AP® Chemistry
2002 Scoring Commentary

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Question 1

Sample 1A (Score 10)

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

Calculations show appropriate use of units and significant figures (±1). The response to part (c)(ii) explains that a pH > 7 results from the hydrolysis of OBr^- to produce OH^-. The response to part (e) indicates a clear understanding of the bonding in the $HBrO_3$ molecule, and correctly describes the effect of additional oxygen atoms on the H–O bond in $HBrO_x$.

Sample 1B (Score 8)

This response earned a total of 8 points — 1 point for part (a), 2 points for part (b), 2 points for part (c)(i), 1 point for part (c)(ii), 2 points for part (d), and 0 points for part (e).

In part (b), the setup is correct, but the numerical answer is the reciprocal of the correct answer; thus 1 point is deducted for a mathematical error (for questions 1, 2, and 3, 1 point is deductible once per question for a mathematical error). Although part (c)(i) earns 2 points, more explicit calculations should be shown for the stoichiometric ratio (2 mol OH^- : 1 mol HOBr). In part (e), the explanation of partial charges is incorrect.

Sample 1C (Score 7)

This response earned a total of 7 points — 1 point for part (a), 3 points for part (b), 1 point for part (c)(i), 0 points for part (c)(ii), 2 points for part (d), and 0 points for part (e).

Part (c)(i) shows appropriate use of units and a correct calculation, but has incorrect stoichiometry (1 mol OH^- : 1 mol HOBr). Part (c)(ii) incorrectly identifies the cause of pH > 7 as an excess of OH^- ions from a strong base. Part (e) contains an ionic versus covalent bond explanation of acid strength.

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Question 2

Sample 2A (Score 10)

This response earned a total of 10 points — 2 points for part (a)(i), 2 points for part (a)(ii), 1 point for part (b), 2 points for part (c), 2 points for part (d), and 1 point for part (e).

In this excellent response, there is clear understanding of the concepts of limiting reactants, electrochemistry, and thermochemistry as posed in this question. The answers were well constructed: there is a definite logical sequence to answering each question, and the final numerical answers are each circled.

Sample 2B (Score 8)

This response earned a total of 8 points — 2 points for part (a)(i), 2 points for part (a)(ii), 0 points for part (b), 1 point for part (c), 2 points for part (d), and 1 point for part (e).

In part (b), the voltage of the Ag half-cell is multiplied by 2, which is a common error. In part (c), the units are not given and there are too many significant digits.

Sample 2C (Score 6)

This response earned a total of 6 points — 1 point for part (a)(i), 2 points for part (a)(ii), 1 point for part (b), 0 points for part (c), 1 point for part (d), and 1 point for part (e).

This response shows some common errors. In part (a)(i), the stoichiometry is forgotten, which leads incorrectly to a determination that Zn is the limiting reactant. The 1 to 2 ratio is not used, but 1 point is earned for correctly continuing on this wrong path and determining that Zn must be consumed first. In part (a)(ii), the response earns both points for the correct determination of the concentration of the Zn^{2+} assuming that Zn is the limiting reactant. Part (b) was answered correctly. No points are earned in part (c) because of the use of the incorrect number of moles of electrons (n) and the lack of units (these were common errors). The response earns 1 point in part (d): the shortened version of the Nernst equation is used, but the substitution for Q is done incorrectly. Part (e) is answered correctly.

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Question 3

Sample 3A (Score 10)

This response earned a perfect score of 10 points — 1 point for part (a), 3 points for part (b), 2 points for part (c), 2 points for part (d), and 2 points for part (e).

An understanding of the relevant concepts and their applications is clearly demonstrated. Calculations are done accurately, and recorded with the correct number of significant figures.

Sample 3B (Score 8)

This response earned a total of 8 points — 1 point for part (a), 3 points for part (b), 2 points for part (c), 2 points for part (d), and 0 points for part (e).

In part (b), all 3 points are earned because a correct formula procedure is selected and correct values are substituted. In part (c), the value of ΔH is correctly calculated, including its negative sign, thus 2 points are earned. In part (d), substitutions are correctly made in Graham's Law, indicating the inverse relationship, and accurate calculations are made. In part (e), there is only a redrawing of the structure given in the question; two additional isomers are not given, thus no points are earned.

Sample 3C (Score 5)

This response earned a total of 5 points — 1 point for part (a), 2 points for part (b), 1 point for part (c), 0 points for part (d), and 1 point for part (e).

The equation is correctly balanced in part (a). While the correct formula is chosen in part (b), there is incorrect substitution for the number of moles of CO_2 . A point is earned by using the correct values for temperature and pressure and an appropriate gas constant. An additional point is earned for calculations based on these substitutions and the correct number of significant figures. In part (c), the correct value for ΔH based on the number of moles of CO_2 is given, but ΔH is not indicated as negative, thus only 1 point out of a possible 2 points is earned. No points are earned in part (d), and in part (e), 1 point is earned for one correct isomer of pentane.

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Question 4

Sample 4A (Score 15)

This response earned a total of 15 points — 3 points for part (a), 3 points for part (c), 3 points for part (f), 3 points for part (g), and 3 points for part (h).

One product point and 2 reactant points were earned for each of the five reactions.

Sample 4B (Score 13)

This response earned a total of 13 points — 1 point for part (a), 3 points for part (c), 3 points for part (e), 3 points for part (g), and 3 points for part (h).

Reaction (a) is treated as a redox reaction instead of a precipitation reaction: no product points are earned, but 1 reactant point is earned.

