C6F Rate and Extent of Chemical Change: Foundation Tier Practice

Total Marks

AQA 8462 · Calculator allowed · about 75 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Collision theory explains how chemical reactions occur between particles.

(a) Give one requirement for a collision between reactant particles to lead to a reaction. **(1)**

(b) Give a second factor that increases the rate of collisions between particles in a gas or solution. **(1)**

(Total for Question 1 is 2 marks)

---

2 A student measures how fast magnesium ribbon reacts with dilute hydrochloric acid. Each test uses the same length of ribbon but different acid concentrations.

(a) State one practical way to increase the rate of this reaction other than changing concentration. **(1)**

(b) State one hazard the student should consider when carrying out this reaction and give one safety precaution. **(1)**

(Total for Question 2 is 2 marks)

---

3 Catalysts increase reaction rates without being used up.

(a) Explain how a catalyst increases the rate of a reaction. **(3)**

(Total for Question 3 is 3 marks)

4 Concentration affects the rate of reaction in solutions.

(a) A student dissolves 0.10 mol of sodium thiosulfate in 0.50 litres of water. Calculate the concentration in mol per litre (molarity). **(2)**

.....

(b) State how increasing the concentration would affect the rate of the reaction and why, in one sentence. **(1)**

(Total for Question 4 is 3 marks)

---

5 Surface area can affect rates when one reactant is a solid.

(a) Mixing powdered calcium carbonate reacts faster with acid than mixing whole marble chips. Give one reason why. **(1)**

(b) A student compares 10 g of marble chips with 10 g of powdered carbonate. Which will react faster and why? One sentence. **(2)**

(Total for Question 5 is 3 marks)

---

6 A student times how long it takes for a cross marked under a solution of sodium thiosulfate and acid to disappear as a measure of rate. Trials give times in seconds: 75 s, 60 s, 45 s.

(a) Calculate the mean time from the three trials. **(2)**

.....

(b) State one reason for repeating experiments and using a mean time. **(1)**

(Total for Question 6 is 3 marks)

7 Rate of reaction may be measured by volume of gas produced.

(a) A reaction produces 48 cm3 of gas in 2 minutes. Calculate the average rate in cm3 per minute. **(2)**

.....

(Total for Question 7 is 2 marks)

---

8 During a reaction the initial rate is faster than later because reactant concentration falls.

(a) Explain why the rate of a reaction decreases as the reaction proceeds in terms of collisions. **(3)**

(Total for Question 8 is 3 marks)

---

9 A reversible reaction can reach dynamic equilibrium in a closed container.

(a) State what is meant by dynamic equilibrium in a closed system. **(1)**

(b) Name one condition that is necessary for dynamic equilibrium to be established. **(1)**

(Total for Question 9 is 2 marks)

---

10 Le Chatelier's principle describes how an equilibrium responds to a change.

(a) Predict what happens to the position of equilibrium if the concentration of a reactant is increased. **(1)**

(b) Predict qualitatively what happens to the amount of product if the pressure is increased for a reaction where there are more gas molecules on the reactant side than the product side. **(1)**

(Total for Question 10 is 2 marks)

11 A reversible reaction: A(g) + B(g) <-> C(g). In an experiment at equilibrium there are 0.20 mol of A in 1.0 litre, 0.30 mol of B in 1.0 litre and 0.10 mol of C in 1.0 litre. Calculate the value of the equilibrium constant Kc given by Kc = [C] / ([A][B]).

(a) Calculate Kc for the reaction using the concentrations given. **(3)**

.....

(Total for Question 11 is 3 marks)

---

12 An experiment studies the effect of temperature on an equilibrium. The student increases the temperature and observes less product formed. State what this suggests about the reaction enthalpy.

(a) State whether the forward reaction is exothermic or endothermic and explain why the amount of product decreased when temperature increased. **(3)**

(Total for Question 12 is 3 marks)

---

13 Preparation of ammonia by Haber process is a reversible reaction: N2(g) + 3H2(g) <-> 2NH3(g). This is an industrial example of controlling equilibrium.

