Concordia University CHEM 205

Fall 2015, Dr. C. Rogers, Section 02, Wed/Fri

LAST NAME:	Rogers
FIRST NAME:	
STUDENT ID:	answer key

F15 205

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).
- Fill in your name & ID # on scansheet, in pencil (fill circles completely).
- Please write clearly and organize your work logically.
- Read the instructions to each section carefully.
- **Duration: 70 minutes. GOOD LUCK!**

Professor use - Grades:

Pages 2-4: 28.3 / 40 = 70.8%

Page 5: 6.6 / 11 = 66.4%

TOTAL: 35 / 50 (MAX. 51)

PERCENT: 69.9 %

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PART A: MULTIPLE-CHOICE QUESTIONS – 2 marks each

Colour in final answer on scansheet, in pencil. Circle answer here too, as a backup.

• % SHOWS HOW POPULAR THE CORRECT ANSWER WAS. • ☐ means "HARD" for class.

 # 1. Many classic experiments have given us indirect evidence of the nature of the atom. Which one of the experiments listed below did (not) give the results described?

a) ✓ The Curies' experiments with radioactivity proved that atoms are made up of smaller particles.
72% b) ✗ Rutherford's experiments proved that Thomson's "plum-pudding" model of the atom is correct. ✗
B c) ✓ Millikan's oil-drop experiment showed that the charge on any particle was a simple multiple of the charge on the electron.
d) ✓ The electric discharge tube proved that electrons have a negative charge.

 # 2. How many protons, neutrons, and electrons are in a $^{80}Br^-$ anion?

a) 35 p^+, 45 n^0, 35 e^- — Z = 35 ∴ 35 p^+, +1 extra e^- = 36 e^-
B 70% b) 35 p^+, 45 n^0, 36 e^-
c) ✗ 45 p^+, 35 n^0, 45 e^- — 80 − 35 = 45 n^0
d) ✗ 45 p^+, 35 n^0, 46 e^-

 # 3. The density of gasoline is 0.7025 g/mL at 20°C. When water (1.00 g/mL at 20°C) is added to gasoline, what will happen?

a) The mixture will improve the running of the engine.
B 91% b) The water will sink to the bottom of the gasoline. — water will sink
c) The water will float on top of the gasoline.
d) The water will mix in so you can't see it.

 # 4. An analysis was performed to find the concentration of an HCl solution, with the following results:

Trial	Molarity
1	1.25 ± 0.01
2	1.24 ± 0.01
3	1.26 ± 0.01

average 1.25 ± 0.01

If the actual concentration of HCl was 1.00 M, which choice best describes the analysis data?

a) both inaccurate and imprecise
D b) ✗ both accurate and precise
c) ✗ accurate but imprecise
86% d) precise but inaccurate

INACCURATE since measurements far from actual value
PRECISE since low scatter in data (reproducible)

 # 5. Which one of the following statements about ionic compounds is incorrect?

a) ✓ Ionic compounds form extended 3-dimensional networks called crystal lattices.
b) ✓ Positive and negative ions are attracted to each other by electrostatic forces.
C 71% c) As the ion charges increase, the attraction between the ions decreases. ✗
d) ✓ Ionic crystals tend to be rigid, and they cleave along planes.

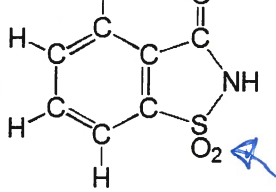
 # 6. What is the concentration of $K_2Cr_2O_7$ (294.18 g/mol) in a 5.00×10^2 mL solution containing 2.335 g of dissolved potassium dichromate?

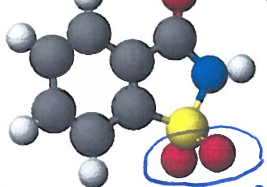
a) ✗ 1.59×10^{-5} M ← if V in mL
b) ✗ 7.94×10^{-3} M ← mol only
D c) 3.18×10^{-2} M
47% d) ✓ 1.59×10^{-2} M

conc. = mol solute / L solution
$= \frac{(2.335\ g\ /\ 294.18\ g/mol)}{0.500\ L} = \frac{7.9373\times10^{-3}\ mol}{0.500\ L} = 0.0159\ mol/L$

 # 7. Which one of the following statements about the artificial sweetener saccharin (shown) is incorrect?

64% a) ✗ Saccharin's formula is $C_7H_5NO_2S$. ✗
A b) ✓ It contains 41% C atoms by mole. 7/17 = 0.41
c) ✓ It is made of molecules, not ions.
d) ✓ A mole of it weighs 183.18 g.





