

Rogers

Chem 205: GENERAL CHEMISTRY I MIDTERM EXAMINATION

PLEASE READ THIS PAGE WHILE WAITING TO START

INSTRUCTIONS: This test paper includes 7 pages, including a periodic table; please check that your paper is complete. You may detach the periodic table if you wish. For Part A, you do not need to show calculations; for Parts B and C, you must show your calculations to receive full marks. Please write clearly and organize your work logically. Non-programmable calculators are permitted; paper translation dictionaries are allowed, but electronic dictionaries and cell phones are not allowed.

Duration: 70 minutes - spend at least half that time on Parts B & C. **GOOD LUCK!**

LAST NAME: marking scheme FIRST NAME: _____
STUDENT NUMBER: _____

Mark breakdown:

	<u>Average</u>	<u>%</u>
Page 2.	10.1 / 14	72.1
Page 3.	7.9 / 12	66.2
Page 4.	4.2 / 8	52.0
Page 5.	4.2 / 8	52.9
Page 6.	4.4 / 9	48.8

TOTAL: 30.8 / 50 (MAXIMUM MARK = 51)

PERCENT: 62.2%

EARNED towards FINAL GRADE: 12.4 / 20

PART A: ONLY YOUR FINAL ANSWER WILL BE MARKED

1. (/ 3 marks) Identify the following statements as true or false. (Circle T or F.)

- T / F Water expands when it freezes; the density of ice is greater than the density of water.
T / F Precision is an indicator of the numerical spread in a set of measurements.
 T / F J.J. Thomson determined the charge-to-mass ratio of the electron by bombarding gold foil with alpha particles.

2. (/ 3 marks) Fill in the blanks:

- a) Number of neutrons in ^{207}Pb (i.e., 207-Pb) $207 - 82 = 125$
 b) Charge on cadmium in cadmium sulfide $2+$
 c) Products of the decomposition of H_2CO_3 $\text{H}_2\text{O}(l) \downarrow, \text{CO}_2(g)$
not dissociation (which yields $2\text{H}^+ + \text{CO}_3^{2-}$)

3. (/ 4 marks) Write each compound's formula or name, and circle ionic or molecular to describe each:

- a) potassium sulfate K_2SO_4 0.75 ionic / molecular? } -0.25 for inappropriate brackets
 b) vanadium(V) bromide VBr_5 0.75 ionic / molecular?
 c) NH_4NO_3 ammonium nitrate 0.75 ionic / molecular?
 d) P_2O_5 diphosphorus pentoxide 0.75 ionic / molecular? } -0.25 for minor spelling errors
(no part marks - except →)

4. (/ 2 marks) Which three elements are likely to have similar chemical and physical properties?

- (a) sodium, lithium, and potassium in same group
 b) sodium, magnesium, and aluminum
 c) nitrogen, oxygen, and neon
 d) nickel, copper, and zinc
 e) uranium, plutonium, and americium

5. (/ 2 marks) Silver has two isotopes, with an average atomic mass of 107.87 amu. If 48.18% of Ag exists as Ag-109 (108.9047 amu), what is the identity and the atomic mass of the other isotope?

- 1 → a) Ag-106: 106.9 amu ×
 2 (b) Ag-107: 106.9 amu possibly ← $107.87 = 0.4818(108.9047) + 0.5183x$
 c) × Ag-107: 107.9 amu ×
 d) × Ag-108: 107.9 amu possibly, except won't $55.400 = 0.5183x$
 e) × Ag-108: 108.9 amu × give average mass < 108 amu! $x = 106.9 \text{ amu}$

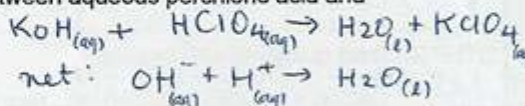
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6. (/ 2 marks) Which of the following will be highly soluble in water: KNO_3 , $\text{Ca}_3(\text{PO}_4)_2$, CuCl_2 , Fe_2S_3 ?

- 2 B
 a) KNO_3 and $\text{Ca}_3(\text{PO}_4)_2$
 b) KNO_3 and CuCl_2
 c) $\text{Ca}_3(\text{PO}_4)_2$ and Fe_2S_3
 d) CuCl_2 and Fe_2S_3
 e) KNO_3 , $\text{Ca}_3(\text{PO}_4)_2$, and Fe_2S_3

7. (/ 2 marks) What are the spectator ions in the reaction between aqueous perchloric acid and aqueous potassium hydroxide?

- 2 C
 a) H^+ , ClO_4^- , K^+ , and OH^-
 b) H^+ and OH^-
 c) K^+ and ClO_4^-
 d) H^+ and ClO_4^-
 e) K^+ and OH^-



8. (/ 2 marks) Choose the correctly balanced half-reaction for the reduction of $\text{ClO}_3^-(aq)$ to $\text{Cl}_2(g)$ in an acidic solution.

