① $BaX_2 + H_2SO_4 \rightarrow BaSO_4 + H_2X$

0.1480g excess 0.1660g

$$0.1660\text{g } BaSO_4 \left| \frac{1\text{mol } BaSO_4}{233.39\text{g}} \right| \frac{1\text{mol } Ba^{2+}}{1\text{mol } BaSO_4^{2-}} \left| \frac{137.33\text{g}}{1\text{mol } Ba^{2+}} \right. = 0.09768\text{ g } Ba^{2+}$$

$0.1480\text{g} - 0.09768\text{g} = 0.05032\text{g } X$

$$0.09768\text{ g } Ba^{2+} \left| \frac{1\text{mol } Ba^{2+}}{137.33\text{g}} \right. = 7.112\times10^{-4} \text{ mol } Ba^{2+} \therefore$$

BaX_2 = 2x mol X than Ba

1.423×10^{-3} mol X

molar mass = g/mol

$\therefore$ $0.05032\text{g } X / (1.423\times10^{-3}\text{mol}) = 35.36\text{ g/mol} \therefore$

$\boxed{X = Cl}$

---

③ A) $KOH + K_2CO_3 + KCl + HCl \rightarrow CO_2$

$$\frac{0.100\text{L}}{} \left| \frac{2\text{mol}}{1\text{L}} \right. = 0.200\text{ mol HCl used} \therefore 0.200\text{ mol } H^+$$

↳ came from

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

$H_2CO_3 \rightarrow CO_2 + H_2O$

$PV = nRT \quad (740)(0.2490) = n(62.4)(273+22)$

$n = 0.0100\text{ mol } CO_2$ made

$\therefore$ 0.0100mol H_2CO_3 formed $\therefore$ 0.0100mol K_2CO_3 used up

$$0.0100\text{ mol } K_2CO_3 \left| \frac{138.2\text{g}}{1\text{mol}} \right. = 1.382\text{ g } K_2CO_3$$

$$\frac{1.382\text{ g } K_2CO_3}{5.00\text{ g sample}} * 100$$

$= \boxed{27.64\%}$

④ A) $2XI_3 + 3Cl_2 \rightarrow 2XCl_3 + 3I_2$

0.5000g 0.2360g

2:2 mole ratio $g \rightarrow mol$ $g/(g/mol) = mol$

∴ equal moles

molar masses:

$XI_3 = (x + 380.73)$

$XCl_3 = (x + 106.35)$

$$\frac{0.5000\,g}{(x + 380.73)} = \frac{0.2360\,g}{(x + 106.35)}$$

moles XI_3 moles XCl_2

$0.5000(x + 106.35) = 0.2360(x + 380.73)$

$0.5000x + 53.175 = 0.2360x + 89.852$

$-0.2360x \quad -53.175 \quad -0.2360x \quad -53.175$

$0.264x = 36.677$ | $x = 138.9$ g/mol = Lanthinum |

B) $2XCl_3 + 3I_2 \rightarrow 2XI_3 + 3Cl_2$

0.520 0.979

$$\frac{0.520}{(x + 106.35)} = \frac{0.979}{(x + 380.73)}$$

$0.520(x + 380.73) = 0.979(x + 106.35)$

$0.520x + 197.98 = 0.979x + 104.12$

$-0.520x \quad -104.12 \quad -0.520x \quad -104.12$

$93.86 = 0.459x$ | $x = 204.5$ g/mol = Thallium |

⑤ $X + O_2 \rightarrow X_?O_?$

2.077 g 3.708 g

3.708 − 2.077 = 1.631 g Oxygen used

Sample X

$$\frac{1.631\text{ g O}}{16\text{ g}} \left| \frac{1\text{ mol}}{} \right. = 0.1019\text{ mol O}$$

$X_?O_?$

↓

mm btwn 40-50

if XO then

$$\frac{2.077\text{ g X}}{0.1019\text{ mol}} = 20.38\text{ g/mol}$$

too small

if XO_2 then

$$\frac{2.077\text{ g X}}{0.05097\text{ mol}} = 40.75\text{ g/mol}$$

btwn 40-50!

