AP® CHEMISTRY
2008 SCORING GUIDELINES (Form B)

Question 3

A 0.150 g sample of solid lead(II) nitrate is added to 125 mL of 0.100 *M* sodium iodide solution. Assume no change in volume of the solution. The chemical reaction that takes place is represented by the following equation.

$$Pb(NO_3)_2(s) + 2\ NaI(aq) \rightarrow PbI_2(s) + 2\ NaNO_3(aq)$$

(a) List an appropriate observation that provides evidence of a chemical reaction between the two compounds.

A precipitate forms with an appearance that is different from that of the dissolving solid.	One point is earned for stating that a precipitate is formed.

(b) Calculate the number of moles of each reactant.

$\text{mol } Pb(NO_3)_2 = 0.150 \text{ g } Pb(NO_3)_2 \times \frac{1 \text{ mol } Pb(NO_3)_2}{331 \text{ g } Pb(NO_3)_2}$ $= 4.53 \times 10^{-4} \text{ mol}$ $\text{mol NaI} = 0.100\ M \times 0.125 \text{ L} = 1.25 \times 10^{-2} \text{ mol}$	One point is earned for the correct number of moles of $Pb(NO_3)_2$. One point is earned for the correct number of moles of NaI.

(c) Identify the limiting reactant. Show calculations to support your identification.

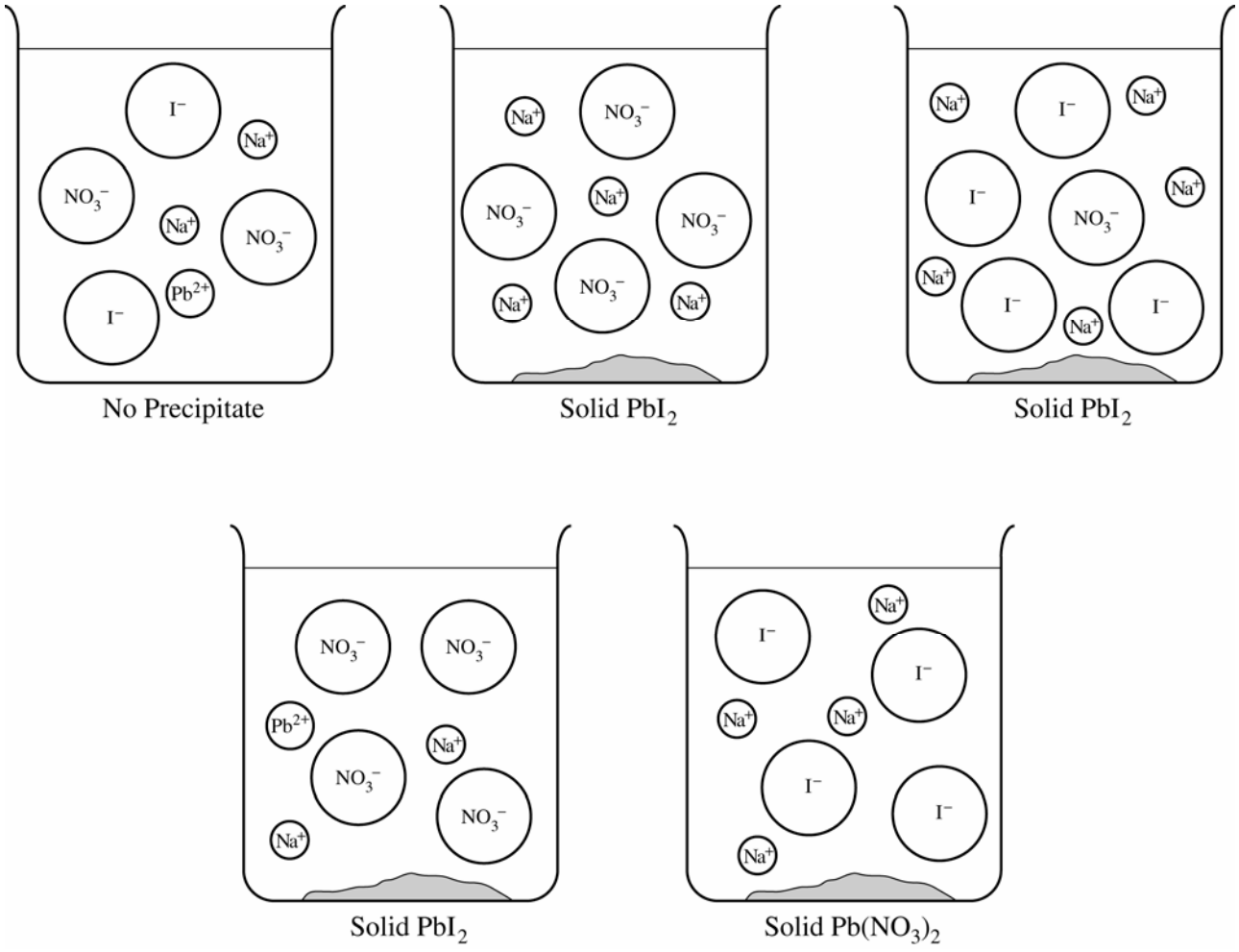
$\text{mol NaI reacting} = 4.53 \times 10^{-4} \text{ mol } Pb(NO_3)_2 \times \frac{2 \text{ mol NaI}}{1 \text{ mol } Pb(NO_3)_2}$ $= 9.06 \times 10^{-4} \text{ mol}$ There is 1.25×10^{-2} mol of NaI initially, thus $Pb(NO_3)_2$ is the limiting reactant.	One point is earned for the identification of $Pb(NO_3)_2$. One point is earned for a justification in terms of the relative numbers of moles.

