Concordia University CHEM 205

Winter 2008, Dr. C. Rogers, Section 03

LAST NAME:	Rogers
FIRST NAME:	
STUDENT ID:	marking scheme

Chem 205: GENERAL CHEMISTRY I
MIDTERM EXAMINATION

PLEASE READ THIS BOX 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!**

Mark breakdown:

	Averages	(%)	
Page 2.	4.8 / 8	60	
Page 3.	9.4 / 15	63	
Page 4.	4.1 / 9	46	← Work on explaining! Practice "conceptual + summary questions" in Kotz textbook.
Page 5.	2.8 / 5	56	
Page 6.	8.1 / 14	58	

TOTAL: 29.2 / 50 (MAXIMUM MARK = 51)

PERCENT: 58 %

EARNED towards FINAL GRADE: 11.6 / 20

CHEM 205 Winter 2008 MIDTERM EXAM
Dr. C. Rogers, Section 03 T/J

Student ID #: marking scheme

PART A: ONLY YOUR FINAL ANSWER WILL BE MARKED

 # 1. (2 marks) The nuclear model of the atom, as proposed by Ernest Rutherford, was based on observations of the scattering of alpha particles by a thin gold foil. Which of the following statements is not true?

⇒ NUCLEUS IN CENTRE OF ATOM, MADE OF ⊕ PARTICLES PACKED TOGETHER
↳ large, ⊕ charged...

Ch. 2

B

a) ✓ Most of the positively charged alpha particles passed directly through the foil without being significantly deflected (scattered) away from their original direction of flight. YES → atoms mostly empty space!
b) The majority of the alpha particles bounced straight back from the shiny gold foil.
c) ✓ A small fraction of the positively charged alpha particles was deflected through very large angles. ↳ only the ones that struck a nucleus!
d) ✓ The alpha particles were scattered because they are much lighter than gold nuclei.
e) ✓ Earlier models of the atom predicted that the majority of the positively charged alpha particles would be deflected, but not by very large angles. → because plum-pudding model (Thomson) suggested ⊕ was diffuse, not in one "big" nucleus

 # 2. (2 marks) When water boils bubbles can be seen rising to the surface. What do the bubbles contain?

Ch. 1

D

a) A mixture of hydrogen, H_2, and oxygen, O_2, gases
b) Nothing (a vacuum)
c) Air (mostly nitrogen, N_2, and oxygen, O_2)
d) H_2O vapour = steam = $H_2O_{(g)}$
e) Ionized water (H^+ and OH^-)

 # 3. (2 marks) What is the pH of 0.0050 M HNO_3?

an acid ∴ pH < 7 definitely

Ch. 5

A

a) 2.30
b) –2.30 ← forgot "–" in formula
c) 5.30
d) –5.30
e) ✗ 7.00 neutral

$pH = -\log[H^+]$ and

$= -\log(0.0050)$

↑ between $10^{-3} \rightarrow 10^{-2}$ mol/L

$\therefore pH = 2.30$

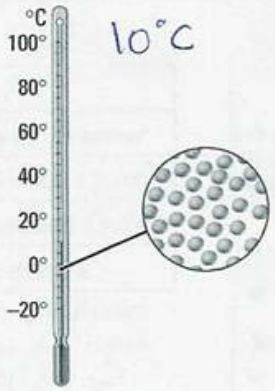
$HNO_{3(aq)} \xrightarrow{100\%} H^+_{(aq)} + NO_3^-{}_{(aq)}$
strong acid
0.0050 mol/L ⇒ 0.0050 mol/L H^+

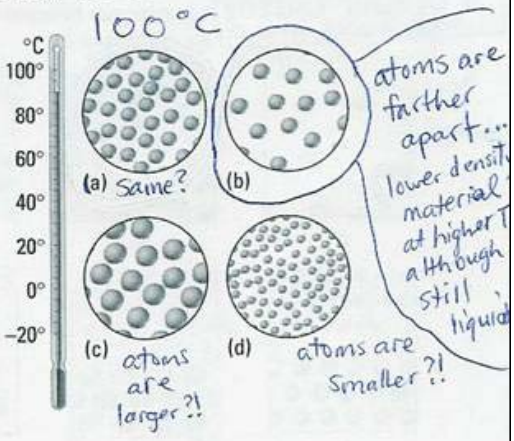
 # 4. (2 marks) The figure on the left shows a "nanoscale" view of the mercury atoms in a thermometer registering 10 °C. Which figure on the right (on the same scale as the figure on the left) best represents the mercury atoms in the thermometer if it is registering 100 °C?

