Chemistry.

moles and stoichiometry.

Equations.

1- metal + acid → salt + H_2 ✓

2. metal oxide/hydroxide + acids → salt + H_2O ✓
NH_4OH

3- metal carbonate + acid → salt + H_2O + CO_2 ✓
$(NH_4)_2CO_3$

4- ammonia + acid → ammonium salts

5- ammonium salt + base → salt + H_2O + NH_3

6- ionic precipitation

$MgCO_3 \rightarrow MgO + CO_2$

7. metal carbonate → metal oxide + CO_2

$Mg(NO_3)_2 \rightarrow MgO + 2NO_2 + \frac{1}{2}O_2$

8. metal nitrate → metal oxide + NO_2 + O_2

(Gp1 nitrate → metal nitrite + O_2)

$NaNO_3 \rightarrow NaNO_2 + O_2$

9. metal + H_2O → metal hydroxide + H_2

$Na + H_2O \rightarrow NaOH + H_2$

10 displacement reactions. $Mg + CuSO_4 \rightarrow MgSO_4 + Cu$

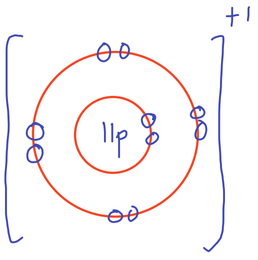
11 metal hydroxide → metal oxide + H_2O.

$Mg(OH)_2 \rightarrow MgO + H_2O$

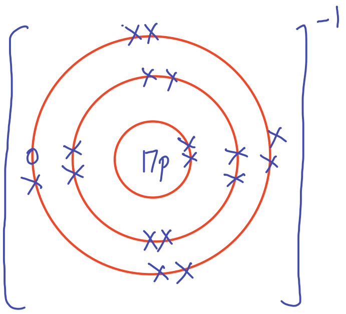
Formulas

metal
lose e
+ve

nonmetal
gain e^-
-ve



Na



Cl

$Na^+ Cl^- \rightarrow NaCl$

sodium chloride

lose e^-
metals

gradual change

gain e
nonmetals

Key
relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	[285] **Cn** copernicium 112	[286] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[294] **Ts** tennessine 117	[294] **Og** oganesson 118

$_3Li$ $_9F$

+3 +9 more +ve charge nucleus
more attraction e^-

metal nonmetals.

Gp1	Gp2	~~transition metal~~ d-block elements	Gp13	Gp14	Gp15	Gp16	Gp17	Gp18
+1	+2		+3	+4/-4	-3	-2	-1	
	Mg				N			

+ve -ve

Mg^{+2} N^{-3} ⟶ Mg_3N_2 Magnesium Nitr~~ogen~~ide

loses 2e = gains 3e
x 3 x 2

6e = 6e

Al^{+3} F^{-1} ⟶ Al_1F_3 Aluminium Flor~~ine~~ide

Al^{+3} O^{-2} ⟶ Al_2O_3 Aluminium Ox~~ygen~~ide

– ide   −ve ion of an element

phosphide P^{-3} (not phosphate PO_4^{-3} or phosphite PO_3^{-3})
sulfide S^{-2}
bromide Br^{-1}
carbide C^{-4}

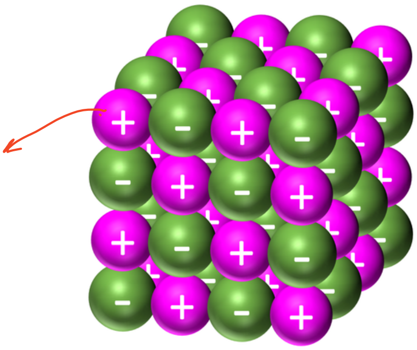
3000 Na^+ 1000 P^{-3}

1. Na + P Na^{+1} P^{-3} → $\boxed{Na_3P}$ sodium phosphide
2. Mg + S Mg^{+2} S^{-2} → Mg_1S_1 magnesium sulfide
3. Ba + N
4. Ca + F
5. Al + S Al^{+3} S^{-2} → Al_2S_3 Aluminium Sulfide
6. K + N

Structures of Ionic Compounds

- Giant Ionic Lattice (Crystalline)