(d) Calculate the molar concentration of $NO_3^-(aq)$ in the mixture after the reaction is complete.

$[NO_3^-]_f = \frac{2 \times (4.53 \times 10^{-4} \text{ mol})}{0.125 \text{ L}} = 7.25 \times 10^{-3}\ M$	One point is earned for the correct NO_3^-/Pb^{2+} stoichiometry. One point is earned for the correct molarity.

Question 3 (continued)

(e) Circle the diagram below that best represents the results after the mixture reacts as completely as possible. Explain the reasoning used in making your choice.



The rightmost diagram in the top row should be circled. PbI_2 precipitates and $Pb(NO_3)_2$ is the limiting reactant, so there is essentially no Pb^{2+} in solution. Because there was so much NaI in excess, some of the I^- remains in solution, along with the Na^+ and NO_3^-.	One point is earned for the selection of the correct diagram. One point is earned for the correct rationale.

3A,

3. A 0.150 g sample of solid lead(II) nitrate is added to 125 mL of 0.100 *M* sodium iodide solution. Assume no change in volume of the solution. The chemical reaction that takes place is represented by the following equation.

$$Pb(NO_3)_2(s) + 2\,NaI(aq) \rightarrow PbI_2(s) + 2\,NaNO_3(aq)$$

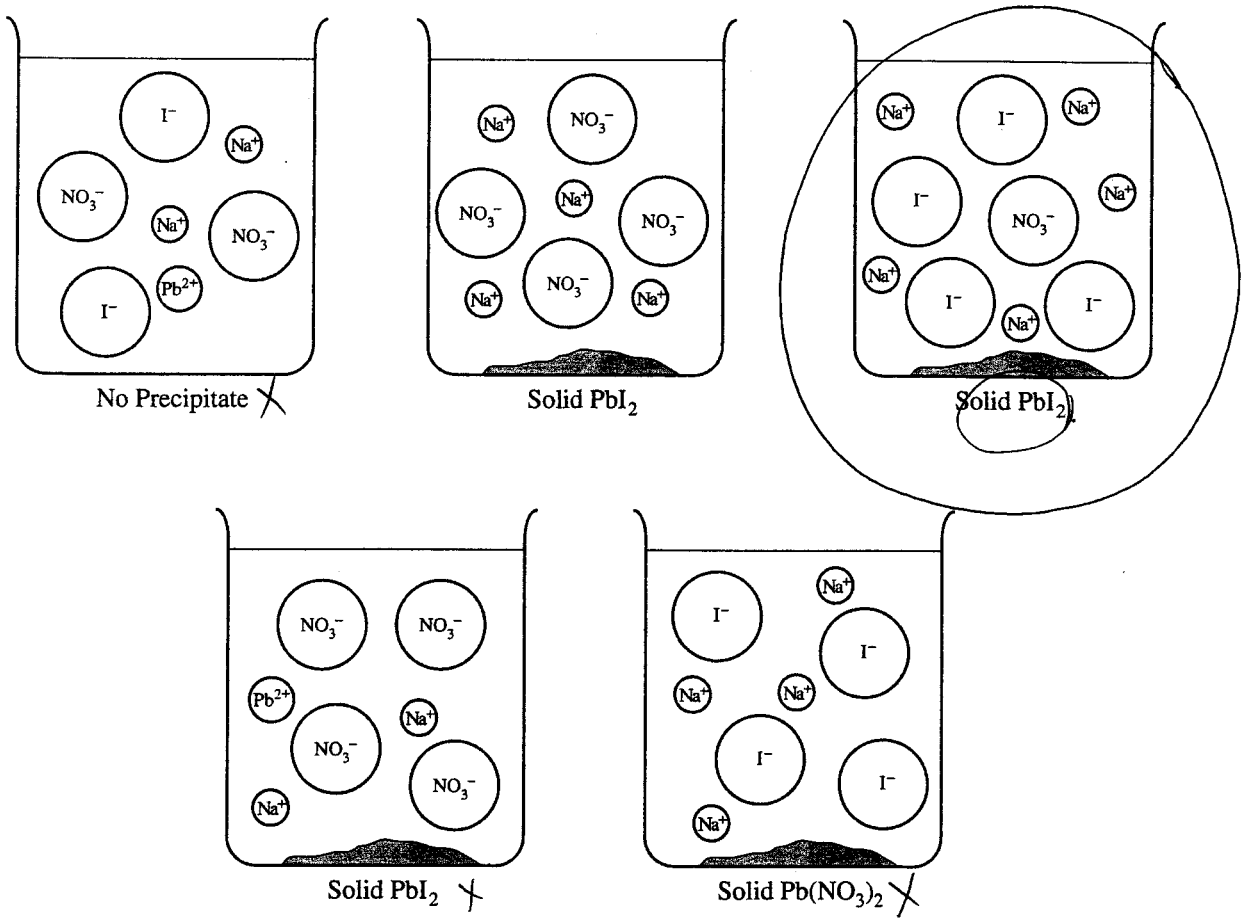
(a) List an appropriate observation that provides evidence of a chemical reaction between the two compounds.

(b) Calculate the number of moles of each reactant.

(c) Identify the limiting reactant. Show calculations to support your identification.

