

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:

Averages

$$\begin{aligned} \text{Page 2. } & 7.9 / 12 = 65.5\% \\ \text{Page 3. } & 8.2 / 15 = 54.6\% \\ \text{Page 4. } & 2.1 / 8 = 26.6\% \\ \text{Page 5. } & 3.9 / 7 = 56.3\% \\ \text{Page 6. } & 3.2 / 10 = 31.7\% \end{aligned}$$

TOTAL: $25.3 / 50$ (MAXIMUM MARK = 52)
PERCENT: % 53.8%

EARNED towards FINAL GRADE: / 20

PART A: ONLY YOUR FINAL ANSWER WILL BE MARKED

1. (2 marks) Which three elements are likely to have very similar chemical and physical properties?

- C
- a) sodium, magnesium, and aluminum in same group
 - b) carbon, phosphorus and selenium
 - c) fluorine, chlorine, and bromine all halogens
 - d) zinc, copper, and nickel
 - e) uranium, plutonium, and americium

2. (2 marks) Bromine has two naturally occurring isotopes. If 50.54% of bromine is found as ^{79}Br (78.9183 amu), what is the mass of the other isotope? The average mass of bromine is 79.904 amu.

- C
- a) 79.82 amu $79.904 \text{ amu} = 0.5054 (78.9183 \text{ amu}) + (1 - 0.5054) x$
 - b) 79.97 amu $40.0189 = 0.4946 x$
 - c) 80.91 amu $x = 80.91 \text{ amu}$
 - d) 81.93 amu
 - e) 82.91 amu

3. (2 marks) You are given a white solid that is either $\text{Pb}(\text{NO}_3)_2$ or $\text{Zn}(\text{NO}_3)_2$. Which one of the following reagents (available as aqueous solutions) would allow you to distinguish between these two compounds?

- A
- a) KBr
 - b) HNO_3
 - c) $\text{CH}_3\text{CO}_2\text{H}$
 - d) NH_4ClO_4
 - e) LiNO_3
- | | | |
|---|---|---|
| $\underline{\text{Pb}^{2+}}$
$\underline{\text{PbBr}_2}$
\uparrow
<small>exception</small>
<small>(insoluble)</small> | $\underline{\text{Zn}^{2+}}$
$\underline{\text{ZnBr}_2}$
\uparrow
<small>normal</small>
<small>halide</small>
<small>(soluble)</small> | x all NO_3^- salts = soluble
xx all acetates = soluble
xxx all perchlorates = soluble |
|---|---|---|

4. (2 marks) The molecular model below depicts a molecule composed of carbon (black), oxygen (gray), and hydrogen (white) atoms. What is the correct empirical formula?

- E
- a) CHO
 - b) $\text{C}_6\text{H}_6\text{O}_2$
 - c) $\text{C}_6\text{H}_7\text{O}$
 - d) $\text{C}_7\text{H}_6\text{O}$
 - e) $\text{C}_7\text{H}_6\text{O}_2$

molecular: $\text{C}_7\text{H}_6\text{O}_2$ empirical = same since not
possible to simplify
ratio more & maintain whole numbers.# 5. (2 marks) All of the following are examples of intensive (also called intrinsic) properties EXCEPT

- B
- a) melting point. ✓
 - b) mass
 - c) colour. ✓
 - d) density. ✓
 - e) boiling point. ✓

↳ characteristic of substance
≈ independent of sample size

6. (2 marks) Pennies made after 1983 have a mass of 2.46 g and are composed of 97% zinc and 3.0% copper. How many atoms of copper are in a penny?

- A
- a) 0.0012 mol
 - b) 0.014 mol
 - c) 0.038 mol
 - d) 0.040 mol
 - e) 25 mol

$$2.46 \text{ g} \times 0.030 = 7.380 \times 10^{-3} \text{ g Cu}$$

$$\# n_{\text{Cu}} = \frac{7.380 \times 10^{-3} \text{ g}}{63.546 \text{ g/mol}} = 1.16 \times 10^{-3} \text{ mol}$$

$$\approx 1.2 \times 10^{-3} \text{ mol of atoms}$$

12

$$\checkmark = 1 \quad \cancel{\checkmark} = 0.5 \quad \cancel{\cancel{\checkmark}} = 0.25$$

PAGE 3

7. (3 marks) Identify the following statements as true or false. (Circle T or F.)

