen need fossil fuels.

6

[13]

7 (a) the forward and backward reactions occur

allow reversible

1

at (exactly) the same rate

1

in a closed system

allow therefore the concentrations / amounts of the reactants and products <u>remain</u> the same

1

(b) (i) increasing the temperature would <u>lower</u> the yield of ethanol **or** the (position of) equilibrium moves to the left

*if student has stated that increasing the temperature increases the yield then award **0** marks*

1

since the backwards reaction is endothermic **or** the forward reaction is exothermic

1

(ii) increasing the pressure would <u>increase</u> the yield of ethanol **or** the (position of) equilibrium moves to the right

*if student has stated that increasing the pressure decreases the yield then award **0** marks*

1

because the position (of equilibrium) moves in the direction of the lower number of moles (of gas)

2 (moles / molecules / volumes / particles) on lhs / 1 (mole / molecule / volume / particle) on rhs

1

(c) (a catalyst) provides an alternative pathway

1

with lower activation energy

or

(a catalyst) lowers the activation energy (1)

so less energy is needed to react **or** more particles react (1)

1

[9]

8 (a) (i) ions cannot move

allow only conducts as a liquid

1

(ii) chlorine

1

(iii) they are positively / oppositely charged

or

they are attracted

1

(iv) 2

1

(b) (i) any **one** from:

- not all the magnesium was collected
  allow some magnesium was lost
- *used less time **or** lower current **or** different battery / power pack **or** different balance **or** lower voltage*
- error in reading balance
- error in recording result

1

(ii) 1.11

*correct answer with or without working gains **2** marks.*

*if answer incorrect, allow **1** mark for 0.99*

***or** for 1.13 + 1.11 + 1.09*

2

(c) (i) *25 – 25.3*

*correct answer with or without working gains **2** marks.*

*If answer incorrect, allow **1** mark for 24 / 95*

2

(ii) 71

1

(d) (i) reversible reaction

1

(ii) decreases

1

[12]

9 (a) ⇌

1

ammonia

allow NH_3

1

(b) increases

1

quickly at first *then slows*

ignore levels off

allow rate of increase slows for first two marking points

1

at any number in range from 160 – 220 (atmospheres)

allow any number in range 60 – 66 (%)

1

(c) (nitrogen and hydrogen) recycled

allow (nitrogen and hydrogen) reused

1

(d) (i) *jobs lost*

accept mines closed ***or*** *local economy damaged*

1

(ii) any **one** from:

- *nitrates* / fertilisers cost less
- more crops / food can be grown
- food costs less
- *nitrates / fertilisers more widely available*

1

[8]

10 (a) $2NH_3$

*allow NH_3 with incorrect or missing balancing for **1** mark*

allow multiples

2

(b) (i) 200

1

(ii) rate of reaction (too) slow

allow converse

ignore references to yield / cost

1

(iii) 400

1

(iv) lower yield

allow converse

accept shifts equilibrium to left

allow favours the backward reaction

allow favours side with more (gaseous) molecules

allow lower rate

1

(c) (gases) cooled

it = ammonia

1

ammonia liquefied

accept ammonia condensed

*accept ammonia cooled below boiling point for **2** marks*

1

[8]

11 (a) fertilisers

1

(b) air

1

(c) speeds up the reaction

accept lowers the activation energy

ignore makes the reaction work

1

(d) reversible reaction

1

(e) (i) 10

1

(ii) water

accept H_2O / hydrogen oxide

1

[6]

12 (a) any **two** from:

- heat water / make steam / boil water **or** heat / steam used in stage 1 or from stage 3
- carbon dioxide from stage 3 used in stage 7 /to make urea
- nitrogen and / or hydrogen recycled
- ammonia and / or carbon dioxide recycled

allow unreacted material / gas recycled from stage 5 (to 4)

allow unreacted material / gas recycled from stage 8 (to 7)

*NB: if neither of the last two points are awarded unreacted material recycled = **1** mark*

