Rates of reaction

Worked solutions

GCSE science calculations

This topic online

1 Olu adds zinc to dilute sulfuric acid. He collects 45 cm^3 of hydrogen in 30 s.

Calculate the mean rate of reaction. (2 marks)

Mean rate = quantity of product ÷ time

rate = 45 ÷ 30

1.5 cm^3/s

2 Marble chips react with hydrochloric acid in a flask on a balance. Carbon dioxide escapes and the mass goes down by 0.84 g in 120 s.

Calculate the mean rate of reaction in g/s. (2 marks)

Mean rate = mass lost ÷ time

rate = 0.84 ÷ 120

0.007 g/s

3 Freya reacts magnesium ribbon with hydrochloric acid and collects the hydrogen in a gas syringe.

Time in s	0	10	20	30	40	50
Volume of hydrogen in cm^3	0	18	32	42	48	50

Calculate the mean rate of reaction during the first 20 s. (2 marks)

Read the volume at 20 s, not the final 50 cm^3

volume at 20 s = 32 cm^3

Mean rate = quantity of product ÷ time

rate = 32 ÷ 20

1.6 cm^3/s

4 A catalyst is added to hydrogen peroxide solution. 96 cm^3 of oxygen is collected in 2 minutes 30 seconds.

Calculate the mean rate of reaction in cm^3/s. (3 marks)

Change the time to seconds

t = (2 x 60) + 30 = 150 s

Mean rate = quantity of product ÷ time

rate = 96 ÷ 150

0.64 cm^3/s

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5 In a water treatment works, a test reaction gives off 0.12 dm^3 of gas in 40 s.

1 dm^3 = 1000 cm^3

Calculate the mean rate of reaction in cm^3/s. (3 marks)

1 dm^3 = 1000 cm^3

0.12 dm^3 = 0.12 × 1000 = 120 cm^3

Mean rate = quantity of product ÷ time

rate = 120 ÷ 40

3 cm^3/s

6 Kieran puts a flask of acid and calcium carbonate on a balance.

- Reading at the start = 152.40 g
- Reading after 4.0 minutes = 148.80 g

Calculate the mean rate of reaction over the 4.0 minutes in g/s. (3 marks)

Use the mass lost, not a balance reading

mass lost = 152.40 − 148.80 = 3.60 g

Change the time to seconds

t = 4.0 × 60 = 240 s

Mean rate = mass lost ÷ time

rate = 3.60 ÷ 240

0.015 g/s

7 A reaction makes carbon dioxide at a mean rate of 2.5 cm^3/s.

Calculate how long it takes to make 80 cm^3 of carbon dioxide. (2 marks)

Mean rate = quantity of product ÷ time

2.5 = 80 ÷ t

Rearrange: time = quantity ÷ rate

t = 80 ÷ 2.5

32 s

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8 A tablet fizzes in a glass of water. Its mass goes down at a mean rate of 0.025 g/s for 3.0 minutes.
Calculate the total mass lost in this time. (3 marks)

The rate is per second, so change minutes to seconds

$t = 3.0 \times 60 = 180$ s

Mean rate = mass lost ÷ time, so mass lost = rate × time

mass lost = 0.025×180

4.5 g

9 Zainab repeats an experiment three times at 20 °C. Each time she measures the volume of gas made in the first 60 s.

Repeat	1	2	3
Volume of gas in cm^3	54	57	51

a. Calculate the mean rate of reaction over the first 60 s at 20 °C, using the mean volume.

b. At 40 °C the mean volume made in the first 60 s is 81 cm^3. How many times faster is the mean rate at 40 °C than at 20 °C? (4 marks)

a)

Find the mean volume (not the total)

$$\text{mean} = \frac{54 + 57 + 51}{3}$$

$$\text{mean} = \frac{162}{3} = 54 \text{ cm}^3$$

Mean rate = quantity of product ÷ time

rate = $54 \div 60$

0.9 cm^3/s

b)

rate at 40 °C = $81 \div 60 = 1.35$ cm^3/s

$$\frac{1.35}{0.9} = 1.5$$

1.5 times faster

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10 **Higher tier**

Daniel plots a graph of volume of gas against time. At 25 s the curve passes through the point (25 s, 40 cm^3).

He draws a tangent to the curve at 25 s. The tangent passes through these two points:

- (10 s, 13 cm^3)
- (40 s, 67 cm^3)

Calculate the rate of reaction at 25 s. Show your working. (3 marks)

Rate at an instant = gradient of the tangent (not 40 ÷ 25)

change in volume = 67 − 13 = 54 cm^3

change in time = 40 − 10 = 30 s

$$\text{gradient} = \frac{54}{30}$$

1.8 cm^3/s

11 **Higher tier**

In a reaction, 1.76 g of carbon dioxide is given off in 80 s.

Relative atomic masses (A_r): C = 12, O = 16

Calculate the mean rate of reaction in mol/s. Give your answer in standard form. Show your working. (4 marks)

Mr of CO_2 = 12 + (2 × 16) = 44

Moles = mass ÷ Mr

moles = 1.76 ÷ 44 = 0.04 mol

Mean rate = quantity of product ÷ time

rate = 0.04 ÷ 80 = 0.0005 mol/s

5 × 10^{-4} mol/s

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12 **Higher tier**

Leah plots the mass of carbon dioxide given off against time in minutes. She draws a tangent to the curve at 2.0 minutes. The tangent passes through these two points:

- (1.0 minutes, 0.62 g)
- (3.0 minutes, 1.10 g)

Relative atomic masses (A_r): C = 12, O = 16

a. Calculate the rate of reaction at 2.0 minutes in g/s.

b. Calculate the rate of reaction at 2.0 minutes in mol/s. Give your answer in standard form to 2 significant figures. Show your working.

(5 marks)

a)

Rate at an instant = gradient of the tangent

change in mass = 1.10 - 0.62 = 0.48 g

change in time = 3.0 - 1.0 = 2.0 minutes

Change minutes to seconds

2.0 minutes = 2.0 x 60 = 120 s

$$\text{gradient} = \frac{0.48}{120}$$

0.004 g/s

b)

Mr of CO_2 = 12 + (2 x 16) = 44

Moles = mass ÷ Mr, so mol/s = g/s ÷ Mr

rate = 0.004 ÷ 44

rate = 0.0000909... mol/s

9.1×10^{-5} mol/s

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