Student ID #: _____ Rogers

F07

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. <u>Please write clearly and organize your work logically.</u> 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: _____

<u>Mark breakdown:</u>

           <u>Average</u>   %

Page 2.   6.4 / 10 = 64
Page 3.   9.8 / 15 = 66
Page 4.   4.3 / 8 = 54
Page 5.   4.4 / ~~10~~ 12 = 36
Page 6.   3.7 / ~~8~~ 6 = 62

TOTAL: 28.6 / 50   (MAXIMUM MARK = 51)

PERCENT: (57 %)

EARNED towards FINAL GRADE: 11.9 / 20

<u>Note</u> = if you do better on the final exam (which is cumulative), I will drop your midterm + count the final as 70% instead of 50%.

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Dr. C. Rogers, Section 02 W/F

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PART A: ONLY YOUR FINAL ANSWER WILL BE MARKED

 # 1. **(2 marks)** Based on their position in the periodic table, which of these pairs of elements would you expect both to be <u>malleable</u> and <u>good electrical conductors</u>?   _both are properties of METALS._

  B

  a) phosphorus and rubidium ✗
  (b) copper and lead
  c) iodine and selenium ✗
  d) calcium and boron ✗
  e) sulphur and germanium ✗

 # 2. **(2 marks)** The density of silver is 10.5 g/cm³. What is the volume of a piece of Ag that contains 2.8×10^{22} atoms?

$$d = \frac{m}{V} \quad \therefore \quad V = \frac{m}{d}$$

where $m = 2.8\times10^{22}$ atoms $\times \dfrac{1\,mol}{6.022\times10^{23}\,atoms} \times \dfrac{107.87\,g}{1\,mol}$

$= 5.016\,g$

  A

  (a) 0.48 cm³
  b) 53 cm³
  c) 4.8×10^{-2} cm³
  d) 2.1 cm³
  e) cannot calculate without knowing the sample's shape (*e.g.*, block, wire, foil, *etc.*)

$= \dfrac{5.06\,g}{10.5\,g/cm^3}$

$= 0.48\,cm^3$

 # 3. **(2 marks)** Consider the reaction shown below and pick the correct statement:

$$\overset{x+3(-2)=-1}{BrO_3^-}(aq) + 2\overset{IV}{Mn}O_2(s) + \overset{2(+1)-II}{H_2O}(\ell) \rightarrow \overset{-I}{Br^-}(aq) + 2\overset{II\;(-II)4}{Mn}O_4^-(aq) + \overset{+I}{2H^+}(aq)$$

$x + 2(-2) = 0$

  C

  a) Bromine is oxidized and hydrogen is reduced.
  b) Bromine is reduced and hydrogen is oxidized.
  (c) Bromine is reduced and manganese is oxidized
  d) ✗ The reaction is an acid – base reaction, NOT an oxidation – reduction reaction!
  e) Manganese is oxidized and hydrogen is reduced.

$x + 2(-2) = -1$
$x = +7$

$\left.\begin{array}{l} \\ \\ \\ \end{array}\right\}$ Mn: $\overline{IV} \rightarrow \overline{VII}$
each lost $3e^-$ (ox)

Br: $\underline{V} \rightarrow -I$
gained $6e^-$ (red)

 # 4. **(2 marks)** An example of a <u>weak acid</u> in water is:

  E

  a) HNO_3 strong
  b) HBr strong
  c) NH_3 weak BASE
  d) H_2SO_4 strong
  (e) CH_3COOH weak

6 common strong acids:
HCl, HBr, HI
$HNO_3, H_2SO_4, HClO_4$

 # 5. **(2 marks)** Consider the following description about the <u>element, sulphur</u>:

  1. Sulphur is a yellow non-metallic element. physical.
  2. It burns in oxygen to form a choking gas, SO_2. chemical rxn
  3. SO_2 reacts with water to produce acid rain. chemical rxn
  4. Sulphur is produced commercially by injecting steam into deposits of it underground to <u>melt it</u>. physical
  5. It is then carried by the steam to the surface, where it <u>separates</u> from the water after cooling. physical

Which of the statements refer to <u>chemical reactions</u> and which refer to <u>physical</u> properties or changes?

