2025

AP® Chemistry

Sample Student Responses and Scoring Commentary

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Free-Response Question 4

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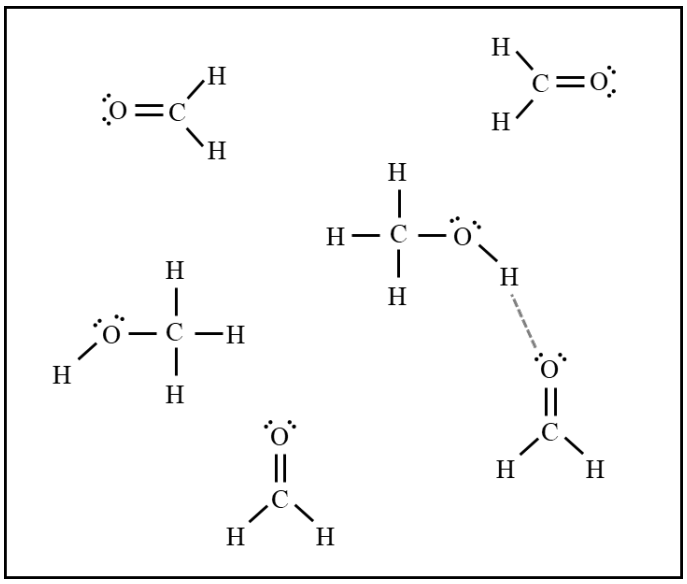
Question 4: Short Answer — 4 points

A For the correct answer: **Point 01**

sp^2

B For a correct diagram: **Point 02**

The diagram should show a dashed line between the O *atom in one* H_2CO *molecule and the* H *atom in the* –OH *group of one* CH_3OH *molecule. See example response below.*



C (i) For a correct proposal: **Point 03**

The proposed temperature should be in the range 181 K – 254 K .

(ii) For the correct calculated value: **Point 04**

$$8.59 \text{ g } CH_3OH \times \frac{1 \text{ mol } CH_3OH}{32.04 \text{ g } CH_3OH} \times \frac{-37.6 \text{ kJ}}{1 \text{ mol } CH_3OH} = -10.1 \text{ kJ}, \textit{ so } 10.1 \text{ kJ } \textit{are removed.}$$

Sample 4A

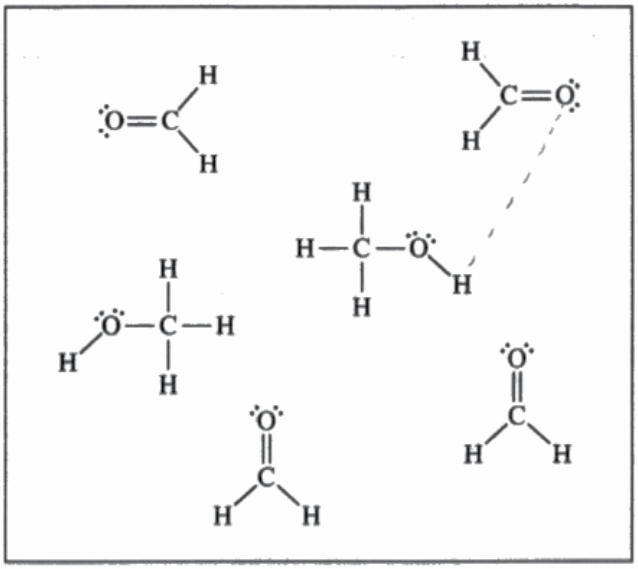
Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 4

Part A

sp^2

Part B



Part C

I) AT 215K both substances will both be liquids

II) $8.59\text{g } CH_3OH \times \frac{1\text{mol } CH_3OH}{32.04\text{g } CH_3OH} = 0.268\text{ mol } CH_3OH$

$0.268\text{ mol } CH_3OH \times \frac{37.6\text{ KJ}}{1\text{mol } CH_3OH} = 10.1\text{ KJ}$ CH_3OH removed

Continue to Question 5.

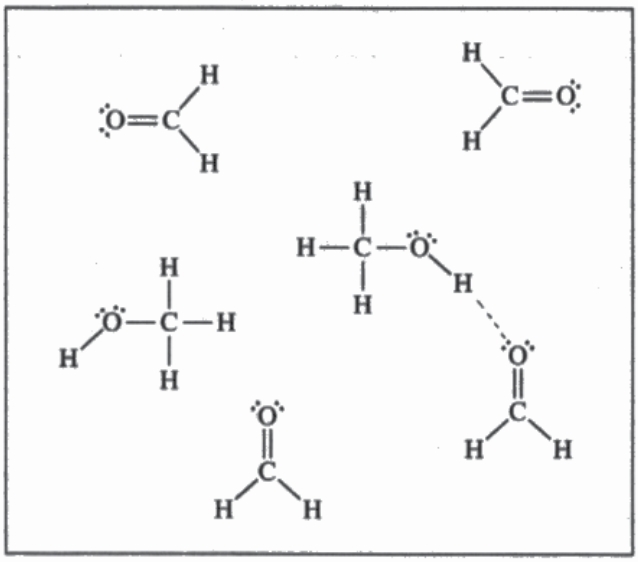
Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 4

Part A

sp^3

Part B



Part C

i) ~~185~~ K

ii) $q = mc\Delta t$

$q = (8.59g)(338)(4.18 J/g \cdot C)$

$q = \frac{12{,}136.29 J \mid 1 kJ}{1000 J} = \boxed{12.14 kJ}$

Continue to Question 5.

