

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

PART A: MULTIPLE-CHOICE QUESTIONS (Answer on Scan Sheet in pencil)

01

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. / 10

Page 4. / 12

Page 5. / 11

Page 6. / 8

Page 7. / 10

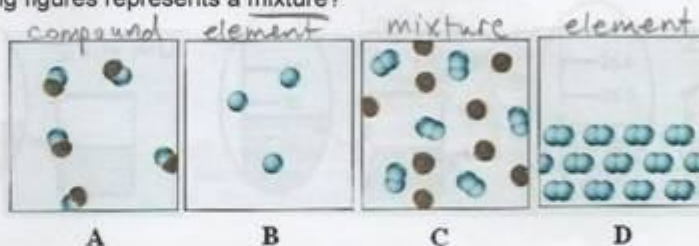
TOTAL: / 60 (MAX. 61)

PERCENT: %

PART A: MULTIPLE-CHOICE QUESTIONS (answer on scan sheet, in pencil)

1. (2 marks) Which of the following figures represents a mixture?

- a) A
b) B
c) C
d) D
e) They all do.



2. (2 marks) What type of statement is this? "The total mass of materials is not affected by a chemical change in those materials"....

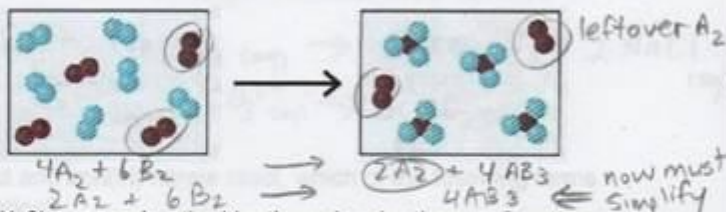
- a) a measurement
b) an observation
c) an experiment
d) a natural law
e) a theory

3. (2 marks) The statements below summarize various scientists' contributions to the understanding of atomic structure. Which statement incorrectly describes the scientist's work?

- a) J. Dalton proposed his atomic theory, in which he (incorrectly) postulated that all atoms of the same element are identical. ✓
b) The Curies showed that some types of atoms can spontaneously disintegrate, based on their experiments involving radioactivity. ✓
c) J.J. Thomson proposed the plum-pudding model of the atom, based on his cathode-ray tube experiments. ✓
d) R. Millikan proposed the law of conservation of matter, using his "oil-drop" experiments. ✓
e) E. Rutherford proposed the nuclear model of the atom, based on his gold-foil experiments. ✓

4. (2 marks) The reaction between reactant A (darker spheres) and reactant B (lighter spheres) is shown in the diagram below. Based on the diagram, which balanced equation best describes the reaction?

- a) $3A + B \rightarrow A_3B$
b) $A + 3B \rightarrow AB_3$
c) $A_2 + 3B_2 \rightarrow 2AB_3$
d) $8A + 12B \rightarrow 4AB_3 + 2A_2$
e) $4A_2 + 6B_2 \rightarrow 4AB_3 + 2A_2$



5. (2 marks) Which of the following statements (1-3) concerning the kinetic-molecular theory of matter is/are CORRECT?

- a) 1 only
b) 2 only
c) 3 only
d) 1 and 2
e) 1, 2 and 3
1. Particles in a liquid vibrate back and forth about an average position. X (solids)
2. Particles in a solid are packed closely together, but are not confined to specific positions. X (liquids)
3. Particles in a gas fly about randomly, colliding with themselves and the walls of their container. ✓

10

$$\begin{array}{r} 26.4 \\ + 26 \\ \hline 26.42 \\ \hline 78.82 \text{ mL} \end{array}$$

6. (2 marks) Suppose you pour the water from the three beakers shown below into one container. Based on the precision of the three beakers, how should you report the new total volume to the correct number of significant figures?

E

a) 78.817 mL
b) 78.82 mL
c) 78.8 mL
d) 80 mL
e) 79 mL

7. (2 marks) A piece of antimony with a mass of 17.41 g is submerged in 46.3 cm³ of water in a graduated cylinder. The water level increases to 48.9 cm³. According to these data, what is the correct value for the density of antimony?