* X_2O doesn't work, and X_2O_3 doesn't either. Have to Guess & Check!

∴ X_2O, closest element = K

---

⑥

$ZrBr_4 \rightarrow AgBr$

12.5843 g 13.2160 g Ag

Ag = 107.868

Br = 79.904

Zn = ? g/mol

$$\frac{13.2160\text{ g Ag}}{} \left| \frac{1\text{ mol Ag}}{107.868\text{ g Ag}} \right| \frac{1\text{ mol Br}}{1\text{ mol Ag}} = 0.1225\text{ mol Br}$$

$$\frac{0.1225\text{ mol Br}}{4\text{ mol Br in } ZrBr_4} \hookrightarrow 0.3063\text{ mol Zn}$$

$$\frac{0.1225\text{ mol Br}}{} \left| \frac{79.904\text{ g}}{1\text{ mol}} \right. = 9.788\text{ g Br}$$

12.5843 g Sample − 9.788 g Br = 2.7963 g Zn

$$\frac{2.7963\text{ g Zn}}{0.3063\text{ mol Zn}} = \boxed{91.29\text{ g/mol}}$$

(12) $5.50 \times 10^{-3}\ g\ O \left|\frac{1\ mol\ O}{16\ g\ O}\right|\frac{3\ mol\ PO_4^{3-}}{13\ mol\ O}\left|\frac{6.02 \times 10^{23}\ ions}{1\ mol}\right| =$

4.78×10^{19} PO_4^{3-} ions

$Ca_5(PO_4)_3OH$ has

13 mol O / 3 mol PO_4^{3-}

---

(13) $\underbrace{NaCl + KCl}_{1.0000\ g} + AgNO_3 \rightarrow AgCl$

excess 2.1476 g

in NaCl: Cl $\frac{35.45\ g}{58.4\ g}$

in KCl: Cl $\frac{35.45}{74.6\ g}$

2.1476 g AgCl $\left|\frac{1\ mol\ AgCl}{143.32\ g}\right|\frac{1\ mol\ Cl}{1\ mol\ AgCl}\left|\frac{35.45\ g}{1\ mol\ Cl}\right.$ = 0.5312 g Cl

$(X\ g\ NaCl)\left(\frac{35.45\ g\ Cl}{58.4\ g\ NaCl}\right) + \left(1-X\ g\ KCl\right)\left(\frac{35.45\ g\ Cl}{74.6\ g\ KCl}\right) = 0.5312\ g\ Cl$

$0.6079x + 0.4759 - 0.4759x = 0.5312$

$0.132x = 0.0561$ $\quad x = 0.425\ g\ NaCl$

$\frac{0.425\ g\ NaCl}{1.0000\ g\ Sample} * 100 = 42.5\%$

---

(14) $N_2 + 3H_2 \rightarrow 2NH_3$ $\quad 2.75 \times 10^7\ Pa = 2.75 \times 10^4\ KPa$

$PV = nRT$ $\quad (2.75 \times 10^4)(8.75 \times 10^3) = n(8.314)(455+273)$

$n = 3.98 \times 10^4$ in reactor $\therefore$ 1.99×10^4 mol N_2

1.99×10^4 mol H_2 → limiting

b/c 1 mol N_2 : 3 mol H_2

$1.99 \times 10^4\ mol\ H_2 \left|\frac{2\ mol\ NH_3}{3\ mol\ H_2}\right|\frac{17.03\ g}{1\ mol\ NH_3} =$ 2.26×10^4 g NH_3

(15) $BaCl_2 \cdot 2H_2O + NaCl \rightarrow BaCl_2 + NaCl + H_2O$

4.250 g
- 0.314 g water driven off
3.936 g
$BaCl_2$ + NaCl left

$$0.314\text{ g } H_2O \left| \frac{1\text{ mol } H_2O}{18.02\text{ g}} \right| \frac{1\text{ mol } BaCl_2 \cdot 2H_2O}{2\text{ mol } H_2O} \left| \frac{244.27\text{ g}}{1\text{ mol } BaCl_2 \cdot 2H_2O} \right.$$

