

75 min
marking scheme
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 the show-your-work questions. **GOOD LUCK!**

LAST NAME: marking scheme FIRST NAME: _____

STUDENT NUMBER: _____

Mark breakdown: AVERAGE
GRADES

Page 2.	9.9 / 15	66%
Page 3.	4.8 / 7	69%
Page 4.	5.4 / 11	49%
Page 5.	4.9 / 9	54%
Page 6.	5.7 / 9	64%

TOTAL: 27.3 / 50 (MAXIMUM MARK = 51)

PERCENT: 61.4 %

EARNED towards FINAL GRADE: 12.3 / 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.)

- 3
T / F Hydrated compounds contain ^{x water} hydrogen gas trapped inside the crystal lattice. $T_c + 273.15 = T_k$
T / F To convert from degrees Celsius to Kelvins, ^x subtract 273.15 from the temperature in Celsius.
T / F Based on the atomic mass of bromine, its most abundant isotope is probably ^{80}Br .
79.904

2. (/ 4 marks) Fill in the blanks:

- 4
a) Number of electrons in $^{80}_{35}\text{Br}$ 35 $\#e = \#p = 35$ (atomic #)
b) Number of neutrons in $^{126}_{53}\text{I}$ 73 $\#n = \text{mass \#} - \#p = 126 - 53 = 73$
c) Charge on oxygen in Li_2O -2 (-II)
d) Oxidation state of C in HCO_3^- +4 (+IV) $(+1) + x + 3(-2) = -1$
 $x = +4$

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

- 4
a) bromine trichloride BrCl_3 ionic / molecular? ^{0.25} nonmetal-nonmetal
b) chromium(III) nitrate $\text{Cr}(\text{NO}_3)_3$ ionic / molecular? ^{0.25} metal - (polyatomic anion)
c) $\text{Fe}_2(\text{SO}_4)_3$ iron (III) sulfate ionic / molecular? ^{0.25} metal - (polyatomic anion)
d) K_3P potassium phosphide ionic / molecular? ^{0.25} metal-nonmetal
- part marks on names/formulas

4. (/ 4 marks) Label the following reactions as precipitation, acid-base, gas-forming or redox.

and: If precipitation: circle the solid product.
If acid-base: circle the reactant that is the base.
If gas-forming: circle the gaseous product.
If redox: circle the oxidizing agent.

- 1 { a) $2\text{CH}_4 + 2\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{HCN} + 6\text{H}_2\text{O}$ REDOX (OX. AGENT) ^{0.5 mark max for HCN/gas-forming since all reactants are gases (∴ hard to tell!)}
2 { b) $2\text{HClO}_4 + \text{Na}_2\text{S} \rightarrow \text{H}_2\text{S} + 2\text{NaClO}_4$ ACID-BASE (BASE) (GAS) ∴ also GAS-FORMING ^{oops, not balanced (but does not affect this question...)}
1 { c) $\text{CuSO}_4 + \text{Na}_2\text{CO}_3 \rightarrow \text{CuCO}_3 + \text{Na}_2\text{SO}_4$ PRECIPITATION (SOLID)

5. (/ 3 marks) American pennies made after 1983 are composed of 97.0% Zn and 3.00% copper and have a mass of 2.46 g. How many atoms of Zn are in one penny? (Circle your choice.)

- C 1 a) 6.81×10^{20} copper...
1 b) 2.27×10^{22} forget %
3 c) 2.20×10^{22}
0 d) 4.44×10^{22}
1 e) 1.44×10^{24} forget moles

$$0.970 \times 2.46 \text{ g} = 2.386 \text{ g Zn in one penny}$$
$$2.386 \text{ g} \times \frac{1 \text{ mol}}{65.409 \text{ g}} = 0.03648 \text{ mol Zn}$$

$$0.03648 \text{ mol} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 2.20 \times 10^{22} \text{ atoms}$$

6. (/ 1 mark) Which of the following choices contain(s) elements that are all in the same period?

