AP Chemistry Exam
Part I: 40 Questions, 40 minutes, Multiple Choice, No Calculator Allowed
Bubble the correct answer on your scantron for each of the following.

Use the following answers for questions 1 - 3.
      (A) F   (B) S   (C) Mg   (D) Ar   (E) Mn

1. Forms monatomic ions with 2^- charge in solutions
2. Forms a compound having the formula KXO_4
3. Forms oxides that are common air pollutants and that yield acidic solution in water

4. Which of the following represents a pair of isotopes?

		Atomic Number	Mass Number
(A)	I.	6	14
	II.	7	14
(B)	I.	6	7
	II.	14	14
(C)	I.	6	14
	II.	14	28
(D)	I.	7	13
	II.	7	14
(E)	I.	8	16
	II.	16	20

5.   .....Mg(s) + ...NO_3^- (aq) +.....H^+(aq) $\rightarrow$ ......Mg^{2+}(aq) + ...NH_4^+(aq) + ...H_2O(l)
When the skeleton equation above is balanced and all coefficients reduced to their lowest whole-number terms. what is the coefficient for H^+ ?
(A) 4   (B) 6   (C) 8   (D) 9   (E) 10

6. What number of moles of O_2 is needed to produce 14.2 grams of P_4O_{10} from P? (Molecular weight P_4O_{10} = 284)
(A) 0.0500 mole (B) 0.0625 mole   (C) 0.125 mole   (D) 0.250 mole   (E) 0.500 mole

7. The alkenes are compounds of carbon and hydrogen with the general formula C_nH_{2n}. If 0.561 gram of any alkene is burned in excess oxygen, what number of moles of H_2O is formed?
(A) 0.0400 mole (B) 0.0600 mole   (C) 0.0800 mole   (D) 0.400 mole   (E) 0.800 mole

8. When 70. milliliters of 3.0-molar Na_2CO_3 is added to 30. milliliters of 1.0-molar $NaHCO_3$ the resulting concentration of Na^+ is
(A) 2.0 M   (B) 2.4 M   (C) 4.0 M   (D) 4.5 M   (E) 7.0 M

9. Which of the following species CANNOT function as an oxidizing agent?
(A) $Cr_2O_7^{2-}$ (B) MnO_4^- (C) NO_3^- (D) S   (E) I^-

10. A 20.0-milliliter sample of 0.200-molar K_2CO_3 solution is added to 30.0 milliliters of 0.400-molar $Ba(NO_3)_2$ solution. Barium carbonate precipitates. The concentration of barium ion, Ba^{2+}, in solution after reaction is
(A) 0.150 M   (B) 0.160 M   (C) 0.200 M   (D) 0.240 M   (E) 0.267 M

11. A 27.0-gram sample of an unknown hydrocarbon was burned in excess oxygen to form 88.0 grams of carbon dioxide and 27.0 grams of water. What is a possible molecular formula of the hydrocarbon?
(A) CH_4 (B) C_2H_2 (C) C_4H_3 (D) C_4H_6 (E) C_4H_{10}

12. The weight of H_2SO_4 (molecular weight 98.1) in 50.0 milliliters of a 6.00-molar solution is
(A) 3.10 grams   (B) 12.0 grams   (C) 29.4 grams   (D) 294 grams   (E) 300. grams

13. $6\ I^- + 2\ MnO_4^- + 4\ H_2O(l) \rightarrow 3\ I_2(s) + 2\ MnO_2(s) + 8OH^-$
Which of the following statements regarding the reaction represented by the equation above is correct?
(A) Iodide ion is oxidized by hydroxide ion.
(B) MnO_4^- is oxidized by iodide ion.
(C) The oxidation number of manganese changes from +7 to +2.
(D) The oxidation number of manganese remains the same.
(E) The oxidation number of iodine changes from -1 to 0.

