Radioactivity

Revisions

4. a) $^{244}_{96}Cm \rightarrow ^{4}_{2}He + ^{240}_{94}Pu$

b) $^{210}_{83}Bi \rightarrow ^{0}_{-1}\beta + ^{210}_{84}Po$

c) $^{74}_{35}Br \rightarrow ^{4}_{2}He + ^{70}_{33}As$

d) $^{116}_{50}Sn \rightarrow ^{0}_{-1}\beta + ^{116}_{51}Sb$

e.) $^{205}_{81}Tl \rightarrow 2\,^{0}_{-1}\beta + ^{205}_{83}Bi \longrightarrow ^{4}_{2}He + ^{201}_{81}Tl$

Sci. Notation Operations

3.) a) $6.91 \times 10^{-2} + 2.4 \times 10^{-3} = 7.15 \times 10^{-2}$

0.24×10^{-2}

b.) $9.7 \times 10^{6} + 8.3 \times 10^{5} = 10.53 \times 10^{6}$

0.83×10^{5} $\quad 1.053 \times 10^{7}$

c.) $3.67 \times 10^{2} - 1.6 \times 10^{1} = 3.51 \times 10^{2}$

d.) $4.3 \times 10^{8} \times 2.0 \times 10^{6} = 8.6 \times 10^{14}$

e.) $6.0 \times 10^{3} \times 1.5 \times 10^{-2} = 9.0 \times 10^{1}$

f.) $7.8 \times 10^{3} \div 1.2 \times 10^{4} = 6.5 \times 10^{-1}$

Light Energy Calcs

11) $9.31 \times 10^{-19} J = E_t$

$1.5 \times 10^{15} Hz = \nu_i$

$E_i = h\nu_i = 6.626 \times 10^{-34} Js \times 1.5 \times 10^{15} \frac{1}{s}$

$= 9.939 \times 10^{-19} J$

$E_i > E_t$ so yes!

13. $\lambda_t = 275 nm$

a) $E_t = \frac{hc}{\lambda_t} = \frac{6.626\times10^{-34} J s \times 3\times10^{8} \frac{m}{s}}{275\times10^{-9} m}$

$E_t = 7.23\times10^{-19}$

b) $2.5\times10^{15} Hz = \nu_i$

$E_i = h\nu_i = 6.626\times10^{-34} J s \times 2.5\times10^{15} \frac{1}{s}$

$E_i = 1.66\times10^{-18} J$

$E_i > E_t \rightarrow$ yes!

Mid-Term Review Answers

Conversions

1) cm = ?
   Km = 3.25
   100cm = 1m
   1000m = 1Km

$$3.25\text{Km} \times \frac{1000\text{m}}{1\text{Km}} \times \frac{100\text{cm}}{1\text{m}} = 325000\text{cm}$$

2.) mL = ?
   5.67 = L
   1L = 1000mL

$$5.67\text{L} \times \frac{1000\text{mL}}{1\text{L}} = 5670\text{mL}$$

3.) 47.5 = cm^3
   L = ?
   $1\ cm^3 = 1\ mL$
   1000mL = 1L

$$47.5\text{mL} \times \frac{1\text{L}}{1000\text{mL}} = .0475\text{L}$$

4) mL = ?
   60 = L
   1L = 1000mL

$$60\text{L} \times \frac{1000\text{mL}}{1\text{L}} = 60000\text{ mL}$$ or 6.0×10^4 mL

5.) nm = ?
   0.0023 = m
   1×10^9 nm = 1m
   1000 mm = 1m

$$.0023\text{mm} \times \frac{1\text{m}}{1000\text{mm}} \times \frac{1\times10^9\text{nm}}{1\text{m}} = 2300\text{nm}$$

6.) 3.337 = g/cm^3
   ? = Kg/mL
   $1\ cm^3 = 1\ mL$
   1000g = 1Kg

$$3.337\ g/cm^3 \times \frac{1\text{Kg}}{1000\text{g}} = .003337\ Kg/cm^3 =$$

.003337 Kg/mL

Formula Problem Solving

1) $D = 11.34\ g/cm^3$

$m = 5.62\ g$

$V = ?$

$D = \frac{m}{V} \rightarrow V = \frac{m}{D} = \frac{5.62\ g}{11.34\ g/cm^3} = 0.450\ cm^3$