2

(b) (i) increase yield

because (forward) reaction is exothermic

ignore references to rate

1

allow because (forward) reaction gives out heat

1

(ii) increase yield

ignore references to rate

1

because more (gaseous) reactant molecules than (gaseous) product molecules

accept because greater volume on the left than the right

1

(c) 76.9 - 77

correct answer gains 2 marks with or without working
*allow 77 **or** 76.923…*
*allow 76 **or** 0.77 **or** 0.76923 for **1** mark*
*if answer incorrect allow **1** mark for **either***

$$\frac{60}{\text{attempt at total } M_r \text{ of all reactants}} \times 100$$

or

$$\frac{\text{attempt at total } M_r \text{ of area}}{78} \times 100$$

2

[10]

13 (a) three bonding pairs

*do **not** allow non-bonding electrons in hydrogen*

ignore any inner shells on nitrogen

1

two non-bonding electrons

allow either dots and crosses or combination of both

1

(b) (i) nitric

1

(ii) fertilisers / explosives

ignore other uses

1

(iii) 80

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow 14 + (1 × 4) + 14 + (16 × 3) for **1** mark*

2

(iv) 35

*allow ecf from **(b)(iii)***

*allow ecf for **1** mark for correct working but incorrect answer.*

*if answer incorrect, allow 28 / 80 × 100 for **1** mark*

*if answer is 17.5 % allow **1** mark*

2

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best−fit' approach to the marking.

0 marks
No relevant content

Level 1 (1 − 2 marks)
There are statements about the conditions used. There is no correct explanation of the link between rate or yield and the conditions.

Level 2 (3 − 4 marks)
There is a correct explanation of the conditions used that links the conditions to rate **or** yield

Level 3 (5 − 6 marks)
There is an explanation covering at least temperature and pressure, which shows understanding of the compromise between rate **and** yield

examples of chemistry points made in the response:

200 atmospheres pressure
- high pressure gives a high yield of ammonia
- too high a pressure causes risk of explosion
- high pressure costly to maintain
- a high pressure will cause the rate to be higher
- 4 moles of gas become 2 (or fewer moles of gas in products)

450 °C
- high temperature increases the rate of reaction
- optimum temperature
- (forward reaction is exothermic so) a high yield of ammonia requires a low temperature
- but too low a temperature causes the rate of reaction to be too slow

iron catalyst
- a catalyst speeds up the reaction
- an iron catalyst allows a lower temperature to be used (saving energy and causing a higher yield)
- iron catalyst increases the rate of reaction equally in both reactions

others
- compromise conditions
- unreacted nitrogen and hydrogen is recycled

6

[14]

14 (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]

15 (a) reversible

1

(b) (from blue) to pink

*do **not** accept*

incorrect initial colour

1

(c) sensible answers such as:

- stop water reaching papers

  accept stop entry of moisture / wet / dampness / condensation

- water (vapour) in air

  ignore references to toxicity of cobalt chloride

1

[3]

16 (a) (i) 10

1

(ii) OH^-

1

(b) (i) air

1

(ii) particles move faster

1

particles collide more often

1

(iii) catalyst(s)

1

(c) liquid

1

[7]

17 (a) 22

1

(b) (i) exothermic

1

(ii) C

1

gives out most heat energy

accept has largest temperature change / increase

*allow has highest (final) temperature **or** hottest*

1

(c) (i) increases

1

(ii) blue

ignore pale / dark etc

1

(iii) reversible (reaction)

*allow goes both ways **or** two / either way*

1

(iv) <u>anhydrous</u> copper sulfate

1

[8]

18 (a) gases

1

white

1

solid

1

ammonium chloride

1

(b) reversible

allow phonetic spelling

allow goes both / two / either way(s)

1

[5]

19 (a) mixture is cooled / cooling

1

so ammonia / it condenses

or
so ammonia turns into a liquid (but nitrogen and hydrogen remain as gases)

1

(b) (i) exothermic reaction

accept reverse reaction is endothermic

or
equilibrium / reaction moves in the direction which raises the temperature

ignore answers based on rate or collisions

1

(ii) they / particles / molecules move faster **or** have more (kinetic) energy

allow atoms instead of particles

ignore particles move more / vibrate

*do **not** accept electrons (max1)*

1

any **one** from:

- particles / molecules collide more often / more frequently / more likely to collide

  ignore collide faster

  ignore more collisions

- more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy

  accept more successful collisions

1

(iii) more molecules / particles / moles / volumes on LHS (of equation than RHS)

accept 4 molecules / particles / moles / volumes on LHS and 2 molecules / particles / moles / volumes on RHS

or
greater volume on LHS (than RHS)
or
equilibrium / reaction moves in the direction which reduces the pressure / volume

accept converse

1

(iv) cost

or
difficulty in containing such a high pressure

allow risk of explosion

ignore dangerous

1

(c) (i) 60

1

(ii) 2.4(2857….)