- 2 D
 a) $\times 2 \text{ClO}_3^-(aq) + 6 \text{H}^+(aq) + 10 e^- \rightarrow \text{Cl}_2(g) + 6 \text{OH}^-(aq)$ $x + 3(-2) = -1$
 b) $\times 2 \text{ClO}_3^-(aq) + 12 \text{H}^+(aq) + 5 e^- \rightarrow \text{Cl}_2(g) + 6 \text{H}_2\text{O}(l)$ $x = +5$
 c) $\times 2 \text{ClO}_3^-(aq) + 10 e^- \rightarrow \text{Cl}_2(g) + 6 \text{H}_2\text{O}(l) + 3 \text{O}_2(g)$?? but 2Cl_2
 d) $2 \text{ClO}_3^-(aq) + 12 \text{H}^+(aq) + 10 e^- \rightarrow \text{Cl}_2(g) + 6 \text{H}_2\text{O}(l)$ $\therefore 10 e^-$
 e) $\times 2 \text{ClO}_3^-(aq) + 18 \text{H}^+(aq) \text{ no } e^- \rightarrow \text{Cl}_2(g) + 6 \text{H}_3\text{O}^+(aq)$ total to make Cl_2

9. (/ 2 marks) When a handful of copper pennies is submerged in water, they displace 8.26 cm^3 of water. If the combined mass of the pennies is 73.86 g , what is the density of copper?

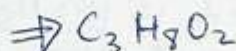
- 2 C
 a) 0.112 g/cm^3
 b) 1.34 g/cm^3
 c) 8.94 g/cm^3
 d) 32.8 g/cm^3
 e) 107 g/cm^3

$$d = \frac{m}{V} = \frac{73.86 \text{ g}}{8.26 \text{ cm}^3} = 8.94 \text{ g/cm}^3$$

10. (/ 4 marks) A compound is found to contain $47.35\% \text{ C}$, $10.60\% \text{ H}$, and $42.05\% \text{ O}$ by mass. What is the empirical formula for this compound? $m = 47.35 \text{ g}$, 10.60 g , 42.05 g in 100 g sample

- 4 C
 a) $\text{C}_2\text{H}_6\text{O}$
 b) $\text{C}_3\text{H}_4\text{O}_2$
 c) $\text{C}_3\text{H}_8\text{O}_2$
 d) $\text{C}_4\text{H}_6\text{O}_2$
 e) $\text{C}_4\text{H}_8\text{O}_3$

element's MM	12.0107	1.00794	15.9994	g/mol
# n	3.942	10.516	2.628	mol
normalized	1.500	4.002	1.000	mole ratio
whole # ratio	3	8	2	whole # mole ratio



✓ = full mark (1)
✓ = half mark (0.5)
✓ = 0.25 mark

PART B: Short written answers

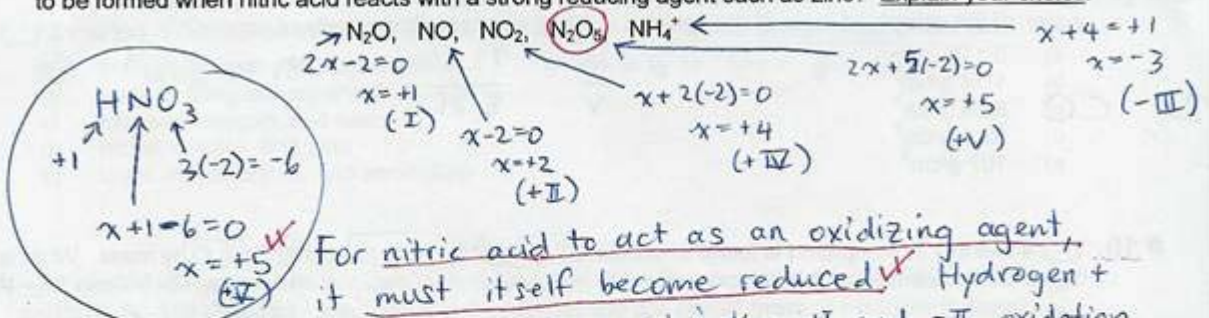
11. (5 / 5 marks) The cheapest way to obtain magnesium metal is to "mine" it from seawater, where Mg^{2+} is quite abundant. Your task is to identify the type of reaction involved in each step of the process; choose as many labels as apply: acid-base, gas-forming, precipitation, OR oxidation-reduction.
(H^+ transfer) (gas...) (e^- transfer \therefore ox. # changes)

