2.10 Rates of Reaction: Collision Theory and Measuring Rate: 30-minute Pack

Total Marks

EDEXCEL 4CH1 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A student measures gas volume from a reaction and obtains a straight-line section on the volume-time graph between 40 s and 70 s. The volume at 40 s is 36.0 cm^3 and at 70 s is 63.0 cm^3. Calculate the rate during this section in cm3 s^{-1} and give the unit in final answer.

(Total for Question 1 is 2 marks)

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2 Sketch and describe the expected shape of a graph showing mass of flask plus contents against time for the marble chips and dilute acid experiment, starting at time zero when acid is added.

(Total for Question 2 is 3 marks)

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3 Data from a loss of mass experiment are: time 0 s: mass 52.00 g; 30 s: 51.60 g; 60 s: 51.35 g. Calculate the mean rate of mass loss between 0 s and 60 s in grams per second. Show working and give answer to 3 significant figures.

(Total for Question 3 is 3 marks)

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4 A student records the volume of gas produced every 15 seconds and plots a volume-time graph. Explain how the initial rate of reaction is determined from the graph and what it represents physically.

(Total for Question 4 is 2 marks)

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5 Predict qualitatively how reducing the particle size of a solid reactant, while keeping its mass constant, will change the initial rate measured by loss of mass in the marble chips experiment, and explain why.

(Total for Question 5 is 2 marks)

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6 Explain how increasing the temperature from 20°C to 50°C increases reaction rate in terms of both collision frequency and collision energy.

(Total for Question 6 is 2 marks)

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7 A student investigates the reaction of marble chips (calcium carbonate) with dilute hydrochloric acid and measures the loss of mass every 30 seconds using a balance. Describe three control variables the student should keep constant to make the test fair, and explain why each must be controlled.

(Total for Question 7 is 3 marks)

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8 In the disappearing cross experiment, sodium thiosulfate reacts with hydrochloric acid to produce a cloudy mixture. Explain how the time taken for the cross to disappear depends on particle collisions, and suggest one way to make the reaction faster.

(Total for Question 8 is 3 marks)

9 A student measures the volume of hydrogen gas produced when 0.50 g magnesium reacts with excess dilute hydrochloric acid. The readings are: 0 s: 0.0 cm^3, 10 s: 12.0 cm^3, 20 s: 20.0 cm^3, 30 s: 24.0 cm^3. Calculate the mean rate of gas production between 10 s and 30 s in cm3 per second. Show working.

(Total for Question 9 is 3 marks)

10 Explain how a catalyst increases the rate of a reaction, using collision theory language but do not draw an energy profile diagram.

(Total for Question 10 is 4 marks)

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Mark scheme · 2.10 Rates of Reaction: Collision Theory and Measuring Rate: 30-minute Pack

Question 1

calculates change in volume 63.0 - 36.0 = 27.0 cm^3 and change in time 30 s — **M1**

gives rate = 0.90 cm^3 s^{-1} cao with unit — **A1**

Answer: Rate = 27.0 cm^3 / 30 s = 0.90 cm^3 s^{-1}

Question 2

sketch: steep initial downward slope that becomes less steep and levels off towards a horizontal line — **B1**

description: mass decreases over time as CO_2 gas is lost, rate is fastest at the start and slows as reactants are used up — **B1**

explain leveling: graph levels off when reaction is nearly complete and mass stops changing — **B1**

Answer: Graph: mass falls quickly at first (steep negative slope) then the slope becomes less steep and the curve levels off to horizontal as reaction finishes

Question 3

calculates change in mass: 52.00 - 51.35 = 0.65 g — **M1**

divides by time interval 60 s to find rate — **M1**

gives mean rate = 0.0108 g s^{-1} cao to 3 s.f. as 0.0108 g s^{-1} — **A1**

Answer: Mean rate = 0.65 g / 60 s = 0.0108 g s^{-1} (3 s.f.)

Question 4

initial rate found by drawing a tangent at time zero and finding its gradient (change in volume / change in time) — **B1**

physically represents the rate when reactant concentrations are at their initial values, the fastest rate — **B1**

Answer: Draw a tangent at t = 0 and calculate its gradient (delta volume / delta time); it represents how fast gas is produced at the start when reactant concentrations are highest

Question 5

prediction: initial rate will increase — **B1**

explanation: smaller particles give larger total surface area so more frequent collisions at the surface — **B1**

Answer: Initial rate increases because smaller particles give a larger surface area for the same mass, increasing collision frequency with acid

Question 6

higher temperature gives particles more kinetic energy so they move faster and collide more often — **B1**

higher energy means a larger proportion of collisions have energy ≥ activation energy, so more successful collisions — **B1**

Answer: Raising temperature increases particle speed so collisions are more frequent, and increases collision energy so a greater fraction exceed the activation energy, raising the rate

Question 7

control the mass or surface area of marble chips, to ensure the amount of reactive solid is the same — **B1**

control concentration and volume of acid, to ensure the number of acid particles available is the same — **B1**

control temperature, to prevent temperature changes affecting collision frequency and energy — **B1**

Answer: Keep marble chip mass or particle size constant so the amount of solid is the same; keep acid concentration and volume constant so reactant quantity is constant; keep temperature constant so collision energy is unchanged

Question 8

disappearance time depends on rate at which reactant particles collide to form cloudy product so more frequent successful collisions give faster clouding — **B1**

suggestion: increase temperature or increase concentration or use smaller particle size if solids present — **B1**

link: increasing temperature or concentration raises collision frequency and energy so time is reduced — **B1**

Answer: The cross disappears faster when particles collide more often or with more energy; increasing temperature or concentration will increase collision frequency and energy and so speed the reaction

Question 9

calculates change in volume: 24.0 - 12.0 = 12.0 cm^3 — **M1**

divides by time interval 20 s to find rate — **M1**

gives mean rate = 0.60 cm^3 s^{-1} cao with units — **A1**

Answer: Mean rate = 12.0 cm^3 / 20 s = 0.60 cm^3 s^{-1}

Question 10

states that a catalyst provides an alternative reaction pathway — **B1**

states that the alternative pathway has a lower activation energy so more collisions are successful — **B1**

links to collision theory: with lower activation energy a larger proportion of collisions have sufficient energy to react — **B1**

may state that the catalyst is not used up at the end of the reaction — **B1**

Answer: A catalyst provides an alternative pathway with lower activation energy so a larger fraction of collisions are successful, increasing the rate; the catalyst is not consumed

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