Concordia University CHEM 205

Fall 2012, Dr. C. Rogers, Section 02, Wed/Fri

LAST NAME: Answer key

FIRST NAME: Rogers

STUDENT ID:

Chem 205 - GENERAL CHEMISTRY I

MIDTERM EXAMINATION

PLEASE READ THIS BOX WHILE WAITING TO START

INSTRUCTIONS:

- Calculators are permitted; cell phones and other electronic devices are not allowed.
- This test paper includes 9 pages; please read over the whole test before starting.
- A periodic table (incomplete) is included and may be detached (not graded).
- Answer the multiple-choice questions on the scan sheet, in pencil.
- Please write clearly and organize your work logically.
- Read the instructions to each section carefully.
- **Duration: 70 minutes. GOOD LUCK!**

Professor use - Grades:

Page 2.		/ 10
Page 3.		/ 12
Page 4.		/ 10
Page 5.	5.3	/ 10 ← avg. 53.1%
Page 6.	6.5	/ 9 ← avg. 72.8%
TOTAL:	33.6	/ 50 (MAX. 51)
PERCENT:	67.3	%

avg. on MC 21.8 = 68.3% / 32

+ BUILT-IN BONUS POINT.

Legend: = many people made errors here (see % for each choice)
= fairly well done by most
= almost everyone got it right

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PART A: MULTIPLE-CHOICE QUESTIONS (final answer on scan sheet, in pencil) circle answer here too, as a back-up

 # 1. **(2 marks)** The statements below summarize various landmarks in the development of modern chemistry. Which one statement links the wrong scientist(s) to the work described?

a) ✓ Alchemists made many important discoveries, while pursuing the impossible goal of transforming cheap substances into gold.
(b) Antoine Lavoisier proposed the ill-conceived phlogiston concept, which described a fire-like entity with negative mass that was released from substances when they burned.
c) ✓ Dmitri Mendeleev envisioned the periodic table of the elements, which has helped future generations of scientists remember important trends in elements' properties.
d) ✓ Svante Arrhenius proposed a theory of electrolytes, which describes acids as producers of H^+ ions when dissolved in water and bases as producers of OH^- ions when dissolved in water.
e) ✓ Ernest Rutherford proposed the nuclear model of the atom, wherein electrons occupy a cloud of space around a central nucleus of close-packed protons and neutrons.

 # 2. **(2 marks)** How many electrons are in a radioactive $^{123}I^-$ ion (used for treating hyperthyroidism)?

a) 1
b) 8
(c) 54
d) 70
e) 123

53 p^+
neutral 53 e^- + 1 = 54 e^-
↑ since anion

 # 3. **(2 marks)** Which one of the following separations requires the use of chemical change?

a) ✗ isolating iron filings from sawdust (wood chips)
b) ✗ isolating sugar from a sand/sugar mixture
c) ✗ isolating pure water from dirty seawater
(d) isolating iron from iron oxide (rust)
e) all require only physical changes

 # 4. **(2 marks)** What is the oxidation state of phosphorus in $(NH_4)_3PO_4$?

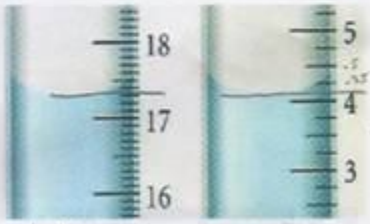
9% a) -V
28 b) -III
10 c) 0
12 d) +III
41 (e) +V

3 NH_4^+ : 1 PO_4^{3-}
$x + 4(-2) = -3$
$x = -3 + 8$
$= +5$ ∴ P(V)

 # 5. **(2 marks)** Suppose you pour the water from these two graduated cylinders into one container. Based on the precision of the two cylinders, how should you report the new total volume to reflect the correct number of significant figures?