Step in "seawater Mg mining" process	Type of reaction	How can you tell?
STEP 1: Produce quicklime $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ <small>$2(+4) + 6(-2) = 2(+2) + 2(-1) + 4(-2)$</small>	✓ gas-forming	no H^+ transfer (not A/B) no ox. # changes (not redox) <u>GAS FORMS</u> ✓
STEP 2: Treat quicklime with seawater $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$ trace is dissolved... <small>$2(+2) + 2(-2) = 2(+2) + 2(-1) + 2(-2)$</small>	✓ acid-base <small>not precipitation because involves more than just trading counter-ions...</small>	no ox. # changes (not redox) ✓ <u>H^+ transferred from H_2O to O^{2-}</u> simply identifying acid + base is not enough
STEP 3: Trap Mg^{2+} from seawater using dissolved OH^- $Mg^{2+}(aq) + 2 OH^-(aq) \rightarrow Mg(OH)_2(s)$	✓ precipitation	soluble ions react to give <u>(insoluble product)</u> ✓
STEP 4: Redissolve trapped Mg^{2+} $Mg(OH)_2(s) + 2 HCl(aq) \rightarrow MgCl_2(aq) + 2 H_2O(l)$	✓ acid-base	<u>H^+ transferred from HCl to OH^- to form H_2O</u> simply identifying acid + base is not enough
STEP 5: After isolating salt, electrolyze molten salt $MgCl_2(l) \rightarrow Mg(l) + Cl_2(g)$	✓ redox	$Mg^{2+} \rightarrow Mg^0$ } changes in oxidation state ✓ $2Cl^- \rightarrow Cl_2$ }

OK gas-forming (gaseous product evolved from liquid)

12. (3 / 3 marks) Nitric acid (HNO_3) is a strong oxidizing agent. Which species listed below is least likely to be formed when nitric acid reacts with a strong reducing agent such as zinc? Explain your choice.

3



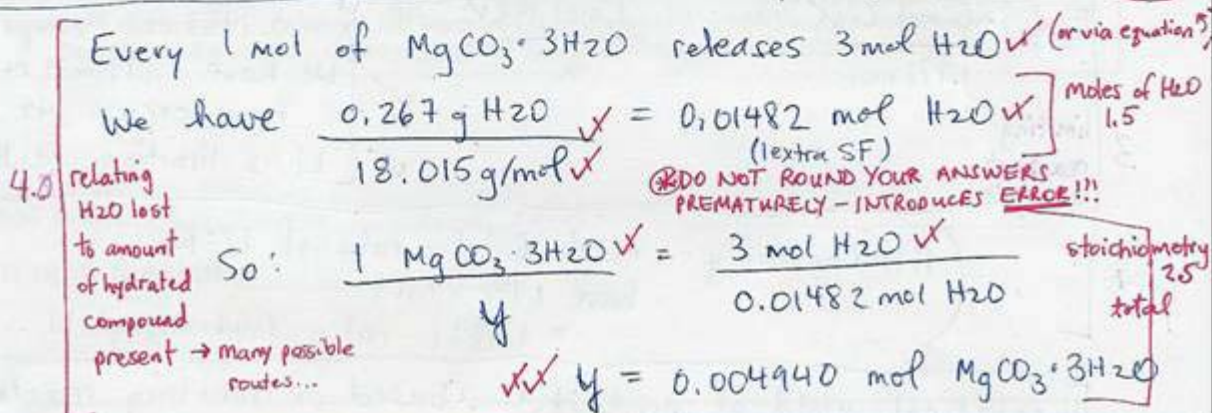
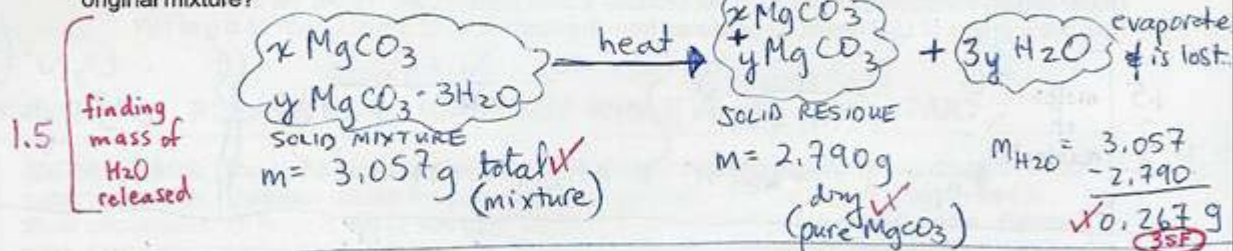
For nitric acid to act as an oxidizing agent, it must itself become reduced. ✓ Hydrogen + oxygen generally exist in the +I and -II oxidation states in compounds, so it is the nitrogen that must undergo reduction (ie: accept electrons + lower its oxidation state) ✓ Thus, the least likely species to form from HNO_3 being reduced is N_2O_5 ✓ because the N is in the +V oxidation state just as it is in HNO_3 ✓ The N's in the other 4 compounds are in lower oxidation states than +V, and so those are all possible reduction products.

