Recitation Worksheet Three: Exam One Review

Name: Key UGA ID:

Textbook:
Chemistry & Chemical Reactivity
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Instructions:

- This recitation worksheet is a review for Exam One.
- Exam coverage: Ch. 1, 1R, 2, 3.1-3.4.
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- The **recitation session during the exam week (September 9-12) is still mandatory**. Your attendance will be recorded.
- A periodic table and formula sheet are attached to the end of this worksheet.

1. Classify each statement as an (A) observation, (B) law, or (C) theory.

I. *n*-butyl lithium combusts immediately in the air [A]

II. A compound always contains the same proportion of elements by mass [B]

III. Each element is made up of tiny particles called atoms [C]

2. Match the following statements with the correct label: (A) hypothesis, (B) law, or (C) theory.

I. Matter is neither created nor destroyed in a chemical reaction [B]

II. Chemical reactions involve the rearrangement of fundamental units called atoms [C]

III. If 10.0 g of hydrogen is reacted with 10.0 g of oxygen, 20.0 g of water will be created [A]

↓

hypothesizing product to form

3. Consider three cubes of magnesium metal and their respective masses in the table below.

Cube A	2.5×10^{-2} megagrams
Cube B	2.5×10^{15} nanograms
Cube C	2.5×10^{14} micrograms

Which cube has the largest mass? You only need to record the corresponding letter in the box below.

Cube: C

$2.5 \times 10^{-2}\ Mg \left(10^{6-0}\right) = 2.5 \times 10^{4}\ g$

$2.5 \times 10^{15}\ ng \left(10^{-9-0}\right) = 2.5 \times 10^{6}\ g$

$2.5 \times 10^{14}\ mg \left(10^{-6-0}\right) = 2.5 \times 10^{8}\ g$

4. A student places a 31.49 gram object into an empty graduated cylinder. They then add enough methanol (a common organic solvent) to the graduated cylinder where the total volume of both components is 55.00 mL. If the mass of both the object and methanol is 61.42 grams, what is the density of the solid? The density of methanol is 0.791 g/mL. Report your answer in **standard notation**.

1.83 g/mL

given: mass of object + methanol = 61.42 g

mass of object = 31.49 g

mass of methanol = $61.42\ g - 31.49\ g = 29.93\ g$

for methanol: $d = m/V \rightarrow 0.791\ g/mL = \frac{29.93\ g}{V}$

$V = 37.838175 \approx 37.838175\ mL$

volume of object: $55.00\ mL - 37.838175\ mL = 17.161825\ mL$

for object: $31.49\ g / 17.161825\ mL = 1.83\ g/mL$

5. A scientist finds a silver rod in the lab. They know silver has a density of 10.49 g/mL, and they realize they can find the density of the rod to confirm its identity. They determine the mass to be 68.19 grams and then carefully transfer the rod to a graduated cylinder with an initial volume of 20.00 mL. Upon transferring, what will the final volume be in the graduated cylinder (assuming the rod is 100% silver metal)? Report your answer in **standard notation**.

26.50	mL

$d = \frac{m}{V} \rightarrow 10.49\ g/mL = \frac{68.19\ g}{V}$

$V = 6.50047766\ mL$

$= 6.500\ mL$

$20.00\ mL + 6.500\ mL = 26.500\ mL$

$= 26.50\ mL$

6. A student goes to chemistry lab and is tasked with determining the density of a10.30 g metal rod. The student carefully places the rod in a graduated cylinder with 20.00 mL of an unknown liquid and they note that it sinks to the bottom. They also find that the new volume reading is 21.15 mL. Using this information, the student finds that the density of the metal rod is 0.112 g/mL.

Which of the following statements is/are **true**?

$d = \frac{10.30\ g}{21.15\ mL - 20.00\ mL} = \frac{10.30\ g}{1.15\ mL} = 8.96\ g/mL$

E

A. The student's calculation for density is correct
B. The density they calculated is an extensive property — intensive
C. A conclusion cannot be made whether the metal rod is more or less dense than the liquid since the liquid's identity (and therefore density) is unknown
D. More than one of the above are true
E. None of the above are true

$d_{metal} > d_{liquid}$ (sinks)

7. Record the number of significant figures for each of the following values below. In each box, you only need to record the integer (e.g. for one sig fig, record "1"). If there is an infinite number of significant figures, write "INF".

5	1.0500 x 10^4 meters
6	1210.00 kilograms
INF	410000 recitation worksheets
3	0.191 ºC
5	0.00070000 milliliters

8. Complete the mathematical operations below and record the answers in the appropriate number of significant figures and in **standard notation**.

7 sf 4 sf 7 sf 3 sf
(75.00000 x 0.9732) + (29.30291 x 0.0538) = **74.57**

(72.99) + (1.576496) = 74.5665

$$\frac{41.870 + 23.12}{5.00 \times 10^1} - 0.1 =$$ **1.2**

$\frac{64.99}{5.00 \times 10^1} - 0.1 \rightarrow 1.2998 - 0.1 = 1.1998$

9. Assuming 100 is an exact number in this mathematical expressions below, what are the answers to the percent calculations expressed to the correct number of significant figures? Report your answer in **standard notation**.

(a) $\dfrac{2.70 - 2.62}{2.70} \times 100 =$

$\dfrac{0.08}{2.70} \times 100 = 2.963\ \%$

3	%

(b) $\dfrac{16.57 - 16.12}{16.57} \times 100 =$

$\dfrac{0.45}{16.57} \times 100 = 2.7158\ \%$

2.7	%

(c) $\dfrac{1.000 - 0.9911}{1.000} \times 100 =$

$\dfrac{0.0089}{1.000} \times 100 = 0.89$

0.9	%

10. How many significant figures will be in the final answer of the expression below?

$$\frac{(112.0 \times 4.200) - 400.1}{70.300000}$$

C

$\frac{(470.4) - 400.1}{70.300000} \rightarrow \frac{70.3}{70.300000} \downarrow 1.00$

A. 1 significant figure
B. 2 significant figures
C. 3 significant figures
D. 4 significant figures
E. 5 significant figures

11. Label the following statements as either (A) qualitative or (B) quantitative.

I. Chemistry is more interesting than biology, math, or physics A

II. The density of copper is much higher than the density of magnesium A

III. The melting point of nickel is 1455 ºC B

12. Using the Law of Multiple Proportions, complete the table to determine the masses of element "X" that will combine with element "M" to form hypothetical "MX" compounds.