10 atom here
20 atoms here

MM matches $C_7H_5NO_3S$

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 # 8. Which choice correctly classifies the following three reactions? (e⁻ transfer) (+I) (-I)

$2\ K(s) + Br_2(\ell) \rightarrow 2\ KBr(s)$ REDOX $K(0) \rightarrow K^+$, $Br_2(0) \rightarrow 2Br^-$

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$ PRECIPITATION

$HCl(aq) + KOH(aq) \rightarrow H_2O(\ell) + KCl(aq)$ ACID-BASE (H^+-transfer)

B 66%.
a) ✗ precipitation, precipitation and acid-base, respectively
b) redox, precipitation, and acid-base, respectively
c) ✗ all precipitation reactions
d) ✗ all acid-base reactions
e) ✗ all redox reactions

 # 9. Which is the best description of the change is involved when water boils? $H_2O(\ell) \rightarrow H_2O(g)$

A 78%.
a) It is a physical change, because the steam produced is chemically the same as the liquid. i.e. H-O-H
b) ✗ It is a chemical change, because heat is needed for the process to occur.
c) It is a physical change, because the substance merely disappears. no, converts to gas phase.
d) ✗ It is a chemical change, because a gas (steam) is given off.
e) ✗ It is a chemical and physical damage.

 # 10. In a recent accident, some containers of uranium hexafluoride (UF_6) were lost in the English Channel, which is known for its cold water (~17°C). The melting point of UF_6 is 148°F. In what physical state was the UF_6 in these containers at 17°C? (Note: $T_F = T_C \times (9°F / 5°C) + 32°F$)

A 70%.
a) solid
b) liquid
c) gas
d) a mixture of solid and liquid
e) a mixture of solid, liquid and gas

→ $T_F = 17°C \times \left(\frac{9°F}{5°C}\right) + 32°F$

$= 30.6 + 32°F$

at $T_F = 62.6°F \ll 148°F$ melting point

it is SOLID.

 # 11. Which one of the following formulae does not represent a possible ionic compound?

↳ ions in neutral ratio

C 72%.
a) ✓ $MgBr_2$ — $1\ Mg^{2+} : 2\ Br^-$
b) ✓ Na_2S — $2\ Na^+ : 1\ S^{2-}$
c) ✗ Al_2O — $2\ Al^{3+} : 1\ O^{2-}$ ⇐ charges do not balance (6+ : 2−)
d) ✓ CaI_2 — $1\ Ca^{2+} : 2\ I^-$
e) ✓ LiCl — $1\ Li^+ : 1\ Cl^-$

 # 12. Which one pair of reactants would react to produce a gas-phase product?

A 48%.
a) $2\ HNO_3(aq) + Na_2CO_3(aq) \rightarrow H_2CO_3 + 2NaNO_3$ then $H_2CO_3 \rightarrow H_2O + CO_2(g)$
b) $NaCl(aq) + CaCO_3(aq)$ no rxn
c) $HCl(aq) + NaNO_3(aq)$ no rxn
d) $H_2SO_4(aq) + 2NH_3(aq) \rightarrow (NH_4)_2SO_4(aq)$
e) $NaOH(aq) + HCl(aq)$ no rxn

 # 13. For the reaction of VO_2^+ and Zn in acidic solution: $VO_2^+ + Zn \rightarrow VO^{2+} + Zn^{2+}$, what is the overall balanced equation?

oxidation state analysis:
in VO_2^+: $V + 2(-2) = +1$, $V = +5$
in VO^{2+}: $V + 1(-2) = +2$, $V = +4$

D 32%.
a) ✗ $Zn + VO_2^+ + 2\ H^+ \rightarrow VO^{2+} + H_2O + Zn^{2+}$
b) $Zn + 2\ VO_2^+ + 2\ H^+ \rightarrow 2\ VO^{2+} + H_2O + Zn^{2+}$
c) ✗ $2\ Zn + VO_2^+ + 2\ H^+ \rightarrow VO^{2+} + H_2O + 2\ Zn^{2+}$
d) $Zn + 2\ VO_2^+ + 4\ H^+ \rightarrow 2\ VO^{2+} + 2\ H_2O + Zn^{2+}$
e) ✗ $Zn + 2\ VO_2^+ \rightarrow 2\ VO^{2+} + O_2 + Zn^{2+}$

ox: $(Zn \rightarrow Zn^{2+} + 2e^-)$ ×1

red: $(2H^+ + VO_2^+ + 1e^- \rightarrow VO^{2+} + H_2O)$ ×2 to balance electrons ox. vs. red.
(+V) (+IV)

net: $Zn + 2VO_2^+ + 4H^+ \rightarrow Zn^{2+} + 2VO^{2+} + 2H_2O$

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 # 14. Which one of the following compounds is named incorrectly?