2) $D = ?$

$m = 25\ g$

$V = 29.4\ cm^3$

$D = \frac{m}{V} \quad \frac{25\ g}{29.4\ cm^3} = 0.85\ g/cm^3$

3) $3\ cm \times 6\ cm \times 4\ cm = V = 72\ cm^3$

(l, w, h)

$80\ g = m$

$D = ?$

$D = \frac{m}{V} \quad \frac{80\ g}{72\ cm^3} = 1.11\ g/cm^3$ ← more dense than 1 sinks!

4.) $96\ m/s$ = velocity (speed)

$17\ s = t$

$v = d/t \quad vt = d$

$d = ?$

$96\ \frac{m}{s} (17\ s) = 1632\ m$ away

OR

$96\ \frac{m}{s} \times \frac{17\ s}{1} = 1632\ m$

5.) $350{,}000\ m = d$

$80\ km/hr$ = velocity

$1\ km = 1000\ m$

$350{,}000\ m \times \frac{1\ km}{1000\ m} = 350\ km$

$v = \frac{d}{t} \rightarrow t = \frac{d}{v} \quad \frac{350\ km}{80\ km/hr} = 4.38\ hrs.$

Also:

$350\ km \times \frac{hr}{80\ km} = 4.38\ hr$

6.) min = ?

450 km = d

120 m/s = v

1000 m = 1 km

$v = \frac{d}{t} \rightarrow t = \frac{d}{v}$

60 s = 1 min

$450 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} = 450{,}000 \text{ m}$

$t = \frac{450000 \text{ m}}{120 \text{ m/s}} = 3750 \text{ s}$

$450{,}000 \text{ m} \times \frac{\text{s}}{120 \text{ m}} = 3750 \text{ s}$

$3750 \text{ s} \times \frac{1 \text{ min}}{60 \text{ s}} = 62.5 \text{ min}$

7.) 500 N = F

$5 \text{ m}^2 = A$

P = ?

$P = F/A$

$\frac{500 \text{ N}}{5 \text{ m}^2} = 100 \text{ N/m}^2 = P$

8.) 500 N + 500 N = F

1000 N = F

$5 \text{ m}^2 = A$

P = ? $P = \frac{F}{A}$

$\frac{1000 \text{ N}}{5 \text{ m}^2} = 200 \text{ N/m}^2 = P$

9.) 600 N = F

$0.5 \text{ m}^2 = A$ $P = \frac{600 \text{ N}}{0.5 \text{ m}^2} = 1200 \frac{\text{N}}{\text{m}^2}$

$P = ? \rightarrow P = \frac{F}{A}$

Error / % Error

1.) 6.82 g/mL = Experimental

6.95 g/mL = Actual

$\frac{|6.82 - 6.95|}{6.95} \times 100 = 1.87\%$ error

2) accepted = 6.3 g

a) 6.022 g $\frac{|6.022 - 6.3|}{6.3} \times 100 = 4.41\%$ ← most precise - most sig figs.

b) 6.51 $\frac{|6.51 - 6.3|}{6.3} \times 100 = 3.33\%$ ← most accurate lowest % error

c) 6.6 $\frac{|6.6 - 6.3|}{6.3} \times 100 = 4.76\%$

d) 6 $\frac{|6 - 6.3|}{6.3} \times 100 = 4.76\%$

Chemical/Physical Properties & Changes

Matter → mass & volume

- Substances
  - Elements
  - Compounds
- Mixtures
  - homogeneous aka Solutions
  - heterogeneous

Properties

1 physical
2 chemical
3 chemical
4 physical
5 physical
6 chemical
7 physical
8 chemical
9 physical

Changes

1 P
2 C
3 P
4 C
5 P
6 C
7 P
8 C
9 P
10 C

Atomic Theory

Dalton - pg 104 Glencoe text

History of atom Sect. 4.1 Book

Radioactivity

1)