Compounds	Mass of M (g)	Mass of X (g)
MX	1.00	1.55
MX_2	1.00	3.10
MX_6	1.00	9.30

3.10 / 2 = 1.55

1.55 × 6 = 9.30

13. A sample of a certain compound contains 10.00 g of carbon and 13.32 g of oxygen. A different sample of the same compound that contains 25.00 g of carbon will contain how many grams of oxygen? Report your answer in **standard notation**.

33.30 g

$\frac{10.00\ g}{13.32\ g} = \frac{25.00\ g}{x} \rightarrow 33.30\ g$

(4 sig figs)

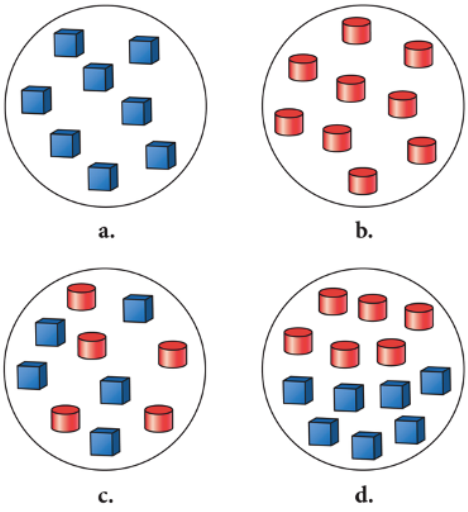
14. Using the images below, label each as either a homogeneous mixture, heterogeneous mixture, or pure substance.

a. Pure substance

b. Pure substance

c. homogeneous mixture

d. heterogeneous mixture



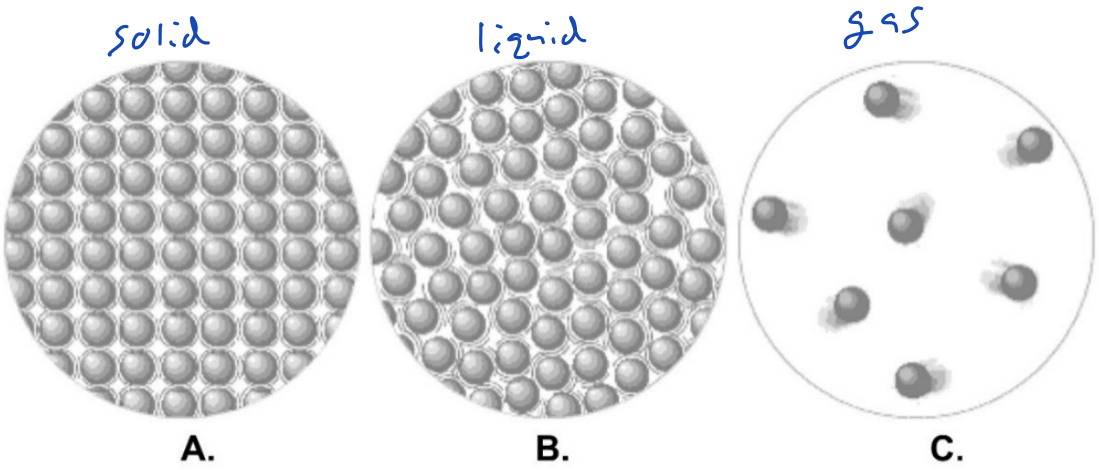
15. Identify each of the following as an element, compound, or mixture.

element — aluminum foil

mixture — soda (carbonated beverage)

compound — sucrose (sugar)

16. Which of the following options best represents image B?



C

A. Solid because the particles are closer together.
B. Gas because the particles are disordered.
C. Liquid because the particles are close together but disordered.
D. Solid because the particles are disordered
E. Gas because the particles are close together but disordered.

17. Which of the statements is **incorrect**?

C

A. A molecule is the smallest part of a compound that can have a stable independent existence.
B. Some elements occur as molecules in their elemental form.
C. The atomic number of an element is defined as the number of neutrons (protons) in the nucleus.
D. Molecules of compounds are composed of more than one kind of atom.
E. The charge on an electron is negative and the charge on a proton is positive.

18. Classify the following as a chemical or physical change.

Physical	sucrose (sugar) dissolving in water
chemical	lighting a match
chemical	grilling a hamburger
Physical	shredding lettuce

19. Which one of these statements about temperature scales is **false**?

B

A. The boiling point of water on the Fahrenheit scale is 212 degrees.
B. One degree Celsius represents a ~~smaller~~ larger temperature difference than one degree Fahrenheit
C. The freezing point of water on the Celsius scale is 0 degrees.
D. All temperatures on the Kelvin scale are positive numbers.

20. Which of the following species does **not** represent an element in its most stable form? Select any that apply and answer with capital letters and no spaces (e.g. ABCDE).

BCD

A. N_2
B. Cl Cl_2
C. C_8 C
D. S_2 S_8
E. He

21. Fill out the table below with the chemical symbol or element name:

Symbol	Element Name
S	Sulfur
Se	Selenium
Mn	Manganese
Sr	Strontium
Mg	Magnesium
Co	Cobalt
Ag	Silver
Br	Bromine
Ba	Barium

22. Consider three students below in the table who each took multiple measurements collecting the mass of a 20.00 gram block of copper metal. Answer the questions below by writing the corresponding letter of each student in the boxes provided.

