2021

AP® CollegeBoard

# AP® Chemistry

## Sample Student Responses and Scoring Commentary

### Inside:

**Free Response Question 6**

- ☑ **Scoring Guideline**
- ☑ **Student Samples**
- ☑ **Scoring Commentary**

## Question 6: Short Answer — 4 points

**(a)** For a correct description: **1 point**

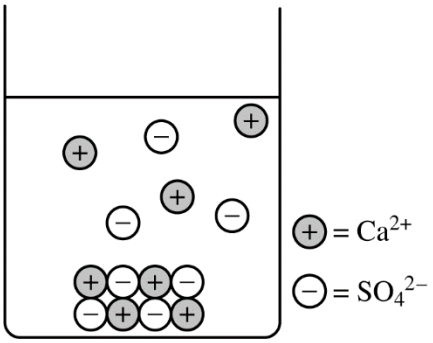
*Ionic solids do not have free-moving ions that are required to carry an electric current. Therefore, there is no conduction of electricity.*

**(b)** For the correct answer and a valid justification: **1 point**

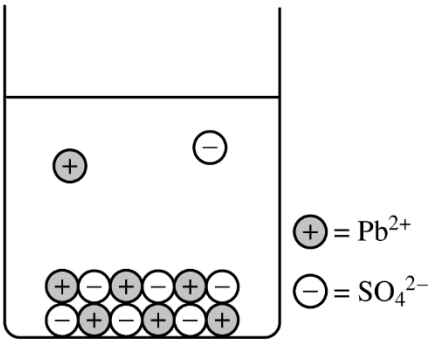
*$CaSO_4$. The greater electrical conductivity of the $CaSO_4$ solution relative to the $PbSO_4$ solution implies a higher concentration of ions, which comes from the dissolution (dissociation) of $CaSO_4$ to a greater extent.*

**(c)** For a correct drawing that shows an equal number of cations and anions: **1 point**

*The drawing shows solid $PbSO_4$ at the bottom of the beaker (similar to the solid shown for $CaSO_4$) and fewer dissociated $Pb^{2+}$ and $SO_4^{2-}$ ions in the solution.*




Higher Conductivity Solution




Lower Conductivity Solution

**(d)** For a correct explanation: **1 point**

*The additional precipitate is $CaSO_4$ that forms in response to the increased $[SO_4^{2-}]$ in solution. According to Le Chatelier's principle ($Q > K_{sp}$), the introduction of $SO_4^{2-}$ as a common ion shifts the equilibrium towards the formation of more $CaSO_4(s)$.*

**Total for question 6 4 points**

Begin your response to **QUESTION 6** on this page.

6. A student is studying the properties of $CaSO_4$ and $PbSO_4$. The student has samples of both compounds, which are white powders.

(a) The student tests the electrical conductivity of each solid and observes that neither solid conducts electricity. Describe the structures of the solids that account for their inability to conduct electricity.

$CaSO_4$ and $PbSO_4$ are ionic compounds, as solids the ions cannot flow freely to conduct electricity. Ionic compounds conduct electricity as liquids or when molten because their ions can dissociate and flow.

The student places excess $CaSO_4(s)$ in a beaker containing 100 mL of water and places excess $PbSO_4(s)$ in another beaker containing 100 mL of water. The student stirs the contents of the beakers and then measures the electrical conductivity of the solution in each beaker. The student observes that the conductivity of the solution in the beaker containing the $CaSO_4(s)$ is higher than the conductivity of the solution in the beaker containing the $PbSO_4(s)$.

(b) Which compound is more soluble in water, $CaSO_4(s)$ or $PbSO_4(s)$ ? Justify your answer based on the results of the conductivity test.

$CaSO_4$ is more soluble in water; $CaSO_4$ had a higher conductivity, which means its ions dissociated more; therefore, it was more soluble.

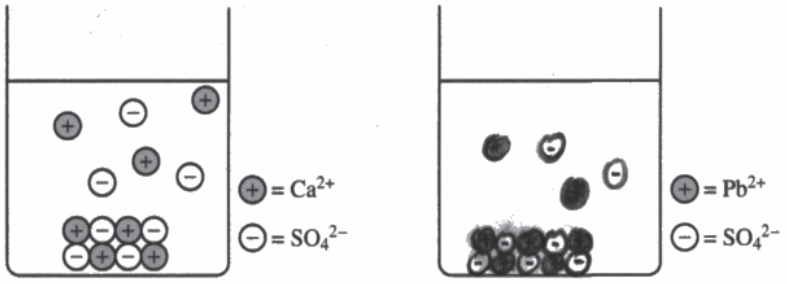




GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 6** on this page.

