Quiz 7 Revision

Equilibrium

Consider the following reaction

$$CO(g) + Cl_2(g) \leftrightharpoons COCl_2(g) \quad \Delta H = -ve$$

In a 2.00 litre reaction vessel a mixture of 2.00 mol of CO and 1.00 mol of Cl_2 gases is placed and allowed to reach equilibrium. When equilibrium was finally reached, at 200 °C, it was found that the mixture contained 0.600 mol of $COCl_2$.

a. Give the expression for Qc

$$\frac{[COCl_2]}{[CO]\ [Cl_2]}$$

b. Calculate the equilibrium constant for this reaction at 200 °C. Give your answer to the right number of significant figures and the correct unit.

	CO	Cl_2	$COCl_2$
Initial (mol)	2.00	1.00	0
change	-0.600	-0.600	0.600
Equilibrium (mol)	1.4	0.400	0.600
[ ]	1.4/2 = 0.70 M	0.400 / 2 = 0.20 M	0.600 / 2 = 0.300 M

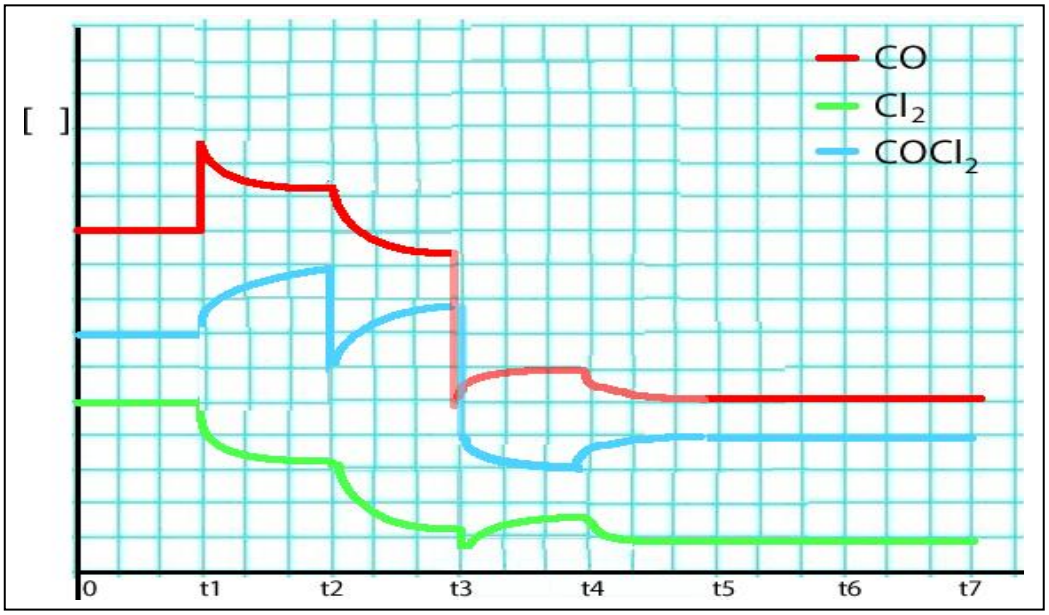
Kc = 0.300 / (0.70 X 0.20) = 2.14 M^{-}

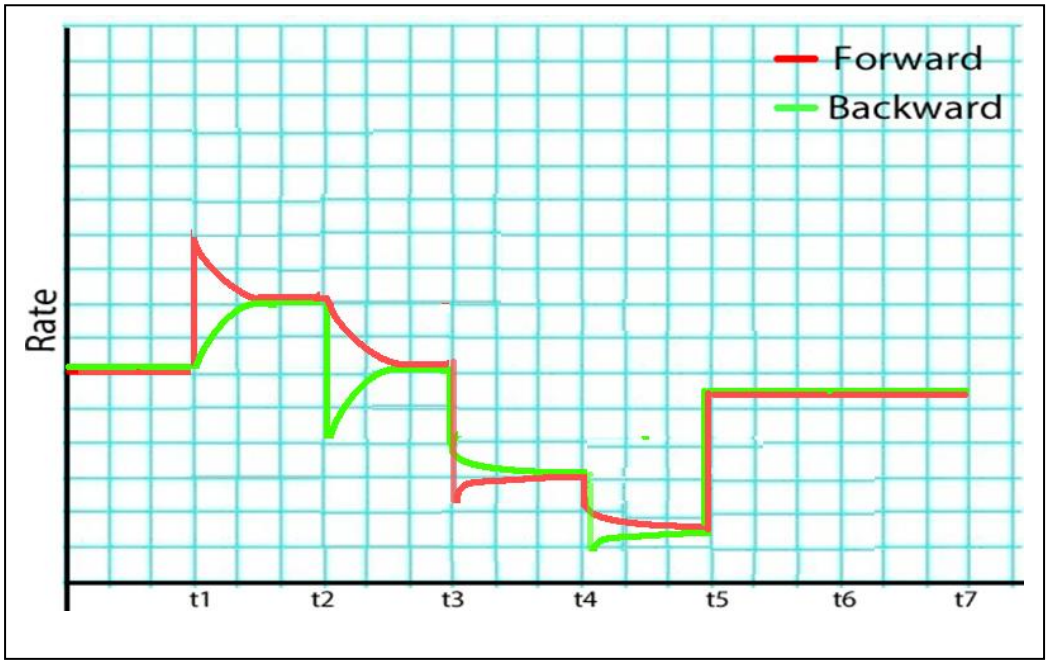
c. Complete the table below.

Stress on the system whilst at equilibrium	Kc	Qc	Reaction response 
Inject more $COCl_2$ into the reaction vessel at constant temperature	No change	Increases	
Remove Cl_2 from the reaction vessel at constant temperature	No change	Increases	
Double the volume of the reaction vessel at constant temperature	No change	Increases	
Increase the temperature of the reaction vessel	Decrease	Decrease	
Addition of a catalyst at constant temperature	No change	No change	

d. The same reaction reached an equilibrium position at another unknown temperature. It concentration time graph is shown below. For each stress draw the response of the system. After each stress equilibrium is achieved before the next stress.

T_1 = CO gas is injected.
T_2 = $COCl_2$ is removed
T_3 = Volume is doubled
T_4 = Temperature decreases
T_5 = a catalyst is added
T_6 = pressure is doubled by the addition of helium gas.





T_1 = CO gas is injected.

Impact on concentrations. Reaction will move in a net forward direction to partially undo the increase in [CO].

When equilibrium is reestablished
[CO] will increase
[Cl_2] will decrease
[$COCl_2$] will increase