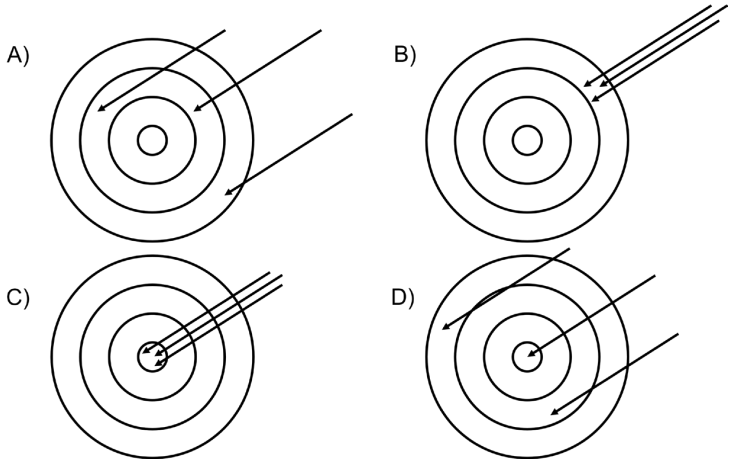
	Student A	Student B	Student C
Trial 1	20.02 g	20.79 g	19.77 g
Trial 2	19.99 g	19.55 g	19.79 g
Trial 3	20.03 g	19.93 g	19.76 g
Trial 4	20.01 g	20.44 g	19.78 g

(a) Which student was inaccurate and imprecise? B

(b) Which student was inaccurate and precise? C

(c) Which student was accurate and precise? A

23. Which of the following drawings demonstrates precision but **not** accuracy?



B

24. Which of these statements is **false**?

B

A. Temperature is an example of an intensive property.
B. The mass percentage of calcium in chalk is an extensive property. intensive
C. Separations of a solid from a liquid by filtration is an example of a physical process.
D. Density is an intensive property.

25. From the chemical decomposition of an unknown liquid, one obtains two new liquid pure substances, both of which are pure substances. Which of the following statements are **true**? Select any that apply and answer with capital letters and no spaces (e.g. ABCDE).

EF

A. one of the products must be an element
B. both products must be elements
C. the original liquid must be a mixture
D. the two new liquids could be separated by filtration
E. the two new liquids could be separated by distillation
F. the original liquid is not an element

26. A worried parent goes to the pharmacy and asks for the best medicine for their 10-year old with a high fever. The druggist recommends 2.5 teaspoons of Children's Tylenol by mouth every 4 hours. If 1 teaspoon is equal to 5 mL, how many milligrams of acetaminophen will the child consume in 24 hours?

Report your answer in **standard notation** and **two significant figures**.

2400 mg

$$24\ \text{h}\left(\frac{2.5\ \text{tsp}}{4\ \text{h}}\right)\left(\frac{5\ \text{mL}}{1\ \text{tsp}}\right)\left(\frac{160\ \text{mg}}{5\ \text{mL}}\right) = 2400\ \text{mg}$$

27. In an alternate universe, the charge to mass ratio of an electron was determined from Rutherford's cathode-ray tube experiment to be 0.759×10^{8} C/g, and the charge on a single electron was determined from the Millikan oil drop experiment to be 2.602×10^{-19} C, so the mass of a single electron is _____ kg. Report your answer in **standard notation**.

3.43×10^{-30} kg

$$2.602 \times 10^{-19}\ \text{C} \times \left(\frac{\text{g}}{0.759 \times 10^{8}\ \text{C}}\right) \times \left(\frac{10^{0-3}\ \text{kg}}{1\ \text{g}}\right)$$

28. If the density of a metal is 634 lb/foot^3 in imperial units, what is the density of that metal in SI units of g/cm^3? (1 foot = 12 in)

B

$$\frac{634\ lb}{ft^3}\left|\frac{1\ kg}{2.205\ lb}\right|\frac{10^{3-0}\ g}{1\ kg}\left|\left(\frac{1\ ft}{12\ in}\right)^3\right|\left(\frac{1\ in}{2.54\ cm}\right)^3$$

see formula sheet

A. 9440 g/cm^3
B. 10.2 g/cm^3
C. 944 g/cm^3
D. 0.00305 g/cm^3
E. 11.45 g/cm^3

29. A living cell is made up mostly of water. Suppose a cell is spherical with a radius of 1.0 micrometers. Estimate how many water molecules are in 1.0 cells, given the density of water is 1.00 g/mL, and 1.0 molecules of water is 18.02 amu. Report your answer in **scientific notation**. (1 amu = 1.6605 × 10^{-24} g; volume of a sphere = (4/3)πr^3)

1.4 × 10 11 molecules

$V = \frac{4}{3}\pi(1.0\ \mu m)^3 = 4.188790\ \mu m^3$ (volume of 1.0 cells)

$4.188790\ \mu m^3 \times \left(\frac{10^{-6-(-2)}\ cm}{1\ \mu m}\right)^3 \times \left(\frac{1\ mL}{1\ cm^3}\right) \times \left(\frac{1.00\ g}{mL}\right)$

$= 4.1887902 \times 10^{-12}\ g$

$4.1887902 \times 10^{-12}\ g \times \left(\frac{1\ amu}{1.6605 \times 10^{-24}\ g}\right) \times \left(\frac{1.0\ molecules}{18.02\ amu}\right)$

$= 1.3998993 \times 10^{11}$ molecules

30. Which of the following are **false**? Select any that apply and answer with capital letters and no spaces (e.g. ABCDE).

AEF

A. The mass of a proton and an electron are approximately equal. $p^+ > e^-$
B. The mass of a proton and a neutron are approximately equal.
C. The charge of a proton and an electron are equal but opposite
D. An isotope occurs when the number of neutrons in an atom changes.
E. An ion occurs when the number of ~~neutrons~~ electrons in an atom changes.
F. An anion occurs when a neutral atom ~~loses~~ gains electrons.

31. Which of the following subatomic particles is the lightest (lowest mass)?

C

A. Proton
B. Neutron
C. Electron
D. More than one of the above

32. The subatomic particle that contributes to the charge of an atom but not the mass is called a(n)…

B

A. Proton
B. Electron
C. Neutron
D. Quark

33. Fill out the missing blanks in the table below for three different hypothetical elements.

Element number	Mass number	Number of protons	Number of neutrons	Number of electrons
1	51	25	26	25
2	50	25	25	25
3	52	26	26	26

mass # = protons + neutrons
electrons = # protons

34. From the table in question 33, which element number was **not** an isotope of the other two elements? You only need to record the integer in the box below (e.g. for element number 1, record "1").

