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.