*correct answer gains **3** marks with or without working*

accept any answer that rounds to 2.4

ignore units

*if answer is incorrect look for evidence of correct working to a maximum of **2** marks.*

moles of N_2 = 2/28 = (0.0714)

moles of ammonia = 2 × 0.0714 = (0.1428)

mass of ammonia = 0.1428 × 17 = (2.4276)

or

28 → 34

1g →34/28

2g →2.4… ….

3

(d) (i) 15

1

(ii) unreacted gases are recycled

allow unreacted gases are reused

1

rate (of production) is fast

accept production is continuous

ignore compromise between rate and yield

1

[14]

20

(a) increases

1

(b) the reaction is reversible

1

(c) A liquid

1

(d) recycled / reused (owtte)

accept returned to pump / start

1

[4]

21

(a) (i) nitrogen - air

accept atmosphere

1

hydrogen - north sea gas / natural gas / methane / CH_4

accept water / (crude) oil / coal / hydrocarbons / brine

1

(ii) *allow converse throughout*

- high temperature gives a low yield

1

- because reaction is exothermic

must be linked to first bullet point

1

- but at low temperatures the rate is (too) slow

if no other marks awarded accept 450°C is a compromise between yield and rate

or

*450°C gives a reasonable yield in a reasonable time for **1** mark*

1

(iii) nitric (acid)

accept HNO_3

1

(b) Ammonia / Haber process can be used to make fertiliser

1

with a specified economical reason
eg raw materials for Haber process readily available
eg transport costs are lower or no need to import
eg Haber process is a continuous process

ignore employment / labour costs

1

[8]

22

(a) white to blue

accept colourless to blue

1

(b) reversible

1

[2]

23 (a) same number of (gaseous) molecules / moles / volume on both sides of the equation

allow particles for molecules

*do **not** accept atoms*

ignore amount

1

(b) (forward) reaction is exothermic

accept reverse answer

1

(c) any **three** from:

- particles gain energy
- particles move faster

  allow particles collide faster / quicker

  ignore move more / vibrate more
- particles collide more **or** more collisions
- more of the collisions are successful **or**
  more of the particles have the activation energy **or**
  particles collide with more force / energy

3

(d) any **two** from:

- more product (obtained in shorter time)
  accept better yield (of product)
- less fuel needed
  accept less energy / heat / electricity needed

  or

  lower fuel costs
  ignore cheaper unqualified
- less pollution caused by burning fuels

  or

  less specified type of pollution caused by producing heat / burning fuels
  *allow correct specified pollutants caused by burning fossil fuels eg CO_2 / greenhouse gases **or** correct effect of burning fossil fuels eg global warming*
  accept thermal / heat pollution
- using less fuel conserves resources
  accept sustainable
  accept fossil fuels are non-renewable

2

[7]

24

(a) water
*accept H_2O **or** $5H_2O$*

2 must be below halfway

1

(b) the cold water / ice / cubes (owtte)
*accept 'cooled down' **or** references to cold*

1

(c) reversible reaction

1

(d) (i) 0.87g

1

(ii) the student made errors in weighing during the experiments

1

the student did not heat the copper sulfate for long enough in one of the experiments

1

(e) white

1

blue

*allow **1** mark for blue to white*

1

[8]

25 (a) fewer product molecules than reactant molecules (owtte) **or**

accept forward reaction produces fewer molecules

accept left hand side for reactants and right hand side for products

3 reactant molecules and 1 product
or 3 volumes of gas becomes 1 volume of gas

accept high pressure favours the side with fewer molecules

ignore references to reaction rate

1

(b) any **three** from:

- low temperature gives best yield

  *accept <u>add</u> heat as increased temperature **or** 'less' as poor yield*

  or high temperature gives poor yield

- because the reaction is exothermic

  accept reverse argument if clearly expressed

- reaction too slow at low temperature
  or reaction faster at high temperature

  accept <u>add</u> heat and reaction goes faster

- temperature used gives a reasonable yield
  at a fast rate / compromise explained

  allow get less product but it takes less time
  *for **2** marks*

3

[4]