(d) Calculate the molar concentration of $NO_3^-(aq)$ in the mixture after the reaction is complete.

(e) Circle the diagram below that best represents the results after the mixture reacts as completely as possible. Explain the reasoning used in making your choice.



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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

a) When a sample of 0.150g solid lead(II) nitrate is added to 125mL of 0.100M of sodium iodide, a precipitation will form.

b) $Pb(NO_3)_2$: molar mass = 331g

$0.150g \times \frac{1 mole\ Pb(NO_3)_2}{331g} = 4.5 \times 10^{-4}$ moles $Pb(NO_3)_2$

NaI : $0.125L \times \frac{0.1 mole}{1L} = 0.0125$ moles NaI

c)

	$Pb(NO_3)_2(s)$	+ 2NaI (aq)	→ $PbI_2(s)$	+ $2NaNO_3$ (aq)
I	4.5×10^{-4} moles	0.0125	0	0
C	-4.5×10^{-4} moles	-9.1×10^{-4}	$+4.5 \times 10^{-4}$	$+9.1 \times 10^{-4}$
F	0	1.2×10^{-2}	4.5×10^{-4}	9.1×10^{-4}

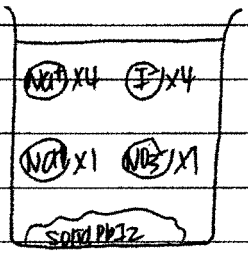
The limiting reactant is $Pb(NO_3)_2$ (s).

d) NO_3^-

: $NaNO_3$ is very soluble. Therefore $[NaNO_3] = [NO_3^-]$

$[NaNO_3] = \frac{9.1 \times 10^{-4} moles}{0.125L} = 7.25 \times 10^{-3}$ M

e)



In reference to the chart in part d, we are able to discover that NaI, PbI_2, $NaNO_3$ are left in the container after the mixture reacts as completely as possible. We are also able to know, from the balanced equation, that there are equal numbers of Na^+ and I^-, and Na^+ and NO_3^- (indicated in diagram). For 1.2×10^{-2} moles of NaI are left, it should have the biggest fraction of the mixture. Furthermore, there must be a precipitate PbI_2.