$= 2.128\text{ g } BaCl_2 \cdot 2H_2O$

$2.128\text{ g} / 4.250\text{ g} * 100 = \boxed{50.08\%}$

---

(17) $2\,NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O$

$2\,KClO_3 \rightarrow 2\,KCl + 3O_2$

A) Per mol solid, $\boxed{KClO_3}$ will generate more $O_2(g)$ b/c there is a 2:3 ratio vs a 2:1 ratio with NH_4NO_3

B) mm NH_4NO_3 = 80.06 g → $(\frac{1}{2})(32\text{ g } O_2) = 16\text{ g}$

mm $KClO_3$ = 122.55 g → $(\frac{3}{2})(32\text{ g } O_2) = 48\text{ g}$

$16 / 80.06 = 0.20$

$48 / 122.55 = 0.39$

mole ratios

per gram solid, $\boxed{KClO_3}$ will generate more grams of O_2

(18) $XCl_2 + Cl_2 \rightarrow XCl_4$

10 g 12.55 g

12.55 g − 10 g = 2.55 g Cl_2 added
XCl_4 XCl_2

$$\frac{2.55\text{ g } Cl_2}{} \left| \frac{1\text{ mol}}{70.9\text{ g}} \right. = 0.03597 \text{ mol } Cl_2 \text{ added}$$

$$\frac{10\text{ g } XCl_2}{0.03597\text{ mol}} = 278\text{ g/mol } XCl_2$$

$- 70.9\text{ g } Cl_2$

$X = 207.1$ g/mol = lead

1 mol Cl_2 : 1 mol XCl_2 & XCl_4 :: 0.03597 mol XCl_2 & mol XCl_4

---

(19) $UF_6 + H_2O \rightarrow U_xO_yF_z + HF$

4.267 g 3.730 g 0.970 g

0.970 × 0.95 = 0.9215 g F
0.970 − 0.9215 = 0.0485 g H

$$\frac{4.2679\text{ g } UF_6}{} \left| \frac{1\text{ mol } UF_6}{352.018\text{ g}} \right| \frac{6\text{ mol F}}{1\text{ mol } UF_6} \left| \frac{19\text{ g F}}{1\text{ mol F}} \right. = 1.382\text{ g F in } UF_6$$

$$\frac{0.9215\text{ g F in gas}}{1.382\text{ g F in } UF_6} * 100 = 66.7\% \text{ in gas}, \quad 33.3\% \text{ in solid } U_xO_yF_z$$

$$\frac{4.267\text{ g } UF_6}{} \left| \frac{1\text{ mol } UF_6}{352.018\text{ g}} \right| \frac{1\text{ mol } U}{1\text{ mol } UF_6} \left| \frac{238.03\text{ g}}{1\text{ mol } U} \right. = 2.885\text{ g } U$$

3.730 g $U_xO_yF_z$ − 0.4605 g F − 2.885 g U = 0.3845 g O

1.382 g F in UF_6 − 0.9215 g F in HF_{gas} = 0.4605 g F in solid $U_xO_yF_z$

$$\frac{0.4605\text{ g F}}{} \left| \frac{1\text{ mol}}{19\text{ g F}} \right. = 0.0242 \text{ mol F} \; / 0.0121 = 2$$

$$\frac{2.885\text{ g U}}{} \left| \frac{1\text{ mol}}{238.03\text{ g}} \right. = 0.01212 \text{ mol U} \; / 0.0121 = 1$$

$$\frac{0.3845\text{ g O}}{} \left| \frac{1\text{ mol}}{16\text{ g}} \right. = 0.0240 \text{ mol O} \; / 0.0121 = 2$$

