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AP CHEMISTRY: STOICHIOMETRY EXAM [PRACTICE]

Exam Info....The actual exam will have 10 multiple choice questions [20 points total], 3 writing reaction questions [15 points total], and 3 short answer questions [25 points total]. The entire test will be a total of 60 points.

PART I: MULTIPLE CHOICE

How many mL of 10.0 *M* HCl are needed to prepare 500. mL of 2.00 *M* HCl ?

(A) 1.00 mL
(B) 10.0 mL
(C) 20.0 mL
(D) 100. mL
(E) 200. mL

$(10\,M)(x) = (500\,mL)(2\,M)$

$x = 100\ mL$

A student mixes equal volumes of 1.0 *M* solutions of tin(II) chloride and copper(II) sulfate and observes that no precipitate forms. Then the student mixes equal volumes of 1.0 *M* solutions of zinc(II) sulfate and tin(II) fluoride and observes the formation of a precipitate. The formula of the precipitate must be

(A) SnF_2
(B) $SnSO_4$
(C) $Sn(SO_4)_2$
(D) ZnF
(E) ZnF_2

① $SnCl_2(aq) + CuSO_4(aq) \rightarrow (SnSO_4(aq)) + CuCl_2(aq)$

② $ZnSO_4(aq) + SnF_2 \rightarrow (SnSO_4) + ZnF_2$ ↓ must be solid

A 360. mg sample of aspirin, $C_9H_8O_4$, (molar mass 180. g), is dissolved in enough water to produce 200. mL of solution. What is the molarity of aspirin in a 50. mL sample of this solution?

(A) 0.0800 *M*
(B) 0.0400 *M*
(C) 0.0200 *M*
(D) 0.0100 *M*
(E) 0.00250 *M*

$360\ mg \times \frac{1\ g}{1000\ mg} = .360\ g$

$\frac{.360\ g}{180\ g/mol} = 2 \times 10^{-3}\ mol$

$\frac{2 \times 10^{-3}\ mol}{.2\ L} = 0.01\ M$

$M_1V_1 = M_2V_2$

$(0.01\ M)(.2\ L) = x\ (.05\ L)$

$x = 0.04\ M$

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Propane gas, C_3H_8, burns in excess oxygen gas. When the equation for this reaction is correctly balanced and all coefficients are reduced to their lowest whole-number terms, the coefficient for O_2 is

(A) 4
(B) 5
(C) 7
(D) 10
(E) 22

combustion reaction

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2 + 4H_2O$

1. look at C
2. look at H
3. look at O last

8 g 92 g ?

$2\,N_2H_4(g) + N_2O_4(g) \rightarrow 3\,N_2(g) + 4\,H_2O(g)$

11. When 8.0 g of N_2H_4 (32 g mol^{-1}) and 92 g of N_2O_4 (92 g mol^{-1}) are mixed together and react according to the equation above, what is the maximum mass of H_2O that can be produced?

(A) 9.0 g
(B) 18 g
(C) 36 g
(D) 72 g
(E) 144 g

$\frac{8\text{ g}}{32\text{ g/mol}} = .25\text{ mol } N_2H_4$ ← limiting reagent

$\frac{92\text{ g}}{92\text{ g/mol}} = 1\text{ mol } N_2O_4$ ← excess

mole ratio $\frac{2\ N_2H_4}{1\ N_2O_4} = \frac{.25\text{ mol}}{x}$

$x = .125$ mol needed to react completely with N_2H_4 and we have more than enough N_2O_4

$\frac{4\ H_2O}{2\ N_2H_4} = \frac{x}{.25\text{ mol}}$

$x = 0.5\text{ mol } H_2O \times 18\text{ g/mol} = 9\text{ g } H_2O$

(A) $H_2SeO_4(aq) + 2\,Cl^-(aq) + 2\,H^+(aq) \rightarrow H_2SeO_3(aq) + Cl_2(g) + H_2O(l)$
(B) $S_8(s) + 8\,O_2(g) \rightarrow 8\,SO_2(g)$
(C) $3\,Br_2^0(aq) + 6\,OH^-(aq) \rightarrow 5\,Br^{-1}(aq) + BrO_3^{+5-2}(aq) + 3\,H_2O(l)$
(D) $Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$
(E) $PtCl_4(s) + 2\,Cl^-(aq) \rightarrow PtCl_6^{2-}(aq)$

11. A precipitation reaction D
12. A reaction that produces a coordination complex E
13. A reaction in which the same reactant undergoes both oxidation and reduction C
14. A combustion reaction B

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PART II: WRITING REACTIONS

For each of the following three reactions, in part (i) write a balanced equation and in part (ii) answer the question about the reaction. In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be scored.