$\overset{+}{Na}\overset{-}{Cl}$ → formula unit, ratio of ions



50 x Na^+ 50 x Cl^-

1million Na^+ 1million Cl^-

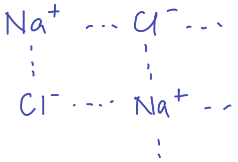
regular arrangement of +ve and -ve ions

1. high MP / BP (mostly solids)

strong attraction b/w +ve and −ve ions
giant ionic lattice with many ionic bonds

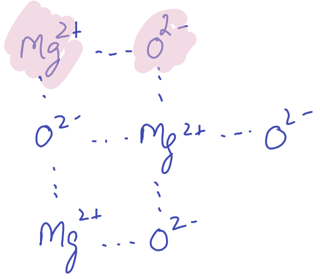
e.g Marble, Cement/Concrete, Ceramics
(really strong)

Strength of ionic lattice

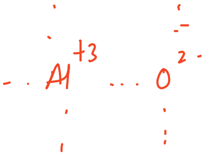


1 - greater charge on ion
stronger attraction.

2 - smaller ions, closer
together in the ionic lattice
stronger attraction



stronger attraction



$\overset{+1}{Na}\overset{-1}{Cl}$ vs $\overset{+1}{K}\overset{-1}{Cl}$

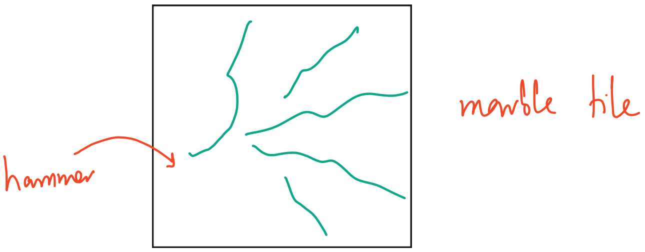
↓ smaller ion
stronger lattice

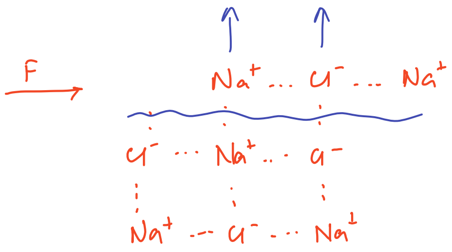
↓ bigger ions

Very Strong / high Melting Points → Ceramics

MgO, Al_2O_3 are often ceramics
(for making furnaces, oven trays, electricity holders/device covers)

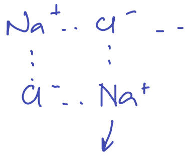
- Ionic Compounds are brittle





3. Ionic Lattices conduct electricity when molten or aqueous

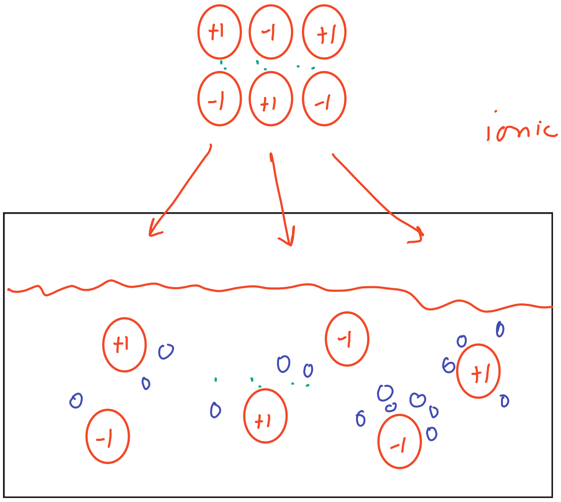
free moving ions .



no electricity conduction happens in solid state .

4. Solubility .

weak lattice , more soluble
strong lattice , less soluble



ionic compounds dissociated in aqueous .

solubility depends on the stregnth of your lattice

Gp1 - +1
Gp2 - +2
Gp3 - +3
Gp4 - +4/-4
Gp5 - -3
Gp6 - -2
Gp7 - -1

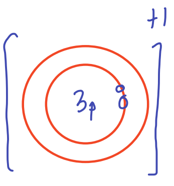
transition metals - variable charges

Polyatomic Ions - molecules that end up gaining or losing e⁻

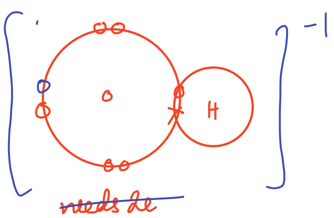
OH^-	hydroxide
SO_4^{-2}	sulfate
SO_3^{-2}	sulfite
NO_3^{-1}	nitrate
NO_2^{-1}	nitrite
PO_4^{-3}	phosphate
PO_3^{-3}	phosphite
CO_3^{-2}	carbonate
NH_4^{+1}	ammonium