14. $\_\_\ Cr_2O_7^{2-} + \_\_\ e^- + \_\_\ H^+ \rightarrow \_\_\ Cr^{3+} + \_\_\ H_2O(l)$ When the equation for the half reaction above is balanced with the lowest whole-number coefficients, the coefficient for H_2O is:
(A) 2   (B) 4   (C) 6   (D) 7   (E) 14

15. How many grams of calcium nitrate, $Ca(NO_3)_2$, contains 24 grams of oxygen atoms?
(A) 164 grams   (B) 96 grams   (C) 62 grams   (D) 50. grams   (E) 41 grams

16. The simplest formula for an oxide of nitrogen that is 36.8 percent nitrogen by weight is
(A) N_2O (B) NO (C) NO_2 (D) N_2O_3 (E) N_2O_5

17. How many milliliters of 11.6-molar HCl must be diluted to obtain 1.0 liter of 3.0-molar HCl?
(A) 3.9 mL   (B) 35 mL   (C) 260 mL   (D) 1,000 mL   (E) 3,900 mL

18. Which of the following conclusions can be drawn from J. J. Thomson's cathode ray experiments?
(A) Atoms contain electrons.
(B) Practically all the mass of an atom is contained in its nucleus.
(C) Atoms contain protons, neutrons, and electrons.
(D) Atoms have a positively charged nucleus surrounded by an electron cloud.
(E) No two electrons in one atom can have the same four quantum numbers.

19. $\_\_\ CH_3CH_2COOH(l) + \_\_\ O_2(g) \dashrightarrow \_\_\ CO_2(g) + \_\_\ H_2O(l)$
How many moles of O_2 are required to oxidize 1 mole of CH_3CH_2COOH according to the reaction represented above?
(A) 2 moles   (B) 5/2 moles   (C) 3 moles   (D) 7/2 moles   (E) 9/2 moles

20. When a hydrate of Na_2CO_3 is heated until all the water is removed, it loses 54.3 percent of its mass. The formula of the hydrate is
(A) $Na_2CO_3 \cdot 10\ H_2O$ (B) $Na_2CO_3 \cdot 7\ H_2O$ (C) $Na_2CO_3 \cdot 5\ H_2O$
             (D) $Na_2CO_3 \cdot 3\ H_2O$ (E) $Na_2CO_3 \cdot H_2O$

21. $2\ K + 2\ H_2O \rightarrow 2\ K^+ + 2\ OH^- + H_2$
When 0.400 mole of potassium reacts with excess water at standard temperature and pressure as shown in the equation above, the volume of hydrogen gas produced is
(A) 1.12 liters   (B) 2.24 liters   (C) 3.36 liters   (D) 4.48 liters   (E) 6.72 liters

22. Which of the following does NOT behave as an electrolyte when it is dissolved in water?
(A) CH_3OH (B) K_2CO_3 (C) NH_4Br (D) HI (E) $NaC_2H_3O_2$

23. $$BrO_3^- + 5\,Br^- + 6\,H^+ \Longleftrightarrow 3\,Br_2 + 3\,H_2O$$
If 25.0 milliliters of 0.200-molar BrO_3^- is mixed with 30.0 milliliters of 0.450-molar Br^- solution that contains a large excess of H^+, the amount of Br_2 formed, according to the equation above, is
(A) 5.00×10^{-3} mole   (B) 8.10×10^{-3} mole   (C) 1.35×10^{-2} mole
           (D) 1.50×10^{-2} mole   (E) 1.62×10^{-2} mole

24. How many moles of solid $Ba(NO_3)_2$ should be added to 300. milliliters of 0.20-molar $Fe(NO_3)_3$ to increase the concentration of the NO_3^- ion to 1.0-molar? (Assume that the volume of the solution remains constant.)
(A) 0.060 mole   (B) 0.12 mole   (C) 0.24 mole   (D) 0.30 mole   (E) 0.40 mole

25. $$2\,H_2O + 4\,MnO_4^- + 3\,ClO_2^- \rightarrow 4\,MnO_2 + 3\,ClO_4^- + 4\,OH^-$$
Which species acts as an oxidizing agent in the reaction represented above?
(A) H_2O (B) ClO_4^- (C) ClO_2^- (D) MnO_2 (E) MnO_4^-

26. In which of the following compounds is the mass ratio of chromium to oxygen closest to 1.62 to 1.00 ?
(A) CrO_3 (B) CrO_2 (C) CrO (D) Cr_2O (E) Cr_2O_3

27.
Mass of an empty container = 3.0 grams
Mass of the container plus the solid sample = 25.0 grams
Volume of the solid sample = 11.0 cubic centimeters
The data above were gathered in order to determine the density of an unknown solid. The density of the sample should be reported as
(A) 0.5 g/cm^3 (B) 0.50 g/cm^3 (C) 2.0 g/cm^3 (D) 2.00 g/cm^3 (E) 2.27 g/cm^3

28. If 87 grams of K_2SO_4 (molar mass 174 grams) is dissolved in enough water to make 250 milliliters of solution, what are the concentrations of the potassium and the sulfate ions?