B

a) 17.4 g/cm³
b) 6.7 g/cm³
c) 2.8 g/cm³
d) 0.36 g/cm³
e) 0.15 g/cm³

$$d = \frac{m}{V} = \frac{17.41 \text{ g}}{(48.9 - 46.3) \text{ cm}^3} = \frac{17.41 \text{ g}}{2.6 \text{ cm}^3} = 6.696 \text{ g/cm}^3 \approx 6.7 \text{ g/cm}^3$$

← 4 SF
← 2 SF (difference = 26)
← 2 SF

8. (2 marks) In the following redox reaction, which type of atom is oxidized?

D

$$8 \text{ NaI} + 5 \text{ H}_2\text{SO}_4 \rightarrow 4 \text{ I}_2 + \text{H}_2\text{S} + 4 \text{ Na}_2\text{SO}_4 + 4 \text{ H}_2\text{O}$$

loses electrons
oxidation state ↑
(becomes more positive)

ox: $8 \text{ I}^- \rightarrow 4 \text{ I}_2 + 8 \text{ e}^-$
red: $\text{H}_2\text{SO}_4 + 8 \text{ e}^- \rightarrow \text{H}_2\text{S} + \dots$

9. (2 marks) When solutions of strontium chloride and sodium carbonate react, which of the following species is a spectator ion? (Note: Strontium has the symbol Sr, Z = 38.)

E

a) carbonate ion
b) strontium ion
c) chloride ion
d) sodium ion
e) two of these

same group as Ca
alkali earth metal

$$\text{SrCl}_2(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{SrCO}_3(\text{s}) + 2 \text{ NaCl}(\text{aq})$$

net ionic equation: $\text{Sr}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{SrCO}_3(\text{s})$

10. (2 marks) When solutions of phosphoric acid and iron(III) nitrate react, which of the following terms will be present in the balanced molecular equation?

B

a) HNO₃(aq)
b) 3 HNO₃(aq)
c) 2 FePO₄(s)
d) 3 FePO₄(s)
e) 2 HNO₃(aq)

$$\text{H}_3\text{PO}_4(\text{aq}) + \text{Fe}(\text{NO}_3)_3(\text{aq}) \rightarrow \text{FePO}_4(\text{s}) + 3 \text{ HNO}_3(\text{aq})$$

yields none
H⁺ + PO₄³⁻ (weak acid)
Fe³⁺
3 NO₃⁻
ppt.
strong acid, fully dissociated

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11. (2 marks) What is the melting point of sodium chloride (801 °C) on the Kelvin scale?

- D
- a) 503 K
 - b) 528 K
 - c) 801 K
 - d) 1074 K
 - e) 1099 K

$$\begin{aligned} 801 &= ^\circ\text{C} \\ + 273.15 & \text{ offset to K since } 0\text{K} = -273.15^\circ\text{C} \\ \hline 1074.15 & \text{ K} \approx \underline{1074 \text{ K}} \end{aligned}$$

12. (2 marks) Which one of the following properties is not characteristic of nonmetals?

- C
- a) tend to form negative ions in chemical reactions with metals
 - b) appear in the upper right-hand corner of the periodic table (except H, true...)
 - c) often bond to each other by forming ionic bonds
 - d) do not have a shiny (lustrous) appearance
 - e) are poor conductors of electricity

13. (2 marks) How many neutrons are in a neutral atom of ²⁵Mg (magnesium-25)?

- D
- a) 0
 - b) 5
 - c) 12
 - d) 13
 - e) 25

↑ in nucleus... ↑ not relevant

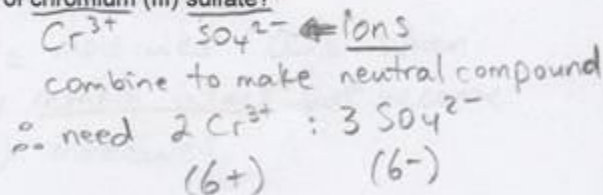
$$\begin{aligned} \text{mass \#} = A &= 25 \\ \text{\# of protons} = Z &= 12 \\ \text{\# n}^\circ = \text{rest of mass} &= 13 \end{aligned}$$

14. (2 marks) Which of the following statements is true?

