

1. You are part of a team of scientists investigating a sports “doping” scandal. A sample suspected of being “andro” (a slang word for androstenedione $C_{19}H_{26}O_2$) is collected during the investigation. A combustion analysis of a 0.1570 g sample of this material yields 0.4586 g of CO_2 and 0.1283 g of H_2O . What is the simplest formula for this sample? Could it be andro?

Determine the formula of the compound using the analysis data:

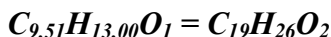
*amount of C = $0.4586 \text{ g } CO_2 \times (12.01 \text{ g C}/44.01 \text{ g } CO_2) = 0.1251 \text{ g C}$
 $(0.1251 \text{ g}/0.1570 \text{ g}) \times 100\% = 79.68\% \text{ C in the sample}$
(moles $CO_2 = 0.010415$ moles)*

*amount of H = $0.1283 \text{ g } H_2O (1 \text{ mol}/18.02 \text{ g } H_2O)(1.01 \text{ g H/mol})(2 \text{ mol H/mol } H_2O) = 0.014382 \text{ g H}$
 $(0.014382 \text{ g}/0.1570 \text{ g}) \times 100\% = 9.160\% \text{ H}$
(moles $H_2O = 0.00713$ moles or 0.01426 moles H)*

$79.68 + 9.160 = 88.84\%$ The remainder should be $O = 11.16\%$

Calculate the empirical formula assuming 100g of sample

*$79.68 \text{ g C} \times 1/12.01 = 6.634$
 $9.160 \text{ g H} \times 1/1.01 = 9.07$
 $11.16 \text{ g O} \times 1/16.00 = 0.6975$*



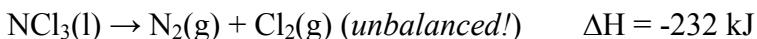
Yes, the sample has the same formula as andro.

By using the molar ratio or by a balanced eqn – got that the CH ratio was correct – gave 3/5

1/5 for the calculation of moles

*Molar mass of androstenedione $C_{19}H_{26}O_2 = 286.41 \text{ g/mol}$
 $\%C \text{ in andro} = 19 \times 12.01 \text{ g/mol} \times 1 \text{ mol}/286.41 \text{ g} \times 100\% = 79.68$
 $\%H \text{ in andro} = 26 \times 1.008 \text{ g/mol} \times 1 \text{ mol}/286.41 \text{ g} \times 100\% = 9.15$
 $\%O \text{ in andro} = 11.17$*

2. A sample of liquid nitrogen trichloride was heated in a 1.50 L, closed container until it decomposed completely into gaseous elements. The resulting mixture exerted a pressure of 744 torr at 75.0°C.

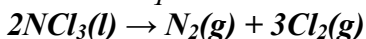


What is the partial pressure of each gas in the container?

What was the mass of the original sample?

Answer:

Balanced equation:



The total pressure = pressure of N₂ + pressure of Cl₂

Partial pressure is proportional to mole fraction and the mole fraction of Cl₂ = 3 mole fraction N₂

$$\begin{aligned} 744 \text{ torr} &= P_{\text{N}_2} + P_{\text{Cl}_2} = \text{mole fraction N}_2 \times P + \text{mole fraction of Cl}_2 \times P \\ &= 4 \times \text{mole fraction N}_2 \times P \end{aligned}$$

$$\text{N}_2 \text{ 186 torr, Cl}_2 \text{ 558 torr}$$

$$\text{N}_2 \text{ 0.245 atm, Cl}_2 \text{ 0.734 atm}$$

Now we can calculate the mass of the original sample

$$\begin{aligned} \text{Moles of N}_2 &= PV/RT = ((186/760 \text{ atm}) \times 1.50\text{L}) / (0.0821 \text{ Latmmol}^{-1} \text{K}^{-1} \times 346.15\text{K}) = \\ &0.01292 \text{ moles N}_2 \end{aligned}$$

or

$$\begin{aligned} \text{Moles Cl}_2 &= ((558/760 \text{ atm}) \times 1.50\text{L}) / (0.0821 \text{ Latmmol}^{-1} \text{K}^{-1} \times 346.15\text{K}) = 0.03875 \\ &\text{moles Cl}_2 \end{aligned}$$