	$[K^+]$	$[SO_4^{2-}]$
(A)	0.020 M	0.020 M
(B)	1.0 M	2.0 M
(C)	2.0 M	1.0 M
(D)	2.0 M	2.0 M
(E)	4.0 M	2.0 M

29. When a 1.00-gram sample of limestone was dissolved in acid, 0.38 gram of CO_2 was generated. If the rock contained no carbonate other than $CaCO_3$, what was the percent of $CaCO_3$ by mass in the limestone?
(A) 17%   (B) 51%   (C) 64%   (D) 86%   (E) 100%

30. $$\ldots\, Fe(OH)_2 + \ldots\, O_2 + \ldots\, H_2O \rightarrow \ldots\, Fe(OH)_3$$
If 1 mole of O_2 oxidizes $Fe(OH)_2$ according to the reaction represented above, how many moles of $Fe(OH)_3$ can be formed?
(A) 2   (B) 3   (C) 4   (D) 5   (E) 6

31. What mass of Au is produced when 0.0500 mol of Au_2S_3 is reduced completely with excess H_2?
(A) 9.85 g   (B) 19.7 g   (C) 24.5 g   (D) 39.4 g   (E) 48.9 g

$$\ldots C_{10}H_{12}O_4S(s) + \ldots\, O_2(g) \rightarrow \ldots\, CO_2(g) + \ldots\, SO_2(g) + \ldots\, H_2O(g)$$
32. When the equation above is balanced and all coefficients are reduced to their lowest whole-number terms, the coefficient for $O_2(g)$ is?
(A) 6   (B) 7   (C) 12   (D) 14   (E) 28

33. $$H_2Se(g) + 4\ O_2F_2(g) \rightarrow SeF_6(g) + 2\ HF(g) + 4\ O_2(g)$$
Which of the following is true regarding the reaction represented above?
(A) The oxidation number of O does not change.
(B) The oxidation number of H changes from -1 to +1.
(C) The oxidation number of F changes from +1 to -1.
(D) The oxidation number of Se changes from -2 to +6.
(E) It is a disproportionation reaction for F.

34. A 1.0 L sample of an aqueous solution contains 0.10 mol of NaCl and 0.10 mol of $CaCl_2$. What is the minimum number of moles of $AgNO_3$ that must be added to the solution in order to precipitate all of the Cl^- as AgCl(s) ? (Assume that AgCl is insoluble.)
(A) 0.10 mol   (B) 0.20 mol   (C) 0.30 mol   (D) 0.40 mol   (E) 0.60 mol

35. $$\ldots\ Li_3N(s) + \ldots\ H_2O(l) \rightarrow \ldots\ Li^+ (aq) + \ldots\ OH^-(aq) + \ldots\ NH_3(g)$$ 35. When the equation above is balanced and all coefficients reduced to lowest whole number terms, the coefficient for OH^- (aq) is
(A) 1   (B) 2   (C) 3   (D) 4   (E) 6

36. When hafnium metal is heated in an atmosphere of chlorine gas, the product of the reaction is found to contain 62.2 percent Hf by mass and 37.4 percent Cl by mass. What is the empirical formula for this compound?
(A) HfCl   (B) $HfCl_2$ (C) $HfCl_3$ (D) $HfCl_4$ (E) Hf_2Cl_3

37. Which of the following is a correct interpretation of the results of Rutherford's experiments in which gold atoms were bombarded with alpha particles?
(A) Atoms have equal numbers of positive and negative charges.
(B) Electrons in atoms are arranged in shells.
(C) Neutrons are at the center of an atom.
(D) Neutrons and protons in atoms have nearly equal mass.
(E) The positive charge of an atom is concentrated in a small region.