(a) State one change (temperature, pressure or concentration) that is used industrially to increase yield of ammonia and state the direction the equilibrium shifts. **(2)**

(Total for Question 13 is 2 marks)

---

14 A student follows a practical method to investigate the effect of concentration on rate by measuring how long it takes for effervescence to start when magnesium reacts with acid. Suggest one improvement to make the timing more accurate.

(a) Suggest one improvement to reduce random timing error and explain briefly how it helps. **(2)**

(Total for Question 14 is 2 marks)

15 Extended answer. A student investigates the reversible reaction: P(g) + Q(g) <-> R(g) + S(g) in a closed container. They carry out two changes separately: (1) increase temperature, (2) remove some R and S from the container. Explain how each change affects the position of equilibrium and the rate of forward and backward reactions. Your answer should use Le Chatelier's principle and refer to rates.

(Total for Question 15 is 6 marks)

---

16 A student uses 25.0 cm3 of 0.10 mol l-1 hydrochloric acid to react with excess magnesium. Calculate the number of moles of HCl used. (Use volume in litres.)

(a) Convert the volume 25.0 cm3 to litres and show the calculation for moles of HCl. **(3)**

.....

(Total for Question 16 is 3 marks)

Mark scheme · C6F Rate and Extent of Chemical Change: Foundation Tier Practice

Question 1

- (a) **B1** particles must collide with sufficient energy (to overcome activation energy) or equivalent
- **(a) Answer: Particles must collide with sufficient energy.**
- (b) **B1** increase in concentration or increase in temperature or increase in pressure (for gases) or increase in surface area for solids, oe
- **(b) Answer: Increase the concentration (or temperature, pressure for gases, or surface area).**

Question 2

- (a) **B1** increase the temperature of the acid or use powdered magnesium (increase surface area) or use thinner ribbon, oe
- **(a) Answer: Increase the temperature of the acid.**
- (b) **B1** hazard: acid splashes or hydrogen gas produced; precaution: wear goggles and use small amounts of acid or work in a fume hood/keep away from flames, oe
- **(b) Answer: Hazard: acid may splash. Precaution: wear safety goggles and use small volumes of acid.**

Question 3

- (a) **M1** states that a catalyst provides an alternative reaction pathway with lower activation energy or equivalent
- (a) **A1** states that more collisions have enough energy to react, increasing the rate, oe
- (a) **A1** mentions that the catalyst is not used up at the end of the reaction, oe
- **(a) Answer: A catalyst provides an alternative pathway with lower activation energy so more collisions have enough energy to react, increasing the rate; the catalyst is not used up.**

Question 4

- (a) **M1** substitutes: concentration = moles / volume = 0.10 / 0.50
- (a) **A1** 0.20 mol per litre (0.20 mol l-1) cao
- **(a) Answer: 0.20 mol l-1**
- (b) **B1** rate increases because there are more particles per unit volume so more frequent collisions, oe
- **(b) Answer: Rate increases because there are more particles in the same volume so collisions are more frequent.**

Question 5

- (a) **B1** powder has a larger total surface area so more particles are exposed to the acid, increasing collision frequency, oe
- **(a) Answer: Powder has a larger surface area so more particles are exposed to the acid.**
- (b) **M1** identifies powder reacts faster because of greater surface area
- (b) **A1** adds that greater surface area means more collisions per second so rate is higher, oe
- **(b) Answer: The powdered carbonate reacts faster because it has a greater surface area so there are more collisions per second.**

Question 6

- (a) **M1** adds times and divides by 3: (75 + 60 + 45) / 3
- (a) **A1** 60 s cao
- **(a) Answer: 60 s**
- (b) **B1** to reduce the effect of random errors and anomalies and increase reliability, oe
- **(b) Answer: Repeating reduces the effect of random errors and makes the result more reliable.**

Question 7

- (a) **M1** divides volume by time: 48 / 2
- (a) **A1** 24 cm3 per minute cao
- **(a) Answer: 24 cm3 per minute**