HCO_3^-	hydrogencarbonate (bicarbonate)
HSO_4^-	hydrogen sulfate
$Cr_2O_7^{2-}$	dichromate (VI)
MnO_4^-	mangnate (VII)
CN^{-1}	cyanide

hydroxide



Li Gp1
metal



~~needs 2e~~
needs 1e

Formula

+ve ion   -ve ion

Mg^{+2} N^{-3} → Mg_3N_2

Calcium Nitrate

Ca^{+2} NO_3^{-1}

$Ca_1(NO_3)_2$.

Aluminium Carbonate

Al^{+3} CO_3^{-2}

loses 3e   gains 2e

$Al_2(CO_3)_3$

ammonium phosphate

NH_4^{+1} PO_4^{-3}

$(NH_4)_3PO_4$

Aluminium hydroxide

Al^{+3} OH^{1-}

$Al(OH)_3$

Iron (III) sulfate

Fe^{3+} SO_4^{-2}

$Fe_2(SO_4)_3$

tin (IV) carbonate

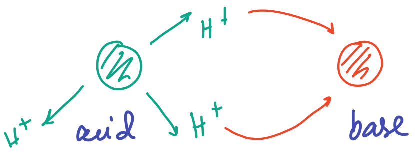
Sn^{+4} CO_3^{-2}

$Sn_{\cancel{2}}(CO_3)_{\cancel{4}2}$.

Acids and Bases Reactions

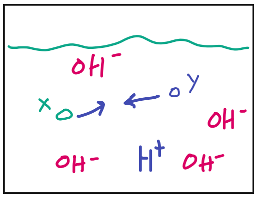
Acids → proton (H^+) donor

Bases → proton (H^+) acceptor .



H_2O is important on planet Earth

H_2O is the main solvent / medium



$$H_2O \rightleftharpoons \underset{\sim}{H^+} + \underset{\sim}{OH^-}$$

$[H^+] = [OH^-]$ neutral $pH = 7$

$\uparrow [H^+] > [OH^-] \downarrow$ acidic $pH < 7$ → digestive juices strongly acidic $pH = 2$

$\downarrow [H^+] < [OH^-] \uparrow$ basic $pH > 7$ → blood, slightly basic "7.44"

reactions are very sensitive to pH

Acids produces H^+ ions

$H^+ X^{-1} \rightarrow HX$

citric acid

malic acid

amino acid

acetic acid (vinegar) .

$H^+ Cl^- \rightarrow HCl$ hydrochloric acid

$H^+ SO_4^{-2} \rightarrow H_2SO_4$ sulfuric acid

$H^+ PO_4^{-3} \rightarrow H_3PO_4$ phosphoric acid

$H^+ NO_3^- \rightarrow HNO_3$ nitric acid

$H^+ CO_3^{-2} \rightarrow H_2CO_3$ carbonic acid

$H^+ NO_2^- \rightarrow HNO_2$ nitrous acid

$H^+ SO_3^{-2} \rightarrow H_2SO_3$ sulfurous acid

$H^+ PO_3^{-3} \rightarrow H_3PO_3$ phosphorous acid

Bases accept H^+ (produce OH^-) $H^+ \downarrow$ $OH^- \uparrow$

+ve ion O^{-2} + $2H^+$ → H_2O

+ve ion OH^{-1} + H^+ → H_2O

weakly basic
+ve ion CO_3^{-2} + $2H^+$ → H_2O + CO_2
NH_3 + H^+ → NH_4^+

- metal oxide $M^+ O^{-2}$
- metal hydroxide or ammonium hydroxide
  $M^+ OH^-$ $NH_4^+ OH^-$
- metal carbonates or ammonium carbonate
  $M^+ CO_3^{-2}$ $NH_4^+ CO_3^{-2}$

1- metal oxide / hydroxide + acids → salt + H_2O

$Mg(OH)_2 + 2[HNO_3] \rightarrow Mg(NO_3)_2 + 2(H_2O)$

accepts H^+ produces H^+

are neutral compounds when acids/ bases react

$Al(OH)_3 + 3\{HCl\} \rightarrow AlCl_3 + 3\{H_2O\}$

$3[Ca(OH)_2] + 2[H_3PO_4] \rightarrow [Ca_3(PO_4)_2] + 6[H_2O]$

Ca	O	H	P
2	4	3	2
✓		✓	✓

start balancing the easiest first (elements that appear the least) sodium hydroxide + phosphoric acid

Iron (III) hydroxide + phosphoric acid.