$$10\ HI + 2\ KMnO_4 + 3\ H_2SO_4 \rightarrow 5\ I_2 + 2\ MnSO_4 + K_2SO_4 + 8\ H_2O$$
38. According to the balanced equation above, how many moles of HI would be necessary to produce 2.5 mol of I_2, starting with 4.0 mol of $KMnO_4$ and 3.0 mol of H_2SO_4?
(A) 20   (B) 10   (C) 8.0   (D) 5.0   (E) 2.5

39. A 40.0 mL sample of 0.25 M KOH is added to 60.0 mL of 0.15 M $Ba(OH)_2$. What is the molar concentration of OH^- (aq) in the resulting solution? (Assume that the volumes are additive)
(A) 0.10 M   (B) 0.19 M   (C) 0.28 M   (D) 0.40 M   (E) 0.55 M

40. What is the final concentration of barium ions, $[Ba^{2+}]$, in solution when 100. mL of 0.10 M $BaCl_2$(aq) is mixed with 100. mL of 0.050 M H_2SO_4(aq)?
(A) 0.00 M   (B) 0.012 M   (C) 0.025 M   (D) 0.075 M   (E) 0.10 M

AP Chemistry Exam
Part II: Essays. Show ALL work below. Work should be done in a clear and orderly fashion. Label and draw a border around each answer.
**4 Essays – 40 minutes Calculator Allowed.**

Essay #1
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.

$$TeO_2(s) + Cr_2O_7{}^{2-}(aq) + H^+(aq) \rightleftharpoons H_2TeO_4(aq) + Cr^{3+}(aq) + H_2O(l)$$
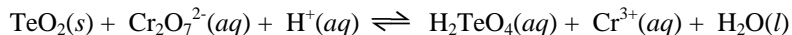
(a) Identify the molecule or ion that is being oxidized in the reaction.
(b) Give the oxidation number of Cr in the $Cr_2O_7{}^{2-}(aq)$ ion.
(c) Give the oxidation number of Te in the $H_2TeO_4(aq)$ ion.
(d) Balance the chemical equation given above.

In a separate reaction iodine reacts with lead(IV) oxide in an acidic environment.

$$I_2(s) + PbO_2(s) \rightarrow IO_3{}^{1-}(aq) + Pb^{2+}(aq)$$
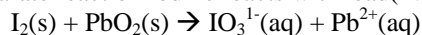
(e) Identify the molecule or ion that is the oxidizing agent the reaction.
(f) Balance the chemical equation given above.

Essay #2

Suppose that a stable element, atomic number 120, symbol St (sartepium), is discovered.

(a) Would St be a metal or a non-metal? Explain/justify your answer.

(b) What would be the most likely charge of the St ion in stable ionic compounds?

(c) An isotope of St has a mass number of 293. How many neutrons does it have?

(d) Write the formula for the compound formed between St and the oxalate ion.

(e) Using your solubility rules, would sartepium oxalate be soluble in water? Explain your reasoning.

Essay #3:

In a chemical reaction 35.0 mL of 0.40 M lead(II) nitrate is added to 25.0 mL of 0.80 M sodium carbonate.

(a) Write the complete balanced chemical equation for the reaction.

(b) Write the net-ionic equation for the reaction.

(c) What is the formula of the precipitate?

(d) What substance is the limiting reagent?

(e) What mass of precipitate formed?

(f) Determine the concentration of each ion remaining in solution.

Essay #4:

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 3.5560 g sample is burned in excess oxygen, 6.0838 g of $CO_2(g)$ is formed.

(i) Determine the mass, in grams, of C in the 3.5560 g sample of the compound.

(ii) When the compound is analyzed for O content only, the mass percent of O is found to be 17.76 percent. Determine the mass, in grams, of O in the original 3.5560 g sample of the compound.

(iii) The combustion analysis showed that 1.4338 grams of water was produced. Calculate the percent of hydrogen in the compound.

(iv) Determine the mass, in grams, of N in the original 3.5560 g sample of the compound.

(v) Determine the empirical formula of the compound.