AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



MARK SCHEME

4.6.1 RATE OF REACTION (PACK 1)

SCORE	PERCENTAGE
/381	%

STEMUP

These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

(a) 83 (cm^3)

allow 83.0 / 83.00

1

(b) mass of magnesium powder

1

temperature of hydrochloric acid

1

(c) $\frac{(46 + 47 + 49)}{3}$

*allow 47.3(333) (cm^3) for **1** mark*

1

= 47 (cm^3) (2 sf)

*an answer of 43 (cm^3) scores **1** mark*

1

*an answer of 47 (cm^3) scores **2** marks*

(d) all points plotted correctly (inc 0,0)

allow a tolerance of ±½ a square
*allow ecf from question **(c)***
ignore line
*allow **1** mark for four points plotted correctly*

2

(e) $\frac{80}{50}$

allow 80 ± 2

1

= 1.6 (cm^3/s)

allow 1.60 ± 0.04

1

*an answer of 1.6 (cm^3/s) scores **2** marks*

(f) rate is greatest at start

allow rate is faster at start

1

(then) rate decreases

allow (then) rate slows down

1

reaction stops

1

(g) there are more particle collisions each second

1

STEMUP.CO.UK

there are more particles in the same volume

1

(h) (gas is) not carbon dioxide

ignore does not react with limewater

1

(i) hydrogen

allow H_2

1

pop sound

1

[17]

Q2.

(a) sulfur (formed)

allow S / S_8 (formed)

1

(which is a) precipitate

allow (which is a) solid
allow (which is) insoluble

1

(b) **Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

method

- measure (indicated) volume of sodium thiosulfate
- place sodium thiosulfate in (conical) flask
- measure (indicated) volume of hydrochloric acid
- place on cross or between light sensor
  or
  connect to a gas syringe
  or
  other suitable method for timing a change
- add hydrochloric acid to (conical) flask
- swirl
- start stopclock / stopwatch
- measure time for cross to become no longer visible
  or
  log light transmission over time

STEMUP.CO.UK

or
measure time for fixed volume of gas to be produced
- repeat and find mean
- repeat for different concentrations of sodium thiosulfate
  or change ratio of sodium thiosulfate volume : water volume

control variables
- concentration of hydrochloric acid
- volume of hydrochloric acid
- (total) volume of sodium thiosulfate solution

[8]

Q3.

(a) a gas is produced

allow carbon dioxide is produced
*do **not** accept an incorrect gas*

1

(which) escapes

***max 1** mark if evaporation mentioned*

1

(b) all eight points plotted correctly

allow a tolerance of ± half a small square.

*allow six or seven points plotted correctly for **1** mark*

2

line of best fit

1

(c) correctly drawn tangent at 0.95 g

1

correct value for x step **and** y step from tangent

allow evidence of use of two points on tangent either on the graph or in the text

1

$$(\text{rate} =) \frac{\text{value for y step}}{\text{value for x step}}$$

1

correctly evaluated and rounded to 2 sig figs

allow

$$(\text{rate} =) \frac{\text{value for x step}}{\text{value for y step}}$$

(i.e. inverted division)
correctly evaluated and rounded to 2 sig figs

1

an incorrect answer for one step does not prevent allocation of marks for subsequent steps

[9]

STEMUP.CO.UK

Q4.

(a) enzyme

1

(b) 2.0×10^3 moles

1

(c) smaller yield

allow less methanol is produced

1

(because) favours endothermic reaction

allow (because) favours reverse reaction
allow equilibrium / reaction shifts to the left
allow equilibrium / reaction shifts to reduce the temperature

ignore reference to forward reaction is exothermic
ignore references to rate

1

(d) (yield)
equilibrium position moves to the product side

allow equilibrium / reaction moves to the right
allow equilibrium / reaction shifts to reduce the pressure

1

(because) fewer molecules / moles / particles on product side

allow (because) fewer molecules / moles / particles on the right
allow (because) smaller volume on product side

1

(rate)
more collisions per unit time

allow increases collision frequency / rate

ignore more collisions alone
ignore faster collisions
*do **not** accept any indication of more energetic / forceful collisions*

1

(because) more molecules / particles per unit volume

allow (gas) molecules / particles closer together

ignore more molecules / particles alone

1

allow converse arguments

(e) provides different reaction pathway

allow provides a different mechanism / route

1

(which has a) lower activation energy

1

ignore references to collisions

STEMUP.CO.UK

(f) less energy is needed

allow reduces the temperature required
allow reduces costs

ignore references to pressure
ignore references to rate or time

1

(g) no effect / change

1

[12]

Q5.