- E
- a) Heating water with a Bunsen burner results in a 2:1 mixture of hydrogen and oxygen gases. !!
 - b) Ions are formed by adding or removing protons or electrons.
 - c) Scientists believe that solids are mostly open space. no, atoms in close-packed arrangement.
 - d) At least two of the above statements (A-C) are true.
 - e) All of the statements (A-C) are false.

15. (2 marks) What is the correct description and formula of chromium (III) sulfate?

- C
- a) molecular, Cr_2SO_4
 - b) molecular, CrSO_4
 - c) ionic, $\text{Cr}_2(\text{SO}_4)_3$
 - d) ionic, $\text{Cr}_3(\text{SO}_4)_2$
 - e) ionic, CrSO_4



16. (2 marks) What is the correct description and name of P_2O_5 ?

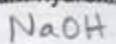
- A
- a) molecular, diphosphorus pentoxide
 - b) ionic, diphosphorus pentoxide
 - c) molecular, phosphorus oxide
 - d) ionic, phosphorus (V) oxide
 - e) ionic, phosphorus oxide

all nonmetals ∴ molecular
(covalently bonded)
diphosphorus pentoxide
(must specify # of each atom)

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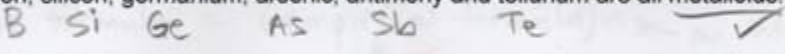
17. (2 marks) When sodium hydroxide dissolves in water, the solution contains Na^+ , H^+ and OH^- ions.

B a) True
b) False



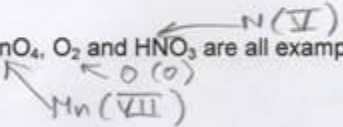
18. (2 marks) Boron, silicon, germanium, arsenic, antimony and tellurium are all metalloids.

A a) True
b) False



19. (2 marks) KMnO_4 , O_2 and HNO_3 are all examples of strong oxidizing agents.

A a) True
b) False



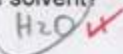
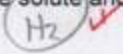
Contain atoms in high oxidation state (relative to element's preference).

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

x = half mark, ✓ = 1 mark

20. Think about hydrogen gas dissolving in water.

a) (1 mark) Which substance is the solute and which substance is the solvent?



b) (1 mark) Is the solute molecular or ionic in nature? How do you know?

H_2 is molecular in nature because hydrogen is a nonmetal; this means it forms covalent bonds to another nonmetal, including itself.

c) (3 marks) Which diagram (a-d) best represents aqueous hydrogen gas? Explain.



Hydrogen gas is made of H_2 molecules (O_2). When these molecules dissolve, they remain intact but become surrounded by water (solvent) molecules.

- a, b + c all show single H atoms → incorrect
- d shows H_2 molecule surrounded by H_2O molecules → correct

Hydrogen is molecular (but not an acid or a base), so it does not yield ions when it dissolves.

Common misconception: ...that H_2cgs is actually 2H^+ ions
NOT TRUE. The molecules DO NOT DISSOCIATE
(Dissolving & dissociating are NOT synonymous)

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

21. (8 marks) Menthol (MM 156.3 g/mol) is a strong-smelling substance that is used in cough drops. By mass, it is 76.83% carbon, 12.91% hydrogen and 10.26% oxygen. What is its molecular formula?

Include explanatory comments at each step of your calculation. **(-1) if inadequate organization +/- explanations**

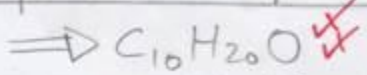
Molecular formula = (empirical formula)ⁿ × an integer
Simplest whole # ratio of atom types in substance, which can be found using mass % data.