Ch. 1

B

a) a
b) b
c) c
d) d
e) none





8

CHEM 205 Winter 2008 MIDTERM EXAM
Dr. C. Rogers, Section 03 T/J

Student ID #: marking scheme

 # 5. (5 marks) Identify the following statements as true or false. *(Circle T or F.)*

Ch.3 F — T / (F) A hydrated ionic compound is an ionic compound which is dissolved in water. ✗ contains H_2O molecules inside crystal lattice

Ch.2 F — T / (F) All isotopes of the same element contain the same number of neutrons ✗ protons (same # as atomic #)

Ch.5 T — (T) / F In elemental form, oxygen generally acts as an oxidizing agent ✓ steals electrons to change from 0 (0) to 0 (−II)

Ch.5 F — T / (F) All reactions involving an acid are classified as acid-base reactions. ✗ A/B rxns involve H^+ transfer from acid to base. No, remember redox rxn in class: $2HCl_{(aq)} + Mg_{(s)} \rightarrow H_{2(g)} + MgCl_{2(aq)}$ (acid... not a base)

Ch.1 T — (T) / F An aqueous solution is an example of a homogeneous mixture. yes, appears to have same composition throughout, BY EYE.

5

 # 6. (5 marks) Fill in the blanks:

Ch.1 a) The boiling point of helium (4.2 K) on the Celsius scale is: $-273.15 + 4.2\,K = -268.95 \doteq -269.0\,^{\circ}C$ (1 decimal pl.)

Ch.2 b) The number of protons in a ^{200}Hg (mercury-200) atom is: Same as atomic # = 80

Ch.2 c) Two allotropes of carbon are: graphite, diamond, buckminsterfullerene

Ch.1 d) The lab technique to separate insoluble solid from a solution is: filtration

Ch.5 e) The unstable species that forms when CO_2 reacts with H_2O is: carbonic acid, H_2CO_3

5

 # 7. (3 marks) Write the missing name or formula, and classify each substance by type: ✓ each 0.25 here

Ch.3

Substance name	Substance formula	Ionic or molecular substance?
potassium carbonate	✓ K_2CO_3 ✓ 0.75	0.25 ionic ✓ (K^+ & CO_3^{2-})
phosphorus pentachloride	✓ PCl_5 ✓ 0.75	0.25 molecular ✓ (no ions)
ammonium ✓ perchlorate 0.75	NH_4ClO_4	0.25 ionic ✓ (NH_4^+ & ClO_4^-)

✓ no comment on #s

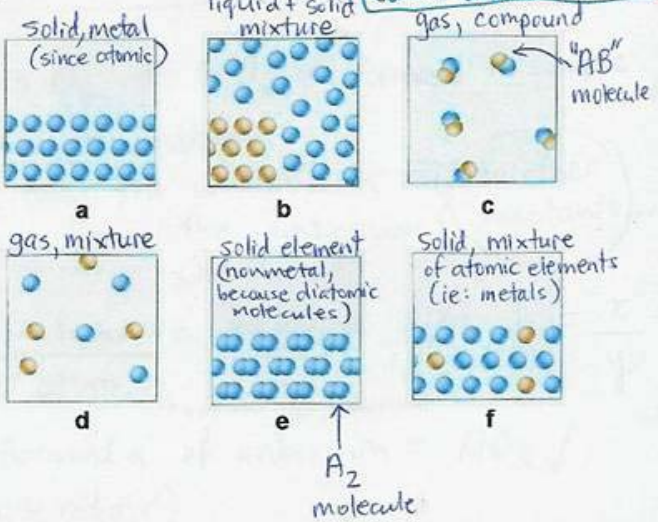
3

 # 8. (2 marks) The diagrams shown here depict various types of matter on the atomic scale. Choose ONE diagram that matches each description in the table (there will be unused diagrams): DIAGRAMS PROJECTED IN COLOUR DURING EXAM...