α	alpha	+	$^{4}_{2}He$
β	Beta	−	$^{0}_{-1}e^{-}$
γ	gamma	$\emptyset$	$\emptyset$

2) a) Al-27 cation (Al^{3+})
protons - 13
neutrons - 27-13 = 14
electrons - 10

b) Mg-24 atom
protons - 12
neutrons - 24-12 = 12
electrons - 12

c) Re-186 cation (+2)
protons - 75
neutrons - 186-75 = 111
electrons - 73

d) Se-79 anion (−2)
protons - 34
neutrons - 79-34 = 45
electrons - 36

~~3.) a) $^{244}_{96}Cm \rightarrow ^{4}_{2}He + ^{240}_{94}Pu$~~

~~b.) $^{210}_{83}Bi \rightarrow ^{0}_{-1}\beta + ^{210}_{84}Po$~~

~~d) $^{116}_{50}Sn \rightarrow ^{0}_{-1}\beta + ^{116}_{51}Sb$~~

~~c.) [illegible]~~
~~$^{74}_{35}Br \rightarrow ^{4}_{2}He + ^{70}_{33}As$~~

~~e) $^{203}_{81}Tl + 2^{1}_{0}n \rightarrow ^{205}_{81}Tl \rightarrow ^{0}_{-1}\beta + ^{205}_{82}Pb$~~
~~$^{205}_{82}Pb \rightarrow ^{0}_{-1}\beta + ^{205}_{83}Bi$~~

3 a) $^{185}_{79}Au \rightarrow ^{4}_{2}He + ^{181}_{77}Ir$ b) $^{99}_{43}Tc \rightarrow \beta + ^{99}_{44}Ru$

c.) $^{293}_{92}U \rightarrow ^{4}_{2}He + ^{289}_{90}Th$ d) $^{47}_{20}Ca \rightarrow \beta + ^{47}_{21}Sc$

i) $^{247}_{95}Am \rightarrow ^{247}_{96}Cm + ^{0}_{-1}\beta$ j) $^{225}_{89}Ac \rightarrow ^{221}_{87}Fr + ^{4}_{2}He$

h.) $^{240}_{95}Am + 2^{1}_{0}n \rightarrow ^{241}_{95}Am \rightarrow ^{0}_{-1}\beta + ^{241}_{96}Cm$

5) $^{69}Ga \rightarrow 60.3\%$
$^{71}Ga \rightarrow 39.7\%$

$RA \rightarrow {}^{69}Ga = 0.603$
$RA \rightarrow {}^{71}Ga = 0.397$

$AM = RA_1(MW_1) + RA_2(MW_2)$
$AM = 0.603(69) + 0.397(71)$
$AM = 69.794$ amu

6.) ^{107}Ag
^{109}Ag
$AM = 107.868$

$AM \stackrel{?}{=} RA_1(MW) + RA_2(MW_2)$
($RA_1 \uparrow x$, $RA_2 \uparrow y$)

$x + y = 1$
$x = 1 - y$

$107.868 = x(107) + y(109)$
$107.868 = 1-y(107) + y(109)$
$107.868 = 107 - 107y + 109y$
$.868 = -107y + 109y$
$.868 = 2y$
$.434 = y$

$1 - y$
$x = 1 - .434$
$x = 0.566$

$^{107}Ag = 56.6\%$
$^{109}Ag = 43.4\%$

7.) 3.64×10^{-6} m = initial amount
$^{222}_{86}Rn$ 19 days = time elapsed
3.8 days = half life

$\frac{19 \text{ days}}{3.8 \text{ days}} = 5$ half lives

$\frac{3.64 \mu m}{2} = \frac{1.82 \mu m}{2} = \frac{0.91 \mu m}{2} = \frac{0.455 \mu m}{2} = \frac{.228 \mu m}{2} = .114 \mu m$