The left side of the diagram below shows a particulate representation of the contents of the beaker containing the $CaSO_4(s)$ from the solution conductivity experiment.




Higher Conductivity Solution

Lower Conductivity Solution

(c) Draw a particulate representation of $PbSO_4(s)$ and the ions dissolved in the solution in the beaker on the right in the diagram. Draw the particles to look like those shown to the right of the beaker. Draw an appropriate number of dissolved ions relative to the number of dissolved ions in the beaker on the left.

(d) The student attempts to increase the solubility of $CaSO_4(s)$ by adding 10.0 mL of 2 $M$ $H_2SO_4(aq)$ to the beaker, and observes that additional precipitate forms in the beaker. Explain this observation.

The addition of $H_2SO_4$ introduces the common ion. effect to the reaction. The $SO_4^{2-}$ ions from $H_2SO_4$ react with $Ca^{2+}$, causing the reaction to favor the formation of reactants, $CaSO_4$.

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(a) The student tests the electrical conductivity of each solid and observes that neither solid conducts electricity. Describe the structures of the solids that account for their inability to conduct electricity.

CaSO4 and PbSO4 are ionic compounds and have no electron mobility in their solid state.

The student places excess $CaSO_4(s)$ in a beaker containing 100 mL of water and places excess $PbSO_4(s)$ in another beaker containing 100 mL of water. The student stirs the contents of the beakers and then measures the electrical conductivity of the solution in each beaker. The student observes that the conductivity of the solution in the beaker containing the $CaSO_4(s)$ is higher than the conductivity of the solution in the beaker containing the $PbSO_4(s)$.

(b) Which compound is more soluble in water, $CaSO_4(s)$ or $PbSO_4(s)$ ? Justify your answer based on the results of the conductivity test.

CaSO4 is more soluble because in solution it is more conductive which means there are more ions in solution. CaSO4 disassociated more completely in water.





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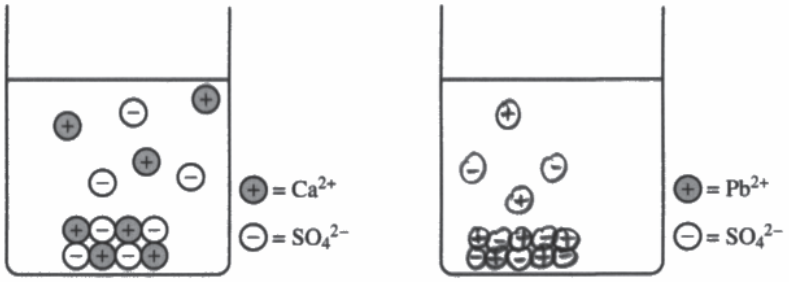
Continue your response to **QUESTION 6** on this page.

The left side of the diagram below shows a particulate representation of the contents of the beaker containing the $CaSO_4(s)$ from the solution conductivity experiment.




Higher Conductivity Solution

Lower Conductivity Solution

(c) Draw a particulate representation of $PbSO_4(s)$ and the ions dissolved in the solution in the beaker on the right in the diagram. Draw the particles to look like those shown to the right of the beaker. Draw an appropriate number of dissolved ions relative to the number of dissolved ions in the beaker on the left.

(d) The student attempts to increase the solubility of $CaSO_4(s)$ by adding 10.0 mL of 2 $M$ $H_2SO_4(aq)$ to the beaker, and observes that additional precipitate forms in the beaker. Explain this observation.

$H_2SO_4$ will disassociate in water which produces additional $SO_4^{2-}$ ions in solution. This will shift equilibrium to producing more $CaSO_4(s)$ according to Le Chatlier's principle.





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6. A student is studying the properties of $CaSO_4$ and $PbSO_4$. The student has samples of both compounds, which are white powders.

(a) The student tests the electrical conductivity of each solid and observes that neither solid conducts electricity. Describe the structures of the solids that account for their inability to conduct electricity.

TO conduct electricity, solids must be metal, and have a high melting point.

The student places excess $CaSO_4(s)$ in a beaker containing 100 mL of water and places excess $PbSO_4(s)$ in another beaker containing 100 mL of water. The student stirs the contents of the beakers and then measures the electrical conductivity of the solution in each beaker. The student observes that the conductivity of the solution in the beaker containing the $CaSO_4(s)$ is higher than the conductivity of the solution in the beaker containing the $PbSO_4(s)$.

