

## Mark schemes

Q1.

- (a) (equation contains the symbol)  $\rightleftharpoons$   
*allow description of arrow / symbol* 1
- (b) the mass of each substance does not change 1  
 the rates of the forward reaction and reverse reaction are equal 1
- (c) the mixture will have become a paler purple 1
- (d) increases  
*must be in this order* 1  
 decreases 1  
 increases 1
- (e) change the temperature  
 or  
 add a catalyst  
*ignore references to pressure* 1
- [8]

Q2.

- (a) (diagram)  
 gas syringe  
 or  
 inverted measuring cylinder over water 1
- (b) (error)  
 (delivery) tube is in (sulfuric) acid 1  
  
 (problem)  
 (sulfuric) acid will travel up tube  
 or  
 no hydrogen / gas will be collected 1
- (c) line of best fit

*must include 0, 0*

1

(d) (volume of gas =) 45 (cm<sup>3</sup>)

*allow a tolerance of  $\pm \frac{1}{2}$  a small square  
allow volume from drawn curve*

1

(rate =)  $\frac{45}{60}$

*allow correct use of incorrectly  
determined volume at 60 seconds*

1

= 0.75

1

cm<sup>3</sup>/s

1

(e) the line of best fit for higher concentration would have a steeper slope

1

[9]

Q3.

(a) (delivery) tube is in (sulfuric) acid

1

(b) reaction has stopped

*allow no more gas produced*

1

(because a) reactant is used up

*allow named reactants*

1

(c) any one from:

- the line (for 0.05 mol/dm<sup>3</sup> sulfuric acid) is less steep

*allow converse statements about 0.10  
mol/dm<sup>3</sup> sulfuric acid*

*ignore produces less gas*

- (0.05 mol/dm<sup>3</sup> sulfuric acid) produces less gas in a fixed time

*do not accept produces less gas in total*

- the reaction (using 0.05 mol/dm<sup>3</sup> sulfuric acid) takes longer to finish

1

(d) tangent drawn at 80 s on 0.05 mol/dm<sup>3</sup> curve

1

(from tangent)  
value for x-step

and  
value for y-step  
*allow a tolerance of  $\pm \frac{1}{2}$  a small square*

1

(rate =)  $\frac{\text{value for y-step}}{\text{value for x-step}}$   
*allow correct use of incorrectly  
determined values from tangent for  
x-step and/or y-step*

1

calculation of rate

1

answer to 2 significant figures  
*allow an answer correctly calculated to  
2 significant figures from an incorrect  
calculation of rate*

1

(e)  $\text{Cu}^{2+}$

1

[10]

Q4.

(a) measuring cylinder  
*allow pipette / burette*

1

(b) limewater turns milky

1

(c) all six points plotted correctly  
*allow a tolerance of  $\pm \frac{1}{2}$  a small square  
allow 1 mark for four or five points  
plotted correctly*

2

line of best fit

1

(d) (volume =) 48 (cm<sup>3</sup>)

1

(rate=)  $\frac{48}{60}$   
*allow correct use of an incorrectly  
determined value for volume*

1

= 0.8 (cm<sup>3</sup>/s)

1

- (e) (between 0 and 20 seconds) (volume of gas) increases 1  
 (between 80 and 100 seconds) no change (in volume of gas)  
*allow reaction stops* 1
- (f) systematic error 1
- (g) (area of one face =  $2 \times 2 =$ ) 4 (mm<sup>2</sup>) 1  
 (total surface area =)  $4 \times 6$   
*allow correct use of an incorrectly  
 calculated area of one face* 1  
 = 24 (mm<sup>2</sup>) 1
- (h) faster 1
- [15]

Q5.