1 half life, 2 half lives, 3 half lives, 4 half lives, 5 half lives

or $N = N_0 (\frac{1}{2})^n$

$N = 3.64 (\frac{1}{2})^5$

8.) half live = 210 days
time elapsed = 810 days
5mg - initial amount

$\frac{810 \text{ days}}{270 \text{ days}} = 3$ half lives

$\frac{5mg}{2} = \frac{2.5mg}{2} = \frac{1.25mg}{2} = 0.625mg$

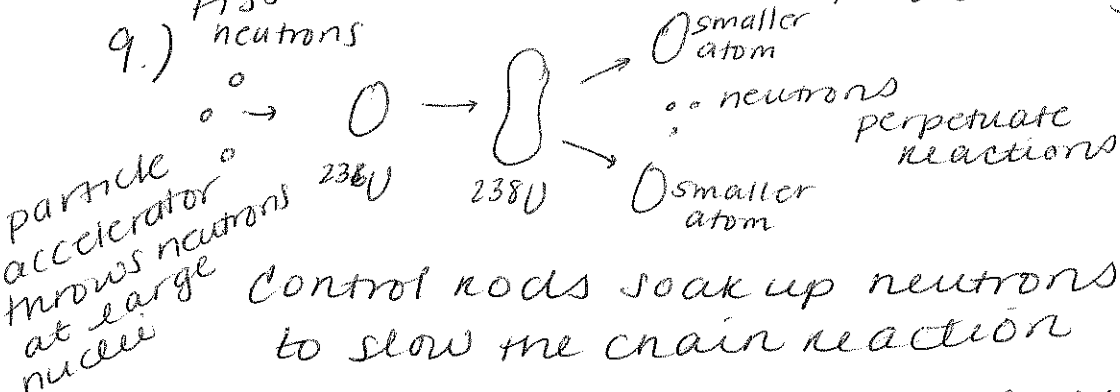
1 half life, 2 half lives, 3 half lives

or

$N = N_0(\frac{1}{2})^n$ $N = 5(\frac{1}{2}^3)$

$N = 0.625mg$

9.) Fission



Control rods soak up neutrons to slow the chain reaction

Fusion → 2 nuclei coming together

Light/Energy calculations

1) m (nm)
2) 1/s or Hz (s^{-1})
3) J
4) Kg
5) photon is a quanta of energy
Quanta is a discreet package of energy.
photoelectric effect describes light as a particle. the threshold energy must be met by the incident energy for an electron to be ejected.
An electron will be ejected if $E_i > E_t$

6.) a) emission high E → low E
b) excitation low E (ground state) → high E (excited state)

7) $\nu = 2.88 \times 10^{21}\ Hz$ $\lambda = ?$ $E = ?$

$\lambda = \frac{c}{\nu}$ $c = 3 \times 10^{8}\ m/s$

$h = 6.626 \times 10^{-34}\ Js$

$E = h\nu$

$\lambda = \frac{3 \times 10^{8}\ m/s}{2.88 \times 10^{21}\ Hz\ (1/s)} = 1.04 \times 10^{-13}\ m$

$E = 6.626 \times 10^{-34}\ Js \times 2.88 \times 10^{21}\ 1/s = 1.91 \times 10^{-12}\ J$

8.) $\nu = 4.48 \times 10^{14}\ \frac{1}{s}$

$\lambda = \frac{c}{\nu}$ $c = 3 \times 10^{8}\ \frac{m}{s}$

$E = h\nu$ $h = 6.626 \times 10^{-34}\ Js$

$\lambda = \frac{3 \times 10^{8}\ m/s}{4.48 \times 10^{14}\ 1/s} = 6.70 \times 10^{-7}\ m$

$E = 6.626 \times 10^{-34} (4.48 \times 10^{14}) = 2.97 \times 10^{-19}\ J$

9.) $\lambda_i = 321 \times 10^{-9}\ m$

$\nu_t = 3.2 \times 10^{14}\ 1/s$

Find E_i & E_t

$E_t = h\nu_t$

$E_i = \frac{hc}{\lambda_i}$

$E_i = \frac{6.626 \times 10^{-34}\ Js\ (3 \times 10^{8}\ \frac{m}{s})}{3.21 \times 10^{-9}\ m} = 6.19 \times 10^{-17}\ J$

$E_t = 6.626 \times 10^{-34} (3.2 \times 10^{14}) = 2.12 \times 10^{-19}$

is $E_i > E_t$? YES!