26 (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]

27 (a) (i) any **one** from:

- they are positive / cations
- they are H^+
- opposite charges attract

ignore atom

1

(ii) potassium is more reactive (or reverse)

assume 'it' refers to hydrogen

allow potassium reacts <u>with</u> water

*allow potassium is very reactive **or** most reactive metal / element*

allow hydrogen gains electrons more easily / is reduced more easily

accept potassium is higher up the reactivity series

1

(b) 6 **and** 2

accept correct multiples and fractions

1

(c) (i) the reaction / it is reversible **or** a description of a reversible reaction

allow 'it is an equilibrium'

allow reversible symbol drawn correctly

allow 'the reverse / back reaction'

1

(ii) **lithium nitride**

assume that 'it' or if they do not specify means lithium nitride

assume lithium / lithium nitrate refers to lithium nitride

- hydrogen is bonded / held / absorbed / has formed a compound / reacted with lithium nitride

1

plus **one** of:

- does not explode / cause a fire
- is not free / less hydrogen
- is not under pressure
- does not leak
- is only released slowly

1

- compound of hydrogen with lithium nitride / product is (more) stable / less reactive / less chance of a reaction

accept converse for hydrogen as below

assume that gas / hydrogen means gas in the cylinder

- *hydrogen (in cylinder) / gas is not bonded / held absorbed / in a compound / reacted with lithium nitride*

1

*plus **one** of:*

- *can explode / cause a fire*
- *is free*
- *is under pressure*
- *can leak*
- *releases quickly*

1

(d) (i) loss of an electron **or** loses electrons

do not accept any ref. to oxygen

1

(ii) full outer shell of 8 electrons on circle

need not be paired

can be ×, dot or e

*do **not** accept if extra electrons added to inner shell*

1

[10]

28

(a) (i) nitrogen + hydrogen → ammonia

accept full correct balanced equation

1

(ii) reversible (reaction) (owtte)

*do **not** allow just 'backwards' (unqualified)*

1

(iii) catalyst / speed up reaction

accept to lower activation energy

1

(iv) boiling point

1

(v) recycled (owtte)

1

(b) (i) used to make explosives (owtte) used to make medicines (owtte)

1

(ii) used to make fertilisers (owtte)

1

(c) (i) sensible answers such as

provides workers (owtte)

good transport links

ignore reference to raw materials

1

(ii) sensible idea

1

linked reason

idea

linked reason

eg escape of chemicals /fumes /waste gases / pollution

harmful to health / environmental damage owtte

*do **not** allow harmful / damage / smell (unqualified)*

risk of explosion

because of high pressures / may endanger local people / dangerous

risk of fire

because of high temperatures / may endanger local people

noise

*any detrimental effect on quality of life **or** night and day*

lorries / traffic

danger / noise / pollution etc

unsightly

detrimental effect on quality of life / house prices / reduced tourism

uses a lot of land

loss of habitats

1

[10]

29 (a) 1213.8 to 1214.3

*gains **3** marks without working*

correct answer not given then check working

1) moles of N_2 $= \frac{1000}{28} = 35.7$ mol

***1** mark for each correct step*

*do **not** penalise rounding errors in this part*

2) moles of NH_3 = 2 × (answer from (1)) = 71.4 mol

3) mass of NH_3 = (answer from 2) × 17 = 71.4 × 17 = 1214 g

3

or

- 28g of N_2 → 34g of NH_3

  1 *mark for each correct step*

- 1g of N_2 → $\frac{34}{28}$ = 1.214g NH_3

  *do **not** penalise rounding errors in this part*

- 1000 g of N_2 → 1000 × 1.214
  = 1214g

  allow error carried forward eg

or

- 1000 × $\frac{34}{28}$

  *gains **2** marks if correct answer not given*

  *1000 × $\frac{28}{34}$ gains **1** mark, **2** marks if correctly calculated*

  *(823.5g) 1000 × $\frac{28}{17}$ gains **1** mark if calculated correctly (1647.05g)*

or

other correct methods

look for the key ideas in the methods above

(b) 25 / 25.035 **or** ecf from (a)

