Mark schemes

1 (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]

2

(a) sterilise / disinfect (water)

ignore removes bacteria / impurities / disease

or

kill bacteria / micro-organisms / microbes / germs / pathogens

ignore cleans the water / makes (water) safe

*allow destroy bacteria **or** gets rid of bacteria*

1

(b) any **two** from:

ignore reference to safe / unsafe

- chlorine is toxic / poisonous
- so (too much) will be dangerous / harmful / kill people / cause illness / health problems

allow causes damage

- cause breathing difficulties **or** cause (more) allergic reactions / skin **or** eye irritation
- too little will not kill bacteria

allow bacteria still there

2

(c) cheap / easy / quick to use (process)

accept prevents typhoid / cholera

ignore reference to specialists or equipment

1

(d) (i) fair / more ideas / views / opinions **or** less chance of bias **or** more democratic

allow idea of different points of view / balanced view

allow avoids undue influence owtte

1

(ii) (more likely) to have support / influence / convince people

ignore well respected

allow ideas about trust eg people will have more confidence in their views / more likely to be believed

allow ideas about expertise eg more likely to know what they are talking about / have done experiments / tests

allow have knowledge / understanding

allow (more) reliable

1

(iii) (more likely) to be correct / less likely to be incorrect

owtte

or

reliable / factual / accurate / based on proof / based on experiments or tests / based on validation

ignore based on evidence unqualified

allow hearsay / opinion can be biased

1

[7]

3

(a) alloys

1

(b) bar drawn correctly up to 4%

ignore width of bar

1

(c) (contains) more carbon

ignore contains 4% carbon

accept higher level responses related to structure / arrangement of atoms

1

(d) (i) 73.8

1

(ii) mild (steel)

1

(iii) corrosion

1

[6]

4

(a) (i) C

must be correct symbol

*do **not** accept carbon*

any balancing must be correct

1

(ii) $Fe + CO_2$

correct formulae

1

2... . + 3... .

correct balancing

allow Fe_2 + 3CO_2 for this mark

1

(iii) layers / atoms in pure iron are able to slide over each other

it = pure iron

accept ions for atoms

ignore molecules / particles

or

layers / atoms in cast iron are unable to slide over each other (easily)

1

(b) any **three** from:

*mention of ozone = max **2***

- less iron ore used

  accept the idea that ores would be conserved but not unspecified conservation

- less other metals extracted / used to make different steels

  accept the idea that ores would be conserved but not unspecified conservation

- less fuel used

  accept the idea that fuels would be conserved

  ignore reduces energy requirements

- less specified pollution

  accept global warming / greenhouse effect / CO_2 / CO / carbon emissions / acid rain / SO_2 / global dimming /

  *do **not** accept ozone layer*

- less / no landfill space needed

  ignore reduces waste

- less / no mining needed **or** fewer specified effects of mining

  accept effect such as eyesore / loss of habitat

  *eg 'less mining iron ore' = **2** marks*

3

[7]

5 (a) atoms

1

(b) mixture

1

metal

1

structure

1

smart

1

(c) (i) any **two** from:

- saves raw materials / iron ore
- saves energy / fuels
  accept cheaper / saves money
- make new / useful items
- make money / it is economic
- <u>reduces</u> pollution
  allow less harmful for the environment
- decreases cost of steel cans
- reduces carbon dioxide emissions
- decreases waste materials / use of landfill

2

(ii) any **one** from:

- provide information / education of the need to recycle
- legislate against / charge for waste
- reward / pay people to recycle
  accept fine people for not recycling
- put labels on the cans
- provide recycling bags / bins / areas

1

[8]

6 (a) (i) polyethene / poly(ethene)

accept polythene / polyethylene

1

(ii) needs heat / energy / high temperature / fuel (for cracking)

ignore other processes

1

produces carbon dioxide / CO_2

ignore use of CO_2 ***or*** *'produces carbon'*

1

(b) any **three** from:

- use water from local sources **or** water from close to home
- recycle bottles in the UK / close to home

  accept do not recycle in other countries / Asia
- (reduction in distance travelled) would reduce CO_2 emitted by transport

  accept use of transport with low / no carbon dioxide emissions
- use tap water
- use glass bottles / waxed cartons / metal bottles

  do ***not*** *accept 'do not use plastic bottles' without an alternative material*
- do not put in landfill **or** recycle <u>more</u>
- reuse / refill plastic bottles
- <u>tax</u> imported water / plastic bottles (to offset carbon cost)
- make more / all plastic bottles in UK

  answers must be about the reduction of carbon cost

3

[6]