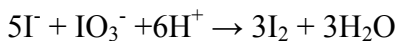
$$\text{Moles NCl}_3 = 2 \times 0.01292 \text{ moles N}_2 = 0.02584 \text{ moles}$$

or

$$\text{Moles NCl}_3 = 2/3 \times 0.03875 \text{ moles Cl}_2 = 0.02584 \text{ moles}$$

$$\text{Mass of NCl}_3 = 0.02584 \text{ moles} \times 120.37\text{g/mol} = 3.11 \text{ g}$$

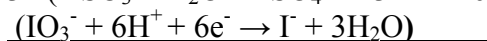
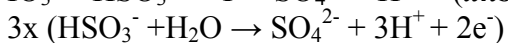
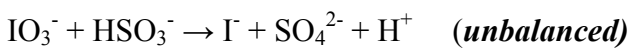
3. Iodine can be prepared from the reduction of sodium iodate (Na^+IO_3^-) in aqueous acidic solution using the following series of reactions:



How many grams of iodine are produced from 100. grams of NaHSO_3 if each reaction has a 78.4% yield?

Answer:

Need to balance the first reaction before we can calculate anything:

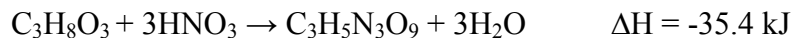


$$100 \text{ grams of NaHSO}_3 \times 1 \text{ mole}/104\text{g} \times 1 \text{ mole I}^-/3 \text{ mole HSO}_3^- \times 0.784 = 0.2513 \text{ moles of I}^-$$

$$0.2513 \text{ moles of I}^- \times 3 \text{ mole I}_2/5 \text{ mole I}^- \times 0.784 = 0.1182 \text{ mol I}_2$$

$$0.1182 \text{ mol I}_2 \times 253.8\text{g/mol} = \mathbf{30\text{g I}_2}$$

4. Nitroglycerin has applications in both medicine and as an explosive. It can be prepared by the carefully controlled reaction of glycerol ($C_3H_8O_3$) with nitric acid:



What mass of nitric acid is required for the production of 10.6 g of nitroglycerin by a process having a 44% yield? Is this reaction exothermic or endothermic?

Answer:

$$10.6 \text{ g nitro} \times 1 \text{ mol} / 227.1 \text{ g} = 0.04668 \text{ mole nitro}$$

$$0.04668 \text{ mole nitro} \times 3 \text{ mol } HNO_3 / \text{mol nitro} \times 1 / 0.44 \times 63 \text{ g/mol } HNO_3 = 20.04 \text{ g } HNO_3$$

20 or 20.0 g HNO_3 with correct sig fig

*A negative value of ΔH means that the reaction is **exothermic***

1. You are part of a team of scientists investigating a sports “doping” scandal. A sample suspected of being “andro” (a slang word for androstenedione $C_{19}H_{26}O_2$) is collected during the investigation. A combustion analysis of a 0.1570 g sample of this material yields 0.4599 g of CO_2 and 0.1151 g of H_2O . What is the simplest empirical formula for this sample? Is it andro?

Determine the formula of the compound using the analysis data:

*amount of C = $0.4599 \text{ g } CO_2 \times (12.01 \text{ g C}/44.01 \text{ g } CO_2) = 0.1255 \text{ g C}$
 $(0.1255 \text{ g}/0.1570 \text{ g}) \times 100\% = 79.94\% \text{ C in the sample}$
(moles $CO_2 = 0.01045$ moles)*

*amount of H = $0.1151 \text{ g } H_2O (1 \text{ mol}/18.02 \text{ g } H_2O)(1.01 \text{ g H/mol})(2 \text{ mol H/mol } H_2O) = 0.01290 \text{ g H}$
 $(0.01290 \text{ g}/0.1570 \text{ g}) \times 100\% = 8.22\% \text{ H}$
(moles $H_2O = 0.006394$ moles or 0.01279 moles H)*

$79.94 + 8.22 = 88.16\%$ The remainder should be O = 11.84%

Calculate the empirical formula assuming 100g of sample

$79.948 \text{ g C} \times 1/12.01 = 6.656$

$8.22 \text{ g H} \times 1/1.01 = 8.14$

$11.84 \text{ g O} \times 1/16.00 = 0.740$

$C_9H_{11}O_1$ (Doubling gives $C_{18}H_{22}O_2$ which is not $C_{19}H_{26}O_2$)

No, the sample has the wrong molecular formula.

By using the molar ratio or by a balanced eqn – got that the CH ratio was correct – gave 3/5

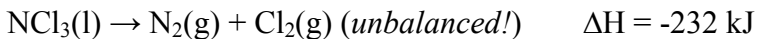
1/5 for the calculation of moles

By the way this is the analytical data for estrone $C_{18}H_{22}O_2$

Mol. Wt.: 270.3661

C, 79.96; H, 8.20; O, 11.84

2. A sample of liquid nitrogen trichloride was heated in a 1.50 L, closed container until it decomposed completely into gaseous elements. The resulting mixture exerted a pressure of 724 torr at 105°C.

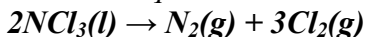


What is the partial pressure of each gas in the container?

What was the mass of the original sample?

Answer:

Balanced equation:



The total pressure = pressure of N₂ + pressure of Cl₂

Partial pressure is proportional to mole fraction and the mole fraction of Cl₂ = 3 mole fraction N₂

$$\begin{aligned} 724 \text{ torr} &= P_{\text{N}_2} + P_{\text{Cl}_2} = \text{mole fraction N}_2 \times P + \text{mole fraction of Cl}_2 \times P \\ &= 4 \times \text{mole fraction N}_2 \times P \end{aligned}$$

$$\text{N}_2 \text{ 181 torr, Cl}_2 \text{ 543 torr}$$

$$\text{N}_2 \text{ 0.238 atm, Cl}_2 \text{ 0.714 atm}$$

Now we can calculate the mass of the original sample

$$\text{Moles of N}_2 = PV/RT = ((181/760 \text{ atm}) \times 1.50\text{L}) / (0.0821\text{Latmmol}^{-1}\text{K}^{-1} \times 378.15\text{K}) = 0.01151 \text{ moles N}_2$$

or

$$\text{Moles Cl}_2 = ((543/760 \text{ atm}) \times 1.50\text{L}) / (0.0821\text{Latmmol}^{-1}\text{K}^{-1} \times 378.15\text{K}) = 0.03452 \text{ moles Cl}_2$$

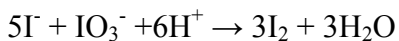
$$\text{Moles NCl}_3 = 2 \times 0.01151 \text{ moles N}_2 = 0.02301 \text{ moles}$$

or

$$\text{Moles NCl}_3 = 2/3 \times 0.03452 \text{ moles Cl}_2 = 0.02301 \text{ moles}$$

$$\text{Mass of NCl}_3 = 0.02301 \text{ moles} \times 120.37\text{g/mol} = 2.77 \text{ g}$$

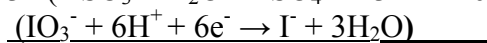
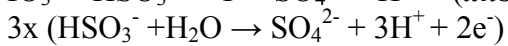
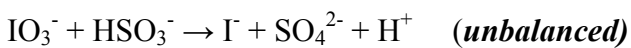
3. Iodine can be prepared from the reduction of sodium iodate (Na^+IO_3^-) in aqueous acidic solution using the following series of reactions:



How many grams of iodine are produced from 100 grams of NaHSO_3 if each reaction has a 39.2% yield?

Answer:

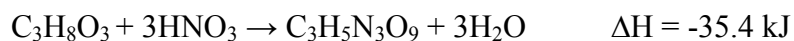
Need to balance the first reaction before we can calculate anything:



$100 \text{ grams of NaHSO}_3 \times 1 \text{ mole}/104 \text{g} \times 1 \text{ mole I}^-/3 \text{ mole HSO}_3^- \times 0.392 \times 3 \text{ mole I}_2/5 \text{ mole I}^-$
 $\times 0.392 = 0.02955 \text{ mol I}_2$

$0.02955 \text{ mol I}_2 \times 253.8 \text{g/mol} = 7.5 \text{g I}_2$

4. Nitroglycerin has applications in both medicine and as an explosive. It can be prepared by the carefully controlled reaction of glycerol ($C_3H_8O_3$) with nitric acid:



What mass of nitric acid is required for the production of 10.6 g of nitroglycerin by a process having a 22% yield? Is this reaction exothermic or endothermic?

Answer:

$$10.6 \text{ g nitro} \times 1 \text{ mol} / 227.1 \text{ g} = 0.04668 \text{ mole nitro}$$

$$0.04668 \text{ mole nitro} \times 3 \text{ mol } HNO_3 / \text{mol nitro} \times 1 / 0.22 \times 63 \text{ g/mol } HNO_3 = 42.01 \text{ g } HNO_3$$

20 or 20.0 g HNO_3 with correct sig fig

*A negative value of ΔH means that the reaction is **exothermic***

1. You are part of a team of scientists investigating a sports “doping” scandal. A sample suspected of being “andro” (a slang word for androstenedione $C_{19}H_{26}O_2$) is collected during the investigation. A combustion analysis of a 0.1570 g sample of this material yields 0.4566 g of CO_2 and 0.1244 g of H_2O . What is the simplest empirical formula for this sample? Is it andro?

Determine the formula of the compound using the analysis data:

*amount of C = $0.4566 \text{ g } CO_2 \times (12.01 \text{ g C}/44.01 \text{ g } CO_2) = 0.1246 \text{ g C}$
 $(0.1246 \text{ g}/0.1570 \text{ g}) \times 100\% = 79.36\% \text{ C in the sample}$
(moles $CO_2 = 0.010377 \text{ moles}$)*

*amount of H = $0.1244 \text{ g } H_2O (1 \text{ mol}/18.02 \text{ g } H_2O)(1.01 \text{ g H/mol})(2 \text{ mol H/mol } H_2O) = 0.01394 \text{ g H}$
 $(0.01394 \text{ g}/0.1570 \text{ g}) \times 100\% = 8.882\% \text{ H}$
(moles $H_2O = 0.006903 \text{ moles}$ or 0.01381 moles H)*

$79.36 + 8.882 = 88.24\%$ The remainder should be O = 11.76%

Calculate the empirical formula assuming 100g of sample

$79.36 \text{ g C} \times 1/12.01 = 6.608$

$8.88 \text{ g H} \times 1/1.01 = 8.79$

$11.76 \text{ g O} \times 1/16.00 = 0.735$

$C_9H_{12}O_1$ (doubling gives $C_{18}H_{24}O_2$ not $C_{19}H_{26}O_2$)

No, the sample does not have the correct molecular formula.

By using the molar ratio or by a balanced eqn – got that the CH ratio was correct – gave 3/5

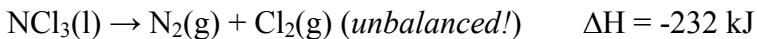
1/5 for the calculation of moles

By the way - This is the analytical data for Estradiol $C_{18}H_{24}O_2$

Mol. Wt.: 272.3820

C, 79.37; H, 8.88; O, 11.75

2. A sample of liquid nitrogen trichloride was heated in a 1.50 L, closed container until it decomposed completely into gaseous elements. The resulting mixture exerted a pressure of 788 torr at 75.0°C.

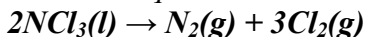


What is the partial pressure of each gas in the container?

What was the mass of the original sample?

Answer:

Balanced equation:



The total pressure = pressure of N₂ + pressure of Cl₂

Partial pressure is proportional to mole fraction and the mole fraction of Cl₂ = 3 x the mole fraction N₂

$$\begin{aligned} 788 \text{ torr} &= P_{\text{N}_2} + P_{\text{Cl}_2} = \text{mole fraction N}_2 \times P + \text{mole fraction of Cl}_2 \times P \\ &= 4 \times \text{mole fraction N}_2 \times P \end{aligned}$$

$$\text{N}_2 \text{ 197 torr, Cl}_2 \text{ 591 torr}$$

$$\text{N}_2 \text{ 0.259 atm, Cl}_2 \text{ 0.778 atm}$$

Now we can calculate the mass of the original sample

$$\begin{aligned} \text{Moles of N}_2 &= PV/RT = ((197/760 \text{ atm}) \times 1.50\text{L}) / (0.0821 \text{ Latmmol}^{-1} \text{K}^{-1} \times 346.15\text{K}) = \\ &0.01368 \text{ moles N}_2 \end{aligned}$$

or

$$\begin{aligned} \text{Moles Cl}_2 &= ((591/760 \text{ atm}) \times 1.50\text{L}) / (0.0821 \text{ Latmmol}^{-1} \text{K}^{-1} \times 346.15\text{K}) = 0.04104 \\ &\text{moles Cl}_2 \end{aligned}$$

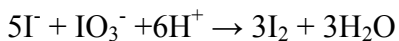
$$\text{Moles NCl}_3 = 2 \times 0.01368 \text{ moles N}_2 = 0.02736 \text{ moles}$$

or

$$\text{Moles NCl}_3 = 2/3 \times 0.04104 \text{ moles Cl}_2 = 0.02736 \text{ moles}$$

$$\text{Mass of NCl}_3 = 0.02736 \text{ moles} \times 120.37\text{g/mol} = 3.29 \text{ g}$$

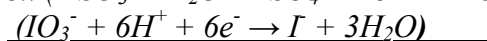
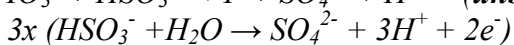
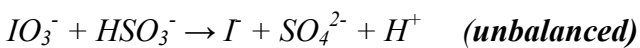
3. Iodine can be prepared from the reduction of sodium iodate (Na^+IO_3^-) in aqueous acidic solution using the following series of reactions:



How many grams of iodine are produced from 100. grams of NaHSO_3 if each reaction has a 55.5% yield?

Answer:

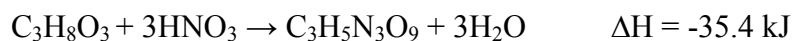
Need to balance the first reaction before we can calculate anything:



100 grams of NaHSO_3 x 1mole/104g x 1mole I^- /3 mole HSO_3^- x 0.555 x 3 mole I_2 /5mole I^- x 0.555 = 0.05902 mol I_2

0.05924 mol I_2 x 253.8g/mol = 15.0g I_2

4. Nitroglycerin has applications in both medicine and as an explosive. It can be prepared by the carefully controlled reaction of glycerol ($C_3H_8O_3$) with nitric acid:



What mass of nitric acid is required for the production of 12 g of nitroglycerin by a process having a 55% yield? Is this reaction exothermic or endothermic?

Answer:

$$12 \text{ g nitro} \times 1 \text{ mol}/227.1 \text{ g} = 0.05284 \text{ mole nitro}$$

$$0.05284 \text{ mole nitro} \times 3 \text{ mol } HNO_3/\text{mol nitro} \times 1/0.55 \times 63 \text{ g/mol } HNO_3 = 18.16 \text{ g } HNO_3$$

or 18 g HNO_3 with correct sig fig

*A negative value of ΔH means that the reaction is **exothermic***