



Chem 205: GENERAL CHEMISTRY I MIDTERM EXAMINATION

PLEASE READ THIS PAGE WHILE WAITING TO START

INSTRUCTIONS: This test paper includes 8 pages, including a periodic table; please ensure your paper is complete. You may detach the periodic table if you wish. For Part A, you do not need to show calculations; for Part C, you must show your calculations to receive full marks. Please write clearly and organize your work logically. Non-programmable calculators are permitted; book-style 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:

Avg %

Page 2.	$9.8 / 15 = 65.8$
Page 3.	$5.8 / 10 = 58.2$
Page 4.	$3.7 / 7 = 52.7$
Page 5.	$5.8 / 8 = 72.1$
Page 6.	$5.2 / 11 = 47.2$

TOTAL: 30.3 / 50 (MAXIMUM MARK = 51)

PERCENT: 60.6 %

EARNED towards FINAL GRADE: 12.1 / 20

PART A: ONLY YOUR FINAL ANSWER WILL BE MARKED

1. / 4 marks) Identify the following statements as true or false. (Circle T or F.)

T / F When water boils, the arrangement and composition of the water molecules change.

T / F A sample containing 3×10^{15} atoms can be described as containing 5×10^{-9} mol atoms. no: 5 $\times 10^{-9}$ mol in sample

4 T / F If a mass of 2.3720 g is measured with a digital balance, the "0" is uncertain but significant.

T / F The coefficients needed to balance the reaction equation shown below are: 1, 1, 2. ✓



2. / 3 marks) Fill in the blanks:

3 a) Number of neutrons in a ^{119}Sn (tin-119) atom

$$\frac{69}{= 119 - 50} = 119 - 50 \text{ p}^+$$

310 gets 35

b) Body temperature (37°C) on the Kelvin scale

$$\frac{310. \cancel{\text{important}}}{= 273.15 + 37} \quad \text{if } 310.15 \text{ gets 35}$$

c) Substance that has more than one allotrope

carbon, phosphorus, sulfur, oxygen } any one is fine.

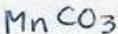
3. / 4 marks) Write each compound's formula or name, & circle ionic or molecular to describe each:

4 a) phosphorus trichloride



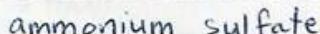
ionic / molecular?

b) manganese(II) carbonate



ionic / molecular?

c) $(\text{NH}_4)_2\text{SO}_4$



ionic / molecular?

d) IF_6



ionic / molecular?

-0.25...

4. / 2 marks) Which one of the following substances yields acid rain when it enters into rain clouds?

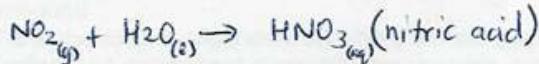
2 a) ammonia

ie: reacts with water

b) calcium oxide

to yield acid

c) nitrogen dioxide



d) hydrogen sulfide

e) sulfur

5. / 2 marks) You have 4.15 g of each of the following elements: Ca, Cu, Ce, Cs, Cf. Which sample contains the largest number of atoms? \rightarrow element with smallest molar mass

2 a) Ca 40.078 g/mol

has largest # atoms in a given

b) Cu 63.546

sample mass.

c) Ce 140.116

d) Cs 132.905

e) Cf ≈ 251

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6. (/ 2 marks) Which two of the following atoms are isotopes? $^{45}_{21}\text{Sc}$, $^{48}_{22}\text{Ti}$, $^{50}_{22}\text{Ti}$, $^{50}_{23}\text{V}$

- a) $^{45}_{21}\text{Sc}$ and $^{50}_{23}\text{V}$
 b) $^{48}_{22}\text{Ti}$ and $^{50}_{22}\text{Ti}$
 c) $^{50}_{22}\text{Ti}$ and $^{50}_{23}\text{V}$
 d) $^{45}_{21}\text{Sc}$ and $^{50}_{22}\text{Ti}$
 e) $^{48}_{22}\text{Ti}$ and $^{50}_{23}\text{V}$

= same element ∴ same # p^+
 different # n^o

2

7. (/ 2 marks) You are given an unknown white solid that is either NaI or NaNO_3 . If you prepare an aqueous solution of the unknown and test it by adding the various reagents listed below, which reagent will allow you to distinguish between the two compounds? → prepare an insoluble salt?

