EQUILIBRIUM Core (SL & HL)

1. (a) Consider the equilibrium: $CO\ (g) + H_2O\ (g) \rightleftharpoons CO_2\ (g) + H_2\ (g)$

(i) Write an expression for the equilibrium constant, K_c, for the reaction.

[1]

$K_c = \dfrac{[CO_2][H_2]}{[CO][H_2O]}$ ✓

(ii) Distinguish between the terms reaction quotient, Q, and equilibrium constant, K_c.

[1]

K_c is measured at equilibrium / equilibrium concentrations

Q measured at any time / any concentration values. ✓

Both needed

(iii) State why this equilibrium reaction is considered homogeneous.

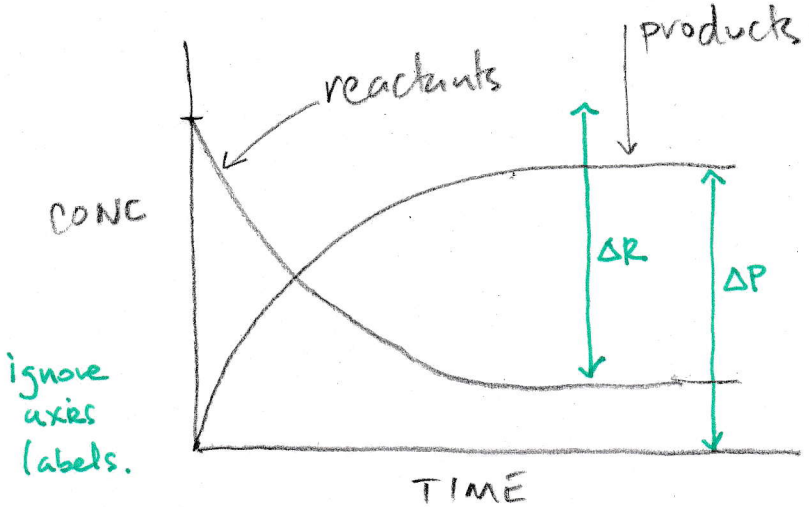
[1]

All of the species (reactants & products) are in the same state/phase. ✓

(iv) Initially, an equal number of moles of CO (g) and H_2O (g) only are present in a cylinder and are allowed to reach equilibrium at 800°C. At 800°C, $K_c = 4.0$ for the reaction.

Sketch a graph to show the change in concentration of the reactants **and** products with time until the equilibrium is established.

[4]



ignore axis labels.

- 2 curves leveling off ✓
- level off at same time ✓
- ΔR approx equal to ΔP ✓
- [products] > [reactants] ✓ (should be approx x4).

(v) The forward reaction in (a) is exothermic. State and explain the effect on the value of K_c if temperature is increased.

[2]

Increase in temperature favours endothermic reaction ✓
so equilibrium shifts left / to reactants ✓
so K_c will decrease ✓

(vi) State the effect on the position of equilibrium and the value of K_c if a catalyst is used.

[2]

(A catalyst will speed up the reaction / attainment of eqm)
but will have no effect on K_c ✓, and will have no effect on position of equilibrium. ✓

2. (a) The Haber process is used to produce ammonia:

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

(i) State and explain how the equilibrium would be affected by increasing the volume of the container at constant temperature.

[3]

Increasing the volume will decrease the pressure ✓
shifting the equilibrium to left ✓
as this is the side with greatest moles of gas. ✓

(Can also score 3 by explaining effect on relative concentrations)

(ii) The percentage yield of ammonia is 25% at 400°C and 11% at 500°C. State and explain whether the reaction is exothermic or endothermic in the forward direction.

[2]

As temperature increases the yield of product decreases
so equilibrium must shift left ✓ (in the endothermic direction)
So the forward reaction is exothermic. ✓

Total 16 marks (24 minutes)