  B

	Chemical	**Physical**
a)	Statements 2, 3, 4, and 5	Statements 1 only
(b)	Statements 2 and 3	Statements 1, 4 and 5
c)	Statements 2, 3 and 4	Statements 1 and 5
d)	Statements 2, 3 and 5	Statements 1 and 4
e)	Statements 1, 4 and 5	Statements 2 and 3

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✓✓ = 0.25

 # 6. (5 marks) Identify the following statements as true or false. *(Circle T or F.)*

yes, not ALWAYS, but usually. (strong + strong...)

(T)/ F   The reaction of an acid with a base [typically] yields a salt and water as products. _yes._

T /(F)   Electrons and protons have identical masses but opposite charges. ✓

T /(F)   A homogeneous mixture is a pure substance that is composed of only one type of atom.

(T)/ F   Particles in a liquid are packed closely together but are not confined to specific positions. _ie: they move a lot and change nearest neighbours frequently_

(T)/ F   In their elemental forms, metals generally act as reducing agents.
lose electrons (cause another species to gain e⁻s + be reduced)

 # 7. (5 marks) Fill in the blanks: −0.25 for "ok" ❌

a)   Carbon dioxide's sublimation point (-78°C) in Kelvin: (195 K) (= 273 − 78)

b)   Number of neutrons in a ^{25}Mg (magnesium-25) atom: (Z=12) $25 - 12 p^+ = (13 n°)$

c)   The species not included in a net ionic equation are called: spectator ions

d)   Sulfuric acid is formed by the reaction of water with: $(SO_{3(g)}) (+ H_2O \rightarrow H_2SO_4)$

e)   The solid that will form if $FeBr_{2(aq)}$ is added to $Ba(OH)_{2(aq)}$: $(Fe(OH)_2 (s))$

↑ not needed

 # 8. (3 marks) Write the missing name or formula, and classify each substance by type:

right elements/ions
wrong ratio (−0.5)

Substance name	Substance formula	Ionic or molecular substance?
calcium phosphate	$Ca_3(PO_4)_2$	0.25 ionic
xenon hexafluoride	XeF_6	0.25 molecular
ammonium nitrate	NH_4NO_3	0.25 ionic
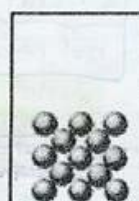
... 0.75

 # 9. (2 marks) Each picture shown below represents a sample (at 25°C) of one of the four substances listed below. **Label each picture with the formula and state** of the substance it most correctly represents.
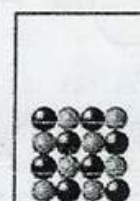
ordered solid
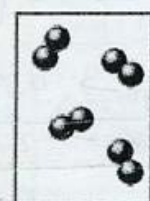
$I_{2(s)}$ $K_{(s)}$ $LiF_{(s)}$ $N_2 (g)$

SUBSTANCES SHOWN:

lithium fluoride $LiF_{(s)}$ (ionic)
potassium $K_{(s)}$
nitrogen $N_{2(g)}$
iodine $I_{2(s)}$

- 0.5 each substance.
- max −0.5 for incorrect state   (−0.25 each...)
- no penalty if give names instead of formulae
- if give incorrect formulae : −0.25 each

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PART B: Short written answers

 # 10. (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.**

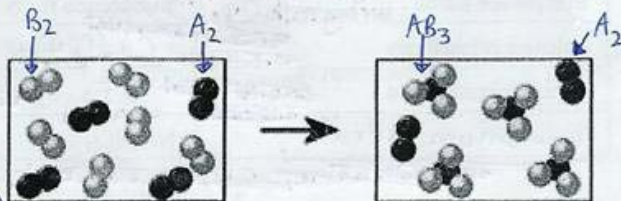| Reaction	Reaction type(s)	How did you decide?
$CH_3CO_2H(s) + NH_3(aq) \rightarrow NH_4CH_3CO_2 (aq)$ *oops is (aq) too.*	① acid-base	A H^+ was transferred from acetic acid to ammonia (BASE) to produce a salt.
$Na(s) + H_2O(\ell) \rightarrow NaOH(aq) + H_2(g)$	① gas-forming ② redox	→ Net formation of gas-phase substances (bubbles...). → Sodium is converted from elemental form Na(o) to cationic form Na(+I), which reveals a transfer of electrons has occurred. Hydrogen is reduced from +I to 0.

