Concordia University CHEM 205 Fall 2005
Dr. C. Rogers, Section 02 MIDTERM EXAM

Wed Oct 26

75 min

Student ID #: 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

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PART A: ONLY YOUR FINAL ANSWER WILL BE MARKED

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

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T / (F) Hydrated compounds contain hydrogen gas (× water) trapped inside the crystal lattice.

T / (F) To convert from degrees Celsius to Kelvins, subtract (×) 273.15 from the temperature in Celsius. $T_c + 273.15 = T_K$

(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:

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a) Number of electrons in $^{80}_{35}Br$ ___35___ $\#e = \#p = 35$ (atomic #)

b) Number of neutrons in $^{126}_{53}I$ ___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:

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a) bromine trichloride ___$BrCl_3$___ ionic / (molecular)? (0.25) nonmetal-nonmetal

b) chromium(III) nitrate ___$Cr(NO_3)_3$___ (ionic) / molecular? (0.25) metal – (polyatomic anion)

c) $Fe_2(SO_4)_3$ ___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) $2\,CH_4 + 2\,NH_3 + 3(O_2) \rightarrow 2\,HCN + 6\,H_2O$
REDOX (OX. AGENT)
0.5 mark max for HCN/gas-forming since all reactants are gases (∴ hard to tell!)

2 b) $2\,HClO_4 + 2(Na_2S) \rightarrow (H_2S) + 2\,NaClO_4$ ← oops, not balanced (but does not affect this question...)
ACID-BASE (BASE) (GAS) ∴ also GAS-FORMING

1 c) $CuSO_4 + Na_2CO_3 \rightarrow (CuCO_3) + Na_2SO_4$
PRECIPITATION (SOLID)

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 # 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.)*

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

$0.970 \times 2.46\,g = 2.386\,g$ Zn in one penny

$2.386\,g \times \frac{1\,mol}{65.409\,g} = 0.03648\,mol\ Zn$

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

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

a) F, Cl, Br, I — same group
b) Na, Ca, Fe, Cu — Na + Ca not in same period
D 1 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?

a) KNO_3
B 1 b) $CaCl_2$
c) $NaClO_4$
d) NH_3
e) CH_3COOH

$Pb(NO_3)_2$ soluble
$PbCl_2$ INSOLUBLE
$Pb(ClO_4)_2$ soluble
} not sure what reaction we'd see here...
} but $Pb(CH_3COO)_2$ is soluble

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

a) as the ion charges increase, the attraction between the ions increases.
b) ionic compounds exist as extended 3-dimensional networks called crystal lattices.
E 1 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?

a) C_5H_4
D 1 b) C_8H_{10}
c) C_9H_{20}
d) $C_{10}H_8$
e) not enough information provided

empirical mass = $5(12.011) + 4(1.0079)$
$= 64.087\,g/mol$

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

∴ molecular formula = $2 \times C_5H_4$
$= C_{10}H_8$

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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 $Mg(OH)_2$, which will react with your excess stomach acid (aqueous HCl).

a) **(1.5 marks)** Would you describe $Mg(OH)_2$ 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 $Mg(OH)_2$ as a weak or strong electrolyte? Why?

It is a weak ✓ electrolyte because it is not ✓ very soluble ∴ 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 $Mg(OH)_2$ and HCl:

✓ Complete ionic eqn: $Mg^{2+}_{(aq)} + 2\,OH^-_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2\,H_2O_{(l)} + Mg^{2+}_{(aq)} + 2Cl^-_{(aq)}$

OR: $Mg(OH)_2{}_{(s)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow Mg^{2+}_{(aq)} + 2Cl^-_{(aq)} + 2H_2O_{(l)}$

✓ Net ionic equation: $2H^+_{(aq)} + 2OH^-_{(aq)} \rightarrow 2\,H_2O_{(l)}$

OR $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

OR $Mg(OH)_2{}_{(s)} + 2H^+_{(aq)} \rightarrow 2\,H_2O_{(l)} + Mg^{2+}_{(aq)}$

-0.5 if do not show subscripts (phases)

-0.5 if not balanced

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

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 # 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.

$$Fe^{3+}(aq) + MnO_4^-(aq) + H^+(aq) \rightarrow Mn^{2+}(aq) + Fe^{2+}(aq) + H_2O(l)$$

1.) ✓ The equation is not balanced (∴ law of conservation of matter is violated) → for neither mass nor charge.

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

✓ $1e^- + Fe^{3+} \rightarrow Fe^{2+}$

✓ $MnO_4^- + 5e^- \rightarrow Mn^{2+}$ (VII → II)

} 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

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 # 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 ✓

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$ ✓

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 $Cl_2(g)$.

