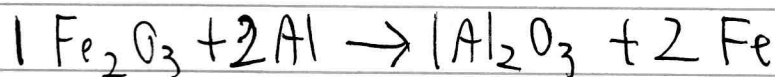


Week 1 PSET: #1: Thermite

The thermite reaction, used to weld rails together in the building of railroads, occurs when Fe_2O_3 reacts with Al to produce Al_2O_3 and Fe.

Write a balanced equation for this reaction:



... with lowest possible whole number coefficients:



Calculate the mass of iron metal (in grams) that can be prepared from 150g Al and 250g Fe_2O_3 :

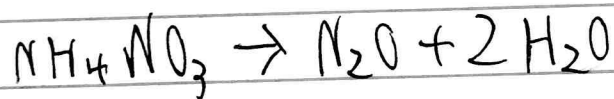
Molar masses:		$150 \text{g Al} \cdot \frac{1 \text{ mole}}{27 \text{g}} \cdot \frac{1}{2} = 2.7 \text{ reaction units.}$	
Al	27		
Fe_2O_3	157	$250 \text{g Fe}_2\text{O}_3 \cdot \frac{1 \text{ mole}}{157 \text{g}} = 1.59 \text{ reaction units.}$	
Fe	55.8		

Fe_2O_3 is the limiting reactant. $2 \cdot 1.58$ moles Fe will be produced.
 $2 \cdot 1.58 \cdot \frac{55.8 \text{g}}{1} = 85.176 \text{g}$

#2: Decomposition of ammonium nitrate

Solid NH_4NO_3 decomposes on heating to 400°C into N_2O gas and H_2O gas.

Write a balanced chemical equation:



Calculate the number of grams of H_2O that will form on decomposition of 0.1 mole NH_4NO_3 .

$$0.1 \cdot 2 = 0.2 \text{ moles } \text{H}_2\text{O} \cdot \frac{18 \text{ g}}{\text{mole}} = 3.6 \text{ g } \text{H}_2\text{O}$$

#3: Kinetic Energy

Select the objects with the same kinetic energy associated with them.

$$\text{Recall: } K = \frac{1}{2} m v^2$$

A	mass 0.5	velocity 1	KE = $\frac{1}{4}$
B	1	2	= 2
C	1	1	= $\frac{1}{2}$
D	2	1	= 1
E	3	1	= $\frac{3}{2}$
F	4	1	= 2

B and F have the same KE

#4 Chlorine Isotopes

Chlorine ~~isotopes~~ has two isotopes, ^{35}Cl and ^{37}Cl . For the anion $^{37}\text{Cl}^-$, specify the following:

protons: 17

neutrons: 20

electrons: 18

Cl has constant proton number 17.

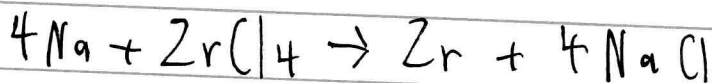
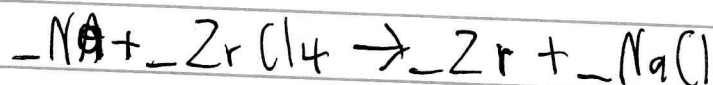
This Cl has $17 - (-1)$ electrons.

This Cl has $37 - 17$ neutrons.

#5: Zirconium

Metallothermic production of zirconium would involve the reaction of Na with $ZrCl_4$ to produce Zr and $NaCl$.

Write a balanced chemical equation:



Calculate the amount of zirconium produced (in kg) if a reactor were charged with 491.0 kg $ZrCl_4$ and 49.0 kg Na.

Begin by dividing all masses by 1000; we'll multiply 1000 back at the end.

~~$$491.0 \text{ g} \cdot \frac{1}{233.04} = 2.11 \text{ reaction units}$$~~

~~$$49 \text{ g} \cdot \frac{1}{23} = 2.13 \text{ reaction units}$$~~

thus $ZrCl_4$ is the limiting reactant.

~~$$\begin{aligned} 2.11 \text{ (units)} \cdot 91.22 &= 192.47 \text{ grams} \\ &\cdot 1000 \\ \hline &192.47 \text{ kg.} \end{aligned}$$~~

~~I forgot to multiply by $\frac{1}{4}$ when finding the reaction units Na.~~

~~$$49 \cdot \frac{1}{23} \cdot \frac{1}{4} = 0.532 \text{ reaction units}$$~~

~~$$\cancel{0.532} \cdot \frac{91.22 \text{ g}}{\text{mole Zr}} =$$~~

This still isn't right, so let's do this in a simpler way.
Recall that: $4\text{Na} + \text{ZrCl}_4 \rightarrow \text{Zr} + 4\text{NaCl}$.

Then for every mole ZrCl_4 there must be 4 moles Na.

$$491 \text{ kg} \cdot \frac{1000 \text{ g}}{\text{kg}} \cdot \frac{1 \text{ mole ZrCl}_4}{91.23 \text{ grams}} = 5382 \text{ moles ZrCl}_4$$

$$49 \text{ kg} \cdot \frac{1000 \text{ g}}{\text{kg}} \cdot \frac{1 \text{ mole Na}}{22.99 \text{ g}} = 2131 \text{ moles Na.}$$

We can elude that Na is the limiting reactant. For 4 moles of Na, 1 mole of Zr is produced.

$$2131 \cdot \frac{1}{4} = 532.75 \text{ moles Zr} \cdot \frac{0.09122 \text{ kg}}{\text{mole}}$$

$$= 48.6 \text{ kg Zr.}$$

I had the right answer with the first method, but I was checking against the wrong solution.

#6: Atomic Weight

Calculate the atomic weight (in amu) of an element X given the following data:

^{24}X : 24 amu at 0.7870 fractional abundance

^{25}X : 25 amu at 0.1017 "

^{26}X : 26 amu at 0.1113 "

$$\frac{(24 \cdot 0.787 + 25 \cdot 0.1017 + 26 \cdot 0.1113)}{1}$$

24.32 amu

#7: Mercury atoms

How many atoms are in 14.0 cm³ of mercury (at room temperature)?

$$14 \text{ cm}^3 \text{ Hg} \cdot \frac{13.53 \text{ g}}{\text{cm}^3} = 189.42 \text{ g Hg} \cdot \frac{1 \text{ mole}}{200.59 \text{ g}} = 0.94 \text{ moles Hg}$$

$$0.94 \text{ moles Hg} \cdot \frac{\text{Avogadro's number}}{\text{mole}} = 5.66 \cdot 10^{23} \text{ atoms Hg}$$