AP® CHEMISTRY
2006 SCORING GUIDELINES

Question 3

3. Answer the following questions that relate to the analysis of chemical compounds.

(a) A compound containing the elements C, H, N, and O is analyzed. When a 1.2359 g sample is burned in excess oxygen, 2.241 g of $CO_2(g)$ is formed. The combustion analysis also showed that the sample contained 0.0648 g of H.

(i) Determine the mass, in grams, of C in the 1.2359 g sample of the compound.

$2.241\ \text{g}\ CO_2(g) \times \frac{1\ \text{mol}\ CO_2}{44.01\ \text{g}\ CO_2} \times \frac{1\ \text{mol C}}{1\ \text{mol}\ CO_2} \times \frac{12.011\ \text{g C}}{1\ \text{mol C}}$ $= 0.6116\ \text{g C}$	One point is earned for the correct answer.

(ii) When the compound is analyzed for N content only, the mass percent of N is found to be 28.84 percent. Determine the mass, in grams, of N in the original 1.2359 g sample of the compound.

$1.2359\ \text{g sample} \times 0.2884 = 0.3564\ \text{g N}$	One point is earned for the correct answer.

(iii) Determine the mass, in grams, of O in the original 1.2359 g sample of the compound.

Because the compound contains only C, H, N, and O, mass of O = g sample − (g H + g C + g N) $= 1.2359 - (0.0648 + 0.6116 + 0.3564) = 0.2031\ \text{g}$	One point is earned for the answer consistent with the answers in parts (a)(i) and (a)(ii).

(iv) Determine the empirical formula of the compound.

Converting all masses to moles, $0.6116\ \text{g C} \times \frac{1\ \text{mol C}}{12.011\ \text{g C}} = 0.05092\ \text{mol C}$ $0.0648\ \text{g H} \times \frac{1\ \text{mol H}}{1.0079\ \text{g H}} = 0.06429\ \text{mol H}$ $0.3564\ \text{g N} \times \frac{1\ \text{mol N}}{14.007\ \text{g N}} = 0.02544\ \text{mol N}$ $0.2031\ \text{g O} \times \frac{1\ \text{mol O}}{16.00\ \text{g O}} = 0.01269\ \text{mol O}$	One point is earned for all masses converted to moles. Note: Moles of C may be shown in part (a)(i).

Divide all mole quantities by the smallest number of moles: 0.05092 mol ÷ 0.01269 mol = 4.013 0.06429 mol ÷ 0.01269 mol = 5.066 0.02544 mol ÷ 0.01269 mol = 2.005 0.01269 mol ÷ 0.01269 mol = 1.000 ⇒ Empirical formula is $C_4H_5N_2O$	One point is earned for dividing by the smallest number of moles. One point is earned for the empirical formula consistent with the ratio of moles calculated.

(b) A different compound, which has the empirical formula CH_2Br, has a vapor density of 6.00 g L^{-1} at 375 K and 0.983 atm. Using these data, determine the following.

(i) The molar mass of the compound

$PV = nRT \Rightarrow \frac{PV}{RT} = n$ $\frac{(0.983\text{ atm})(1.00\text{ L})}{(0.0821\text{ L atm mol}^{-1}\text{K}^{-1})(375\text{ K})} = 0.0319\text{ mol}$ molar mass of gas (M) $= \frac{6.00\text{ g}}{0.0319\text{ mol}} = 188\text{ g mol}^{-1}$ *OR* $M = \frac{DRT}{P} = \frac{6.00\text{ g L}^{-1} \times 0.0821\text{ L atm mol}^{-1}\text{ K}^{-1} \times 375\text{ K}}{0.983\text{ atm}}$ $= 188\text{ g mol}^{-1}$	One point is earned for applying the gas law to calculate n. One point is earned for calculating the molar mass. *OR* Two points are earned for calculating the molar mass using $M = \frac{DRT}{P}$

(ii) The molecular formula of the compound

Each CH_2Br unit has mass of 12.011 + 2(1.0079) + 79.90 = 93.9 g, and $\frac{188\text{ g}}{93.9\text{ g}} = 2.00$, so there must be two CH_2Br units per molecule. Therefore, the molecular formula of the compound is $C_2H_4Br_2$.	One point is earned for the molecular formula that is consistent with the molar mass calculated in part (b)(i).

