SCH 4U1-a

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Chapter 7 Test - Equilibrium Systems

Knowledge /15	Thinking /15	Application /12

PART A: THINKING (15 MARKS)

Answer the following questions in the space provided.

1. At 700K the equilibrium constant for the following reaction is 0.83.

$$CO\ (g) + H_2O\ (g) \Leftrightarrow H_2\ (g) + CO_2\ (g)$$

If 1.0 moles each of carbon monoxide gas and water vapour are introduced into a 5.0 L container and allowed to reach equilibrium, what is the equilibrium concentration of the various gases at equilibrium? (6 MARKS)

① $[CO_{(g)}] = 0.5\ mol/L$
$[H_2O_{(g)}] = 0.5\ mol/L$

② ICE table

	CO	H_2O	H_2	CO_2
I	0.5	0.5	0	0
C	$-x$	$-x$	$+x$	$+x$
E	$0.5-x$	$0.5-x$	x	x

③ $K = \dfrac{[H_{2(g)}][CO_{2(g)}]}{[CO_{(g)}][H_2O_{(g)}]}$

$\sqrt{0.83} = \sqrt{\dfrac{x^2}{(0.5-x)^2}}$

$0.91(0.5-x) = x$
$0.455 - 0.91x = x$
$0.24 = x$

③ $[CO_{(g)}]_e = 0.5-x$
$= 0.5 - 0.24$
$= 0.26\ mol/L$

$[H_2O_{(g)}]_e = 0.5-x$
$= 0.26\ mol/L$

$[H_{2(g)}]_e = x$
$= 0.24\ mol/L$

$[CO_{2(g)}]_e = x$
$= 0.24\ mol/L$

2. What is the solubility of strontium fluoride if the K_{sp} of strontium fluoride is 4.3×10^{-9}? (4 MARKS)

① $SrF_{2(s)} \Leftrightarrow Sr^{2+}_{(aq)} + 2F^-_{(aq)}$

	—	$Sr^{2+}_{(aq)}$	$F^-_{(aq)}$
I	—	0	0
C	—	$+x$	$+2x$
E	—	x	$2x$

② $K_{sp} = [Sr^{2+}_{(aq)}][F^-_{(aq)}]^2$

$4.3 \times 10^{-9} = (x)(2x)^2$

$\sqrt[3]{\dfrac{4.3 \times 10^{-9}}{4}} = x$

$1.0 \times 10^{-3} = x$

③ as SrF_2 and $Sr^{2+}_{(aq)}$ = 1:1 ratio
$[SrF_{2(s)}] = 1.0 \times 10^{-3}\ mol/L$
$[SrF_{2(s)}] = [Sr^{2+}_{(aq)}]$

3. Will a precipitate form if 40 mL of 0.0080 mol/L magnesium nitrate solution is added to 60 mL of a 0.010 mol/L solution of potassium carbonate? (5 MARKS)

$Mg(NO_3)_{2(aq)} + K_2CO_{3(aq)} \leftrightarrow MgCO_{3(s)} + KNO_{3(aq)}$

$MgCO_{3(s)} \rightarrow Mg^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)}$

* $C_2 = \frac{C_1V_1}{V_2}$

① $[Mg^{2+}_{(aq)}] = 0.0080 mol/L \times \frac{40mL}{100mL}$

$= 0.0032 mol/L$

$[CO_3^{2-}{}_{(aq)}] = 0.010 mol/L \times \frac{60mL}{100mL}$

$= 0.0060 mol/L$

② $Q = [Mg^{2+}_{(aq)}][CO_3^{2-}{}_{(aq)}]$

$= [0.0032][0.0060]$

$= 1.9 \times 10^{-5}$

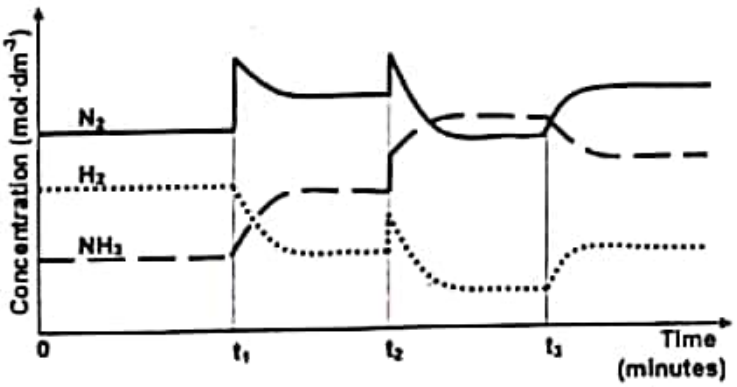
③ * $K_{sp} = 6.8 \times 10^{-6}$

$Q > K_{sp}$ ∴ a precipitate will form

PART B: APPLICATION (12 MARKS)

1. Identify the nature (cause) of the change imposed on the equilibrium system, shown in the graph below, at each of the times indicated. Include the direction the equilibrium would shift to account for this change. (6 MARKS

$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$ $\Delta H = -91.8 kJ$



t = 1	concentration of N_2 increased shift right
t = 2	pressure increased/volume decreased shift right due to less mols
t = 3	heat is added to favour reverse reaction shift left

2. At a certain temperature, $K_{eq} = 0.18$ for the following equilibrium:

$$PCl_{3(g)} + Cl_{2(g)} \text{ <===> } PCl_{5(g)}$$

Suppose a reaction vessel at this temperature contained these three gases at the following concentrations: $[PCl_3] = 0.0420$ M, $[Cl_2] = 0.0240$ M, $[PCl_5] = 0.00500$ M.

(a) Determine Q_{eq} for the system. (2 marks)
(b) Is the system at equilibrium? If it is not, indicate the direction toward which the system will move to reach equilibrium. (1 mark)

a) $Q = \frac{[PCl_{5(g)}]}{[PCl_{3(g)}][Cl_{2(g)}]}$

$= \frac{[0.00500]}{[0.0420][0.0240]}$

$= 4.96$

b) this system is not at equilibrium as $Q > K$. the system must shift left to accomidate.

3. Explain why a syringe containing NO_2 gas will first get *darker* and *then lighter* in colour when compressed. Use the equilibrium equation: (1 mark)

$$N_2O_4(g) + \text{heat} \leftrightarrow 2NO_2(g)$$
colourless *brown*

- pressure increased/volume reduced
- as you apply pressure, the concentration of both will increase and become darker
- right after, the equilibrium will shift to the left in order to produce more $N_2O_{4(g)}$
- this is because the ratio is 1:2 and therefore equilibrium shifts to the side with less moles, $N_2O_{4(g)}$

4. Most barium salts are highly poisonous. They are used in medical diagnostics, where it creates more contrast of internal organs so they are more clearly seen in an X-ray. Patients are often required to drink large volumes of barium sulfate prior to gastrointestinal X-ray exams, and they suffer no ill side effects.

Why is it that barium sulfate ($K_{sp} = 1.1 \times 10^{-10}$) is safe to ingest, while other barium salts such as barium nitrate ($K_{sp} = 4.64 \times 10^{-3}$) are highly poisonous? (2 marks)

- the ksp is far less than 1 and therefore favours the reactants
- this means that barium sulfate is way less soluable than other barium salts that have a much higher ksp
- in short, barium sulfate favours reactants and therefore is less soluable and will not dissolve