E 61%

a) ✓ NH_4ClO_4, ammonium perchlorate
b) ✓ $Mg(OH)_2$, magnesium hydroxide
c) ✓ $Pb_3(PO_4)_2$, lead(II) phosphate
d) ✓ N_2O_4, dinitrogen tetroxide
e) $NaNO_3$, sodium nitrite ← nitrate ion = NO_3^- , nitrite ion = NO_2^-

 # 15. Which one of the following statements is not true?

C 69%

a) ✓ When a redox reaction occurs, the oxidizing agent steals electrons from the reducing agent.
b) ✓ When two soluble salts are mixed together, an insoluble salt may form and precipitate.
c) ✗ When an acid reacts with a base, the acid accepts a proton from the base. acid = H^+ DONOR
d) ✓ When a metal reacts with a nonmetal, an ionic compound is formed.
e) ✓ When two nonmetals react, a covalent compound is formed.

 # 16. A piece of indium metal with a mass of 16.6 g is submerged in 46.3 cm^3 of water in a graduated cylinder, and the volume increases to 48.6 cm^3. Based on these data, what is the density of indium?

B 74%

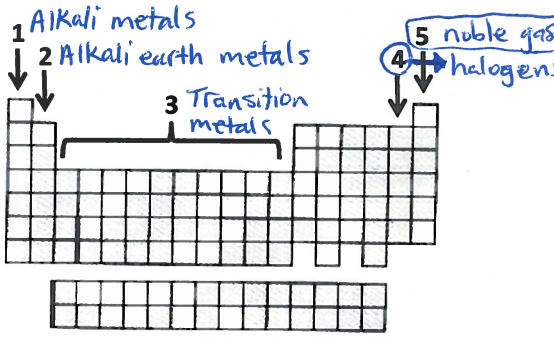
a) 7.217 g/cm^3
b) 7.2 g/cm^3
c) 0.14 g/cm^3
d) 0.138 g/cm^3
e) more than 0.1 g/cm^3 away from any of these values.

$V_{In} = 48.6 - 46.3\ cm^3 = 2.3\ cm^3$ (2SF)
$m_{In} = 16.6\ g$ (3SF)
$\therefore d = \frac{m}{V} = \doteq 7.2\ g/cm^3$ (to 2SF)

 # 17. Which choice correctly identifies the numbered sets of elements?

D 79%

a) ✗ 1=transition metals, 2=alkali earth metals, 5=halogens
b) ✗ 1=alkali metals, 2=alkali earth metals, 5=halogens
c) ✗ 1=alkali metals, 3=alkali earth metals, 4=halogens
d) 1=alkali metals, 3=transition metals, 4=halogens
e) ✗ 1=transition metals, 3=alkali metals, 5=halogens



 # 18. Which one of the following elements exists in its elemental form as diatomic molecules?

B 78%

a) ✗ magnesium — metal = atoms packed in 3D solid
b) nitrogen — nonmetal = molecules ... N_2
c) ✗ sodium — metal = atoms packed in 3D solid
d) carbon — nonmetal with many allotropes: graphite, diamond, C_{60} but NOT C_2!
e) ✗ neon — noble gas = free atoms in gas phase

 # 19. Which one statement best describes what happens when white sugar ($C_{12}H_{24}O_{12}$) dissolves in water? (MOLECULES) physical change