EXAMPLE:

A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:

$$Mg + 2Ag^+ \longrightarrow Mg^{2+} + 2Ag$$

(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

(a) Solid magnesium hydroxide is added to a solution of hydrobromic acid.

(i) Balanced equation: $Mg(OH)_2(s) + 2HBr(aq) \rightarrow 2H_2O_{(l)} + MgBr_2(aq)$

$Mg(OH)_2(s) + 2H^+(aq) \rightarrow 2H_2O(l) + Mg^{2+}(aq)$

(ii) What volume, in mL, of 2.00 *M* hydrobromic acid is required to react completely with 0.10 mol of solid magnesium hydroxide?

$\frac{1\ Mg(OH)_2}{2\ HBr} = \frac{0.10\ mol}{x}$ $\quad M = \frac{mol}{L}$

$x = .02\ mol\ HBr$ $\quad 2M = \frac{.02\ mol}{x}$

$x = 0.1\ L = 100\ mL\ HBr$

(c) A copper wire is dipped into a solution of silver(I) nitrate.

(i) Balanced equation: $Cu(s) + AgNO_3(aq) \rightarrow Ag^+ + CuNO_3(aq)$

$Cu(s) + Ag^+ + NO_3^- \rightarrow Ag^+ + Cu^+ + NO_3^-$

$Cu(s) \rightarrow Cu^+(aq)$

(ii) Describe what is observed as the reaction proceeds.

copper wire dissolves into solution and creates copper ions

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Solid mercury(II) oxide decomposes as it is heated in an open test tube in a fume hood.

(i) Balanced equation: $2HgO \xrightarrow{heat} 2Hg^{+2} + O_2(g)$

(ii) After the reaction is complete, is the mass of the material in the test tube greater than, less than, or equal to the mass of the original sample? Explain.

Less than, because oxygen gas is formed and released from system since the test tube is open.

Hydrogen chloride gas is oxidized by oxygen gas.

(i) Balanced equation: $4HCl(g) + O_2(g) \rightarrow 2H_2O_{(l)} + 2Cl_2(g)$

(ii) If three moles of hydrogen chloride gas and three moles of oxygen gas react as completely as possible, which reactant, if any, is present in excess? Justify your answer.

$\frac{3\ mol\ HCl}{x} = \frac{4\ HCl}{1\ O_2}$

$x = .75\ mol\ O_2$ needed, and there is 3 mol so O_2 is in excess.
to react with 3 mol HCl

(ii)

C: $\frac{.0433\ mol}{.0124} = 3.5 \times 2 = 7$

H: $\frac{.0374\ mol}{.0124} = 3.0 \times 2 = 6$

O: $\frac{.0124\ mol}{.0124} = 1 \times 2 = 2$

PART III: SHORT ANSWER

Answer the following questions about a pure compound that contains only carbon, hydrogen, and oxygen.

(a) A 0.7549 g sample of the compound burns in $O_2(g)$ to produce 1.9061 g of $CO_2(g)$ and 0.3370 g of $H_2O(g)$.

(i) Calculate the individual masses of C, H, and O in the 0.7549 g sample.