- D 1 a) F, Cl, Br, I same group Row.
b) Na, Ca, Fe, Cu Na + Ca not in same period
c) Li, Na, K, Rb same group
d) Ba, W, Au, Pb
e) both (a) and (c)

7. (/ 1 mark) Imagine you are trying to remove dissolved Pb^{2+} ions from the waste-water in a water treatment plant. Which ONE of the following substances, if added to the waste-water, would cause the lead ions to precipitate out as an insoluble compound?

- B 1 a) KNO_3 $\text{Pb}(\text{NO}_3)_2$ soluble
b) CaCl_2 PbCl_2 INSOLUBLE
c) NaClO_4 $\text{Pb}(\text{ClO}_4)_2$ soluble
d) NH_3
e) CH_3COOH } not sure what reaction w'd see here...
but $\text{Pb}(\text{CH}_3\text{COO})_2$ is soluble

8. (/ 1 mark) Which ONE of the following statements concerning ionic compounds is incorrect?

- E 1 a) as the ion charges increase, the attraction between the ions increases.
b) ionic compounds exist as extended 3-dimensional networks called crystal lattices.
c) ionic crystals tend to be rigid, and they cleave along planes.
d) positive and negative ions are attracted to each other by electrostatic forces.
e) although not ductile like metals, ionic compounds are often malleable. no - brittle crystalline solids

9. (/ 1 mark) Mothballs contain naphthalene, which has a molar mass of 128.17 g/mol. The empirical formula of naphthalene is C_5H_4 . What is its molecular formula?

- D 1 a) C_5H_4
b) C_8H_{10}
c) C_9H_{12}
d) C_{10}H_8
e) not enough information provided

$$\text{empirical mass} = 5(12.01) + 4(1.0079) = 64.087 \text{ g/mol}$$

$$\text{Scaling factor} = \frac{128.17 \text{ g/mol}}{64.087 \text{ g/mol}} \div 2$$

$$\therefore \text{molecular formula} = 2 \times \text{C}_5\text{H}_4 = \text{C}_{10}\text{H}_8$$

7

PART B: Short written answers

10. (/ 6 marks) Imagine you swallow a spoonful of an antacid preparation containing milk of magnesia to settle your upset stomach. The preparation is an aqueous suspension of $\text{Mg}(\text{OH})_2$, which will react with your excess stomach acid (aqueous HCl).

a) (1.5 marks) Would you describe $\text{Mg}(\text{OH})_2$ as an acid or a base? Why?

It is a base because it releases OH^- ions into solution.

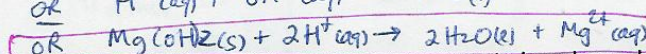
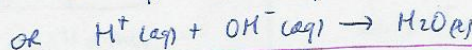
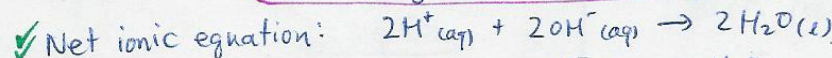
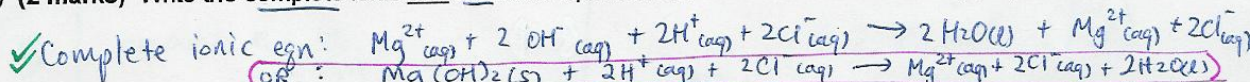
b) (1.5 marks) Would you describe $\text{Mg}(\text{OH})_2$ as a weak or strong electrolyte? Why?

It is a weak electrolyte because it is not very soluble \therefore only releases a small quantity of ions into solution.

c) (1 mark) Is HCl a strong acid or a weak acid?

Strong (dissociates 100% to yield H^+ in solution)

d) (2 marks) Write the complete ionic and net ionic equations for the reaction between $\text{Mg}(\text{OH})_2$ and HCl :

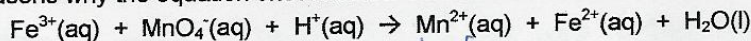


-0.5 if do not show subscripts (phases)

-0.5 if not balanced

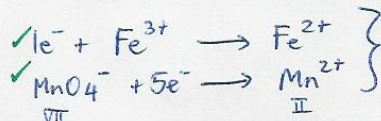
pink answers ok too since $\text{Mg}(\text{OH})_2$ is not very soluble.

