CH1012 Tutorial 1 Answers

1. Fuel desulfurization is often used in natural gas power plants to reduce one of the major pollutants resulting from fossil fuel combustion SO_2. The compound removed from the fuel is hydrogen sulfide (H_2S).

$$2H_2S_{(g)} + O_{2(g)} \leftrightarrows 2S_{(s)} + 2H_2O_{(g)}$$

Write down the equilibrium expression for this reaction.

$K_c = [H_2O]^2 / [H_2S]^2 [O_2]$ or

$K_p = p(H_2O)^2 / p(H_2S)^2 p(O_2)$

What happens to the equilibrium concentration of H_2S if O_2 is added?

Le Chatelier's principle – equilbrium moves to the RHS lowers both $[O_2]$ and $[H_2S]$

What happens to the equilibrium concentration of S if H_2S is removed?

S is not in the equilibrium constant expression and doesn't have a concentration!

2. Write down the equilibrium constant (K_p) for the decomposition of liquid water for form gaseous hydrogen and oxygen.

$$2H_2O_{(l)} \leftrightarrows O_{2(g)} + 2H_{2(g)}$$

$K_p = p(H_2)^2 p(O_2)^1$

3. What is the difference between a Lyophobic and a Lyophilic colloid – provide examples to illustrate your answer? Include a clear definition of each colloid.

A **lyophobic colloid** is a dispersion of solid particles (with approximate diameters in the range 1μm -10 nm) in a liquid. The particles are made up of aggregates of large numbers of molecules or ions that are insoluble in the liquid dispersion medium, hence this is a 2 phase system. Lyophobic colloids are thermodynamically unstable and form either through condensation from low M.W. ions or molecules or through dispersion of bulk matter. e.g. soil colloid (clay minerals + H_2O)

A **lyophillic colloid** is a dispersion of large macromolecular molecules (dimensions as above MW 100 000DA) which have similar polarities to the dispersion medium and so this is a 1 phase system where there are no clear dividing surfaces between the colloid and the medium. Lyophillic colloids are thermodynamically stable and form spontaneously. eg. PVA + water → PVA glue (PVA polymer + H2O).

4. The relative mobility of the hydrated Group 1A ions increases as we go down the group and yet the ionic size increases. Explain this apparent anomaly.

The ionic size (cationic radii) increases as we go down group 1A as a result of the increasing number of filled shells as we progress down period by period. If as we descend the period the charge on the cation is constant then there is a reduced positive charge density. The relative mobility is a result of the effective size of the ion in solution. When any ionic solid is dissolved in water it will dissociate and a hydration shell will build around the ion with the water molecules aligning according to ion / dipole forces. The group 1A ions (M^+) in periods 2 and 3 are quite small and have a significant +ve charge / size ratio (**higher charge**

density), this results in a large cluster of water molecules arranging around the ion (**higher hydration number**). In contrast the larger group 1A ions in periods 4 and 5 now have a lower charge/ size ratio and fewer water molecules cluster around the ion. The size of the hydrated ions is larger for periods 2 and 3 hence the mobility of these ions in solution is reduced (around 1/2 group 4 & 5 values) reflecting the hydration numbers with Li^+ having a hydration number of 25 while Cs^+ only has a hydration number of 10.

5. Define the term **organometallic compound** and give an example of a Group 2A organometallic compound.

An organometallic compound is a metal complex containing an organic ligand where there is at least 1 bond between the metal and carbon (M-C).
A Grignard reagent is a good example of a polar covalent organometallic Group 2A compound.

RX + Mg $\rightarrow$ R - Mg - X
(eg. MeBr) ether (eg. MeMgBr)
δ - δ+

The Grignard reagent is not soluble in water as it is polar covalent rather than ionic. As water is a polar solvent it requires the solute to have considerable ionic character or to be capable of hydrogen bonding.