1. You are part of a team 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 g CO_2 x (12.01 g C/44.01 g CO_2) = 0.1251 g C
(0.1251 g/0.1570 g) x 100% = 79.68% C in the sample
(moles CO_2 = 0.010415moles)

amount of H = 0.1283 g H_2O (1mol/18.02 g H_2O)(1.01 g H/mol)(2mol H/mol H_2O) = 0.014382 g H
(0.014382g/0.1570 g) x 100% = 9.160 % H
(moles H_2O = 0.00713moles or 0.01426moles H)

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

Calculate the empirical formula assuming 100g of sample
79.68 g C x 1/12.01 = 6.634
9.160 g H x 1/1.01 = 9.07
11.16 g O x 1/16.00 = 0.6975

$C_{9.51}H_{13.00}O_1 = C_{19}H_{26}O_2$

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 g/mol
%C in andro = 19 x 12.01g/mol x 1mol/286.41 g x 100% = 79.68
% H in andro = 26 x 1.008g/mol x 1mol/286.41 g x 100% = 9.15
% O 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 75.0ºC.

$NCl_3(l) \rightarrow N_2(g) + Cl_2(g)$ (*unbalanced!*) $\Delta H = -232$ kJ

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

What was the mass of the original sample?

Answer:

Balanced equation:

$\boldsymbol{2NCl_3(l) \rightarrow N_2(g) + 3Cl_2(g)}$

The total pressure = pressure of N_2 + pressure of Cl_2

Partial pressure is proportional to mole fraction and the mole fraction of Cl_2 = 3 mole fraction N_2

744 torr = $PN_2 + PCl_2$ = mole fraction N_2 x P + mole fraction of Cl_2 x P
= 4 x mole fraction N_2 xP

N_2 186 torr, Cl_2 558 torr
N_2 0.245 atm, Cl_2 0.734 atm

Now we can calculate the mass of the original sample

Moles of N_2 = PV/RT = ((186/760 atm) x 1.50L)/(0.0821Latmmol^{-1}K^{-1} x 346.15K) = 0.01292 moles N_2
or
Moles Cl_2 = = ((558/760 atm) x 1.50L)/(0.0821Latmmol^{-1}K^{-1} x 346.15K) = 0.03875 moles Cl_2

Moles NCl_3 = 2 x 0.01292 moles N_2 = 0.02584 moles
or
Moles NCl_3 = 2/3 x 0.03875 moles Cl_2 = 0.02584 moles

Mass of NCl_3 = 0.02584 moles x 120.37g/mol = 3.11 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:

$IO_3^- + HSO_3^- \rightarrow I^- + SO_4^{2-}$ (***unbalanced)***

$5I^- + IO_3^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

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:

$IO_3^- + HSO_3^- \rightarrow I^- + SO_4^{2-} + H^+$ (***unbalanced)***

$3x\ (HSO_3^- + H_2O \rightarrow SO_4^{2-} + 3H^+ + 2e^-)$

$\underline{(IO_3^- + 6H^+ + 6e^- \rightarrow I^- + 3H_2O)}$

$\mathbf{IO_3^- + 3HSO_3^- \rightarrow I^- + 3SO_4^{2-} + 3H^+}$ **Balanced!**

100 grams of $NaHSO_3$ x 1mole/104g x 1mole I^-/3 mole HSO_3^- x 0.784 =
0.2513 moles of I^-

0.2513 moles of I^- x 3 mole I_2/5mole I^- x 0.784 = 0.1182 mol I2

0.1182 mol I_2 x 253.8g/mol = ***30g 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:

$$C_3H_8O_3 + 3HNO_3 \rightarrow C_3H_5N_3O_9 + 3H_2O \qquad \Delta H = -35.4 \text{ kJ}$$

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 g nitro x 1mol/227.1g = 0.04668 mole nitro

0.04668 mole nitro x 3 mol HNO_3/mol nitro x 1/0.44 x 63g/mol HNO_3 = 20.04g 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 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 g CO_2 x (12.01 g C/44.01 g CO_2) = 0.1255 g C
(0.1255 g/0.1570 g) x 100% = 79.94% C in the sample
(moles CO_2 = 0.01045moles)

amount of H = 0.1151 g H_2O (1mol/18.02 g H_2O)(1.01 g H/mol)(2mol H/mol H_2O) = 0.01290 g H
(0.01290g/0.1570 g) x 100% = 8.22 % H
(moles H_2O = 0.006394moles 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 g C x 1/12.01 = 6.656
8.22 g H x 1/1.01 = 8.14
11.84 g O x 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 105ºC.

$NCl_3(l) \rightarrow N_2(g) + Cl_2(g)$ (*unbalanced!*) $\Delta H = -232$ kJ

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

What was the mass of the original sample?