Impact on rate – This will increase the net forward reaction rate and both backward and forward reaction will adjust to be equal once more albeit at a higher rate. Due to more particles in the system.

T_2 = $COCl_2$ is removed

Impact on concentrations. Reaction will move in a net forward direction to partially undo the decrease in [$COCl_2$].

When equilibrium is reestablished
[CO] will decrease
[Cl_2] will decrease
[$COCl_2$] will decrease
Impact on rate – This will increase the net forward reaction rate and both backward and forward reaction will adjust to be equal once more albeit at a lower rate. Due to more particles in the system.

T_3 = Volume is doubled

Impact on concentrations. Concentrations will halve and reaction will move in a net backward direction, to most particles, to partially undo the dilution of all species.

When equilibrium is reestablished
[CO] will decrease
[Cl_2] will decrease
[$COCl_2$] will decrease
Impact on rate – This will increase the net forward reaction and both backward and forward reaction will adjust to be equal once more albeit at a higher rate. Due to more particles in the system.

T_4 = Temperature decreases
Impact on concentrations. Since the reaction is exothermic an increase in temperature will drive the reaction backwards to partially undo the energy input.

When equilibrium is reestablished
[CO] will increase
[Cl_2] will increase
[$COCl_2$] will decrease
Impact on rate – A temperature rise will increase the forward and reverse reaction rates. Since the reaction moves in a net backward direction the reaction rate for the backward increases more than the rate of the forward reaction before adjusting to become equal once more when a new equilibrium position is reached with a lower k_c.

T_5 = a catalyst is added

Impact on concentrations. A catalyst does not change the concentrations of species at equilibrium. Catalysts increase the forward and revers reaction equally hence do not change concentrations of species.
Impact on rate – A catalyst increase the both the forward and backward reactions equally.
T_6 = pressure is doubled by the addition of helium gas.

Since helium is an inert and not part of the system no change is observed in rate or concentration.