*gains **2** marks even when there is no working*

*incorrect answer then 304/(their answer from (a)) × 100 gains **1** mark*

or using figures from part (b)

27.6 / **28**

*gains **2** marks even when there is no working*

*accept 27 for **1** mark*

*if answers incorrect then304/1100 × 100 gains **1** mark*

2

(c) (i) increase yield

1

reaction is exothermic

or

allow decreased yield because rate of reaction is slower / fewer collisions for **2** marks

***must** get both points for **2** marks*

1

(ii) increase yield

1

plus **one** from:

- more (gaseous) reactant molecules than (gaseous) product molecules (owtte)

  accept greater volume on the left than the right owtte

- increased rate of reaction / more collisions

1

(d) any **one** from:

economic

- large town provides workforce
- workers do not have to travel far to the factory. (owtte)
- transport infrastructure already in place for large town. (owtte)
- factory brings prosperity to town (owtte)
- factory provides employment
- reduced tourism
- reduction in local house prices
- any other sensible economic factor linked to town

1

any **one** from:

safety

- escape of dangerous / harmful chemicals / gases (owtte)
  *do **not** allow polluting gases unqualified*
- danger of increased traffic
- risk of explosion.(owtte) /danger of high pressure
- consequences of an accident could be severe if the town is close
- any other sensible safety idea

1

any **one** from:

environmental

- factory might be unsightly (owtte)
- screening of factory (owtte)
- loss of habitats (owtte)
- plant trees/ hedges etc on and around plant site
- pollution of water / air / soil could harm plants / animals **or** noise pollution
  must be explained
- CO_2 is produced by burning fuels / heating
- CO_2 causes global warming / any effect of global warming
- eye sore
- any other sensible environmental factor

1

[12]

-

30 (a) endothermic **and** because it takes in heat / energy
__both__ for one mark

1

(b) (i) reversible reaction (or explanation)

1

(ii) add water

*do **not** accept cooling **or** reverse the reaction*

1

[3]

31 (a) (i) high temperature

accept temperature given if ≥ 400 °C
ignore value if "high" stated, unless silly value

1

endothermic or reaction takes in energy
or Δ H is +ve

independent marks

1

(ii) low pressure

or up to and including 10 atmospheres

1

(low pressure) favours a reaction in which more molecules are formed

2 moles → 4 moles
(2 molecules → 4 molecules)

independent marks

1

(iii) nickel **and** it is a transition / transitional element / metal (owtte) **or** nickel **and** variable oxidation state / number or it is similar to other named transition elements e.g. iron

1

(b) (i) (bonds broken =) 2005 (kJ)

1

(bonds formed =) 2046 (kJ)

1

energy change = 2005 – 2046 = (–)41

for correct subtraction ignore sign

1

(ii) (exothermic)

if in part (b)(i) answer is <u>not</u> 41
answer is consequential on endothermic or exothermic shown
*accept correct reasoning for **incorrect** answer from (b)(i)*

energy given out forming new bonds

*do **not** accept energy <u>needed</u> to form new bonds*

1

greater than energy put in to break old bonds

*accept exothermic **and** more energy given out than taken in for 1 mark*
*accept negative value for energy change **or** energy in products less than energy in reactants for 1 mark*

1

[10]

32 (a) (i) high **and** low

both needed for mark

1

(ii) reversible

1

(iii) to prevent ammonium chloride / solid / particles escaping

idea of a filter
*do **not** accept 'to prevent gases escaping'*

1

(b) endothermic

1

[4]

33 (a) ***2** marks for comments related to temperature*

low / lower / lowest temperature (**or** 100 °C from graph)

ignore references to catalyst

1

any **one** from:

- (forward) reaction exothermic

  ***or** reverse reaction endothermic*

- if the temperature is increased the yield of product will decrease **or** reaction right to left

  *high temperature favours reverse reaction **or** reverse argument*

  *the lower the temperature the greater the yield = **2** marks*

  ***2** marks for comments related to pressure*

1

high / higher / highest pressure (or greater than 200 atm. from graph)

1

any **one** from:

- four reactant molecules but only two product molecules (owtte)

  reverse reaction goes from 2 molecules / moles / volumes to 4 molecules / moles / volumes

- increase in pressure favours the reaction which produces the least number of molecules

  decrease in pressure favours the back reaction because it produces the most molecules

