

Equilibrium constants and shifting equilibria

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Model answers and mark schemes follow. Award method marks even if a numerical slip occurs, and check that predicted shifts are justified by moles of gas or by the sign of ΔH .

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R2.3

Question 1 Writing K_c (2 marks)

(a) $K_c = [\text{CO}_2]^2 / ([\text{CO}]^2[\text{O}_2])$

(b) Units: $\text{mol}^2 \text{dm}^{-6} / (\text{mol}^2 \text{dm}^{-6} \times \text{mol dm}^{-3}) = \mathbf{dm^3 mol^{-1}}$.

Marking: 1 for the correct powers; 1 for the units.

Question 2 Calculating K_c (3 marks)

$$K_c = [C] / ([A][B]^2) = 0.60 / (0.10 \times 0.20^2) = 0.60 / 0.0040 = \mathbf{150 \text{ dm}^6 \text{ mol}^{-2}}.$$

Marking: 1 for the expression; 1 for the value; 1 for the units.

Question 3 Butane isomerisation (3 marks)

Let x mol of methylpropane form: butane = $1 - x$. The volume cancels because the mole numbers on both sides are equal. $x / (1 - x) = 2.5$, so $x = 2.5 / 3.5 = 0.714$. Methylpropane = **0.714 mol** and butane = **0.286 mol**.

Marking: 1 for the ICE setup; 1 for the equation; 1 for both amounts.

Question 4 Nitrogen monoxide yield (3 marks)

(a) The yield **increases**: the forward reaction is endothermic, so a rise in temperature shifts the equilibrium to the right, and K increases.

(b) **No effect**: there are 2 moles of gas on each side, so pressure does not change the position.

Marking: 1 for the effect in (a); 1 for the explanation in (a); 1 for (b) with reason.

Question 5 K_c and temperature (3 marks)

(a) **Exothermic**, because K_c falls as temperature rises.

(b) A rise in temperature shifts the equilibrium in the endothermic direction, here the reverse, so less product forms.

(c) K_c keeps falling and approaches zero.

Marking: 1 mark per part.

Question 6 Calculating K_p (2 marks)

$$K_p = \frac{p(\text{NO}_2)^2}{p(\text{N}_2\text{O}_4)} = \frac{50^2}{25} = \mathbf{100 \text{ kPa}}.$$

Marking: 1 for the expression; 1 for the value with units.

Question 7 Role of a catalyst (2 marks)

A catalyst lowers the activation energy of both the forward and reverse reactions equally, so both rates increase by the same factor and K is unchanged. Equilibrium is reached sooner.

Marking: 1 for both reactions affected equally; 1 for K unchanged and faster approach.

Question 8 Direction of change (2 marks)

Q is less than K , so the mixture has too much reactant relative to equilibrium. It shifts **to the right**, forming more products until $Q = K$.

Marking: 1 for the direction; 1 for the comparison of Q with K .