Answer:

Balanced equation:

$\boldsymbol{2NCl_3(l) \rightarrow N_2(g) + 3Cl_2(g)}$

The total pressure = pressure of N_2 + pressure of Cl_2

Partial pressure is proportional to mole fraction and the mole fraction of Cl_2 = 3 mole fraction N_2

724 torr = $PN_2 + PCl_2$ = mole fraction N_2 x P + mole fraction of Cl_2 x P
= 4 x mole fraction N_2 xP

N_2 181 torr, Cl_2 543 torr
N_2 0.238 atm, Cl_2 0.714 atm

Now we can calculate the mass of the original sample

Moles of N_2 = PV/RT = ((181/760 atm) x 1.50L)/(0.0821Latmmol^{-1}K^{-1} x 378.15K) = 0.01151 moles N_2
or
Moles Cl_2 = = ((543/760 atm) x 1.50L)/(0.0821Latmmol^{-1}K^{-1} x 378.15K) = 0.03452 moles Cl_2

Moles NCl_3 = 2 x 0.01151 moles N_2 = 0.02301 moles
or
Moles NCl_3 = 2/3 x 0.03452 moles Cl_2 = 0.02301 moles

Mass of NCl_3 = 0.02301 moles x 120.37g/mol = 2.77 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:

$IO_3^- + HSO_3^- \rightarrow I^- + SO_4^{2-}$ (***unbalanced)***

$5I^- + IO_3^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

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:

$IO_3^- + HSO_3^- \rightarrow I^- + SO_4^{2-} + H^+$ (***unbalanced)***

$3x\ (HSO_3^- + H_2O \rightarrow SO_4^{2-} + 3H^+ + 2e^-)$

$\underline{(IO_3^- + 6H^+ + 6e^- \rightarrow I^- + 3H_2O)}$

$\mathbf{IO_3^- + 3HSO_3^- \rightarrow I^- + 3SO_4^{2-} + 3H^+}$ **Balanced!**

100 grams of $NaHSO_3$ x 1mole/104g x 1mole I^-/3 mole HSO_3^- x 0.392 x 3 mole I_2/5mole I^- x 0.392 = 0.02955 mol I2

0.02955 mol I_2 x 253.8g/mol = ***7.5g 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:

$$C_3H_8O_3 + 3HNO_3 \rightarrow C_3H_5N_3O_9 + 3H_2O \qquad \Delta H = -35.4 \text{ kJ}$$

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 g nitro x 1mol/227.1g = 0.04668 mole nitro

0.04668 mole nitro x 3 mol HNO_3/mol nitro x 1/0.21 x 63g/mol HNO_3 = 42.01g 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 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 g CO_2 x (12.01 g C/44.01 g CO_2) = 0.1246 g C
(0.1246 g/0.1570 g) x 100% = 79.36% C in the sample
(moles CO_2 = 0.010377moles)

amount of H = 0.1244 g H_2O (1mol/18.02 g H_2O)(1.01 g H/mol)(2mol H/mol H_2O) = 0.01394 g H
(0.01394g/0.1570 g) x 100% = 8.882 % H
(moles H_2O = 0.006903moles 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 g C x 1/12.01 = 6.608
8.88 g H x 1/1.01 = 8.79
11.76 g O x 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 75.0ºC.

$NCl_3(l) \rightarrow N_2(g) + Cl_2(g)$ (*unbalanced!*) $\Delta H = -232$ kJ

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

What was the mass of the original sample?

Answer:

Balanced equation:

$2NCl_3(l) \rightarrow N_2(g) + 3Cl_2(g)$

The total pressure = pressure of N_2 + pressure of Cl_2

Partial pressure is proportional to mole fraction and the mole fraction of Cl_2 = 3 x the mole fraction N_2

788 torr = $PN_2 + PCl_2$ = mole fraction N_2 x P + mole fraction of Cl_2 x P
= 4 x mole fraction N_2 xP

N_2 197 torr, Cl_2 591 torr
N_2 0.259 atm, Cl_2 0.778 atm

Now we can calculate the mass of the original sample

Moles of N_2 = PV/RT = ((197/760 atm) x 1.50L)/(0.0821$Latmmol^{-1}K^{-1}$ x 346.15K) = 0.01368 moles N_2
or
Moles Cl_2 = = ((591/760 atm) x 1.50L)/(0.0821$Latmmol^{-1}K^{-1}$ x 346.15K) = 0.04104 moles Cl_2

Moles NCl_3 = 2 x 0.01368 moles N_2 = 0.02736 moles
or
Moles NCl_3 = 2/3 x 0.04104 moles Cl_2 = 0.02736 moles

Mass of NCl_3 = 0.02736 moles x 120.37g/mol = 3.29 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:

$IO_3^- + HSO_3^- \rightarrow I^- + SO_4^{2-}$ (***unbalanced)***

$5I^- + IO_3^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

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:

$IO_3^- + HSO_3^- \rightarrow I^- + SO_4^{2-} + H^+$ ***(unbalanced)***

$3x\ (HSO_3^- + H_2O \rightarrow SO_4^{2-} + 3H^+ + 2e^-)$

$(IO_3^- + 6H^+ + 6e^- \rightarrow I^- + 3H_2O)$

$\mathbf{IO_3^- + 3HSO_3^- \rightarrow I^- + 3SO_4^{2-} + 3H^+}$ ***Balanced!***

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 I2*

0.05924 mol I_2 *x 253.8g/mol =* $\mathbf{15.0g\ I_2}$

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:

$$C_3H_8O_3 + 3HNO_3 \rightarrow C_3H_5N_3O_9 + 3H_2O \qquad \Delta H = -35.4 \text{ kJ}$$

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 g nitro x 1mol/227.1g = 0.05284 mole nitro

0.05284 mole nitro x 3 mol HNO_3/mol nitro x 1/0.55 x 63g/mol HNO_3 = 18.16g HNO_3

or 18 g HNO_3 with correct sig fig

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