3.2 Rates and equilibria

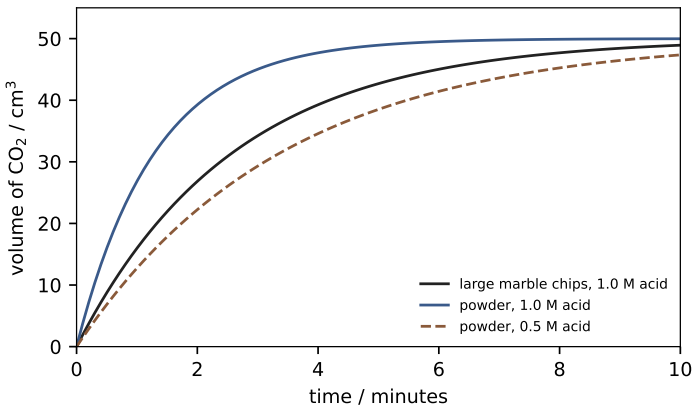
Name: _____ Class: _____ Date: _____ **Total: 23 marks**

Objective

Cover rates of reaction (3.9–3.16) and equilibria (3.17–3.22C): the four rate levers with collision theory, catalysts, (C) reaction profiles, reversible reactions and the shifts of dynamic equilibrium. Original IGCSE-level practice.

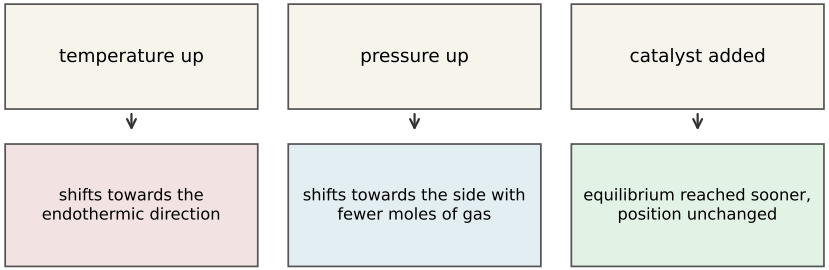
1 Key knowledge and worked examples

Four levers, one explanation



Surface area, concentration, pressure and temperature all work through **collisions**: more frequent (area, concentration, pressure) or more energetic (temperature – the only lever raising the fraction that beats the activation energy). A **catalyst** lowers the activation energy by an alternative pathway, unchanged at the end.

(C) Equilibrium shifts



Temperature up → endothermic direction; pressure up → fewer gas moles; catalyst → faster both ways, position unchanged. Forward and reverse rates equal; concentrations constant.

2 Practice

2.1 State four factors that affect the rate of reaction. [4]

2.2 Explain, using collision theory, why a higher concentration speeds a reaction. [2]

2.3 Which factor increases the energy of collisions? [1]

2.4 Define a catalyst. [2]

2.5 (C) Give the two characteristics of a reaction at dynamic equilibrium. [2]

3 Exam-style questions

3.1 Explain two differences between the effect of raising temperature and the effect of adding a catalyst on a reaction. [4]

3.2 Marble chips react with dilute hydrochloric acid. Describe how the rate changes when the acid concentration is doubled and when the chips are crushed, and explain each. [4]

3.3 (C) For $2SO_2 + O_2 \rightleftharpoons 2SO_3$ (forward reaction exothermic), state and explain the effect on the yield of SO_3 of (a) increasing the pressure and (b) increasing the temperature. [4]

Solutions

2.1 Surface area of a solid; concentration of solution; pressure of gas; temperature; (catalyst).

2.2 More particles of reactant in the same volume → more frequent collisions per second, so more successful collisions per second.

2.3 Temperature.

2.4 A substance that increases the rate of a reaction but is chemically unchanged at the end.

2.5 (C) The forward and reverse reactions occur at the same rate; the concentrations of reactants and products remain constant.

3.1 Temperature raises the energy of particles, so a greater fraction of collisions exceeds the activation energy; a catalyst provides an alternative pathway of lower activation energy without changing the particles' energy – and unlike temperature it does not shift an equilibrium position.

3.2 Doubled concentration: faster rate – twice as many acid particles in the same volume, so more frequent collisions. Crushed chips: faster rate – a larger exposed surface area, so more collisions at the solid surface per second.

3.3 (C) (a) Pressure up shifts equilibrium to the right – 3 moles of gas on the left, 2 on the right – so the SO_3 yield rises. (b) Temperature up shifts equilibrium in the endothermic direction – to the left – so the SO_3 yield falls.