AP® Chemistry
2005 Scoring Commentary

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Question 1

Overview

This question was designed to test students' understanding of solution equilibria involving weak acids. Students were asked to write the K_a expression for a weak acid, to determine the pH of a solution of that acid, and to determine the concentrations of species in a buffer solution of that acid. The students were then asked to calculate K_b for the conjugate base of a different acid given the hydroxide concentration of a solution of a sodium salt of that acid, and then to calculate K_a for that acid from the K_b for the conjugate base. Finally, the students were asked to compare the strengths of two acids and explain the difference.

Sample: 1A
Score: 10

This response earned all 10 points: 1 point for part (a), 3 points for part (b), 2 points for part (c)(i), 1 point for part (c)(ii), 1 point for part (d)(i), 1 point for part (d)(ii), and 1 point for part (e).

Sample: 1B
Score: 7

This response earned 1 out of 2 points in part (c)(i). The number of moles of $NaC_3H_5O_2$ is calculated correctly as 0.005 mol (no deduction for incorrect number of significant figures in an intermediate step), but the molarity is not. The point was not earned in part (c)(ii). The point was not earned in part (e) because a pH argument with no reference to equal concentrations is not acceptable.

Sample: 1C
Score: 5

Only 1 out of 3 points was earned in part (b) because the response does not treat $HC_3H_5O_2$ as a weak acid, and the problem is not set up as an equilibrium problem. However, 1 point was earned for calculating pH from the acid concentration (as if it were a strong acid). The point was not earned in part (d)(i) because there is no acknowledgment that $[OH^-] = [HCO_2H]$. The point was not earned in part (d)(ii) because numbers are not substituted into the correct formula given. The point was not earned in part (e) because a pH argument with no reference to equal concentrations is not acceptable.

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Question 2

Overview

This question was designed mainly to test students' ability to solve multistep stoichiometry problems. Starting with combustion analysis data, students were first asked to calculate the mass of each of the elements in a sample of a compound and then to find the compound's empirical formula. The students then needed to use colligative property data to find the molar mass and explain how to find the molecular formula. In the last part of the question, students were expected to identify the functional group that accounts for the low pH.

Sample: 2A
Score: 9

This response earned all 9 points: 3 points for part (a)(i), 2 points for part (a)(ii), 1 point for part (b)(i), 1 point for part (b)(ii), 1 point for part (c), and 1 point for part (d).

Sample: 2B
Score: 7

Only 2 out of 3 points were earned in part (a)(i) because the mass of oxygen in the products (rather than the mass of oxygen in the original sample) is calculated—a common error. The number of moles of C, O, and H calculated in part (a)(ii) is consistent with the masses calculated in part (a)(i), so the point for calculating the number of moles was earned. The point was not earned for the empirical formula because the number of moles is not used correctly.

Sample: 2C
Score: 6

Only 2 out of 3 points were earned in part (a)(i) because the response does not recognize that there are two moles of H atoms in one mole of H_2O—a common error. The mass of oxygen calculated is incorrect, but the response is consistent with the correct mass of carbon calculated and the incorrect mass of hydrogen calculated. In part (a)(ii) the number of moles of C, H, and O calculated is consistent with the masses in part (a)(i). However, the empirical formula is not determined correctly from these masses, so that point was not earned. The point was not earned in part (d) because the correct functional group is not named.

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Question 3

Overview

This question was designed to test students' understanding of chemical kinetics. The students were provided with two sets of kinetics data in tabular form and asked a series of questions about each set. For the first set, they were asked to determine the order of reaction for each of the two reactants, to write a consistent rate law, and to determine the value of the rate constant, *k*, and its units. For the second set, they were asked to label the *y*-axis for a linear plot of a catalyzed first order reaction, to give the units of the rate constant, and to draw a line to represent the uncatalyzed reaction.

Sample: 3A
Score: 9

This response earned all 9 points: 1 point for part (a)(i), 1 point for part (a)(ii), 1 point for part (b)(i), 2 points for part (b)(ii), 1 point for part (c)(i), 1 point for part (c)(ii), and 2 points for part (c)(iii).

Sample: 3B
Score: 7

This response earned only 1 out of 2 points in part (b)(ii) because the reciprocal of the rate constant is calculated, not the rate constant. The units are correct. The point was not earned in part (c)(i) because the *y*-axis should be labeled with the natural log of the molarity of H_2O_2, not the molarity of H_2O_2.

Sample: 3C
Score: 5

The point was not earned in part (a)(ii) because the order with respect to ClO^- is 1, not 0. The point was earned in part (b)(i) because the rate law given is consistent with the answers in part (a)(i) and (a)(ii). In part (b)(ii) the value of the rate constant is consistent with the rate law given in part (b)(i): a point was earned for the value, but no point was earned for the incorrect units. The point was not earned in part (c)(i) because the *y*-axis should be labeled $\ln[H_2O_2]$, not $[H_2O_2]$. The point was not earned in part (c)(ii).

Question 4

Overview

This question was designed to assess students' familiarity with chemical nomenclature, knowledge of common classes of chemical reactions, and ability to apply their knowledge in predicting the products(s) of a variety of chemical reactions.