To find empirical formula: Convert mass % → mass → moles, then normalize moles to find mole ratio of elements in substance
or, choose 156.3 g as your sample mass!!
atomic weight = molar mass of element

Element (mass %)	Mass in a 100g sample	M.M. of element	Moles in 100g	Normalized moles (÷ smallest)	Ratio as whole #
Carbon (76.83%)	0.7683 × 100g = 76.83g ✓	12.01 g/mol	$\frac{76.83g\ C}{12.01g/mol\ C}$ = 6.397 mol ✓	$\frac{6.397\ mol}{0.6413\ mol}$ = 9.975 ✓	10
Hydrogen (12.91%)	0.1291 × 100g = 12.91g ✓	1.008 g/mol	$\frac{12.91g\ H}{1.008g/mol\ H}$ = 12.808 mol ✓	$\frac{12.808\ mol}{0.6413\ mol}$ = 19.97 ✓	20
Oxygen (10.26%)	0.1026 × 100g = 10.26g ✓	15.999 g/mol	$\frac{10.26g\ O}{15.999g/mol\ O}$ = 0.6413 mol ✓	$\frac{0.6413\ mol}{0.6413\ mol}$ = 1.000 ✓	1

Total 100g (100%)

(all or none)



Note (1.5) the empirical formula's molar mass is the same as menthol's MM, which means C₁₀H₂₀O is BOTH the empirical + molecular formula.

empirical formula's MM = 156.259 g/mol
≅ 156.3 g/mol!

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✓ = 1 mark
✓ = 0.5 mark
✓ = 0.25 mark

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

22. (10 marks) An Alka-Seltzer® pain-relieving antacid tablet contains 324 mg of aspirin ($C_9H_8O_4$) plus about 2 g of baking soda ($NaHCO_3$) and 1 g of citric acid ($H_3C_6H_5O_7$).

a) (3 marks) Calculate the number of molecules of aspirin ($C_9H_8O_4$) in one tablet. Show your work.

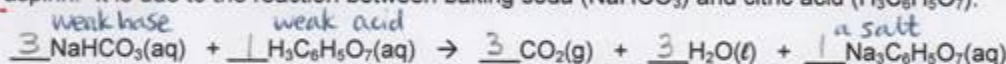
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① Molar mass of $C_9H_8O_4$ = $9 \times 12.01 \text{ g/mol C}$
 $8 \times 1.008 \text{ g/mol H}$
 $4 \times 15.999 \text{ g/mol O}$
 \checkmark 180.15 g/mol

② Moles of $C_9H_8O_4$ in one tablet via molar mass
 $\frac{(324 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}}) \checkmark}{180.15 \text{ g/mol } C_9H_8O_4} = 1.7985 \times 10^{-3} \text{ mol}$

③ Molecules via Avogadro's #: ^{3sf mass}
 $\frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \checkmark \times 1.7985 \times 10^{-3} \text{ mol}$
 $= 1.0776 \times 10^{21} \text{ molecules}$
 $\approx 1.08 \times 10^{21} \text{ molecules}$
 \checkmark (3F)
 mass limited sf via x/+ rules

The fizz produced when an Alka-Seltzer® tablet is dissolved in water has nothing to do with the aspirin. It is due to the reaction between baking soda ($NaHCO_3$) and citric acid ($H_3C_6H_5O_7$):



b) (1 mark) Fill in the missing stoichiometric coefficients needed to balance the reaction equation.

c) (3 marks) What type of reaction is this? Circle all that apply, and explain your choice(s).

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✓ acid-base ✓ gas-forming ~~oxidation-reduction~~ ~~precipitation~~ ... from acid to base ✓

• Acid-base: The reaction occurs via transfer of H^+ from citric acid to the bicarbonate ion (a base), to form carbonic acid:
 $3 HCO_3^-(aq) + H_3C_6H_5O_7(aq) \rightarrow 3 H_2CO_3(aq) + C_6H_5O_7^{3-}(aq)$
 Then, carbonic acid decomposes to form carbon dioxide and water:
 $H_2CO_3(aq) \rightarrow CO_2(g) + H_2O(l)$ if rule out redox ✓
if rule out pptn ✓

• Gas-forming: Because CO_2 is a gas, we would notice it bubbling out of the solution. This is dramatic when no reactants are gases!

d) (3 marks) This reaction is product-favoured. What drives it to produce a high yield of product? Explain briefly.

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The formation of a gas-phase product makes the reaction product-favoured when the reaction vessel (container) is open. Because the $CO_2(g)$ can escape the system when it forms, it does not remain in close contact with the other products. This makes it difficult for the reverse reaction to occur, so the products build up and we observe "high yield".
 Note: the initial acid-base reaction itself does not drive the reaction, because it involves a weak acid + weak base.