Aluminium oxide + sulfuric acid

Barium hydroxide + nitric acid.

Copper (I) oxide + phosphoric acid.

potassium oxide + sulfurous acid.

$Al(OH)_3 + 3\{\underline{\underline{H}}NO_3\} \longrightarrow Al(NO_3)_3 + 3H_2O$

2. $\boxed{\text{metal} + \text{acid} \longrightarrow \text{salt} + H_2 .}$

redox reaction

some metals are very reactive while others are very unreactive

$Mg + 2[\underline{\underline{H}}Cl] \longrightarrow MgCl_2 + H_2$

$2\,Al + 3[\underline{\underline{H}}_2SO_4] \longrightarrow Al_2(SO_4)_3 + 3[H_2]$

$3\,Ca + 2[\underline{\underline{H}}_3PO_4] \longrightarrow \overset{+2}{Ca_3}(\overset{-3}{PO_4})_2 + 3H_2$

3- carbonate + acid → salt + H_2O + CO_2

$X^+ CO_3^{-2}$

$3\{Na_2CO_3\} + 2\{\underline{\underline{H}}_3PO_4\} \rightarrow 2\{Na_3PO_4\} + 3\{H_2O\} + 3\{CO_2\}$

$\overset{+2}{Ca}\overset{-2}{CO_3} + 2\{\underline{\underline{H}}Cl\} \rightarrow \overset{+2}{Ca}\overset{-1}{Cl_2} + H_2O + CO_2$.

$\overset{+3}{Al_2}(\overset{-2}{CO_3})_3 + 6[\underline{\underline{H}}NO_3] \rightarrow 2[\overset{+3}{Al}(\overset{-1}{NO_3})_3] + 3\{H_2O\} + 3[CO_2]$

$3\{MgCO_3\} + 2[\underline{\underline{H}}_3PO_4] \rightarrow \overset{2+}{Mg_3}(\overset{3-}{PO_4})_2 + 3[H_2O] + 3[CO_2]$

4- ammonia + acid → ammonium salt

frequently used as NPK fertilizers

$NH_3 + \underline{\underline{H}}Cl \rightarrow NH_4^+ Cl^-$

NH_3 base accept H^+

HCl produces H^+

$NH_3 + \underline{\underline{H}}_2SO_4 \rightarrow (NH_4^+)_2 SO_4^{-2}$

$NH_3 + \underline{\underline{H}}_3PO_4 \rightarrow (NH_4^+)_3 PO_4^{-3}$

$NH_3 + \underline{\underline{H}}NO_3 \rightarrow NH_4^+ NO_3^-$

5- ammonium salt (acid) + metal oxide/hydroxide (base) → Salt + H_2O + NH_3

$$\underbrace{NH_4^+}_{\text{produces } H^+} Cl^- + Na\underbrace{OH}_{\text{gains } H^+} \rightarrow NaCl + H_2O + NH_3$$

$$2\left[(NH_4^+)_3 PO_4^{-3}\right] + 3\left[Ba(OH)_2\right] \rightarrow Ba_3^{2+}(PO_4^{3-})_2 + 6\left[H_2O\right] + 6\left[NH_3\right]$$

$$(NH_4^{+1})_2 SO_4^{-2} + 2\left[KOH\right] \rightarrow K_2^+ SO_4^{-2} + 2\left[H_2O\right] + 2\left[NH_3\right]$$

