AP Chemistry Name: Keys

Summer Assignment 2019 Date: ____________ Per: ________

Welcome to AP Chemistry! I am excited to have you in my class. The following assignment will allow us to start on the AP Chemistry learning objectives immediately at the beginning of the school year. Your ability to understand this material and complete the corresponding problems is a strong indication of your readiness for AP Chemistry. *You will be tested on this material the first week of school!*

WHAT YOU NEED TO DO RIGHT NOW IS SIGN UP FOR THE FOLLOWING CLASS WEBSITES:
Remind: Text message @22fe4k to number 81010.
Quizlet: https://quizlet.com/join/F2d7DN9Rq
EdPuzzle: https://edpuzzle.com, join as a student then enter class code:nediafl

BY THE END OF THE SUMMER BREAK YOU SHOULD:

1. **Be prepared for a Mental Math Challenge**

Fifty percent of the AP Exam is multiple choice questions that must be done without a calculator. ***I cannot stress*** the importance of practicing what is commonly referred to as "Mental Math" during the summer before you start learning AP Chemistry content.

- Watch the video AP Chem Exam Review: Mental Math – take notes for your future use.
- Memorize the fractions to decimal and decimal to fractions using the sets on Class Quizlet
- Practice multiplying/dividing with exponents using sets on Class Quizlet
- Do quizzes online at **Khan Academy, "Preparing to Study Chemistry,"** (access at tiny.cc/khan)
- **Complete the math problems worksheet without a calculator.**

2. **Be prepared for a test on Chemistry Honors material**

- Review all your material (Interactive Notebook) over the summer so you don't forget it.
- Use Quizlet to study the common polyatomic and metal/nonmetal ion names and charges.
- Know the symbol to name of the first 40 elements on the periodic table.

3. **Complete all of the attached worksheets**. These will be collected for a grade.

4. **Watch the assigned videos on EdPuzzle.** EdPuzzle is a way for me to track and give you credit for watching required videos. Please watch the following videos on EdPuzzle:
   a. AP Chem Exam Review: Mental math
   b. Short cut significant figures – 3 short videos
   c. Melissa Maribel Adding and Multiplying Significant Figures in the Same Problem

Helpful websites where you can search for specific topics.
Professor Dave: https://www.youtube.com/playlist?list=PLybg94GvOJ9H-HhKkr-peYKxTeE3XUeQf
Tyler DeWitt: https://www.youtube.com/user/tdewitt451
Melissa Maribel https://www.youtube.com/channel/UC88Pezsxv3IUMAoQGP2w07w

You may send me a remind text or email me at hermads@nv.ccsd.net during the summer for specific questions. Check my school website in August for more helpful information.

I look forward to a great year together!

Mrs. Herman

Summer Assignment

Math Practice Problems

Key

DO NOT use a calculator on these problems!

1) Complete the following chart, writing the fractions in lowest terms.

	Decimal	# SigFig	Fraction		Decimal	#SigFig	Fraction
a)	0.375	3	$\frac{3}{8}$	j)	0.67	2	$\frac{2}{3}$
b)	0.75	2	$\frac{3}{4}$	k)	0.125	3	$\frac{1}{8}$
c)	0.875	3	$\frac{7}{8}$	l)	0.33	2	$\frac{1}{3}$
d)	0.60	2	$\frac{3}{5}$	m)	0.5	1	$\frac{1}{2}$
e)	0.25	2	$\frac{1}{4}$	n)	0.20	2	$\frac{1}{5}$
f)	0.020	2	$\frac{1}{5}\times10^{-1} = \frac{1}{50}$	o)	0.75	2	$\frac{3}{4}$
g)	0.075	2	$\frac{3}{4}\times10^{-1} = \frac{3}{40}$	p)	0.25	2	$\frac{1}{4}$
h)	0.005	1	$\frac{1}{2}\times10^{-2} = \frac{1}{200}$	q)	0.2	1	$\frac{1}{5}$
i)	0.625	3	$5/8$	r)	0.0625	3	$\frac{1}{16}$

2) Solve the following by rewriting them as fractions (if needed) and show your work.

Express answers in this column as a fraction or whole number		Express answers in this column as a decimal (may approximate if needed)	
a)	$\frac{0.5}{0.125} = \frac{\frac{1}{2}}{\frac{1}{8}} = \frac{1}{\cancel{2}}\times\frac{\cancel{8}}{1} = 4$	g)	$\frac{1}{1.25} = \frac{1}{1/8\times10^{1}} = 1\times\frac{8}{1}\times10^{-1} = 0.8$
b)	$\frac{0.25}{0.50} = \frac{1/4}{1/2} = \frac{1}{4}\times\frac{2}{1} = \frac{1}{2} = 0.5$	h)	$\frac{0.5}{0.2} = \frac{1/2}{1/5} = \frac{1}{2}\times\frac{5}{1} = \frac{5}{2} = 2.5$
c)	$\frac{0.025}{0.075} = \frac{0.25\times\cancel{10^{-1}}}{0.75\times\cancel{10^{-1}}} = \frac{1/4}{3/4} = \frac{1}{\cancel{4}}\times\frac{\cancel{4}}{3} = \frac{1}{3}$	i)	$\frac{1/8}{1/5} = \frac{1}{8}\times\frac{5}{1} = \frac{5}{8} = 0.625$
d)	$\frac{0.125}{0.075} = \frac{1/8}{3/4\times10^{-1}} = \frac{1}{\underset{2}{\cancel{8}}}\times\frac{\cancel{4}}{3}\times10^{1} = \frac{1}{6}\times10^{1} = 1\frac{2}{3}$	j)	$\frac{1}{2\frac{1}{5}} = 1\times\frac{5}{11}$ $\begin{array}{r} .454 \\ 11\overline{)5.000} \end{array}$ $= 0.454$
e)	$\frac{0.6}{0.02}$ $\frac{3/5}{1/5\times10^{-1}} = \frac{3}{\cancel{5}}\times\frac{\cancel{5}}{1}\times10^{1} = 3\times10^{1} = 30$	k)	$\frac{3/8}{2.5} = \frac{3/8}{1/4\times10^{1}} = \frac{3}{\underset{2}{\cancel{8}}}\times\frac{\cancel{4}}{1}\times10^{-1} = \frac{3}{2}\times10^{-1} = 1.5\times10^{-1}$
f)	$\frac{0.6}{0.2}$ $\frac{3/5}{1/5} = \frac{3}{\cancel{5}}\times\frac{\cancel{5}}{1} = 3$	l)	$\frac{2.625}{1.75} = \frac{2\,5/8}{1\,3/4} = \frac{\frac{21}{8}}{\frac{7}{4}} = \frac{\overset{3}{\cancel{21}}}{\underset{2}{\cancel{8}}}\times\frac{\cancel{4}}{\cancel{7}} = \frac{3}{2} = 1.5$

3) Solve the following, **showing all of your work.** **Watch for Significant Figures!**

a)	$\frac{\overset{3}{\cancel{6}}\times10^{18}}{\overset{2}{\cancel{4}}\times10^{-5}} = \frac{3}{2}\times 10^{18-(-5)} = 1.5\times10^{23}$ (1 SF) 2×10^{23}
b)	$\frac{1}{4\times10^{-5}} = \frac{1}{4}\times10^{5} = 0.25\times10^{5} = 2.5\times10^{4}$ (1 SF) 3×10^{4}
c)	$\frac{(4\times10^{-5})(\cancel{1.5}\times10^{13})}{\cancel{1.5}\times10^{4}} = 4\times10^{-5+13-4} = 4\times10^{4}$ (1 SF)
d)	$(4\times10^{-5})(1.5\times10^{13}) = 4\times1.5\times10^{-5+13} = 6\times10^{8}$ (1 SF)
e)	$\frac{(2\times10^{7})(1.5\times10^{4})}{4.5\times10^{8}} = 2\times10^{7}\times\frac{\cancel{15}\times10^{3}}{\underset{3}{\cancel{45}}\times10^{7}} = \frac{2}{3}\times10^{7+3-7} = 0.67\times10^{3}$ (1 SF) $= 7\times10^{2}$

4) Solve the following problems, using cross canceling of numbers. **Show your work.**

a) $\cancel{9}\times\frac{1}{\underset{\cancel{2}}{\cancel{18}}}\times\frac{\cancel{2}}{\cancel{4}}\times\frac{\overset{11}{\cancel{44}}}{1} =$ 11

e) $\cancel{87}\times\frac{1}{\underset{2\ \cancel{3}}{\cancel{174}}}\times\frac{3}{\cancel{2}}\times\frac{\overset{7}{\cancel{28}}}{1} =$ 21

b) $\overset{10}{\cancel{280}}\times\frac{1}{\cancel{28}}\times\frac{3}{1}\times\frac{\overset{18}{6}}{1} =$ 180

f) $\overset{6}{\cancel{12}}\times\frac{1}{\cancel{2}}\times\frac{1}{\cancel{2}}\times\frac{\overset{21}{\cancel{42}}}{1} = \frac{(6\times20)+(6\times1)}{120+6} = 126$

c) $\overset{5\ \cancel{10}}{\cancel{70}}\times\frac{1}{\underset{\cancel{4}\ \cancel{2}}{\cancel{28}}}\times\frac{1}{1}\times\frac{\overset{21}{\cancel{42}}}{1} =$ 105

g) $\overset{3\ \cancel{33}}{\cancel{165}}\times\frac{1}{\underset{\cancel{11}}{\cancel{55}}}\times\frac{\cancel{2}}{\underset{2}{\cancel{4}}}\times\frac{158}{1} = \frac{3\times79}{=237}$

$$\begin{array}{r} 79 \\ 2\overline{)158} \\ 14 \\ \hline 18 \end{array} \qquad \begin{array}{r} \overset{2}{79} \\ \times\ 3 \\ \hline 237 \end{array}$$

d) $\overset{\cancel{3}\ \cancel{6}}{\cancel{48}}\times\frac{1}{\underset{\cancel{2}\ \cancel{16}}{\cancel{32}}}\times\frac{\cancel{2}}{\cancel{3}}\times\frac{158}{1} =$ 158

h) $\overset{3\ \cancel{33}}{0.\cancel{33}}\times\frac{1}{\underset{4}{\cancel{44}}}\times\frac{1}{1}\times\frac{\overset{1}{\cancel{100}}}{1} = \frac{3}{4} = 0.75$

5) Solve for "*x*".

a) $\frac{(x)(x)}{\underset{5\times10^{-1}}{\cancel{0.5}}} = 5.0\times10^{-5}$ $x^2 = (5.0\times10^{-5})(5\times10^{-1})$

$= 25\times10^{-6}$

$\sqrt{x^2} = \sqrt{25}\times(10^{-6})^{\frac{1}{2}} = \boxed{5\times10^{-3}}$

b) $\frac{(x)(x)}{\underset{25\times10^{-2}}{\cancel{0.25}}} = 6.4\times10^{-7}$ $x^2 = (64\times10^{-8})(25\times10^{-2})$

$\sqrt{x} = \sqrt{64}\times\sqrt{25}\times(10^{-10})^{\frac{1}{2}}$

$= 8\times5\times10^{-5} = \boxed{40\times10^{-5}}$ $\boxed{4.0\times10^{-4}}$

c) $\frac{(x)(x)}{\underset{\frac{1}{8}}{0.\cancel{125}}} = 3.2\times10^{-9}$ $x^2 = (\overset{4}{\cancel{32}}\times10^{-10})\times\frac{1}{\cancel{8}}$

$x = \sqrt{4}\times(10^{-10})^{1/2}$

$= \boxed{2\times10^{-5}}$

Thanks to Todd Abronowitz

d) $\frac{\cancel{(x)}(2x)^2}{4x^3} = 3.2\times10^{-8}$ $2^2 = 4$ $x^3 = \frac{32\times10^{-9}}{4} = 8\times10^{-9}$

$x = \sqrt[3]{8}\times(10^{-9})^{\frac{1}{3}} = \boxed{2\times10^{-3}}$

e) $\frac{(x)(x)}{0.5} = 8.0\times10^{-16}$ $x^2 = (0.5)(8.0\times10^{-16})$

$x = \sqrt{4}\times(10^{-16})^{1/2} = \boxed{2.0\times10^{-8}}$

f) $(3x)^3(2x)^2 = 1.08\times10^{-3}$

$(27x^3)(4x^2) =$

$$\begin{array}{r} 27 \\ \times\ 4 \\ \hline 108 \end{array}$$

$108x^5 = 1.08\times10^{-3}$

$x^5 = \frac{1.08\times10^{-3}}{108}$

$x^5 = \cancel{1.08}\times10^{-3}$

$x^5 = 10^{-3-2}$

$= 10^{-5}$

$\sqrt[5]{x^5} = (10^{-5})^{\frac{1}{5}}$

$x = 10^{-1} = \boxed{0.1}$

Name ____________________

Give the number of significant figures in each of the following:

3 402 m
3 0.00420 g
2 5.1 x 10^4 kg
7 78 323.01 g

4 34.20 lbs
2 3 200 liters
2 0.48 m
3 1.10 torr

1 0.03 sec
3 0.0300 ft.
5 1 400.0 m
2 760 mm Hg

Multiply each of the following, observing significant figure rules:

17 m x 324 m = 5500 m^2

1.7 mm x 4 294 mm = 7300 mm^2

0.005 in x 8 888 in = 40 in^2

0.050 m x 102 m = 5.1 m^2

0.424 in x .090 in = 0.038 in^2

324 000 cm x 12.00 cm = 3,888,000 cm^2

Divide each of the following, observing significant figure rules:

23.4 m ÷ 0.50 sec = 47 m/sec

12 miles ÷ 3.20 hours = 3.8 miles/hr

0.960 g ÷ 1.51 moles = 0.636 g/mol

1 200 m ÷ 12.12 sec = 99 m/sec

Add each of the following, observing significant figure rules:

3.40 m
0.022 m
0.5 m
3.922 → 3.9 m

102.45 g
2.44 g
1.9999 g
106.8899 → 106.89 g

102. cm
3.14 cm
5.9 cm
111.04 → 111 cm

Subtract each of the following, observing signigicant figure rules:

42.306 m
1.22 m
41.086 → 41.09 m

14.33 g
3.468 g
10.862 → 10.86 g

234.1 cm
62.04 cm
172.06 → 172.1 cm

Work each of the following problems, observing significant figure rules:

Three determinations were made of the percentage of oxygen in mercuric oxide. The results were 7.40%, 7.43%, and 7.35%. What was the average percentage?

$22.18 \div 3 = \boxed{7.39\,\%}$

A rectangular solid measures 13.4 cm x 11.0 cm x 2.2 cm. Calculate the volume of the solid.

V = ?   V = h x l x w = 13.4 cm x 11.0 cm x 2.2 cm = 324.28 → $\boxed{324\ cm^3}$

If the density of mercury is 13.6 g/ml, what is the mass in grams of 3426 ml of the liquid?

m = ?
D = 13.6 g/ml
V = 3,426 ml

$D = \frac{m}{V}$

m = D x V

$m = \frac{13.6\,g}{\cancel{ml}} \times 3{,}426\,\cancel{ml} = \boxed{46{,}600\,g}$ (3 sig fig)

A copper cylinder, 12.0 cm in radius, is 44.0 cm long. If the density of copper is 8.90 g/cm^3, calculate the mass in grams of the cylinder. (assume pi = 3.14)

m = ?
r = 12.0 cm
h = 44.0 cm
π = 3.14
D = 8.90 g/cm^3

$V_{cylinder} = \pi r^2 h$
$= (3.14)(12.0\,cm)^2(44.0\,cm)$
$= 19895.04\,cm^3$

m = D x V
$= \frac{8.90\,g}{\cancel{cm^3}} \times 19895.04\,\cancel{cm^3} = 177{,}00$
(3 sigfig

Isotope Notation

Chem Worksheet 4-2

Name ____________________

Any given element can have more than one isotope. To distinguish between the different isotopes of an atom, the element is named with its mass number, for example lithium-7. Remember that the **mass number** is the number of protons and neutrons. When symbols are used to represent an isotope the mass number is written next to the symbol on the top left. The atomic number is written on the bottom left. Recall that the **atomic number** is the number of protons.

EXAMPLES

Mass number → A
Atomic number → Z

$$^{A}_{Z}\text{X}$$

Lithium-7

$$^{7}_{3}\text{Li}$$

3 protons
4 neutrons

Answer the following questions about atoms.

1. The identity of an atom is determined by the number of protons.
2. The particle(s) found inside the nucleus are called: protons and, neutrons.
3. The number of protons and neutrons combined is called the mass number.
4. In large atoms the number of protons is less than the number of neutrons.
5. The number of protons is also called the atomic number.
6. Isotopes have the same number of protons, but different numbers of neutrons.
7. The number of protons found in a sulfur atom is 16.
8. The number of neutrons found in an aluminum-27 atom is 14.
9. The number of electrons found in a zinc atom is 30.
10. What is the name of the element with 82 protons? lead.

Give the symbols for the nuclides described by the following particles. Include the atomic number and the mass number.

11. 92 protons, 145 neutrons $^{237}_{92}\text{U}$
12. 8 protons, 10 neutrons $^{18}_{8}\text{O}$
13. 82 protons, 125 neutrons $^{207}_{82}\text{Pb}$
14. 80 protons, 119 neutrons $^{199}_{80}\text{Hg}$
15. 20 protons, 20 neutrons $^{40}_{20}\text{Ca}$
16. 22 protons, 23 neutrons $^{45}_{22}\text{Ti}$
17. 18 protons, 22 neutrons $^{40}_{18}\text{Ar}$
18. 25 protons, 32 neutrons $^{57}_{25}\text{Mn}$

Determine the number of protons and neutrons from the following symbols.

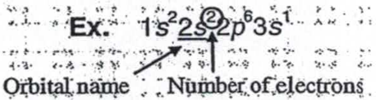
19. $^{10}_{5}\text{B}$ 5 P 5 N
20. $^{15}_{7}\text{N}$ 7 P 8 N
21. $^{79}_{34}\text{Se}$ 34 P 45N
22. $^{119}_{50}\text{Sn}$ 50 P 69 N
23. $^{165}_{66}\text{Dy}$ 66 P 99 N
24. ^{56}Fe 26 P 30 N
25. ^{151}Sm 62 P 89 N
26. ^{195}Pt 78 P 117 N
27. ^{126}Te 52 P 74 N
28. ^{35}Cl 17 P 18 N
29. ^{107}Ag 47 P 60 N
30. $^{93}_{41}?$ $^{93}_{41}\text{Nb}$

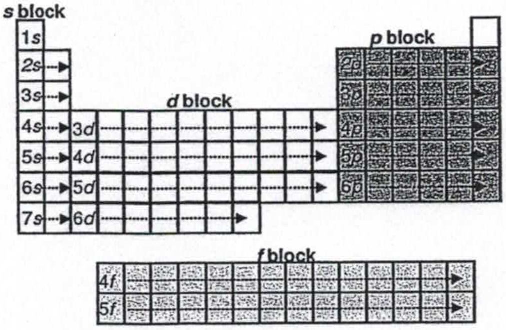
Electron Configuration

Chem Worksheet 5-6

Name ________________

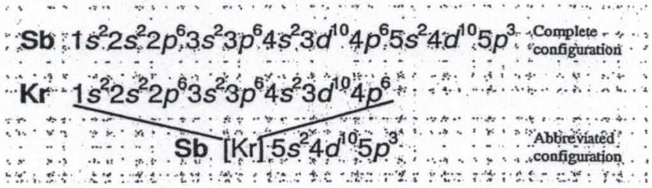
An **electron configuration** is simply a list of the orbitals that contain electrons for a given element. The orbital designation is followed by a superscript number that tells how many electrons are found in that orbital. The following designation represents an atom with electrons found in the 1*s*, the 2*s*, the 2*p*, and the 3*s* orbitals. There are a total of 11 electrons in the atom. This represents the element sodium.





The orbitals of an atom fill in a specific sequence. The pattern fits very nicely with various regions of the periodic table. The table is been sectioned into blocks which are labeled: *s* block, *p* block, *d* block, and *f block*. The rows of each block are labeled as well. Using this shortcut, electron configurations can be determined easily. The element manganese is the fifth element in the 3*d* row. The orbitals before the 3*d* orbital are all filled so it has full 1*s*, 2*s*, 2*p*, 3*s*, 3p, and 4*s* orbitals. Since manganese is the fifth element in the 3*d* row we designate the 3*d* orbital with 5 electrons.

Electron configurations can be abbreviated by writing the element symbol for the previous noble gas in brackets, followed by the remaining electrons. For example, rather than writing all of the electrons in antimony (element 51), the first 36 electrons are represented by [Kr]. The remaining electrons are notated using orbital names and superscript numbers.



Required all even problems.

Write the name and symbol for the atoms with the following electron configurations.

1. $1s^22s^22p^63s^23p^64s^23d^{10}4p^4$ Se
2. $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^66s^1$ Cs
3. $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^7$ Rh
4. $1s^22s^22p^63s^23p^1$ Al
5. [Rn]$7s^25f^9$ Bk
6. [Xe] $6s^24f^{14}5d^{10}6p^2$ Pb

Write complete electron configurations for the following substances.

7. nitrogen
8. magnesium $1s^2 2s^2 2p^6 3s^2$
9. niobium
10. nickel $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
11. tin
12. chlorine $1s^2 2s^2 2p^6 3s^2 3p^5$

Write abbreviated electron configurations for the following elements.

13. arsenic
14. thulium [Xe] $6s^2 4f^{13}$
15. rubidium
16. einsteinium [Rn] $7s^2 5f^{11}$
17. platinum
18. molybdenum [Kr] $5s^2 4d^4$
19. sulfur
20. zirconium [Kr] $5s^2 4d^2$
21. argon
22. iron [Ar] $4s^2 3d^6$
23. polonium
24. bohrium [Rn] $7s^2 5f^{14} 6d^5$

Naming Ionic Compounds

Chem Worksheet 8-2

Name ____________

An **ionic compound** is a combination of oppositely charged ions. Ionic compounds generally contain a metal bonded to a non-metal (or non-metals). When naming ionic compounds we simply name the cation (the positive ion) then the anion (the negative ion). The cations generally retain the name of the element, so Na^+ is named sodium. The **monatomic anions** are formed when a non-metal gains an electron and these ions have an –ide ending, so S^{2-} is named sulfide. There are a group of **polyatomic ions** as well that have their own unique names. A list of these appears below.

Some metals can form more than one positive ion. Copper for example forms Cu^{1+} and Cu^{2+} ion. These ions are named using Roman numerals: copper (I) and copper (II) respectively. Most metals that form more than one type of cation are found in the transition metal family or below the non-metals in the *p*-block.

Rules for naming Molecular Compounds

1. Name the positive ion. Most cations have the same name as their elements.
2. Name the negative ion. Monatomic anions have an –ide ending. Polyatomic anions names' must be memorized.
3. If the positive ion is a transition metal or located on the right side of the table it may have more than one charge. In this case use Roman numerals to designate the charge.

Common Polyatomic Ions	
NH_4^+	Ammonium
OH^{1-}	Hydroxide
CN^{1-}	Cyanide
NO_3^{1-}	Nitrate
ClO_3^{1-}	Chlorate
$C_2H_3O_2^{1-}$	Acetate
SO_4^{2-}	Sulfate
CO_3^{2-}	Carbonate
PO_4^{3-}	Phosphate
HCO_3^{1-}	Bicarbonate
HSO_4^{1-}	Bisulfate

Examples

Name the following compounds:

Formula	Name
NaCl	Sodium chloride
K_2S	Potassium sulfide
$MgSO_4$	Magnesium sulfate
$Mn(OH)_2$	Manganese (II) hydroxide

Write the names for the following ionic compounds.

	Formula	Name
1.	Li_2S	Lithium Sulfide
2.	KF	Potassium Fluoride
3.	Mg_3N_2	Magnesium Nitride
4.	$Ca(OH)_2$	Calcium Hydroxide
5.	$Ba(NO_3)_2$	Barium Nitrate
6.	$CuCl_2$	Copper (II) Chloride
7.	PbO	Lead (II) Oxide
8.	ZnF_2	Zinc Fluoride
9.	$NaC_2H_3O_2$	Sodium Acetate
10.	$SrCO_3$	Stronium Carbonate
11.	$CrSO_4$	Chromium (II) Sulfate
12.	Na_3PO_4	Sodium Phosphate

	Formula	Name
13.	$CaBr_2$	Calcium Bromide
14.	$Ni(CN)_2$	Nickel (II) Cyanide
15.	$Al(NO_3)_3$	Aluminum Nitrate
16.	$Sn(OH)_2$	Tin (II) Hydroxide
17.	HgI_2	Mercury (II) Iodide
18.	$Fe_2(SO_4)_3$	Iron (III) Sulfate
19.	$Ca(C_2H_3O_2)_2$	Calcium Acetate
20.	$TiCl_3$	
21.	$KClO_3$	Potassium Chlorate
22.	$ZnCO_3$	Zinc Carbonate
23.	$NaHCO_3$	Sodium Bicarbonate
24.	$Co(HSO_4)_2$	Cobalt (II) Bisulfate

Writing Formulas: Ionic Compounds
Chem Worksheet 8-3

Name ____________________

Ionic compounds are composed of a positive ion and a negative ion bonded together in a specific proportion. For example, magnesium chloride is made of one magnesium ion (Mg^{2+}) and two chloride ions (Cl^{1-}). These two ions are combined in a ratio that creates a neutral compound ($MgCl_2$). The 2+ charge on the magnesium ion is balanced by the two negative charges from the chloride ions. All ionic compounds follow this rule: the charge from the positive ions must be equal to the charge from the negative ions.

In a compound of aluminum ion (Al^{3+}) and nitrate ion (NO_3^{1-}) there must be three nitrate ions. So, the formula for this compound is $Al(NO_3)_3$. Recall that nitrate is a polyatomic ion, so this combination of atoms remains intact when writing a chemical formula. Also notice that the proper way to designate more than one polyatomic ion involves the use of parenthesis.

An easy technique for creating a neutral combination of two charged ions is called the criss-cross technique. When writing a formula for an ionic compound the charges from each ion are simply switched to become the subscript values written to designate the number of atoms present in a compound. See the example below.

Common Polyatomic Ions

NH_4^{+}	Ammonium
OH^{1-}	Hydroxide
CN^{1-}	Cyanide
NO_3^{1-}	Nitrate
ClO_3^{1-}	Chlorate
$C_2H_3O_2^{1-}$	Acetate
SO_4^{2-}	Sulfate
CO_3^{2-}	Carbonate
PO_4^{3-}	Phosphate
HCO_3^{1-}	Bicarbonate
HSO_4^{1-}	Bisulfate

The Criss-Cross Technique

Write the chemical formula for calcium phosphide.

Write the chemical formulas for the following ionic compounds. Remember all ionic compounds must be neutral.

	Formula	Name
1.	K_2O	Potassium oxide
2.	Na_2S	Sodium sulfide
3.	NH_4Cl	Ammonium chloride
4.	$Ca(NO_3)_2$	Calcium nitrate
5.	$FeBr_2$	Iron (II) bromide
6.	$Cr(OH)_3$	Chromium (III) hydroxide
7.	$CuSO_4$	Copper (II) sulfate
8.	AlI_3	Aluminum iodide
9.	$(NH_4)_2CO_3$	Ammonium carbonate
10.	$LiHSO_4$	Lithium bisulfate
11.	Mn_2O_3	Manganese (III) oxide
12.	$Sn(ClO_3)_4$	Tin (IV) chlorate

	Formula	Name
13.	$Mg(HCO_3)_2$	Magnesium bicarbonate
14.	$ZnOH$	Zinc hydroxide
15.	K_3PO_4	Potassium phosphate
16.	$Al(NO_3)_3$	Aluminum acetate
17.	$HgCl_2$	Mercury (II) chloride
18.	$SrSO_4$	Strontium sulfate
19.	Ag_2S	Silver sulfide
20.	$Fe_3(PO_4)_2$	Iron (II) phosphate
21.	Ca_3N_2	Calcium nitride
22.	PbO_2	Lead (IV) oxide
23.	Cu_2CO_3	Copper (I) carbonate
24.	$NH_4C_2H_3O_2$	Ammonium acetate

Naming Molecular Compounds
Chem Worksheet 9-2

Name ______________

A **molecular compound** is a group of atoms held together by a covalent bond. Compounds made entirely of non-metals are generally molecular compounds. Carbon tetrachloride, CCl_4, is an example of a molecular compound. When naming these compounds prefixes are used to denote how many of each atom is bonded in the compound. However, the prefix *mono-* is not used with the first element in the compound, even if there is only one element. The ending of the second element in the compound is always changed to *–ide*, in the same way the ending is changed for monatomic anions.

Rules for naming Molecular Compounds

1. Name the first element using the element's full name.
2. Name the second element using the *–ide* ending.
3. Use prefixes to tell how many of each element is present. (do not use the prefix *mono-* on the first element).

Naming Prefixes	
1	mono-
2	di-
3	tri-
4	tetra-
5	penta-
6	hexa-
7	hepta-
8	octa-
9	nona-
10	deca-

Examples

#1. Write the chemical formula for diphosphorus pentoxide.

– this compound contains two phosphorus atoms and five oxygen atoms: **P_2O_5**

#2. Name the following compound: IF_7.

– there is one iodine and there are seven fluorine atoms: **iodine heptafluoride**
(the prefix *mono-* is not used on the first element and that the ending of fluorine is changed to *–ide*.)

Fill in the following table with the missing information.

	Formula	Name
1.	SO_2	Sulfur Dioxide
2.		Sulfur trioxide
3.	N_2O_4	Dinitrogen tetra Oxide
4.		Chlorine dioxide
5.	P_4O_{10}	Tetra phosphorus deca oxide
6.	CS_2	Carbon disulfide
7.	NO_2	Nitrogen Dioxide
8.	N_2Cl_4	Dinitrogen tetrachloride
9.		Xenon difluoride
10.	S_2Cl_2	Disulfur Dichloride
11.		Iodine trichloride
12.	P_2S_5	Di phosphorus penta sulfide

	Formula	Name
13.	SF_6	Sulfur hexafluoride
14.	P_4S_6	Tetraphosphorus hexasulfide
15.	SeO_2	Selenium Dioxide
16.	NH_3	Ammonia
17.	BCl_3	Boron trichloride
18.	N_2O	Dinitrogen Oxide
19.	BrF_5	Bromine pentafluoride
20.	CO_2	Carbon dioxide
21.	CO	Carbon monoxide
22.	ClF_3	Chlorine trifluoride
23.	ICl	Iodine monochloride
24.	CH_4	Carbon tetrahydride (methane)

Dimensional Analysis Review

Chem Worksheet 11-1

Name ________________

There are a variety of units that can be used when measuring. For example, the length of an object can be measured in millimeters, centimeters, meters, and even inches. A measurement made in inches can be converted to other units, such as centimeters using a conversion factor. A **conversion factor** is a ratio of two equivalent values expressed with different units.

Conversion Factors

1 L = 1000 mL	1 km = 1000 m
1 m = 100 cm	1 mm = 1000 μm
1 gal = 3.785 L	1 in = 2.54 cm
1 km = 0.6214 mi	1 kg = 2.20 lb
1 yek = 18 mem	1 mem = 180 tezl

To solve conversion problems we use a strategy known as **dimensional analysis.** This technique focuses on canceling units by placing them on the top and bottom of the fractions used to set up a problem. For example, when converting 18 inches to centimeters we place the inches on the bottom of the conversion factor so that they cancel with the inches in the 'given'.

$$\frac{18\,\cancel{\text{in}}}{1}\times\frac{2.54\text{ cm}}{1\,\cancel{\text{in}}}=45.72\text{ cm}$$

Example

Convert 25 gallons to liters.

- Write the 'given' over 1. $\frac{25\text{ gal}}{1}\times \quad =$
- Write the units of the unknown. $\frac{25\text{ gal}}{1}\times \quad = \quad \text{L}$
- Insert the conversion factor so that units cancel. Solve. $\frac{25\,\cancel{\text{gal}}}{1}\times\frac{3.785\text{ L}}{1\,\cancel{\text{gal}}}= 95\text{ L (rounded)}$

Convert the following measurements using dimensional analysis. Set up problem using fractions. Cross out the units that cancel. You must show work for credit.

1. Convert 42.3 cm to m.

$42.3\,\cancel{\text{cm}}\times\frac{1\text{ m}}{100\,\cancel{\text{cm}}}=\boxed{0.423\text{ m}}$ (3 sig.fig)

2. Convert the measurement 5.0 km to mi.

$5.0\,\cancel{\text{km}}\times\frac{0.6214\text{ mile}}{1\,\cancel{\text{km}}}=\boxed{0.62\text{ mile}}$ (2 sig.fig)

3. Convert the measurement 150 lb to kg.

$150\,\cancel{\text{lb}}\times\frac{1\text{ kg}}{2.20\,\cancel{\text{lb}}}=\boxed{2.3\text{ kg}}$ (2 sigfigs)

4. Convert 1.5 tezl to mem.

$1.5\,\cancel{\text{tezl}}\times\frac{1\text{ mem}}{180\,\cancel{\text{tezl}}}=\boxed{0.0083\text{ mem}}$ (2 sig.fig)

5. Convert 2.00 liters to gal.

$2.00\,\cancel{\text{L}}\times\frac{1\text{ gal}}{3.785\,\cancel{\text{L}}}=\boxed{0.528\text{ gal}}$ (3 sigfigs)

6. Convert 4.2 L to mL.

$4.2\,\cancel{\text{L}}\times\frac{1000\text{ mL}}{1\,\cancel{\text{L}}}=\boxed{4{,}200\text{ mL}}$ (2 sig figs)

7. Convert the measurement 1.8 yek to mem.

$1.8\,\cancel{\text{yek}}\times\frac{18\text{ mem}}{1\,\cancel{\text{yek}}}=\boxed{32\text{ mem}}$ (2 sigfigs)

8. Convert the measurement 325 mi to km.

$325\,\cancel{\text{mi}}\times\frac{1\text{ km}}{0.6214\,\cancel{\text{mi}}}=\boxed{523\text{ km}}$ (3 sigfigs)

9. Convert 180 cm to in.

$180\text{ cm}\times\frac{1\text{ in}}{2.54\text{ cm}}=\boxed{71\text{ in}}$ (2 sig fig)

10. Convert 42 mem to yek.

$42\text{ mem}\times\frac{1\text{ yek}}{18\text{ mem}}=\boxed{2.3\text{ yek}}$ (2 sig fig)

Chemistry Calculation Review

Chem Worksheet 12-1

Name ______________

The first step in performing a stoichiometric calculation is to write a balanced equation. Recall that balancing an equation involves placing coefficients before each of the reactants and products in order to ensure that the number of each type of atom is the same before and after the reaction.

Ex. $\underline{2}\,Al + \underline{3}\,Cl_2 \rightarrow \underline{2}\,AlCl_3$

Another important aspect to doing a stoichiometric calculation is finding the molar mass of an element or compound using the periodic table. The molar mass of iron (III) nitrate is shown below.

$AlCl_3$

$$26.98 + 3(35.45) = 133.33\text{ g/mol}$$

Finally, the ability to convert units using dimensional analysis is an important skill in performing stoichiometric calculations. In this technique conversion factors are placed next to values in a manner that allows units to be cancelled. An example of a mole conversion is shown below.

$$\frac{6.3\,\cancel{g\,AlCl_3}}{1} \times \frac{1\text{ mol }AlCl_3}{133.33\,\cancel{g\,AlCl_3}} = 0.047\text{ mol }AlCl_3$$

Balance the following equations.

1. ___$Mg(OH)_2$ + 2 HCl → ___$MgCl_2$ + 2 H_2O

2. 2 K + ___Br_2 → 2 KBr

3. ___P_4O_{10} + 6 H_2O → 4 H_3PO_4

4. 2 SO_3 → 2 SO_2 + ___O_2

5. 6 Na + ___Fe_2O_3 → 3 Na_2O + 2 Fe

6. 2 Na + 2 H_2O → 2 $NaOH$ + ___H_2

Find the molar mass of each of the following compounds.

7. $Mg(OH)_2$ 58.32 g/mol

8. KBr 119.00 g/mol

9. H_3PO_4 97.99 g/mol

10. SO_3 80.06 g/mol

11. Fe_2O_3 159.7 g/mol

12. Na_2O 61.98

Convert the following measurements. Show all work, including units that cancel.

assume H_2O →

13. 18.2 g → ? mol $18.2g\left(\frac{1\text{ mol}}{18.02\text{ g }H_2O}\right) = \boxed{1.01\text{ mol }H_2O}$

14. 8.5×10^{24} molecules NO_2 → mol $\left(\frac{1\text{ mol}}{6 \times 10^{23}\text{ molecules}}\right) = \boxed{14.\text{ mol }NO_2}$

15. 82.6 L of neon at STP → mol $\left(\frac{1\text{ mol}}{22.4L}\right) = \boxed{3.69\text{ mol }Ne}$

16. 4.14 g of Na_2O → mol

17. 9.3 mol SO_3 → liters @ STP $\left(\frac{22.4L}{1\text{ mol}}\right) = \boxed{208L}$

18. 1.4×10^{24} atoms of K → mol

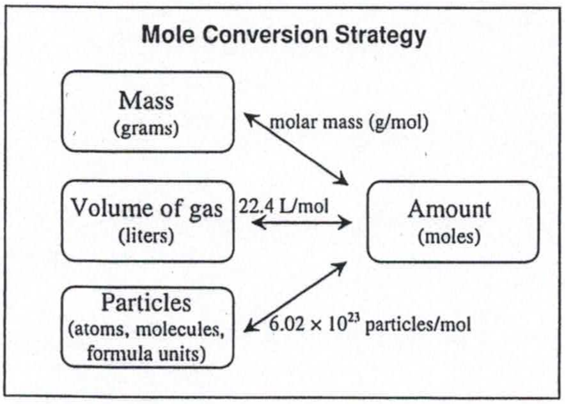
$1.4 \times 10^{24}\text{ atoms}\left(\frac{1\text{ mol}}{6.02 \times 10^{23}\text{ atoms}}\right) = \boxed{2.3\text{ mol K}}$

Mole Conversions

Chem Worksheet 11-3

Name ______________

It is important to be able to convert units from and into units of moles. The mole is a unit for count, as is the dozen. A dozen is 12 items, but a mole is 602 000 000 000 000 000 000 000 , or 6.02×10^{23} particles. Using the periodic table we can find the **molar mass**, or the mass of a mole of a substance.



The **molar volume** is the volume of a mole of substance. All gases have the same molar volume when measured at standard temperature and pressure (STP) : 22.4 L/mol. These values allow the conversion of grams, liters, or particles into moles.

example

How many molecules are present in a sample of calcium chloride $CaCl_2$ with a mass of 1.62 grams?

- develop a strategy: grams → moles → molecules

- write 'given' and unknown units: $\frac{1.62\text{ g}}{1} \times \frac{\quad}{\quad} \times \frac{\quad}{\quad} =$ molecules

- fill in conversion factors: $\frac{1.62\cancel{\text{g}}}{1} \times \frac{1\cancel{\text{mol}}}{110.98\cancel{\text{g}}} \times \frac{6.02\times10^{23}\text{ molecules}}{1\cancel{\text{mol}}} =$ molecules

- solve: $\frac{(1.62\cancel{\text{g}})(1\cancel{\text{mol}})(6.02\times10^{23}\text{ molecules})}{(1)(110.98\cancel{\text{g}})(1\cancel{\text{mol}})} = 8.79\times10^{21}$ molecules

Answer the following questions. Required 1-6 Show work on back

1. A sample of neon has a volume of 75.8 L at STP. How many moles are present?
2. What is the mass in grams of a 8.4 mole sample of iron?
3. Convert 0.45 g of sodium hydroxide, NaOH to moles.
4. How many molecules are present in a sample of carbon dioxide, CO_2 with a mass of 168.2 g?
5. How many moles of potassium nitrate, KNO_3 are present in a sample with a mass of 85.2 g.
6. What is the mass in grams of 0.94 moles of sodium bicarbonate, $NaHCO_3$?
7. Convert 7.8 liters of carbon tetrafluoride CF_4 to grams.
8. A gold coin contains 3.47×10^{23} gold atoms. What is the mass of the coin in grams?
9. What is the volume in liters of 7500 g of helium atoms. Assume STP conditions.
10. A teaspoon of salt, NaCl has a mass of about 5.0 g. How many formula units are in a teaspoon of salt?
11. What is the mass of 500 trillion (5.0×10^{14}) molecules of water?
12. One component of smog is nitrogen monoxide, NO. A car produces about 8 g of this gas per day. What is the volume at STP?

Mole Conversions

Problems 1-6

1. L → mol $\quad 75.8\cancel{L} \times \frac{1\text{ mol}}{22.4\cancel{L}} = \boxed{3.38\text{ mol}}$ (3 sig fig)

2. mol → g $\quad 8.4\cancel{\text{mol}}\text{ Fe} \times \frac{55.85\text{ g Fe}}{\cancel{\text{mol}}} = 469.14\text{ g} \rightarrow \boxed{470\text{ g}}$ (2 Sig Fig)

3. g → mol $\quad$ molar mass NaOH $= 1(22.99) + 1(16.00) + 1(1.008) = 40.00\frac{\text{g NaOH}}{\text{mol}}$

$0.45\cancel{g}\text{ NaOH} \times \frac{1\text{ mol NaOH}}{40.00\cancel{g}} = 0.01125\text{ mol} \rightarrow \boxed{0.011\text{ mol}}$ (2 sig fig)

4. g → mole → molecules $\quad$ molar mass $CO_2 = 1(12.01) + 2(16.00) = 44.01\frac{\text{g } CO_2}{\text{mol}}$

$168.2\cancel{g}\text{ }CO_2 \times \frac{1\cancel{\text{mol}}\text{ }CO_2}{44.01\cancel{g}} \times \frac{6.022 \times 10^{23}\text{ molecules}}{\cancel{\text{mol}}} = \boxed{2.302\text{ molecules}} \times 10^{24}$ (4 sig fig

5. g → mole $\quad$ molar mass $KNO_3 = 1(39.10) + 1(14.01) + 3(16.00) = 101.11\frac{\text{g } KNO_3}{\text{mole}}$

$85.2\cancel{g}\text{ }KNO_3 \times \frac{1\text{ mol }KNO_3}{101.11\cancel{g}} = \boxed{0.843\text{ mol }KNO_3}$ (3 sig fig)

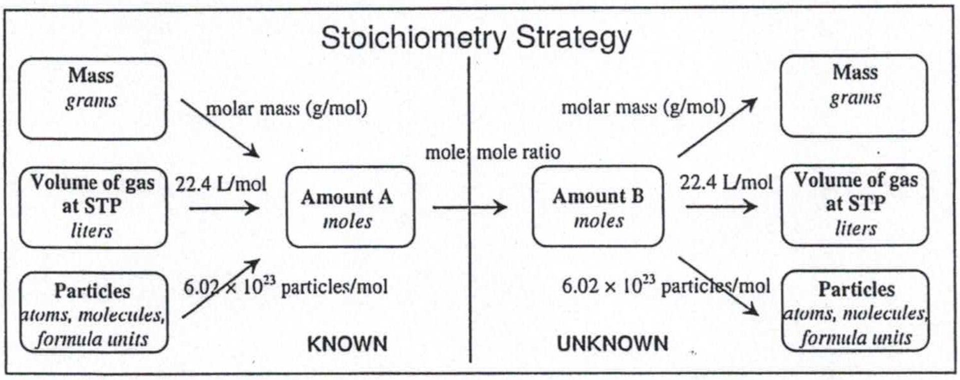
6. mol → g $\quad$ molar mass $NaHCO_3 = 1(22.99) + 1(1.008) + 1(12.01) + 3(16.00) = 84.01\frac{\text{g }NaHCO_3}{\text{mol}}$

$0.94\cancel{\text{mol}}\text{ }NaHCO_3 \times \frac{84.01\text{g }NaHCO_3}{\cancel{\text{mol}}} = \boxed{79\text{g }NaHCO_3}$ (2 sig fig)

Stoichiometry Problems
Chem Worksheet 12-2

Name ________________

With a balanced equation it is possible to calculate the amount of expected product or reactant for a reaction. The **products** are the substances formed in a chemical reaction and these are found on the right side of the reaction arrow. The **reactants** are the substances required in a chemical reaction and these are written on the left side of the arrow. Using the technique of unit cancellation and the strategy outlined to the left, given the mass, volume, or number of particles of a substance, it is possible to determine the mass, volume, or particles of another.



Example

What mass of aluminum is required to produce 25.8 L of hydrogen gas at STP in the reaction below?

$\_\_Al + \_\_H_2SO_4 \rightarrow \_\_Al_2(SO_4)_3 + \_\_H_2$

- balance the equation $\underline{2}\ Al + \underline{3}\ H_2SO_4 \rightarrow \underline{1}\ Al_2(SO_4)_3 + \underline{3}\ H_2$

- develop a strategy: liters H_2 → moles H_2 → moles Al → grams Al

- write 'given' and 'unknown' units: $\frac{25.8\ L\ H_2}{1} \times \frac{\quad}{\quad} \times \frac{\quad}{\quad} \times \frac{\quad}{\quad} =$ grams Al

- fill in conversion factors: $\frac{25.8\ \cancel{L\ H_2}}{1} \times \frac{1\ \cancel{mol\ H_2}}{22.4\ \cancel{L\ H_2}} \times \frac{2\ \cancel{mol\ Al}}{3\ \cancel{mol\ H_2}} \times \frac{26.98\ g\ Al}{1\ \cancel{mol\ Al}} =$ grams Al

- solve: $\frac{(25.8\ \cancel{L\ H_2})(1\ \cancel{mol\ H_2})(2\ \cancel{mol\ Al})(26.98\ g\ Al)}{(1)(22.4\ \cancel{L\ H_2})(3\ \cancel{mol\ H_2})(1\ \cancel{mol\ Al})} =$ 20.7 g Al

Balance the following equations. Solve the stoichiometric problems. Required 1-5

Show work on back.

1. How many molecules of oxygen are required to react with 174 g of carbon monoxide?
   $\_\_\ CO + \_\_\ O_2 \rightarrow \_\_\ CO_2$

2. How many liters of oxygen at STP are required for the combustion of 1.4 g of magnesium?
   $\_\_\ Mg + \_\_\ O_2 \rightarrow \_\_\ MgO$

3. What mass of hydrogen peroxide must decompose to produce 48.64 g of water?
   $\_\_\ H_2O_2 \rightarrow \_\_\ O_2 + \_\_\ H_2O$

4. How many liters of oxygen at STP are needed to react with 5.2×10^{22} molecules of hydrogen sulfide?
   $\_\_\ H_2S + \_\_\ O_2 \rightarrow \_\_\ SO_2 + \_\_\ H_2O$

5. What mass of chlorine gas is necessary to synthesize 258 L of hydrogen chloride at STP?
   $\_\_\ H_2 + \_\_\ Cl_2 \rightarrow \_\_\ HCl$

6. If there are 6.2×10^{22} molecules of calcium carbide, CaC_2, what mass of acetylene (C_2H_2) can be formed?
   $\_\_\ CaC_2 + \_\_\ H_2O \rightarrow \_\_\ Ca(OH)_2 + \_\_\ C_2H_2$

7. What mass of sodium iodide (NaI) will react with 7.82 grams of chlorine?
   $\_\_\ NaI + \_\_\ Cl_2 \rightarrow \_\_\ NaCl + \_\_\ I_2$

8. If 8.2 L of hydrogen gas at STP are produced in this reaction, how many atoms of sodium react?
   $\_\_\ Na + \_\_\ H_2O \rightarrow \_\_\ NaOH + \_\_\ H_2$

9. What volume of nitrogen gas at STP is produced when 68.2 g of trinitrotoluene, $C_7H_5(NO_2)_3$ reacts?
   $\_\_\ C_7H_5(NO_2)_3 \rightarrow \_\_\ C + \_\_\ CO + \_\_\ H_2 + \_\_\ N_2$

10. What mass of carbon dioxide is produced when 6.2 moles of propane, C_3H_8 is burned in oxygen?
    $\_\_\ C_3H_8 + \_\_\ O_2 \rightarrow \_\_\ CO_2 + \_\_\ H_2O$

Stoichiometry

Problems 1-5

1. $2CO + O_2 \rightarrow 2CO_2$

$174g\ CO \rightarrow$ molecules O_2

MM CO = 12.01 + 16.00 = 28.01 g/mol

$$174g\ \cancel{CO} \times \frac{1\ \cancel{mol\ CO}}{28.01\ \cancel{g\ CO}} \times \frac{1\ \cancel{mol}\ O_2}{2\ \cancel{mol\ CO}} \times \frac{6.022\times10^{23}\ molecules\ O_2}{1\ \cancel{mol\ O_2}} = \boxed{1.83\times10^{24}\ molecules\ O_2}$$

(3 SF)

2. $2Mg + O_2 \rightarrow 2MgO$

$1.4\ g\ Mg \rightarrow L\ O_2$

MM Mg = 24.30 g/mol

$$1.4\cancel{g\ Mg} \times \frac{1\ \cancel{mol\ Mg}}{24.30\ \cancel{g\ Mg}} \times \frac{1\ \cancel{mol}\ O_2}{2\ \cancel{mol\ Mg}} \times \frac{22.4\ L\ O_2}{1\ \cancel{mol\ O_2}} = \boxed{0.65\ L\ O_2}$$

(2 SF)

3. $2H_2O_2 \rightarrow O_2 + 2H_2O$

$48.64g\ H_2O \rightarrow g\ H_2O_2$

MM H_2O_2 = 2(1.008) + 2(16.00) = 34.02g/mol

MM H_2O = 2(1.008) + 16.00 = 18.02g/mol

$$48.64\ \cancel{g\ H_2O} \times \frac{1\ \cancel{mol\ H_2O}}{18.02g\ \cancel{H_2O}} \times \frac{2\ \cancel{mol\ H_2O_2}}{2\ \cancel{mol\ H_2O}} \times \frac{34.02g\ H_2O_2}{1\ \cancel{mol\ H_2O_2}} = \boxed{91.83g\ H_2O_2}$$

(4 SF)

4. $2H_2S + 3O_2 \rightarrow 2SO_4 + 2H_2O$

5.2×10^{22} molecules $H_2S \rightarrow L\ O_2$

$$5.2\times10^{22}\ \cancel{molecules\ H_2S} \times \frac{1\ \cancel{mol\ H_2S}}{6.022\times10^{23}\ \cancel{molecules}} \times \frac{3\ \cancel{mol\ O_2}}{2\ mol\ \cancel{H_2S}} \times \frac{22.4\ L\ O_2}{1\ \cancel{mol}\ O_2}$$

$$= \boxed{2.9\ L\ O_2}\ (2\ SF)$$

5. $H_2 + Cl_2 \rightarrow 2HCl$

$258L\ HCl \rightarrow g\ Cl_2$

MM Cl_2 = 2(35.45) = 70.90g/mol

$$258L\ HCl \times \frac{1\ mol\ HCl}{22.4\ L\ HCl} \times \frac{1\ mol\ Cl_2}{2\ mol\ HCl} \times \frac{70.90g\ Cl_2}{1\ mol\ Cl_2} = \boxed{408g\ Cl_2}$$

(3 SF)

Limiting Reactants

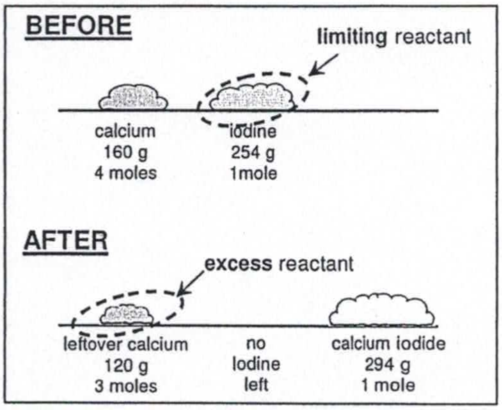
Chem Worksheet 12-3

Name ________________

When an automobile production plant runs out of tires no more cars can be produced even if there are still plenty of engines, bodies, seats, and other parts. When one of the reactants in a chemical reaction runs out the reaction stops as well. The substance that limits production in a chemical reaction is known as the **limiting reactant.** The reactant that is left over when the reaction stops is called the **excess reactant.**

$\underline{1}\,Ca + \underline{1}\,I_2 \rightarrow \underline{1}\,CaI_2$

Consider the chemical reaction between calcium and iodine. When 160 g (4 moles) of calcium reacts with 254 g (1 mole) of iodine the reaction makes 294 g (1 mole) of calcium iodide. Although there is enough calcium to make more calcium iodide, the iodine runs out first. Since all of the iodine gets used up it is called the limiting reactant. According to the balanced equation, if one mole of iodine reacts, one mole of calcium will react. This means that there are still 3 moles of calcium left. Because calcium is left over it is called the excess reactant.



Example

What mass of iron (II) sulfide will be produced if 9.68 g of iron reacts with 6.28 g of sulfur? $\_\_Fe + \_\_S \rightarrow \_\_FeS$

- balance the equation $\underline{1}\,Fe + \underline{1}\,S \rightarrow \underline{1}\,FeS$

- perform a calculation for each reactant:

F: $\frac{9.68\text{ g }\cancel{Fe}}{1} \times \frac{1\text{ mol }\cancel{Fe}}{55.85\text{ g }\cancel{Fe}} \times \frac{1\text{ mol }\cancel{FeS}}{1\text{ mol }\cancel{Fe}} \times \frac{87.91\text{ g FeS}}{1\text{ mol }\cancel{FeS}} = 15.24\text{ g FeS}$

S: $\frac{6.28\text{ g }\cancel{S}}{1} \times \frac{1\text{ mol }\cancel{S}}{32.06\text{ g }\cancel{S}} \times \frac{1\text{ mol }\cancel{FeS}}{1\text{ mol }\cancel{S}} \times \frac{87.91\text{ g FeS}}{1\text{ mol }\cancel{FeS}} = 17.22\text{ g FeS}$

- whichever reactant makes less product is the limiting reactant: Iron is the limiting reactant. There is enough sulfur to make 17.22 g FeS, but only enough iron to make 15.24 g of FeS.

Find the amount of product formed in each of the following reactions. Required 1-5 Show work on back

1. What mass of H_2O will be produced if 9.5 g of H_2 reacts with 1.2 g of O_2?
   $\_\_H_2 + \_\_O_2 \rightarrow \_\_H_2O$

2. If 1.85 g of $Mg(OH)_2$ reacts with 3.71 g of HCl, how much $MgCl_2$ is produced? What is the limiting reactant?
   $\_\_Mg(OH)_2 + \_\_HCl \rightarrow \_\_MgCl_2 + \_\_H_2O$

3. What mass of AgCl is produced when 53.42 g of $AgNO_3$ reacts with 14.19 g of NaCl?
   $\_\_AgNO_3 + \_\_NaCl \rightarrow \_\_AgCl + \_\_NaNO_3$

4. If 14.7 g of calcium is placed in 11.5 g of water, what mass of hydrogen gas is produced?
   $\_\_Ca + \_\_H_2O \rightarrow \_\_Ca(OH)_2 + \_\_H_2$

5. What mass of potassium hydroxide is formed when 8.2 g of potassium oxide is added to 1.3 g of water?
   $\_\_K_2O + \_\_H_2O \rightarrow \_\_KOH$

6. What mass of aluminum chloride could be made from 8.1 g of aluminum and 4.2 L of chlorine at STP?
   $\_\_Al + \_\_Cl_2 \rightarrow \_\_AlCl_3$

7. If 5.26 L of nitrogen monoxide and 7.64 L of oxygen are combined, what mass of nitrogen dioxide is formed? Assume conditions are STP.
   $\_\_NO + \_\_O_2 \rightarrow \_\_NO_2$

8. If 18.1 g of silicon tetrachloride reacts with 8.4 L of hydrogen at STP, what mass of silicon is formed?
   $\_\_SiCl_4 + \_\_H_2 \rightarrow \_\_Si + \_\_HCl$

9. What mass of $Cu(OH)_2$ is produced in the reaction of 7.6 g $Cu(NO_3)_2$ with 6.2 g of KOH?
   $\_\_Cu(NO_3)_2 + \_\_KOH \rightarrow \_\_Cu(OH)_2 + \_\_KNO_3$

10. What mass of carbon dioxide is formed when 64 kg of ethylene is burned in 142 kg of oxygen?
   $\_\_C_2H_4 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$

Limiting Reactants using BCA Tables

Chem WS 12-3, P 4-5, 7-10

4. $Ca + \underline{2}H_2O \rightarrow Ca(OH)_2 + H_2$

	Ca	H_2O	$Ca(OH)_2$	H_2
	14.7 g	11.5 g		? g
MM	40.08 g/mol	18.02	34.02	2.02 g/mol

$14.7\,g\,Ca\left(\frac{1\,mol}{40.08\,g\,Ca}\right) = 0.367\,mol\,Ca$

$11.5\,g\,H_2O\left(\frac{1\,mol}{18.02\,g\,H_2O}\right) = 0.638\,g\,H_2O$

Ca vs H_2O

$\frac{0.361\,mol}{1\,mol}$ $\frac{0.638\,mol}{2\,mol}$

0.361 > 0.319

$\boxed{H_2O \text{ is L.R.}}$

$\overset{\text{XS}}{Ca} + \overset{\text{L.R}}{2H_2O} \rightarrow Ca(OH)_2 + H_2$

B	0.367	0.638	0	0
C	− x	− 2x	+ x	+ x
A	0.367−x	0.638−2x = 0	x	x

0.367−0.319
= 0.048 mol Ca

0.638 = 2x
$\boxed{0.319 = x}$

0.319 mol $Ca(OH)_2$

0.319 mol H_2

$0.319\,mol\,H_2\left(\frac{2.02\,g\,H_2 \;\; \cancel{18.02\,g}}{1\,mol}\right)$

$= \boxed{0.644\,g\,H_2 \text{ produced}}$ (3 SF)

$0.048\,mol\,Ca\left(\frac{40.08\,g\,Ca}{1\,mol}\right)$

$= \boxed{1.92\,g\,Ca \text{ in excess}}$ (3 SF)

5. $\overset{8.2g}{K_2O} + \overset{1.3g}{H_2O} \rightarrow \underline{2}\,\overset{?g}{KOH}$

MM 94.2 g/mol 18.02 g/mol 56.11 g/mol

$8.2\,g\,K_2O\left(\frac{1\,mol}{94.2\,g}\right) = 0.087\,mol\,K_2O$

$1.3\,g\,H_2O\left(\frac{1\,mol}{18.02\,g\,H_2O}\right) = 0.072\,mol\,H_2O$

K_2O vs H_2O

$\frac{0.087\,mol}{1\,mol}$ > $\frac{0.072\,mol}{1\,mol}$

$\boxed{H_2O \text{ is L.R}}$

$\overset{\text{XS}}{K_2O} + \overset{\text{L.R}}{H_2O} \rightarrow 2\,KOH$

B	0.087	0.072	0
C	−x	−x	+ 2x
A	0.087−x	0.072−x = 0	2x

0.087−0.072
= 0.015 mol K_2O

0.072 = x

2(0.072) =
0.144 mol KOH

$0.144\,mol\,KOH\left(\frac{56.11\,g}{1\,mol}\right) = \boxed{8.1\,g\;KOH}$ (2 SF)

$0.015\,mol\,K_2O\left(\frac{94.2\,g\,K_2O}{1\,mol}\right) = \boxed{1.6\times10^{-4}\;K_2O\text{ excess}}$ (2 SF)

Limiting Reactants, cont. page 2

17. $2\,NO + O_2 \rightarrow 2\,NO_2$

$5.26\,L \quad 7.64\,L \quad ?\,g$

@ STP $\quad 22.4\,\frac{L}{mol} \quad 22.4\,\frac{L}{mol}$

$5.26\,L\,NO\left(\frac{1\,mol}{22.4\,L}\right) = 0.235\,mol\,NO$

$7.64\,L\,O_2\left(\frac{1\,mol}{22.4\,L}\right) = 0.339\,mol\,O_2$

NO vs O_2

$\boxed{NO\text{ is L.R}}$

$\frac{0.235\,mol\,NO}{2\,mol\,NO} \quad \frac{0.339\,mol\,O_2}{1\,mol\,O_2}$

$0.1175 < 0.339$

	LR $2NO$	+ XS O_2	$\rightarrow 2\,NO_2$
B	0.235	0.339	0
C	$-2x$	$-x$	$+2x$
A	$0.235-2x = 0$	$0.339-x$	$2x$

$\frac{0.235}{2} = x$

$0.118\,mol = x$

$0.339 - 0.118 = 0.221\,mol\,O_2$

$2(0.118\,mol) = 0.236\,mol\,NO_2$

$0.236\,mol\,NO_2\left(\frac{46.01\,g\,NO_2}{1\,mol}\right) = \boxed{10.9\,g\,NO_2\text{ produced}}$

$0.221\,mol\,O_2\left(\frac{32.00\,g\,O_2}{1\,mol}\right) = \boxed{7.07\,g\,O_2\text{ excess}}$

18. $SiCl_4 + 2\,H_2 \rightarrow Si + 4\,HCl$

$18.1\,g \quad 8.4\,L \quad ?\,g$

MM $169.89\,\frac{g}{mol}$ $\quad$ @ STP $22.4\,\frac{L}{mol}$

$18.1\,g\,SiCl_4\left(\frac{1\,mol}{169.89\,g}\right) = 0.107\,mol\,SiCl_4$

$8.4\,L\,H_2\left(\frac{1\,mol}{22.4\,L}\right) = 0.375\,mol\,H_2$

$SiCl_4$ vs H_2

$\boxed{SiCl_4\text{ is LR}}$

$\frac{0.107\,mol}{1\,mol} \quad \frac{0.375\,mol}{2\,mol}$

$0.107 < 0.188$

	LR $SiCl_4$	+ XS $2\,H_2$	$\rightarrow Si$	+ $4\,HCl$
B	0.107	0.375	0	0
C	$-x$	$-2x$	$+x$	$+4x$
A	$0.107-x = 0$	$0.375-2x$	x	$4x$

$x = 0.107$

$0.375 - 2(0.107) = 0.161\,mol\,H_2$

$0.107\,mol\,Si$

$4(0.107) = 0.428\,mol\,HCl$

$0.107\,mol\,Si\left(\frac{28.09\,g\,Si}{1\,mol}\right) = \boxed{3.01\,g\,Si\text{ produced}}$

$0.161\,mol\,H_2\left(\frac{\overset{2.02}{\cancel{32.02}}\,g\,H_2}{1\,mol}\right) = \boxed{0.325\,g\,H_2\text{ excess}}$

Limiting Reactant page 3

$\boxed{19}$ $Cu(NO_3)_2 + \underline{2}\ KOH \rightarrow Cu(OH)_2 + \underline{2}\ KNO_3$

	$Cu(NO_3)_2$	KOH	KNO_3
	7.6 g	6.2 g	? g
MM	$187.57 \frac{g}{mol}$	$56.11 \frac{g}{mol}$	$101.11 \frac{g}{mol}$

$7.6\,g\ Cu(NO_3)_2 \left(\frac{1\ mol}{187.57\,g}\right) = 0.0405\ mol\ Cu(NO_3)_2$

$6.2\,g\ KOH \left(\frac{1\ mol}{56.11\,g}\right) = 0.110\ mol\ KOH$

$Cu(NO_3)_2$	vs	KOH
$\frac{0.0405\ mol}{1\ mol}$		$\frac{0.110\ mol}{2\ mol}$
0.0405	<	0.055

$\boxed{Cu(NO_3)_2 \text{ is LR}}$

	LR	XS		
	$Cu(NO_3)_2$ +	$2\ KOH$ →	$Cu(OH)_2$ +	$2\ KNO_3$
B	0.0405	0.110	0	0
C	$-1x$	$-2x$	$+x$	$+2x$
A	$0.0405 - 1x = 0$ $x = 0.0405$	$0.110 - 2x$ $0.110 - 2(0.0405)$ $= 0.029\ mol$	x $0.0405\ mol\ Cu(OH)_2$	$2x$ $2(0.0405)$ $= 0.081\ mol\ KNO_3$

$0.081\ mol\ KNO_3 \left(\frac{101.11\,g}{1\ mol}\right) = \boxed{8.19\,g\ KNO_3 \text{ produced}}$

$0.029\ mol\ KOH \left(\frac{56.11\,g}{1\ mol}\right) = \boxed{1.62\,g\ KOH \text{ in excess}}$

Limiting Reactant page 4

$\boxed{10}$

$C_2H_4 + \underline{3}\,O_2 \rightarrow \underline{2}\,CO_2 + \underline{2}\,H_2O$

	64 kg	142 kg	? g	
MM	28.05 g/mol	32.0 g/mol	44.01 g/mol	

$64\,kg\,C_2H_4\left(\frac{1000\,g}{1\,kg}\right)\left(\frac{1\,mol}{28.05\,g}\right) = 2281.63\,mol\,C_2H_4$

$142\,kg\,O_2\left(\frac{1000\,g}{1\,kg}\right)\left(\frac{1\,mol}{32.0\,g}\right) = 4437.5\,mol\,O_2$

C_2H_4 vs O_2

$\frac{2281.63\,mol}{1}$ $\frac{4437.5\,mol}{3}$

2281.63 > 1479.17

$\boxed{O_2 \text{ is LR}}$

$\overset{XS}{C_2H_4} + \overset{LR}{3O_2} \rightarrow 2CO_2 + 2H_2O$

B	2281.63	4437.5	0	0
C	−1x	−3x	+2x	+2x
A	2281.63−x	4437.5−3x =0	2x	2x
	2281.63−1479.17 = 802.46 mol C_2H_4	$\frac{4437.5}{3}$ = x 1479.17 = x mol O_2	2(1479.17) = 2958.34 mol CO_2	2958.34 mol H_2O

$2958.34\,mol\,CO_2\left(\frac{44.01\,g}{1\,mol}\right) = 130,196.54\,g\,CO_2 = \boxed{130.19\,kg\,CO_2\text{ produced}}$

$130.\,kg\,CO_2$ (2SF)

$802.46\,mol\,C_2H_4\left(\frac{28.05\,g}{1\,mol}\right) = 22,509.00\,g\,C_2H_4 = \boxed{22.509.00\,kg\,C_2H_4\text{ excess}}$

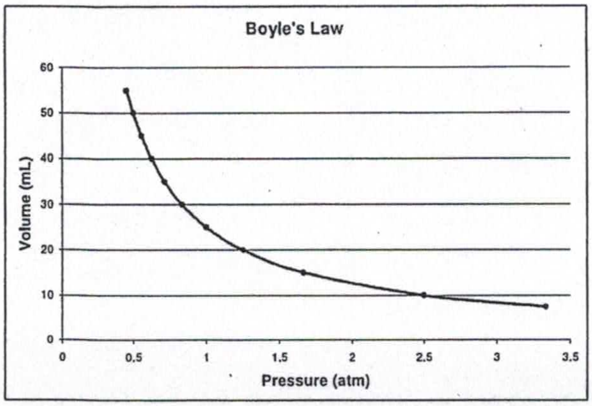
$23\,kg\,C_2H_4$ excess (2SF)

Boyle's Law

Chem Worksheet 14-1

Name ___________________

Robert Boyle observed the relationship between the pressure and volume for a gas sample. These two variables are **inversely proportional.** This means that when the pressure goes up the volume goes down. This is expressed in the equation $P_1 \times V_1 = P_2 \times V_2$, which is known as **Boyle's Law**. The relationship between pressure and volume is only observed when the temperature and amount of gas particles do not change. The graph below shows this relationship.



USEFUL EQUATIONS

$P_1 \times V_1 = P_2 \times V_2$

1.00 atm = 101300 Pa

1.00 atm = 101.3 kPa

1.00 atm = 760 mmHg

1.00 atm = 760 torr

1.00 atm = 14.7 psi

lb/in^2

example

A gas occupies a volume of 5.4 L at a pressure of 1.06 atm. What volume will the gas occupy if when the pressure is increased to 1.52 atm? Assume the temperature does not change.

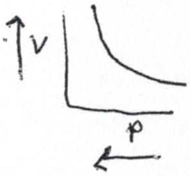
- list the variables: $V_1 = 5.4$ L $P_1 = 1.06$ atm $P_2 = 1.52$ atm
- substitute into the equation: $P_1 \times V_1 = P_2 \times V_2$ $(1.06\text{ atm}) \times (5.4\text{ L}) = (1.52\text{ atm}) \times V_2$
- solve: $\frac{(1.06\,\cancel{\text{atm}}) \times (5.4\text{ L})}{1.52\,\cancel{\text{atm}}} = \frac{(\cancel{1.52}\,\cancel{\text{atm}}) \times V_2}{\cancel{1.52}\,\cancel{\text{atm}}}$ $V_2 = 3.8$ L

If needed use dimensional analysis to change units so they match at this step.

Solve the following problems. Required 1, 5-8 watch units! Show work on back

1. According to the graph, when the pressure of a gas sample is decreased what happens to the volume?
2. The gas in a 600 mL balloon has a pressure of 1.20 atm. If the temperature remains constant, what will be the pressure of the gas in the balloon when it is compressed to 400 mL?
3. An oxygen container has a volume of 48 mL and a pressure of 420 kPa. What is the volume of this gas when the pressure is 105 kPa?
4. A tank of compressed CO_2 has a pressure of 850 psi and a volume of 150 mL. What is the volume of this gas when the pressure is 45 psi?
5. A scuba tank has a pressure of 19,300 kPa and a volume of 10.3 L. What would be the pressure of the gas if it were transferred to a 50.0 L container?
6. Air fills a room with a volume of 5600 L. Atmospheric pressure is 740 torr. What will be the pressure if all of the gas is pumped into an 80 L tank? Convert this pressure to kPa. unit conversion need
7. psi A sample of 24 L of helium gas is stored in a cylinder at a pressure of 110 lb/in^2. The helium is transferred to a container with a volume of 15 L. Assuming the temperature has not changed what will be the pressure?
8. An air compressor has a volume of 110 L. What volume of gas is pumped into the tank if the pressure goes from 750 torr to a pressure of 145 psi?

Boyle's Law 1, 5-8

1.


when the pressure of a gas is decreased
the volume increases.

5. $P_2 = ?$ $P_1 = 19,300\,kPa$ $P_1V_1 = P_2V_2$ $P_2 = \frac{(19.300\,kPa)(10.3\cancel{L})}{50.0\cancel{L}} = \boxed{3.98\,kPa}$ (3 SF)

$V_1 = 10.3\,L$ $P_2 = \frac{P_1V_1}{V_2}$

$V_2 = 50.0\,L$

6. $P_2 = ?$ $P_1 = 740\,torr$ $P_2 = \frac{P_1V_1}{V_2}$ $P_2 = \frac{(740\,torr)(5600\cancel{L})}{80\cancel{L}} = 50{,}000\,torr$ (1 SF)

$V_1 = 5600\,L$

$V_2 = 80\,L$

$50{,}000\,\cancel{torr} \times \frac{1\,\cancel{atm}}{760\,\cancel{torr}} \times \frac{101.3\,kPa}{1\,\cancel{atm}} = \boxed{7{,}000\,kPa}$ (1 SF)

7. $P_2 = ?$ $P_1 = 110\,lb/in^2$ $P_2 = \frac{P_1V_1}{V_2}$ $P_2 = \frac{(110\,psi)(24\cancel{L})}{15\cancel{L}} = \boxed{180\,psi}$ (2 SF)

$= 110\,psi$

$V_1 = 24\,L$

$V_2 = 15\,L$

~~8. $V_2 = ?$ $V_1 = 110\,L$ $P_1V_1 = P_2V_2$~~

~~$P_1 = 750\,torr = 100\,kPa$ $V_2 = \frac{P_1V_1}{P_2}$ $V_2 = \frac{(100\,kPa)(110\,L)}{}$~~

~~$P_2 = 145\,psi$~~

~~$P_1 = 750\,\cancel{torr} \times \frac{1\,\cancel{atm}}{760\,\cancel{torr}} \times \frac{101.3\,kPa}{1\,\cancel{atm}} = 100\,kPa$~~

8. $V_2 = ?$ $V_1 = 110\,L$ $P_1V_1 = P_2V_2$ $V_2 = \frac{(750\,\cancel{torr}).(110\,L)}{(7500\,\cancel{torr})}$

$P_1 = 750\,torr$ $V_2 = \frac{P_1V_1}{P_2}$

$P_2 = 145\,psi$

$P_2 = 145\,\cancel{psi} \times \frac{1\,\cancel{atm}}{14.7\,\cancel{psi}} \times \frac{760\,torr}{1\,\cancel{atm}}$ $\boxed{V_2 = 11\,L}$

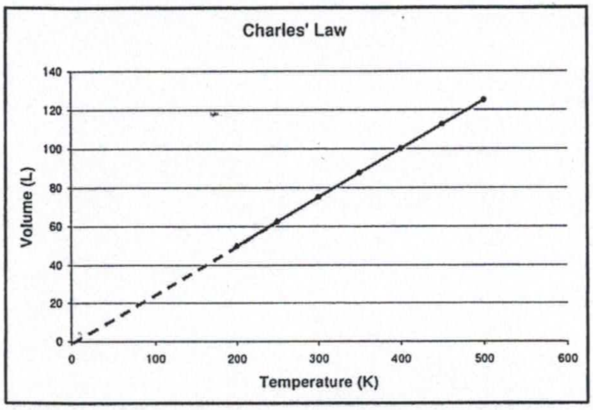
$= 7500\,torr$

Charles' Law

Chem Worksheet 14-2

Name ____________________

Jacques Charles made the observation the volume of a gas is directly proportional to the Kelvin temperature of the gas. If the Kelvin temperature is doubled, the volume also doubles. The equation for this relationship is $\frac{V_1}{T_1}=\frac{V_2}{T_2}$, where V represents volume and T represents temperature. The volume of a gas can be measured in liters, milliliters, cubic meters, or a variety of other units, but the temperature must be converted to kelvins. This relationship is only observed when the pressure remains constant.



USEFUL EQUATIONS

$$\frac{V_1}{T_1}=\frac{V_2}{T_2} \qquad T_K = T_C + 273$$

$$1\ \text{mL} = 1\ \text{cm}^3 \qquad T_c = \frac{5}{9}(T_f - 32)$$

$$1\ \text{L} = 1000\ \text{mL}$$

example

A gas sample with a volume of 35 mL is heated from 25°C to 425°C. What is the new volume? Assume a constant pressure.

- list the variables: $V_1 = 35$ mL $\quad T_1 = 25°\text{C} = 298$ K $\quad T_2 = 425°\text{C} = 698$ K

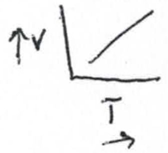
- substitute into the equation: $\frac{V_1}{T_1}=\frac{V_2}{T_2} \qquad \frac{35\ \text{mL}_1}{298\ \text{K}}=\frac{V_2}{698\ \text{K}}$

- solve by cross-multiplying: $(35\ \text{ml})\times(698\ \text{K}) = V_2\times(298\ \text{K}) \qquad \frac{(35\ \text{ml})\times(698\ \cancel{\text{K}})}{298\ \cancel{\text{K}}}=\frac{V_2\times(\cancel{298\text{K}})}{\cancel{298\text{K}}} \qquad V_2 = 82\ \text{mL}$

Solve the following problems. Assume that the pressure does not change. Required 1-6 Show work on back

1. According to the graph, when the Kelvin temperature of a gas is doubled, what happens to the volume?
2. Using the graph, estimate the Kelvin temperature that the gas sample would reach a volume of 140 L.
3. A 240 mL sample of argon gas at 270 K is cooled until the volume is 180 mL. What is the new temperature?
4. A container of oxygen with a volume of 60 L is heated from 300 K to 400 K. What is the new volume?
5. When a piston with a volume of 35 mL is heated from 25°C to 323°C it expands. Assuming the pressure on the piston remains the same, determine the new volume of the cylinder.
6. A balloon with a volume of 5.3 L is taken from an indoor temperature of 24°C to the outdoors. The volume of the balloon outside is 4.9 L. Determine the Celsius temperature outside.
7. A movable piston contains a sample of 680 mL of neon gas with a temperature of -5°C. When the piston is heated the sample expands to a volume of 1.32 L. What is the new temperature of the neon gas?
8. A helium balloon has a volume of 2600 cm^3 when the temperature is 21°C. What is the volume of the balloon when it's placed in a freezer with a temperature of -15°C?
9. The Kelvin temperature of sample of 650 cm^3 sample of ammonia gas is doubled. What is the new volume of the gas? Assume that the pressure stays constant.
10. A movable piston is allowed to cool from 392°F to 104°F. If the initial volume is 105 mL, what will be the new volume?

Charles' Law 1-6



when the temperature of a gas is doubled the volume is doubled.

. Using the graph at a volume of 140L the Temp. in K would be close to 550K.

?. $T_2 = ?$ $V_1 = 240\text{mL}$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $T_2 = \frac{V_2 T_1}{V_1} = \frac{(180\cancel{\text{mL}})(270\text{K})}{240\cancel{\text{mL}}} = \boxed{203\text{K}}$ (3 SF)

$V_2 = 180\text{ mL}$

$T_1 = 270\text{K}$

1. $V_2 = ?$ $V_1 = 60\text{L}$ $V_2 = \frac{V_1 T_2}{T_1} = \frac{(60\text{L})(400\cancel{\text{K}})}{(300\cancel{\text{K}})} = \boxed{80\text{L}}$ (2 SF)

$T_1 = 300\text{K}$

$T_2 = 400\text{K}$

5. $V_2 = ?$ $V_1 = 35\text{mL}$ $V_2 = \frac{V_1 T_2}{T_1} = \frac{(35\text{mL})(596\cancel{\text{K}})}{298\cancel{\text{K}}} = \boxed{70\text{mL}}$ (2 SF)

$T_1 = 25°\text{C}$

$= 25°\text{C} + 273$

$= 298\text{K}$

$T_2 = 323°\text{C} + 273$

$= 596\text{K}$

6. $T_2(°\text{C}) = ?$ $V_1 = 5.3\text{L}$ $T_2 = \frac{V_2 T_1}{V_1} = \frac{(4.9\cancel{\text{L}})(297\text{K})}{5.3\cancel{\text{L}}} = 270\text{K}$ (2 SF)

$T_1 = 24°\text{C} + 273$

$= 297\text{K}$

$V_2 = 4.9\text{L}$

$270\text{K} - 273 = \boxed{-3°\text{C}}$

Combined Gas Law

Chem Worksheet 14-3

Name ______________

Boyle's law shows that the pressure and volume of a gas are inversely related. **Charles' law** shows that the kelvin temperature and volume of a gas are directly related. These two relationships can be combined into a single equation known as the **combined gas law**. The formula for the combined gas law is: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ This equation could be memorized instead of memorizing Boyle's law, Charles' law, and Guy-Lussac's law. Each of these other gas laws can be derived from the combined gas law by canceling out the variable that does not change.

Law	**Equation**	**Constant Variable**
Boyle's Law	$\frac{P_1V_1}{\cancel{T_1}} = \frac{P_2V_2}{\cancel{T_2}}$	temperature
Charles' Law	$\frac{\cancel{P_1}V_1}{T_1} = \frac{\cancel{P_2}V_2}{T_2}$	pressure
Guy-Lussac's Law	$\frac{P_1\cancel{V_1}}{T_1} = \frac{P_2\cancel{V_2}}{T_2}$	volume

USEFUL EQUATIONS

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad T_K = T_C + 273$$

example

A 28 L sample of gas has a pressure of 25 psi when the temperature is 45°C. What is the volume of the gas if the pressure is increased to 175 psi and the temperature is increased to 320°C?

- list the variables: $V_1 = 28\text{ L}$ $V_2 = ?$ $P_1 = 25\text{ psi}$ $P_2 = 175\text{ psi}$ $T_1 = 45°\text{C} = 313\text{ K}$ $T_2 = 320°\text{C} = 593\text{ K}$ } change units as needed at this step
- substitute into the equation: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{(25\text{ psi})(28\text{ L})}{(313\text{ K})} = \frac{(175\text{ psi})(V_2)}{(593\text{ K})}$
- cross-multiply and simplify: $(25\text{ psi})(28\text{ L})(593\text{ K}) = (175\text{ psi})(V_2)(313\text{ K})$ $\frac{(25\cancel{\text{ psi}})(28\text{ L})(593\cancel{\text{ K}})}{(175\cancel{\text{ psi}})(313\cancel{\text{ K}})} = \frac{(\cancel{175\text{ psi}})(V_2)(\cancel{313\text{ K}})}{(\cancel{175\text{ psi}})(\cancel{313\text{ K}})}$
- solve: $V_2 = 7.6\text{ L}$

Solve the following problems. Required 1-2, 6 Show work on back.

1. A canister containing air has a volume of 85 cm^3 and a pressure of 1.45 atm when the temperature is 310 K. What is the pressure when the volume is increased to 180 cm^3 and the temperature is reduced to 280 K?
2. Air is transferred from a 75 L tank where the pressure is 125 psi and the temperature is 288 K to a tire with a volume of 6.1 L and a pressure of 25 psi. What is the new temperature?
3. A helium balloon at 28°C has a volume of 1.8 L and a pressure of 102 kPa. What is the volume of the balloon when is rises into the atmosphere where the pressure is 85 kPa and the temperature is 4°C?
4. The pressure of a piston with a volume of 650 cm^3 and 85°C is 830 torr. It is heated to 350°C and compressed to a volume of 65 cm^3. What is the new pressure?
5. A gas tank has a volume of 28.1 m^3 and a pressure of 18.4 atm. The temperature of the gas is 32°C. What is the Celsius temperature when the gas is put in an 11.2 m^3 tank with a pressure of 22.7 atm?
6. A metal can is able to withstand 3800 kPa before is bursts. The gas in the can has a volume of 235 mL and the pressure is 110 kPa at 25°C. If the can is crushed to a volume of 8.5 mL and the temperature does not change will it burst? What is the pressure of the gas in the can?

Combined Gas Law 1-2,6

1. $P_2 = ?$

$V_1 = 85 cm^3$

$P_1 = 1.45$ atm

$T_1 = 310$ K

$V_2 = 180 cm^3$

$T_2 = 280$ K

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$P_2 = \frac{P_1V_1T_2}{T_1V_2} = \frac{(1.45 atm)(85 \cancel{cm^3})(280 \cancel{K})}{(310 \cancel{K})(180 \cancel{cm^3})}$$

$$= \boxed{0.62 \text{ atm}} \text{ (2 SF)}$$

2. $T_2 = ?$

$V_1 = 75$ L

$P_1 = 125$ psi

$T_1 = 288$ K

$V_2 = 6.1$ L

$P_2 = 25$ psi

$$T_2 = \frac{P_2V_2T_1}{P_1V_1} = \frac{(25 \cancel{psi})(6.1 \cancel{L})(288 K)}{(125 \cancel{psi})(75 \cancel{L})}$$

$$= \boxed{4.7 K} \text{ (2 SF)}$$

6. $P_2 = ?$

$V_1 = 235$ mL

$P_1 = 110$ kPa

$T_1 = 25°C + 273$

$= 298$ K

$V_2 = 8.5$ mL

$T_2 = 298$ K

$$P_2 = \frac{P_1V_1\cancel{T_2}}{\cancel{T_1}V_2} = \frac{P_1V_1}{V_2} = \frac{(110 kPa)(235 \cancel{mL})}{8.5 \cancel{mL}}$$

$$= 3000 kPa \text{ (2 SF)}$$

$P_2 = 3000$ kPa $<$ 3800 kPa "Burst Pressure"

Can will not burst

Ideal Gas Law
Chem Worksheet 14-4

Name ______________

The ideal gas law is an equation that relates the volume, temperature, pressure and amount of gas particles to a constant. The ideal gas constant is abbreviated with the variable R and has the value of 0.0821 atm·L/mol·K. The ideal gas law can be used when three of the four gas variables are known. When using this equation it is important that the units for **pressure** are atmospheres (atm), **volume** is in liters (L), and **temperature** is converted to kelvins (K). The **amount** of gas is measured in units called moles (mol).

USEFUL EQUATIONS

$PV = nRT$

$R = 0.0821 \frac{atm \cdot L}{mol \cdot K}$

$T_K = T_C + 273$

$1\ cm^3 = 1\ mL$

$1\ L = 1000\ mL$

1.00 atm = 101300 Pa

1.00 atm = 101.3 kPa

1.00 atm = 760 mmHg

1.00 atm = 760 torr

1.00 atm = 14.7 psi

Unknown	Equation	Known Variables
pressure	$P = \frac{nRT}{V}$	amount, temp., volume
volume	$V = \frac{nRT}{P}$	amount, temp., pressure
temperature	$T = \frac{PV}{nR}$	pressure, volume, amount
amount	$n = \frac{PV}{RT}$	pressure, volume, temp.

example

The pressure exerted by 2.8 moles of argon gas at a temperature of 85°C is 420 torr. What is the volume of this sample?

- list the variables: $P = 420\ torr$ $V = ?$ $n = 2.8\ mol$ $R = 0.0821 \frac{atm \cdot L}{mol \cdot K}$ $T = 85°C$
- convert the variables: $\frac{420\ \cancel{torr}}{1} \times \frac{1\ atm}{760\ \cancel{torr}} = 0.553\ atm$ $T = 85°C + 273 = 358\ K$
- substitute into the equation: $V = \frac{nRT}{P}$ $V = \frac{(2.8\ \cancel{mol})(0.08206 \frac{\cancel{atm} \cdot L}{\cancel{mol} \cdot \cancel{K}})(358\ \cancel{K})}{0.553\ \cancel{atm}} = 82\ L$

Solve the following problems. Required 1-4 Show work on back.

1. A tank contains 115 moles of neon gas. It has a pressure of 57 atm at a temperature of 45°C. Calculate the volume of the tank.
2. A scuba tank has a pressure of 195 atm at a temperature of 10°C. The volume of the tank is 350 L. How many moles of air are in the tank?
3. A helium-filled balloon has a volume of 208 L and it contains 9.95 moles of gas. If the pressure of the balloon is 1.26 atm, determine the temperature in Celsius degrees.
4. A tank of oxygen has a volume of 1650 L. The temperature of the gas inside is 35°C. If there are 9750 moles of oxygen in the tank what is the pressure in PSI?
5. A canister of acetylene has a volume of 42 L. The temperature of the acetylene is 305 K and the pressure is 780 torr. Determine the amount (moles) of gas in the canister.
6. Calculate the volume of a CO_2 cartridge that has a pressure of 850 PSI at a temperature of 21°C. The cartridge contains 0.273 mol of CO_2.
7. A tank contains 2500 L of argon gas. The pressure is13790 kPa and the temperature is 25°C. How many moles of argon are in the tank?

Ideal Gas Law 1-4

1. $V = ?$

$n = 115 \text{ mol}$
$P = 57 \text{ atm}$
$T = 45°C + 273$
$= 318 K$

$PV = nRT$

$$V = \frac{nRT}{P}$$

$$V = \frac{(115 \cancel{\text{mol}})\left(0.0821 \frac{\cancel{\text{atm}}\cdot L}{\cancel{\text{mol}}\cdot \cancel{K}}\right)(318 \cancel{K})}{57 \cancel{\text{atm}}}$$

$V = \boxed{53 L}$ (2 SF)

2. $n = ?$

$P = 195 \text{ atm}$
$T = 10°C + 273$
$= 283 K$
$V = 350 L$

$$n = \frac{PV}{RT} = \frac{(195 \cancel{\text{atm}})(350 \cancel{L})}{\left(0.0821 \frac{\cancel{\text{atm}}\cdot \cancel{L}}{\text{mol}\cdot \cancel{K}}\right)(283 \cancel{K})}$$

$n = \boxed{12900 \text{ mol}}$ (2 SF)

3. $T (°C) = ?$

$V = 208 L$
$n = 9.95 \text{ mol}$
$P = 1.26 \text{ atm}$

$$T = \frac{PV}{nR} = \frac{(1.26 \cancel{\text{atm}})(208 \cancel{L})}{(9.95 \cancel{\text{mol}})\left(0.0821 \frac{\cancel{\text{atm}}\cdot \cancel{L}}{\cancel{\text{mol}}\cdot K}\right)}$$

$T = 321 K - 273$
$T °C = \boxed{48°C}$

4. $P (\text{psi}) = ?$

$V = 1650 L$
$T = 35°C + 273$
$= 308 K$
$n = 9750 \text{ mol}$

$$P = \frac{nRT}{V} = \frac{(9750 \cancel{\text{mol}})\left(0.0821 \frac{\text{atm}\cdot \cancel{L}}{\cancel{\text{mol}}\cdot \cancel{K}}\right)(308 K)}{1650 \cancel{L}}$$

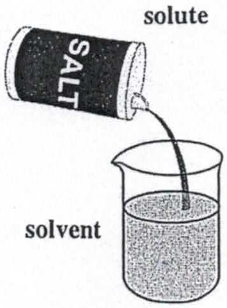
$P = 150 \text{ atm}$ (2 SF)

$$150 \cancel{\text{atm}} \left(\frac{14.7 \text{ psi}}{1 \cancel{\text{atm}}}\right) = \boxed{2200 \text{ psi}}$$

Calculating percent by mass/volume

Chem Worksheet 15-2

Name ______________



Solutions are comprised of two parts – the solute and the solvent. The **solute** is the substance that gets dissolved, and is present in a smaller amount. The **solvent** is the substance that does the dissolving and is present in a greater amount. A solution that has a lot of solute per solvent is described as **concentrated**, while a solution with a small amount of solute is called **dilute**.

The concentration of a solution is commonly given a number value by dividing the moles of the solute by the liters of the solution. This measurement is known as the **molarity** of a solution and it has units of mol/L or *M*. To find the molarity of a solution, you must know the moles of solute and the liters of solution. Recall the grams can be converted to moles using the molar mass. Also remember that the volumes in milliliters can be converted to liters (see table to the right).

USEFUL EQUATIONS

$$\text{molarity} = \frac{\text{mol solute}}{\text{L solution}} \qquad 1\text{ L} = 1000\text{ mL}$$

example

What is the molarity of a solution that contains 7.8 g of $Al(OH)_3$ dissolved in 250.0 mL of water.

- convert grams of solute to moles: $\frac{7.8\text{ g }\cancel{Al(OH)_3}}{1} \times \frac{1\text{ mol }Al(OH)_3}{78.0\ \cancel{\text{g }Al(OH)_3}} = 0.10\text{ mol }Al(OH)_3$

- convert milliliters of solution to liters: $\frac{250.0\ \cancel{\text{mL}}}{1} \times \frac{1\text{ L}}{1000\ \cancel{\text{mL}}} = 0.250\text{ L}$

- divide the moles solute by the liters solution: $\frac{0.10\text{ mol }Al(OH)_3}{0.250\text{ L solution}} = 0.40\ M\ Al(OH)_3$

Required 1-5 Show work on back

Answer the following questions. Show all work and report answers with units.

1. A solution has a volume of 2500 mL. How many liters is this?

2. Convert 50 g of calcium carbonate, $CaCO_3$, into moles.

3. A solution contains 0.42 moles of solute in 0.75 L. Calculate the molarity of the solution.

4. What is the molarity of a solution that contains 15.0 g of NaOH per 500.0 mL of solution?

5. A 250.0 mL solution contains 4.6 g of copper (II) chloride, $CuCl_2$. Find the molarity of this solution.

6. How many moles of hydrochloric acid, HCl, are present in 0.085 L of a 3.0 *M* solution?

7. A 37.5 mL solution contains 0.181 g of potassium chromate, K_2CrO_4. What is the molarity?

8. What is the molarity of a solution that contains 0.85 g of ammonium nitrate, NH_4NO_3, dissolved in a solution with volume 100.0 mL?

9. Calculate the mass of lead (II) nitrate, $Pb(NO_3)_2$, necessary to make 50.0 mL of a 0.100 *M* solution.

10. What volume of a 0.35 *M* solution of sodium chloride could be formed with 25 g of NaCl?

Calculating percent by mass/volume 1-5

1. $2500 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = \boxed{2.5 \text{ L}}$

2. MM $CaCO_3$ = $(40.08) + (12.01) + 3(16.00) = 100.09 \frac{\text{g}}{\text{mol}} CaCO_3$

$50 \text{ g } CaCO_3 \times \frac{1 \text{ mol } CaCO_3}{100.09 \text{ g}} = 0.4995 = \boxed{0.50 \text{ (2 SF)}}$

3. $\frac{0.42 \text{ mol}}{0.75 \text{ L}} = \boxed{0.56 \text{ M}}$

4. MM NaOH = $(22.99) + (16.00) + (1.008) = 39.998 = 40.00 \frac{\text{g}}{\text{mol}}$ NaOH

$15.0 \text{ g NaOH} \times \frac{1 \text{ mol NaOH}}{40.00 \text{ g}} = 0.375 \text{ mol NaOH}$

$\frac{0.375 \text{ mol NaOH}}{.5000 \text{ L solution}} = \boxed{0.750 \text{ M}}$ (3 SF)

5. MM [illegible] $CuCl_2$ = $(63.55) + (2)(35.45) = 134.45 \frac{\text{g } CuCl_2}{\text{mol}}$

~~$4.6 \text{ g } CuCl_2 \times \frac{134.45 \text{ g } CuCl_2}{\text{mol}}$~~

$4.6 \text{ g } CuCl_2 \times \frac{1 \text{ mol } CuCl_2}{134.45 \text{ g}} = 0.034 \text{ mol } CuCl_2$

$\frac{0.034 \text{ mol } CuCl_2}{0.2500 \text{ L solution}} = 0.136 \frac{\text{mol}}{\text{L}} = \boxed{0.136 \text{ M}}$

Solution Stoichiometry
Chem Worksheet 15-6

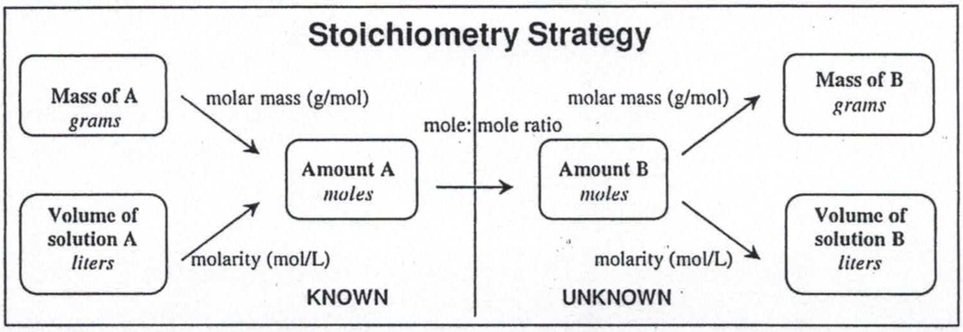
Name ________________

The **molarity** of a solution is a ratio of the moles of solute per liters of solution. The units for molarity are written as mol/L or *M*. This measurement is used to perform stoichiometric calculations. The strategy used for solving these solution stoichiometry problems is to set up the problem so that the units cancel.

USEFUL EQUATIONS

$$\text{molarity} = \frac{\text{mol solute}}{\text{L solution}} \qquad 1\text{ L} = 1000\text{ mL}$$

When the volume of a solution is multiplied by the molarity of a solution the resulting units are moles. A balanced equation allows us to convert from moles of a known substance to moles of an unknown. Finally, the moles of an unknown substance can be converted into grams, liters of solution, molarity, or other units.



Example

How many grams of solid calcium hydroxide, $Ca(OH)_2$, are required to react with 350 mL of 0.40 *M* HCl?

$$\_\_HCl + \_\_Ca(OH)_2 \rightarrow \_\_CaCl_2 + \_\_H_2O$$

- balance the equation: $\underline{2}\,HCl + \_\_Ca(OH)_2 \rightarrow \_\_CaCl_2 + \underline{2}\,H_2O$

- convert mL to L: $\frac{350\,\cancel{mL}\,HCl}{1} \times \frac{1\,L}{1000\,\cancel{mL}} = 0.350\,L\,HCl$

- write the 'given' and 'unknown' units: $\frac{350\,L\,HCl}{1} \times \_\_\_\_ \times \_\_\_\_ \times \_\_\_\_ = \text{ grams } Ca(OH)_2$

- fill in factors and solve: $\frac{0.350\,\cancel{L\,HCl}}{1} \times \frac{0.40\,\cancel{mol\,HCl}}{1\,\cancel{L\,HCl}} \times \frac{1\,\cancel{mol\,Ca(OH)_2}}{2\,\cancel{mol\,HCl}} \times \frac{74.10\,g\,Ca(OH)_2}{1\,\cancel{mol\,Ca(OH)_2}} = 5.19\text{ grams } Ca(OH)_2$

Required 1-4
Show work on back

Answer the following questions. Show all work and report answers with units.

1. How many grams of aluminum are required to react with 35 mL of 2.0 *M* hydrochloric acid, HCl?
   $\underline{6}\,HCl + \underline{2}\,Al \rightarrow \underline{2}\,AlCl_3 + \underline{3}\,H_2$

2. How many grams of sodium can be reacted with 750 mL of a 6.0 *M* solution of sulfuric acid, H_2SO_4?
   $\_\_Na + \_\_H_2SO_4 \rightarrow \_\_Na_2SO_4 + \_\_H_2$

3. If 45 mL of a 1.5 *M* $AgNO_3$ is added to KCl how many grams of AgCl can be formed?
   $\_\_AgNO_3 + \_\_KCl \rightarrow \_\_AgCl + \_\_KNO_3$

4. How many liters of a 0.75 *M* solution of $Ca(NO_3)_2$ will be required to react with 148 g of Na_2CO_3?
   $\_\_Ca(NO_3)_2 + \_\_Na_2CO_3 \rightarrow \_\_CaCO_3 + \_\_NaNO_3$

5. How many liters of a 3.0 *M* H_3PO_4 solution are required to react with 4.5 g of zinc?
   $\_\_H_3PO_4 + \_\_Zn \rightarrow \_\_Zn_3(PO_4)_2 + \_\_H_2$

6. How many milliliters of 0.10 *M* $Pb(NO_3)_2$ are required to react with 75 mL of 0.20 *M* NaI?
   $\_\_Pb(NO_3)_2 + \_\_NaI \rightarrow \_\_PbI_2 + \_\_NaNO_3$

7. How many grams of solid $BaSO_4$ will form when Na_2SO_4 reacts with 25 mL of 0.50 *M* $Ba(NO_3)_2$?
   $\_\_Ba(NO_3)_2 + \_\_Na_2SO_4 \rightarrow \_\_BaSO_4 + \_\_NaNO_3$

8. If 525 mL of 0.80 *M* HCl solution is neutralized with 315 mL of $Sr(OH)_2$ solution what is the molarity of the $Sr(OH)_2$?
   $\_\_HCl + \_\_Sr(OH)_2 \rightarrow \_\_SrCl_2 + \_\_H_2O$

Solution Stoichiometry 1-4

1. $$6\,HCl + \underset{g?}{2Al} \rightarrow 2AlCl_3 + 3H_2$$

$$0.035\,\cancel{L} \times \frac{2.0\text{ mol }HCl}{\cancel{L}} = 0.070\text{ mol }HCl$$

$$0.070\text{ mol }\cancel{HCl} \times \frac{2\text{ mol }\cancel{Al}}{6\text{ mol }\cancel{HCl}} \times \frac{26.98\text{ g }Al}{1\text{ mol }\cancel{Al}} = .62.95\text{ g} = \boxed{.63\text{ g }Al}$$

(2 SF)

2. $$\underset{g?}{2Na} + H_2SO_4 \rightarrow Na_2SO_4 + H_2$$

$$0.750\,\cancel{L} \times \frac{6.0\text{ mol }H_2SO_4}{\cancel{L}} = 4.5\text{ mol }H_2SO_4$$

$$4.5\text{ mol }\cancel{H_2SO_4} \times \frac{2\text{ mol }\cancel{Na}}{1\text{ mol }\cancel{H_2SO_4}} \times \frac{22.99\text{ g }Na}{1\text{ mol }\cancel{Na}} = 206.91\text{ g} = \boxed{210\text{ g }Na}$$

(2 SF)

3. $$AgNO_3 + KCl \rightarrow \underset{g?}{AgCl} + KNO_3$$

$$0.045\,\cancel{L} \times \frac{1.5\text{ mol }AgNO_3}{1\,\cancel{L}} = 0.068\text{ mol }AgNO_3$$

$$0.068\text{ mol }\cancel{AgNO_3} \times \frac{1\text{ mol }\cancel{AgCl}}{1\text{ mol }\cancel{AgNO_3}} \times \frac{143.32\text{ g }AgCl}{1\text{ mol }\cancel{AgCl}} = \boxed{9.75\text{ g }AgCl}$$

$$MM\ AgCl = (107.87) + (35.45) = 143.32\,\frac{g}{mol}\ AgCl$$

4. $$\underset{?}{Ca}(NO_3)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaNO_3$$

$$MM\ Na_2CO_3 = 2(22.99) + (12.01) + (3)(16.00) = 105.99\,\frac{g\ Na_2CO_3}{mol}$$

$$148\,\cancel{g\ Na_2CO_3} \times \frac{1\text{ mol }\cancel{Na_2CO_3}}{105.99\,\cancel{g}} \times \frac{1\text{ mol }Ca(NO_3)_2}{1\text{ mol }\cancel{Na_2CO_3}} = 1.40\text{ mol }Ca(NO_3)_2$$

how much?

$$\left\{\frac{0.75\text{ mol }Ca(NO_3)_2}{L}\right\}$$

$$1.40\text{ mol }\cancel{Ca(NO_3)_2} \times \frac{1\text{ L}}{0.75\,\cancel{\text{mol }Ca(NO_3)_2}} = \boxed{1.87\text{ L}}$$