Sample: 4A
Score: 15

This response earned all 15 points. In each part, 1 point was earned for the correct reactant(s), and 2 points were earned for the correct product(s).

Sample: 4B
Score: 11

Only 1 point was earned in part (d). The reactant point was not earned because acetic acid should not be shown as ionized, and 1 product point was earned for two of the four correct products. The reactant point was not earned in part (g) because Na^+ is included, and 1 product point was earned for H_2O.

Sample: 4C
Score: 10

No credit was earned for part (d). $HC_2H_3O_2$ is not extensively ionized, and the charge is missing from the hydrogen carbonate ion. In part (e), the reactant point was earned, but only 1 of the 2 product points was earned because Li_3N is shown as ionized. In part (g) the reactant point was earned, and 1 product point was earned for H_2O.

Question 5

Overview

This question was intended to test students' understanding of descriptive chemistry in some common laboratory experiments. Students were first asked to predict the results of inserting a glowing splint into samples of nitrogen, hydrogen and oxygen gases, and then to predict the pH that would result from the combinations of the oxides of calcium, silicon, and carbon with water. Students were then presented with a partially completed grid of the results of combining three solutions and asked to identify the solutions and predict the results of another combination.

Sample: 5A
Score: 9

This response earned all 9 points: 3 points for part (a), 3 points for part (b), 1 point for part (c)(i), 1 point for part (c)(ii), and 1 point for part (c)(iii).

Sample: 5B
Score: 6

Only 2 out of 3 points were earned in part (a) because the phrase "nothing would occur" is taken to mean that the splint would continue to glow. In part (b) the point was earned for the description of CaO in water, even though the formula $CaOH$ is incorrect. The point was not earned for the description of SiO_2 in water because the response does not indicate that SiO_2 would not dissolve. The point was not earned for the description of CO_2 because the description does not mention the formation of H_2CO_3 .

Sample: 5C
Score: 5

Only 2 out of 3 points were earned in part (a) because the description for hydrogen is not correct. The point was not earned in part (c)(i) because the precipitate is Ag_2S, not $AgCl$. The point was not earned in part (c)(ii) because the precipitate is not K_2S. The point was not earned in part (c)(iii) because the identifications are not consistent with the information provided.

Question 6

Overview

This question tested students' ability to draw Lewis structures and predict geometry, bond angles, and hybridization from the structures. Students were also asked to determine the number of sigma and pi bonds in a molecule and to use formal charge to predict the best Lewis structure for a molecule.

Sample: 6A
Score: 9

This response earned all 9 points: 3 points for part (a), 1 point for part (b)(i), 1 point for part (b)(ii), 1 point for part (b)(iii), 2 points for part (c)(i), and 1 point for part (c)(ii).

Sample: 6B
Score: 7

Only 2 out of 3 points were earned in part (a) because the structure drawn for SF_4 is missing a lone pair of electrons on one of the fluorine atoms. The point was not earned in part (b)(i) because the bond angle is not consistent with the structure drawn in part (a).

Sample: 6C
Score: 5

The point was not earned in part (b)(i) because the bond angle is not consistent with the structure drawn in part (a). The point was not earned in part (b)(ii). The point was not earned in part (b)(iii) because the geometric shape is not consistent with the structure drawn in part (a). The point was not earned in part (c)(ii) because the structure chosen and the justification are incorrect.

Question 7

Overview

This question was designed to test students' knowledge of a variety of concepts, including intermolecular forces and boiling points, bonding and melting points, quantum numbers, why ionization trends on the periodic table occur, isotopes, and an isotope's relationship to the average atomic mass.

Sample: 7A
Score: 8

This response earned all 8 points: 1 point for part (a)(i), 1 point for part (a)(ii), 1 point for part (b)(i), 1 point for part (b)(ii), 1 point for part (c)(i), 1 point for part (c)(ii), 1 point for part (d)(i), and 1 point for part (d)(ii).

Sample: 7B
Score: 7

The point was not earned in part (d)(ii) because, even though the explanation is correct, the wrong isotope is chosen.

Sample: 7C
Score: 6

The point was not earned in part (b)(ii) because the difference in melting points is attributed to a difference in electronegativity. The point was not earned in part (c)(ii) because the reason given is the difference in the number of valence electrons.

Question 8

Overview

This question was designed to test students' ability to apply thermodynamic concepts and to make electrochemical predictions based on reduction half-reactions.

Sample: 8A
Score: 8

This response earned all 8 points: 1 point for part (a), 1 point for part (b), 1 point for part (c)(i), 1 point for part (c)(ii), 1 point for part (d)(i), 1 point for part (d)(ii), 1 point for part (d)(iii), and 1 point for part (d)(iv).

Sample: 8B
Score: 6

The point was not earned in part (c)(i) because the explanation is incorrect. The point was not earned in part (d)(ii) because the incorrect half-reaction is given.

Sample: 8C
Score: 5

The point was not earned in part (d)(i) or (d)(ii) because the incorrect half-reactions are given. The point was not earned in part (d)(iii) because it is the oxidation (not reduction) reaction that takes place at the anode.