10.) $E_i = 6.27 \times 10^{-19}\ J$

$E_t = 9.24 \times 10^{-20}\ J$

$E_{KE} = 6.27 \times 10^{-19}\ J - 9.24 \times 10^{-20}\ J$
$= 5.35 \times 10^{-19}\ J$

$E_{KE} = E_i - E_t$

$\nu_t = ?$

$\nu_t = \frac{E_t}{h}$

$\nu_t = \frac{9.24 \times 10^{-20}\ J}{6.626 \times 10^{-34}\ Js} = 1.39 \times 10^{14}\ 1/s$

11.) $9.31 \times 10^{-19}\ J = E_t$

$2.34 \times 10^{-20}\ J = E_{KE}$

Revised

$E_{KE} = E_i - E_t$

$E_i = E_t + E_{KE} \rightarrow E_i = 9.31 \times 10^{-19}\ J + 2.34 \times 10^{-20}\ J$

$E_i = 9.5 \times 10^{-19}\ J$

a) E_i = ?

b) λ_i ? $E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E}$

$\lambda = \frac{6.626 \times 10^{-34}\ Js\ (3 \times 10^{8}\ \frac{m}{s})}{9.5 \times 10^{-19}\ J} = 2.09 \times 10^{-7}\ m$

(8)

12) ~~um~~ Bad question... but...

$v = 5.4 \times 10^6 \frac{m}{s}$

$\lambda = 1.35 \times 10^{-10} m$

$m = ?\ kg$

$\lambda = \frac{h}{mv}$

$m = \frac{h}{\lambda v} = \frac{6.626 \times 10^{-34} Js}{(1.35 \times 10^{-10} m\ (5.4 \times 10^6 \frac{m}{s}))} =$

$9.1 \times 10^{-31} kg = m$

(13) $275 nm = \lambda_t$

a) $E_t = \frac{hc}{\lambda_t} = \frac{6.626 \times 10^{-34} Js\ (3 \times 10^8 \frac{m}{s})}{275 \times 10^{-9} m} = 7.23 \times 10^{-19} J$

b) ν? $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8 \frac{m}{s}}{275 \times 10^{-9} m} = 1.09 \times 10^{15}$

Revised

c) $120 nm = \lambda_i$

$E_i = \frac{hc}{\lambda_i} = \frac{6.626 \times 10^{-34} (3 \times 10^8 \frac{m}{s})}{120 \times 10^{-9} m} = 1.65 \times 10^{-18} J$

