CHEM 142 - Exam 1 Version A

!!! DO NOT OPEN THIS EXAM BOOK UNTIL TOLD TO DO SO BY THE INSTRUCTOR !!!

Instructor: Dr. Kari Pederson

Date: Friday, July 15

Time: 9:40-10:40am

Location: BAG 154

NO GRAPHING CALCULATORS ALLOWED

ONLY CALCULATORS MAY BE USED AS CALCULATORS
(you may not use your *cellular phone* as a calculator)

NO HEADPHONES ALLOWED (EARPLUGS ARE OK)

NO HATS WITH BRIMS ALLOWED

!!! PLEASE READ THIS !!!

Indicate *all* of the following on your scantron form or ***five points*** will be deducted from your exam score:

First Name, Last Name, Student Number, Section, Exam Version

YOUR FULL NAME: _____ _____
first name *last name*

YOUR SECTION/SEAT: _____ _____
discussion section *seat number*

Question	Points Possible	Score
1-8	24	
9-16	40	
17-20	16	
21	20	
Scantron Info?	-5	
TOTAL	**100**	

MULTIPLE CHOICE: CONCEPTS. 8 @ 3 pts each → **24 POINTS TOTAL**
Please mark the *one* correct answer for each of the following questions on your scantron.

1. Which of the following is a *chemical property* of the element cesium?
   A) Cesium will react explosively if placed in water.
   B) Cesium is a soft metal that can be cut easily.
   C) Cesium, like other metals, conducts electricity.
   D) Cesium has a much smaller density than lead.
   E) Cesium is grayish in color.

2. Which metric prefix symbol means 1×10^3?
   A) p
   B) m
   C) M
   D) k
   E) n

3. As chemists and other scientists seek to understand the principles that govern nature they employ what is called the scientific method. The first step in this method is ____.
   A) the proposal of a hypothesis
   B) the testing of a scientific law
   C) the application for a research grant
   D) the testing of a hypothesis
   E) the making of observations

4. Sodium metal reacts vigorously with water, releasing hydrogen gas as one of the products. A piece of sodium weighing 34.0 g was added to a beaker containing 76.0 g of water. The resulting solution weighed 98.0 g. How many grams of hydrogen gas were produced (assume no hydrogen gas remains in solution)?
   A) 12.0 g
   B) 22.0 g
   C) 32.0 g
   D) 42.0 g
   E) none of the above

Conservation of Mass:
total mass reactants = total mass products
$mass\ H_2 = (34.0g\ Na + 76.0g\ water) - 98.0g\ solution = 12.0g$

5. Of the following, *only* _____ would be classified as a **pure substance**.
   A) beer
   B) water from the drinking fountain
   C) carbon dioxide
   D) salted popcorn
   E) skim milk

6. Which statement best describes ions?
   A) atoms in the same vertical group
   B) atoms with the same number of protons and electrons and different numbers of neutrons
   C) atoms with the same number of neutrons and electrons and different numbers of protons
   D) atoms with the same numbers of protons and neutrons and different numbers of electrons
   E) atoms in the same horizontal period

7. The element _____ is classified as a *metal* whereas _____ is classified as a *nonmetal*.
   A) Ca, N
   B) P, Zn
   C) Se, F
   D) Fe, Cd
   E) Ge, Cl

8. In an atom of ${}^{34}_{16}S$ _____.
   A) the number of protons equals the number of neutrons
   B) 18 electrons are found outside the nucleus
   C) 16 neutrons are found in the nucleus
   D) the sum of protons and neutrons is 34
   E) the total number of electrons and protons equals 34

MULTIPLE CHOICE: SHORT CALCULATIONS. 8 @ 5 pts each → **40 TOTAL POINTS**
Please mark the *one* correct answer for each of the following questions on your scantron.