 # 11. (4 marks) The diagram to the right represents the gas-phase reaction of A_2 (darker spheres) with B_2 (lighter spheres). Write a balanced equation for the reaction, and identify the limiting reactant. **Explain each answer briefly.** = limiting reagent (rgt)

a) Balanced equation:

worth 1 { $6 B_{2(g)} + 4 A_{2(g)} \rightarrow 4 (AB_3)(g)$ worth 0.5 (part marks) $+ 2 A_{2(g)}$ not reacted ∴ excess rgt ∴ not a PRODUCT at all. ∴ NOT INCLUDED IN EQN!

worth 1.5 { NET: $6 B_{2(g)} + 2 A_{2(g)} \rightarrow 4 AB_3 (g)$

worth 2 { BETTER: $3 B_{2(g)} + A_2 (g) \rightarrow 2 AB_3 (g)$
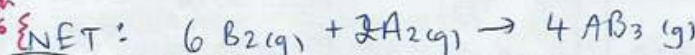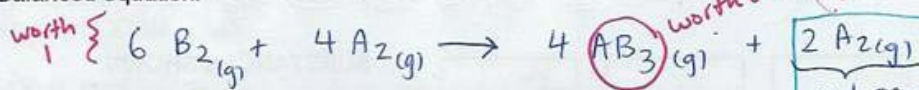
b) Limiting reagent:

All of the B_2 was consumed ∴ B_2 was the limiting reactant.
Some A_2 molecules remained unreacted ∴ A_2 was in excess.

NOTE: regarding balanced equation
- should be NET equation
- we never show excess reactants on products' side of equation
- not same as net ionic equation vs. complete ionic equation
  (in which spectator ions would be shown, but not excess reactants).

did not even grade SF here!!

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* Direct analogy to example given in class notes.

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

12 changed

 # 12. (10 marks) Dissolved lead ions are toxic, and precipitation reactions are often done to remove lead from waste solutions. Imagine a solution containing 1.50 g of $Pb(NO_3)_2$ is mixed with 125 mL of 0.100 M Na_2SO_4 solution to produce a precipitate of $PbSO_4$ and 175 mL of supernatant* solution (*the liquid phase left after the precipitate has been filtered off).

$Pb^{2+}?$ (NO_3^-) (Na^+) $SO_4^{2-}?$

Calculate the concentrations of all ions that remain in the solution after the reaction is complete. Has all of the dissolved lead been precipitated? ie: Is Pb^{2+} the limiting reactant?

any type

Balanced: ✓ $Pb(NO_3)_2 \ (aq) \ + \ Na_2SO_4 (aq) \longrightarrow PbSO_4 (s) \ + \ 2 NaNO_3 (aq)$

(ppt) (all in solution)

Moles:
$\#n = \dfrac{1.50 g}{331.21 g \cdot mol^{-1}}$ ✓

(1.5)

$= 0.004529 \ mol$

$\#n = (0.125 L)(0.100 \frac{mol}{L})$ ✓
$= 0.0125 \ mol$

• made up from Pb^{2+} and SO_4^{2-}

Spectator ions

none reacted but treat ion separately...