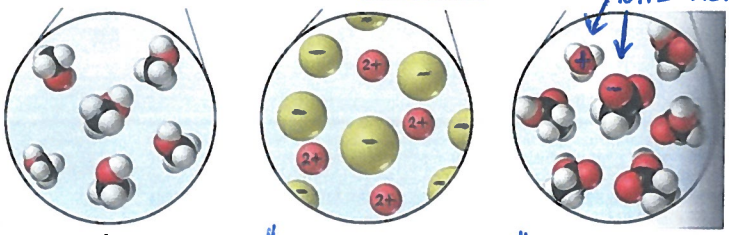
A 66%

a) Attractions between $C_{12}H_{24}O_{12}$ molecules are broken and replaced by attractions to H_2O.
b) ✗ Ionic bonds within $C_{12}H_{24}O_{12}$ molecules are broken and replaced by attractions to H_2O.
c) ✗ Covalent bonds within $C_{12}H_{24}O_{12}$ molecules are broken because of reaction with H_2O. ← if acid or base
d) ✗ Some $C_{12}H_{24}O_{12}$ molecules dissociate and form ionic bonds to H_2O molecules. ← never possible
e) ✗ The $C_{12}H_{24}O_{12}$ molecules are converted into CO_2 and H_2O. ← chemical reaction (combustion?!)

 # 20. Which one of the three diagrams below represents an aqueous solution of a weak electrolyte?

C 70%

a) A
b) B
c) C



A: no ions at all, just molecules — NONELECTROLYTE
B: all ions — STRONG ELECTROLYTE (carries current)
C: ions here but rest are neutral molecules; low yield of ions in solution, mostly just intact molecules = WEAK ELECTROLYTE

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

 # 21. Imagine you add an exact stoichiometric amount of yellow K_2CrO_4 solution to a colourless solution of $AgNO_3$, and a yellow solid forms. Once the solid precipitates, the supernatant is clear and colourless.

a) **(1.5 marks)** Write the balanced molecular equation for the reaction. (1.5)

$$K_2CrO_4(aq) + 2AgNO_3(aq) \longrightarrow 2KNO_3(aq) + Ag_2CrO_4(s)$$

formulae graded here

b) **(1.5 marks)** Write the net ionic equation for the reaction; be sure to include phase indicators (states). (1.5)

$$2Ag^+(aq) + CrO_4^{2-}(aq) \longrightarrow Ag_2CrO_4(s)$$

phases graded here

c) **(3 marks)** What could you do in the lab to separate the two products from each other, to obtain a solid sample of each one? Explain briefly (point-form is acceptable). (3/6)

- filter off the solid $Ag_2CrO_4(s)$, rinse with water + dry fully.
- collect filtrate solution that contains $KNO_3(aq)$
  - ↳ evaporate water (boil off) to collect solid KNO_3

OR: add another ionic compound that might precipitate those soluble ions... BUT CAN'T: all K^+ and NO_3^- salts are actually SOLUBLE.

 # 22. (5 marks) The food flavour enhancer *monosodium glutamate* (MSG) has the percent mass composition of 13.6% sodium, 35.5% carbon, 4.8% hydrogen, 8.3% nitrogen and 37.8% oxygen. What is the empirical formula of MSG? Show full calculations and explanatory key words for each step. (5)

① Consider a 100g sample (simplest approach with mass % data): (3)

Na: (0.136)(100g) = 13.6g ⇒ $\#n_{Na} = \frac{13.6\,g}{22.99\,g/mol} \doteq 0.5916$ mol Na (← divide all by this #)		1.000 ≈ 1
C: (0.355)(100g) = 35.5g ⇒ $\#n_C = \frac{35.5\,g}{12.01\,g/mol} \doteq 2.956$ mol C		4.997 ≈ 5
H: (0.048)(100g) = 4.8g ⇒ $\#n_H = \frac{4.8\,g}{1.008\,g/mol} \doteq 4.762$ mol H		8.049 ≈ 8
N: (0.083)(100g) = 8.3g ⇒ $\#n_N = \frac{8.3\,g}{14.007\,g/mol} \doteq 0.5926$ mol N		1.002 ≈ 1
O: (0.378)(100g) = 37.8g ⇒ $\#n_O = \frac{37.8\,g}{15.999\,g/mol} \doteq 2.363$ mol O		3.994 ≈ 4

(% sample mass ✓; all MM's correct ✓ (-0.5 if error); mole calc. ✓; normalize for mole ratio)

② Empirical formula is simplest mole RATIO of elements in compound. Thus, take element with smallest # of moles (= Na here) + divide all others by that amount to NORMALIZE to the least abundant atom.

③ This yields the mole ratio of elements in the formula:

$$1Na : 5C : 8H : 1N : 4O = NaC_5H_8NO_4$$

(formula style ✓, formula correctness ✓)

EMPIRICAL FORMULA

(11)