9. The density of magnesium metal (used in fireworks) is 1.65 kg/m^3. Express this density in g/cm^3.

A) 1.65×10^{-3} g/cm^3
B) 1.65×10^{-1} g/cm^3
C) 1.65×10^{1} g/cm^3
D) 1.65×10^{3} g/cm^3
E) none of the above

$$1.65\,kg/m^3 \times \frac{1000g}{1kg} \times \left(\frac{1m}{100cm}\right)^3 = 1.65 \times 10^{-3}\,g/cm^3$$

10. Hydroquinone, used as a photographic developer, is 65.4% C, 5.5% H, and 29.1% O, by mass. What is the molecular formula of hydroquinone if the molecular mass is 110.1 amu?

A) $C_5H_{18}O_2$
B) $C_6H_6O_2$
C) $C_4H_{14}O_3$
D) C_3H_3O
E) none of the above

$$65.4g\ C \times \frac{1mol\ C}{12.001g\ C} = 5.45mol\ C$$

$$5.5g\ H \times \frac{1mol\ H}{1.008g\ H} = 5.45mol\ H$$

$$29.1g\ C \times \frac{1mol\ O}{15.9994g\ O} = 1.82mol\ O$$

empirical formula: C_3H_3O

$$empirical\ mass = (3 \times 12.001amu\ C) + (3 \times 1.008amu\ H) + (1 \times 15.9994amu\ O) = 55.0amu$$

$$\frac{empirical\ mass}{molecular\ mass} = \frac{55.0amu}{110.1amu} = 2$$

molecular formula: $C_6H_6O_2$

11. Calculate the moles of sodium ions present in a milliliter of 0.235 M sodium bicarbonate.

A) 2.35×10^{-1} moles
B) 4.70×10^{-1} moles
C) 2.35×10^{-4} moles
D) 4.70×10^{-4} moles
E) none of the above

Formula: $NaHCO_3$

$$1mL \times \frac{1L}{1000mL} \times \frac{0.235mol\ NaHCO_3}{1L} \times \frac{1mol\ Na^+}{1mol\ NaHCO_3} = 2.35 \times 10^{-4} mol\ Na^+$$

12. What volume of 2.050 M copper(II) sulfate must be diluted with water to prepare 750.0 mL of a 0.8612 M sulfate solution?

A) 892.6 mL
B) 315.1 mL
C) 1.785 mL
D) 157.5 mL
E) none of the above

$M_1V_1 = M_2V_2$

$$V_1 = \frac{750mL \times 0.8612\,mol/L}{2.050\,mol/L} = 315.1mL$$

13. An ionic compound forms when lithium reacts with oxygen. If a sample of the compound contains 5.3×10^{20} lithium ions, how many moles of oxide ions does it contain?

A) 4.4×10^{-4} mol
B) 1.6×10^{44} mol
C) 1.8×10^{-3} mol
D) 8.8×10^{-4} mol
E) none of the above

Formula: Li_2O

$$5.3 \times 10^{20} Li^+\ ions \times \frac{1mol\ Li^+}{6.02 \times 10^{23} Li^+\ ions} \times \frac{1mol\ O^{2-}}{2mol\ Li^+} = 4.4 \times 10^{-4} mol\ O^{2-}$$

14. What is the mass % of H in ammonium phosphate ($(NH_4)_3PO_3$?

A) 2.3%
B) 6.0%
C) 9.1%
D) 17%
E) none of the above

$$molar\ mass = 3\times\left(14.00674\,g/mol\,N + \left(4\times 1.008\,g/mol\,H\right)\right) + 30.973761\,g/mol\,P + 3\times 15.9994\,g/mol\,O$$

$$= 133.09\,g/mol\ \ \left(NH_4\right)_3 PO_4$$

$$mass\%H = \frac{3\times 4\times 1.008\,g/mol\,H}{133.09\,g/mol\ \ \left(NH_4\right)_3 PO_4}\times 100\% = 9.1\%$$

15. Naturally occurring rubidium has an atomic mass of 85.5amu. It is composed of two isotopes, rubidium–85 (84.9amu) and rubidium–87 (86.9amu). From this information one can conclude that naturally occurring rubidium is composed of _____.