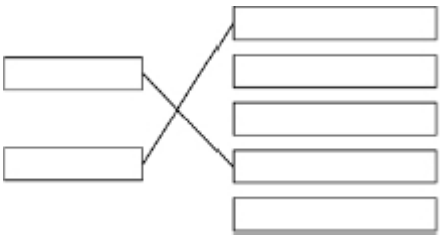
(a) S(s)

1

(b) measuring cylinder

1

(c)



1

*allow for **1** mark an answer of dependent variable --- concentration of sodium thiosulfate solution and independent variable --- time for cross to become no longer visible*

1

(d) cross might be darker or paler

allow cross may not be the same size / shape

1

(e) $\frac{43 + 41}{2}$

*an answer of 42 (s) scores **2** marks*

1

= 42 (s)

*an answer of 54 (s) scores **1** mark*

1

(f) smooth curve through all points

must touch all crosses
*do **not** allow straight lines between points*
*ignore attempt to plot **X***

1

(g) reproducible

1

(h) particles collide more frequently

1

STEMUP.CO.UK

there are more particles in a fixed volume

1

[11]

Q6.

(a) sulfur

1

precipitate

allow solid

1

(b) any **one** from:

- (volumetric) pipette
- burette

1

(c) any **one** from:

- concentration of hydrochloric acid
- volume of hydrochloric acid
- volume of sodium thiosulfate solution
- temperature (of solution)
- darkness of cross

allow same cross

- same stirring / swirling

1

(d) 7 points plotted correctly

allow tolerance of ± half a small square

*allow 5 or 6 points plotted correctly for **1** mark*

2

line of best fit

must avoid anomalous point

1

(e) repeatable

*do **not** accept reproducible*

1

(f) discard any anomalous results

1

calculate a mean

1

(g) **conclusion:**

the higher the concentration, the higher the rate of reaction

1

explanation:

(at higher concentrations) there are more particles in a fixed volume

1

(therefore the) collisions are more frequent

1

STEMUP.CO.UK

allow converse

(h) 120 (s)

1

0.18 / 120

allow 0.0015

1

= 1.5 × 10^{-3} (g / s)

*an answer of 9 × 10^{-2} scores **2** marks*

*allow an answer of 0.09 for **1** mark*

1

*an answer of 1.5 × 10^{-3} (g / s) scores **3** marks*

[16]

Q7.

(a) cool

1

to −34 °C

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

1

(b) recycled (to the reactor)

1

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

1

= 550 (dm^3)

1

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

(d) a lower pressure would decrease the equilibrium yield

1

a lower temperature would make the reaction too slow

1

(e) nitrogen / N

1

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

1

contain nitrogen, phosphorus and potassium

1

(g) (**B**)

any **two** from:

- more stages
- uses more energy
- uses more raw materials
- takes longer

STEMUP.CO.UK

*allow converse for **C***

2

[12]

Q8.

(a) in a closed system

1

the rate of the forward and backward reactions are equal

1

(b) concentration increases

1

(because) reaction / equilibrium moves to the left / reactant side

1

(since the) reverse reaction is exothermic
allow (so that) temperature increases

1

(c) becomes blue

1

(because) reaction / equilibrium moves to the right / product side

1

(so) concentration of blue cobalt compound increases
allow (so that) concentration of hydrochloric acid decreases

1

(d) (cobalt has) ions with different charges
allow (cobalt is a) transition metal

1

(e) Co^{3+}

1

(f) they allow reactions to reach equilibrium more quickly

1

they provide a different reaction pathway

1

(g) $\mathbf{13}H_2 + \mathbf{6}CO \rightarrow C_6H_{14} + \mathbf{6}H_2O$
allow multiples