- T / F When sugar melts, the arrangement and composition of the sugar molecules change. $\frac{2 \text{ digits}}{2 \text{ SF total}} = 0.15$
- T / F A solution's pH value always has more digits than the solution's H^+ concentration. e.g. $1.0 \times 10^{-8} \text{ M}$
- T / F For the reaction below, 1 gram of C_3H_8 would yield 4 grams of water vapour.
 $\text{C}_3\text{H}_8(\text{g}) + 5 \text{ O}_2(\text{g}) \rightarrow 3 \text{ CO}_2(\text{g}) + 4 \text{ H}_2\text{O}(\text{g})$ } mole ratios, not masses!

3 digits
(2 S.F.)

8. (3 marks) Fill in the blanks:

i.e., not molecules

- 3 a) An example of an element that exists as free atoms: He, Ne, etc (any noble gas, or metal)
- b) Liquid nitrogen's boiling point (77 K) in Celsius: $-196^\circ\text{C} = (-273) + 77$
- c) Number of electrons in a ^{48}Ti (titanium-48) atom: 22 = same as atomic number ($Z = \# \text{e}^+$)

9. (3 marks) Write the missing name or formula, and classify each substance by type:

Substance name	Substance formula	Ionic or molecular substance?
potassium acetate	$\text{CH}_3\text{COO}^- \text{K}^+$	0.75 ionic ($M + NM^{1+}$)
sulfur trioxide	SO_3	0.75 molecular ($NM + NM$)
Copper (I) phosphate	Cu_3PO_4	0.75 ionic ($M + NM^{1+}$)

10. (3 marks) Draw particulate-level pictures (i.e., 1 atom = ●) of the molecules involved in a small sample of Br_2 in each of the three states of matter. Use a sample size of approximately 6 molecules.

Solid state (close-packed)	Liquid state (touching/touching)	Gaseous state (not touching)
well-ordered crystal 0.75 -0.25 if ionic	disorganized but still in contact 0.75 ↑ -0.25 if not... -0.5 if molecules break!!	0.75 0.75 0.75

11. (3 marks) Classify the two reactions below, and briefly justify your choices. Use as many of the following "type" labels as apply to each reaction: precipitation, acid-base, gas-forming or redox.

Reaction	Reaction type(s)	How did you decide?
$2 \text{ NaBr}(\text{aq}) + \text{F}_2(\text{g}) \rightarrow 2 \text{ NaF}(\text{aq}) + \text{Br}_2(\text{l})$ soluble soluble not solid	0.25 oxidation-reduction (redox) 0.5	elemental fluorine $\text{F}(0)$ gains e^- to form $\text{F}(-1)$ while $\text{Br}(-1)$ loses e^- to form $\text{Br}(0)$ in Br_2 change in ox. state $\Rightarrow e^-$ transfer. 0.75
$\text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Ca}(\text{OH})_2(\text{s})$ solid liquid insoluble/solid	0.25 acid-base not pptn, 0.5	H $^+$ transferred from H_2O to O^{2-} to form OH^- and OH^- (new bonds to H $^+$) H $^+$ transfer \Rightarrow acid-base rxn. 0.75

because
 * ① not simple ion-exchange
 ② solid reactant, so solid product not obvious!
 BUT: get 0.25 if say most OH^- salts are insoluble.

15

PART B: Short written answers

- # 12. (4 marks) Sulfuric acid and nitric acid are strong acids but also strong oxidizing agents, while hydrochloric acid is not an oxidizing agent. Explain why the chloride ion is not a strong oxidizing agent like SO_4^{2-} and NO_3^- . Include any relevant calculations.

- strong oxidizing agents (easily reduced)
 - strong ability to steal electrons from other species (cause oxidation)
 - contain an atom in a relatively high oxidation state, thus can accept e^- & be converted to a lower oxidation state

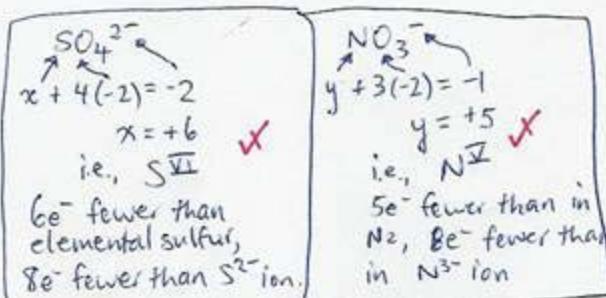
oxidation states

MUST COMPARE

Higher ox. # does not guarantee greater oxidizing strength, but often correlates. However, if ox. # is already at element's lowest value, it cannot accept e^- !!.