A) approximately 30% rubidium-85 and 70% rubidium-87
B) approximately 70% rubidium-85 and 30% rubidium-87
C) approximately 20% rubidium-85 and 80% rubidium-87
D) approximately 80% rubidium-85 and 20% rubidium-87
E) none of the above

$$85.5amu = (x)84.9amu + (1-x)86.9amu$$

$$x = 0.7$$

16. What is the correct name of $Sn(HSO_4)_2$?

A) tin(IV) sulfite
B) tin(II) sulfate
C) tin(IV) sulfate
D) tin(II) hydrogen sulfate
E) tin(IV) hydrogen sulfate

MATCHING. 8 @ 2 pts each → **16 POINTS TOTAL**
Please indicate the letter of the *one* correct answer for each of the following questions in the blank.

17. The conversion of CO_2 (g) into CO_2 (s) is an example of a(n) ___A__ change/reaction.

18. Give the chemical symbol/name (whichever is missing) for each of the following elements:
    A) Oxygen ___T____
    B) Bromine ___W____
    C) Ca ___E____
    D) Potassium ___B____
    E) Iodine ____H___

19. According to the Law of _____Y_____ a pure compound always contains the same elements in exactly the same proportions by mass.

20. The atomic number of an element is equal to its number of ____I_____.

A)	Physical	B)	K	C)	Chemical	D)	Os
E)	Calcium	F)	Electrons	G)	Nitrogen	H)	I
I)	Protons	J)	B	K)	Decomposition	L)	Fe
M)	Sodium	N)	Ir	O)	Sulfur	P)	In
Q)	Nickel	R)	P	S)	Carbon	T)	O
U)	Neutrons	V)	Lead	W)	Br		
X)	Multiple Proportions	Y)	Definite Proportions	Z)	Conservation of Mass		

LONG ANSWER. 20 POINTS TOTAL

21. In lab, a student mixes 4.0 mL of 3.0 M lead(II) nitrate reacts with 9.0 mL of 2.5 M sodium chloride in aqueous solution to form a precipitate.

A) What is the net ionic equation for this reaction? **(3 pts)**

Pb^{2+} (*aq*) + 2Cl^- (*aq*) → $PbCl_2$ (*s*)

If you are unable to write the balanced net ionic equation or no precipitate would form in this reaction (i.e., no reaction would occur), use the following information for the remainder of the problem:

60. mL of 0.50 M iron(III) chloride solution and 40.0 mL of 7.5 M ammonium sulfide solution are mixed in order to precipitate iron(III) sulfide according to the following balanced net ionic equation:

$$2Fe^{3+}\,(aq) + 3S^{2-}\,(aq) \rightarrow Fe_2S_3\,(s)$$

B) Assuming the reaction goes to completion, what mass of precipitate will form? **(6 pts)**

$$0.0040L\ solution \times \frac{3.0mol\ Pb(NO_3)_2}{1L\ solution} \times \frac{1mol\ Pb^{2+}}{1mol\ Pb(NO_3)_2} = 0.012mol\ Pb^{2+}$$

$$0.0090L\ solution \times \frac{2.5mol\ NaCl}{1L\ solution} \times \frac{1mol\ Cl^-}{1mol\ NaCl} = 0.0225mol\ Cl^-$$

Need 2 Cl^- ions for every 1 Pb^{2+} ion, so Cl^- is limiting reactant.

$$0.0225mol\ Cl^- \times \frac{1mol\ PbCl_2}{2mol\ Cl^-} \times \frac{278.1054g\ PbCl_2}{1mol\ PbCl_2} = 3.1g\ PbCl_2$$

Alternate problem:

$$\frac{0.50mol\ FeCl_3}{L\ solution} \times 0.060L\ solution = 0.030mol\ FeCl_3 \times \frac{1mol\ Fe^{3+}}{1mol\ FeCl_3} = 0.030mol\ Fe^{3+}$$

$$\frac{7.5mol\ Na_2S}{L\ solution} \times 0.0400L\ solution = 0.30mol\ (NH_4)_2S \times \frac{1mol\ S^{2-}}{1mol\ (NH_4)_2S} = 0.30mol\ S^{2-}$$

