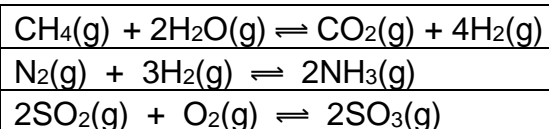


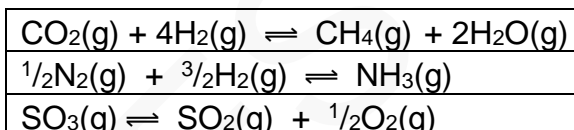
**I am able to:**

- 1 Explain what you understand by the term *dynamic equilibrium*.
- 2 Explain what is meant by a *closed system*.
- 3 Describe, on a molecular level, how equilibrium is established when a liquid is placed in a closed container.

- 4 Write expressions for the equilibrium constant,  $K_c$ , for

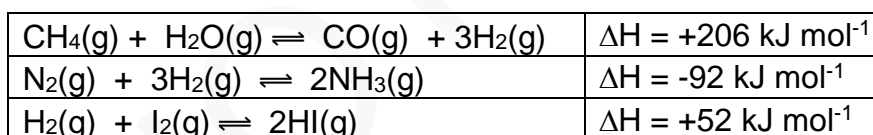


- 5 Write expressions for the equilibrium constant,  $K_{c1}$ , for the reactions shown and state the relationship between the values of  $K_{c1}$  and  $K_c$  in 4



- 6 Explain the connection between the value of the equilibrium constant and the position of equilibrium.

- 7 Predict, for each of the reactions shown, the effect of the changes below on the position of equilibrium and the value of the equilibrium constant

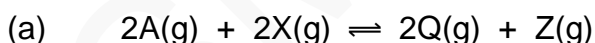


- increasing the pressure
- decreasing the temperature
- adding hydrogen
- adding a catalyst

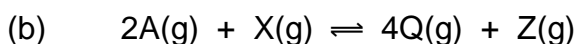
- 8 Explain whether the reaction  $\text{A} \rightleftharpoons \text{B}$  is endothermic or exothermic from the values of the equilibrium constant.

$$K_c = 1.2 \times 10^4 \text{ at } 500 \text{ K and } K_c = 5.6 \times 10^5 \text{ at } 1000 \text{ K}$$

- 9 Calculate  $K_c$  for the each of the following reactions:

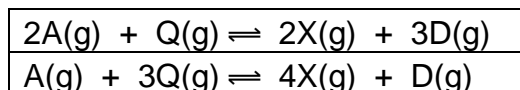


Initial number of moles of A = 0.200 mol	initial number of moles of X = 0.200 mol
initial number of moles of Q = 0.200 mol	initial number of moles of Z = 0.200 mol
number of moles of X at equilibrium = 0.100 mol	Volume of container = 10.0 dm <sup>3</sup>



Initial number of moles of A = 0.800 mol	initial number of moles of X = 0.400 mol
initial number of moles of Q = 0.000 mol	initial number of moles of Z = 0.000 mol
number of moles of Z at equilibrium = 0.100 mol	Volume of container = 10.0 dm <sup>3</sup>

- 10 Write expressions for the reaction quotient,  $Q$ , for the following reactions



11 Given the data shown and the value of  $K_c$  work out the value of  $Q$  and whether

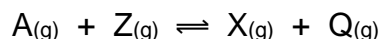
- A the system is at equilibrium  
 B proceeds to the right towards equilibrium  
 C proceeds to the left towards equilibrium

(a) $A(g) + X(g) \rightleftharpoons 2Q(g) + Z(g)$	moles of A = 0.200 mol	moles of X = 0.200 mol
	moles of Q = 0.200 mol	moles of Z = 0.200 mol
	Value of $K_c = 0.0300$	container volume = 10.0 dm <sup>3</sup>

(b) $2A(g) + X(g) \rightleftharpoons 2Q(g) + 2Z(g)$	moles of A = 0.100 mol	moles of X = 0.400 mol
	moles of Q = 0.200 mol	moles of Z = 0.200 mol
	Value of $K_c = 0.0200$	container volume = 10.0 dm <sup>3</sup>

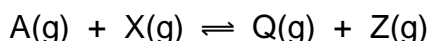
(c) $A(g) + 2X(g) \rightleftharpoons Q(g) + 3Z(g)$	moles of A = 0.100 mol	moles of X = 0.200 mol
	moles of Q = 0.100 mol	moles of Z = 0.400 mol
	Value of $K_c = 0.160$	container volume = 10.0 dm <sup>3</sup>

12 Calculate the number of moles present at equilibrium given the value of the equilibrium constant.



At a certain temperature, 0.100 mol of A and 0.100 mol of Z are placed in a container of volume 1.00 dm<sup>3</sup> and allowed to come to equilibrium. The value of the equilibrium constant at this temperature is 9.00. Calculate the number of moles of X at equilibrium.

13 Use  $Q$  and  $K_c$  to explain Le Chatelier's principle for changes in concentration.



The system at equilibrium contains the following number of moles in a vessel of volume 1.00 dm<sup>3</sup>.

Moles of A / mol	Moles of X / mol	Moles of Q / mol	Moles of Z / mol
0.100	0.100	0.200	0.200

Explain what happens (using the values of  $Q$  and  $K_c$ ) when another 0.100 mol of A is introduced into the container.

14 State how entropy and Gibbs free energy vary as a system moves towards equilibrium.

15 For a system at equilibrium:  $A \rightleftharpoons B$

state the relationship between the Gibbs free energy of A and B and hence the value of  $\Delta G$ .

16 For each of the following situations state whether the value of the equilibrium constant is less than or greater than 1.

$\Delta G$  is negative

$\Delta G$  is positive

17 Calculate the value of  $\Delta G$  (with units) from the following data.  
 $R=8.31 \text{ JK}^{-1}\text{mol}^{-1}$

Value of K	temperature
$1.5 \times 10^3$	500 °C
$2.0 \times 10^{-4}$	300 K
10	400 K

18 Calculate the value of the equilibrium constant from the following data  
 $R=8.31 \text{ JK}^{-1}\text{mol}^{-1}$

$\Delta G / \text{kJ mol}^{-1}$	temperature
-100	300 °C
40	400 K
-500	500 K

19 Explain for each of the system in 17 and 18 whether the position of equilibrium lies more to the left or more to the right.