- a) NaOH
 b) HCl
 c) K_3PO_4
 d) NH_4Br
 e) $\text{Pb}(\text{NO}_3)_2$

- all Na^+ salts = soluble
 - same for NO_3^- salts
 - must be based on I^-
 EXCEPTIONS:
 Pb^{2+} , Ag^+ , Hg_2^{2+} ...

8. (/ 2 marks) Write a net ionic equation for the reaction of aqueous acetic acid and aqueous potassium hydroxide. → leave out spectator ions $\text{CH}_3\text{CO}_2\text{H} + \text{KOH} \rightarrow \text{H}_2\text{O} + \text{KCH}_3\text{CO}_2$

- a) $\text{CH}_3\text{CO}_2\text{H}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{K}^+(\text{aq}) + \text{CH}_3\text{CO}_2^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$
 b) $\text{CH}_3\text{CO}_2\text{H}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{KCH}_3\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$ molecular
 c) $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
 d) $\text{CH}_3\text{CO}_2\text{H}(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{CH}_3\text{CO}_2\text{H}_2^-(\text{aq})$
 e) $\text{CH}_3\text{CO}_2\text{H}(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{CH}_3\text{CO}_2^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$

9. (/ 2 marks) Which statement concerning solid MgSO_4 is true?

- a) It is a homogeneous mixture.
 b) It is a heterogeneous mixture.
 c) It is a chemical compound.
 d) The percentage of S in the solid is dependent on where the sample is obtained.
 e) It has properties similar to its component elements: magnesium, sulfur and oxygen.

10. (/ 2 marks) The density of iron is 7.87 g/cm^3 . Calculate the number of iron atoms present in a cube that has an edge of length 3.00 cm.

- a) 1.75×10^{21} atoms
 b) 3.69×10^{22} atoms
 c) 1.75×10^{23} atoms
 d) 2.29×10^{24} atoms
 e) 1.28×10^{26} atoms

$$\begin{aligned} \text{① Sample volume: } V &= l^3 = (3.00 \text{ cm})^3 = 27.00 \text{ cm}^3 \\ \text{② Mass of iron: } m &= d \times V = (7.87 \frac{\text{g}}{\text{cm}^3})(27.00 \text{ cm}^3) \\ &= 212.49 \text{ g Fe} \end{aligned}$$

$$\text{③ Moles of iron: } n = \frac{212.49}{55.845 \text{ g/mol}} = 3.805 \text{ mol}$$

$$\text{④ # atoms} = n \times N = 3.805 \times 6.022 \times 10^{23} \text{ atoms (to 3 SF)}$$

Avogadro's # = 6.022×10^{23} atoms/mol

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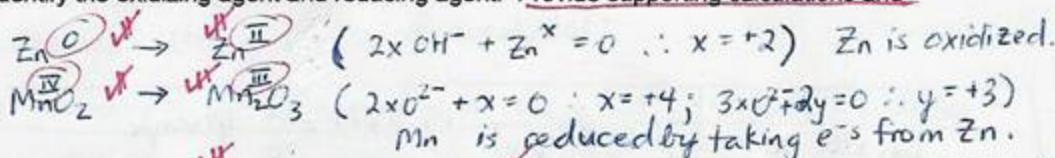
PART B: Short written answers

- # 11. (1/5 marks) Alkaline batteries exploit the following oxidation-reduction reaction, which occurs in the presence of a basic aqueous electrolyte solution inside the battery:

Unbalanced: $\text{Zn(s)} + \text{MnO}_2(\text{s}) \rightarrow \text{Mn}_2\text{O}_3(\text{s}) + \text{Zn(OH)}_2(\text{s})$

1 each

- a) (2 marks) Identify the oxidizing agent and reducing agent. Provide supporting calculations and explanation.