UO_2F_2

(20) $Ti_xCl_y \rightarrow TiO_2 + AgCl$
1.20g 6.45g

$$\frac{1.20\,g\ TiO_2}{} \left|\frac{1\,mol\ TiO_2}{79.90\,g}\right|\frac{1\,mol\ Ti}{1\,mol\ TiO_2} = 0.0150\,mol\ Ti$$

$$\frac{6.45\,g\ AgCl}{} \left|\frac{1\,mol\ AgCl}{143.32\,g}\right|\frac{1\,mol\ Cl}{1\,mol\ AgCl} = 0.0450\,mol\ Cl$$

0.0450 mol / 0.0150 mol = 3 Cl

0.0150 mol / 0.0150 mol = 1 Ti

$TiCl_3$

---

(21) $XBr_2 + Cl_2 \rightarrow XCl_2 + Br_2$
1.50g 0.8897g

g → mol g/(g/mol) = mol

1:1 ratio
∴ equal moles:

$XBr_2 = (x + 159.8)$
$XCl_2 = (x + 70.9)$

$$\frac{1.50\,g}{(x+159.8)} = \frac{0.8897\,g}{(x+70.9)}$$

$1.50(x+70.9) = 0.8897(x+159.8)$

$1.50x + 106.35 = 0.8897x + 142.17$
$-0.8897x \ \ -106.35 \ \ -0.8897x \ \ -106.35$

$0.6103x = 35.82$

x = 58.69 g/mol = Ni

---

(23) $Fe_2O_3 + 6HCl \rightarrow 2FeCl_3 + 3H_2O$

$(525\,cm^2)(0.0021\,cm) = 1.1025\,cm^3$

$$\frac{1.0125\,cm^3}{} \left| \frac{5.29}{cm^3}\right. = 5.733\,g\ Fe_2O_3$$

$$\frac{5.733\,g\ Fe_2O_3}{} \left|\frac{1\,mol}{159.7\,g}\right|\frac{6\,mol\ HCl}{1\,mol} = 0.2154\ mol\ HCl\ needed$$

$$\frac{0.2154\,mol}{} \left| \frac{1\,L}{4.11\,Mol}\right. = 0.0524\,L = \textbf{52.4 mL}\ *$$

1000g Sol'n × 0.14 = 140g HCl

$$\frac{140\,g}{} \left| \frac{1\,mol}{36.46\,g}\right. = 3.84\,mol\ HCl$$

$$\frac{1000\,g}{} \left| \frac{1\,mL}{1.07\,g}\right. = 934.6\,mL$$

3.84 mol / 0.9346 L = 4.11 M HCl

(24) $M_2SO_4 + CaCl_2 \rightarrow CaSO_4 + 2MCl$

1.142 g — excess — 1.36 g

g → mol

g / (g/mol) = mol

$1.36\text{ g } CaSO_4 \left| \frac{1\text{ mol } CaSO_4}{136.14\text{ g}} \right. = 9.99 \times 10^{-3}$ mol $CaSO_4$

1:1 ratio ∴ equal to mol M_2SO_4

molar mass M_2SO_4 = $(2x + 96.06)$

$$\frac{1.42\text{ g}}{(2x + 96.06)} = 9.99 \times 10^{-3}$$

$$1.42 = 9.99 \times 10^{-3}(2x + 96.06)$$

$$1.42 = 1.998 \times 10^{-2}x + 0.9596$$

$$-0.9596 \qquad -0.9596$$

$$0.4604 = (1.998 \times 10^{-2})x$$

$$\boxed{x = 23.04\text{ g/mol} = \text{Sodium}}$$

---

(25) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

7.7879 g/cm³ — 5.249 g/cm³

$$\frac{1\text{ cm}^3\text{ Fe}}{1} \left| \frac{7.7879\text{ g Fe}}{1\text{ cm}^3} \right| \frac{1\text{ mol Fe}}{55.845\text{ g Fe}} \left| \frac{2\text{ mol } Fe_2O_3}{4\text{ mol Fe}} \right| \frac{159.69\text{ g}}{1\text{ mol } Fe_2O_3} \left| \frac{1\text{ cm}^3}{5.249\text{ g } Fe_2O_3} \right. = 2.125\text{ cm}^3$$

Volume changes from $1\text{ cm}^3 \rightarrow 2.125\text{ cm}^3$

∴ $\Delta V = 1.125\text{ cm}^3$ for every 1 cm^3 Fe used.