Question 8

- (a) **M1** states that concentration of reactants decreases over time
- (a) **A1** states that fewer particles per unit volume mean fewer collisions per second
- (a) **A1** concludes that therefore the rate decreases, oe
- **(a) Answer: As reactants are used up their concentration falls so there are fewer particles per unit volume and fewer collisions per second; this reduces the rate.**

Question 9

- (a) **B1** forward and backward reactions occur at the same rate and concentrations of reactants and products remain constant, oe
- **(a) Answer: Forward and backward reactions occur at the same rate and concentrations stay constant.**
- (b) **B1** system must be closed so no substances enter or leave
- **(b) Answer: The system must be closed (no substances can enter or leave).**

Question 10

- (a) **B1** equilibrium shifts to make more product (shifts to the right) to reduce the added reactant, oe
- **(a) Answer: The equilibrium shifts to make more product (shifts to the right).**
- (b) **B1** equilibrium shifts to the side with fewer gas molecules (products), so amount of product increases, oe
- **(b) Answer: The equilibrium shifts to the side with fewer gas molecules, so the amount of product increases.**

Question 11

- (a) **M1** substitutes concentrations: Kc = 0.10 / (0.20 x 0.30)
- (a) **A1** evaluates denominator: 0.20 x 0.30 = 0.060
- (a) **A1** final Kc = 1.7 (to 2 significant figures) cao
- **(a) Answer: 1.7**

Question 12

- (a) **M1** identifies forward reaction is exothermic (gives correct direction)
- (a) **A1** explains that increasing temperature favours the endothermic direction (backward) so equilibrium shifts to make less product
- (a) **A1** gives clear link between temperature increase and decrease in product amount, oe
- **(a) Answer: The forward reaction is exothermic. Increasing temperature favours the endothermic reverse reaction so the equilibrium shifts to make less product.**

Question 13

- (a) **M1** states a change and direction: e.g. increase pressure, equilibrium shifts to the right (fewer gas molecules) or decrease temperature, equilibrium shifts to the right (exothermic forward), oe
- (a) **A1** makes correct link to increased yield of ammonia
- **(a) Answer: Increase the pressure; equilibrium shifts to the right to make more ammonia increasing yield.**

Question 14

- (a) **M1** suggests an improvement, e.g. use a video camera or use a gas syringe or start timing from mixing using a clamp and release or use more repeats
- (a) **A1** explains how it reduces error, e.g. video allows accurate replay to see first bubble or gas syringe gives measurable volume rather than subjective observation, oe
- **(a) Answer: Use a camera to record the reaction so you can replay and see exactly when effervescence starts, reducing timing error.**

Question 15

- **Level 3** (5-6): Detailed answer that correctly explains the effect of both changes on equilibrium position and rates. Uses Le Chatelier's principle, identifies direction of shift for each change, describes how the forward and backward rates change until a new dynamic equilibrium is reached, and gives cause (temperature favours endothermic direction; removal of products shifts to right).
- **Level 2** (3-4): Partial answer that explains one change clearly and gives a correct but incomplete explanation for the other, or gives correct direction of shifts for both but with limited comment on rates.
- **Level 1** (1-2): Basic statements such as 'equilibrium shifts left or right' with little or no justification about Le Chatelier or rates.
- **Indicative content:**
  - For increase in temperature: identify whether forward or backward is endothermic; state equilibrium shifts to favour endothermic direction; explain that immediately the rate of the favoured direction increases, the other rate decreases, and a new dynamic equilibrium is reached with concentrations changed.
  - For removal of R and S: state that removing products shifts equilibrium to the right to make more R and S; explain that forward rate initially exceeds backward rate until new equilibrium is established.
  - Refer to Le Chatelier's principle in both parts and mention that rates change because concentrations and/or temperature affect frequency and energy of collisions.
  - Mention the system is closed and that at the new equilibrium forward and backward rates are equal again.

Question 16

- (a) **M1** converts volume to litres: 25.0 cm3 = 0.0250 l and substitutes: moles = concentration x volume = 0.10 x 0.0250
- (a) **A1** 0.00250 mol cao
- (a) **A1** shows units correct or expresses to appropriate s.f., oe
- **(a) Answer: 0.00250 mol**