1- Calcium oxide + sulfuric acid

2 - " + phosphoric acid

3 - Iron (III) carbonate + hydrochloric acid

4 Iron (III) carbonate + sulfuric acid

5- ammonium nitrate + calcium oxide

ammonium chloride + Iron (III) hydroxide

Moles and Stoichiometry

1 mol number of particles equal to avagadro's constant

$$\begin{tikzcd} 2 \text{ dozen} \arrow[r, bend left, "\times 12"] & 24 \arrow[l, bend left, "\div 12"] \end{tikzcd}$$

$$\begin{tikzcd} 1 \text{ billion} \arrow[r, bend left] & 1\,000\,000\,000 \arrow[l, bend left] \end{tikzcd}$$

$$\begin{tikzcd} 100 \text{ thousand} \arrow[r, bend right, "\times 1000"'] & 100000 \arrow[l, bend right, "\div 1000"'] \end{tikzcd}$$

$$\boxed{\text{mol} = \frac{\text{number of particles}}{6.02 \times 10^{23}}.}$$

$1 \text{ mol} - 6.02 \times 10^{23}$

$2.47 \text{ mol} - x$

$x = 2.74 \times 6.02 \times 10^{23}$

$= \underline{1.649 \times 10^{24}}$

(a) 10×10^{26} atoms of Na $\rightarrow (10 \times 10^{26}) / (6.02 \times 10^{23})$.

1661 mol.

(b) 11.23×10^{18} molecules of Cl_2 $\rightarrow \dfrac{(11.23 \times 10^{18})}{(6.02 \times 10^{23})} = 1.865 \times 10^{-5}$ mol

(c) 8×10^{21} atom $\rightarrow$ 0.0133 mol

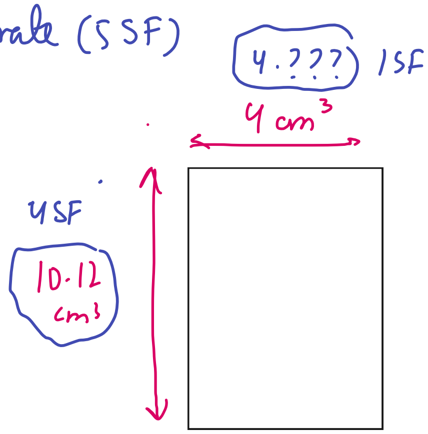
Significant figures

→ represent accuracy.

2.22, 2.01 ← 2.???? not accurate (1SF)

2.00??

2.0000?? more accurate (5SF)



$A = L \times W.$

4SF 1SF

$= \underline{10.12} \times \underline{4}.???$

$= \overset{?\,?\,?}{40.48} \text{ cm}^3$

$= 40 \text{ cm}^3$ 1SF

Answers are only accurate upto the least SF value.

$n = c \times V$

$= 0.120 \times 12/1000$

$= 0.00144$ ~~mol~~

0.0014 mol.

$c = 0.120$ mol/dm³ 3SF

$V = 12$ cm³ 2SF ✓

$$\boxed{\text{mol} = \frac{\text{mass}}{A_r/M_r}}$$

relative atomic (molecular) mass

average mass of an atom compared to 1/12th the mass of C-12 atom

1 mol — molar mass (A_r/M_r expressed in grams).

1 mol of Na — 23g.

10 mol of Na — 230g

2 mol of Na — 46g.

12 → proton no / always a whole number ~~12.0~~

Mg 24.3 → relative atomic mass

always a decimal value

average value of isotopes of Mg

~~→~~ not the nucleon number (very close but different) → number (protons + neutrons)

3p + 4n

always a whole number

3p + 4n

nucleon = 7

$3\times(1.00727) + 4\times(1.0086) =$

(a) 200g of Na_2O

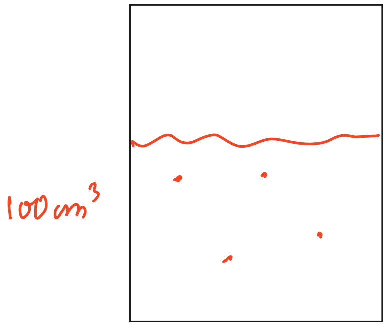
$$n = \frac{200}{(23.0\times2 + 16.0)} = 3.23\text{mol}$$

