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

$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

5 Write expressions for the equilibrium constant, Kc_1, for the reactions shown and state the relationship between the values of Kc_1 and K_c in 4

$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g)$
$^1/_2N_2(g) + {}^3/_2H_2(g) \rightleftharpoons NH_3(g)$
$SO_3(g) \rightleftharpoons SO_2(g) + {}^1/_2O_2(g)$

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

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$	$\Delta H = +206$ kJ mol^{-1}
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	$\Delta H = -92$ kJ mol^{-1}
$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	$\Delta H = +52$ kJ mol^{-1}

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

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

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

9 Calculate K_c for the each of the following reactions:

(a) $2A(g) + 2X(g) \rightleftharpoons 2Q(g) + Z(g)$

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^3

(b) $2A(g) + X(g) \rightleftharpoons 4Q(g) + Z(g)$

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^3

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

$2A(g) + Q(g) \rightleftharpoons 2X(g) + 3D(g)$
$A(g) + 3Q(g) \rightleftharpoons 4X(g) + D(g)$

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^3

(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^3

(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^3

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

$$A_{(g)} + Z_{(g)} \rightleftharpoons X_{(g)} + Q_{(g)}$$

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^3 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.

$$A(g) + X(g) \rightleftharpoons Q(g) + Z(g)$$

The system at equilibrium contains the following number of moles in a vessel of volume 1.00 dm^3.

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 ΔG.

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

ΔG is negative ΔG is positive

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

Value of K	temperature
$1.5x10^3$	500 °C
$2.0x10^{-4}$	300 K
10	400 K

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

ΔG/ 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.