

PART I Multiple Choice (45 pts.) Choose **one** correct answer for each of the following 15 questions.

1. If 18.50 moles of $C_2Cl_4(l)$ are required for a chemical reaction, determine the volume, in liters, of this liquid compound that are needed. The density of $C_2Cl_4(l)$ is 1.63 g/mL and its MW = 165.8 g/mole.

A. 5.00 mL
 B. 1.88 L
 C. 5.00 L
 D. 1.88 mL
 E. none of the above

$$\frac{18.50 \text{ mol } C_2Cl_4 | 165.8 \text{ g } C_2Cl_4 | 1 \text{ mL} | 1 \text{ L}}{1 \text{ mol } C_2Cl_4 | 1.63 \text{ g} | 1000 \text{ mL}}$$

2. An example of a **weak** electrolyte in aqueous solution is

- A. only nitric acid solution HNO_3 is a strong acid, thus strong electrolyte
 B. only ammonium chloride solution NH_4Cl is a soluble salt, thus strong electrolyte
 C. only acetic acid solution weak acid, thus weak electrolyte
 D. only sodium chlorate solution soluble salt, thus strong electrolyte
 E. more than one of the above

3. How many **atoms** are in 75.0 g of nitrogen gas?

- A. 1.61×10^{24} atoms
 B. 6.44×10^{24} atoms
 C. 6.32×10^{24} atoms
 D. 3.22×10^{24} atoms
 E. none of the above
- $$\frac{75.0 \text{ g } N_2 | 1 \text{ mol } N_2 | 2 \text{ mol } N | 6.022 \times 10^{23} \text{ atoms } N}{28 \text{ g } N_2 | 1 \text{ mol } N_2 | 1 \text{ mol } N}$$

4. How many grams of Al metal, Al(s), are needed to produce 100.0 g of $Al_2(SO_4)_3(s)$ (FW = 342.17) from the reaction of aluminum metal with sulfuric acid?

A. 7.90 g
 B. 316 g
 C. 15.8 g
 D. 31.6 g
 E. none of the above

$$2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3 + 3H_2(g)$$

$$\frac{100.0 \text{ g } Al_2SO_4 | 1 \text{ mol } Al_2(SO_4)_3 | 2 \text{ mol } Al | 26.98 \text{ g } Al}{342.17 \text{ g } Al_2(SO_4)_3 | 1 \text{ mol } Al_2(SO_4)_3 | 1 \text{ mol } Al}$$

5. A sample of $Mg(ClO_3)_2$ (FW = 191.2) contains 3.60×10^{23} oxygen atoms. How many grams of chlorine atoms does the sample contain?

A. 21.2 g
 B. 19.8 g
 C. 7.1 g
 D. 14.1 g
 E. none of the above

$$\frac{3.60 \times 10^{23} \text{ O atoms} | 1 \text{ mol O}}{6.022 \times 10^{23} \text{ atoms O} | 6 \text{ mol O} | 1 \text{ mol Cl}} \quad \frac{2 \text{ mol Cl} | 35.45 \text{ g Cl}}$$

6. An oxide of lead contains 90.65% Pb and 9.35% O by weight. Determine its empirical formula.

AW of Pb = 207.2 g/mole; AW of O = 16.0 g/mole

Assume 100. g of compound, then:

- A. PbO₂
 B. Pb₂O₃
 C. PbO
 D. Pb₃O₄
 E. none of the above

↗ multiply both by 3 to get whole #s

$$\frac{90.65 \text{ g Pb} / 1 \text{ mol Pb}}{207.2 \text{ g Pb}} = \frac{0.4375 \text{ mol Pb}}{0.4375} = 1 \text{ mol Pb}$$

$$\frac{9.35 \text{ g O} / 1 \text{ mol O}}{16.00 \text{ g O}} = \frac{0.584375 \text{ mol O}}{0.4375} = 1.33 \text{ mol O}$$