AP® CHEMISTRY
2008 SCORING GUIDELINES

Question 2

Answer the following questions relating to gravimetric analysis.

In the first of two experiments, a student is assigned the task of determining the number of moles of water in one mole of $MgCl_2 \cdot n\,H_2O$. The student collects the data shown in the following table.

Mass of empty container	22.347 g
Initial mass of sample and container	25.825 g
Mass of sample and container after first heating	23.982 g
Mass of sample and container after second heating	23.976 g
Mass of sample and container after third heating	23.977 g

(a) Explain why the student can correctly conclude that the hydrate was heated a sufficient number of times in the experiment.

No additional mass was lost during the third heating, indicating that all the water of hydration had been driven off.	One point is earned for the correct explanation.

(b) Use the data above to

(i) calculate the total number of moles of water lost when the sample was heated, and

mass of H_2O lost $= 25.825 - 23.977 = 1.848$ g *OR* $25.825 - 23.976 = 1.849$ g $1.848\text{ g } H_2O \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O} = 0.1026\text{ mol } H_2O$	One point is earned for calculating the correct number of moles of water.

(ii) determine the formula of the hydrated compound.

mass of anhydrous $MgCl_2 = 23.977 - 22.347 = 1.630$ g $1.630\text{ g } MgCl_2 \times \frac{1\text{ mol } MgCl_2}{95.20\text{ g } MgCl_2} = 0.01712\text{ mol } MgCl_2$ $\frac{0.1026\text{ mol } H_2O}{0.01712\text{ mol } MgCl_2} = 5.993 \approx 6\text{ mol } H_2O \text{ per mol } MgCl_2$ $\Rightarrow$ formula is $MgCl_2 \cdot 6H_2O$	One point is earned for calculating the correct number of moles of anhydrous $MgCl_2$. One point is earned for writing the correct formula (with supporting calculations).

Question 2 (continued)

(c) A different student heats the hydrate in an uncovered crucible, and some of the solid spatters out of the crucible. This spattering will have what effect on the calculated mass of the water lost by the hydrate? Justify your answer.

The calculated mass (or moles) of water lost by the hydrate will be too large because the mass of the solid that was lost will be assumed to be water when it actually included some $MgCl_2$ as well.	One point is earned for the correct answer with justification.

In the second experiment, a student is given 2.94 g of a mixture containing anhydrous $MgCl_2$ and KNO_3. To determine the percentage by mass of $MgCl_2$ in the mixture, the student uses excess $AgNO_3(aq)$ to precipitate the chloride ion as $AgCl(s)$.

(d) Starting with the 2.94 g sample of the mixture dissolved in water, briefly describe the steps necessary to quantitatively determine the mass of the AgCl precipitate.

Add excess $AgNO_3$. - Separate the AgCl precipitate (by filtration). - Wash the precipitate and dry the precipitate completely. - Determine the mass of AgCl by difference.	Two points are earned for all three major steps: filtering the mixture, drying the precipitate, and determining the mass by difference. One point is earned for any two steps.

(e) The student determines the mass of the AgCl precipitate to be 5.48 g. On the basis of this information, calculate each of the following.

(i) The number of moles of $MgCl_2$ in the original mixture

$5.48 \text{ g AgCl} \times \frac{1 \text{ mol AgCl}}{143.32 \text{ g AgCl}} = 0.0382 \text{ mol AgCl}$ $0.0382 \text{ mol AgCl} \times \frac{1 \text{ mol Cl}}{1 \text{ mol AgCl}} \times \frac{1 \text{ mol } MgCl_2}{2 \text{ mol Cl}} = 0.0191 \text{ mol } MgCl_2$	One point is earned for calculating the number of moles of AgCl. One point is earned for conversion to moles of $MgCl_2$.