8

- 0.25 significant figures wrong
- 0.25 units missing or wrong
- 0.25 premature rounding (SF usage/rounding error in mid-calculation)
- 0.25 math error/transcription error

PART C: Problems - SHOW YOUR WORK TO GET FULL CREDIT

13. (1/8 marks) A mixture of $MgCO_3$ and $MgCO_3 \cdot 3H_2O$ has a mass of 3.057 g. After heating to drive off all the water, the mass of the sample is 2.790 g. What was the mass percent of $MgCO_3 \cdot 3H_2O$ in the original mixture?



2.5 calculating mass %

$$\begin{aligned}
 \text{Mass \%} &= \frac{m_{MgCO_3 \cdot 3H_2O}}{m_{\text{total sample}}} \times 100\% \quad \text{"Sample" = original mixture} \\
 &= \frac{(0.004940 \text{ mol})(138.359 \text{ g/mol})}{3.057 \text{ g sample}} \times 100\% \\
 &= \frac{0.6835 \text{ g}}{3.057 \text{ g}} \times 100\% \\
 &= 22.358\% \\
 \text{mass \% } MgCO_3 \cdot 3H_2O &= 22.4\% \text{ (3 SF)} \quad \Rightarrow 22.4\% \text{ of the original mixture's mass was due to } MgCO_3 \cdot 3H_2O \text{ (s).} \\
 &\quad \text{due to } m_{H_2O} \dots
 \end{aligned}$$

8

-0.25 sig. figs. errors
-0.25 units errors/absent
-0.25 math errors/transcription errors

-0.25 rounding errors (premature... improper SF mid-calculation)

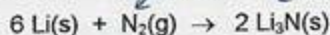
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CHEM 205 Winter 2006 MIDTERM EXAM
Dr. C. Rogers, Section 03

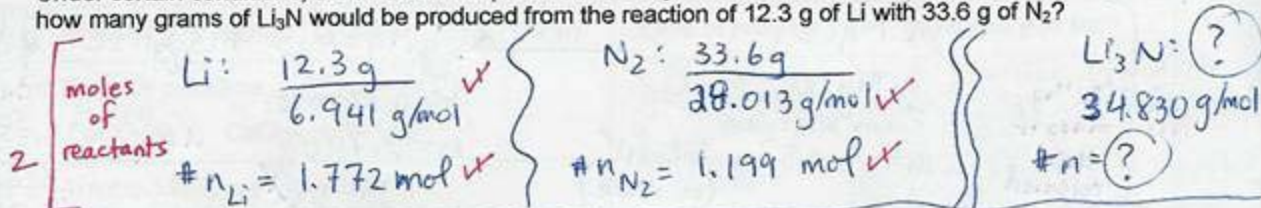
Student ID #: marking scheme

NOTE: Please include some explanatory words/phrases!!

14. (/ 9 marks) When heated, lithium metal reacts with nitrogen gas to form lithium nitride, which is a substance used in hydrogen-storage units:



Under certain conditions, the reaction will produce a 38% yield of Li_3N . Under the same conditions, how many grams of Li_3N would be produced from the reaction of 12.3 g of Li with 33.6 g of N_2 ?



3. limiting reactant analysis

Every $\frac{6 \text{ mol Li}}{1.772 \text{ mol}}$ requires $\frac{1 \text{ mol N}_2}{x} \Rightarrow x = 0.2953 \text{ mol N}_2$ required

✓ We have 1.199 mol N_2
✓ \therefore have excess N_2 .
✓ Li is limiting reactant

(Alternatively: need 6:1 ratio of Li:N₂
have 1.772:1.199
= 1.48:1 ratio (not enough Li...))

3. theor. product yield

Theoretical yield of product ✓ based on limiting reactant

$\frac{6 \text{ mol Li}}{1.772 \text{ mol}}$ yields $\frac{2 \text{ mol Li}_3\text{N}}{y} \Rightarrow y = 0.5907 \text{ mol Li}_3\text{N}$

mass expected = $(0.5907 \text{ mol}) (34.830 \text{ g/mol})$
= 20.57 g if have 100% yield.

1. actual yield

Expected yield is only 38%

Thus: $0.38 \times 20.57 \text{ g} = 7.818 \text{ g}$
 $\hat{=} 7.8 \text{ g Li}_3\text{N product}$
should be produced.
(2 SF due to 38%...)

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