7. How many grams of magnesium (at.no.12) contain the same number of atoms as 20.04 g of calcium (at.no.20)?

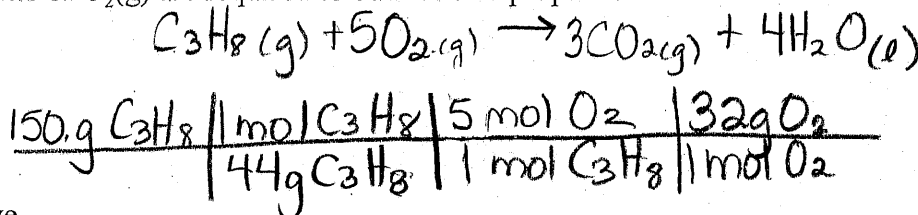
- A. 24.30 g
 B. 40.08 g
 C. 12.15 g
 D. 48.60 g
 E. none of the above

$$\frac{20.04 \text{ g Ca} / 1 \text{ mol Ca}}{40.08 \text{ g Ca}} \times \frac{1 \text{ mol Mg}}{24.30 \text{ g Mg}} = 1 \text{ mol Mg}$$

* note that equal # of moles contain equals #s of atoms, so no conversion needed

8. The complete combustion of propane gas, C₃H₈(g) with oxygen gas produces carbon dioxide and water. How many grams of O₂(g) are required to burn 150 of propane?

- A. 545 g
 B. 109 g
 C. 1320 g
 D. 273 g
 E. none of the above



9. How many mL of water should be added to 25.0 mL of a stock 12.0 M HCl(aq) solution to make 1.50 M HCl(aq)? Assume that the volumes are additive.

- A. 175 mL
 B. 200 mL
 C. 4.50 mL
 D. 275 mL
 E. none of the above

$$M_1 V_1 = M_2 V_2$$

$$(12.0 \text{ M})(25.0 \text{ mL}) = (1.50 \text{ M})(x \text{ mL})$$

$$\frac{(12.0 \text{ M})(25.0 \text{ mL})}{(1.50 \text{ M})} = x \text{ mL}$$

$$x = 200 \text{ mL} - 25.0 \text{ mL} = 175 \text{ mL}$$

10. Element M forms an oxide, M₂O₃, that is 65.2% M and 34.8% oxygen by weight. The atomic mass (weight) of M is

- A. 52.0 g/mole
 B. 65.4 g/mole
 C. 45.0 g/mole
 D. 55.8 g/mole
 E. none of the above

3 mol of O = 48g, which is 34.8% (0.348) of the compound's mass

$$\frac{48 \text{ g}}{x} = 0.348 \quad x = 137.93 \text{ g (the molar mass of M}_2\text{O}_3)$$

$$137.93 \text{ g} - 48 \text{ g} = 89.93 \text{ g}$$

$$\frac{89.93 \text{ g}}{2 \text{ mol M}} = 44.96 \text{ g/mol}$$

11. How many mL of a 0.200 M NaOH(aq) solution contain 2.00 g NaOH (FW = 40.0)?

- A. 400 mL
 B. 25.0 mL
 C. 40 mL
 D. 250 mL
 E. none of the above
- Handwritten solution:*

$$\frac{2.00 \text{ g NaOH}}{40.0 \text{ g NaOH}} \times \frac{1 \text{ mol NaOH}}{1 \text{ mol NaOH}} \times \frac{1000 \text{ mL solution}}{0.200 \text{ mol NaOH}}$$

12. The element ${}_{29}\text{Cu}$, which has an average atomic mass of 63.546, consists of two isotopes: isotope A with an isotopic mass of 62.930 amu, and isotope B with an isotopic mass of 64.928 amu. The relative fractional abundance of the heavier isotope B is

