

NAME (PRINT) KEY

SECTION _____

SIGNATURE _____

TA _____

PLEASE READ THE FOLLOWING INSTRUCTIONS

Do NOT begin the exam until asked to do so.

There are 8 numbered pages, and a periodic table in this exam. Check to see that they are all here before you begin the exam. Return all these papers when you are finished. Write your name on every page. Use a **pen** with blue or black ink for the entire exam.

Exams done in pencil, erasable ink, or where white-out, liquid paper, etc. have been used are *ineligible for regrades.*

Be sure to follow the directions in answering all questions. Write your final answers in the blanks provided. In working problems and the BONUS, you must **SHOW ALL WORK**. No credit will be given unless all work is clearly shown and the method of solution is logically correct. Use correct units and significant figures.

Do not write below this line

		Grader
I	(50) _____	_____
II	(28) _____	_____
III	(47) _____	_____
IV	(25) _____	_____
BONUS	_____	_____
TOTAL	_____	_____

I. (50 points)

A. (10 points) Write your answers to the following questions on the blanks provided.

No 1. The number of moles of HCl in 10 mL of 12 M HCl is equal to that in 1000 mL of 0.012 M. (Yes or No)

BaSO₄, AgCl 2. Solutions of silver sulfate and barium chloride are mixed. Write the formula of the precipitate(s) that form(s). If no precipitate forms, write NR.
1pt 1pt

weak acid 3. Classify HClO₃ as strong acid, weak acid, strong base or weak base

No 4. C₆H₅NH₂ is an Arrhenius acid when added to water? (Yes or No)

Na⁺ 5. Acetic acid and sodium hydroxide are combined. What are the spectator ion(s)?

B. (9 points) Write the **net ionic** equations for the reactions between aqueous solutions of the following compounds. (Do not forget to indicate the physical states of the compounds) -1 for not showing physical states (one time)
-1 for not having (s) for Ba₃(PO₄)₂

1. HCN(aq) and KOH(aq): HCN(aq) + OH⁻(aq) → H₂O + CN⁻(aq)

2. Na₃PO₄(aq) and Ba(OH)₂(aq): PO₄³⁻(aq) + Ba²⁺(aq) → Ba₃(PO₄)₂(s)

3. NH₃(aq) and HCl(aq): NH₃(aq) + H⁺(aq) → NH₄⁺(aq)

C. (11 points) Ten milliliters of a 0.250 M solution of Al₂(CO₃)₃ is mixed with 25.0 mL of a 0.012 M solution of K₂CO₃.

1. (6 points) How many moles of CO₃²⁻ ions are present in the final mixture?

$$10 \text{ mL} \times \frac{0.250 \text{ mol Al}_2(\text{CO}_3)_3}{1000 \text{ mL}} \times \frac{3 \text{ mol CO}_3^{2-}}{1 \text{ mol Al}_2(\text{CO}_3)_3} = 7.50 \times 10^{-3} \text{ mol}$$

$$25.0 \text{ mL} \times \frac{0.012 \text{ mol K}_2\text{CO}_3}{1000 \text{ mL}} \times \frac{1 \text{ mol CO}_3^{2-}}{1 \text{ mol K}_2\text{CO}_3} = 3.0 \times 10^{-4} \text{ mol}$$

$$7.8 \times 10^{-3} \text{ mol CO}_3^{2-} \text{ total} = 7.8 \times 10^{-3} \text{ mol}$$

2. (5 points) What is the molarity of CO₃²⁻ ions in the final solution? (Assume the volumes are additive)

$$M_{\text{CO}_3^{2-}} = \frac{7.8 \times 10^{-3}}{0.0350} = 0.22 \text{ M}$$

$$M_{\text{CO}_3^{2-}} = \frac{\text{answer in \#1}}{0.0350}$$

0.22 M

2 pts each

3 pts each

-1 for each mistake

3 pts (not having mole ratio=2)

5 pts

- D. (10 points) A sample of limestone weighing 1.005 g is dissolved in 75.00 mL of 0.2500 M hydrochloric acid. The following reaction occurs:



It is found that 18.50 mL of 0.150 M NaOH is required to titrate the excess HCl left after reaction with the limestone.