a) 21.400 mL
b) 21.40 mL
(c) 21.4 mL
d) 21 mL
e) 20 mL

17.32
4.1
21.42



between 17.3 and 17.4 → 17.32

between 4.0 + 4.25 → 4.1

can estimate only 1 decimal place between markings

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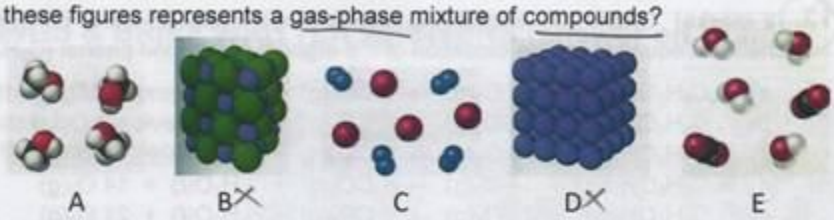
 # 6. **(2 marks)** Which one of these figures represents a gas-phase mixture of compounds?

a) A
b) B
c) C
d) D
e) (e) E



 # 7. **(2 marks)** When you clean the hard-water deposits in a coffee-maker using vinegar, the following substances react: $CaCO_3(s)$ + $CH_3COOH(aq)$. What type of reaction results?

16% a) both acid-base & precipitation
46 (b) both acid-base & gas-forming
7 c) precipitation only
11 d) gas-forming only
20 e) acid-base only

① $CO_3^{2-} + 2H^+ \rightarrow H_2CO_3$ ← acid-base
then ② $H_2CO_3 \rightarrow H_2O + CO_2(g)$ ← gas family
net: $CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_2(g)$

 # 8. **(2 marks)** What is the freezing point of liquid mercury (234.3 K) on the Celsius scale?

a) × -234.3 °C
(b) -38.9 °C
c) × 0.0 °C
d) 38.9 °C
e) × 234.3 °C

−273.15 offset
= −38.85 °C
≈ −38.9 °C

 # 9. **(2 marks)** Which one statement best describes what happens when liquid gasoline (whose main component is octane, C_8H_{18}) evaporates to form vapour?

9% a) × The C_8H_{18} molecules' thermal energy decreases relative to their attractions.
23 b) × Liquid C_8H_{18} molecules are converted into CH_4, which is a gas. ←
45 (c) Attractions between intact C_8H_{18} molecules are broken.
18 d) Covalent bonds within C_8H_{18} molecules are broken. ←
4 e) × Ionic bonds within C_8H_{18} molecules are broken.

 # 10. **(2 marks)** What is the molar mass of Epsom salt, which has the formula $MgSO_4 \cdot 7H_2O$?

a) × 90.04 g/mol
b) 120.38 g/mol
c) 128.40 g/mol
(d) 246.48 g/mol
e) 860.65 g/mol

24.305
32.07 } from $MgSO_4$
4(15.999)
14(1.0079) } from waters of hydration
7(15.999)
= 246.48 g/mol

 # 11. **(2 marks)** Which one statement describes the characteristic feature of all acid-base reactions?

a) × transfer of electron(s) from reducing agent to oxidizing agent
b) × exchange of soluble ions to form an insoluble salt
(c) transfer of H^+ from acid to base
d) formation of salt and water
e) × net formation of gas

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 # 12. (2 marks) Ozone, O_3, is a strong oxidizing agent used in water purification. What is the balanced chemical equation for the oxidation of the organic compound phenol (C_6H_5OH) by ozone?

a) $C_6H_5OH(aq) + 14\,O_3(g) \rightarrow 6\,CO_2(g) + 3\,H_2O(\ell) + 14\,O_2(g)$
b) $C_6H_5OH(aq) + 4\,O_3(g) \rightarrow 6\,CO_2(g) + 3\,H_2O(\ell) + 3\,O_2(g)$
c) $C_6H_5OH(aq) + 8\,O_3(g) \rightarrow 6\,CO_2(g) + 5\,H_2O(\ell) + 12\,O_2(g)$
(d) $C_6H_5OH(aq) + 14\,O_3(g) \rightarrow 6\,CO_2(g) + 3\,H_2O(\ell) + 14\,O_2(g)$
e) $C_6H_5OH(aq) + 14\,O_3(g) \rightarrow 6\,CO_2(g) + 6\,H_2O(\ell) + 21\,O_2(g)$

 # 13. (2 marks) Many elements are too reactive towards oxygen and water to exist long-term on Earth in elemental form are therefore found in nature only in compounds. Which one of the elements listed below is actually found in nature both in compounds and in elemental form?