- A. 0.36
 B. 0.69
 C. 0.64
 D. 0.31
 E. none of the above
- Handwritten solution:*
 avg atomic mass = (%A)(mass A) + (%B)(mass B)
 $\%A + \%B = 100\%$ or $A + B = 1$ $B = 1 - A$
 $63.546 \text{ amu} = (A)(62.930 \text{ amu}) + (1 - A)(64.928 \text{ amu})$
 $63.546 \text{ amu} = 62.930 \text{ amu} A + 64.928 \text{ amu} - 64.928 \text{ amu} A$
 $1.998 \text{ amu} A = 1.382 \text{ amu}$ $A = 0.69169$
 $B = 1 - 0.69169$

13. What weight of $\text{KClO}_3(\text{s})$ (FW = 122.55) contains 5.0 g of oxygen atoms?

- A. 1.99 g
 B. 7.66 g
 C. 12.77 g
 D. 38.3 g
 E. none of the above
- Handwritten solution:*

$$\frac{5.0 \text{ g O}}{16.00 \text{ g O}} \times \frac{1 \text{ mol O}}{3 \text{ mol O}} \times \frac{1 \text{ mol KClO}_3}{1 \text{ mol KClO}_3} \times \frac{122.55 \text{ g KClO}_3}{1 \text{ mol KClO}_3}$$

14. Which of the following equations represents a redox reaction?

1. $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
 2. $\text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Ca}(\text{OH})_2(\text{s})$
 3. $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{SO}_3(\text{g})$
 4. $\text{P}_4\text{O}_{10}(\text{s}) + 6 \text{H}_2\text{O}(\text{l}) \rightarrow 4 \text{H}_3\text{PO}_4(\text{aq})$
- Handwritten note:* I know this is redox because $\text{O}_2(\text{g})$ is in its elemental state on reactant side ($\text{ox}^\# = 0$) and in a compd on the product side ($\text{ox}^\# \neq 0$)
- A. one of the four reactions
 B. two of the four reactions
 C. three of the four reactions
 D. four of the four reactions
 E. none of the four reactions

15. If 26.32 mL of 0.10 M $\text{H}_2\text{SO}_4(\text{aq})$ is neutralized by 34.56 mL of NaOH(aq) solution, determine the molarity of the NaOH(aq).

- A. 0.26 M
 B. 0.15 M
 C. 0.075 M
 D. 0.13 M
 E. none of the above
- Handwritten solution:*

$$\frac{26.32 \text{ mL}}{1000 \text{ mL}} \times \frac{0.10 \text{ mol H}_2\text{SO}_4}{1 \text{ mol H}_2\text{SO}_4} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol H}_2\text{SO}_4} \times \frac{1000 \text{ mL}}{34.56 \text{ mL}}$$
- Chemical equation:*

$$\text{H}_2\text{SO}_4(\text{aq}) + 2 \text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2 \text{H}_2\text{O}(\text{l})$$

PART IIA (14 pts.)

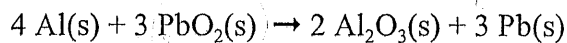
1. The common name of the symbol ${}_{33}\text{As}$ is arsenic
2. The common name of the symbol ${}_{27}\text{Co}$ is cobalt
3. The name of $\text{Mn}_3(\text{PO}_4)_2$ is manganese (II) phosphate
4. The name of SiF_4 is silicon tetrafluoride
5. The formula of iron(III) sulfide is Fe_2S_3
6. The formula of aluminum nitrite is $\text{Al}(\text{NO}_2)_3$
7. The oxidation state of Cr in $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ is 6^+

PART IIB (22 pts.)