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3B,

3. A 0.150 g sample of solid lead(II) nitrate is added to 125 mL of 0.100 M sodium iodide solution. Assume no change in volume of the solution. The chemical reaction that takes place is represented by the following equation.

$$Pb(NO_3)_2(s) + 2\,NaI(aq) \rightarrow PbI_2(s) + 2\,NaNO_3(aq)$$

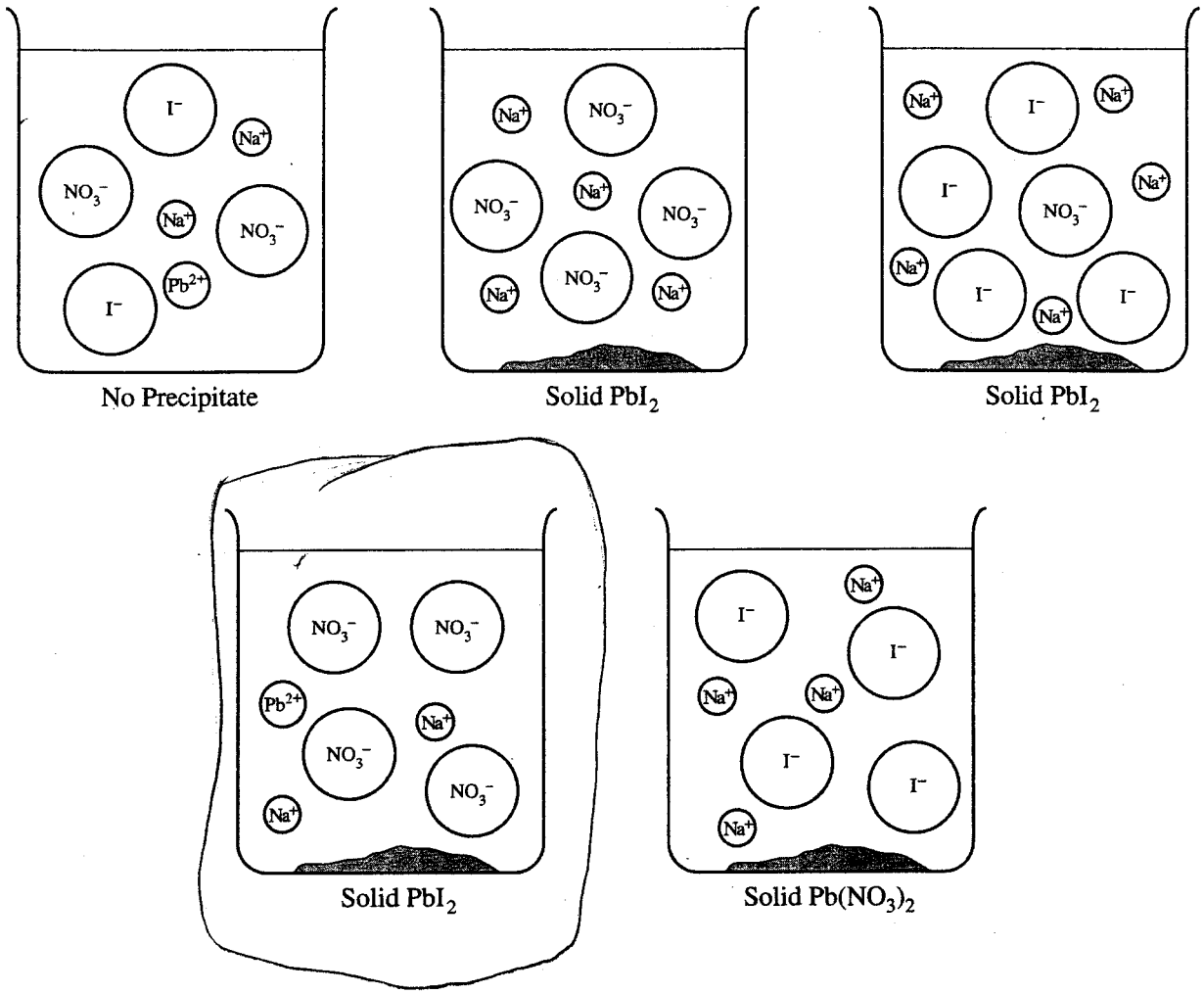
(a) List an appropriate observation that provides evidence of a chemical reaction between the two compounds.

