

Exercise walk-through

## 2.4.2

# Equilibrium shifts and industrial choices

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Pearson Edexcel · International A-Level · Chemistry

## Controls distinguish chemical evidence from contamination

- 1 Set up** Match measured amounts, particle size, apparatus and heating rate; compare sample temperature at a consistent decomposition criterion.
- 2 Reason**  $\text{CO}_2$ : milky limewater;  $\text{O}_2$ : glowing splint relights;  $\text{NO}_2$ : brown and acidic.
- 3 Conclude** Clean flame-test wire and keep the flame region/loading consistent. Na yellow, K lilac, Ca brick-red, Sr crimson-red; sodium carry-over can mask another colour.

## Equilibrium is dynamic

- 1** Forward and reverse rates are equal in a closed system; concentrations need not be equal.
- 2** Higher pressure favours fewer gas moles; higher temperature favours the endothermic direction.
- 3** A catalyst reaches the same equilibrium sooner. Industrial operation balances rate, yield and cost.

## Independent identification

### Your turn

$\text{C}_3\text{H}_6\text{O}$  has a carbonyl IR absorption and gives a positive Fehling's test. Which structure fits all evidence?

- A.  $\text{CH}_3\text{COCH}_3$
- B.  $\text{CH}_3\text{CH}_2\text{CHO}$
- C.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- D.  $\text{CH}_3\text{COOH}$

## Exercises 2.1·2.3

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**2.1** State the two defining observations/conditions of dynamic equilibrium and explain why equal concentrations are not required. [3]

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**2.2** For  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$ , predict the composition effect of compressing the equilibrium mixture at fixed temperature and justify. [2]

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**2.3**  $\text{A} + \text{B} \rightleftharpoons \text{C}$  is exothermic forward. Explain the effect of raising temperature on C yield and the effect of adding a catalyst at fixed temperature. [3]

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**2.1** State the two defining observations/conditions of dynamic equilibrium and explain why equal concentrations are not required. [3]

**2.1** A closed system with equal forward and reverse rates. Constant concentrations result from equal rates; there is no requirement for equal amounts of different substances.

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**2.2** No shift: two gas moles on each side. Rates may change, but the pressure comparison does not favour one side.

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**2.3** Higher temperature favours the endothermic reverse reaction and lowers C yield. Catalyst changes approach speed, not equilibrium composition.

## Exercises 3.1·3.2

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**3.1** For  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ ,  $\Delta\text{H} < 0$ , explain how pressure and temperature favour yield. Then give two reasons an industrial plant might not use the highest pressure and lowest temperature. [5]

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**3.2** An equilibrium mixture becomes richer in product when one product is continuously removed. Explain this result without claiming the equilibrium constant has changed, and state why an open flowing process needs care when using the phrase dynamic equilibrium. [3]

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**3.1** For  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ ,  $\Delta H < 0$ , explain how pressure and temperature favour yield. Then give two reasons an industrial plant might not use the highest pressure and lowest temperature. [5]

**3.1** Higher pressure favours two rather than three gas moles; low temperature favours the exothermic direction. Low temperature gives a slow rate. High pressure requires costly equipment/energy and greater safety provision; an explicit rate–yield–cost compromise is needed.

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**3.2** An equilibrium mixture becomes richer in product when one product is continuously removed. Explain this result without claiming the equilibrium constant has changed, and state why an open flowing process needs care when using the phrase dynamic equilibrium. [3]

**3.2** Removal lowers product concentration, so net forward reaction replaces some product. The closed-system definition does not directly describe the whole flowing process; local equilibrium/steady operation must be distinguished.