- (a) HCOOH 1  
*allow HCO<sub>2</sub>H*
- propanoic acid 1
- (b) incomplete / partial ionisation 1  
*allow incomplete / partial dissociation*
- (because) reaction is reversible 1  
*allow (because) reaction is in  
 equilibrium*
- (c) mass (of flask and contents) decreases 1  
 (because) carbon dioxide is produced 1  
 (and) carbon dioxide escapes (from the flask)  
*allow mark for the gas produced  
 escapes (from the flask)* 1
- (d) (0.01 mol/dm<sup>3</sup>) methanoic acid has a lower pH  
*allow converse argument for ethanoic*

*acid*  
*allow (0.01 mol/dm<sup>3</sup>) methanoic acid is*  
*a stronger acid*

1

(so 0.01 mol/dm<sup>3</sup>) methanoic acid has a higher concentration of hydrogen ions

1

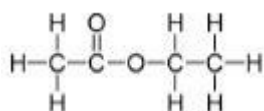
(therefore) more collisions per unit time

1

(e) ethyl ethanoate

1

(f)



1

[12]

Q6.

(a) all seven points plotted correctly

*allow a tolerance of  $\pm\frac{1}{2}$  small square*  
*allow 1 mark for five or six points plotted correctly*

2

line of best fit

1

(b) 0.0038 and 0.0014

1

$$\frac{0.0038 - 0.0014}{105 - 20}$$

*allow correct use of incorrectly determined mole value(s)*

1

$$= 0.000028$$

or

$$= 2.8 \times 10^{-5}$$

1

mol/s

*allow moles per second*

1

(c) (for large lumps) a smaller number of moles of gas is collected in the same time

or

(for large lumps) more time is needed to collect the same number of

moles of gas  
 or  
 the line (of best fit for large lumps) is less steep  
*allow converse statement for small lumps*  
*allow the line (of best fit for large lumps) takes more time to become horizontal*

1

(d) (surface area =  $6 \times 0.5 \times 0.5$ ) = 1.5 (cm<sup>2</sup>)

1

(volume =  $0.5 \times 0.5 \times 0.5$ ) = 0.125 (cm<sup>3</sup>)

1

(surface area : volume =) 12 : 1

*allow correctly calculated ratio using incorrectly calculated values for surface area and/or volume*

1

(e) decreases by a factor of 10

*allow 10 times smaller*

*allow one tenth*

*allow 1/10*

*allow 1 : 10 (large cube to small cube)*

1

[12]

Q7.

(a) a glowing splint

1

(b) student A should measure the mass of manganese dioxide.

1

(c) calculate a mean but do not include any anomalous results.

1

(d)

*an answer of 0.173 (cm<sup>3</sup>/s) scores 4 marks*

(volume of oxygen formed =)

(58 - 20 =) 38 (cm<sup>3</sup>)

*allow values between 36 (cm<sup>3</sup>) and 40 (cm<sup>3</sup>) inclusive*

1

(time taken = 250 - 30 =) 220 (s)

1

$\frac{38}{220}$  or 0.1727 (cm<sup>3</sup>/s)

*allow a correct calculation using an incorrectly determined value for volume and / or time*

1

= 0.173 (cm<sup>3</sup>/s)

*allow a correctly calculated answer given to 3 significant figures from an incorrect attempt at the rate equation*

1

(e) line starts at the origin and steeper than existing line

1

final volume same as existing line

*allow a tolerance of  $\pm \frac{1}{2}$  a small square*

1

(f) fine manganese dioxide powder has a larger surface area

1

[10]

Q8.

(a) (aq)

*allow aqueous / aq*

1

(b) (gas) syringe

*allow measuring cylinder (and water trough)  
allow balance*

1

stopclock / stopwatch

*allow timer / clock / watch*

1

(c) all points plotted correctly

*allow a tolerance of  $\pm \frac{1}{2}$  a small square  
allow at least 3 points plotted correctly for 1 mark.*

2

line of best fit

*allow correctly drawn line of best fit for incorrectly plotted points*

1

(d) (rate) decreases

*allow slows down*

1

(rate decreases) more slowly as time increases

*allow (rate decreases) at a non-linear rate*

- 1
- (rate) becomes zero at 60 s  
*allow the reaction stops at 60 s*  
*allow ecf from part (c)*
- 1
- (e) more bubbles were produced in the first 10 seconds
- 1
- the magnesium was used up more quickly
- 1
- [11]

Q9.