(ii) Determine the empirical formula for the compound. $C_7H_6O_2$

(i)

C: $\frac{1.9061\ g\ CO_2}{12 + 2(16)\ g/mol\ CO_2} = \frac{1.9061\ g}{44\ g/mol} = 0.0433\ mol\ CO_2 = 0.0433\ mol\ C \times 12\ g/mol = .52\ g\ C$
(1:1 ratio)

H: $\frac{.3370\ g\ H_2O}{18\ g/mol\ H_2O} = .0187\ mol\ H_2O$

$\frac{.0187\ mol\ H_2O}{x} = \frac{1\ H_2O}{2\ H}$

$x = .0374\ mol\ H \times 1\ g/mol = .037\ g\ H$

1.9061 g + 0.3370 g = 2.2431 g products

mass reactants = mass products

.7549 g + x = 2.2431 g

$x = 1.4882\ g\ O_2 = 0.0465\ mol\ O_2$

$\frac{1\ O_2}{2\ O} = \frac{.0465\ mol\ O_2}{x} \rightarrow x = .093\ mol\ O$

mass of O in compound = .7549 g − (.52 + .037)

.198 g O / 16 g/mol = .0124 mol O

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Answer the following questions that relate to chemical reactions.

OMIT

Sorry. Haven't learned this yet.

(a) Iron(III) oxide can be reduced with carbon monoxide according to the following equation.

$$Fe_2O_3(s) + 3\,CO(g) \rightarrow 2\,Fe(s) + 3\,CO_2(g)$$

A 16.2 L sample of $CO(g)$ at 1.50 atm and 200.°C is combined with 15.39 g of $Fe_2O_3(s)$.

(i) How many moles of $CO(g)$ are available for the reaction?

(ii) What is the limiting reactant for the reaction? Justify your answer with calculations.

(iii) How many moles of $Fe(s)$ are formed in the reaction?

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$$2\ Al(s) + 2\ KOH(aq) + 4\ H_2SO_4(aq) + 22\ H_2O(l) \rightarrow 2\ KAl(SO_4)_2 \cdot 12H_2O(s) + 3\ H_2(g)$$

In an experiment, a student synthesizes alum, $KAl(SO_4)_2 \cdot 12H_2O(s)$, by reacting aluminum metal with potassium hydroxide and sulfuric acid, as represented in the balanced equation above.

(a) In order to synthesize alum, the student must prepare a 5.0 *M* solution of sulfuric acid. Describe the procedure for preparing 50.0 mL of 5.0 *M* H_2SO_4 using any of the chemicals and equipment listed below. Indicate specific amounts and equipment where appropriate.

10.0 *M* H_2SO_4	50.0 mL volumetric flask
Distilled water	50.0 mL buret
100 mL graduated cylinder	25.0 mL pipet
100 mL beaker	50 mL beaker

(b) Calculate the minimum volume of 5.0 *M* H_2SO_4 that the student must use to react completely with 2.7 g of aluminum metal.

(c) As the reaction solution cools, alum crystals precipitate. The student filters the mixture and dries the crystals, then measures their mass.

(i) If the student weighs the crystals before they are completely dry, would the calculated percent yield be greater than, less than, or equal to the actual percent yield? Explain.

(ii) Cooling the reaction solution in an ice bath improves the percent yield obtained. Explain.

(d) The student heats crystals of pure alum, $KAl(SO_4)_2 \cdot 12H_2O(s)$, in an open crucible to a constant mass. The mass of the sample after heating is less than the mass before heating. Explain.

(a) ~~(5.0 M)(x) = (50 mL)(5.0 M)~~

Stock solution of 10.0 M H_2SO_4

$M_1V_1 = M_2V_2$

$(10\ M)(x) = (5\ M)(50\ mL)$

$x = 25\ mL$ stock solution needed

Use 100 mL graduated cylinders. Put 25.0 mL of 10 M H_2SO_4 in 50.0 mL volumetric flask. Put distilled water into 50 mL beaker and fill volumetric flask with water until just before the line. Use a pipette to fill rest of flask w/ water drop by drop.

(b) $\frac{2.7\ g}{27\ g/mol} = 0.1\ mol\ Al$

$\frac{2\ Al}{4\ H_2SO_4} = \frac{0.1\ mol\ Al}{x}$

$x = 0.2\ mol\ H_2SO_4$

$5.0\ M = \frac{0.2\ mol}{x}$

$x = 0.04\ L = \boxed{40.\ mL}$

(c) (i) Greater than because of the residual water adding more mass to the precipitate.

(ii) Cooling in an ice bath ensures the formation of more crystals by reducing the amount of ions floating in solution.

(d) The alum is a hydrate, so heating the alum in an open crucible will cause the loosely bound H_2O molecules to evaporate and reduce the mass of the alum.