1

(b) any **three** from:

- at low temperatures the reaction is too slow
- 450 °C gives a reasonable yield at a fast rate / compromise between yield and rate (*)
- 200 atm. gives a reasonable yield at a reasonable cost / safely / compromise between yield and cost / safety (*)

  *(*) or 450°C and 200 atm / these are compromise conditions for **1** mark*
- catalyst works better at higher temperature
- (very) high pressures could be dangerous (owtte)

  safety factor
- (very) high pressures are expensive (owtte)
- (yield is not too important because) unreacted gases can be recycled

3

[7]

34 (a) (i) yield increases

two marks are linked

1

because more (gaseous) reactant molecules / particles than (gaseous) product molecules / particles

accept 7 → 4 moles or volumes
ignore more reactants
accept fewer particles on the right

1

(ii) increased (rate) / faster / speeds up etc

two marks are linked

1

more collisions **or** increased concentration **or** particles closer together

greater chance of more successful collisions

1

(b) heat / high temperatures

*do **not** accept burn it ignore cracking / catalyst*

1

[5]

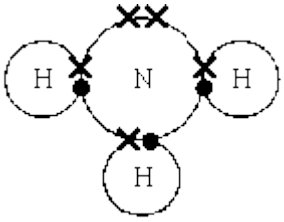
35 (i) reversible (reaction)

1

(ii) (yield of ammonia) increases

1

(iii)



1

[3]

36 (i) a reaction in which the products can be changed back to reactants

*accept a reaction that can go forwards **or** backwards*

1

under certain conditions

1

(ii) M_r $CaCO_3$ = 100

1

M_r CaO = 56

1

mass of CaO = 140 (tonnes)

1

mark consequentially

[5]

37 (a) 16%

for 2 marks

(attempt by drawing lines etc gains 1 mark)

2

(b) iron is a catalyst;
which speeds up the reaction

for 1 mark each

2

(c) (from the graph) the best **yield** is obtained at high pressure;
and low temperature;
it is a reversible reaction;
in which formation of ammonia is favoured at low temperature
(because) the reaction is exothermic;
and the formation of ammonia is favoured at high pressure
because greater number of gaseous reactant molecules than
gaseous product molecules/because greater vol of reactant
than volume of product molecules;
pressure used is limited by cost/materials;
rate of reaction slow at low temperatures;
actual temperature and pressure used is a good compromise
(between a good yield and reasonable rate);
removal of ammonia makes rate more important than yield;

any 8 for 1 mark each

8

[12]

38

Effect of pressure

- high pressure increases yield

for 1 mark

- either because less product molecules (Le Chatelier)
or but high pressure increases cost/safety

for 1 mark

Effect of temperature

- low temperature increases yield

for 1 mark

- either because exothermic reaction (Le Chatelier)

for 1 mark

- or but at low temperature rate is slow/catalyst does not work

Compromise

- optimum conditions to balance rate and % yield

for 1 mark

- or rate is slow (at higher temperature) so need a catalyst
or low percentage conversion so recycle untreated gases

[5]

39 (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]

40 (a) (i) A = air
B = natural gas / methane / north sea gas / CH_4 / oil / naphtha/ steam water (H_2O)

Accept answers written in the box at the start of the question.
each for 1 mark
2

(ii) catalyst / speed up the reaction / lower the activation energy
for 1 mark
1

(b) (i) 3 2
for 1 mark
1

(ii) reversible reaction

so that amount of product depends on conditions used
(linked to first point)

best yield at low temperatures

because it is an exothermic reaction / gives out heat (linked)

reaction rate too slow at low temperatures

450 °C is a compromise between a reasonable yield of ammonia at a fast rate of reaction

catalyst works best when heated

best yield at high pressures

because there is a decrease in the number of gaseous molecules (linked)

increasing the pressure also increases the rate

the pressure used is limited by cost, safety etc

the fact that all the nitrogen and hydrogen are not converted to ammonia does not matter because unreacted gases can be recycled through process

any six for 1 mark each

6

[10]

