M1.(a) add excess copper carbonate (to dilute hydrochloric acid)

accept alternatives to excess, such as 'until no more reacts'

1

filter (to remove excess copper carbonate)

reject heat until dry

1

heat filtrate to evaporate some water **or** heat to point of crystallisation

accept leave to evaporate or leave in evaporating basin

1

leave to cool (so crystals form)

until crystals form

1

*must be in correct order to gain **4** marks*

(b) M_r $CuCl_2$ = 134.5

*correct answer scores **4** marks*

1

moles copper chloride = (mass / M_r = 11 / 134.5) = 0.0817843866

1

M_r $CuCO_3$= 123.5

1

Mass $CuCO_3$ (=moles × M_2= 0.08178 × 123.5) = 10.1(00)

1

*accept 10.1 with no working shown for **4** marks*

(c) $\frac{79.1}{100} \times 11.0$

or

11.0 × 0.791

1

8.70 (g)

1

*accept 8.70(g) with no working shown for **2** marks*

(d) Total mass of reactants = 152.5

1

$\frac{134.5}{152.5}$

allow ecf from step 1

1

88.20 (%)

1

*allow 88.20 with no working shown for **3** marks*

(e) atom economy using carbonate lower because an additional product is made **or** carbon dioxide is made as well

allow ecf

1

[14]

M2. (a) 2.61 / range 2.5 to 2.7

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

(accept answers between 2.5 and 2.7)

*if answer incorrect moles of salicylic acid = 2/138 = 0.0145 moles ie 2/138 **or** 0.0145 gains **1** mark*
or
*(180/138) × 2 gains **1** mark*
or
*1 g → 180/138 = (1.304 g) gains **1** mark*
*(**not** 1.304g alone)*

2

(b) 42.1 range 40.7 to 42.3

*accept correct answer with **or** without **or** with wrong working for **2** marks*

*ecf ie (1.1 / their answer from (a)) × 100 correctly calculated gains **2** marks*

*if answer incorrect percentage yield = 1.1 / 2.61 × 100 gains **1** mark*

if they do not have an answer to part (a)
or
they choose not to use their answer then:

- yield = (1.1 / 2.5) × 100 (1)
- = 44

*accept 44 for **2** marks with no working*

2

(c) any **one** from:

- errors in weighing
- some (of the aspirin) lost

  *do **not** allow 'lost as a gas'*
- not all of the reactant may have been converted to product

  eg reaction didn't go to completion

  allow loss of some reactants
- the reaction is reversible

  accept other products / chemicals

- side reactions
  ignore waste products
- reactants impure
- not heated for long enough
- not hot enough for reaction to take place

1

(d) any **one** from:

- use lower temperature
- use less fuel / energy
  ignore references to use of catalyst
- produce product faster **or** speed up reaction
- more product produced in a given time (owtte)
- increased productivity
- lowers activation energy

1

[6]

M3. (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]