- (a) glowing splint  
*do not accept burning splint*
- 1
- (which) relights  
*dependent on correct test in MP1*  
*ignore with a pop*
- 1
- (b) place the conical flask in a water bath at constant temperature.
- 1
- use a mass of 1 g manganese dioxide each time.
- 1
- (c)
- an answer of 0.092 (cm<sup>3</sup>/s) scores 3 marks*  
*allow an answer of 0.091666 (cm<sup>3</sup>/s) correctly rounded to at least 2 significant figures for 2 marks*  
*allow an answer of 0.033 (cm<sup>3</sup>/s) for 2 marks*  
*allow an answer of 0.033333 (cm<sup>3</sup>/s) for 1 mark*

11 (cm<sup>3</sup>) and 120 (seconds)

1

(mean rate of reaction =  $\frac{11}{120}$  )  
 = 0.09167

*allow a correct calculation using incorrectly determined value(s) for difference in volume and / or time*

1

= 0.092 (cm<sup>3</sup>/s)

*allow a correctly calculated answer given to 2 significant figures from an*



- incorrect attempt at the rate equation* 1
- (d) line starts at origin and less steep than solid line 1
- line levelling off at 40 (cm<sup>3</sup>)  
allow a tolerance of  $\pm \frac{1}{2}$  a small square 1
- (e) (because) surface area (of fine manganese dioxide powder) greater  
allow converse for coarse lumps 1
- (so) more collisions (with hydrogen peroxide molecules / particles)  
per unit time
- do not accept references to changes in  
kinetic energy or speed (of molecules /  
particles)  
ignore references to activation energy.* 1
- [11]

Q10.

- (a) 83 (cm<sup>3</sup>)  
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<sup>3</sup>) for 1 mark 1
- = 47 (cm<sup>3</sup>) (2 sf)  
an answer of 43 (cm<sup>3</sup>) scores 1 mark 1  
an answer of 47 (cm<sup>3</sup>) scores 2 marks
- (d) all points plotted correctly  
(inc 0,0)  
allow a tolerance of  $\pm \frac{1}{2}$  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<sup>3</sup>/s)  
*allow 1.60 ± 0.04* 1  
*an answer of 1.6 (cm<sup>3</sup>/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  
 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<sub>2</sub>* 1  
 pop sound 1
- [17]

Q11.

- (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]

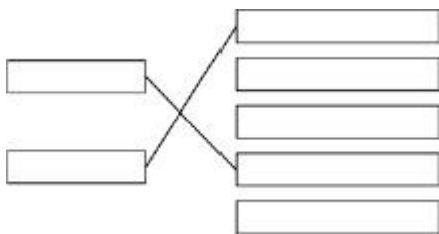
Q12.

(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
- there are more particles in a fixed volume
- 1
- [11]
- Q13.
- (a) cotton wool
- 1
- (b) all points correct  
 $\pm \frac{1}{2}$  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
- allow for 1 mark collected gas*
- or counted bubbles*
- (g) The particles have more energy
- 1
- The particles move faster
- 1
- [14]

Q14.

- (a)  $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
- 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
- $\frac{2.2}{270} = 0.00814814$   
*allow ecf for values given for mass and time* 1
- 0.00815 (g / s)  
 or
- $8.15 \times 10^{-3}$   
*allow 1 mark for correct calculation of value to 3 sig  
 figs*  
*accept 0.00815 or  $8.15 \times 10^{-3}$  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
- $7 \times 10^{-3}$  1  
*accept  $7 \times 10^{-3}$  with no working shown for 4 marks*
- [20]
- Q15.
- (a) sulfur dioxide  
*accept SO<sub>2</sub>* 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 1
- [8]

Q16.

- (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
- allow converse*
- (h) 120 (s) 1
- 0.18 / 120  
*allow 0.0015* 1
- =  $1.5 \times 10^{-3}$  (g / s)  
*an answer of  $9 \times 10^{-2}$  scores 2 marks*  
*allow an answer of 0.09 for 1 mark*  
*an answer of  $1.5 \times 10^{-3}$  (g / s) scores 3 marks* 1

[16]