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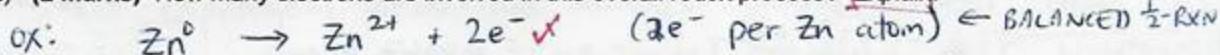
Oxidizing agent = Mn since it steals e^- from Zn metal (causes oxidation).
Reducing agent = Zn since it provides e^- to Mn (causes reduction).

- b) (1 mark) Can you balance this chemical equation by inspection? Why or why not?

No, this reaction requires participation of solvent (H_2O) to account for the missing H atoms in the reactants.

NOTE: the question DOES NOT ask for you to balance it!

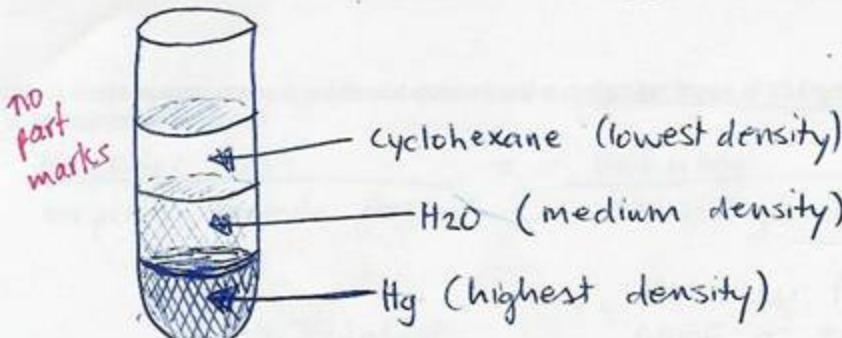
- c) (2 marks) How many electrons are involved in this overall redox process? Explain.



2

Overall: $\{2\text{e}^- \text{ involved because oxidation feeds the reduction,}$
 $\text{so the reduction half reaction would need to occur}$
 $\text{twice for every one time the oxidation occurs.}$

- # 12. (1/2 marks) The liquid substances water ($d = 1.00 \text{ g/mL}$), mercury ($d = 13.5 \text{ g/mL}$) and cyclohexane ($d = 0.778 \text{ g/mL}$) do not form a solution when mixed, but separate into distinct layers. Sketch how the liquids would position themselves in a test tube; clearly label your diagram.



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

13. (1/8 marks) The koala eats exclusively eucalyptus leaves, which are poisonous to other animals. The chief constituent of eucalyptus oil is a substance called eucalyptol, which contains 77.87% C, 11.76% H, and remainder O by mass. 34SF

a) (7 marks) What is the empirical formula for this substance?

For a hypothetical 100-g sample of eucalyptol:

	mass per element	moles of each element	normalized	ratio
C	$0.7787 \times 100\text{g} = 77.87\text{ g}$ ✓	$\frac{77.87\text{ g C}}{12.01\text{ g/mol C}} = 6.4832\text{ mol C}$ ✓	10.00 ✓	10
H	$0.1176 \times 100\text{g} = 11.76\text{ g}$ ✓	$\frac{11.76\text{ g H}}{1.0079\text{ g/mol H}} = 11.668\text{ mol H}$ ✓	18.00 ✓	18
O	$100 - (77.87 + 11.76)$ ✓ $= 10.37\text{ g}$	$\frac{10.37\text{ g O}}{15.9994\text{ g/mol O}} = 0.6481\text{ mol O}$ ✓	1.000 ✓	1

Do NOT round off atomic masses!!

The experiment yields the smallest whole-number ratio of elements, so the EMPIRICAL FORMULA is $\boxed{\text{C}_{10}\text{H}_{18}\text{O}}$.

- correct MM's : worth 1 ∵ periodic table was incomplete
 - using properly : worth 0.5
 - mole values : worth 0.5 each
 - SF: if give 3 SF (lose 1)
2 SF (lose 1.5)
1 SF (lose 2) → won't even get correct formula since rounding error is so large!
- } this applies to molar masses of elements also!

b) (1 mark) A mass spectrometry experiment determined a molecular mass of 154 g/mol for this substance. What is its molecular formula?