1. (4 points) How many moles of hydrochloric acid are used?

4pts

$$n_{\text{HCl}} = 75.00 \text{ mL HCl} \times \frac{0.2500 \text{ mol HCl}}{1000 \text{ mL}} - 18.50 \text{ mL NaOH} \times \frac{0.150 \text{ mol NaOH}}{1000 \text{ mL}}$$

$$= 0.01875 - 0.002775$$

0.01598 mol HCl

2. (4 points) How many grams of CaCO_3 (MM = 100.09 g/mol) are there in the sample?

4pts

$$\text{mass of CaCO}_3 = 0.01598 \text{ mol HCl} \times \frac{1 \text{ mol H}^+}{1 \text{ mol HCl}} \times \frac{1 \text{ mol CaCO}_3}{2 \text{ mol H}^+} \times \frac{100.09 \text{ g}}{1 \text{ mol CaCO}_3}$$

OR = $\frac{\text{answer in \# 1}}{2} \times 100.09$

2 pts for using right mole ratio
2 pts for the mass

0.7997 g

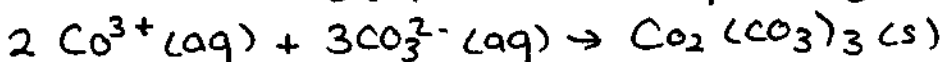
3. (2 points) What is the mass percent of CaCO_3 in the limestone?

2pts all or nothing

$$\frac{0.7997}{1.005} \times 100 = 79.57\% \text{ -OR- } \frac{\text{answer in \# 2}}{1.005} \times 100$$

79.57%

- E. (10 points) What is the volume of 0.2500 M cobalt (III) sulfate, $\text{Co}_2(\text{SO}_4)_3$, required to react completely with 11.20 mL of 1.45 M sodium carbonate to form cobalt (III) carbonate? $\text{Na}_2\text{CO}_3(\text{s}) \rightarrow 2\text{Na}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$



10pts

$$11.20 \text{ mL Na}_2\text{CO}_3 \times \frac{1.45 \text{ mol Na}_2\text{CO}_3}{1000 \text{ mL}} \times \frac{1 \text{ mol CO}_3^{2-}}{1 \text{ mol Na}_2\text{CO}_3} \times \frac{2 \text{ mol Co}^{3+}}{3 \text{ mol CO}_3^{2-}} \times \frac{1 \text{ mol Co}_2(\text{CO}_3)_3}{2 \text{ mol Co}^{3+}}$$

$$n_{\text{Co}_2(\text{SO}_4)_3} = 0.00541 \text{ mol}$$

$$V = \frac{0.00541}{0.2500} = 0.0217 \text{ L}$$

21.7 L or 0.0217 L

2pts for # of moles of Na_2CO_3
2pts for volume

2pts for # of moles of Na_2CO_3

2pts for volume

II. (28 points)

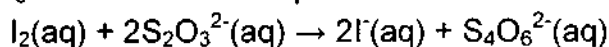
A. (10 points) Three experiments are performed:

- (A) $\text{Ca}(\text{OH})_2$ is mixed with HF .
 (B) NaOH is mixed with $\text{Mg}(\text{NO}_3)_2$
 (C) Cu reacts to form Cu^{2+} .

Write the letter of the experiment(s) that answers each of the following questions. If none of the experiments applies, write NONE.

- None 1. Which experiment involves a strong acid?
B 2. Which experiment produces a precipitate?
A, B 3. Which experiment involves a strong base?
None 4. Which experiment involves Cu as an oxidizing agent?
A 5. Which experiment produces water as a product?