(b) Calculate the number of moles of each reactant.

(c) Identify the limiting reactant. Show calculations to support your identification.

(d) Calculate the molar concentration of $NO_3^-(aq)$ in the mixture after the reaction is complete.

(e) Circle the diagram below that best represents the results after the mixture reacts as completely as possible. Explain the reasoning used in making your choice.



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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

(a) Evidence that a chemical reaction has occured is the precipatite formed in the bottom of the container

(b) $.150\text{g } Pb(NO_3)_2 \left| \frac{1 \text{ Mole}}{331.22\text{g}} \right| 4.53 \times 10^{-4} \text{ Moles } Pb(NO_3)_2$

$\frac{.100\text{M NaI}}{.125\text{ L}} = .8 \text{ Moles NaI}$

(c) $4.53 \times 10^{-4} \text{ Moles } Pb(NO_3)_2 \left| \frac{1 \text{ Mole } PbI_2}{1 \text{ Mol } Pb(NO_3)_2} \right| \left| \frac{461.02\text{ g}}{1 \text{ Mol } PbI_2} \right| .209\text{ g } PbI_2$

$.8 \text{ Mole NaI} \left| \frac{1 \text{ Mole } PbI_2}{2 \text{ Mole NaI}} \right| \left| \frac{461.02\text{ g}}{1 \text{ mol } PbI_2} \right| 184.4\text{ g } PbI_2$

The limiting reactant is $Pb(NO_3)_2$

(d) $4.53 \times 10^{-4} \text{ moles } Pb(NO_3)_2 \left| \frac{2 \text{ Mol } NaNO_3}{1 \text{ Mol}} \right| 9.06 \times 10^{-11} \text{ Moles } NaNO_3$

$9.06 \times 10^{-4} \text{ Moles } NO_3^- / .125\text{L}$

$.00725\text{ M } NO_3^-$

(e) I choose that one because in the next picture, a new reaction began. You can tell because there is a different precipitate in that one. And the I^- is used up completely.

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3C, 1

3. A 0.150 g sample of solid lead(II) nitrate is added to 125 mL of 0.100 *M* sodium iodide solution. Assume no change in volume of the solution. The chemical reaction that takes place is represented by the following equation.

$$Pb(NO_3)_2(s) + 2\,NaI(aq) \rightarrow PbI_2(s) + 2\,NaNO_3(aq)$$

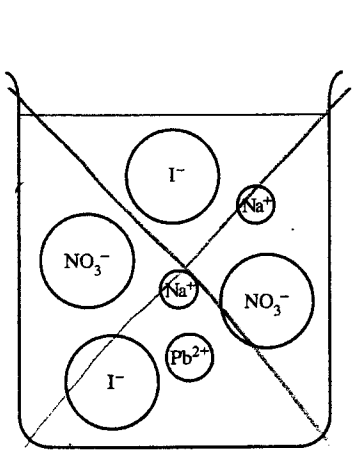
(a) List an appropriate observation that provides evidence of a chemical reaction between the two compounds.

(b) Calculate the number of moles of each reactant.