$E_{KE} = E_i - E_t$

$= 1.65 \times 10^{-18} J \times 7.23 \times 10^{-19} J$

$= 9.34 \times 10^{-19} J$

Electron configs/Lewis Structures

1) Zr [Kr] $5s^2 4d^2$

Mo [Kr] $5s^1 4d^5$

Fr [Rn] $7s^1$

Pt [Xe] $6s^2 5d^8 4f^{14}$

F [He] $2s^2 2p^5$

2) 1, 2 s

5, 10 d

3, 6 p

7, 14 f

3) a.) F e.) Md

b.) Ca f.) Br

c.) Pm g.) Cu

d.) Te h.) Kr

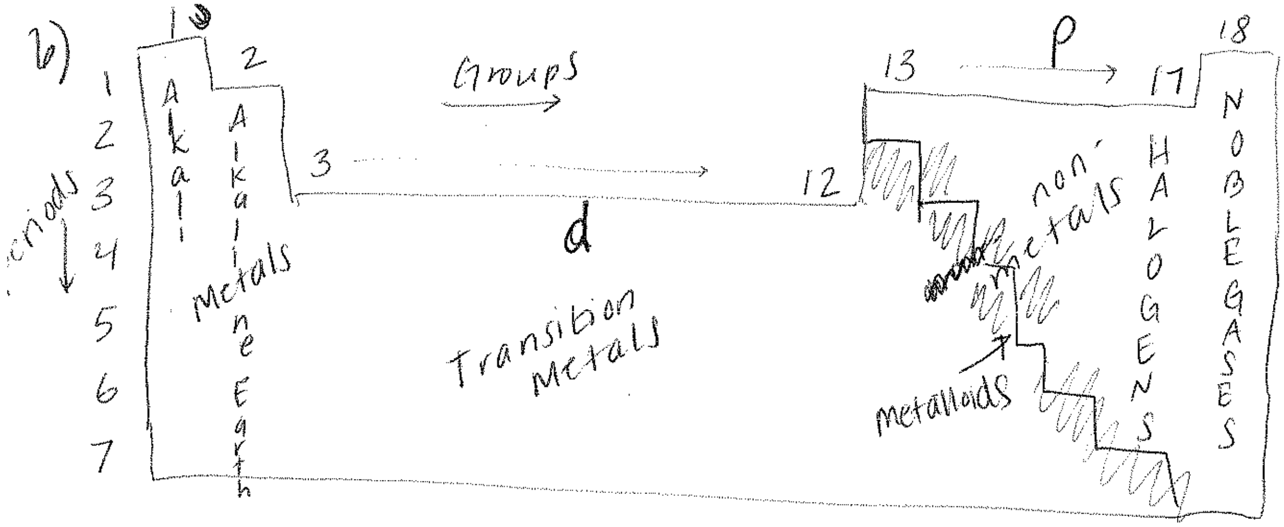
4.) K ⇅ (1s) ⇅ (2s) ⇅ ⇅ ⇅ (2p) ⇅ (3s) ⇅ ⇅ ⇅ (3p) ↑ (4s) K·

5) O ⇅ (1s) ⇅ (2s) ⇅ ↑ ↑ (2p) :Ö:

Si ⇅ (1s) ⇅ (2s) ⇅ ⇅ ⇅ (2p) ⇅ (3s) ↑ ↑ _ (3p) ·Si·

H ↑ (1s) H·

b)



Atomic radi

smaller ← smaller

larger ↓

more electronic levels larger larger "rings"

more attraction between nucleus & electrons b/c higher # e-

Ionization Energy

→ increases

larger / smaller easier to ionize

larger harder to remove e- smaller radii ~~[illegible]~~ nucleus has tighter hold on e-

decreases ↓

smaller easier to ionize larger radii doesn't hold e- so tightly

Francium ↓ Fr — not electronegative

Electronegativity increases →

F ↙ fluorine — highly electronegative

7. • radius decrease from left to Right due to an increased attraction between the protons and electrons
• radius increases from top to bottom due to an increased # of energy levels

8. a Cation's size is smaller than the atom because it has lost electron an anion is larger than it's atom because it has gained electrons

9. Ionization energy is the energy required to remove an electron from an atom to make an ion. It increases from left to right because as you get closer to the noble gas configuration an atom becomes more stable. As you go down the table IE decreases because the electrons are in higher energy levels which are further away from the Nucleus which makes them easier to pull away.

10. electronegativity is the tendency for a bonded atom to attract electrons. The reasons for the trends are similar to those for a I.E. as you get closer to the NGC atoms have a tendency to pull electrons to them to become more stable

11. Mg^{2+}, Se^{2-}, Br^{-}, B^{+3}, P^{-3}, H^{+1}

12. Mg 2 valence e^- gain 6 or lose 2

Se 6 Valence e^- gain 2 or lose 6

Br 7 Valence e^- gain 1 or lose 7

B 3 valence e^- gain 5 or lose 3

P 5 valence e^- gain 3 or lose 5

H 1 Valence e^- gain 7 or lose 1

Naming and Formula Writing

1)

Ammonium Carbonate	$(NH_4)_2CO_3$	Sulfuric Acid	H_2SO_4	A
Lead (II) phosphate	$Pb_3(PO_4)_2$	Zinc Iodide	ZnI_2	I
Phosphorus pentachloride	PCl_5	Chromium (III) Nitrate	$Cr(NO_3)_3$	I
Copper (I) Sulfate	Cu_2SO_4	dinitrogen Pentoxide	N_2O_5	M
hydrochloric Acid	HCl	Silver Nitride	Ag_3N	I
Carbon monoxide	CO	Calcium Chlorate	$Ca(ClO_3)_2$	I
Magnesium Hydroxide	$Mg(OH)_2$	Dinitrogen	N_2	M
Iron (II) chlorate	$Fe(ClO_3)_2$	Sulfur Trioxide	SO_3	M
Sodium phosphide	Na_3P	Ammonium Sulfite	$(NH_4)_2SO_3$	I
phosphoric Acid	H_3PO_4	lead (II) Fluoride	PbF_2	I
Chromium (III) chlorate	$Cr(ClO_3)_3$	Nitrous Acid	HNO_2	A