(ii) The percent by mass of $MgCl_2$ in the original mixture

$0.0191 \text{ mol } MgCl_2 \times \frac{95.20 \text{ g } MgCl_2}{1 \text{ mol } MgCl_2} = 1.82 \text{ g } MgCl_2$ $\frac{1.82 \text{ g } MgCl_2}{2.94 \text{ g sample}} \times 100\% = 61.9\% \text{ } MgCl_2 \text{ by mass}$	One point is earned for calculating the correct percentage.

AP® CHEMISTRY
2008 SCORING GUIDELINES (Form B)

Question 3

A 0.150 g sample of solid lead(II) nitrate is added to 125 mL of 0.100 *M* sodium iodide solution. Assume no change in volume of the solution. The chemical reaction that takes place is represented by the following equation.

$$Pb(NO_3)_2(s) + 2\,NaI(aq) \rightarrow PbI_2(s) + 2\,NaNO_3(aq)$$

(a) List an appropriate observation that provides evidence of a chemical reaction between the two compounds.

A precipitate forms with an appearance that is different from that of the dissolving solid.	One point is earned for stating that a precipitate is formed.

(b) Calculate the number of moles of each reactant.

$\text{mol } Pb(NO_3)_2 = 0.150 \text{ g } Pb(NO_3)_2 \times \frac{1 \text{ mol } Pb(NO_3)_2}{331 \text{ g } Pb(NO_3)_2}$ $= 4.53 \times 10^{-4} \text{ mol}$ $\text{mol NaI} = 0.100\,M \times 0.125 \text{ L} = 1.25 \times 10^{-2} \text{ mol}$	One point is earned for the correct number of moles of $Pb(NO_3)_2$. One point is earned for the correct number of moles of NaI.

(c) Identify the limiting reactant. Show calculations to support your identification.

$\text{mol NaI reacting} = 4.53 \times 10^{-4} \text{ mol } Pb(NO_3)_2 \times \frac{2 \text{ mol NaI}}{1 \text{ mol } Pb(NO_3)_2}$ $= 9.06 \times 10^{-4} \text{ mol}$ There is 1.25×10^{-2} mol of NaI initially, thus $Pb(NO_3)_2$ is the limiting reactant.	One point is earned for the identification of $Pb(NO_3)_2$. One point is earned for a justification in terms of the relative numbers of moles.

(d) Calculate the molar concentration of $NO_3^-(aq)$ in the mixture after the reaction is complete.

$[NO_3^-]_f = \frac{2 \times (4.53 \times 10^{-4} \text{ mol})}{0.125 \text{ L}} = 7.25 \times 10^{-3}\,M$	One point is earned for the correct NO_3^-/Pb^{2+} stoichiometry. One point is earned for the correct molarity.