11. (/ 3 marks) The reaction between iron(III) ion and permanganate ion shown below does not occur. Provide two reasons why the equation shown below cannot describe a real reaction.



1.) The equation is not balanced (\therefore law of conservation of matter is violated).
 \rightarrow for neither mass nor charge.

2.) Reduction can only occur if oxidation also occurs simultaneously.



Both of these are being reduced, and none of the other species listed (ie. H^+) is oxidized! No source of electrons to feed the reductions. is included in the reaction equation given here ie: no reducing agent present

12. (/ 2 marks) Imagine you read a newspaper article about an accidental spill of hydrochloric acid in an area where sodium hydroxide solution is also present. The article describes the potential for the formation of hazardous chlorine gas if the two solutions come into contact. Is this an accurate description of the potential danger of the situation? Why or why not? NO



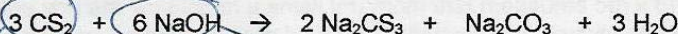
Hydrochloric acid is a strong acid and sodium hydroxide is a strong base. When an acid + a base react, the only process involved is transfer of H^+ ions from the acid to the base. This still might be dangerous due to the release of a lot of heat, but not due to formation of $\text{Cl}_2(\text{g})$.

To convert the Cl^- ions from the $\text{HCl}(\text{aq})$ into $\text{Cl}_2(\text{g})$, the Cl atoms would have to be oxidized from $\text{Cl}(\text{I})$ to $\text{Cl}(\text{0})$. This would require an oxidizing agent, ie. an electron acceptor, but H^+ and Na^+ are not strong oxidants. We know this because we have seen this above acid/base reaction enough that we know it is not accompanied by a redox process.

✓ means 0.5 marks
-0.5 for wrong SF (at end)
-0.5 for rounding error

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

13. (9 marks) A side reaction in the manufacture of rayon from wood pulp is:



If 92.5 mL of liquid CS_2 ($d = 1.26 \text{ g/mL}$) is reacted with 110 g of solid NaOH , and the reaction occurs with 73% yield, what mass of Na_2CS_3 is produced?

2SF.

quantities of reactants
3

$$\begin{aligned} \text{density } \text{CS}_2 &= 1.26 \text{ g/mL} \\ \text{volume} &= 92.5 \text{ mL} \\ \therefore \text{mass} &= d \times V \\ &= (1.26 \text{ g mL}^{-1}) (92.5 \text{ mL}) \\ &= 116.6 \text{ g } \text{CS}_2 \end{aligned}$$

$$\begin{aligned} \text{amount: } n &= \frac{m}{\text{MM}} \\ &= \frac{116.6 \text{ g } \text{CS}_2}{76.14 \text{ g mol}^{-1}} \\ &= 1.531 \text{ mol (but 3SF)} \end{aligned}$$

$$\begin{aligned} \text{mass } \text{NaOH} &= 110 \text{ g} \\ \text{MM} &= 40.00 \text{ g mol}^{-1} \\ \text{amount: } n &= \frac{110 \text{ g}}{40.00 \text{ g mol}^{-1}} \\ &= 2.75 \text{ mol (but 2SF)} \end{aligned}$$

Which reactant is the limiting reactant?

Limiting reactant determination
3

$$\text{For reaction: } \frac{\text{need } 3 \text{ mol } \text{CS}_2}{\text{need } x \text{ mol}} = \frac{\text{to use } 6 \text{ mol } \text{NaOH}}{\text{to use } 2.75 \text{ mol } \text{NaOH}}$$

$$\begin{aligned} x &= 1.375 \text{ mol } \text{CS}_2 \text{ needed} \quad \text{logic } \checkmark \\ &\text{have } 1.53 \text{ mol } \text{CS}_2 \quad \checkmark \\ \therefore \text{excess } \text{CS}_2, \text{ NaOH limiting} \end{aligned}$$

theoretical yield
5

Theoretical yield of product depends on 100% reaction of the limiting reactant:

$$\frac{\text{use } 6 \text{ mol } \text{NaOH}}{\text{have } 2.75 \text{ mol } \text{NaOH}} = \frac{\text{form } 2 \text{ mol } \text{Na}_2\text{CS}_3}{y \text{ mol } \text{Na}_2\text{CS}_3}$$

$$y = 0.917 \text{ mol } \text{Na}_2\text{CS}_3$$

$$\begin{aligned} \text{Theoretical yield in mass} &= n \times \text{MM}_{\text{Na}_2\text{CS}_3} \\ &= (0.917 \text{ mol}) (154.186 \text{ g mol}^{-1}) \\ &= 141.39 \text{ g} \end{aligned}$$

actual yield
1

$$\begin{aligned} \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100\% &= \% \text{ yield} \\ \therefore \text{Actual yield} &= (0.73) (141.39 \text{ g}) \\ &= 103.2 \text{ g} \\ &= 1.0 \times 10^2 \text{ g (2SF)} \end{aligned}$$

-0.5 for wrong SF
✓ means 0.5 marks

Student ID #: marking scheme

14. (9 marks) HCN is a poisonous gas. A lethal dose of HCN can be inhaled if you breathe air that contains about 300 mg of HCN per 1 kg of air. 1 significant figure (300mg)

a) (5 marks) Imagine you are working in a small lab room that measures 5m x 6m x 3m. How much HCN (in grams) would cause room's air to be lethal? Assume the density of air is 0.00118 g/cm³, and that the room's entire volume is filled with air.

Room volume = 5m x 6m x 3m = 90m³ ✓

Air density = $\frac{0.00118 \text{ g}}{1 \text{ cm}^3}$ ∴ should convert room volume into cm³ (or density into g/m³)

90m³ x $\left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3$ = 90m³ x $\left(\frac{10^3 \text{ cm}^3}{1^3 \text{ m}^3}\right)$ = 90 x 1000 000 cm³ ∴ V = 9.0 x 10⁷ cm³ ✓

Thus: mass of air = d x V = $\left(\frac{0.00118 \text{ g}}{\text{cm}^3}\right) (9.0 \times 10^7 \text{ cm}^3)$ = 106 200 g air ∴ m_{air} = 106.2 kg air

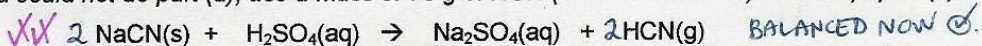
Lethal dose of HCN = $\left(\frac{300 \text{ mg HCN}}{1 \text{ kg air}}\right) \times (106.2 \text{ kg air}) \times \left(\frac{1 \text{ g}}{1000 \text{ mg}}\right)$

= 31.86 g (but only 1 SF)

∴ 30 g of HCN gas in the room would be lethal

b) (4 marks) HCN is formed when NaCN comes into contact with acid (usually by accident). If HCN forms by the reaction below (unbalanced), what mass of NaCN would cause the lethal dose of HCN from part (a) to be released into the air?

Note: if you could not do part (a), use a mass of 75 g of HCN (which is incorrect) to attempt part (b).



Need to calculate how much NaCN required to form 30g of HCN.

How many moles of HCN?

$n_{\text{HCN}} = \frac{m_{\text{HCN}}}{MM_{\text{HCN}}}$
= (30g) / (27.0256 g mol⁻¹ HCN)
= 1.1 mol

$\frac{2 \text{ mol HCN produced}}{1.1 \text{ mol HCN}} = \frac{2 \text{ mol NaCN used}}{x \text{ NaCN}}$

x = 1.1 mol NaCN required

$m_{\text{NaCN}} = n_{\text{NaCN}} \times MM_{\text{NaCN}}$
= (1.1 mol) (49.0075 g/mol)
= 54.40g
∴ m = 50g (1 sig. fig.)

For 75g of HCN: (2 SF)

$n = 75 \text{ g} / 27.0256 \text{ g mol}^{-1}$
= 2.775 mol HCN

1:1 stoichiometry
∴ 2.775 mol NaCN needed

$m = (2.775 \text{ mol}) (49.0075 \text{ g/mol})$
= 136.00g
= 140g (2 SF)

To release the lethal dose, 140g of NaCN would need to react: