ANSWERS TO SECTION 4.4 QUESTIONS

Example 4.4a

Question: Calculate the %S in above coal sample.

* The 1g Coal sample was treated with a reducing reagent to reduse ~~the~~ all the sulfur in the sample to H_2S, which was isolated and found to weigh 0.0130g of H_2S.

Answer:

If we know how much H_2S we have, we can calculate the amount of sulfur by calculating the mass % of S in H_2S

$\therefore$ %S in H_2S = ?

$M_S = 32.1\ g \cdot mol^{-1}$

$M_{H_2S} = 34.12\ g \cdot mol^{-1}$

$$\therefore \%S = \frac{\text{Molar mass of S}}{\text{Molar mass of } H_2S} \times 100$$

$$= \frac{32.1\ g \cdot mol^{-1}}{34.12\ g \cdot mol^{-1}} \times 100$$

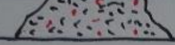
$$= 94.08\%\ S \text{ in } H_2S$$

Now: If we have 0.0130g of H_2S, we will have: 94.08% (0.0130) = 0.0122g S

$$\therefore \%S \text{ in 1g of Coal} = \frac{0.0122g\ S}{1g\ Coal} \times 100$$

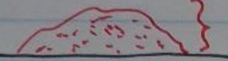
$$= 1.22\%\ S \text{ in 1g Coal}$$

Try yourself 4.4b



} Mixture of $CuSO_4 \cdot 5H_2O$ and $CuSO_4$
= 1.245 g mixture

↓ heat ⇒ (− H_2O assosiated with $CuSO_4 \cdot 5H_2O$)



} Anhydrous $CuSO_4$ only = 0.832 g

question ⇒ Calculate mass % of $CuSO_4 \cdot 5H_2O$ in original mixture (sample).

Answer:

By calculating the amount of H_2O lost we can work out the ratio between the anhydrous $CuSO_4$ and hydrated $CuSO_4 \cdot 5H_2O$ in the original mixture, because all the water can only be assosiated with the $CuSO_4 \cdot 5H_2O$.

$\therefore$ H_2O lost = 1.245 g − 0.832 g = 0.413 g of H_2O lost during heating

$\therefore n_{H_2O} = \frac{m}{M} = \frac{0.413\,g}{18.02\,g\,mol^{-1}} = 0.0229$ mol H_2O →

$\therefore$ Ratio of $H_2O : CuSO_4 \cdot 5H_2O$

5 : 1

$\therefore n_{CuSO_4 \cdot 5H_2O} = \frac{0.0229}{5} = 0.00458$ mol of $CuSO_4 \cdot 5H_2O$ in origin. mixture.

$\therefore m_{CuSO_4 \cdot 5H_2O} = n \times M = (0.00458\,mol)(249.6\,g \cdot mol^{-1})$
$= 1.144$ g $CuSO_4 \cdot 5H_2O$ in the original sample.

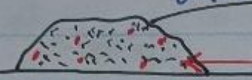
$\therefore$ mass % of $CuSO_4 \cdot 5H_2O$ in original sample

$= \frac{1.144\,g}{1.245\,g} \times 100 = 91.89\%$ →

$\therefore$ 91.89% of the original mixture was $CuSO_4 \cdot 5H_2O$ the rest (8.11%) was anhydrous $CuSO_4$.

Try yourself 4.4 C

0.468g Mineral sample containing **some** NiS.



NiS = •

The mineral sample containing the NiS was dissolved in HNO_3 which converted all the NiS to $Ni(NO_3)_2$ according to the following balanced eq.

eq. 1
$$\underset{(90.8\,g\cdot mol^{-1})}{NiS_{(s)}} + \underset{(63.01\,g\cdot mol^{-1})}{HNO_{3(aq)}} \rightarrow \underset{(182.7\,g\cdot mol^{-1})}{Ni(NO_3)_{2}(aq)} + 2NO_{2(g)} + 2H_2O(l) + S_{(s)}$$

The aqueous $Ni(NO_3)_2$ was then reacted with $C_4H_8N_2O_2$ to yield $Ni(C_4H_7N_2O_2)$ as one of the products and according to the following balanced eq.

eq. 2
$$Ni(NO_3)_{2}(aq) + 2C_4H_8N_2O_{2}(aq) \rightarrow \underset{(288.84\,g\cdot mol^{-1})\ \to 0.206g}{Ni(C_4H_7N_2O_2)_{2}(s)} + 2HNO_{3}(aq)$$

Answer: Suppose a 0.468g sample containing some NiS produced 0.206g of $Ni(C_4H_7N_2O_2)_2$. Calculate the % NiS in the original sample.

* We will work with what we have and work backwards to the answer.

We know the mass of $Ni(C_4H_7N_2O_2)_2$ and the molar mass of the compound (worked out from P.T.)

$$\therefore n_{Ni(C_4H_7N_2O_2)_2} = \frac{m}{M} = \frac{0.206g}{288.84\,g\cdot mol^{-1}} = 0.0007132\ mol \rightarrow$$

Mol Ratio between $Ni(C_4H_7N_2O_2)_2 : Ni(NO_3)_2$ from eq 2 = 1 : 1

$$\therefore n_{Ni(NO_3)_2} = \underline{0.0007132\ mol} \rightarrow$$

go to page 2

Try yourself 4.4 c continued

$n_{Ni(NO_3)_2} = 0.0007132$ mol

From eq 1 the ratio between $Ni(NO_3)_2$ and NiS = 1 : 1

* Therefor: $n_{NiS} = 0.0007132$ mol

* mass NiS in original mineral sample (mixture)

=: $m = n \times M$

$= (0.0007132 \text{ mol})(90.8 g \cdot mol^{-1})$

$= 0.0648 g$ →

∴ In the original mineral sample there is 0.0648g of NiS.

∴ % NiS in 0.468g of sample:

$$= \frac{0.0648g \text{ NiS}}{0.468g \text{ sample}} \times 100$$

$= 13.85\%$ →

∴ 13.85% of the original NiS containing sample is NiS.

Try yourself 4.4 d

→ Mixture of limestone ($CaCO_3$) and other soil materials = 1.506g

↳ limestone = •

Decomposing the limestone containing sample at high temp. yielded 0.558g of CO_2.

Quest → Calculate the mass % of $CaCO_3$ in the original sample mixture.

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

↳ ($M = 100.1\ g \cdot mol^{-1}$)   ↳ (0.558g and $M = 44\ g \cdot mol^{-1}$)

$$n_{CO_2} = \frac{m}{M} = \frac{0.558g}{44\ g \cdot mol^{-1}} = \underline{0.0127\ mol\ CO_2}$$

From the balanced eq the mol ratio between $CaCO_3$ and CO_2 = 1 : 1

$$\therefore n_{CaCO_3} = \underline{0.0127\ mol\ CaCO_3}$$

$$m_{CaCO_3} = n \times M = (0.0127\ mol)(100.1\ g \cdot mol^{-1})$$
$$= \underline{1.271\ g\ CaCO_3}$$

∴ mass % $CaCO_3$ in mixture:

$$= \frac{m\ of\ CaCO_3}{m\ of\ sample} \times 100$$

$$= \frac{1.271\ g}{1.506\ g} \times 100 = \underline{84.39\ \%}$$

∴ 84.4% of the sample is $CaCO_3$.