* Full ionic equation is quite a useful way to organize data here, plus table:

Rxn:	$Pb^{2+}_{(aq)}$	$+ \ 2 NO_3^-_{(aq)}$	$+ \ 2 Na^+_{(aq)}$	$+ \ SO_4^{2-}_{(aq)}$	$\longrightarrow \ PbSO_4 (s)$	$+ \ 2 Na^+_{(aq)}$	$+ 2 NO_3^-_{(aq)}$
#moles of ions	0.004529 same as $Pb(NO_3)_2$ since 1:1 ratio	2(0.004529) = 0.009058 2 NO_3^- per Na_2NO_3 unit ✓	2(0.0125 mol) = 0.0250 mol 2 Na^+ per Na_2SO_4 unit ✓	0.0125 mol same as Na_2SO_4 since 1:1 ratio ✓	question doesn't ask for this...	spectator ∴ all still in solution at end	spectator
Amount reacted	limiting reactant (see right) ∴ all used	none	none NOTE: cannot simply calculate $NaNO_3$ produced.	excess reactant. Amount used = same as Pb^{2+} since 1:1 ✓ required to make $PbSO_4$	Find limiting reactant: ② Need $1 Pb^{2+}$ ✓ $1 SO_4^{2-}$	Have $\frac{0.004529}{0.0125} = \frac{0.36}{1}$ (Not enough Pb^{2+}! = Limiting ✓	
Amount remaining	none ✓ 0 mol	ALL spectator 0.009058 mol Same as #n $NaNO_3$ ✓	ALL spectator 0.0250 mol More ✗ than #n $NaNO_3$!	0.0125 −0.004529 ✓ 0.007971 mol	*Recall! important	some of the excess reactant" ion will still be in solution	
Conc. in supernatant solution	≈ 0 ✓	$\dfrac{0.009058 mol}{0.175 L}$ $= 0.0518 \ M$ ✓	$\dfrac{0.0250 \ mol}{0.175 L}$ $= 0.143 M$ ✓	$\dfrac{0.007971 mol}{0.175 L}$ $= 0.0455 \ M$ ✓	Recall: volume of supernatant given as 175 mL Notice: total [] of ⊕ charges = total [] of ⊖ charges		
	$[Pb^{2+}]$	$[NO_3^-]$	$[Na^+]$	$[SO_4^{2-}]$			

Thus: all of the dissolved lead has been ✓① precipitated. The supernatant contains 0.143 M Na^+, 0.0518 M NO_3^- and 0.0455 M SO_4^{2-}.

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(6 changed)

 # 13. (8 marks) Toluene is a volatile organic solvent that gives its characteristic smell to some paint thinners and glues. It is a compound composed of 91.25% C and 8.75% H.

Determine the empirical formula for toluene. Show and briefly explain all calculations.

$C_x H_y$ = empirical formula derived from mass % data.

• (represents simplest mole ratio of elements)

• must be whole number ratio

no explanation (-1)

(-2 if we use as mol %)

x mol C : y mol H

① Calculate moles of each:

2.5

• Carbon:

$0.9125 \times 100g = 91.25 \, g \, C$

eg. 100g or 1g etc → arbitrary sample ✓

$\dfrac{91.25 \, g \, C}{12.01 \, g \cdot mol^{-1} C} = 7.598 \, mol \, C$ ✓

• hydrogen

$0.0875 \times 100g = 8.75 \, g \, H$

$\dfrac{8.75 \, g \, H}{1.0079 \, g \cdot mol^{-1} H} = 8.681 \, mol \, H$ ✓

② Normalize to find simplest ratio:

1.5

Ratio $\dfrac{H}{C} = \dfrac{8.681}{7.598} = \dfrac{1.14 \, mol \, H}{1 \, mol \, C}$ ✓✓ (not a simple ✗ 1:1 ratio)

③ Scale up by factor (same for both) to reach whole #s: ✓

1.5

• tried 1, 2, 3, 4, 5, 6... none worked well... but 7 works perfectly...

$\dfrac{1.14 \, mol \, H}{1 \, mol \, C} \dfrac{\times 7}{\times 7} = \dfrac{7.98}{7} \approx \dfrac{8 \, mol \, H}{7 \, mol \, C}$ ✓

MUST TRY TO FIT DATA. DO NOT SIMPLY ROUND TO 1:1...

1

④ Thus: empirical formula = $C_7 H_8$ ✓

Toluene is this:

6