1. (8 pts.)
 - A. 4.0 kilograms is equivalent to 4.0×10^{12} nanograms. $\frac{4.0 \text{ kg} | 1000 \text{ g} | 10^9 \text{ ng}}{1 \text{ kg} | 1 \text{ g}}$
 - B. The diameter of $6.0 \mu\text{m}$ (micrometers) of a red blood cell is equivalent to 6.0×10^6 picometers. $\frac{6 \mu\text{m} | 1 \text{ m} | 10^{12} \text{ pm}}{10^6 \mu\text{m} | 1 \text{ m}}$
 - C. The density of a 6.0 g/cm^3 is equivalent to 1.3×10^4 lb/m^3 , where 1.0 pound is equivalent to 454 grams. $\frac{6.0 \text{ g} | 1 \text{ lb} | (100 \text{ cm})^3}{1 \text{ cm}^3 | 454 \text{ g} | (1 \text{ m})^3}$
 - D. If the mass of one atom of an element is $1.709 \times 10^{-22} \text{ g}$, the identity (symbol) of the element is Rh.
 $\frac{1.709 \times 10^{-22} \text{ g} | 6.022 \times 10^{23} \text{ atoms}}{1 \text{ mole}} = 102.9 \text{ g/mol}$
2. (6 pts.) For one particular X^{2+} ion with pure (100%) isotopic mass of 49.9621 amu which has 20 electrons.
 - A. The mass number is 50
 - B. The number of protons is 22
 - C. The number of neutrons is 28
3. (8 pts.)
 - A. The J.J. Thomson cathode ray experiment in 1897 determined the charge/mass ratio of an electron.
 - B. The R. Millikan oil drop experiment in 1909 determined the charge of an electron.
 - C. The E. Rutherford scattering experiment in 1911 involving the bombardment of gold foil with alpha ${}^4_2\text{He}^{2+}$ particles determined the mass + charge of the atom are concentrated in a very small area (the nucleus)
 - D. Isotopes and their relative fractional abundances of an element were determined from analytical measurements with mass spectrometer.

PART IIC (7 pts.) For the problem below, show all of your work (including units) for credit.

1. Aluminum metal reacts with $\text{PbO}_2(\text{s})$ to give $\text{Al}_2\text{O}_3(\text{s})$ and $\text{Pb}(\text{s})$ in accordance with the following balanced equation.



In one experiment, 200 g of $\text{Al}(\text{s})$ and 400 g of $\text{PbO}_2(\text{s})$ are mixed and allowed to react by ignition to form the above products.

- A. The limiting reactant (reagent) is PbO_2 .

$$\frac{200. \text{g Al} \left| \frac{1 \text{ mol Al}}{26.98 \text{g Al}} \right| \frac{3 \text{ mol Pb}}{4 \text{ mol Al}} \left| \frac{207.2 \text{g Pb}}{1 \text{ mol Pb}} \right.}{=} = 1152 \text{ g Pb}$$

$$\frac{400 \text{g PbO} \left| \frac{1 \text{ mol PbO}_2}{239.2 \text{g PbO}} \right| \frac{3 \text{ mol Pb}}{3 \text{ mol PbO}} \left| \frac{207.2 \text{g Pb}}{1 \text{ mol Pb}} \right.}{=} = 346 \text{ g Pb}$$

* since the amt of PbO yields less $\text{Pb}(\text{s})$, PbO limits how much product can be made

- B. Calculate the maximum number of atoms of solid lead, $\text{Pb}(\text{s})$ formed by the above reaction.

$$\frac{400 \text{g PbO} \left| \frac{1 \text{ mol PbO}}{239.2 \text{g PbO}} \right| \frac{3 \text{ mol Pb}}{3 \text{ mol PbO}} \left| \frac{6.022 \times 10^{23} \text{ atoms Pb}}{1 \text{ mol Pb}} \right.}{=} =$$

answer 1.01×10^{24} atoms Pb

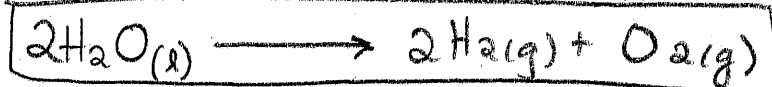
- C. The reducing agent in the above redox reaction is $\text{Al}(\text{s})$.

