



## AP<sup>®</sup> Chemistry 2003 Scoring Commentary

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**Question 1**

Sample 1A (Score 10)

This response earned a full score: 1 point for part (a), 3 points each for parts (b) and (c), 2 points for part (d), and 1 point for part (e). The answers are clear and well organized.

Sample 1B (Score 8)

This is a good response. No points were earned in part (d); the hydrolysis of the conjugate acid formed when the titration was completed was not considered, but instead the pH of the solution half-way to the equivalence point was calculated (which was an error that was commonly seen). The point in part (e) was earned because the conclusion is correct based on the pH calculated in part (d).

Sample 1C (Score 7)

In part (b) of this response, 2 points were earned; 1 point for the correct value of  $[\text{OH}^-]$  and 1 point for recognizing that  $[\text{OH}^-]$  is equal to  $[\text{C}_6\text{H}_5\text{NH}_3^+]$ . The third point is not earned due to an error that leads to the wrong answer. All 3 points were earned in part (c) even though the final answer is incorrect due to a wrong value of  $K_b$  carried down from part (b); this is an example of the grading policy of not counting a single mistake more than once in a given problem. No points are earned for part (d), but in part (e) the point is earned for the correct choice of indicator, given the answer to part (d).

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**Question 2**

Sample 2A (Score 8)

This response earned a perfect score. The work setup is clear with units appropriate to the calculations. An unusual approach to the mathematics is evident in part (e); the answer is in the range of acceptable values. Possible point values for the question parts are: 2 points for part (a), 1 point each for parts (b)(i) and (b)(ii), 1 point each for parts (c) and (d), and 2 points for part (e).

Sample 2B (Score 7)

This response earned 1 of 2 possible points in part (a) because of a mathematical error for the moles of O<sub>2</sub>. The point was earned in part (b)(i) because the calculations are correct using the result from part (a). Part (e) includes a complete explanation about the limiting reactant and excess reactant.

Sample 2C (Score 5)

This response earned no point in part (b)(ii) because the incorrect pressure at 298 K was used in the calculation. Also, no point was earned in part (c) because the correct explanation was followed by an indecisive change in the mole ratio. Only 1 point was earned in part (e) because the calculations did not account for the limiting reactant (NO) and  $(2 \times 0.176)$  mole was used to determine pressure.

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**Question 3**

Sample 3A (Score 8)

This is an excellent response with clear explanations in part (a) showing the reasoning applied to the experimental data involving concentrations and rate relationships. In part (e), though the scoring guidelines indicate an answer of 5 electrons, the response of 10 electrons is supported and earned the point. Possible point values for the question parts are: 1 point each for the three answers in part (a), 1 point each for parts (b), (d), and (e), and 2 points for part (c).

Sample 3B (Score 7)

This is a good response. No point was earned in part (e), where the electron total is calculated as  $5 + 5$  and does not reflect the electrochemistry.

Sample 3C (Score 5)

In this response, parts (a) and (b) earned full credit. Part (c) shows the correct numerical value of the rate constant,  $k$ , but fails to earn the second because the units given for  $k$  are wrong. In part (d) the voltage is correct but the sign is wrong due to a math error (not a setup error). In part (e), the incorrect number of electrons is indicated and no point is earned.

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**Question 4**

Sample 4A (Score 15)

This excellent response earned a perfect score of 15 points. Each of the five chosen reactions has the correct formulas and charges for the reactant(s) (1 point) and for the product(s) (2 points). No spectator ions or extraneous species are shown.

Sample 4B (Score 13)

In this good response, reactions (a), (f), (g), and (h) are written correctly. In reaction (e), the reactant silver chloride is indicated as a solid, thus it should have been written as  $\text{AgCl}$  instead of  $\text{Ag}^+$ . The response earned no reactant point. This resulted in the omission of the chloride ion on the product side, and only 1 product point was earned (for the diamminesilver(I) ion).