24% a) ✗ phosphorus → white + red P are both flammable in air/water
11 b) ✗ potassium → reacts violently with H_2O (Gp I metal) and O_2 too
18 c) ✗ chlorine → halogen! would react with any metal it encounters, for example
18 d) ✗ calcium → Gp II metal, reactive with H_2O + O_2
28 (e) sulfur → found as $S_{(s)}$ at volcanic vents, + in many compounds in nature

 # 14. (2 marks) What is the correct description and formula of iron (III) chromate?

Fe^{3+} CrO_4^{2-} ∴ need $2Fe^{3+}$: $3CrO_4^{2-}$
$Fe_2(CrO_4)_3$

a) ✗ molecular, $Fe_2(CrO_4)_3$
b) ✗ molecular, $FeCrO_4$
(c) ionic, $Fe_2(CrO_4)_3$
d) ionic, Fe_3CrO_4
e) ✗ ionic, $FeCrO_4$

 # 15. (2 marks) What is the correct description and name of S_2F_{10}? → both NM ∴ molecular

di deca

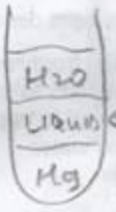
(a) molecular, disulfur decafluoride
b) ✗ ionic, disulfur decafluoride
c) molecular, sulfur fluoride
d) ✗ ionic, sulfur (V) fluoride
e) ✗ ionic, sulfur fluoride

 # 16. (2 marks) Imagine you are given 3.25 mL of a liquid and you find that it weighs 5.10 g. If you add this liquid to a test tube that contains some water (d = 1.00 g/mL) and mercury (d = 13.5 g/mL), and the liquid is not miscible with water or mercury, where would the liquid come to rest in the test tube?

$d = \frac{5.10\ g}{3.25\ mL} = 1.60\ g/mL$

denser than H_2O
less dense than Hg

a) ✗ mixed evenly throughout the water and mercury
(b) in between the water and mercury layers
c) below the mercury layer
d) above the water layer
e) impossible to predict



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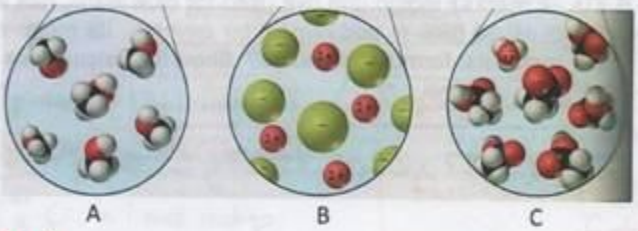
PART B: DRAWINGS & BRIEF WRITTEN ANSWERS (answer on exam)

 # 17. The diagrams to the right represent different kinds of substances dissolved in water. For simplicity, the water molecules are not shown.



a) **(1 mark)** Which diagram represents a solution of $CaCl_2$? How can you tell?

soluble → ions dissociate
1 Ca^{2+} : 2 Cl^- ⇒ (B) ✓ ✓

b) **(1 mark)** Which diagram represents a solution of a non-electrolyte? How can you tell?

↳ no ions dissociate ⇒ (A) ✓ ✓ ↳ only neutral molecules shown

c) **(2 marks)** Which diagram represents a weak electrolyte? Which is it: a weak acid or a weak base? How can you tell?

0.5 ↳ low conc. ions ⇒ (C) ✓
1.0 weak acid b/c H_3O^+ + anion produced to small extent; (mostly intact molecules are shown plus one H_3O^+ and one big molecule with ⊖ charge)

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 # 18. **(3 marks)** When an iron object rusts, its mass increases. When a match burns, its mass decreases. Do these observations violate the law of conservation of mass? Explain briefly.

- rust includes O atoms from air + H atoms from water ∴ heavier than Fe alone eg. FeO, Fe_2O_3, $Fe(OH)_3$ ...
- match burns to yield gases, which escape so mass seems to disappear
No matter is lost/gained; it can all be accounted for by looking for other reactants consumed or other products formed that escape the container.

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 # 19. **(3 marks)** Imagine you mix two aqueous solutions, one of $BaCl_2$ and the other of $CuSO_4$.

a) **(1 mark)** Write the molecular equation for the reaction; include phase indicators (states).