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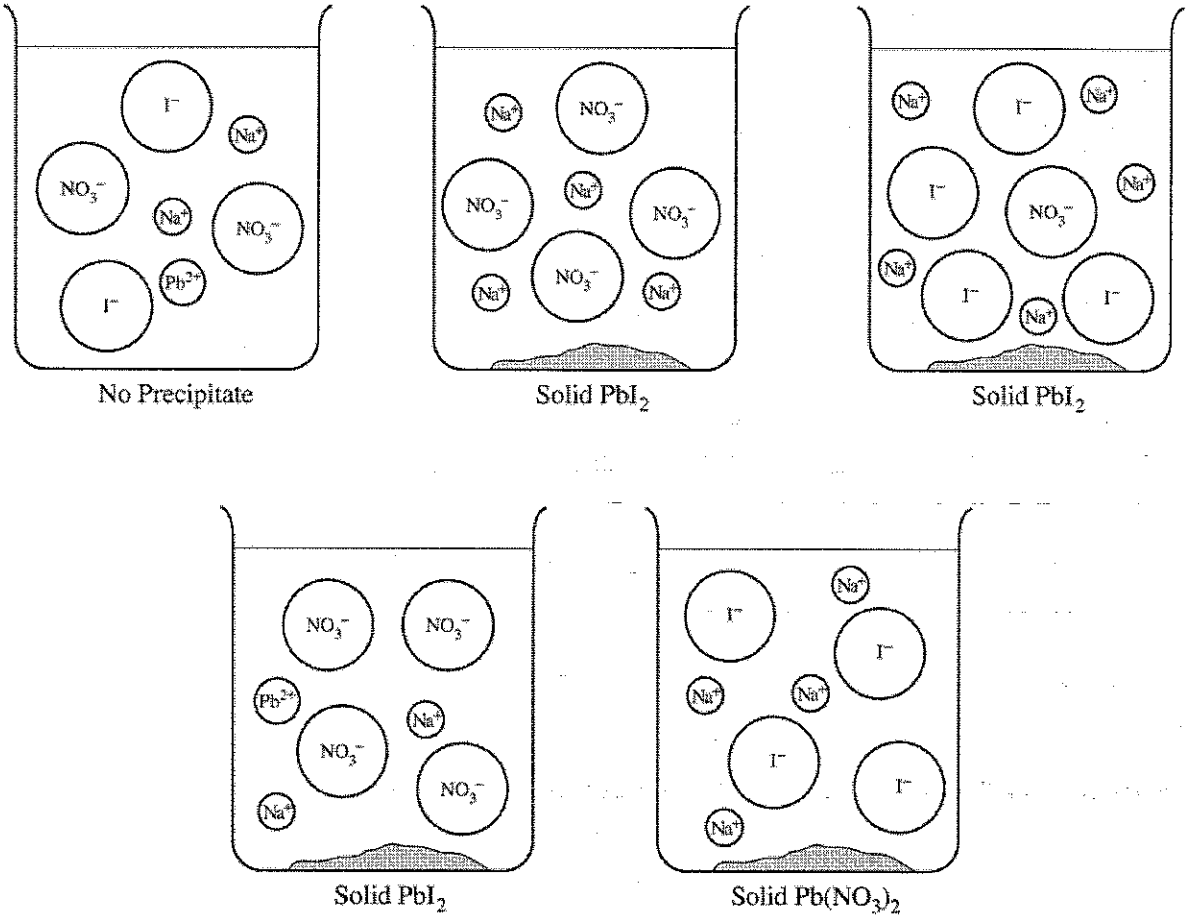
2008 SCORING GUIDELINES (Form B)

Question 3 (continued)

(e) Circle the diagram below that best represents the results after the mixture reacts as completely as possible. Explain the reasoning used in making your choice.



The rightmost diagram in the top row should be circled. PbI_2 precipitates and $Pb(NO_3)_2$ is the limiting reactant, so there is essentially no Pb^{2+} in solution. Because there was so much NaI in excess, some of the I^- remains in solution, along with the Na^+ and NO_3^-.	One point is earned for the selection of the correct diagram. One point is earned for the correct rationale.

AP® CHEMISTRY
2009 SCORING GUIDELINES

Question 2 (10 points)

A student was assigned the task of determining the molar mass of an unknown gas. The student measured the mass of a sealed 843 mL rigid flask that contained dry air. The student then flushed the flask with the unknown gas, resealed it, and measured the mass again. Both the air and the unknown gas were at 23.0°C and 750. torr. The data for the experiment are shown in the table below.

Volume of sealed flask	843 mL
Mass of sealed flask and dry air	157.70 g
Mass of sealed flask and unknown gas	158.08 g

(a) Calculate the mass, in grams, of the dry air that was in the sealed flask. (The density of dry air is 1.18 g L^{-1} at 23.0°C and 750. torr.)