7 (a) (Chromium =) 20

1

in correct order

(Nickel =) 8

accept Chromium = 8 ***and*** *Nickel = 20 for* ***1*** *mark*

1

(b) (i) (because iron is made up of only) one type of atom

1

(ii) not strong

ignore soft / corrosive / flexible

*accept it rusts / corrodes **or** that it could wear away*

accept could change shape / bend

accept layers / atoms could slide (over each other)

1

(iii) has different sized atoms / particles

or

structure is different/distorted / disrupted

*accept not in layers **or** not regular*

1

so it is difficult for layers / atoms / particles to slip / slide (over each other)

accept layers cannot slip / slide

1

[6]

8 (a) (i) C_2H_4

1

(ii) poly(ethene)

1

(b) (i) is not biodegradable

1

(ii) not enough landfill sites / space

*accept landfill sites are filling up **or** plastics remain for years **or** plastics not broken down*

ignore cost / waste of resources / not biodegradable / wildlife

1

(iii) less (crude) oil / fuels / energy used

accept (crude) oil is a non-renewable resource

1

[5]

9 (a) (i) reacts with carbon / C

accept burns / oxidises carbon

1

carbon dioxide / CO_2 / gas is formed / given off

accept carbon monoxide / CO

*accept correctly balanced equation for **2** marks*

ignore state symbols

1

(ii) change / improve properties

accept any specific property

accept to make alloys / special steels

ignore brittle

1

(b) any **two** from:

- to conserve ores / iron

  accept ores / iron are non-renewable / non-sustainable
  allow less quarrying / mining

- to prevent the use of landfills

  allow reduce waste

- to conserve energy / fuel

  accept fossil fuels are non-renewable

- to reduce carbon / carbon dioxide emissions

- to meet EU / International targets

  ignore costs / demand

2

[5]

10 (a) (i) many ethene / molecules / monomers

accept double bonds open / break

1

join to form a long hydrocarbon / chain / large molecule

accept addition polymerisation

ignore references to ethane

*correct equation gains **2** marks*

1

(ii) (can be deformed but) return to their original shape (when heated or cooled)

ignore 'it remembers its shape'

1

(iii) cross links / extra bonds in PEX

accept inter-molecular bonds
ignore inter-molecular forces

1

molecules / chains in PEX are held in position

accept rigid structure

1

molecules / chains in PEX unable to slide past each other / move

it = PEX throughout

1

(b) any **four** from:

- less (hydrocarbon) fuels used
  allow less energy
- less / no electrical energy used
  allow no electrolysis
- reduce carbon / carbon dioxide emissions
  allow less global warming
- reduce / no pollution by sulfur dioxide / acid rain
- continuous process
  allow less / no transportation
- conserve copper which is running out or only low-grade ores available
- reduce the amount of solid waste rock that needs to be disposed
  allow less waste
- reduce the need to dig large holes (to extract copper ores)
  allow less mining
  ignore costs / sustainability / non-renewable

4

[10]

11 (a) pressure

1

(b) nitrogen

1

hydrogen

1

(c) cooled

1

[4]

12 (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]

13 (a) kills bacteria / sterilises (water)

allow kills microorganisms / microbes / germs

*allow 'makes (water) safe (to drink)' **or** disinfectant*

*ignore cleans water **or** removes impurities / bacteria*

1

(b) goes colourless / decolourised (from red / red-brown / brown / yellow / orange)

allow colour disappears

*ignore 'goes clear' **or** discoloured*

*do **not** accept incorrect initial colour*

*do **not** accept precipitate*

1

(c) (i) Br_2 **and** $2Cl^-$

allow multiples / fractions if whole equation balanced

1

(ii) changes to red / red-brown / brown / yellow / orange

*do **not** accept effervescence / fizzing / precipitate / gas given off*

ignore vapour / temperature changes / ignore initial colour

1

(d) (i) 7 <u>outer</u> electrons **or**

same number of <u>outer</u> electrons

allow last / final shell for outer

allow energy level / orbit / ring for shell

allow 'need to gain 1 e^- to have a full outer shell'

ignore 'similar number of outer electrons'