(26) $M + H_2SO_4 \rightarrow MSO_4 + H_2$

0.204 g V = 213 mL mm = g/mol

P = 756 wet gas
− 23.756 H_2O vapor
= 732.24 dry gas

$PV = nRT$

T = 25 + 273 = 298 K

$(732.24)(0.213) = n(62.36)(298)$

$n_{H_2} = 8.387 \times 10^{-3}$ mol

1:1 ratio ∴ same as mol M

$\frac{0.2049\ g}{8.387 \times 10^{-3}\ mol} = 24.32$ g/mol = Mg

---

(27) $2MO + C \rightarrow 2M + CO_2$

5.00 g excess V = 738 mL mm = g/mol

P = 0.978 atm

T = 200 + 273 = 473 K

$PV = nRT$

$(0.978)(0.738) = n(0.08206)(473)$ $n = 0.0186$ mol CO_2

2 mol : 1 mol
MO : CO_2

∴ 0.03719 mol MO

$\frac{5\ g}{0.03719\ mol} = 134.4$ g/mol

134.4 g/mol − 16 g/mol = 118.4 g/mol = M = Tin

MO O

---

(28) P_xF_y

0.2324 g V = 0.378 P = 97.3 mmHg T = 77 + 273 = 350 K

$PV = nRT$

$(97.3)(0.378) = n(62.4)(350)$

1.684×10^{-3} mol P_xF_y

$P_xF_y + CaCl_2 \rightarrow CaF_2$

0.2631

$\frac{0.2324\ g}{1.684 \times 10^{-3}\ mol} = 138$ g/mol

$0.2631\ g\ CaF_2 \left| \frac{1\ mol}{78.08\ g} \right| \frac{2\ mol\ F}{1\ mol} \left| \frac{19\ g}{1\ mol\ F} \right. = 0.128$ g F

0.2324 g − 0.128 g = 0.1044 g P

$0.128\ g\ F \left| \frac{1\ mol}{19\ g} \right. = 6.74 \times 10^{-3}$ mol F

$0.1044\ g\ P \left| \frac{1\ mol}{30.97\ g} \right. = 3.37 \times 10^{-3}$ mol P

$6.74 \times 10^{-3} / 3.37 \times 10^{-3} = 2$ F

$3.37 \times 10^{-3} / 3.37 \times 10^{-3} = 1$ P

PF_2 empirical

$\frac{138\ g/mol}{69\ g/mol} = \times 2$ ∴ P_2F_4

mm = g/mol

g → mol: g / (g/mol) = mol

(29) $MCl_2 + 2AgNO_3 \rightarrow M(NO_3)_2 + 2AgCl$

0.4750 g → 1.435 g

$1.435\,g \times \frac{1\,mol\,AgCl}{143.32\,g} = 0.01001\,mol\,AgCl$

2:1 ratio ∴ $0.005006\,mol\,MCl_2$

$\frac{0.4750\,g}{(x + 70.9)} = 0.005006$

$0.4750 = 0.005006(x + 70.9)$

$0.4750 = 0.005006x + 0.3549$

$-0.3549 \quad -0.3549$

$0.1201 = 0.005006x$

$x = 23.99\,g/mol$ = magnesium

---

(30) $2MX_2 \rightarrow 2MX + X_2$

1.12 g → 0.720 g, V = 0.056 @ STP

$0.056\,L \times \frac{1\,mol}{22.4\,L} = 2.5 \times 10^{-3}\,mol\,X_2$

2:1 ratio ∴ 5×10^{-3} mol MX & MX_2

$1.12\,g\,MX_2 - 0.720\,g\,MX = 0.4\,g\,X_2$

$mm\,X_2 = 0.4\,g / (2.5 \times 10^{-3}\,mol) = 160\,g/mol\,X_2$

$\frac{0.720\,g}{(5 \times 10^{-3}\,mol)} = 144\,g/mol\,MX$

$144 - 80\,g/mol\,Br = 64\,g/mol$ = copper

$X = 80\,g/mol$ ∴ Bromine

---

(31) $M_2SO_4 + BaCl_2 \rightarrow BaSO_4$

10.99 g, 0.025 L; excess; 1.1679 g

$1.1679\,g\,BaSO_4 \times \frac{1\,mol}{233.36\,g} = 5.00 \times 10^{-3}\,mol\,BaSO_4$