$m = D \times V = (1.18 \text{ g L}^{-1})(0.843 \text{ L}) =$ **0.995 g**	One point is earned for the correct setup and calculation of mass.

(b) Calculate the mass, in grams, of the sealed flask itself (i.e., if it had no air in it).

157.70 g – 0.995 g = **156.71 g**	One point is earned for subtracting the answer in part (a) from 157.70 g.

(c) Calculate the mass, in grams, of the unknown gas that was added to the sealed flask.

158.08 g – 156.71 g = **1.37 g**	One point is earned for subtracting the answer in part (b) from 158.08 g.

(d) Using the information above, calculate the value of the molar mass of the unknown gas.

$n = \frac{PV}{RT} = \frac{\left(\frac{750.}{760}\text{atm}\right)(0.843 \text{ L})}{(0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1})(296 \text{ K})} = 0.0342 \text{ mol}$ molar mass $= \frac{1.37 \text{ g}}{0.0342 \text{ mol}} =$ **40.1 g mol^{-1}** **OR** molar mass $= \frac{DRT}{P}$ $= \frac{\left(\frac{1.37 \text{ g}}{0.843 \text{ L}}\right)(0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1})(296 \text{ K})}{\left(\frac{750.}{760}\text{atm}\right)}$ = **40.0 g mol^{-1}**	One point is earned for the conversion of pressure (if necessary) and temperature and the use of the appropriate R. One point is earned for the correct setup and calculation of moles of gas. One point is earned for the correct setup and calculation of molar mass. **OR** If calculation is done in a single step, 1 point is earned for the correct P and T, 1 point is earned for the correct density, and 1 point is earned for the correct answer.

AP® CHEMISTRY
2009 SCORING GUIDELINES

Question 2 (continued)

After the experiment was completed, the instructor informed the student that the unknown gas was carbon dioxide ($44.0\ g\ mol^{-1}$).

(e) Calculate the percent error in the value of the molar mass calculated in part (d).

$\text{percent error} = \frac{\left\lvert 44.0\ g\,mol^{-1} - 40.1\ g\,mol^{-1} \right\rvert}{44.0\ g\,mol^{-1}} \times 100 = 8.9\%$	One point is earned for the correct setup and answer.

(f) For each of the following two possible occurrences, indicate whether it by itself could have been responsible for the error in the student's experimental result. You need not include any calculations with your answer. For each of the possible occurrences, justify your answer.

Occurrence 1: The flask was incompletely flushed with $CO_2(g)$, resulting in some dry air remaining in the flask.

This occurrence could have been responsible. The dry air left in the flask is less dense (or has a lower molar mass) than CO_2 gas at the given T and P. This would result in a lower mass of gas in the flask and a lower result for the molar mass of the unknown gas.	One point is earned for the correct reasoning and conclusion.

Occurrence 2: The temperature of the air was 23.0°C, but the temperature of the $CO_2(g)$ was lower than the reported 23.0°C.

This occurrence could not have been responsible. The density of CO_2 is greater at the lower temperature. A larger mass of CO_2 would be in the flask than if the CO_2 had been at 23.0°C, resulting in a higher calculated molar mass for the unknown gas.	One point is earned for the correct reasoning and conclusion.

(g) Describe the steps of a laboratory method that the student could use to verify that the volume of the rigid flask is 843 mL at 23.0°C. You need not include any calculations with your answer.

Valid methods include the following: 1. Find the mass of the empty flask. Fill the flask with a liquid of known density (e.g., water at 23°C), and measure the mass of the liquid-filled flask. Subtract to find the mass of the liquid. Using the known density and mass, calculate the volume. 2. Measure 843 mL of a liquid (e.g., water) in a 1,000 mL graduated cylinder and transfer the liquid quantitatively into the flask to see if the water fills the flask completely.	One point is earned for a valid method.

AP® CHEMISTRY
2009 SCORING GUIDELINES

Question 2 (continued)

Note: Significant figures were checked in this problem: parts (a) and (d) were scored with ±1 significant figure needed, and parts (b) and (c) were scored with the correct number of significant figures needed for the subtraction.