41 (a) (i) both scales (must be sensible) (use at least half the paper)
plots for 350°C (to accuracy of +/- 1/2 square)
plots for 500°C (to accuracy of +/- 1/2 square)
lines of best fit (sensible smooth curves) (ignore below 50 atm.)
(must not join the dots and each curve must be a single line)

for 1 mark each

4

(ii) read accurately from their graph (must be 350 °C and pressure read to +/– half square from their graph)

for one mark

1

(iii) smooth curve drawn between 350°C and 500 °C - must be of similar shape to the other curves - a dashed line would be accepted here but would not be accepted for part (i)

for one mark

1

(b) (i) reversible reaction (owtte) / equilibrium / equilibria / reaction goes in both directions etc.

for one mark

1

(ii) maximum of 2 marks from each section up to a maximum total of 5

<u>effect of temperature (max. 2 marks)</u>
best yield at low temperature / poor yield at high temperature
reaction too slow at low temperature / fast at high temperature

<u>effect of pressure (max. 2 marks)</u>
high yield at high pressure (owtte) / low yield at low pressure
ideas to do with cost / safety factor of using higher pressures

evaluation (max. 2 marks)
formation of ammonia favoured at low temperature **because** reaction is exothermic formation of ammonia favoured at high pressure **because** more reactant molecules than product molecules
actual temperature and / or pressure used are a compromise between good yield and reasonable rate ammonia removed / unreacted nitrogen and hydrogen recycled so rate more important than yield catalyst used (not a wrongly named catalyst)

for 1 mark each

5

(c) (i) $NH_4NO_3 = 14 + (4 \times 1) + 14 + (3 \times 16) = 80$ (ignore units)

for one mark

1

(ii) ecf (error carried forward from part (i))
look for (28/80) for first mark

gains 1 mark

but 35% (% sign not needed)

special case of (14/80 × 100 = 17.5%) gains one mark

gains 2 marks

2

[15]

42 (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]

43 (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]

44 (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]

45

(a) Bunsen (burner)

accept spirit burner do not credit candle

1

(b) blue

1

white

credit (1) if both colours correct but answers are reversed

1

to cool the tube (B)

*accept answers which anticipate part (d) e.g. 'to condense the water vapour' or gases **or** vapours*

1

(d) (i) water

do not credit 'condensation'

1

(ii) (Water) vapour from the crystals (from tube A)

*accept steam **or** steam from tube A*

1

condenses **or** cools

accept turns to (liquid) water

1

(e) add water

gets hot **or** hotter **or** warm **or** warmer turns into solution dissolves

or the temperature rises or there is an exothermic reaction
*accept steams **or** hisses ignore any reference to colour(s)*

2

(f) sulphuric acid

accept H_2S0_4 only if correct in every detail

1

[10]

46 (a) (i) atmosphere

or (fractional distillation of liquid) air

1

(ii) **either**

more (chance) of them colliding/

not just 'faster'

coming into contact

or

the volume of the product / the ammonia is less than /

only half the volume of the reactants / the nitrogen and hydrogen

1

(iii) 3 × (1 ×2) of hydrogen

→ 2 × (14 +1 ×3) of ammonia

*accept 6 parts of hydrogen →34 parts of ammonia **or** similar*

i.e. candidate uses the atomic masses and works correctly from the equation

1

= 225 (tonnes/t)

unit not required

1

(b) (i) megapascal(s)

accept million pascal(s)

1

(ii) 28 (%)

accept any answer in the range 28.0 to 28.5 inclusive

1

(iii) reduce the temperature and increase the pressure

both required

1

(iv) **either**

use a catalyst

accept use iron as a catalyst

accept use iron which has been more finely divided

accept use iron / catalyst with a bigger (surface) area

accept use a better catalyst

1

or

remove the ammonia (as it is produced)

*accept react the ammonia with **or** dissolve the ammonia in water (as it is produced)*

1

(c) ammonia
nitric acid
phosphoric acid

all three on the left correct

ammonia potassium chloride

all three on the right correct

water **or** water vapour

accept 'steam'

1

[10]