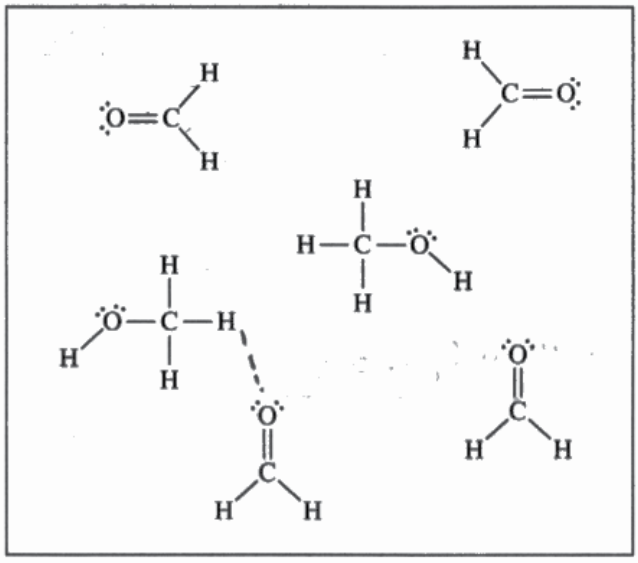
Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 4

Part A

sp^2

Part B



Part C

i. 120°K

ii. $\frac{8.59\text{g} \times 1\text{mol}}{37.04} \approx .268\text{ mol} \times \frac{1\text{kJ}}{37.6} = .007\text{kJ}$

Continue to Question 5.

Question 4

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

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 4A
Score: 4

Point 01: 1
Part A: The point was earned for correctly identifying that the carbon has sp^2 hybridization.

Point 02: 1
Part B: The point was earned. While the response does not use the closest potential interaction, it correctly identifies the H covalently bonded to the O in a CH_3OH molecule and draws a dashed line from that H to the O of H_2CO. The bond between the O and H within CH_3OH would have a sufficiently large bond dipole to form the intermolecular attraction with the O in the H_2CO molecule.

Point 03: 1
Part C (i): The point was earned for recognizing that at $215\ K$ the mixture is between the melting and boiling points of both CH_3OH and H_2CO, so both will be liquids.

Point 04: 1
Part C (ii): The point was earned for correctly calculating the number of moles of CH_3OH present and subsequently calculating the kilojoules of energy transferred in the condensation. The response correctly indicates that the energy was removed.

Sample: 4B
Score: 2

Point 01: 0
Part A: The point was not earned. The response incorrectly identifies the carbon in H_2CO as having sp^3 hybridization, which would require four electron domains rather than three domains.

Point 02: 1
Part B: The point was earned for correctly identifying an H covalently bonded to the O in a CH_3OH molecule and drawing a dashed line from that H to the O of H_2CO. The bond between the O and H within CH_3OH would have a sufficiently large bond dipole to form the intermolecular attraction with the O in the H_2CO molecule.

Point 03: 1
Part C (i): The point was earned for recognizing that at $185\ K$, the temperature of the mixture is between the melting and boiling points of both CH_3OH and H_2CO, so both will be liquids.

Question 4 (continued)

Point 04: 0
Part C (ii): The point was not earned. The response incorrectly calculates the kilojoules of energy transferred in the condensation by using $q = mc\Delta T$ and substituting the boiling point for the change in temperature and water's specific heat capacity for c. The application of $q = mc\Delta T$ requires a temperature change, which does not happen at the boiling point.

Sample: 4C
Score: 1

Point 01: 1
Part A: The point was earned for correctly identifying that the carbon in H_2CO has sp^2 hybridization.

Point 02: 0
Part B: The point was not earned. The bond between the C and H within CH_3OH would not have a sufficiently large dipole to form a hydrogen bonding attraction with the O in the H_2CO molecule.

Point 03: 0
Part C (i): The point was not earned. At $120\ K$, the temperature of the mixture is below the melting points of both CH_3OH and H_2CO, and so both substances will be solids rather than liquids. The response also incorrectly uses a degree symbol for kelvins.

Point 04: 0
Part C (ii): The point was not earned. While the number of moles of CH_3OH present is correctly calculated, the energy transferred in the condensation is incorrectly calculated by dividing, rather than multiplying, by the enthalpy of vaporization.