Sample 4C (Score 10)

This response earned a total of 10 points — 3 points for part (b), 3 points for part (d), 2 points for part (e), 0 points for part (g), and 2 points for part (h).

In reaction (h), one of the reactants is solid ammonium chloride: the reactant point is not earned, but both product points are earned. Reaction (g) is treated as a precipitation reaction instead of a redox reaction. CO_2 is the only correct product given for reaction (e): 1 product point and 1 reactant point are earned.

Sample 4D (Score 9)

This response earned a total of 9 points — 2 points for part (a), 2 points for part (c), 2 points for part (f), 1 point for part (g), and 2 points for part (h).

In reaction (c), the Cs ion has the wrong charge, so only 1 product point is earned. In reaction (f), ZnS is not shown as being insoluble: the reactant point is not earned, but 2 product points are earned because the response is consistent. In reaction (a), lead(II) acetate should have been shown as soluble: the reactant point is not earned, but 2 product points are earned because the response is consistent. In reaction (g), the permanganate ion has the wrong charge: 1 product point is earned for the formation of water.

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Question 5

Sample 5A (Score 10)

This response earned a total of 10 points — 2 points for part (a), 2 points for part (b), 1 point for part (c)(i), 2 points for part (c)(ii), 1 point for part (d)(i), 1 point for part (d)(ii), and 1 point for part (e).

This is a superior response that includes considerable detail of the steps needed to calculate the results from the measurements made in the experiment.

Sample 5B (Score 8)

This response earned a total of 8 points — 2 points for part (a), 2 points for part (b), 1 point for part (c)(i), 1 point for part (c)(ii), 0 points for part (d)(i), 1 point for part (d)(ii), and 1 point for part (e).

In part (c)(ii), there is no explanation of how to calculate ΔH from the q value obtained in the experiment. In part (d)(i), it is indicated that q increases because mass, m , in the equation increases. This is incorrect, as m is the total mass of solution in the calorimeter.

Sample 5C (Score 6)

This response earned a total of 6 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), and 0 points for part (e).

In part (a), the units for c are incorrect. In part (b), temperature change earns no point because it is not a direct measurement. In part (c)(ii), grams of water formed by the reaction should not be used in the calculation of q (total mass of the water should be used instead). No points are earned for the incorrect answer and explanation in part (e).

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Question 6

Sample 6A (Score 8)

This response earned a total of 8 points — 2 points for part (a), 2 points for part (b), 2 points for part (c), and 2 points for part (d).

This response contains concise and clear answers for all four parts.

Sample 6B (Score 6)

This response earned a total of 6 points — 1 point for part (a), 2 points for part (b), 1 point for part (c), and 2 points for part (d).

The response for part (a) earns only 1 point because it does not address whether or not the electrons are in the same shell. The response for part (c) earns only 1 point because it does not indicate that the double bond is stronger than the single bond.

Sample 6C (Score 4)

This response earned a total of 4 points — 2 points for part (a), 1 point for part (b), 1 point for part (c), and 0 points for part (d).

The response for part (b) fails to earn the second point because it does not address why it is harder to remove an electron from a filled shell. In part (c), the structures are correct but there is an insufficient explanation of why the bond energy is greater in a double bond — simply restating the prompt does not earn the point. In part (d), no points are earned; there is a description of London dispersion forces being *inside* the atom, the statement that the forces for chlorine are *greater* than on bromine, and an incorrect electronegativity argument.

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Question 7

Sample 7A (Score 8)

This response earned a total of 8 points — 1 point for part (a), 2 points for part (b), 2 points for part (c), 1 point for part (d)(i), 1 point for part (d)(ii), and 1 point for part (d)(iii).

This is an excellent response, with all answers correct and clearly shown.

Sample 7B (Score 6)

This response earned a total of 6 points — 1 point for part (a), 1 point for part (b), 2 points for part (c), 1 point for part (d)(i), 0 points for part (d)(ii), and 1 point for part (d)(iii).

Only 1 of 2 points is earned in part (b) because no mention is made of the fact that Cl reappears as a product, unchanged. In part d(ii), the units should be M^{-1} s^{-1} (or M^{-1} $time^{-1}$)

Sample 7C (Score 5)

This response earned a total of 5 points — 1 point for part (a), 1 point for part (b), 2 points for part (c), 0 points for part (d)(i), 0 points for part (d)(ii), and 1 point for part (d)(iii).

Only 1 of 2 points is earned in part (b) because no mention is made of the fact that Cl reappears as a product, unchanged. In part d(i), the reaction order should be 2, and in part d(ii), the units should be M^{-1} $time^{-1}$.

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Question 8

Sample 8A (Score 8)

This response earned a total of 8 points — 2 points for part (a), 2 points for part (b), 2 points for part (c), and 2 points for part (d).

A wonderful response — the graph is particularly well drawn and labeled.

Sample 8B (Score 6)

This response earned a total of 6 points — 2 points for part (a), 2 points for part (b), 2 points for part (c), and 0 points for part (d).

In part (d), the response does not earn any points because solid carbon is stated to have an effect on equilibrium.

Sample 8C (Score 5)

This response earned a total of 5 points — 2 points for part (a), 2 points for part (b), 1 point for part (c), and 0 points for part (d).

Only 1 point is earned in part (c) because the graph drawn is for an exothermic reaction. The 2 points for part (d) are not earned because solid carbon is said to have an effect on equilibrium.