2)

HCl	hydrochloric Acid	CO_2	Carbon dioxide	M
$MgCl_2$	Magnesium chloride	$Cu_3(PO_4)_2$	Copper (II) phosphate	I
$Ca(ClO_3)_2$	Calcium Chlorate	H_2Se	hydroselenic Acid	A
$LiNO_2$	Lithium Nitrite	B_2O_3	boron oxide	I
$CaSO_4$	Calcium Sulfate	N_2O	dinitrogen monoxide	M
HNO_3	Nitric Acid	$Ca(IO_2)_2$	Calcium Iodite	I
$CuSO_4$	Copper (II) sulfate	$Al(NO_2)_3$	Aluminum Nitrite	I
SnI	tin (I) Iodide	NaBr	Sodium bromide	I
$KClO_2$	potassium Chlorite	H_2CO_3	Carbonic Acid	A
$SnCl_4$	tin (IV) chloride	NH_4OH	Ammonium hydroxide	I
HCN	hydrocyanic Acid	$Fe(ClO_4)_3$	Iron (III) perchlorate	I

3. a) $Al(NO_2)_3$

1 Al, 3 N, 6 O = 10

b) $Ca(IO_2)_2$

1 Ca, 2 I, 4 O = 7

c) $Cu_3(PO_4)_2$

3 Cu, 2 P, 8 O = 13

d) NH_4OH

1 N, 5 H, 1 O = 7

4) form crystals, Brittle, high melting points, Conductive when melted or disolved in H_2O, electrons are transferred

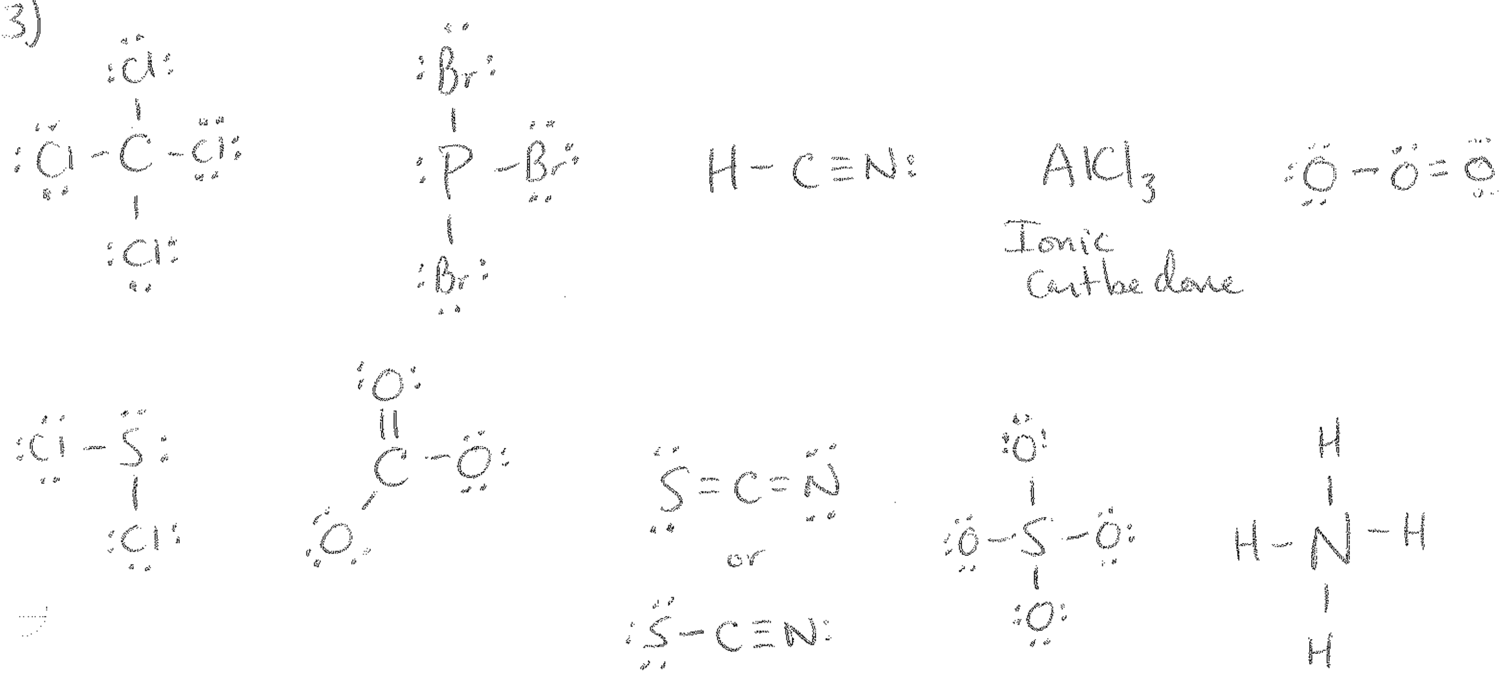
5) Can take any state of matter, low melting points, not conductive named with prefixes, electrons are shared.

