C6aD Rates of Reaction: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Define the term 'rate of reaction' as used in chemistry.

(Total for Question 1 is 1 mark)

2 State two ways, other than changing the concentration, that the rate of a chemical reaction can be increased.

(Total for Question 2 is 2 marks)

3 Collision theory explains why temperature affects reaction rate. Give the two key ideas of collision theory needed to explain this effect.

(Total for Question 3 is 2 marks)

4 In the required practical for investigating how concentration affects rate, a student measures the time for a mark to disappear when sodium thiosulfate reacts with dilute hydrochloric acid. Name one control variable that must be kept constant and state why it must be controlled.

(Total for Question 4 is 3 marks)

5 A student mixes 25.0 cm3 of 0.200 mol/dm3 hydrochloric acid with magnesium ribbon. Use the idea of moles to calculate how many mol of HCl are present in the 25.0 cm3 sample. Show your working.

(Total for Question 5 is 3 marks)

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6 Hydrogen peroxide decomposes to oxygen and water. The table shows initial rates measured at two temperatures using a catalyst.

Temperature / degrees C: 25, initial rate = 0.012 mol/s
Temperature / degrees C: 45, initial rate = 0.048 mol/s

Calculate the factor by which the rate increases when temperature increases from 25 degrees C to 45 degrees C. Show your working.

(Total for Question 6 is 3 marks)

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7 A student investigates the effect of surface area on the rate of reaction between marble chips (calcium carbonate) and 1.0 mol/dm3 hydrochloric acid. The student uses large chips in Trial 1 and powdered marble in Trial 2, keeping acid volume, concentration and temperature constant. Predict and explain the difference in the rate of gas formation between Trial 1 and Trial 2.

(Total for Question 7 is 4 marks)

8 Explain briefly how a catalyst increases the rate of a reaction, using collision theory and activation energy in your answer.

(Total for Question 8 is 3 marks)

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9 A student plots a graph of volume of gas against time for the reaction between marble chips and excess dilute hydrochloric acid. The curve is steepest at the start and becomes less steep as the reaction proceeds. Explain how the student could find the rate of reaction at 20 seconds (rather than the mean rate for the whole reaction) using the graph.

(Total for Question 9 is 3 marks)

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10 The initial rate of a reaction is measured as 0.020 mol/dm3 s. After 30 s the concentration of product is 0.60 mol/dm3. Using initial rate as an approximation, estimate the concentration of product after 60 s. Show your working.

(Total for Question 10 is 2 marks)

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11 A student measures the volume of gas produced from marble and acid over time. Their table of results for one run is:

Time / s: 0, 10, 20, 30, 40
Volume / cm3: 0, 16, 28, 34, 37

Using the data, calculate the initial rate of reaction in cm3/s by using the gradient from 0 to 10 s. Show working and give a unit.

(Total for Question 11 is 4 marks)

12 Explain how you would alter the method for the sodium thiosulfate required practical to reduce random error in timing when measuring the time for the cross to disappear.

(Total for Question 12 is 4 marks)

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13 A student compares two methods for measuring the rate of reaction between excess marble chips and dilute hydrochloric acid, which produces carbon dioxide gas: Method A, measuring the loss in mass of the flask and its contents on a balance; Method B, collecting the gas in a gas syringe. The student's mass-loss results for Method A are shown below.

Time / s: 0, 20, 40, 60, 80, 100
Mass loss / g: 0.00, 0.28, 0.48, 0.60, 0.66, 0.68

Calculate the mean rate of reaction, in g/s, between 0 and 60 s, showing your working. Then evaluate which of the two methods (A or B) is likely to give the more precise results, and explain one limitation of Method A.

(Total for Question 13 is 6 marks)

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14 A catalysed decomposition of X has activation energy of 45 kJ/mol, and the uncatalysed reaction has activation energy of 110 kJ/mol. Explain, using an energy profile diagram description, why the catalysed reaction is faster and state one limitation of catalysts in reversible reactions.

(Total for Question 14 is 4 marks)

15 The table shows the concentration of hydrochloric acid used and the time taken for a fixed volume of gas (10 cm3) to be collected when the acid reacts with excess magnesium ribbon.