4

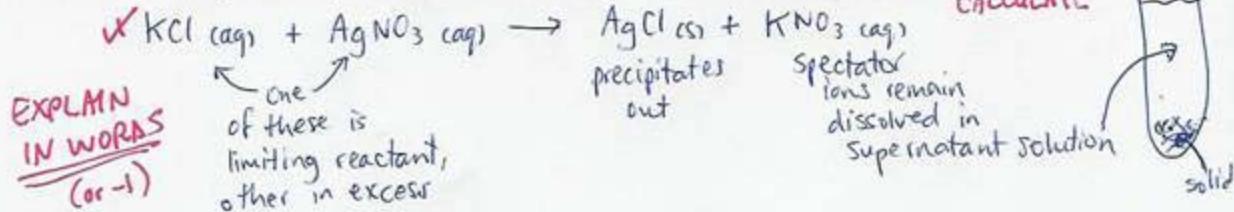
eg.



vs.

Cl^- (already stable : same e⁻ count as noble gas)
 ✓ oxidation state - I
 ✓ already the lowest oxidation state available to Cl,
 ✓ so cannot be reduced
 ✓ cannot act as an oxidant.
 (It is a reducing agent, actually).

- # 13. (4 marks) Imagine you mix known but unequal quantities of aqueous KCl and aqueous AgNO_3 to precipitate out solid AgCl . Explain in detail how you would determine the concentration of excess reactant remaining in the supernatant after the reaction occurs (assume 100% yield).



4

- ✓ ① determine which reactant is limiting \Rightarrow it will ALL be consumed
 \therefore none remains in supernatant

② based on 1:1 stoichiometry ✓ amount (moles) of L.R. present is equal to amount (moles) of other reactant actually consumed

③ calculate amount unreacted: ✓ amount initial - amount consumed = amount excess

④ calculate concentration: $\frac{\text{amount excess} \checkmark}{\text{total solution volume} \checkmark} = \frac{\text{moles}}{\text{L}}$ of excess reactant

8

\checkmark = 1 mark
 \checkmark = 0.5 mark

PAGE 5

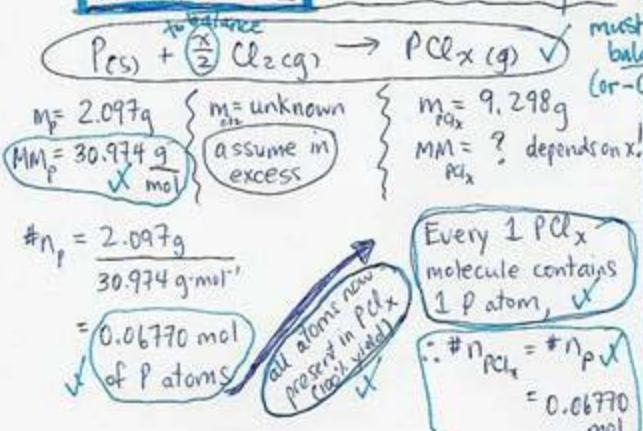
CHEM 205 Winter 2007 MIDTERM EXAM
Dr. C. Rogers, Section 04 W/F

Student ID #: marking scheme

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

- # 14. (7 marks) Phosphorus, P, is combined with chlorine, Cl_2 , to give a gaseous compound with the formula PCl_x . If you start with 2.097 g of P and isolate 9.298 g of PCl_x , what is the value of x? Show your calculations, and briefly explain your answer.

APPROACH #1: molar mass analysis



Now focus of molar mass of PCl_x :

$$MM_{\text{PCl}_x} = \frac{m_{\text{PCl}_x}}{\#n_{\text{PCl}_x}} = \frac{9.298 \text{ g}}{0.06770 \text{ mol}}$$

$= 137.3 \text{ g/mol}$ \checkmark

One mole of PCl_x contains 1 mole P and x moles Cl

i.e. $MM_{\text{PCl}_x} = MM_p + x MM_{\text{Cl}}$ \checkmark

$$\therefore x = \frac{MM_{\text{PCl}_x} - MM_p}{MM_{\text{Cl}}}$$

$= \frac{(137.3 - 30.974)}{35.45} \text{ g/mol}$

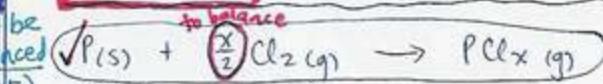
$= 3.000$

$\therefore x = 3 \checkmark$

Thus: the compound is PCl_3 (g).