1

(h) C_8H_{18}

1

(i) curve below printed curve
*do **not** accept different reactant or product levels*

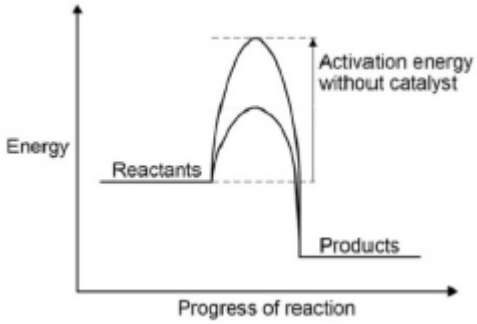
1

vertical arrow from reactant level to peak of **printed** curve

1

STEMUP.CO.UK

an answer of:



scores **2** marks

[16]

Q9.

(a) 36 cm^3

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 6 or 7 of the points are correct*

2 best fit lines drawn

must not deviate towards anomalous point

2

*allow **1** mark if 1 line correct*

(c) The bung was not pushed in firmly enough.

1

The measuring cylinder was not completely over the delivery tube.

1

(d) as mass of lithium carbonate increases volume of gas produced increases

1

linear / (directly) proportional

1

(e) A gas / carbon dioxide is produced.

allow because the air in the tube expands

1

(f) any **one** from:

- Potassium carbonate does not decompose to produce carbon dioxide / a gas.
- Potassium carbonate does not decompose at the temperature of the Bunsen burner **or** the Bunsen burner is not hot enough to decompose potassium carbonate.
- When potassium carbonate decomposes a gas is not formed.

1

[11]

Q10.

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

STEMUP.CO.UK

1

(b) catalyst

1

(c) as pressure increases percentage yield increases

1

(d) 32−23

both readings correct

1

= 9 (%)

1

[5]

Q11.

(a) cotton wool

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 5 or 6 of the points are correct*

best fit line

must not deviate towards anomalous point

1

(c) (mass)
2.1 (g)

allow ecf from drawn best fit line

1

(time)
100 (s)

1

(d) a gas is produced

1

which escapes from the flask

1

(e) $\frac{9.85}{150} = 0.0656$

1

0.07 (g / s)

allow ecf answer correctly calculated to 2 decimal places

1

(f) collect the gas in a gas syringe

1

measured the volume of gas

allow carbon dioxide for gas

1

STEMUP.CO.UK

*allow for **1** mark*
collected gas
or
counted bubbles

(g) The particles have more energy

1

The particles move faster

1

[14]

Q12.

(a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

2

*allow **1** mark for correct formulae*

(b) sensible scales, using at least half the grid for the points

1

all points correct
± ½ small square
*allow **1** mark if 8 or 9 of the points are correct*

2

best fit line

1

(c) steeper line to left of original

1

line finishes at same overall volume of gas collected

1

(d) acid particles used up
allow marble / reactant used up

1

so concentration decreases
allow surface area of marble decreases

1

so less frequent collisions / fewer collisions per second
*do **not** accept fewer collisions unqualified*

1

so rate decreases / reaction slows down

1

(e) mass lost of 2.2 (g)

1

time taken of
270 s
allow values in range 265 − 270

1

STEMUP.CO.UK

$\frac{2.2}{270} = 0.00814814$

allow ecf for values given for mass and time

1

0.00815 (g / s)

or

8.15×10^{-3}

*allow **1** mark for correct calculation of value to 3 sig figs*
*accept 0.00815 or 8.15×10^{-3} with no working shown for **4** marks*

1

(f) correct tangent

1

eg 0.35 / 50

1

0.007

allow values in range of 0.0065 − 0.0075

1

7×10^{-3}

1

*accept 7×10^{-3} with no working shown for **4** marks*

[20]

Q13.

(a) sulfur dioxide

accept SO_2

1

(b) (i) curved line of best fit between the 4 non-anomalous points

1

(ii) temperature was lower (than 40 °C)

accept student missed the moment when the cross disappeared
accept smaller volume of acid or acid more dilute

1

(iii) 0.005 **or** 1/200

*correct answer with or without working gains **2** marks*
*if answer incorrect, allow **1** mark for 0.32 / 64*

2

(iv) The particles move faster.