Concentration / mol/dm3: 0.50, time taken / s: 40
Concentration / mol/dm3: 1.00, time taken / s: 20
Concentration / mol/dm3: 2.00, time taken / s: 10

Describe the relationship between concentration and rate shown by this data, then explain, using collision theory, why increasing the concentration of hydrochloric acid increases the rate of reaction.

(Total for Question 15 is 4 marks)

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16 A student plots concentration against time and obtains a curve that levels off as time increases. What does the curve indicate about the reaction progress and why does the curve level off?

(Total for Question 16 is 2 marks)

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17 A student reports that doubling temperature always doubles reaction rate. State why this statement is incorrect, using activation energy and Boltzmann distribution in your answer.

(Total for Question 17 is 2 marks)

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18 Give one experimental source of systematic error when measuring gas volume in a reaction and suggest a practical way to reduce it.

(Total for Question 18 is 1 mark)

Mark scheme · C6aD Rates of Reaction: Exam Drill

Question 1

- **B1** the change in amount of reactant or product per unit time, oe
- **Answer: Change in amount of reactant or product per unit time.**

Question 2

- **B1** increase the temperature, oe
- **B1** use a catalyst or increase surface area, or increase pressure for gases, any two distinct answers allowed
- **Answer: Increase the temperature; use a catalyst. (Other valid answers: increase surface area, increase pressure for gases.)**

Question 3

- **B1** particles must collide for a reaction to occur, oe
- **B1** higher temperature increases frequency of collisions and proportion of collisions with energy greater than the activation energy, oe
- **Answer: Particles must collide; higher temperature increases collision frequency and the proportion with enough energy to react.**

Question 4

- **B1** temperature
- **B1** because temperature affects rate so differences would change the time measured, oe
- **B1** or: volume of reactants or total volume, because changing volumes changes collision frequency and concentrations, oe
- **Answer: Temperature; it must be kept constant because temperature changes the rate of reaction.**

Question 5

- **M1** uses formula: moles = concentration x volume (in dm3) and substitutes: 0.200 x 0.025
- **A1** 0.00500 mol cao
- **B1** explicitly shows unit mol or states 'mol' with the numerical answer
- **Answer: 0.00500 mol**

Question 6

- **M1** divides rates: 0.048 / 0.012
- **A1** 4.0 cao
- **B1** answer given as '4 times' or factor 4 with unitless statement
- **Answer: 4.0**

Question 7

- **B1** prediction that Trial 2 (powder) will have a faster rate or produce gas faster
- **B1** state that powdered marble has greater surface area so more particles are exposed, oe
- **B1** therefore more frequent collisions per unit time between acid and carbonate particles, oe
- **B1** conclusion linking increased collision frequency to increased rate of gas formation, oe
- **Answer: The powdered marble (Trial 2) will produce gas faster because it has a larger surface area, giving more exposed particles and more frequent collisions so the reaction rate is higher.**

Question 8

- **B1** a catalyst provides an alternative reaction pathway, oe
- **B1** this alternative pathway has a lower activation energy, oe
- **B1** so a greater proportion of collisions have enough energy to react, increasing rate, oe
- **Answer: A catalyst provides an alternative pathway with lower activation energy, so a greater proportion of collisions have enough energy to react and the rate increases.**

Question 9

- **B1** draw a tangent to the curve at the point where time = 20 s
- **B1** calculate the gradient of the tangent by dividing the change in volume by the change in time (rise / run)
- **B1** the gradient of the tangent gives the rate of reaction (in cm3/s) at that instant, not the mean rate, oe
- **Answer: Draw a tangent to the curve at t = 20 s, then calculate its gradient (change in volume / change in time); this gradient gives the instantaneous rate of reaction in cm3/s at 20 s.**

Question 10

- **M1** uses rate x time to find increase in concentration for next 30 s: 0.020 x 30 = 0.60
- **A1** 1.20 mol/dm3 cao
- **Answer: 1.20 mol/dm3**

Question 11

- **M1** uses gradient = change in volume / change in time with numbers: (16 - 0) / (10 - 0)
- **A1** 1.6 cm3/s cao
- **B1** states unit cm3/s with the numerical answer
- **B1** accepts sensible rounding to 2 significant figures if shown
- **Answer: 1.6 cm3/s**

