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QUESTION WORKBOOK

Dynamic equilibrium, Le Chatelier's principle and industrial compromise

Chemical equilibria · Unit C06

AQA 3.1.6.1 · OCR A 3.2.3

16 questions · 55 marks

NAVY SCREEN EDITION

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SECTION A · Short, 1 to 2 marks

A1 DEL-Q1

State two features of a reversible reaction that has reached dynamic equilibrium. [2]

SECTION B · Standard, 3 to 5 marks

B1 DEL-Q2

Explain, using Le Chatelier's principle, why raising the pressure increases the equilibrium yield of SO_3 in $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ but has no effect on the equilibrium yield of HI in $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$. [4]

B2 DEL-Q7

Explain what is seen when the plunger of a sealed syringe containing an equilibrium mixture of N_2O_4 and NO_2 is pulled out quickly and held. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$; N_2O_4 is colourless and NO_2 is brown. [4]

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B3 DEL-Q8

Explain why adding a catalyst to a reaction at equilibrium does not change the position of equilibrium, and explain how a catalyst active at a lower temperature than iron could reduce the energy used by a Haber process plant. [4]

B4 DEL-Q17

Evaluate a proposal to raise the pressure in a methanol plant from its usual 50 to 100 atm to 300 atm. The reaction is $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$, $\Delta H = -91$ kJ mol^{-1}, run at about 250 °C. [4]

B5 DEL-Q18

Compare the conditions chosen for the Haber process with those for the Contact process step $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, giving a reason for each difference. [4]

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B6 DEL-Q4 Give the temperature, the pressure and the catalyst used in the industrial hydration of ethene to ethanol. [3]

B7 DEL-Q5 Describe how the rates of the forward and reverse reactions change from the moment hydrogen and iodine are sealed in a hot flask until equilibrium is reached. [3]

B8 DEL-Q6 Explain why calcium carbonate heated in a sealed container reaches equilibrium, $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$, but calcium carbonate heated in an open lime kiln decomposes completely. [3]

B9 DEL-Q11 Suggest the effect on the equilibrium yield of hydrogen of raising the pressure and of raising the temperature for $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$, $\Delta H = -41$ kJ mol^{-1}, and suggest one reason for using a catalyst. [3]

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B10 DEL-Q12 Suggest the sign of ΔH for the forward reaction in the equilibrium pink $[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons$ blue $[CoCl_4]^{2-}(aq) + 6H_2O(l)$, given that the mixture turns blue when heated, and suggest the colour seen when concentrated hydrochloric acid is added and when water is added. [3]

B11 DEL-Q15 Calculate the amounts of nitrogen and hydrogen in 1.00×10^4 mol of a Haber equilibrium mixture that contains 27.0% ammonia by moles, the rest being nitrogen and hydrogen in the ratio 1 : 3. [3]

B12 DEL-Q16 Outline how ammonia is separated from the gas leaving a Haber converter, and why the conversion of only about 15% per pass is acceptable. [3]

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B13 DEL-Q19 Explain how the colours seen when tubes of a purple solution of the equilibrium $[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CoCl_4]^{2-}(aq) + 6H_2O(l)$ are put in hot water and in iced water show that the forward reaction is endothermic. $[Co(H_2O)_6]^{2+}$ is pink and $[CoCl_4]^{2-}$ is blue. [3]

B14 DEL-Q20 Describe how three boiling tubes of a purple cobalt(II) chloride solution could be used to show the effect of temperature on the position of an equilibrium. [3]

SECTION C · Long, 6 marks or more

C1 DEL-Q9 Explain why the Haber process, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -92$ kJ mol^{-1}, is run at about 450 °C and 200 atm over an iron catalyst with the unreacted gases recycled, with reference to equilibrium yield, rate and cost. [6]

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