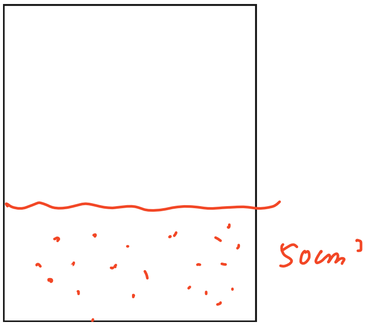
(b) 50.0 g of $Cu_3(PO_4)_2$

$$n = \frac{50}{63.5\times3 + (31.0 + 16.0\times4)\times2}$$

$$= 0.131\text{mol}$$

Solutions (or gases)





$$\text{concentration} = \frac{\text{mol}}{\text{Vol(dm}^3)} \qquad \text{mol/dm}^3.$$

$$C = \frac{n}{V}$$

$$\boxed{n = c \times V}$$

mol/dm^3 dm^3

$$\begin{tikzcd} cm^3 \arrow[r, "\div 1000"] & dm^3 \arrow[l, bend left, "\times 1000"] \arrow[r, "\div 1000"] & m^3 \arrow[l, bend left, "\times 1000"] \end{tikzcd}$$

(a) 500g NaCl dissolved in 10000 cm^3 ✓ water.

$$n = \frac{500}{23.0 + 35.5}$$

$$C = \frac{n}{V} = \frac{8.55\text{mol}}{10\text{dm}^3} = 0.855 \text{ mol/dm}^3$$

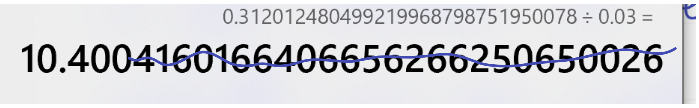
In a multi-step reaction, don't round off values on your calculator at each step.

round off, once you reach the final answer

$n = \frac{20.0 \text{ g}}{(32.1+16\times2)}$

$C = \frac{n}{0.03 \text{ dm}^3}$

$\frac{0.312}{0.03} = \underline{\underline{10.4}}$



0.312012480499219968798751950078 ÷ 0.03 =

10.400~~4160166406656266250650026~~

10.4.

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moles and gases

1 mol of gas — 24 dm³ at r.t.p

make sure things are at r.t.p

$$\boxed{n = \frac{\text{Vol of gas}}{24 \text{ dm}^3}}$$

- 0.56 moles of $N_2(g)$
  $V = 13 \text{ dm}^3$
- 500 cm³ of O_2 gas
  $\text{mol} = \frac{(500/1000)}{24 \text{ dm}^3} = 0.0208 \text{ mol}$

if not at r.t.p, don't use this formula.

$\text{mol} = \frac{\text{number of particles}}{6.02 \times 10^{23}}$

$\text{mol} = \frac{\text{mass}}{Ar | Mr}$

$\text{mol} = \text{Vol} \times \text{conc}$
(dm^3)

$\text{mol} = \frac{\text{vol of gas}}{24 \text{dm}^3}$

mol, eqts and ratios

$$6\left[Na\right] + 2\left\{H_3PO_4\right\} \longrightarrow 2\left\{Na_3PO_4\right\} + 3\left[H_2\right]$$

ratio of moles

6 :	2	2 :	3
600	200	200	300
$\boxed{0.56\,mol}$	0.19 mol	$\frac{0.56}{6}\times 2$	$\frac{0.56}{6}\times 3$
		0.19 mol .	0.28 mol

6 : 2

0.56 : x

x = 0.56×2/6

$$2\left\{P_2\right\} + 5\left\{O_2\right\} \longrightarrow 1\left\{P_4O_{10}\right\}$$

$\frac{0.85}{5}\times 2$	0.85 mol	$\frac{0.85}{5}\times 1$
0.34 mol		0.17 mol

$$6\,NaOH + 3Cl_2 \longrightarrow 5NaCl + NaClO_3 + 3H_2O$$

$\frac{2.25}{5}\times 6$	$\frac{2.25}{5}\times 3$	2.25 mol	$\frac{2.25}{5}\times 1$	1.35 mol
2.7 mol	1.35 mol		0.45 mol	

25.0g of $CaCO_3$ reacts with 400 cm³ H_3PO_4 acid

(i) Find concentration of H_3PO_4

(ii) Find mass of salt produced

(iii) Find vol. of CO_2 produced.

$$3\ CaCO_3 \ + \ 2\ H_3PO_4 \longrightarrow Ca_3(PO_4)_2 \ + 3\ H_2O \ + \ 3\ CO_2$$

