

2.4.2 Equilibrium shifts and industrial choices

Name: _____ Class: _____ Date: _____ **Total: 16 marks**

KEY WORDS dynamic equilibrium

Objective

Separate equilibrium composition from the speed of reaching it and justify a compromise. All questions and marking guidance are original.

1 Key knowledge and worked examples

In a closed system at dynamic equilibrium, forward and reverse rates are equal. Both reactions continue; concentrations are constant, not necessarily equal. More reactant shifts toward its consumption. Higher pressure favours fewer gas moles. Higher temperature favours the endothermic direction.

■ Worked explanation

$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ is exothermic forward. Higher pressure favours the side with two rather than four gas moles. Lower temperature favours exothermic ammonia formation but slows reaction. A catalyst gives a useful rate at a lower operating temperature without changing equilibrium at that temperature.

2 Practice

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

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]

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]

3 Exam-style questions

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]

3.2 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]