Element number: 3 → different # protons

35. How many protons (p) and neutrons (n) are in an atom of calcium-46? → protons + neutrons

↓

20 protons

A

A. 20 p, 26 n
B. 20 p, 46 n
C. 26 p, 20 n
D. 46 p, 60 n

36. Which of the following has 13 protons, 10 electrons, and 13 neutrons?

B

A. $^{23}_{13}Al^{2+}$

B. $^{26}_{13}Al^{3+}$ ↳ protons

neutrons = 27 − 13 = 14

electrons = 13 − 3 = 10

C. $^{27}_{13}Al^{3-}$

D. $^{22}_{13}Al^{2-}$

37. The theoretical element Hx has three isotopes: Hx-302, Hx-303, and Hx-305. If the average atomic mass for Hx is 304.300 amu, what is likely the most abundant isotope?

C

closest to Hx-305

A. Hx-302
B. Hx-303
C. Hx-305

38. The hypothetical element "R" has two naturally occurring isotopes: ^{109}R and ^{110}R. What is the average atomic mass of "R" if the isotope ^{109}R has a natural abundance of 55.45%? The masses of both isotopes are provided in the table below. Report your answer in **standard notation**.

Isotope of "R"	Mass
^{109}R	109.112231 amu
^{110}R	110.718210 amu

→ 55.45 %

→ 100 − 55.45 = 44.55 %

→ careful with sig figs!

109.83 amu

(109.112231 amu × 0.5545) + (110.718210 amu × 0.4455)

60.502732 amu + 49.324963 amu

109.827695 amu → 109.83 amu

39. Record the number of electrons for each of the ions written below. Answer by using an integer (e.g. 0, 1, etc.).

K^+ [18] electrons $19 - 1 = 18$

Fe^{2+} [24] electrons $26 - 2 = 24$

Cl^- [18] electrons $17 + 1 = 18$

O^{2-} [10] electrons $8 + 2 = 10$

40. The formula of a salt is XCl_2. The X ion in this salt has 28 electrons, and a chloride ion has a -1 charge. The metal X is (write the chemical symbol):

[Zn]

$X = +2$ charge $= 28$ e⁻s

$=$ neutral charge $= 30$ e⁻s $\rightarrow$ Zn

41. When a metal forms a cation, it... (+)

[3]

A. gains one or more electrons → changes charge
B. loses one or more electrons
C. gains one or more protons → changes element
D. loses one of more protons
E. gains one or more neutrons → changes isotope
F. loses one or more neutrons

42. Which of the statements is **not** an idea from Dalton's Atomic Theory?

C

A. An element is composed of extremely small indivisible particles called atoms.
B. All atoms of a given element have identical properties which differ from those of all other elements.
C. Atoms can be transformed into atoms of another element.
D. Compounds are formed when atoms of different elements combine with each other in small whole-number ratios.
E. The relative numbers and kind of atoms are consistent in a given compound.

43. If the Thomson Model (the Plum Pudding Model) of the atom had been correct, Rutherford would have observed:

A

A. Alpha particles going through the foil with little or no deflection.
B. Alpha particles greatly deflected by the metal foil.
C. Positive particles formed in the foil.
D. None of the above observations is consistent with the Thomson model of the atom.

44. Label the following elements below as an alkali metal, alkaline earth metal, transition metal, halogen, noble gas, lanthanide, or actinide.

U	Actinide	Ba	Alkaline earth metal
Zr	Transition metal	K	Alkali metal
Ce	Lanthanide	Br	Halogen

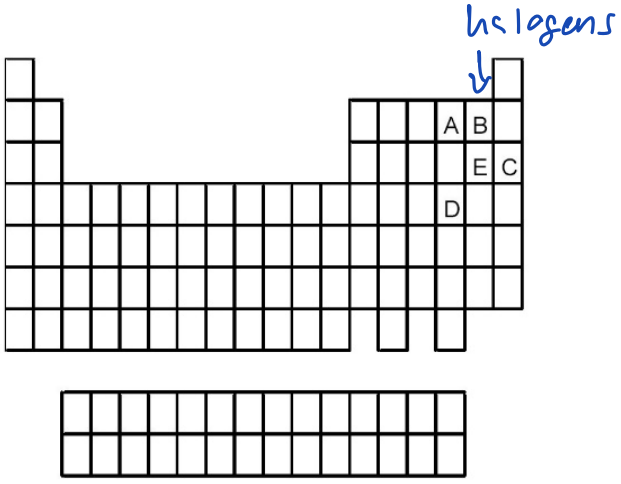
45. Which element is in group 5 and period 6 of the periodic table? Write the chemical symbol in the box below (e.g. H, Br, etc.).

Ta

46. Which element is most chemically similar to the element indicated by the letter E in this periodic table?

B

A. Element A
B. Element B
C. Element C
D. Element D



47. Fill out the table below with either the proper name or formula.

Compound Name	Formula
Calcium chloride dihydrate	$CaCl_2 \cdot 2H_2O$
Iron (II) hydroxide	$Fe(OH)_2$
Sulfur hexafluoride	SF_6
Iodous acid	HIO_2
Magnesium cyanide	$Mg(CN)_2$

Mg^{+2} CN^-

+2 -1
$Fe(OH)_2$
+2 -2 = 0

48. Hydrates are:

B

A. moisture sensitive hygroscopic inorganic salts
B. compounds in which each formula unit has one or more water molecules associated with it
C. readily soluble in water and release energy
D. organic compounds that contain oxygen together with usual carbon and hydrogen
E. concentrated solutions of salts in water

49. Which of the following is the **correct** name for the compound PCl_3?

E

A. Phosphorus(III) chloride
B. Phosphorus tetrachloride
C. Monophosphorus tetrachloride
D. Phosphorus(I) trichloride
E. Phosphorus trichloride

50. Which one of the following compounds is chromium(III) oxide?

Cr^{3+} O^{2-}

B

A. CrO_3
B. Cr_2O_3
C. Cr_3O_2
D. Cr_3O
E. Cr_2O_4

51. Which of the following compounds is named **correctly**?

A

A. CuCl; copper(I) chloride
B. K_2SO_4; potassium(I) sulfate
C. $MnCO_3$; magnesium carbonate
D. $Al(CN)_3$; aluminum(III) cyanide
E. More than one of the compounds above is named correctly

52. Which of the following compounds has their formula and name **incorrectly** matched? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

CD

A. Na_2SO_3; sodium sulfite
B. $(NH_4)_2O$; ammonium oxide
C. $Cu_2Cr_2O_7$; copper(II) chromate copper (I) dichromate
D. $Ca(SCN)_2$; carbon thiocyanate calcium thiocyanate
E. Li_3PO_4; lithium phosphate

53. The names of multiple compounds or ions and their proposed chemical formulas are given below. Which of the options below have the chemical formula written **incorrectly**?

F

A. Sodium sulfite decahydrate; $Na_2SO_3 \cdot 10\ H_2O$
B. Silver acetate; $AgC_2H_3O_2$
C. Calcium bromate; $Ca(BrO_3)_2$
D. Copper(II) cyanide; $Cu(CN)_2$
E. Ammonium nitride; $(NH_4)_3N$
F. All of the above are written correctly

54. Which of the following have the name and formula written **correctly**?

E

A. Mononitrogen trichloride; NCl_3 (nitrogen trichloride)
B. Tetracarbon decahydride; C_4H_{10} (butane)
C. Dialuminum trisulfide; Al_2S_3 (aluminum sulfide)
D. Dinitride tetroxide; N_2O_4 (dinitrogen tetroxide)
E. Sulfur tetrafluoride; SF_4

55. The generic compound MX is an ionic compound. Which statement must be **true**?

D

→ examples: (M^{2+}, X^{2-}) (M^{3+}, X^{3-}) etc.

A. M and X must be from the same group.
B. M must be from group 1, and X must be from group 17.
C. The prefix mono- must be used in its name.
D. M and X must have the same numeric charge with opposite signs.
E. M and X must both be nonmetals.
F. More than one of the above is correct.

56. The organic compound CH_3COOH may also be written as $HC_2H_3O_2$. What are plausible names for this compound? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

BE

$C_2H_3O_2^-$ → acetate

-ate → -ic

$HC_2H_3O_2$ acetic acid

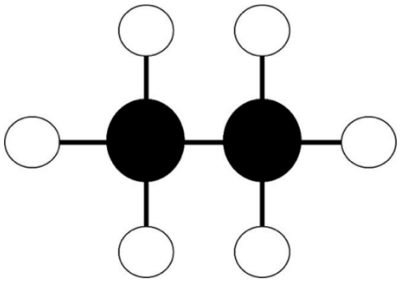
CH_3COOH
(1) (2)

two carbons → -eth-

ethanoic acid

A. Propanoic acid
B. Ethanoic acid
C. Butanol
D. Ethanol
E. Acetic acid
F. Methanol

57. What is the name of the pictured compound if white spheres represent hydrogen and black spheres represent carbon?



CH_3CH_3

C

A. Dicarbon hexahydride
B. Methane
C. Ethane
D. Methanol
E. Ethanol

58. What is the name of the compound $CH_3CH_2CH_2CH_2CH_2OH$?

pentane → pentanol

A

A. Pentanol
B. Hexanol
C. Pentanoic acid
D. Hexanoic acid

59. What is the name of the compound CH_3COOH?

ethane → ethanoic acid

D

A. Methanol
B. Ethanol
C. Methanoic acid
D. Ethanoic acid

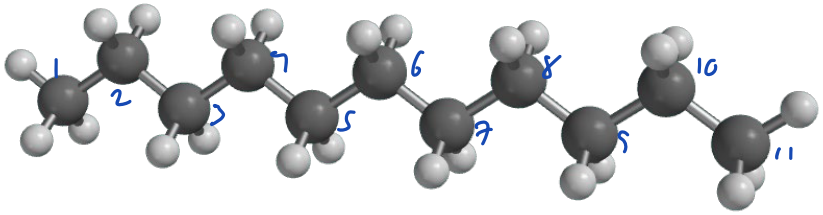
60. What is the name of the compound $CH_3CH_2CH_2CH_2COOH$?

D

Pentane → Pentanoic acid

A. Pentacarbon decahydrogen dioxide
B. Butanol
C. Butanoic acid
D. Pentanoic acid
E. Pentanol

61. What is the name of the organic compound pictured below, given the dark atoms are carbon and the light atoms are hydrogen?



11

A. Nonane
B. Decane
C. Undecane → 11 carbon system
D. Dodecane

62. What is the molar mass of ammonium oxide? Report your answer in **standard notation** and **two decimal places**.

52.10 g/mol

$(NH_4)_2O$

2×14.01 g/mol
8×1.01 g/mol
1×16 g/mol

52.10 g/mol

63. Which of the following will have the greatest molar mass?

B

A. Elemental calcium → Ca
B. Elemental bromine → Br_2
C. Magnesium chloride → $MgCl_2$
D. Elemental tin → Sn
E. Cobalt(I) chloride → CoCl
F. Phosphorus trifluoride → PF_3

64. How many chromium atoms are in 46.8 g of lead(IV) dichromate? Report your answer in **standard notation**.

Pb^{4+} $Cr_2O_7^{2-}$

1.76e23 atoms

$$46.8\ g\ Pb(Cr_2O_7)_2 \times \left(\frac{mol}{635.184\ g}\right)\left(\frac{6.022e23\ \text{formula units}}{1\ mol}\right)\left(\frac{4\ Cr\ \text{atoms}}{1\ Pb(Cr_2O_7)_2\ \text{formula unit}}\right)$$

65. What is the mass of an ethanol (CH_3CH_2OH) sample containing 6.91×10^{22} molecules of ethanol? Report your answer in **standard notation**.

5.29 g

$$6.91e22\ \text{molecules}\left(\frac{1\ mol\ CH_3CH_2OH}{6.022e23\ \text{molecules}}\right)\left(\frac{46.08\ \text{grams}}{mol}\right)$$

$1500.\ \mu L \times \left(\frac{10^{-6-(-3)}\ mL}{1\ \mu L}\right) \times \left(\frac{1\ cm^3}{1\ mL}\right) = 1.500\ cm^3$

66. How many mercury atoms are in 1500. µL of liquid elemental mercury? The density of liquid mercury is 13.5 g/cm^3. Report your answer in **standard notation**.

6.08e22 atoms

$d = \frac{m}{V} \rightarrow 13.5\ g/cm^3 = \frac{x}{1.500\ cm^3}$

$x = 20.25\ g$

$20.25\ g\ Hg \times \left(\frac{mol}{200.59\ g}\right) \times \left(\frac{6.022e23\ atoms}{1\ mol}\right)$

67. Which of the quantities below contain the **greatest** number of atoms?

B

$10\ mol\ C_6H_{12}O_6 \times \left(\frac{6.022e23\ molecules}{1\ mol\ C_6H_{12}O_6}\right) \times \left(\frac{24\ atoms}{1\ molecule}\right)$

A. 10 moles of NaCl
B. 10 moles of $C_6H_{12}O_6$
C. 10 moles of N_2O_4
D. 10 moles of $AlBr_3$
E. They all contain the same number of atoms because there is an equal number of moles present in each quantity

68. Calculate the mass (in grams) of a sample of oxygen difluoride that contains 500. atoms of fluorine. Report your answer in **scientific notation** and **three significant figures**.

OF_2

2.24 × 10 -20 g

$500.\ F\ atoms \times \left(\frac{1\ OF_2\ molecule}{2\ F\ atoms}\right) \times \left(\frac{1\ mol\ OF_2}{6.022e23\ molecules}\right) \times \left(\frac{54.00\ g}{mol}\right)$

$(NH_4)_2SO_4$ ⇒ MM = 132.16 g/mol

5.00×10^{13} pg $\times \left(\frac{10^{-12}\ g}{1\ pg}\right) = 50.0$ g

69. Consider a sample of ammonium sulfate that has a mass of 5.00×10^{13} picograms. How many formula units are present? How many total atoms? How many nitrogen, hydrogen, sulfur, and oxygen atoms are present? How many cations and anions? Report your answers in **scientific notation**.

I. Number of formula units:

2.28 × 10 23 formula units

II. Number of total atoms:

3.42 × 10 24 total atoms

III. Number of nitrogen atoms:

4.56 × 10 23 nitrogen atoms

IV. Number of hydrogen atoms:

1.82 × 10 24 hydrogen atoms

V. Number of sulfur atoms:

2.28 × 10 23 sulfur atoms

The remaining answer boxes are on the next page...

VI. Number of oxygen atoms:

9.11 × 10 23 oxygen atoms

VII. Number of cations:

4.56 × 10 23 cations

VIII. Number of anions:

2.28 × 10 23 anions

work starts here:

I. $50.0\ g\ (NH_4)_2SO_4 \times \left(\frac{mol}{132.16\ g}\right) \times \left(\frac{6.022e23\ \text{formula units}}{1\ mol}\right) =$

$2.27829503 \times 10^{23}$ formula units

II. $2.27829503 \times 10^{23}$ formula units $\times \left(\frac{15\ \text{total atoms}}{1\ \text{formula unit}}\right) = 3.41744485 \times 10^{24}$ total atoms

III. $2.27829503 \times 10^{23}$ formula units $\times \left(\frac{2\ N\ \text{atoms}}{1\ \text{formula unit}}\right) = 4.55659581 \times 10^{23}$ N atoms

IV. $2.27829503 \times 10^{23}$ formula units $\times \left(\frac{8\ H\ \text{atoms}}{1\ \text{formula unit}}\right) = 1.82263922 \times 10^{24}$ H atoms

V. $2.27829503 \times 10^{23}$ formula units $\times \left(\frac{1 \text{ S atom}}{1 \text{ formula unit}} \right) = 2.27829503 \times 10^{23}$ S atoms

VI. $2.27829503 \times 10^{23}$ formula units $\times \left(\frac{4 \text{ O atoms}}{1 \text{ formula unit}} \right) = 9.1131961 \times 10^{23}$ O atoms

VII. $(NH_4)_2SO_4 \rightarrow$ 2 cations (NH_4^+), 1 anion (SO_4^{2-})

$2.27829503 \times 10^{23}$ formula units $\times \left(\frac{2 \text{ cations}}{1 \text{ formula unit}} \right) = 4.5565981 \times 10^{23}$ cations

VIII.

$2.27829503 \times 10^{23}$ formula units $\times \left(\frac{1 \text{ anion}}{1 \text{ formula unit}} \right) = 2.27829503 \times 10^{23}$ anions

70. What is the mass percent of manganese in manganese(VI) oxide? Report your answer in **standard notation** and **four significant figures**.

Mn^{6+} O^{2-}

MnO_3

53.37	%

$\frac{54.94}{102.94} \times 100$

71. Heme, the portion of red blood cells that produce the red color, has a formula of $C_{34}H_{32}FeN_4O_4$. What is the mass percent of iron in heme? Report your answer in **standard notation** and **three significant figures**.

9.06	%

$\frac{55.85 \text{ g/mol}}{616.55 \text{ g/mol}} \times 100$

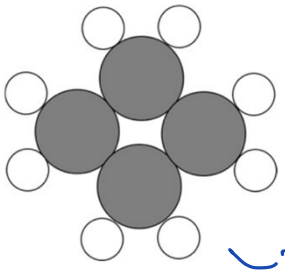
72. Which of the following is an empirical formula? Select any that apply and answer with capital letters and no spaces (e.g. ABCDE).

BE

A. $C_2H_6O_2$
B. N_2O_3
C. C_4H_8
D. N_3O_9
E. OCl_2

73. In the diagram below, gray circles represent atoms of element A and white circles represent atoms of element B. What is the correct **empirical formula** for the compound shown?

A



$A_4B_8 \rightarrow AB_2$

A. AB_2
B. AB
C. AB_4
D. A_4B_8

74. The molar mass of an unknown compound is 60.21 g/mol. If the compound is 6.71% hydrogen and 93.29% silicon by mass, what is the molecular formula? Answer by listing the chemical formula with the silicon first and then hydrogen (e.g. Si_xH_y).

Si_2H_4

$6.71\ g\ H \left(\frac{mol}{1.01\ g}\right) = 6.64356\ mol$

$93.29\ g\ Si \left(\frac{mol}{28.09\ g}\right) = 3.32111\ mol$

$H: \frac{6.64356\ mol}{3.32111\ mol} = 2$

$Si: \frac{3.32111\ mol}{3.32111\ mol} = 1$

$Si:H_2 \rightarrow 30.11\ g/mol$

$60.21\ g/mol \,/\, 30.11\ g/mol \rightarrow 2 \rightarrow Si_2H_4$

75. A compound is 51.43% copper, 9.72% carbon, and 38.85% oxygen. What is the empirical formula? Answer by listing the chemical formula with the copper first, then carbon, then oxygen (e.g. $Cu_xC_yO_z$).

$CuCO_3$

Cu: $51.43\ g\ Cu \left(\frac{mol}{63.55\ g}\right) = 0.809284\ mol / 0.809284\ mol = 1$

C: $9.72\ g\ C \left(\frac{mol}{12.01\ g}\right) = 0.809326\ mol / 0.809284\ mol = 1$

O: $38.85\ g\ O \left(\frac{mol}{16.00\ g}\right) = 2.428125\ mol / 0.809284\ mol = 3$

76. What is the molar mass (g/mol) of a compound, composed solely of nickel, carbon, and oxygen, if it is 34.38% nickel and there is one nickel atom in the formula unit? Report your answer in **standard notation** and **two decimal places**.

170.71 g/mol

$\frac{1\ Ni\ atom}{\text{molar mass compound}} \rightarrow \frac{58.69\ g/mol}{\text{molar mass}} \times 100 = 34.38\ \%$

$\downarrow$

$\frac{58.69\ g/mol}{\text{molar mass}} = 0.3438$

$\downarrow$

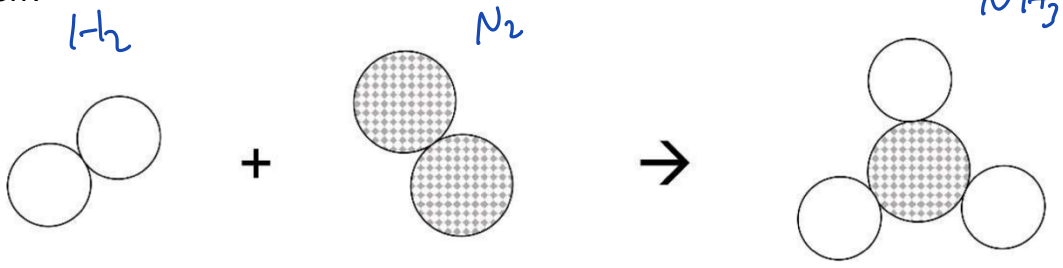
molar mass = 170.71 g/mol

77. Which of the following statements about chemical equations are **false**? Select any that apply and answer with capital letters and no spaces (e.g. ABCDE).

ABC

A. When balancing a chemical equation, you can never change the coefficient in front of any chemical formula.
B. The coefficients in a balanced chemical equation refer to the number of grams of reactants and products.
C. In a chemical equation, the reactants are on the right and the products are on the left.
D. When balancing a chemical equation, you can never change the subscripts of any chemical formula.
E. In chemical reactions, matter is neither created nor destroyed so a chemical equation must have the same number of atoms on both sides of the equation.

78. If the white circles represent gaseous hydrogen and the patterned circles represent gaseous nitrogen in the **unbalanced** image below, what is the correct, balanced equation?

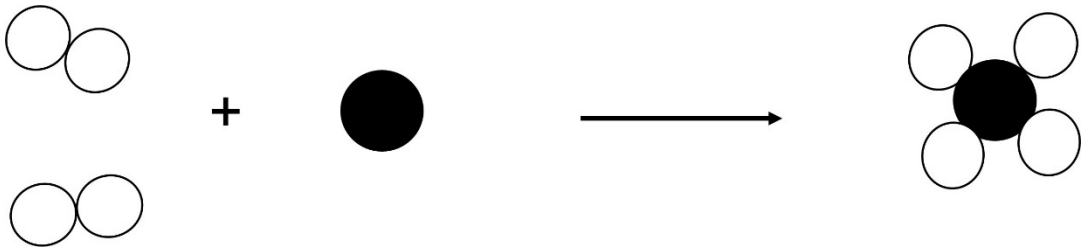


B

$H_2 + N_2 \rightarrow NH_3$ (unbalanced)

A. $H_2\ (g) + N_2\ (g) \rightarrow NH_3\ (g)$
B. $3\ H_2\ (g) + N_2\ (g) \rightarrow 2\ NH_3\ (g)$
C. $2\ H\ (g) + 2\ N\ (g) \rightarrow N\ (g) + 3\ H\ (g)$
D. $6\ H\ (g) + 2\ N\ (g) \rightarrow 2\ N\ (g) + 6\ H\ (g)$
E. $2\ H_2\ (g) + N_2\ (g) \rightarrow 2\ NH_3\ (g)$

79. What is the balanced reaction depicted in the following image, given the black spheres represent solid carbon and the white spheres represent gaseous hydrogen forming a gaseous product? Make sure to include states of matter.



$2\,H_{2(g)} + C_{(s)} \rightarrow CH_{4(g)}$

80. Write the balanced reaction of elemental aluminum with aqueous hydrochloric acid, which yields aqueous aluminum chloride salt and hydrogen gas. Make sure to include states of matter.

$2\,Al_{(s)} + 6\,HCl_{(aq)} \rightarrow 2\,AlCl_{3(aq)} + 3\,H_{2(g)}$

81. Write the balanced reaction of liquid propanol (C_3H_7OH) reacting with gaseous oxygen to form gaseous carbon dioxide and gaseous water. Make sure to include states of matter.

$2\,C_3H_7OH_{(l)} + 9\,O_{2(g)} \rightarrow 6\,CO_{2(g)} + 8\,H_2O_{(g)}$

82. What is the coefficient for each compound when the following reaction is balanced? Write the integers in order, with no commas (e.g. 1234) on your answer sheet and include 1 even if it is usually left out.

$$\underline{2}\ Co_2O_3\ (s) + \underline{3}\ C\ (s) \rightarrow \underline{4}\ Co\ (s) + \underline{3}\ CO_2\ (g)$$

2343

83. What is the coefficient for each compound when the following reaction is balanced? Write the integers in order, with no commas (e.g. 1234) on your answer sheet and include 1 even if it is usually left out.

$$\underline{3}\ Ni(C_2H_3O_2)_4\ (aq) + \underline{4}\ H_3PO_4\ (aq) \rightarrow \underline{1}\ Ni_3(PO_4)_4\ (aq) + \underline{12}\ HC_2H_3O_2\ (aq)$$

34112

84. Which of the following statements is **false**?

A

A. The concentrations of reactants and products in a reaction must be equal to each other to reach chemical equilibrium

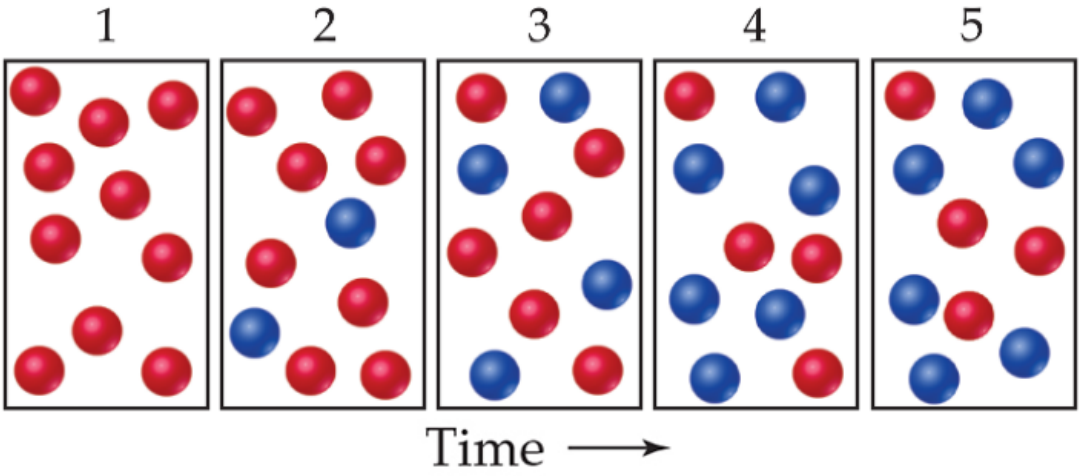
B. All chemical reactions will always proceed toward equilibrium

C. When dynamic equilibrium is reached, the forward and reverse reactions are occurring, but the concentrations of both the reactants and products are constant

D. Dynamic equilibrium reactions are represented using a double arrow symbol (↔, ⇆, ⇋, etc.)

E. None of the above are false

85. Consider a hypothetical reaction below in which the red spheres represent a reactant and the blue spheres represent a product. Is equilibrium established below?



D

A. Yes, boxes 1 and 2 indicate equilibrium is established
B. Yes, boxes 2 and 3 indicate equilibrium is established
C. Yes, boxes 3 and 4 indicate equilibrium is established
D. Yes, boxes 4 and 5 indicate equilibrium is established
E. No, equilibrium is not established here

Periodic Table of the Elements

1																	18
1 H 1.01	2											13	14	15	16	17	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc [97]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
37 Cs 132.91	56 Ba 137.33		72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]		104 Rf [267]	105 Db [268]	106 Sg [269]	107 Bh [270]	108 Hs [269]	109 Mt [277]	110 Ds [281]	111 Rg [282]	112 Cn [285]	113 Nh [286]	114 Fl [290]	115 Mc [290]	116 Lv [293]	117 Ts [294]	118 Og [294]

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 kg·m^2/s^2
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 kg/m·s^2
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
c = 2.998×10^8 m/sec
h = 6.626×10^{-34} J·sec
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: 9.109 x 10^{-31} kg
Mass of a proton: 1.673 x 10^{-27} kg
RH = 2.18 x 10^{-18} J
Specific heat of water = 4.184 J/g·K
Avogadro's number: 6.022×10^{23}
F = 96485 J/(V·mol e$^-$)
$K_w = 1.0 \times 10^{-14}$ at 25 °C
$k_b = 1.381 \times 10^{-23}$ J/K

Equations
$(P + a(n^2/V^2))\cdot(V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT

$$KE = \frac{3}{2}RT$$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution} = P_{solvent}\ X_{solvent}$
$P_{solution} = \sum P_j = \sum P_j X_j$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$\Delta S = q_{rev}/T$
$\Delta G = \Delta G° + RT \cdot \ln Q$
$R = 8.314$ J/mol.K
$\Delta G° = -RT \cdot \ln K$
$\Delta G = -nFE_{cell}$
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} = E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = I × t = n × F

Integrated Rate Laws & half-life

$$\ln\frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{E_a}{R}(\frac{1}{T_2} - \frac{1}{T_1})$$

Equilibrium and Acid / Base

$K_P = K_c \times (RT)^{\Delta n}$

$$ln\frac{K_2}{K_1} = \frac{\Delta H^\circ_{rxn}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$