Question 12

- **B1** use multiple repeats and take the mean
- **B1** use a more precise timing method such as a video recording or a light sensor and timer
- **B1** use a consistent volume and mixing method and start timing at a defined point (e.g. when reactants are fully mixed), oe
- **B1** explain that these reduce random error by averaging out variability and improving timing resolution, oe
- **Answer: Repeat each measurement and take an average; use a more precise timing method such as video or a light sensor; ensure consistent mixing and start timing at a defined moment to reduce random error.**

Question 13

- **Level 3** (5-6): Correct calculation of the mean rate with correct units and a clear, justified evaluation of both methods, including a valid limitation of Method A and sound reasoning for which method is more precise.
- **Level 2** (3-4): Correct or nearly correct calculation of the mean rate, with some evaluation of the two methods but with limited justification or one omission.
- **Level 1** (1-2): Attempts the calculation with errors, or gives an unsupported statement about which method is better without valid reasoning.
- **Indicative content:**
  - Mean rate between 0 and 60 s = change in mass / change in time = 0.60 / 60 = 0.010 g/s (accept 0.01 g/s).
  - Method B (gas syringe) is likely to give the more precise results because it measures the volume of gas produced directly, and is not affected by loss of water vapour or acid spray as gas escapes.
  - One limitation of Method A: some of the mass lost may be due to evaporation of water or acid spray carried out with the gas, not only carbon dioxide escaping, which can make the measured rate appear larger than the true rate.
  - A further limitation of Method A: if the total mass loss is small, the balance may not measure the change precisely, whereas a gas syringe can measure small gas volumes accurately.
  - A valid conclusion justifies the choice of method using precision or accuracy of measurement, not simply personal preference.

Question 14

- **B1** states that energy profile for catalysed reaction has a lower peak / lower activation energy (45 kJ/mol) than uncatalysed (110 kJ/mol)
- **B1** states that lower activation energy means more particles have enough energy to overcome the barrier so rate increases, oe
- **B1** describes that the overall energy change (delta H) is unchanged between catalysed and uncatalysed reactions, oe
- **B1** limitation: catalysts do not change equilibrium position or yield; they only speed up forward and reverse equally, or catalysts can be poisoned or deactivated, oe
- **Answer: The catalysed pathway has a much lower activation energy peak (45 kJ/mol) than the uncatalysed route (110 kJ/mol), so more particles have enough energy to react and the rate is faster; the overall delta H is unchanged. Limitation: catalysts do not change the equilibrium position or final yield and can be poisoned or deactivated.**

Question 15

- **B1** as concentration doubles, the time taken halves, oe
- **B1** so the rate of reaction doubles each time the concentration doubles, i.e. rate is directly proportional to concentration, oe
- **B1** increasing concentration increases the number of acid particles in a given volume
- **B1** this increases the frequency of collisions between acid and magnesium particles per unit time, increasing the rate of reaction, oe
- **Answer: As concentration doubles, the time taken halves, so the rate doubles (rate is directly proportional to concentration). This is because a higher concentration means more acid particles in a given volume, increasing the frequency of collisions with the magnesium and so increasing the rate of reaction.**

Question 16

- **B1** curve shows concentration of reactant/product changing over time and approaching completion or equilibrium
- **B1** levels off because reactant is used up or the reaction reaches equilibrium so net change is zero, oe
- **Answer: The reaction progresses and approaches completion; the curve levels off because reactant is used up or the system reaches equilibrium so there is no further net change in concentration.**

Question 17

- **B1** temperature effect on rate is not linear; depends on activation energy and how the Boltzmann distribution shifts
- **B1** raising temperature increases fraction of particles above activation energy, but factor depends on Ea and temperature change, not simply doubling
- **Answer: Incorrect because increasing temperature changes the fraction of particles with energy above the activation energy according to the Boltzmann distribution; the change in rate depends on Ea and temperature change, not a simple doubling.**

Question 18

- **B1** example: gas loss due to leaks in apparatus; reduce by sealing joints with rubber tubing or using a gas syringe with no leaks, oe
- **Answer: Leakage from apparatus; fix by sealing joints or using a properly fitted gas syringe to prevent gas loss.**