2:3 Fe^{3+}:S^{2-} mole ratio in balanced net ionic equation, so 0.015 equivalents Fe^{3+} and 0.10 equivalents S^{2-}. Fe^{3+} is limiting reagent.

$$0.030mol\ S^{2-} \times \frac{1mol\ Fe_2S_3}{2mol\ Fe^{3+}} = 0.015mol\ Fe_2S_3 \times \frac{207.888g\ Fe_2S_3}{1mol\ Fe_2S_3} = 3.1g\ Fe_2S_3$$

C) What mass of each excess ion will remain? **(9 pts)**

$$0.0225 mol\ Cl^- \times \frac{1 mol\ Na^+}{1 mol\ Cl^-} = 0.0225 mol\ Na^+\ initially - 0 mol\ Na^+\ used = 0.0225 mol\ Na^+ excess$$

$$0.0225 mol\ Na^+ \times \frac{22.989770 g\ Na^+}{1 mol\ Na^+} = 0.52 g\ Na^+\ excess$$

$$0.012 mol\ Pb^{2+} \times \frac{2 mol\ NO_3^-}{1 mol\ Pb^{2+}} = 0.024 mol\ NO_3^-\ initially - 0 mol\ NO_3^-\ used = 0.024 mol\ NO_3^- excess$$

$$0.024 mol\ NO_3^- \times \frac{62.00494 g\ NO_3^-}{1 mol\ NO_3^-} = 1.5 g\ NO_3^-\ excess$$

$$0.012 mol\ Pb^{2+}\ initially - \left(0.0225 mol\ Cl^- \times \frac{1 mol\ Pb^{2+}}{2 mol\ Cl^-} \right) used = 0.00075 mol\ Pb^{2+}\ excess$$

$$0.00075 mol\ Pb^{2+} \times \frac{207.2 g\ Pb^{2+}}{1 mol\ Pb^{2+}} = 0.16 g\ Pb^{2+}\ excess$$

Alternate Problem:

$$0.30 mol\ \ S^{2-} \times \frac{2 mol\ NH_4^+}{1 mol\ \ S^{2-}} = 0.60 mol\ NH_4^+\ initially - 0 mol\ NH_4^+\ used = 0.60 mol\ NH_4^+ excess$$

$$0.60 mol\ NH_4^+ \times \frac{18.03874 g\ NH_4^+}{1 mol\ NH_4^+} = 11 g\ NH_4^+\ excess$$

$$0.030 mol\ Fe^{3+} \times \frac{3 mol\ Cl^-}{1 mol\ Fe^{3+}} = 0.090 mol\ Cl^-\ initially - 0 mol\ Cl^-\ used = 0.090 mol\ Cl^- excess$$

$$0.090 mol\ Cl^- \times \frac{35.4527 g\ Cl^-}{1 mol\ Cl^-} = 3.2 g\ Cl^-\ excess$$

$$0.30 mol\ S^{2-}\ initially - \left(0.030 mol\ Fe^{3+} \times \frac{3 mol\ S^{2-}}{2 mol\ Fe^{3+}} \right) used = 0.255 mol\ S^{2-}\ excess$$

$$0.255 mol\ S^{2-} \times \frac{32.066 g\ S^{2-}}{1 mol\ S^{2-}} = 8.2 g\ S^{2-}\ excess$$

D) If the student recovers 2.00 g of precipitate, what is the percent yield? (If you did not calculate a theoretical yield in part B, use 3.53 g here) **(2 pts)**

$$\frac{2.00 g\ PbCl_2}{3.1 g\ PbCl_2} \times 100\% = 65\%\ yield \qquad \textbf{Alt.}\ \frac{2.00 g\ Fe_2S_3}{3.1 g\ Fe_2S_3} \times 100\% = 65\%\ yield$$