1

(ii) bromine / it (atom) is <u>bigger</u> **or**

must be a comparison

outer electrons (level / shell) further from nucleus **or** more shells

*do **not** accept more outer shells*
ignore more electrons

forces / attractions are weaker **or** more shielding **or** attracts less

*do **not** accept magnetic / gravitational / intermolecular forces*
allow 'electron(s) <u>attracted</u> less easily'

electron(s) gained <u>less</u> easily

*"outer / last / final" must be mentioned once, otherwise max **2** marks.*
accept converse for chlorine throughout where clearly stated

3

(e) (i) white precipitate **or** white solid

ignore names of chemicals

1

(ii) cream precipitate **or** cream solid

allow <u>pale</u> yellow / off-white precipitate / solid
ignore names of chemicals

1

[10]

14 (a) (i) monomers

1

(ii) crude oil

1

(b) any **three** from:

- metal may not corrode away / remains
- plastic remains / does not break down (decay) / not affected by microorganisms
  accept non-biodegradable
- should recycle / conserve resources / mend the kettle / burn (plastic) as a fuel
  accept it is a waste of materials / resources
- landfill sites are limited / filling up
- water pollution
  *ignore harms wildlife / habitats **or** problems caused by burning the kettle*

3

[5]

15 (a) any **three** from:

- resources / aluminium / ores are conserved
  accept converse argument
- less / no mining **or** less associated environmental problems
  eg quarrying / eyesore / dust / traffic / noise / loss of land / habitat
  ignore just pollution
- less / no waste (rock) / landfill
  *do **not** accept 'wastes 50% of the ore'*
- no purification / separation (of aluminium oxide)
- (aluminium extraction / production) has high energy / electricity / heat / temperature requirements
- less carbon dioxide produced
  accept no carbon dioxide produced
  ignore references to cost

3

(b) statement

ignore density

1

linked reason

eg
(pure) Al / it is weak / soft (1)
as layers / rows can slide (over each other) (1)
or
alloy / other metals / they make it stronger / harder (1)
stops layers / rows sliding over each other (1)
accept disrupts the structure owtte if no other mark awarded
*accept to form an alloy **or** to change properties for **1** mark*

1

[5]

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

- naphtha has a different / low(er) boiling point
  accept different volatility
- condenses at a different temperature / height / place in the column / when it reaches it's boiling point
- different size of molecules

2

(b) (i) $C_{10}H_{22} \rightarrow C_6H_{14} + \mathbf{2}C_2H_4$

allow multiples

1

(ii) (hydrocarbon) heated / vapours

1

(passed over a) catalyst / alumina / porous pot

ignore other catalysts

1

(iii) it / ethene is unsaturated **or** decane and hexane / they are saturated

accept decane and hexane are alkanes / C_nH_{2n+2}
***or** ethene is an alkene / C_nH_{2n}*
***or** different homologous series / general formula*

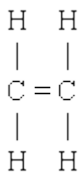
1

ethene has a double (carbon carbon) bond **or** decane and hexane have only single (carbon carbon) bonds

*accept ethene has a reactive double (carbon carbon) bond for **2** marks*

1

(c) all bonds drawn correctly



1

(d) **economic argument** against recycling

any **one** from:

- poly(ethene) / plastic must be collected / transported / sorted / washed
- this uses (fossil) fuels which are expensive

1

environmental argument against recycling

any **one** from:

- uses (fossil) fuels that are non-renewable / form CO_2 / CO / SO_2 / NO_x / particulates

  ignore pollution / harmful gases / etc

- washing uses / pollutes water

1

counter arguments

any **two** from:

- collect / transport alongside other waste
- use biofuels (instead of fossil)
- landfill is running out
- landfill destroys habitats
- incinerators are expensive to build
- saves raw materials / crude oil
- saves energy needed to make new plastic
- incinerators may produce harmful substances
- incinerator ash goes to landfill
- poly(ethene) is non-biodegradable
- poly(ethene) can be made into other useful items
- more jobs / employment for people

2

[12]

17 (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]

18 (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]

-

19 (a) (i) hydrogen
must be name

1

(ii) a line of four or more ethene molecules joined to the original two with single bonds
*at least two other ethene molecules joined to the original two in a chain gains **1** mark*

2

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

- non-biodegradable
  accept remains a long time
- landfill sites are filling up / limited
  accept land / space used up
- <u>waste of a resource</u> / could be recycled / reused
  ignore references to tablets / animals

2

(ii) any **one** from:

- (two) different polymers / plastics / materials
- need to be separated
- limited collection points / many need to be collected
- tablets may still be present