To convert the Cl^- ions from the $HCl_{(aq)}$ into $Cl_2(g)$, the Cl atoms would have to be oxidized from Cl(-I) to Cl(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.

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✓ means 0.5 marks
−0.5 for wrong SF (1st end)
−0.5 for rounding error

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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:

$$3\,CS_2 + 6\,NaOH \rightarrow 2\,Na_2CS_3 + Na_2CO_3 + 3\,H_2O$$

If 92.5 mL of liquid CS_2 (d = 1.26 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

density CS_2 = 1.26 g/mL
volume = 92.5 mL
∴ mass = d × V
= (1.26 g mL^{-1})(92.5 mL) ✓
= 116.6 g CS_2

amount: $n = \frac{m}{MM}$ ✓
$= \frac{116.6\text{ g } CS_2}{76.14\text{ g·mol}^{-1}}$ ✓
= 1.531 mol (but 3SF)

mass$_{NaOH}$ = 110 g
MM = 40.00 g·mol^{-1}
amount: $n = \frac{110\text{ g}}{40.00\text{ g·mol}^{-1}}$ ✓ ✓
= 2.75 mol (but 2SF)

Which reactant is the limiting reactant?

limiting reactant determination 3

For reaction: $\frac{\text{need } 3\text{ mol } CS_2}{\text{need } x\text{ mol}} = \frac{\text{to use } 6\text{ mol NaOH}}{\text{to use } 2.75\text{ mol NaOH}}$ ✓

x = 1.375 mol CS_2 needed } logic ✓
have 1.53 mol CS_2 } ✓
∴ excess CS_2, NaOH limiting

theoretical yield 3

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

$\frac{\text{use } 6\text{ mol NaOH}}{\text{have } 2.75\text{ mol NaOH}} = \frac{\text{form } 2\text{ mol } Na_2CS_3}{y\text{ mol } Na_2CS_3}$ ✓

y = 0.917 mol Na_2CS_3

Theoretical yield in mass = $n \times MM_{Na_2CS_3}$ ✓ ✓
= (0.917 mol)(154.186 g·mol^{-1})
= 141.39 g

actual yield 1

$\frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100\% = \%\text{ yield}$ ∴ Actual yield = (0.73)(141.39 g) ✓
= 103.2 g
= 1.0×10^2 g (2SF)

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−0.5 for wrong SF
✓ means 0.5 marks

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 # 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 × 6m × 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.*

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Room volume = 5m × 6m × 3m = 90 m³ ✓ } 1

Air density = $\frac{0.00118\ g}{1\ cm^3}$ ∴ Should convert room volume into cm³ (or density into g/m³) } 1.5

$90\ m^3 \times \left(\frac{100\ cm}{1\ m}\right)^3$ ✓✓ = $90\ m^3 \times \left(\frac{100^3\ cm^3}{1^3\ m^3}\right)$ = 90 × 1000 000 cm³

∴ V = $9.0 \times 10^7\ cm^3$ ✓✓

Thus: mass of air = d × V = $\left(\frac{0.00118\ g}{cm^3}\right)(9.0 \times 10^7\ cm^3)$ ✓✓ = 106 200 g air ✓✓ } 1

∴ m_{air} = 106.2 kg air

Lethal dose of HCN = $\left(\frac{300\ mg\ HCN}{1\ kg\ air}\right)$ ✓✓ × (106.2 kg air) × $\left(\frac{1\ g}{1000\ mg}\right)$ ✓✓ } 1.5

= 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? 30g ←

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

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✓✓ $2\ NaCN(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2HCN(g)$ BALANCED NOW ✓

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

How many moles of HCN?

$n_{HCN} = m_{HCN} / MM_{HCN}$ ✓✓

$= (30\ g)/(27.0256\ g\ mol^{-1}\ HCN)$

= 1.11 mol ✓✓

$\frac{2\ mol\ HCN\ produced}{1.11\ mol\ HCN} = \frac{2\ mol\ NaCN\ used}{x\ NaCN}$ ✓✓

x = 1.11 mol NaCN required ✓✓

$m_{NaCN} = n_{NaCN} \times MM_{NaCN}$ ✓✓

$= (1.11\ mol)(49.0075\ g/mol)$ ✓✓

= 54.40 g

∴ m ≈ 50 g (1 sig. fig.)

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For 75g of HCN: (2SF)

n = 75g / 27.0256 g mol⁻¹ ✓✓

= 2.775 mol HCN ✓✓

1:1 stoichiometry ✓✓

∴ 2.775 mol NaCN needed

m = (2.775 mol)(49.0075 g/mol) ✓✓

= 136.00 g ✓✓

= 140 g (2 SF)

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