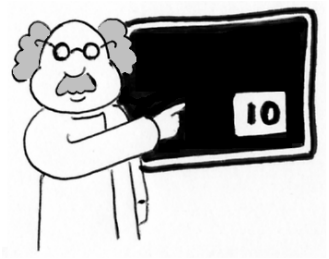

STARTER FOR 10...

2.5. The solubility product, K_{sp}

1. Define the following terms. Illustrate your definitions with examples from the box.

$PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2\ I^-(aq)$
$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

Homogeneous equilibrium .....

.....

Heterogeneous equilibrium .....

..... (4 marks)

The solubility product is a special example of a heterogeneous equilibrium.

When writing an expression for the equilibrium constant for a heterogeneous equilibrium, terms for pure solids or pure liquids are left out of the expression.

2. A student tests for the presence of chloride ions in solution by adding a solution of lead nitrate. A white precipitate of lead chloride is formed.

The precipitate exists in equilibrium with its ions;

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2\ Cl^-(aq), \quad K_{sp} = 1.6 \times 10^{-5}\ mol^3\ dm^{-9} \text{ at } 298\ K$$

(a) Write an expression for K_{sp} for this equilibrium.

.....(1 mark)

(b) Calculate the solubility of lead chloride at 298 K in mol dm^{-3}.

.....

.....

.....(2 marks)

(c) Describe an experiment the student could do to obtain an experimental value for the solubility product, K_{sp} of lead chloride.

.....

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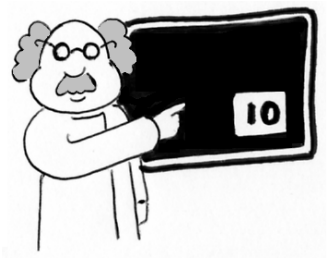
.....(3 marks)



STARTER FOR 10...

2. Equilibria answers

2.5 The solubility product, K_{sp}

1. *Homogeneous equilibrium* = an equilibrium where all the substances are in the same phase.
e.g. $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

Heterogeneous equilibrium = an equilibrium where all the substances are not all in the same phase.
e.g. $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ or $PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2\ I^-(aq)$

(2 marks for each correct definition with matching correct example from the table)

2. (a) $K_{sp} = [Pb^{2+}][Cl^-]^2$ *(1 mark)*

(b) At equilibrium call $[Pb^{2+}]$ '*s*' and $[Cl^-]$ '*2s*'

Substituting into the equation for K_{sp};

$1.6 \times 10^{-5} = s \times (2s)^2$ *(1 mark)*

$1.6 \times 10^{-5} = 4\ s^3$

$4 \times 10^{-6} = s^3$ and hence $s = 0.0158$

Therefore the solubility of lead chloride at 298 K is $0.016\ mol\ dm^{-3}$. *(1 mark)*

(c) **Step 1**: Dissolve as much lead chloride as possible in water, allowing the solution time to equilibrate.

Step 2: Filter off the undissolved lead chloride and measure out a known volume of the filtrate.

Step 3: Evaporate this volume of filtrate to dryness and record the mass of lead chloride left.

Step 4: Use this mass of lead chloride to determine $[Pb^{2+}]$ and $[Cl^-]$ in the original volume of filtrate and from these values calculate K_{sp}.

(3 marks for steps 1-3 clearly described)