B. (8 points) Iodine reacts with thiosulfate ion, $\text{S}_2\text{O}_3^{2-}$, to give iodide ion and the tetrathionate ion, $\text{S}_4\text{O}_6^{2-}$. The balanced equation for the reaction that takes place is



If 25.0 g of iodine is dissolved in enough water to make 1.50 L of solution, what volume of 0.244 M sodium thiosulfate will be needed for complete reaction?

$$n_{\text{I}_2} = 25.0 \text{ g I}_2 \times \frac{1 \text{ mol I}_2}{253.8 \text{ g}} = 0.0985 \text{ mol I}_2 \quad \uparrow 2 \text{ pts}$$

$$0.0985 \text{ mol I}_2 \times \frac{2 \text{ mol S}_2\text{O}_3^{2-}}{1 \text{ mol I}_2} = 0.197 \text{ mol} \quad \uparrow 3 \text{ pts}$$

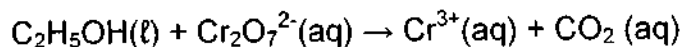
$$V_{\text{Na}_2\text{S}_2\text{O}_3} = 0.197 \text{ mol S}_2\text{O}_3^{2-} \times \frac{1 \text{ mol Na}_2\text{S}_2\text{O}_3}{1 \text{ mol S}_2\text{O}_3^{2-}} \times \frac{1 \text{ L}}{0.244 \text{ mol}}$$

$$= 0.807 \text{ L}$$

\uparrow
3 pts

0.807 L or 807 mL

C. (10 points) Consider the *unbalanced* equation for a redox reaction in *acidic medium*:

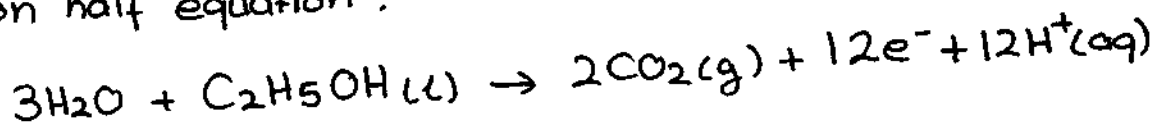


Write a balanced equation for this reaction using smallest whole number coefficients. The equation itself will not be graded but you will need to balance it to answer the following questions. Write your answers in the blanks provided.

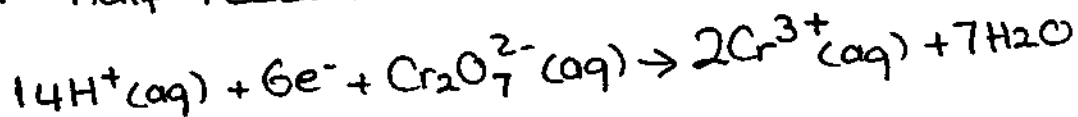
2 pts each

- C 1. Which element is being oxidized?
- C₂H₅OH 2. What species is the reducing agent?
- 6 3. How many electrons are being gained in the balanced reduction half equation (use smallest whole numbers)?
- 14 4. In the balanced reduction half equation (using the smallest whole number coefficients), what is the coefficient of H⁺?
- 4 5. What is the coefficient of Cr³⁺ in the balanced redox reaction? (use the smallest whole numbers)

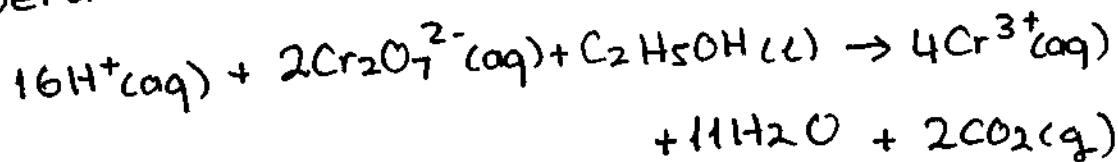
oxidation half equation:



reduction half reaction:



overall:



III. (47 points)

A. (15 points) Answer Y for Yes or N for No.

3 pts each

- NO 1. After the pressure of one mole of gas is tripled (at constant temperature), its volume is three times greater than its original value.
- No 2. The partial pressure of water vapor in a gas collected over water is independent of the temperature.
- No 3. A molecule of He at 100 °C and 1 atm pressure will have exactly the same speed as a molecule of N₂ at the same temperature and pressure.
- Yes 4. At a constant temperature and pressure, CH₄ gas will effuse twice as fast as SO₂ gas.
- No 5. You are given two tanks of equal volume, each at the same temperature and pressure. One contains H₂ and the other He. The tank containing the hydrogen has a larger number of molecules than the one containing helium.

B. (6 points) What increase in the Celsius temperature will produce a 5.0% increase in the volume of a sample of gas originally at 25.0°C if the gas pressure held constant?