(b) Which compound is more soluble in water, $CaSO_4(s)$ or $PbSO_4(s)$ ? Justify your answer based on the results of the conductivity test.

CaSO4 bic we know the student could not see if it conducted electricity before it went in water, therefore when it did go in the water it is soluble because we could see the conductivity.





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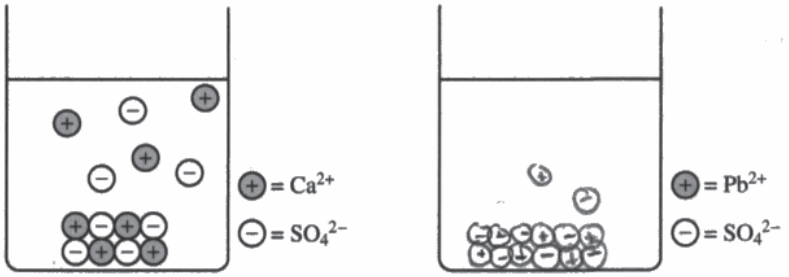
Continue your response to **QUESTION 6** on this page.

The left side of the diagram below shows a particulate representation of the contents of the beaker containing the $CaSO_4(s)$ from the solution conductivity experiment.




Higher Conductivity Solution

Lower Conductivity Solution

(c) Draw a particulate representation of $PbSO_4(s)$ and the ions dissolved in the solution in the beaker on the right in the diagram. Draw the particles to look like those shown to the right of the beaker. Draw an appropriate number of dissolved ions relative to the number of dissolved ions in the beaker on the left.

(d) The student attempts to increase the solubility of $CaSO_4(s)$ by adding 10.0 mL of 2 $M$ $H_2SO_4(aq)$ to the beaker, and observes that additional precipitate forms in the beaker. Explain this observation.

she's adding in an acid (strong) so a chemical change is occuring, which we know from the formation of precipitate.

# Question 6

**Note:** Student samples are quoted verbatim and may contain spelling and grammatical errors.

**Overview**

Question 6 focuses upon two salts, $CaSO_4$ and $PbSO_4$. In part (a), the student must explain why neither compound conducts electricity in its solid state (SAP-5.B, 1.B). The student is then presented with electrical conductivity data on saturated solutions of each salt and asked to identify which compound is more soluble in water and to explain why (SAB-5.B, 2.D). A particulate representation of the saturated solution of $CaSO_4$ is provided, and a corresponding diagram of the $PbSO_4$ solution must be drawn that is consistent with the relative solubility of the two salts (SPQ-5.A, 3.C). Finally, in part (d), the student explains why adding sulfuric acid to the saturated solution of $CaSO_4$ produces additional precipitate (SPQ-5.B, 6.F).

**Sample: 6A**
**Score: 4**

In part (a) 1 point was earned. The response states that the ions in the solid cannot flow freely to conduct electricity. In part (b) 1 point was earned. The response states that $CaSO_4$ is more soluble and explains that the higher conductivity is a result of the greater solubility due to a larger proportion of dissociated ions. In part (c) 1 point was earned. The response shows fewer ions dissolved in solution. In part (d) 1 point was earned. The response identifies the precipitate, $CaSO_4$, and correctly states that the common ion ($SO_4^{2-}$) causes more $CaSO_4$ to form.

**Sample: 6B**
**Score: 3**

In part (a) 0 points were earned. The response identifies electron mobility instead of free-moving ions as being necessary to conduct electricity. In part (b) 1 point was earned. The response states that $CaSO_4$ is more soluble and there are more ions (dissociation) to conduct electricity. In part (c) 1 point was earned. The response shows fewer ions dissolved in solution. In part (d) 1 point was earned. The response indicates that additional $SO_4^{2-}$ ions shift the equilibrium to produce more solid $CaSO_4$, according to Le Chatelier's principle.

**Sample: 6C**
**Score: 1**

In part (a) 0 points were earned. The response does not address why the solids cannot conduct electricity: the absence of free-flowing ions. In part (b) 0 points were earned. The response does not make the connection between conductivity and the presence of ions to solubility. In part (c) 1 point was earned. The response shows fewer ions dissolved in solution. In part (d) 0 points were earned. The response does not demonstrate an understanding of the common ion effect and Le Chatelier's principle.