1

The particles collide with more energy.

1

(v) activation

STEMUP.CO.UK

1

[8]

Q14.

(a) (i) (mass number = 16) because there are 8 protons and 8 neutrons (in the nucleus)

accept mass number is total number of protons and neutrons
*for **1** mark*

2

(ii) same number of protons **or** both have 6 protons

accept same atomic number

1

^{12}C has 6 neutrons

1

^{14}C has 8 neutrons

1

*accept different number of neutrons for **1** mark*
numbers, if given, must be correct
*incorrect reference to electrons = **max 2** marks*

(b) (i) 2 bonding pairs

1

additional unbonded electrons negates this mark

4 unbonded electrons around oxygen

1

accept dot, cross or e or – or any combination

(ii) covalent

1

(iii) any **one** from:

- no delocalised / free electrons
  ignore mobile electrons
- no overall electric charge
  accept no charge (carriers)
- no ions

1

*do **not** accept any implications of the presence of ions*

(c) (i) larger

accept the size of a few hundred atoms
accept atoms are smaller (than nanoparticles)
allow up to 1000 atoms)

1

(ii) (nanoparticles have) large(r) surface area

1

[11]

Q15.

(a) because sulfur / S (forms)

STEMUP.CO.UK

1

(which) is solid / insoluble / a precipitate / a suspension

1

(b) any **two** from:

- volume of sodium thiosulfate
  ignore amount of sodium thiosulfate
- volume of (hydrochloric) acid
  ignore amount of (hydrochloric) acid
- concentration of sodium thiosulfate
- concentration of (hydrochloric) acid

*if no other mark, allow **1** mark for same cross **or** same flask **or** unspecified volume **or** unspecified concentration*

ignore same person

*do **not** accept references to temperature*

2

(c) rate increases

1

because particles move faster

accept particles have more energy

1

so frequency of collisions increases

*accept particles are more likely to collide **or** more chance of collisions*

ignore more collisions

1

more particles / collisions have energy greater than (or equal to) the activation energy

1

(d) cool

*accept refrigerate **or** method to decrease temperature*

or

decrease the temperature (of the solutions)

1

[9]

Q16.

(a) sulfur / sulphur / S / S(s)

1

(b) as the temperature increases, the rate of reaction increases

allow two correct values for rate quoted (from graph) at different temperatures

1

the rate of increase increases **or** there is an exponential relationship

*accept the rate of reaction increases slowly (from 20 °C to 50 °C) then increases more rapidly for **2** marks*

answer MUST be based on rate / speed of reaction

1

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

STEMUP.CO.UK

- temperature (of the reactants)
- concentration of hydrochloric acid
- volume of hydrochloric acid
- volume of sodium thiosulfate
- the (size / darkness / thickness of the) cross
- total volume of solution.

*if no other marks gained, allow **1** mark for:*

rate of stirring

OR

amount of hydrochloric acid / sodium thiosulfate

OR

volume of solution

2

(ii) (because as the concentration increases) the number of particles per unit volume increases **or** particles are closer together.

idea of more particles in a given space is required for the first mark.

ignore references to area.

1

(therefore) the frequency of (successful) collisions increases

allow increased chance / probability of collisions

number of collisions increases is insufficient here.

***must** mention per unit time or frequency.*

ignore speed of collisions.

if reference to space and time missing from M1 and M2 but they are otherwise correct, then award 1 mark.

1

so the number of particles (per unit volume) doubles **or** (the frequency of) collisions doubles.

*students can score **2** marks for a qualitative explanation; the third mark is for a quantitative explanation.*

1

[8]

Q17.

(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

STEMUP.CO.UK

(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]

Q18.