1

[6]

20

(a) contains (large amounts of) dissolved solids / difficult to remove dissolved solids

allow salty / too much salt

allow sea water makes you thirsty / vomit

allow polluted / untreated / contaminated

1

(b) filtered: removes solids / removes insoluble material / dirt

ignore large objects

1

chlorine: kills/destroy bacteria/microbes/ germs etc

*allow disinfect / sterilise **or** gets rid of bacteria*

ignore purify / clean

1

[3]

21

two methods and **1 linked** explanation **or 1** method and **two** explanations, **1** linked = **3** marks

no linking of method and explanation then max **2** marks

ignore references to removal of hardness

method 1:

filter

ignore screening / sedimentation

explanation 1:

remove insoluble substances / remove solids / small bits / dirt / mud/ soil / sand / silt

method 2:

precipitate / flocculate / add eg. alum

allow other named substances

explanation 2:

removes (some) soluble material as solids / removes (some) metal ions

method 3:

add chlorine / chlorine dioxide / ozone

explanation 3:

sterilise / kill bacteria / microorganisms / microbes

ignore 'remove bacteria'

ignore disinfect

[3]

22 (a) (i) poly(ethene)

accept polythene

1

(ii) cracking

1

(iii) hydrogen

1

(b) (i) bar labelled 9

1

bar drawn to correct height

1

(ii) (boiling point) increases

1

(iii) heat / evaporate (the crude oil)

accept separate by boiling point

1

cool / condense (hydrocarbons at different temperatures)

accept smaller molecules go to top / larger molecules stay at bottom

*accept fractional distillation for two marks **or** distillation / fractionation for **one** mark*

1

(c) **yes**

any **two** from:

- because plastic does not biodegrade **or** running out of space for landfills **or** land cannot be used for a long time
- it provides heat energy
- which can be used to generate electricity / heat homes or greenhouses
- any other advantage of burning
- any other disadvantage of landfill

or

no

- burning plastic produces carbon dioxide / carbon emissions / toxic gases

  accept landfill does not produce carbon dioxide / carbon emissions

- causes global warming / climate change / increase greenhouse effect / global dimming / acid rain
- any other disadvantage of burning
- any other advantage of landfill

2

[10]

23 (a) (i) contain enough metal to make it economical / worth while to extract

1

(ii) reduction

accept displacement

accept redox

1

(iii) $Fe + CO_2$

*do **not** accept Fe_2 / Fe_4*

1

correct balancing

accept multiples and halves

$\mathbf{2}Fe_2O_3 + \mathbf{3}C \rightarrow \mathbf{4}Fe + \mathbf{3}CO_2$

allow Fe_2 / Fe_4 as ecf

1

(b) **Pure Iron**

(in pure metal all the atoms are the same size and) able to slip / slide over each other – (property soft)

OWTTE

ignore references to molecules / particles

if they say 'move' both times, allow ***one*** *mark but 'crack' or 'split' is wrong..*

1

Cast iron

(in cast iron) different sized atoms / larger atoms **or** structure is distorted / disrupted

OWTTE

1

so it is difficult for layers of atoms to slip / slide over each other

OWTTE

1

(c) any **three** from:

- conserves / saves resources / metal ores
- saves energy resources (used for extraction / processing)

  accept cheaper / saves money
- decreases waste materials
- decreases a named pollution

  do ***not*** *accept acid rain*

3

[10]

24 (a) (i) $Cu_2S + 2O_2 \rightarrow 2CuO + SO_2$

accept fractions and multiple

1

(ii) any **two** from:

- sulfur dioxide

  accept sulphur dioxide / sulphur oxide / SO_2
- causes acid rain

  ignore other comments eg global warming / ozone / global dimming / greenhouse effect
- consequence of acid rain eg kills fish / plants

2

(b) any **two** from:

- heat (copper oxide with carbon)
- oxygen is removed by carbon
  accept copper (oxide) loses oxygen

  or

  carbon gains oxygen
  accept carbon oxide

  or

  carbon monoxide / carbon dioxide is produced

  or

  carbon displaces copper
  accept a correct word or balanced symbol equation
- because carbon is more reactive than copper
  allow a correct comparison of reactivity

2

(c) (i) electrolysis
accept electroplating

1

(ii) (electrical) wiring / appliances / coins / pipes / cladding for buildings / jewellery / making alloys

1

or

named alloys

(d) any **three** explanations from:

<u>for recycling</u>

- less acid rain (pollution)
- copper reserves last longer / conserved

  or

  do not run out
- energy for extraction (saved)

  or

  less energy required
- less mining / quarrying
- less waste (copper) / electrical appliances dumped

  or

  less landfill

  <u>against recycling</u>
- collection problems
- transport problems
- difficult to separate copper from appliances
- energy used to melt the collected copper

  ignore electrolysis / pollution
  ignore ideas about less machinery / plant
  ignore idea of cost

3

[10]

25 (i) potassium hydroxide

accept correct formulae

1

water

1

(ii) fertiliser

1

(iii) H^+

*accept hydrogen but **not** H*

1

[4]

26 (a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ **or**

$H_3O^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

mark for correct equation
mark for state symbols
any other symbols = 0 marks
accept correct spectator ions e.g.
$Na^+(aq) + OH^-(aq) + H^+(aq) + Cl^-(aq) \rightarrow Na^+(aq) + Cl^-(aq) + H_2O(l)$

2

(b) (i) <u>nitric</u> <u>acid</u> **and** ammonia (solution)
HNO_3 NH_3 / NH_4OH

mark for both
accept ammonium hydroxide / NH_4OH instead of ammonia
*do **not** accept ammonia hydroxide*
*do **not** accept hydrogen nitrate solution*
accept correct formulae

1

(ii) provides oxygen or oxidising (agent) **or** oxidant

*do **not** accept it contains oxygen alone*
***or** rich in oxygen*

1

[4]

27 (a) hydrogen

accept H_2
*do **not** accept H*

1

(b) litmus paper / Universal Indicator paper / pH paper

allow any suitable named indicator

1

bleached / turns white **or** loses its colour

*do **not** accept bleached cloth / leaves etc.*

allow second mark unless incorrect indicator given

allow starch iodide paper (1)
goes black / blue black (1)

allow potassium iodide solution (1) goes brown / orange / black precipitate (1)

1

(c) because they have a negative charge **or** opposite charges attract

accept (because) it is Cl^-
*accept chlorine, Cl **or** chlorine ions has a negative charge*

*do **not** accept Cl^- on its own*
*do **not** accept Cl_2 o.e. has negative charge*

1

(d) kill bacteria / germs, etc. **or** sterilise / disinfect

accept destroys bacteria etc.
ignore clean / purify water (owtte)
*do **not** accept just gets rid of bacteria*

1

(e) hydroxide (ion)

accept OH^-

1

[6]

28 (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]

29 (a) put on soil **or** for plants

*accept land **or** field **or** garden **or** crops **or** plants*

accept alternative answer to provide more food for increased population

for growth

*accept to improve plant yield **or** help them grow*

*accept to replace **or** add nutrients (**not** nitrates) **or** minerals **or** to make plants grow better **or** for healthy plants*

*do **not** accept to make soil fertile **or** to feed plants*

2

(b) (i) 2

1

(ii) 80

1

[4]

30 (a) any **two** points **one** mark each

accept comparison between aluminium and iron

aluminium has:

- a low density

  accept lighter or fewer pylons

- a good conductor of electricity
- does not corrode **or** rust

  *do **not** accept does not react with air*

  *do **not** accept last longer*

2

OR

- iron has:
- high density
- is a less good conductor (of electricity)
- rusts or reacts with air

(b) any **5** from:

- employment of people **or** cost of employment
- depletion or use of resources

  *do **not** accept depletion here*

- cost of energy resources
- cost of machines **or** buildings
- pollution by noise from traffic **or** quarrying

- air pollution by dust **or** traffic fumes
- danger of traffic on roads
- damage to landscape (eyesore)
- damage to habitats of wildlife
- lowers the value of houses nearby
- subsidence **or** vibration can affect roads **or** houses
- providing raw materials

*do **not** accept danger **or** falling in*

5

[7]

31 (a) (i) 78-80%

1

(ii) proteins

accept amino acids

1

(b) (i) natural gas

accept methane (CH_4)

accept water (H_2O)

1

(ii) carbon dioxide

1

(c) (i) $N_2 + H_2$

1

correct balancing $1 + 3 \rightarrow 2$

award only if reactants are correct

1

(ii) iron

accept Fe

1

(iii) at low temperatures rate of reaction is too slow

accept very few collisions at low temperatures

accept converse

particles need enough (activation) energy to react

accept particles need enough energy for bonds to break

accept converse

1

(d) all three covalent bonds displayed correctly as electron pairs

1

two lone electrons displayed not necessarily as a pair

1

[11]