47 (a) (i) 8

ammonia

do not credit ammonium

sulphuric acid

do not credit just sulphuric; credit sulfuric acid

do not credit hydrogen sulphate

3

(ii) (as a) fertiliser

1

(iii) nitric (acid)

accept HNO_3 if correct in every detail

1

(b) (i) chemical change (in which)

or *under suitable conditions*

1

product(s) can be converted to reactant(s)

or *direction of reaction can be reversed*

or *equilibrium can be achieved*

do not credit reaction can be reversed

1

(ii) air

or *(the) atmosphere*

1

(iii) made of atoms

1

which are all the same

credit the idea that the particles (in an element) are all the same even if the name of the particles (the first mark) is incorrect

or *which have the same number of protons*

or *which have the same atomic number / proton number*

it cannot be broken down into anything simpler (2) marks

1

[10]

48 (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]

49 (a) any **one** from

(as a) catalyst

***or** to mix with promoters*

to speed up the reaction (process)

***or** process is quicker do not credit just it is quicker*

to save energy
to reduce costs

***or** process is cheaper*
do not credit just it is cheaper

larger surface area
(than lumps of iron)

***or** larger surface area for the (catalysed) reaction (to take place)*

1

(b) (i) water **or** steam
and methane
or natural gas
or North Sea gas

both required either order

1

(ii) **EITHER**
more (chance) of them colliding / coming into contact

do not credit just faster

OR volume of the product / ammonia less than / only half the volume of the reactants / the nitrogen and hydrogen

1

(iii) **EITHER**
680 (tonnes)

OR 28 (of nitrogen) → 34 (of ammonia)

accept any correct 14 : 17 ratio

1

560 (of nitrogen) → 34 × 20 (of ammonia)

3

[6]

50 (a) $N_2 + \mathbf{3}\ H_2 \leftrightarrow \mathbf{2}\ NH_3$

2

(b) (i) lower temperature gives higher % conversion
higher pressure gives higher % conversion

each for 1 mark

2

(for T = 350 °C and P = 400 At. award 2 marks)

the most economical combination
reaction too slow at lower temperatures
plant too expensive at higher pressures

any 2 for 1 mark each

2

[6]

51 (a) rate of reaction is increased
iron/powder
acts as catalyst
at higher temperatures
at higher pressures

any 4 answers for 1 mark each

4

(b) yield of ammonia is increased at higher pressure
since equilibrium is moved to the right (idea)
but there is high cost in manufacturing the plant to withstand very high pressures
so optimum* pressure of about 250 atmospheres is used
(– just quoting the figures not enough)*
very high pressure increases safety risk
yield of ammonia is increased at lower temperatures
since equilibrium is moved to the right
but the rate of reaction is reduced at lower temperatures
so process becomes uneconomic
optimum temperature of about 450°C is used
yield of ammonia is increased if the ammonia is removed from the reaction mixture

since equilibrium is moved to the right (idea)
so ammonia is removed as a liquid after cooling and condensing
unreacted nitrogen and hydrogen recycled

(credit nitrogen and ammonia because of misprint on the diagram)

NB Answers in (b) must clearly relate to yield not to rate
(except for the qualification w.r.t. temperature)

any 7 points for 1 mark each

7

[11]

52 (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) $2\ NO + O_2 \rightarrow 2NO_2$
for 1 mark each

1

(iii) $3\ NO_2 + H_2O \rightarrow 2HNO_3 + NO$
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]

53 (a) from natural gas [*allow from water/ steam / brine / river / lake / sea*]

for 1 mark

1

(b) *idea that* they are recycled / re-used

for 1 mark

1

(c) *ideas that*

- nitrates may get into ground water / rivers
- so contaminate / get into our drinking water
- eating animals which have eaten crop/ or eating contaminated fish

[do not allow 'eutrophication']

any two for 1 mark each

2

(d) (i) *idea that*
when rate of forward = rate of reverse reaction
[not just 'reversible' or 'can be reversed']
[allow ammonia is breaking up into nitrogen and hydrogen as fast as nitrogen and hydrogen are forming ammonia
or amounts of products and reactants stay constant*]*

for 1 mark

1

(ii) *ideas that*

- at higher temperatures, equilibrium moves to **the** left **or** reverse / endothermic
- reaction / favoured **or** makes products → reactants
- but at lower temperatures the (rate of) reaction is (very) slow
- so a higher temperature is used for economic reasons/so ammonia is produced at higher rate
- iron powder is a catalyst / speeds up the reaction
  [not increases the yield]
- low yield not wasteful if reactants re-cycled

[credit iron powder has a greater surface area]

each for 1 mark

4

[9]