AP® CHEMISTRY
2009 SCORING GUIDELINES (Form B)

Question 3 (10 points)

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

The mass of an aqueous solution of H_2O_2 is 6.951 g. The H_2O_2 in the solution decomposes completely according to the reaction represented above. The $O_2(g)$ produced is collected in an inverted graduated tube over water at 23.4°C and has a volume of 182.4 mL when the water levels inside and outside of the tube are the same. The atmospheric pressure in the lab is 762.6 torr, and the equilibrium vapor pressure of water at 23.4°C is 21.6 torr.

(a) Calculate the partial pressure, in torr, of $O_2(g)$ in the gas-collection tube.

$P_{atm} = P_{O_2} + P_{H_2O} \Rightarrow P_{O_2} = P_{atm} - P_{H_2O}$ $P_{O_2} = 762.6 \text{ torr} - 21.6 \text{ torr} = \mathbf{741.0 \text{ torr}}$	One point is earned for the correct answer.

(b) Calculate the number of moles of $O_2(g)$ produced in the reaction.

$PV = nRT \Rightarrow n = \frac{PV}{RT}$ $P = 741.0 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 0.9750 \text{ atm}$ $T = 273.15 + 23.4°C = 296.6 \text{ K}$ $V = 182.4 \text{ mL} \times \frac{1 \text{ L}}{1{,}000 \text{ mL}} = 0.1824 \text{ L}$ $n_{O_2} = \frac{PV}{RT} = \frac{(0.9750 \text{ atm})(0.1824 \text{ L})}{(0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1})(296.6 \text{ K})} = \mathbf{7.304 \times 10^{-3} \text{ mol}}$	One point is earned for the correct substitutions. One point is earned for the correct answer.

(c) Calculate the mass, in grams, of H_2O_2 that decomposed.

$(7.304 \times 10^{-3} \text{ mol } O_2) \times \frac{2 \text{ mol } H_2O_2}{1 \text{ mol } O_2} \times \frac{34.0 \text{ g } H_2O_2}{1 \text{ mol } H_2O_2} = \mathbf{0.497 \text{ g } H_2O_2}$	One point is earned for the conversion of mol O_2 to mol H_2O_2. One point is earned for the correct mass.

(d) Calculate the percent of H_2O_2, by mass, in the original 6.951 g aqueous sample.

$\frac{0.497 \text{ g } H_2O_2}{6.951 \text{ g sample}} \times 100 = \mathbf{7.15\%}$	One point is earned for the correct answer.

Question 3 (continued)

(e) Write the oxidation number of the oxygen atoms in H_2O_2 and the oxidation number of the oxygen atoms in O_2 in the appropriate cells in the table below.

Substance	Oxidation Number of Oxygen Atoms
H_2O_2	
O_2	

In H_2O_2, the oxidation number of O is -1. In O_2, the oxidation number of O is 0.	Two points are earned for the correct oxidation numbers (1 point each).

(f) Write the balanced oxidation half-reaction for the reaction.

$H_2O_2(aq) \rightarrow O_2(g) + 2\,H^+(aq) + 2\,e^-$	One point is earned for the correct reactant and products. One point is earned for correct balancing.

AP® CHEMISTRY
2010 SCORING GUIDELINES (Form B)

Question 3
(10 points)

A sample of ore containing the mineral tellurite, TeO_2, was dissolved in acid. The resulting solution was then reacted with a solution of $K_2Cr_2O_7$ to form telluric acid, H_2TeO_4. The unbalanced chemical equation for the reaction is given below.

$$\ldots TeO_2(s) + \ldots Cr_2O_7^{2-}(aq) + \ldots H^+(aq) \rightarrow \ldots H_2TeO_4(aq) + \ldots Cr^{3+}(aq) + \ldots H_2O(l)$$

(a) Identify the molecule or ion that is being oxidized in the reaction.