Sample 4C (Score 7)

For reaction (b) in this response, no reactant point is earned due to the presence of the unlikely species, uncharged  $\text{HSO}_4$ . Zinc ion and sulfate ion are not shown as products, but one product point is earned for  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . For reaction (d), no reactant point is earned due to the presence of spectator ions  $\text{Ca}^{2+}$  and  $\text{Cl}^-$ , but one of the two product points is earned for  $\text{H}_2\text{O}$ . In reaction (e), no points were earned because the reactant silver chloride has the wrong formula, and the correct product is absent. Reaction (f) earned the full 3 points, and reaction (g) had the correct products, but did not earn the reactant point because of the inclusion of a spurious and unlikely species,  $\text{NO}_3^{2-}$ .

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**Question 5**

Sample 5A (Score 9)

This response earned a perfect score of 9 points; 2 points each for parts (a), (d) and (e), and 1 point each for parts (b), (c), and (f).

Sample 5B (Score 7)

This response earned the full 2 points for part (a), 1 point each for parts (b) and (c), and 1 point for part (f). Only 1 point was earned for part (d) because neither path length or molar absorptivity was provided as a factor. For part (e), lower absorbance is related to lower apparent concentration and 1 point is earned for consistency, even though the calculated concentration would actually be too high.

Sample 5C (Score 5)

In part (a) of this response, 1 of the two points is earned because the correct amount of  $\text{CoCl}_2$  solution is indicated, but the procedure does not specify adding enough distilled water to bring the final level up to the 100-mL calibration mark. Answers to parts (b) and (c) earn full credit, but no correct factors are cited in part (d), so no points were earned for that part. In part (f), no point is earned because the reason does include the critical fact that  $\text{NaCl}$  is colorless.

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**Question 6**

Sample 6A (Score 8)

This is an excellent response that earned the maximum score for each of the parts: 2 points for part (a), 1 point each for part (b)(i) and part (b)(ii), and 2 points each for part (c) and part (d).

Sample 6B (Score 7)

This response is good, but in part (c), the excluded volume argument, though hinted at, is not explained. The statement in the second sentence that implies that the particles of an ideal gas have neither size nor mass is incorrect, but since it does not contradict the argument made about intermolecular forces among gas particles at low temperatures, the point was earned.

Sample 6C (Score 4)

Part (a) of this response was weak, but the mention of carbon dioxide as a decomposition product earns 1 point. In part (b)(i), the answer given is essentially a restatement of the prompt and thus earns no point. In part (b)(ii), the concept of two particles for NaCl versus the one particle for sugar earned the point. The response for part (c) mentions low kinetic energy at low temperatures, but fails to invoke intermolecular forces or non-negligible volume of particles at high pressure/low volume conditions and so does not earn any points. The response to part (d) earns both available points.

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**Question 7**

Sample 7A (Score 8)

This response earned full credit, 2 points for each of the four parts.

Sample 7B (Score 7)

This response was good, earning 2 points each for parts (a), (b), and (c). The second and third sentences of the explanation in part (c) earn no credit; it is the last sentence that comes through. In part (d), 1 point is earned for the activation energy argument.

Sample 7C (Score 5)

In this response, only 1 point is earned in part (a) because the sign of the enthalpy change is incorrect (this was a commonly seen error). The answer in part (b) does not earn both points because the change in numbers of moles of gaseous particles was not mentioned. In part (c), two points were earned, and in part (d), one point was earned for the partial explanation.



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**Question 8**

Sample 8A (Score 8)

This excellent response earned a perfect score: 1 point for each answer in part (a) and in part (b), 1 point for part (c), and 3 points for part (d).

Sample 8B (Score 6)

This response was typical for a 6-point response. The response for part (b)(i) involves intramolecular forces, not intermolecular forces, and thus earned no credit. The argument in part (b)(ii) also earns no credit due to the confounding of the concept of forces within molecules with the concept of the bonding between the molecules themselves. The responses for parts (c) and (d) earned full credit.

Sample 8C (Score 5)

This response earned full credit for parts (a) and (c). However, the response earns neither of the two points available in part (b) because of confusion between intra- and inter-molecular forces and unclear and insufficient arguments. In part (d), the number of sigma bonds is tallied to be only 5, most likely due to overlooking that the carbon-to-carbon triple bond contains one sigma bond along with the two pi bonds.