6 pts

$$V_1 = V \quad V_2 = V_1 + 0.05V_1 = 1.05V$$

$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$\frac{V}{1.05V} = \frac{298}{T_2}$$

$$T_2 = 313$$

15 °C ← -1 for not having T in °C

-2 if the temp. is in °C
-3 for wrong set up

C. (5 points) A compound has the simplest formula C₂H₂X₂. A 256.0 mL flask, at 373 K and 740.0 mm Hg, contains 0.789 g of the gaseous compound. What is the atomic mass of the unknown element, X?

5 pts

$$\frac{740.0}{760.0} \times 0.2560 = \frac{0.789}{MM} \times 0.0821 \times 373$$

$$MM = 96.93 \text{ g/mol}$$

if the # of moles found first 2 pts
MM 2 pts

$$96.93 = 2 \times 12.01 + 2 \times 1.008 + 2X$$

$$X = 35.45 \text{ g/mol}$$

35.45 g/mol

for finding MM 4 pts
for dividing by 2 to obtain atomic mass 1 pt
26 pts

D. (9 points) A metal hydride, MH_2 reacts with water according to the following equation:



When 0.1232 g of $MH_2(s)$ reacts with water, 225.0 mL of dry $H_2(g)$ are produced at $16^\circ C$ and 0.9870 atm pressure. Calculate the molar mass of MH_2 and identify the metal M.

9 pts

$$0.9870 \times 0.225 = n_{H_2} \times 0.0821 \times 289 \quad 2 \text{ pts}$$

$$n_{H_2} = 0.009360 \text{ mol} \quad \Downarrow$$

4 pts (each mistake -2)

$$n_{MH_2} = \frac{0.009360}{2} = 0.004680 \text{ mol}$$

$$MM = \frac{0.1232}{0.004680} = 26.32 \text{ g/mol} \quad \Uparrow 2 \text{ pts}$$

26.32 g/mol; Mg 1 pt

E. (6 points) Consider two different containers separated from each other by a valve. Both containers are at the same temperature. Calculate the final pressure inside the system after the valve connecting the two containers is opened. Ignore the volume of the tube connecting the two containers.

	Container A
Gas	Ar
V	2.0 L
P	1.0 atm
T	$25^\circ C$

	Container B
Gas	O_2
V	3.0 L
P	2.0 atm
T	$25^\circ C$

If they find the partial pressure of one of the gases 3 pts

6 pts

$$\frac{P_1 V_1}{P_2 V_2} = \frac{n R T_1}{n R T_2}$$

$$1.0 \text{ atm} \times 2.0 \text{ L} = 5.0 \text{ L} \times P_2$$

$$P_{Ar} = 0.40 \text{ atm}$$

3 pts

1.60 atm

$$2.0 \text{ atm} \times 3.0 \text{ L} = 5.0 \text{ L} P_2$$

$$P_2 = 1.2 \text{ atm}$$

1 pt

$$P_{Ar} + P_{O_2} = 0.40 + 1.20 = 1.60 \text{ atm}$$

2 pts

F. (6 points) If a 0.0250 mol of NO effuses through a pinhole in a certain amount of time, how much N_2O_4 would effuse in that same amount of time under the same conditions?

6 pts

$$\frac{n_{N_2O_4}}{n_{NO}} = \sqrt{\frac{MM_{NO}}{MM_{N_2O_4}}}$$

$$\frac{n_{N_2O_4}}{0.0250} = \sqrt{\frac{30.01}{92.02}}$$

for inverse -4
for not taking square root -2

0.0143 mol N_2O_4

2 pts

IV. (25 points)

A. (15 points) A student weighs out 0.1965 grams of an unknown chloride into an Erlenmeyer flask and titrates it with AgNO_3 using K_2CrO_4 as indicator. To reach the endpoint, 17.24 mL of 0.1529 M AgNO_3 is required.