$[M_2SO_4] = \frac{(5 \times 10^{-3})}{(0.025)} = 0.20\,M$

1:1 ratio ∴ mol $BaSO_4$ = mol M_2SO_4

$\frac{10.99\,g}{0.50\,L} = 21.98\,\frac{g}{L}$

$0.025\,L \times \frac{21.98\,g}{1\,L} = 0.5495\,g\,M_2SO_4$ used

$\frac{0.5495\,g}{(5 \times 10^{-3})\,mol} = 109.9\,g/mol\,M_2SO_4$

$-96.06\,g/mol\,SO_4^{2-} = 13.84\,g/mol\,M_2$

$= 6.92\,g/mol$

= lithium

(32) $XBr_2 + Br_2 \rightarrow XBr_4$

10 g, excess, 14.35 g

14.35 g − 10 g = 4.35 g Br_2 added

$\frac{4.35\text{ g } Br_2}{159.8\text{ g}} \left| \frac{1\text{ mol}}{} \right. = 0.0272\text{ mol } Br_2$ added

1:1 mole ratio

∴ 0.0272 mol XBr_2

mm = g/mol 10 g / (0.0272 mol) = 367.6 g/mol XBr_2

− 159.8 g/mol Br_2

= 207.8 g/mol X

= lead

---

(33) $\underbrace{CH_3OH + C_2H_5OH}_{2.16\text{ g}} + O_2 \rightarrow CO_2 + H_2O$

4.32 g

mm CH_3OH = 32 g/mol

mm C_2H_5OH = 46 g/mol

$CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

X g CH_3OH + Y g C_2H_5OH = 2.16 g total

$\left(\frac{1.5}{1}\right)\left(\frac{x}{32}\right) + \frac{(3)}{(1)}\left(\frac{y}{46}\right) = \frac{4.32}{32}$ (4.32/32 = mol O_2)

mol O_2 for x + mol O_2 for y = total mol O_2

$x = 2.16 - y$ g = g/(g/mol)

$\frac{(1.5)(2.16-y)}{(32)} + 3\left(\frac{y}{46}\right) = 0.135$

$32 \times 46\left(\frac{3.24 - 1.5y}{32} + \frac{3y}{46}\right) = (0.135)\,32 \times 46$

$46(3.24 - 1.5y) + 32(3y) = 198.72$

$149.04 - 69y + 96y = 198.72$

$27y = 49.68$ $y = 1.84$ g

$\left(\frac{\text{mol } O_2}{\text{mol x}}\right)\left(\frac{g\ x}{g\ x/\text{mol x}}\right) = \left(\frac{\text{mol } O_2}{\text{mol x}}\right)(\text{mol x}) = \text{mol } O_2$

[same for y]

ethanal

$x = 0.32$ g methanol

$\frac{1.84\text{ g}}{46\text{ g}} \left| \frac{1\text{ mol}}{} \right. =$ 0.040 mol ethanol

$\frac{0.32\text{ g}}{2.16\text{ g}} \times 100 =$ 14.8%

(34) $2M + X_2 \rightarrow 2MX$

3.41g 0.0158 mol 4.53g

mm = g/mol

g → mol

g/(g/mol)

2:1 ratio ∴ 0.0316 mol M & MX

$\frac{3.41g\ M}{0.0316\ mol} = \underbrace{107.9\ g/mol}_{M}$ $\frac{4.53g\ MX}{0.0316\ mol} = 143.4\ g/mol$

$\underset{MX}{143.4\ g/mol} - \underset{M}{107.9\ g/mol} = \underbrace{35.45\ g/mol}_{X}$

M = Silver, X = Bromine