0.250mol

$$\frac{0.250\times2}{3} \qquad \frac{0.250\times1}{3}$$

$$n = 25g/40.1 + 12.0 + 16.0\times3$$

$$= 25/100.1 = 0.250\,mol$$

0.167mol

0.0833mol

0.250mol

0.250 mol

$$n = C \times V$$

$$0.167 = C \times 0.4\,dm^3$$

$$C = 0.418\,mol/dm^3$$

$$n = \frac{V}{24\,dm^3}$$

$$0.250 \times 24 = V$$

$$V = 6.00\,dm^3$$

$$n = m/(Ar/Mr)$$

$$m = 0.0833 \times (40.1\times3 + 31.0\times2 + 16.0\times8)$$

$$m = 25.9g.$$

Al reacts with 0.250mol/dm³ sulfuric acid and produces 1500 cm³ of H_2 (g)

i. Find mass of Al

ii Find vol of sulfuric acid

$$2\,Al + 3\,H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\,H_2$$

$\frac{0.0625}{3} \times 2$ 0.0625mol 0.0625mol

0.0417 mol

$n = \frac{1.5 dm^3}{24 dm^3}$

$n = C \times V$

$0.0625 mol = 0.250 \times V$

$V = 0.25 dm^3$

$0.0417 mol \times 27 = m$

$m = 1.125g$

✓

30g of ammonium phosphate reaching with 0.15 mol/dm³ NaOH.

Find Volume of NaOH

Find mass of salt produced ✓

Find volume of NH_3 (g) produced

$n = \frac{V}{24 dm^3}$

$0.603 \times 24 =$

$$\overset{0.201mol}{(NH_4)_3PO_4} + \overset{0.603mol}{3\,NaOH} \rightarrow \overset{0.201mol}{Na_3PO_4} + \overset{0.603mol}{3\,H_2O} + \boxed{\overset{0.603mol}{3\,NH_3}}$$

$n = \frac{30}{(95 + 18 \times 3)}$

$n = c \times V$

$V = 0.603 / 0.15 = 4.02 dm^3$

$m = 0.201 \times 164$

$= 32.964g$

Limiting and excess reactant

$NaOH + HCl \rightarrow NaCl + H_2O$

1 ✓ :	1 ✓		
L.R 0.21 mol	excess 0.~~78~~ mol only 0.21 mol react	0.21 mol	0.21 mol

only limiting reactant moles used

excess reactant moles are never used

3 :	1		
$3Ca$ +	H_3PO_4 →	$Ca_3(PO_4)_2$ +	$3H_2O$
0.6 mol	~~0.5 mol~~	0.2 mol	0.6 mol.
$\frac{0.6}{3}$	$\frac{0.5}{1}$ ✓		

2 :	5.	
$2P_2$ +	$5O_2$ →	P_4O_{10}
0.15 mol	~~0.40 mol~~	
$\frac{0.15 \text{ mol}}{2} = 0.075$	$\frac{0.40 \text{ mol}}{5} = 0.08$ ✓	

1 : 2

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

~~0.50 mol~~ ✓ 0.40 mol.

$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2$

~~0.5 mol~~ ✓ 2.0 mol ? ?

$0.5/1 > 2/6$

$2Na + Cl_2 \rightarrow 2NaCl$

0.15 mol ~~0.10 mol~~ ?

0.075 mol

$\frac{0.15}{2} < \frac{0.1}{1}$

moles and gas volume

mol ratio : and vol. ratio of gases is the same

$$\begin{array}{ccccc} 1 & & 3 & & 2 \\ N_2 & + & 3H_2 & \longrightarrow & 2NH_3 \\ 1000\,cm^3 & & 3000cm3 & & 2000\,cm^3 \end{array}$$

$$\begin{array}{ccccc} 1 & & 1 & & 2 \\ H_2 & + & Cl_2 & \longrightarrow & 2HCl \\ 500\,cm^3 & & & & 1000\,cm^3 \end{array}$$

$$\begin{array}{ccc} N_2O_4 & \longrightarrow & 2NO_2 \\ 4500\,cm^3 & & 9000\,cm^3 \end{array}$$

Combustion Analysis

$$\boxed{C_xH_y} + O_2 \longrightarrow CO_2 + H_2O$$

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

$$C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$$

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$