TeO_2 or Te^{4+}	One point is earned for correct identification of molecule or ion.

(b) Give the oxidation number of Cr in the $Cr_2O_7^{2-}(aq)$ ion.

+6	One point is earned for the correct answer.

(c) Balance the chemical equation given above by writing the correct lowest whole-number coefficients on the dotted lines.

$3\ TeO_2(s) + 1\ Cr_2O_7^{2-}(aq) + 8\ H^+(aq) \rightarrow 3\ H_2TeO_4(aq) + 2\ Cr^{3+}(aq) + 1\ H_2O(l)$
One point is earned for either (1) two correct balances among Cr, H, O, charge, and Te vs. $Cr_2O_7^{2-}$ (for balancing by inspection or oxidation number method) *OR* (2) one correct half reaction or use of the correct multiplier to balance the charge (for balancing by half-reaction method). One additional point is earned for a correctly balanced equation.

In the procedure described above, 46.00 mL of 0.03109 *M* $K_2Cr_2O_7$ was added to the ore sample after it was dissolved in acid. When the chemical reaction had progressed as completely as possible, the amount of unreacted (excess) $Cr_2O_7^{2-}(aq)$ was determined by titrating the solution with 0.110 *M* $Fe(NO_3)_2$. The reaction that occurred during the titration is represented by the following balanced equation.

$$6\ Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14\ H^+(aq) \rightarrow 2\ Cr^{3+}(aq) + 6\ Fe^{3+}(aq) + 7\ H_2O(l)$$

A volume of 9.85 mL of 0.110 *M* $Fe(NO_3)_2$ was required to reach the equivalence point.

Question 3 (continued)

(d) Calculate the number of moles of excess $Cr_2O_7^{2-}(aq)$ that was titrated.

By the stoichiometry of the titration reaction, moles of excess $Cr_2O_7^{2-}$ titrated $= \left(\frac{1}{6}\right)$ mol Fe^{2+} in 9.85 mL of 0.110 *M* $Fe(NO_3)_2$ $= \left(\frac{1}{6}\right)(0.00985\text{ L})(0.110\text{ mol } Fe(NO_3)_2\text{ L}^{-1})$ $= 0.000181$ mol	One point is earned for either the correct stoichiometric factor *OR* correct use of (0.00985)(0.110) factor. One point is earned for the correct numerical answer with the correct number of significant figures.

(e) Calculate the number of moles of $Cr_2O_7^{2-}(aq)$ that reacted with the tellurite.

moles $Cr_2O_7^{2-}$ that reacted with TeO_2 = total mol $Cr_2O_7^{2-}$ added − excess mol $Cr_2O_7^{2-}$ titrated = (0.04600 L)(0.03109 mol $Cr_2O_7^{2-}$ L^{-1}) − excess mol $Cr_2O_7^{2-}$ titrated = 0.001430 mol − 0.000181 mol = 0.001249 mol $Cr_2O_7^{2-}$	One point is earned for correct calculation of initial moles of dichromate ion. One point is earned for correct numerical answer with correct number of significant figures.

(f) Calculate the mass, in grams, of tellurite that was in the ore sample.

mass of TeO_2 in sample $= 0.001249\text{ mol } Cr_2O_7^{2-} \times \frac{3\text{ mol } TeO_2}{1\text{ mol } Cr_2O_7^{2-}} \times \frac{159.6\text{ g } TeO_2}{1\text{ mol } TeO_2}$ $= 0.5980$ g	One point is earned for appropriate use of the stoichiometric factor *OR* for correct calculation of molar mass of TeO_2. One point is earned for the correct numerical answer.

AP® CHEMISTRY
2011 SCORING GUIDELINES

Question 2

A student is assigned the task of determining the mass percent of silver in an alloy of copper and silver by dissolving a sample of the alloy in excess nitric acid and then precipitating the silver as AgCl.

First the student prepares 50. mL of 6 *M* HNO_3.