1. What is the number of moles of chloride ion in the sample?

5 pts

$$17.24 \text{ mL AgNO}_3 \times \frac{0.1529 \text{ mol AgNO}_3}{1000 \text{ mL AgNO}_3} \times \frac{1 \text{ mol Ag}^+}{1 \text{ mol AgNO}_3} \times \frac{1 \text{ mol Cl}^-}{1 \text{ mol Ag}^+}$$

0.002636 mol Cl⁻

3 pts for 1 mistake

2. What is the mass of chloride in the sample?

3 pts

$$\text{mass} = 0.002636 \text{ mol} \times \frac{35.45 \text{ g}}{1 \text{ mol Cl}}$$

0.09345 g

-OR-
answer in #1 x 35.45

3. Calculate the mass percent Cl⁻ ion in the sample.

3 pts

$$\frac{0.09345}{0.1965} \times 100$$

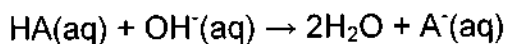
47.56 %

-OR-
 $\frac{\text{answer in \#2}}{0.1965} \times 100$

4. If the student read the molarity of the AgNO_3 as 0.1259 M instead of the correct value, would the calculated mass percent Cl⁻ be LESS than or GREATER than or the SAME as (CIRCLE ONE) the actual value.

5. If the student was past the endpoint of the titration when he took the final buret reading, would the calculated mass percent Cl⁻ be LESS than or GREATER than or the SAME as (CIRCLE ONE) the actual value.

B. (10 points) A 0.100 g sample of an unknown acid requires 12.95 mL of 0.0857 M NaOH for neutralization to a phenolphthalein endpoint. What is the molar mass of the unknown acid?



10 pts

$$12.95 \text{ mL OH}^- \times \frac{0.0857 \text{ mol}}{1000 \text{ mL}} = 0.00111 \text{ mol}$$

$$\text{MM} = \frac{0.100}{0.00111} = 90.1 \text{ g/mol}$$

↑
5 pts

90.1 g/mol

↑
5 pts

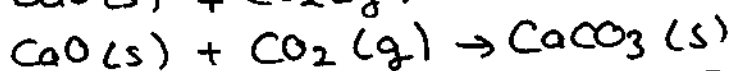
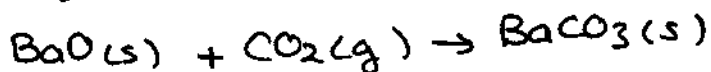
25 pts

BONUS (15 points) ALL or NOTHING

The bonus should be done only after you have completed the main part of this exam and checked your work for errors. The time allotted for this exam does not include time for the bonus. (SHOW ALL WORK! Lucky guesses will not be considered. Method of solution should be reasonable and must get all answers correct for any credit)

A chemist weighed out 5.14 g of a mixture containing unknown amounts of BaO(s) and CaO(s) and placed the sample in a 1.50 L flask containing CO₂(g) at 30.0°C and 750.0 mm Hg. After the reaction to form BaCO₃(s) and CaCO₃(s) was completed, the pressure of CO₂(s) remaining was 230.0 mm Hg. Calculate the mass percentage of CaO(s) in the mixture.

$$m_{\text{BaO}} + m_{\text{CaO}} = 5.14 \text{ g}$$



$$n_{\text{CO}_2 \text{ reacted}} = \frac{1.50 \times 750/760}{303 \text{ K} \times 0.0821} - \frac{1.50 \times 230.0/760}{303 \times 0.0821} = 0.0413 \text{ mol}$$

$$n_{\text{BaO}} + n_{\text{CaO}} = 0.0413 \text{ mol}$$

$$n_{\text{BaO}} = 0.0413 - n_{\text{CaO}}$$

$$n_{\text{BaO}} \times \frac{153.3 \text{ g}}{1 \text{ mol}} + n_{\text{CaO}} \times \frac{56.08 \text{ g}}{1 \text{ mol}} = 5.14 \text{ g}$$

$$(0.0413 - n_{\text{CaO}}) 153.3 + n_{\text{CaO}} \times 56.08 = 5.14$$

$$6.32 - 153.3 n_{\text{CaO}} + 56.08 n_{\text{CaO}} = 5.14$$

$$-97.22 n_{\text{CaO}} = -1.18$$

$$n_{\text{CaO}} = 0.0122 \text{ mol}$$

$$\text{mass of CaO} = 0.0122 \times 56.08 = 0.684 \text{ g}$$

$$\underline{13.3\%}$$

$$\text{mass \%} = \frac{0.684}{5.14} \times 100$$