7

APPROACH #2: mole fraction \Rightarrow formula



$m_p = 2.097 \text{ g}$ (excess)

$m_{\text{PCl}_x} = 9.298 \text{ g}$

explanations
 PCl_x is composed of phosphorus atoms + chlorine atoms, and assuming we had 100% conversion (yield) of PCl_x from P,

$\checkmark \quad M_{\text{PCl}_x} = M_p \text{ atoms from P used} + M_{\text{Cl}} \text{ atoms}$

$\therefore M_{\text{Cl}} = M_{\text{PCl}_x} - M_p$

$= 9.298 \text{ g} - 2.097 \text{ g}$

$\therefore M_{\text{Cl}} = 7.201 \text{ g}$ \checkmark

our source of chlorine atoms was Cl_2 gas

In our sample of PCl_x weighing 9.298 g:

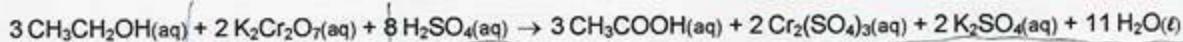
element	mass	$\#n = \frac{\text{mass}}{MM}$	mole ratio
P	2.097 g	$\frac{2.097 \text{ g}}{30.974 \text{ g/mol}} = 0.06770 \text{ moles P atoms}$	$\frac{0.06770}{0.06770} = 1$
Cl	7.201 g	$\frac{7.201 \text{ g}}{35.45 \text{ g/mol}} = 0.2031 \text{ moles Cl atoms}$	$\frac{0.2031}{0.06770} = 3$

explanations

We normalize the number of moles of the two elements to find the whole number ratio of elements, which yields the empirical formula:

PCl_3 ie: $x = 3 \checkmark$

15. (10 marks total) The alcohol ($\text{CH}_3\text{CH}_2\text{OH}$) content in a 10.3 g sample of blood from a driver required 2.79 mL of 0.07923 M $\text{K}_2\text{Cr}_2\text{O}_7$ solution to reach the equivalence point in a titration involving the reaction shown below. If the legally allowed limit is 0.10 % alcohol by mass in the blood, should the police charge the driver with drunk driving? Show your calculations, and briefly explain your answer. Worth 2



$$M = ?$$

If > 0.10 %

of blood mass
is ethanol,
must be charged

$$C = 0.07923 \text{ M}$$

$$V = 0.00279 \text{ L}$$

assume
excess

$$\#n = C (\text{mol/L}) \times V (\text{L})$$

$$= (0.07923 \text{ mol/L}) (0.00279 \text{ L})$$

\therefore Find m: 2.0 \checkmark $\frac{V}{X} = 2.211 \times 10^{-4} \text{ mol used}$

\checkmark to consume all the ethanol

Experiment
designed to
give exact
stoch. ratio
OR,
alcohol
was L.R.

Alternate approach
to point ②: find 0.10%
of blood mass = $0.010 \times 10.3 \text{ g}$

35
masses = 0.103 g.

4.0 for
calc. for
mass. est.
or compare to our sample
mass (0.0153 g)
too much

① According to the reaction's stoichiometry, 2 mol $\text{K}_2\text{Cr}_2\text{O}_7$ consumes 3 mol ethanol:

$$\frac{3 \text{ mol ethanol}}{X \text{ mol ethanol}} = \frac{2 \text{ mol } \text{K}_2\text{Cr}_2\text{O}_7}{2.211 \times 10^{-4} \text{ mol } \text{K}_2\text{Cr}_2\text{O}_7 \text{ used}} \Rightarrow X = 3.317 \times 10^{-4} \text{ mol}$$

ethanol was consumed.

② This ethanol was present in the blood sample (10.3 g). Must find mass %.

$$\text{mass \% ethanol} = \left(\frac{\text{mass ethanol}}{\text{mass sample}} \right) \times 100\% \quad 2\text{MM}_C + 6\text{MM}_H + 1\text{MM}_O = \text{Mol ethanol}$$

$$= \frac{(3.317 \times 10^{-4} \text{ mol})(46.069 \text{ g/mol of ethanol})}{10.3 \text{ g blood sample}} \times 100\%$$

$$= 0.1528 \text{ g ethanol} \times 100\%$$

$$= \frac{0.1528 \text{ g ethanol}}{10.3 \text{ g blood}} \times 100\%$$

$$= 0.148\% > 0.10\% \quad \checkmark$$

③ The legal limit is 0.10 %, so this driver should be charged, because their blood alcohol is above the limit. ✓

(1 mark) What type of reaction is this? Explain your choice.

1 0.5 Redox reaction, because changes of oxidation states occur (evidence of electron transfer).

10 + proof 0.25 Most obvious: $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}_2(\text{SO}_4)_3$ chromium was reduced.
 $2x + 7(-2) = -2$ Something else must have
 $\therefore x = +6$ been oxidized (carbon was.)