Ch.1 0.5 each

Diagram	Description
d	A mixture that fits its container (gas!)
a	A solid elemental metal (pure)
c	A gas-phase compound (pure)
b	A heterogeneous mixture

2 visible phases eg. solid + liquid, solid + gas, etc.



2

15

CHEM 205 Winter 2008 MIDTERM EXAM
Dr. C. Rogers, Section 03 T/J

Student ID #: marking scheme

PART B: Short written answers

Ch. 5

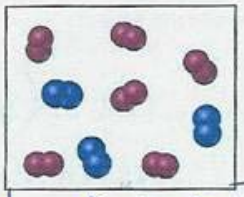
 # 9. (4 marks) Classify the two reactions below, and briefly justify your choices. Use as many of the following "type" labels as apply to each reaction: **precipitation, acid-base, gas-forming, redox.**

Reaction	Reaction type(s)	How did you decide? (A/B)
acid $2\,HCl(aq) + H_2O_2(aq) + 2\,Fe^{II}Cl_2(aq) \rightarrow 2\,Fe^{III}Cl_3(aq) + 2\,H_2O(\ell)$ ↑ but not reacting with a base (∴ not A/B) ↑ chlorides usually SOLUBLE ∴ not precipitation	REDOX ✓ (oxidation-reduction = e^- transfer)	$Fe^{2+} \rightarrow Fe^{3+} + 1e^-$ charge on iron ion changed! ✓ ∴ must have lost electron ✓ ∴ was oxidized $H_2O_2 \rightarrow H_2O$ (not yet balanced) $(+I)_2$ $(-I)_2$ $(+I)_2$ $-II$ but see O must gain e^-s (be reduced)
both reactants soluble $Na_2S(aq) + ZnSO_4(aq) \rightarrow ZnS(s) + Na_2SO_4(aq)$ ↑ insoluble corrected on board	PRECIPITATION ✓ (ion-exchange)	Both reactants were soluble ionic compounds, but one product is an INSOLUBLE ionic compound (ZnS) ✓ ↑ most sulfides INSOLUBLE except alkali metal + NH_4^+ salts...

2 2

Ch. 3/4

 # 10. (5 marks) The diagram shown to the right represents the products formed when a sample of an unknown compound decomposed into elements (via an oxidation-reduction reaction with itself; no other reactants were involved). If the dark (BLUE) spheres represent nitrogen atoms and the light (RED) spheres represent oxygen atoms, what was the empirical formula of the original compound? Briefly explain your answer.



Reaction: (decomposition)

unknown → product + product

$N_xO_y \rightarrow \frac{x}{2} N_2 + \frac{y}{2} O_2$ (✓)

3 blue N_2
6 red O_2
Colour projected during exam...

5

What box shows us: $3\,N_2 + 6\,O_2$ ✓ formed in sample

Based on the law of conservation of matter:

~~Since~~ All the N_2 ✓ came from the unknown
AND all the O_2 ✓ came from the unknown
} ...no other reactants...

∴ In the unknown,

the ratio of $\frac{N\ atoms}{O\ atoms} = \frac{3(2)}{6(2)} = \frac{6}{12}$ ✓ $= \frac{1}{2} = \frac{x}{y}$

(3 molecules, 2 N per molecule; 6 molecules, 2 O per molecule)

Thus, the empirical formula of unknown = NO_2 ✓

↑ simplest mole ratio (✓) of elements

CHEM 205 Winter 2008 MIDTERM EXAM
Dr. C. Rogers, Section 03 T/J

Student ID #: marking scheme

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

Ch. 5

#11. (5 marks) Imagine a man with a serious medical condition that causes him suffer from *hyponatremia* (not enough sodium ion in the blood). He has a blood-plasma sodium ion concentration of 0.118 M and a total blood volume of 4.6 L.

What mass of sodium chloride would need to be added to his blood to bring the sodium ion concentration up to 0.138 M (a healthy level). *[Assume no change in blood volume.]*

Include explanatory comments at each step of your calculation.

