Try Yourself 9.5

Solid PbI_2 ($K_{sp} = 9.8 \times 10^{-9}$) is placed in a beaker of water. After a period of time the lead(II) concentration is measured and found to be 1.1×10^{-3} M. Is the solution saturated? If not, will more PbI_2 dissolve?

Try Yourself 9.5

$$PbI_2 \, (s) \rightleftharpoons Pb^{2+} (aq) + 2 I^- (aq)$$

$$K_{sp} = 9.8 \times 10^{-9}$$

If $[Pb^{2+}] = 1.1 \times 10^{-3}$ M,

then $[I^-] = 2[Pb^{2+}]$
$= 2(1.1 \times 10^{-3})$
$= 2.2 \times 10^{-3}$ M

$\therefore Q = (Pb^{2+})(I^-)^2$
$= (1.1 \times 10^{-3})(2.2 \times 10^{-3})^2$
$= 5.32 \times 10^{-9}$

$Q < K_{sp}$

$5.32 \times 10^{-9} < 9.8 \times 10^{-9}$

$\therefore$ The solution is not saturated. Equilibrium has not been established yet. More PbI_2 will dissolve forming more Pb^{2+} and I^- ions until equilibrium has been established.
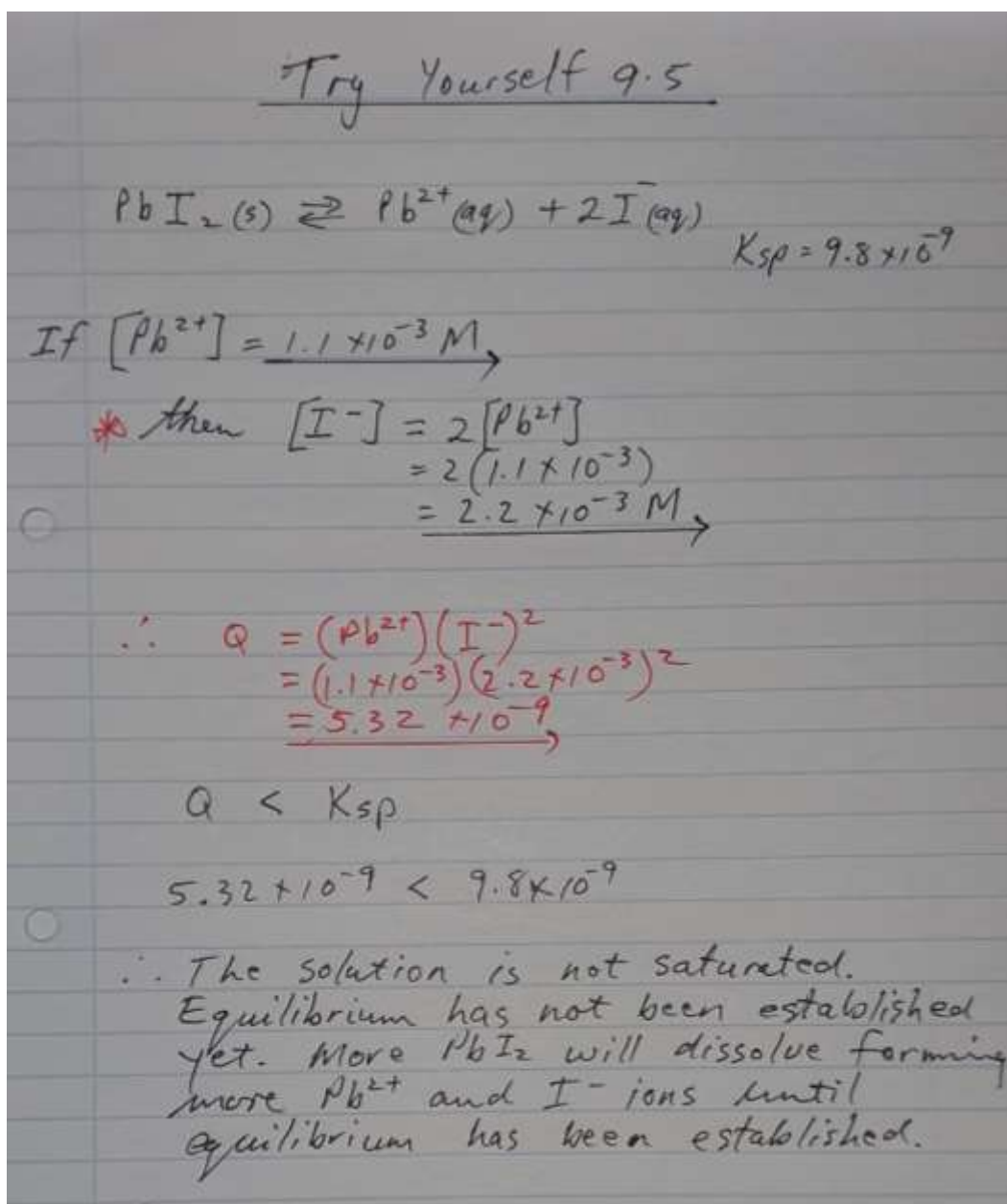
Try yourself 9.5 second part

Equilibrium has not been established yet. More PbI_2 will dissolve.

* How much will dissolve?

$$PbI_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2I^-_{(aq)}$$

I	—	0	0
C	—	$+x$	$+2x$
E	—	x	$2x$
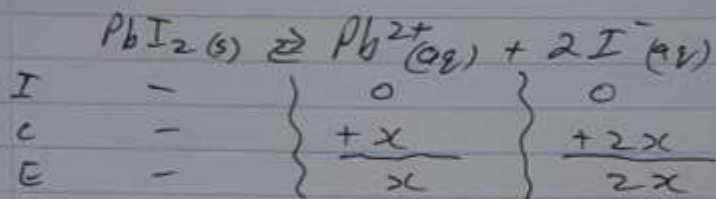
$$K_{sp} = [Pb^{2+}][I^-]^2$$
$$9.8 \times 10^{-9} = (x)(2x)^2$$

$$\therefore \quad 4x^3 = 9.8 \times 10^{-9}$$
$$x = \sqrt[3]{\frac{9.8 \times 10^{-9}}{4}}$$
$$x = 1.348 \times 10^{-3}$$

$$x = [Pb^{2+}]_E = [PbI_2] = 1.348 \times 10^{-3} \, M$$

$\therefore$ 1.348×10^{-3} mol PbI_2 will dissolve in $1 L \, H_2O$

$$m = n \times M$$
$$= (1.348 \times 10^{-3} \, mol)(461 \, g \cdot mol^{-1})$$
$$= 0.621 \, g$$

$\therefore$ $0.621 \, g$ of PbI_2 will dissolve in $1L$ H_2O in total.

1.1×10^{-3} M dissolved

$= 1.1 \times 10^{-3}$ mol already dissolved in
1L solution.

$m = n \times M = (1.1 \times 10^{-3} \text{ mol})(461 \text{ g} \cdot \text{mol}^{-1})$
$= 0.5071 \text{ g}$ already dissolved.

In total 0.621 g will dissolve.

So, at time of taking and determining
the concentration $0.621 - 0.507 = 0.114 \text{ g}$
another 0.114 g of PbI_2 can dissolve.

— D. ☺

When the concentration was determined to be 1.1 x 10^{-3} M for the Pb^{2+} ions in solution another 0.114 g of PbI$_2$ could have dissolved before equilibrium (and therefor saturation) would have been established.