Aluminum goes from an oxidation state of zero (reactant side) to an oxidation state of 3^+ (product side) Thus, aluminum was oxidized, and $\text{Al}(\text{s})$ is the reducing agent

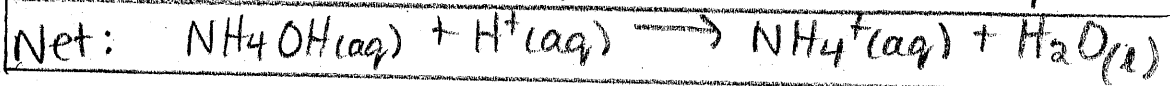
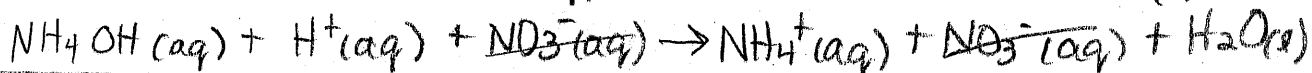
PART IID (15 pts.) Write a **balanced net** equation for each of the following. If no reaction occurs, write NO REACTION as the final answer in the space provided.

Hint: Initially write a balanced molecular equation and then the corresponding net equation.

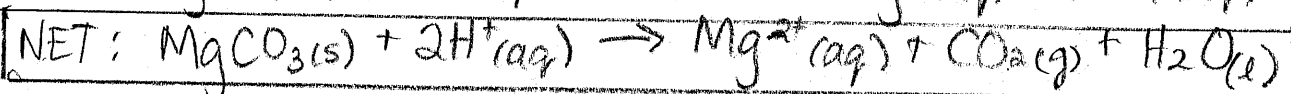
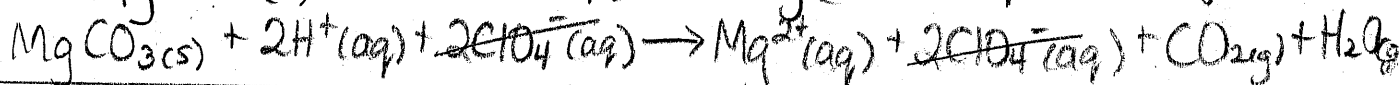
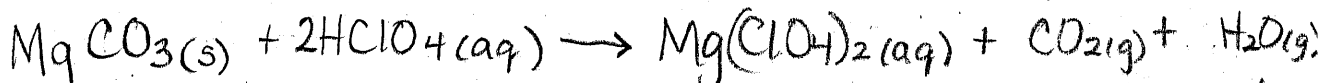
1. (3 pts.) Electrolysis of liquid water to give hydrogen and oxygen gases (demo).



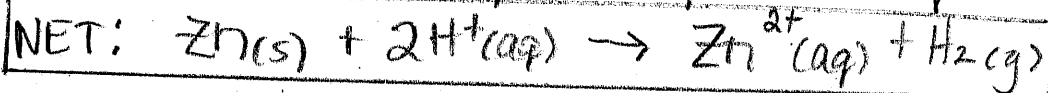
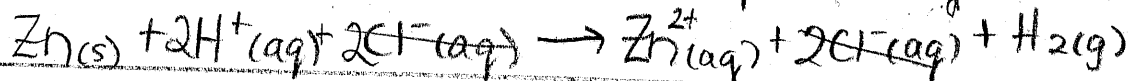
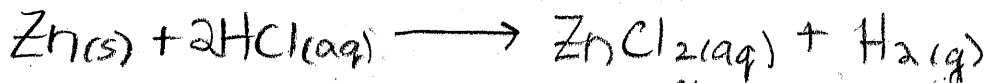
2. (3 pts.) Preparation of aqueous ammonium nitrate solution from acid/base reaction.



3. (3 pts.) Formation of magnesium chlorate(aq) from a reaction producing carbon dioxide gas.



4. (3 pts.) Zinc metal is added to hydrochloric acid (demo). Note that ZnCl_2 is soluble in $\text{H}_2\text{O}(\ell)$.



5. (3 pts.) Milk of magnesia (magnesium hydroxide) is taken to reduce acidity of hydrochloric acid (demo) in stomach. Note that MgCl_2 is soluble in $\text{H}_2\text{O}(\ell)$.