Problem: patient has low $[Na^+] = 0.118 \frac{mol}{L}$ in 4.6 L blood

Needs: NaCl added to get total $0.138 \frac{mol}{L}$ Na^+ in 4.6 L blood.

need 1 — So: man needs total # $n_{Na^+} = \left(0.138 \frac{mol}{L}\right)(4.6\,L) = 0.6348\ mol\ Na^+$

have 1 — right now he has # $n_{Na^+} = \left(0.118 \frac{mol}{L}\right)(4.6\,L) = 0.5428\ mol\ Na^+$

add 1 — ⇒ must add difference = $0.6348 - 0.5428 = 0.0920\ mol\ Na^+$

stoichiometry 1 — Our source of Na^+ will be NaCl (sodium chloride)
↑
1 Na^+ per 1 NaCl unit added.
∴ must add 0.0920 mol NaCl to his blood.

mass 1 — Thus: mass NaCl needed = $(0.0920\ mol\ NaCl)\left(58.45 \frac{g}{mol\ NaCl}\right)$

$= 5.377\ g$

$\doteq 5.4\ g$ (1 or 2 SF accepted here)

↑
must add this to the man's blood
Note that they would do this by very carefully adding a solution of this much NaCl to his blood... And slowly...

Explanations worth 1.5 total

−0.25 for wrong SF

5

CHEM 205 Winter 2008 MIDTERM EXAM
Dr. C. Rogers, Section 03 T/J

Student ID #: marking scheme

Ch. 4

 # 12. (14 marks) Aspirin can be made in the laboratory by reacting acetic anhydride ($C_4H_6O_3$) with salicylic acid ($C_7H_6O_3$) to form aspirin ($C_9H_8O_4$) and acetic acid ($C_2H_4O_2$). The balanced equation is:

$$C_4H_6O_3 + C_7H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$$

In a laboratory synthesis, a student begins with 3.00 mL of acetic anhydride (density 1.08 g/mL) and 1.25 g of salicyclic acid. Once the reaction is complete, the student collects 1.22 g of aspirin. Determine the limiting reactant, the theoretical yield of aspirin and the percent yield of the reaction.

Include explanatory comments at each step of your calculation.

① First: find quantities of reactants used by student

$$\#n_{\text{acetic anhydride}} = \frac{\left(1.08 \frac{g}{mL}\right)(3.00\,mL)}{102.091 \frac{g}{mol}} \quad \text{✓ density calc.}$$

$$= 0.03174 \text{ mol } C_4H_6O_3$$

$$\#n_{\text{salicylic acid}} = \frac{1.25\,g}{138.123 \frac{g}{mol}}$$

$$= 0.009050 \text{ mol } C_7H_6O_3$$

② Limiting reactant = reactant that runs out first (is completely consumed in rxn):

Rxn needs $\frac{1 \text{ mol acetic anhydride}}{1 \text{ mol salicylic acid}}$ ✓; Student had $\frac{0.03174 \text{ mol}}{0.009050 \text{ mol}} = 1.23$ ✓ > 1 ✓ (more than needed)

Thus: all the salicylic acid will be used up (i.e. L.R.) ✓ whereas some acetic anhydride will remain unreacted (excess)

③ Theoretical yield of product aspirin = based on using up all the L.R. ✓

For $\frac{1 \text{ mol salicylic acid}}{\text{Have } 0.009050 \text{ mol S.A.}} = \frac{1 \text{ mol aspirin}}{x \text{ mol aspirin}}$ ✓ ⇒ $x = 0.009050$ mol aspirin ($C_9H_8O_4$) ✓

∴ Expected aspirin mass = $(0.009050 \text{ mol})(180.161 \text{ g/mol})$ ✓

$= 1.630$ g ✓

$\doteq 1.63$ g (3 SF)

④ Percent yield = how close did we come to getting the expected yield?

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 \quad \text{✓}$$

$$= \frac{1.22 \text{ g obtained}}{1.63 \text{ g expected}} \times 100 \quad \text{✓ ✓}$$

$\doteq 74.8\%$ ✓ (3 SF) ← lose 0.25 for wrong SF.

14