(a) The student is provided with a stock solution of 16 *M* HNO_3, two 100 mL graduated cylinders that can be read to ±1 mL, a 100 mL beaker that can be read to ±10 mL, safety goggles, rubber gloves, a glass stirring rod, a dropper, and distilled H_2O.

(i) Calculate the volume, in mL, of 16 *M* HNO_3 that the student should use for preparing 50. mL of 6 *M* HNO_3.

moles before dilution = moles after dilution $M_iV_i = M_fV_f$ $(16\ M)(V_i) = (6\ M)(50.\ mL)$ V_i = 19 mL or 20 mL (to one significant figure)	1 point is earned for the correct volume.

(ii) Briefly list the steps of an appropriate and safe procedure for preparing the 50. mL of 6 *M* HNO_3. Only materials selected from those provided to the student (listed above) may be used.

Wear safety goggles and rubber gloves. Then measure 19 mL of 16 *M* HNO_3 using a 100 mL graduated cylinder. Measure 31 mL of distilled H_2O using a 100 mL graduated cylinder. Transfer the water to a 100 mL beaker. Add the acid to the water with stirring.	1 point is earned for properly measuring the volume of 16 *M* HNO_3 and preparing a 6 *M* HNO_3 acid solution. 1 point is earned for wearing protective gear and for adding acid to water.

(iii) Explain why it is <u>not</u> necessary to use a volumetric flask (calibrated to 50.00 mL ±0.05 mL) to perform the dilution.

The graduated cylinders provide sufficient precision in volume measurement to provide two significant figures, making the use of the volumetric flask unnecessary.	1 point is earned for an acceptable explanation.

(iv) During the preparation of the solution, the student accidentally spills about 1 mL of 16 *M* HNO_3 on the bench top. The student finds three bottles containing liquids sitting near the spill: a bottle of distilled water, a bottle of 5 percent $NaHCO_3(aq)$, and a bottle of saturated $NaCl(aq)$. Which of the liquids is best to use in cleaning up the spill? Justify your choice.

$NaHCO_3(aq)$ should be used. The HCO_3^- ion will react as a base to neutralize the HNO_3.	1 point is earned for the correct choice with explanation.

Then the student pours 25 mL of the 6 M HNO_3 into a beaker and adds a 0.6489 g sample of the alloy. After the sample completely reacts with the acid, some saturated $NaCl(aq)$ is added to the beaker, resulting in the formation of an AgCl precipitate. Additional $NaCl(aq)$ is added until no more precipitate is observed to form. The precipitate is filtered, washed, dried, and weighed to constant mass in a filter crucible. The data are shown in the table below.

Mass of sample of copper-silver alloy	0.6489 g
Mass of dry filter crucible	28.7210 g
Mass of filter crucible and precipitate (first weighing)	29.3587 g
Mass of filter crucible and precipitate (second weighing)	29.2599 g
Mass of filter crucible and precipitate (third weighing)	29.2598 g

(b) Calculate the number of moles of AgCl precipitate collected.

mass of AgCl collected $= (29.2598 - 28.7210)\text{ g} = 0.5388\text{ g}$ $\frac{0.5388\text{ g}}{(107.87 + 35.45)\text{ g mol}^{-1}} = 3.759 \times 10^{-3}\text{ mol AgCl}$	1 point is earned for the correct mass of AgCl. 1 point is earned for the correct number of moles of AgCl given with the correct number of significant figures.

(c) Calculate the mass percent of silver in the alloy of copper and silver.

$3.759 \times 10^{-3}\text{ mol Ag} \times \frac{107.87\text{ g Ag}}{1\text{ mol Ag}} = 0.4055\text{ g Ag}$ $\frac{0.4055\text{ g}}{0.6489\text{ g}} \times 100\% = 62.49\%\text{ Ag}$	1 point is earned for the correct setup and the correct calculation of the mass of Ag. 1 point is earned for the correct percent of Ag.