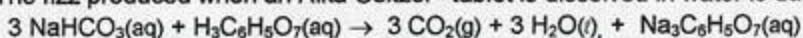
$$\frac{\text{molecular mass}}{\text{empirical formula mass}} = \frac{154\text{ g/mol}}{154.252\text{ g/mol}} = \frac{1}{1}$$

$$\begin{aligned} &\downarrow \\ &\text{C}_{10}\text{H}_{18}\text{O} \\ &= 154.252\text{ g/mol} \end{aligned}$$

∴ Molecular formula is the SAME as empirical formula
= $\text{C}_{10}\text{H}_{18}\text{O}$ ✓

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- # 14. (11 marks) The fizz produced when an Alka-Seltzer® tablet is dissolved in water is due to:

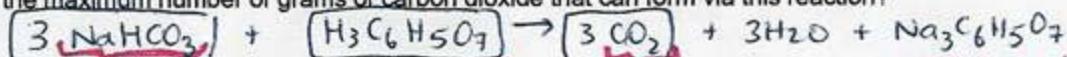


- a) (2 marks) What type(s) of reaction is this? How you can tell (be specific)?

✓ Acid-base reaction: $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$ (acid) transfers H^+ to bicarbonate HCO_3^- to yield H_2CO_3 (occurs 3x per 1 $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$)

2 ✓ + Gas-forming reaction: H_2CO_3 decomposes to yield H_2O & $\text{CO}_2(\text{g})$

- c) (7 marks) If you start with 1.00 g of sodium bicarbonate and 1.00 g of $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$, dissolved in a glass of water, what is the maximum number of grams of carbon dioxide that can form via this reaction?



$$\text{MM} = 84.01 \text{ g/mol} \checkmark$$

$$m = 1.00 \text{ g}$$

$$\therefore n = 0.01190 \text{ mol} \checkmark$$

$$\text{MM} = 192.13 \text{ g/mol} \checkmark$$

$$m = 1.00 \text{ g}$$

$$\therefore n = 0.005205 \text{ mol} \checkmark$$

NOTE: Keep extra SF in molar masses (don't round off!!)

*n = ? based on limiting reactant + stoichiometric ratio...

Find limiting reactant:

To use $3 \text{ mol NaHCO}_3 \checkmark$ = Need $1 \text{ mol H}_3\text{C}_6\text{H}_5\text{O}_7$
Have 0.01190 mol \times

\Rightarrow Need $x = 0.003967 \text{ mol H}_3\text{C}_6\text{H}_5\text{O}_7$
Have $0.005205 \text{ mol} \checkmark$ (EXCESS!)

$\therefore \text{L.R.} = \text{NaHCO}_3 \checkmark$

Alternatively:

Need $\frac{3 \text{ NaHCO}_3}{1 \text{ H}_3\text{C}_6\text{H}_5\text{O}_7} \checkmark$

Have $\frac{0.01190}{0.005205} = 2.286 \checkmark$
 \downarrow not enough

$\therefore \text{LR} = \text{NaHCO}_3 \checkmark$ (insufficient supply...)

To find mass of CO_2 produced: using L.R.!

Use $3 \text{ mol NaHCO}_3 \checkmark$ = make 3 mol CO_2
 $0.01190 \text{ mol} \quad y$

$\Rightarrow y = 0.01190 \text{ mol CO}_2$ theoretical yield

$$\therefore M_{\text{CO}_2} = (0.01190 \text{ mol})(44.01 \text{ g/mol}) \\ = 0.524 \text{ g produced.}$$

- d) (2 marks) What mass of excess reagent remains in the reaction solution after the reaction is complete?

Excess $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$ = unreacted.

= initial moles - reacted moles

$$= 0.005205 \text{ mol} - 0.003967 \text{ mol}$$

$$= 0.001238 \text{ mol}$$

Alternatively:

$$= 1.00 \text{ g} - (0.003967 \text{ mol})(192.13 \text{ g/mol})$$

$$= 1.00 \text{ g} - 0.762$$

$$= 0.238 \div 0.24 \text{ g}$$

$$M_{\text{H}_3\text{C}_6\text{H}_5\text{O}_7} = (0.001238 \text{ mol})(192.13 \text{ g/mol}) \therefore 0.238 \text{ g remains.} \\ (\text{So } \frac{1}{2} \text{ or } 3 \text{ SF are ok})$$