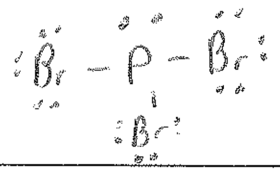
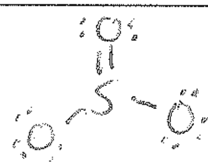
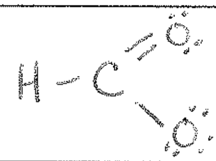
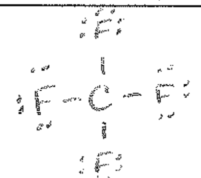
VSPER Theory + Molecular Geometry

1) Valence shell electron pair repulsion

2) lone pairs take up more space than bonding pairs so they force angles to squeeze together and get smaller

3)



Name	formula	Lewis Structure	# of σ bonds	# of π bonds	# of Lone Pairs on central atom	Electron Geometry	Molecular Geometry	Bond Angle
osphorous ribromide	PBr_3		3	0	1	Tetrahedral	Trigonal Pyrimidal	107
Trioxygen (ozone)	O_3		2	1	1	trigonal planar	Bent	118.5
Sulfur trioxide	SO_3		3	1	0	trigonal planar	trigonal planar	120
NA	HCO_2^-		3	1	0	Trigonal planar	trigonal Planar	120
arbon tetra-fluoride	CF_4		4	0	0	tetrahedral	tetrahedral	109.5

Writing and balancing equations

6.)

a) $2Al(s) + Fe_2O_3(aq) \longrightarrow Al_2O_3(aq) + 2Fe(s)$

- Single Replacement

b) $2C_6H_6(l) + 15O_2(g) \longrightarrow 12CO_2(g) + 6H_2O(g)$

- Combustion

c) $HNO_3(aq) + KOH(aq) \longrightarrow KNO_3(aq) + H_2O(l)$

- double replacement

d) $Hg(s) + I_2(aq) \longrightarrow HgI_2(s)$

- Synthesis/combination

e) $2KI\ (aq) + Cl_2\ (g) \longrightarrow 2KCl\ (aq) + I_2\ (g)$

- Single replacement

f) $Li_2O\ (s) + H_2O\ (l) \longrightarrow 2LiOH\ (aq)$

- Synthesis/combination

g) $C_7H_{16} + 11O_2 \longrightarrow 7CO_2 + 8H_2O$

- Combustion

h) $2K\ (s) + Cl_2\ (g) \longrightarrow 2KCl\ (s)$

- Synthesis/combination

i) $H_2SO_3\ (aq) \longrightarrow SO_2\ (g) + H_2O\ (l)$

- decomposition

j) $Ag_2CO_3\ (s) \longrightarrow Ag_2O(s) + CO_2\ (g)$

- decomposition

k) $HCl\ (aq) + NaHCO_3\ (s) \longrightarrow H_2CO_3\ (aq) + NaCl\ (aq)$

- double replacement