32 (a) nitrogen

consider answers as a list

1

hydrogen

1

(b) speed up the reaction

accept increase rate of reaction

1

(c) fertiliser

*accept to replace **or** add nitrogen **or** nutrients*
*do **not** accept minerals or nitrates*

1

growth

*accept for protein **or** increased yield*

1

[5]

33 (a) (i) fertilisers

for 1 mark

1

(ii) 7

for 1 mark

1

(iii) 5

for 1 mark
(ignore other units)

1

(b) (i) both nitrogen and hydrogen

for 1 mark

1

(ii) two of:
nitrogen;
hydrogen/methane/natural gas;
oxygen/air;
water;
any fuel
(allow symbols, do not allow nitrogen oxides)
any two for 1 mark each

2

(c) (i) alkali/alkaline/base/basic
for 1 mark

1

(ii) must be nitrate
for 1 mark

1

(iii) thermometer or any other temperature measuring device
for 1 mark

1

[9]

34 (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]

35

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]

36 (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]

37 (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]

38

(a) plot correct (2 segments)

for 1 mark

1

(b) nitrogen + hydrogen $\rightleftharpoons$ ammonia

or N_2 H_2 NH_3

all correct for 1 mark

1

(c) largest area labelled nitrogen or shaded

for 1 mark

1

(d) (i) nitrogen

1

oxygen

hydrogen

1

three correct for 2 marks
two correct for 1 mark

(ii) potassium chloride

for 1 mark

1

(e) (i) $NH_4NO_3 = 14 + (4 \times 1) + 14 + (3 \times 16) = 80$

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 1 mark

gains 2 marks

2

[9]

39 (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]

40 (a)

*the answer yes **or** no does not gain a mark*

Yes – plants will grow faster

*do **not** accept grow better*

1

more food available, greater yield

1

OR

No – plants still grow without adding nitrates

*accept the idea that **small** amounts of nitrate could be used*

1

(nitrates) can 'kill' babies / causes brain damage

do not accept can stop respiration in babies

1

(b) (i) 2

accept two

1

(ii) $2 \times 14 + 4 \times 1 + 3 \times 16$

1

$= 80$

1

$\frac{28}{80} \times 100 = 35\ \%$

1

allow 1 mark for correct working for percentage 28/Y × 100, where Y is an incorrect formula mass
allow 2 marks for formula mass of 80 where no working ***or*** *correct working is shown*
allow 3 marks for 35 where no working ***or*** *correct working is shown*

[6]

41 (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

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]

42 (a) increases % / amount of ammonia

1

favours the forward reaction

1

(b) reaction(s) would be too slow

1

(c) any **three** from:

- rate increased
- decreases % / amount of ammonia
- the forward reaction is exothermic
- the backward reaction is endothermic
- backward reaction favoured / forward reaction not favoured
- yield / amount of nitrogen and hydrogen increased
- the relative amount (yield) of ammonia decreases as the equilibrium is changed
- the relative amount (yield) of nitrogen and hydrogen increases as the equilibrium is changed

explanations in terms of particles are neutral

3

[6]

43 (a) ammonium nitrate

accept NH_4NO_3
*do **not** accept ammonia nitrate*

1

(b) different reactions need different catalysts

1

(c) they are used over and over again

accept they are reused
accept they are not used up
accept they are not changed
recycling is neutral

1

(d) any **two** from

they speed up reactions

they reduce energy requirements

accept allow reactions to take place at a lower temperature

they reduce costs

accept make process more economic

2

(e) (high pressure) increases the frequency of collisions

accept more collisions
move faster is neutral

1

this increases the rate of reaction

accept 'more successful collisions' for 2 marks

1

[7]

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 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** <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) (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]

46 (i) zinc

accept Zn

1

iron only

accept Fe

1

copper

accept Cu

do not credit iron

1

(ii) iron

1

(iii) copper **or** iron or manganese

*accept Cu **or** Fe **or** Mn*

1

[5]

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) 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]

49 (a) hydrogen

for 1 mark

1

(b) chloride ions are negative;
negative ions move to positive electrode

each for 1 mark

2

(c) any **one** use of chlorine e.g.
sterilisation;
bleaching;
making plastics

any one for 1 mark

1

[4]

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) $\underline{2}\ NO + O_2 \rightarrow \underline{2}NO_2$
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]