STEMUP.CO.UK

(a) (i) the higher the temperature, the greater the rate
or
at 40 °C rate is faster than at 20 °C
accept the higher the temperature, the faster the reaction

1

(ii) 40 °C curve is steeper
accept the 40 °C line becomes horizontal sooner
accept at higher temperatures the reaction finishes sooner
accept reaction finishes sooner at 40 °C
accept at higher temperatures the gas is produced faster
or

correct comparison of data from the graph

1

(iii) 2

1

(b) (i) Concentration of acid
Mass of marble chips

2

(ii) increases rate
*incorrect reference to energy = max **1***

1

(because of) more frequent collisions (between particles)
accept particles are more likely to collide
ignore more collisions
ignore more successful collisions

1

(c) any **one** from:

- increases rate of reaction
- reduces energy required
- lower temperature can be used
- catalyst is not used up.

1

[8]

Q19.

(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

STEMUP.CO.UK

(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]

Q20.

(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

STEMUP.CO.UK

(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]

Q21.

(a) any **two** from:

- temperature (of the HCl)
- mass or length of the magnesium
- surface area of the magnesium
- volume of HCl

STEMUP.CO.UK

2

(b) (i) (a greater concentration has) more particles per unit volume

allow particles are closer together

1

therefore more collisions <u>per unit time</u> **or** more frequent collisions.

1

(ii) particles move faster

allow particles have more (kinetic) energy

1

therefore more collisions <u>per unit time</u> **or** more frequent collisions

1

collisions more energetic (therefore more collisions have energy greater than the activation energy) **or** more productive collisions

1

(c) (i) add (a few drops) of indicator to the acid in the conical flask

allow any named indicator

1

add NaOH (from the burette) until the indicator changes colour **or** add the NaOH dropwise

candidate does not have to state a colour change but penalise an incorrect colour change.

1

repeat the titration

1

calculate the **average** volume of NaOH **or** repeat until concordant results are obtained

1

(ii) **moles of NaOH**

0.10 × 0.0272 = 0.00272 moles

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

1

Concentration of HCl

0.00272 / 0.005 = 0.544

allow ecf from mp1 to mp2

1

correct number of significant figures

1

[14]

Q22.

(a) left hand: (conical) flask

*do **not** accept round bottomed flask or container which is not a flask*

STEMUP.CO.UK

1

right hand: beaker / trough
accept plastic box

1

(b) (i) 157

1

(ii) all calcium carbonate used up **or** reaction stopped
*do **not** accept all acid used up*

1

(c) (i) 0.007(272727…)
*correct answer with or without working gains **2** marks*
*if answer incorrect, allow (0.32 / 44) for **1** mark*

2

(ii) 0.007(272727…)
*allow ecf from **(c)(i)***

1

(iii) (M_r = mass / moles = 1 / 0.00727…) = 137.5 or 138
*allow ecf from **(c)(ii)***
if use 0.00943 moles then = 106
if use 0.007 allow 143 (142.857)

1

(iv) (138) – 60 (= 78)
23 / 85

1

(78 / 2) = 39

1

potassium
sodium / rubidium
*identity of metal ecf on A_r, but **must** be Group 1*
*If no working max **1** mark*

1

(d) (i) (relative atomic mass) would decrease

1

because the mass lost greater

1

so moles carbon dioxide larger **or** moles metal carbonate greater

1

(ii) no change

1

because the acid (already) in excess

1

so the amount carbon dioxide lost is the same

1

STEMUP.CO.UK

[17]

Q23.

(a) (i) precipitation

1

(ii) (aq) on left hand side

1

(s) on right hand side

1

(iii) potassium iodide

1

potassium nitrate

1

(iv) filtration

1

(b) (i) diffusion

1

(ii) iodide ions move / diffuse faster than lead ions **or** travel further in the same time

Must be a comparison

Accept converse

1

because the lead iodide forms much closer to the lead nitrate (or **X**) than the potassium iodide (or **Y**).

allow because iodide ions are smaller than lead ions

allow references to potassium iodide and lead nitrate

1

(iii) the particles / ions move / diffuse faster

ignore which particles / ions the student refers to

1

because they have more energy **or** will collide / meet sooner

ignore reference to frequency of collisions

1

[11]

Q24.

(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

STEMUP.CO.UK

1

(b) (i) increasing the temperature would lower 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 increase 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]

Q25.

