

# Equilibrium Test Mark Scheme

1 Consider the equilibrium:  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$

What is the effect of decreasing the pressure on the position of equilibrium and the value of the equilibrium constant,  $K_c$ ?

- A The position of equilibrium shifts to the right and  $K_c$  increases
- B The position of equilibrium shifts to the left and  $K_c$  decreases
- C The position of equilibrium is unchanged and  $K_c$  does not change
- D The position of equilibrium shifts to the left and  $K_c$  stays the same**

2 Consider the equilibrium



What is the effect of increasing the temperature on the position of equilibrium and the value of the equilibrium constant,  $K_c$ ?

- A The position of equilibrium shifts to the right and  $K_c$  increases
- B The position of equilibrium shifts to the left and  $K_c$  decreases**
- C The position of equilibrium is unchanged and  $K_c$  does not change
- D The position of equilibrium shifts to the left and  $K_c$  stays the same

3 Explain what is meant by the term *dynamic equilibrium*. [2]

Macroscopic properties remain constant;

Rate of forward reaction = rate of reverse reaction;

4  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \quad \Delta H = -92 \text{ kJ mol}^{-1}$

State and explain the effect of introducing an iron catalyst on the position of equilibrium and the value of the equilibrium constant,  $K_c$ ? [3]

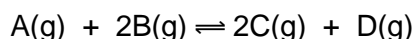
No effect of on position of equilibrium;

or value of  $K_c$ ;

Speeds up forward and reverse reactions equally;

5 Consider the reversible reaction  $\text{A}(\text{g}) + 2\text{B}(\text{g}) \rightleftharpoons 2\text{C}(\text{g}) + \text{D}(\text{g})$

2.0 mol A and 2.0 mol of B are put in a reaction vessel of volume  $5 \text{ dm}^3$  and allowed to come to equilibrium. At equilibrium there were 1.6 mol of A present. Calculate the value of the equilibrium constant. [3]



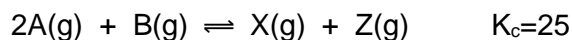
Equilibrium number of moles      1.6      1.2      0.8      0.4      ;

Equilibrium concs                      0.32      0.24      0.16      0.08      ;

$$K_c = \frac{0.16^2 \times 0.08}{0.32 \times 0.24^2} = 0.11 ; \quad \text{correct final answer scores [3]}$$

# Equilibrium Test Mark Scheme

6 Consider the following reversible reaction at 300K



A and B are introduced into a reaction vessel of volume 10 dm<sup>3</sup>. At a certain point in time the number of moles of each species present is given in the table.

Species	Number of moles
A	0.10
B	0.30
X	0.20
Z	0.20

State and explain whether the system is at equilibrium or not.

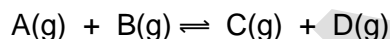
[2]

$$Q = \frac{0.020 \times 0.020}{0.010^2 \times 0.030} = 133 ;$$

$Q \neq K_c$  therefore the system is not at equilibrium ;

7 Consider the reversible reaction:  $A(g) + B(g) \rightleftharpoons C(g) + D(g)$   $K_c=1.20$  at 300 K

(a) 1.00 mol A, 1.00 mol of B, 2.00 mol C and 2.00 mol D were introduced into a reaction vessel of volume 1.00 dm<sup>3</sup> and allowed to come to equilibrium. Calculate the number of moles of A present at equilibrium. [3]



Initial / mol            1.00    1.00    2.00    2.00

Equilibrium/mol        1+x    1+x    2-x    2-x    ;

*( $Q > K_c$  therefore reaction will proceed to left towards equilibrium – although this does not affect the calculation)*

$$1.20 = \frac{(2-x)(2-x)}{(1+x)(1+x)} ;$$

$x = 0.43$     number of moles of A at equilibrium = 1.43 mol;

(b) Calculate the value of  $\Delta G$  for this reaction at 300 K.

[2]

$$\Delta G = -RT \ln K$$

$$= -8.31 \times 300 \times \ln 1.20 ;$$

$$\Delta G = -455 \text{ J mol}^{-1} ;$$