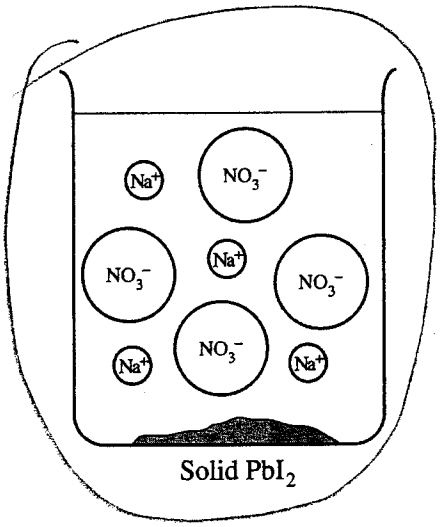
(c) Identify the limiting reactant. Show calculations to support your identification.

(d) Calculate the molar concentration of $NO_3^-(aq)$ in the mixture after the reaction is complete.

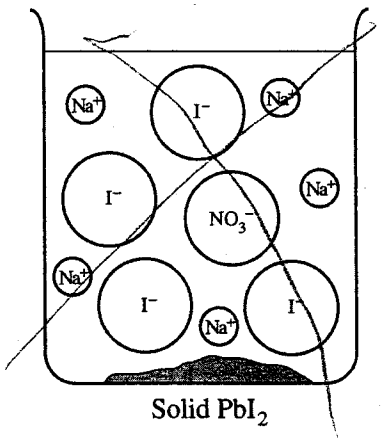
(e) Circle the diagram below that best represents the results after the mixture reacts as completely as possible. Explain the reasoning used in making your choice.



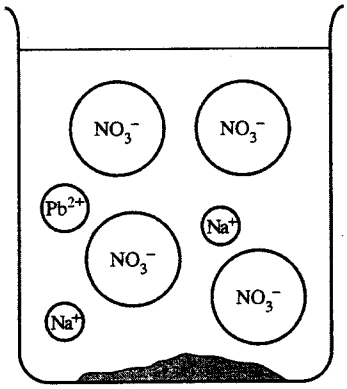
No Precipitate



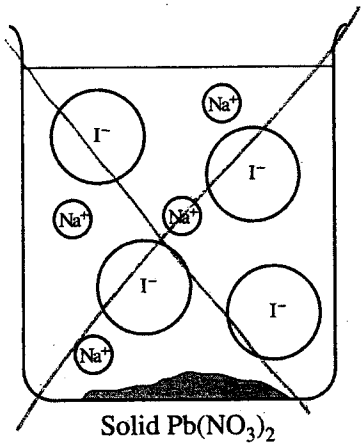
Solid PbI_2



Solid PbI_2



Solid PbI_2



Solid $Pb(NO_3)_2$

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

A) In the reaction, a precipitate is formed therefore, a chemical reaction is occuring.

B) $\frac{.150}{331.22}$ | 1 mol = 4.5×10^{-4} mol $Pb(NO_3)_2$

$2(Pb(NO_3)_2) = 9.1 \times 10^{-4}$ mol $= NaI$

C) The limiting reactant is $Pb(NO_3)_2$.

D)

E) $Pb(NO_3) + 2NaI \longrightarrow PbI_2 + 2NaNO_3$

$Pb^{+2} + 2NO_3^- + 2Na^{+1} + 2I^- \rightarrow PbI_{2(s)} + 2Na^+ + 2NO_3$

$Pb^{+2} + 2I^- \longrightarrow PbI_{2(s)}$

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AP® CHEMISTRY
2008 SCORING COMMENTARY (Form B)

Question 3

Sample: 3A
Score: 9

This response earned 9 points: 1 for part (a), 2 for part (b), 2 for part (c), 2 for part (d), and 2 for part (e).

Sample: 3B
Score: 6

The point was earned in part (a). In part (b) 1 point was earned for the correct calculation of the number of moles of $Pb(NO_3)_2$, but the point was not earned for the number of moles of NaI. In part (c) 2 points were earned for the selection of $Pb(NO_3)_2$ as the limiting reactant with a calculation to justify the choice. In part (d) 2 points were earned for the correct calculation of the molar concentration of NO_3^-. The points were not earned in part (e).

Sample: 3C
Score: 3

The point was earned in part (a). In part (b) 1 point was earned for the correct calculation of the number of moles of $Pb(NO_3)_2$, but the point was not earned for the number of moles of NaI. In part (c) 1 point was earned for the selection of $Pb(NO_3)_2$ as the limiting reactant, but the justification point was not earned. No points were earned in parts (d) and (e).