(a) (i) brown

1

(ii) oxygen + iron + water $\longrightarrow$ hydrated iron oxide / rust

allow correct symbol equation

ignore oxidation numbers for product

1

(b) (i) 32.3

1

(ii) 7.6

ecf from (b)(i)

1

(iii) do not know start volume of air

1

because the burette not graduated to the end

STEMUP.CO.UK

allow iron wool takes up some of the space

*if no other marks awarded accept all iron may have rusted (**1**) **or** still some oxygen left / not all used up (**1**)*

1

(c) (i) gains oxygen and water **or** oxygen and water are added

allow reacts with or gains oxygen

allow reacts with or gains water

allow reacts with or gains elements which add to mass

ignore iron oxide forms

1

(ii) as temperature increases (from 10 °C to 42 °C or to 50 °C) the increase in mass of nail increases

accept positive correlation

accept mass increases

1

rate of increase gets faster as temperature goes up

accept exponential

ignore non linear

1

no further increase at temperatures over 42 °C

accept no further increase at high temperatures

*exponential increase scores **2** marks*

1

(iii) use a (bigger) flask **or** let air into the tube **or** leave for less time **or**

ignore more water

1

to make sure sufficient oxygen / air **or** not all oxygen used up

accept converse

*if no other marks awarded allow change in surface area for rusting **or** change in number of nails for **1** mark*

1

[12]

Q26.

(a) (i) oxygen, sulfur trioxide

both needed for mark

1

(ii) compound

1

(b) increases

accept (goes) higher / (goes) up / (is) faster) / (are) more frequent

1

(c) activation

1

STEMUP.CO.UK

(d) catalyst **or** increase temperature

1

[5]

Q27.

(a) O_2 in correct space

1

correct balancing

accept multiples

1

(b) (i) rate increases

*incorrect reference to energy = max **2***

ignore references to equilibrium

1

because particles are closer together

accept because there are more particles (per unit volume)

allow particles have less space / room to move around

1

so frequency of collisions increases

accept particles are more likely to collide

ignore more collisions

ignore more successful collisions

1

(ii) has a greater surface area

1

so the reaction is faster

accept so more frequent collisions

1

(c) the (minimum) amount of energy (particles must have) to react ***or** to start a reaction*

accept the energy needed to break bonds

ignore references to heat

1

(d) (i) (potassium is) too / *very* reactive

ignore potassium is a Group 1 / alkali metal

1

so dangerous / *violent reaction*

accept hydrogen produced rapidly

1

(ii) $ZnSO_4$

accept products in either order

ignore names of substances

1

H_2

STEMUP.CO.UK

*do **not** accept brackets or charges in the formulae*

1

(iii) any **one** from:
- increase concentration (of sulfuric acid)
- increase temperature **or** heat it
- increase surface area of zinc

1

[13]

Q28.

(a) time from when the heating is started until

1

the limewater turns cloudy / milky

1

(b) (i) the temperature was not high enough

accept the copper carbonate had not started to decompose / react

accept it takes time to heat up the copper carbonate

1

the bubbles of gas were air

accept no carbon dioxide produced

1

(ii) the copper carbonate was decomposing / reacting

accept the temperature was high enough to cause decomposition / a reaction

1

so carbon dioxide was produced

allow correct word / symbol equation

1

(iii) copper oxide was produced

allow correct word / symbol equation

1

because the copper carbonate had <u>completely</u> decomposed / reacted

ignore all of the carbon dioxide had been given off

1

[8]

Q29.

(a) would melt

accept they have a low melting point

allow lose their shape

ignore would soften when hot

ignore boiling point

1

(b) to speed up the reaction

STEMUP.CO.UK

accept can use a lower temperature
accept less energy needed

1

(c) (i) mass spectrometer
allow mass spectroscopy

1

(ii) any **one** from:
ignore reliable
ignore more precise

- accurate
- sensitive
- rapid / quicker
- small amount of sample

1

(d) any **two** from:
allow concentration

- pressure
- temperature
- catalyst **or** initiator
- solvent

2

[6]

Q30.