$BaCl_{2(aq)} + CuSO_{4(aq)} \longrightarrow BaSO_{4(s)} + CuCl_{2(aq)}$
PRECIPITATES REMAINS IN SOLUTION

b) **(1 mark)** Write the net ionic equation for the reaction; include phase indicators (states).

$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$

c) **(1 mark)** Which species are spectator ions in the reaction? Explain in a few key words.

↳ Cl^- & Cu^{2+} present as freely dissociated ions before and after rxn not really changed

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PART C: SHOW COMPLETE WORK TO GET FULL CREDIT (answer on exam)

 # 20. (9 marks) Indigo, the dye used for blue jeans, has a percent composition by mass of 73.27 % C, 3.84 % H, 10.68% N and remainder oxygen. Its molar mass is 262.3 g/mol. What are the empirical and molecular formulas of indigo? **Show full calculations and explanatory comments for each step.** WORTH 1

$C_xH_yN_zO_n$ Imagine 100g sample. (÷ smallest (N)) penalty if missing

C: $0.7327 \times 100g = 73.27g\ C \Rightarrow n_c = \frac{73.27g}{12.011\ g/mol} = 6.100\ mol\ C \Rightarrow 8$

H: $0.0384 \times 100g = 3.84g\ H \Rightarrow n_H = \frac{3.84g}{1.0079\ g/mol} = 3.810\ mol\ H \Rightarrow 5$

N: $0.1068 \times 100g = 10.68g\ N \Rightarrow n_N = \frac{10.68g}{14.0067\ g/mol} = 0.7625\ mol\ N \Rightarrow 1$

Calc. worth 0.5

O: $0.1221 \times 100g = 12.21g\ O \Rightarrow n_O = \frac{12.21g}{15.999\ g/mol} = 0.7632\ mol\ O \Rightarrow 1$

① Convert to mass of each element in 100g sample. worth 1

② Convert to moles of each element using molar mass. worth 2
correct #s worth 1 pt total
premature rounding (-0.5)

worth 1.5 ③ Normalize to derive simplest mole ratio of elements present. (÷ least abundant element)

⇒ Empirical formula = C_8H_5NO, F.M. = 131.13 g/mol worth 1

Molecular formula = $\left(\frac{\text{M.M. of compound}}{\text{F.M. of empirical formula}}\right) \times C_8H_5NO$ worth 2 pts

$= \left(\frac{262.3\ g/mol}{131.13\ g/mol}\right) \times C_8H_5NO$

$= 2 \times C_8H_5NO$

$= C_{16}H_{10}N_2O_2$

- If forgot to analyze for one element: (-2)
- If use MM x % approach + leave out emp. formula: (-2)

Inform: better to use whole % data set on its own + THEN compare to MM data...

9

Direct molecular-formula route

less reliable method ∵ combines 2 sets of experimental data at the outset, rather than comparing results of each at the end → what if one exp't was in error?!

worth 1

C: $0.7327 \times 262.3\,g = 192.19\,g$ C in 1 mol indigo

H: $0.0384 \times 262.3\,g = 10.07\,g$ H in 1 mol indigo

N: $0.1068 \times 262.3\,g = 28.01\,g$ N in 1 mol indigo

clarifying units worth 0.5

O: $0.1221 \times 262.3\,g = 32.03\,g$ O in 1 mol indigo

remainder of % mass } worth 0.5

(matches difference in calc'd masses ✓)

Comments: (-1) if absent

Full Calc'n: (-1) if absent

Convert to moles using MM of each element: worth 1

C: $\frac{192.19\,g\,C}{12.011\,g/mol\,C} = 16.00\,mol\,C$

H: $\frac{10.07\,g\,H}{1.0079\,g/mol\,H} = 9.99\,mol\,H$

N: $\frac{28.01\,g\,N}{14.0067\,g/mol\,N} = 2.00\,mol\,N$

O: $\frac{32.03\,g\,O}{15.999\,g/mol\,O} = 2.00\,mol\,O$

mole calcns worth 2

⇒ 16 C : 10 H : 2 N : 2 O] worth 1

$= C_{16}H_{10}N_2O_2$] molecular formula worth 1

vs.

Empirical formula is the simplest mole ratio, ∴ ÷ 2 ✓

C_8H_5NO ✓

worth 2