(a) because sulfur / S forms

1

which is insoluble / a solid / a precipitate

1

(b) (i) 32
*correct answer with or without working gains **2** marks*
*accept evidence of 31 + 33 / 2 for **1** mark*
*allow 35 for **1** mark*

2

(ii) reaction rate increases
*if incorrect reference to energy = max **2***

1

because of more particles (per unit volume)
allow because particles are closer together

1

and because there is an increase in frequency of collisions

STEMUP.CO.UK

*accept because particles are more likely to collide **or** higher chance of collision*

ignore more (successful) collisions

1

[7]

Q31.

(a) heat / energy

1

given out / transfers to surroundings

the mark for given out / transfers to cannot be awarded without heat / energy

allow given off

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

Q32.

(a) (i) a continuous <u>straight line</u> missing anomalous point

allow a line which does not start at zero / origin

1

(ii) any **two** sensible errors eg

*ignore systematic / zero error / weighing error **or** error unqualified*

- timing errors and / or example
- measurement errors and / or example
- apparatus errors and / or example
- human / experimental / reading / random error and / or example or 'did not do it right'

  *could be two from **same** category*
  eg two timing errors – watch not started at the same time plus difficulty in deciding when the cross has disappeared.
- temperature fluctuation
- anomalous point

  accept outlier / wrong result

STEMUP.CO.UK

- results not recorded correctly
- plotting error
- rate calculated incorrectly

  ignore 'not repeated'

2

(b) (i) straight line

*allow as concentration increases the rate goes up **or** converse*

allow numerical example

allow positive correlation

allow same gradient

ignore 'most points near / on line of best fit'

1

(ii) because of an increase in frequency of collisions

*max **1** if incorrect reference to energy **or** if subatomic particle specified*

accept because particles are more likely to collide or higher chance of collision

ignore more (successful) collisions

1

because there are more particles (per unit volume)

allow because particles are closer together

1

[6]

Q33.

(a) (i) In suntan creams

1

(ii) Much smaller

1

(b) (i) have a high surface area to volume ratio

1

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration at the surface'
ignore absorption

1

(that has) lower activation energy

allow weakens bonds

allow idea of increased successful collisions

*max **1** mark for incorrect chemistry eg increased energy of particles*

1

[5]

STEMUP.CO.UK

Q34.

(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

STEMUP.CO.UK

- 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]

Q35.

(a) (s) (aq) (aq) (g)

must be in this order

***2** marks if all four correct*

***1** mark if 2 or 3 correct*

2

(b) (i) 55

ignore units

1

(ii) 54

*allow ecf from **(b)(i)***

1

(iii) 0.92

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

*ecf from volume in **(b)(i)***

accept 2 d.p. up to calculator value

*if answer incorrect, allow rate = (b)(i) / 60 for **1** mark*

2

(c) (i) circle round point at (48,22)

1

(ii) problem (1) and explanation (1)

*explanation **must** give lower volume of gas or slower reaction*

ignore human error unless qualified

problem with bung

e.g. bung not placed in firmly / quickly enough

STEMUP.CO.UK

so gas lost

or

problem with reagent

e.g. acid was diluted **or** acid not replaced

so reaction slower

or

problem with temperature

e.g. temperature was lower than recorded temperature

so reaction slower

or

problem with measurement

e.g. length of magnesium less than 8 cm **or** timed for less than a minute

so less gas produced

2

(d) repeat the experiment (several times)

1

because anomalous results could be excluded

1

and then the mean can be determined / calculated

*accept suggestion of alteration to method, which is explained as to why it would reduce the error, for **3** marks (e.g. place the magnesium in a container within the flask (1) so it can be tipped into the acid once the bung is in place (1). This will prevent anomalous results or gas loss (1))*

ignore idea of more accurate gas syringe
ignore shorter time intervals

1

(e) (i) use clean magnesium **or** use magnesium without oxide coating

1

compare results

1

(ii) **either**

measure the temperature of the acid before (adding magnesium)

1

and after adding magnesium

or

place the conical flask in a water bath (at 40 °C) (1)

STEMUP.CO.UK

compare results (1)

1

[16]

STEMUP.CO.UK