Chemistry 141 Name

Dr. Cary Willard

Quiz 3a (20 points) February 20, 2013

1. (7 points) Titanium occurs in the magnetic mineral ilminite (FeTiO3), which is often found mixed up with sand. The ilmenite can be separated from the sand with magnets. The titanium can then be extracted from the ilmenite by the following set of reactions:

FeTiO3*(s)* + 3Cl2*(g)* + 3 C*(s)* 🡪 3CO*(g)* + FeCl2*(s)* + TiCl4*(g)*

TiCl4*(g)* + 2 Mg*(s)* 🡪 2MgCl2*(l)* + Ti*(s)*

Suppose that an ilmenite-sand mixture contains 22.8% ilmenite by mass and that the first reaction is carried out with a 90.8% yield. If the second reaction is carried out with an 85.9% yield, what mass (in grams) of titanium can be obtained from 3.50 kg of the ilmenite-sand mixture?

0.00526 kmol

0.798 kg

$$?g Ti=3.50 kg sand mix×\frac{22.8 kg FeTiO\_{3}}{100 kg sand}×\frac{1 kmol FeTiO\_{3}}{151.73 kg FeTiO\_{3} }×\frac{1 kmol TiCl\_{4}(theor)}{1 kmol FeTiO\_{3}}×\frac{90.8 kmol TiCl\_{4}(act)}{100 kmol TiCl\_{4}(theor)}×\frac{1 kmol Ti}{1 kmol TiCl\_{4}}×\frac{85.9 kmol Ti (act)}{100 kmol Ti(theor)}×\frac{47.88 kg Ti}{1 kmol Ti}×\frac{1000 g Ti}{1 kg Ti}=196 g Ti$$

0.00410 kmol

1. (6 points) Calculate the molarity of sodium and phosphate ions in a solution formed by dissolving 42.8 g of sodium phosphate to a final volume of 750.0 mL?

$$?M Na\_{3}PO\_{4}=\frac{42.8 g Na\_{3}PO\_{4}}{0.7500 L soln}×\frac{1 mol Na\_{3}PO\_{4}}{163.9 g Na\_{3}PO\_{4}}=0.348 M Na\_{3}PO\_{4}$$

$$\left[Na^{+}\right]=\frac{0.3482 mol Na\_{3}PO\_{4}}{1 L}×\frac{3 mol Na^{+}}{1 mol Na\_{3}PO\_{4}}=1.05 M Na^{+} $$

$$\left[PO\_{4}^{3-}\right]=\frac{0.3482 mol Na\_{3}PO\_{4}}{1 L}×\frac{1 mol PO\_{4}^{3-}}{1 mol Na\_{3}PO\_{4}}=0.348 M PO\_{4}^{3-} $$

1. (7 points) Iron(III) oxide reacts with carbon monoxide according to the equation

Fe2O3*(s)* + 3CO*(g)* 🡪 2Fe*(s)* + 3CO2*(g)*

A reaction mixture initially contains 35.23 g Fe2O3 and 17.94 g CO. Calculate the final mass of all reactants and products expected. Once the reaction has occurred as completely as possible, 19.44 g of metallic iron is formed. Calculate the percent yield for the reaction.

$$35.23 g Fe\_{2}O\_{3}×\frac{1 mol Fe\_{2}O\_{3}}{159.7g Fe\_{2}O\_{3}}=0.2207 mol Fe\_{2}O\_{3}$$

$$17.94 g CO×\frac{1 mol CO}{28.01 g CO}=0.6408 mol CO$$

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | x=0.2207 |  | x=0.2135 |  |  |  |  |
|  | Fe2O3 | + | 3CO | 🡪 | 2Fe | + | 3CO2 |
| I | 0.2207 mol |  | 0.6408 mol |  | 0 mol |  | 0 mol |
| D | -x |  | -3x |  | +2x |  | +3x |
| E | 0.2207-x=0.2207-0.2135=0.0072 mol |  | 0.6408-3x=.6408-3(0.2135)=0 mol |  | 2x=2(0.2135)=0.4270 mol |  | 3x=3(0.2135)=0.6408 mol |
|  |  |  |  |  |  |  |  |

$$0.4270 mol Fe×\frac{55.85 g Fe}{1 mol Fe}=23.85 g Fe$$

$$0.6408 mol CO\_{2}×\frac{44.01 g CO\_{2}}{1 mol CO\_{2}}=28.20 g CO\_{2}$$

$$0.0072 mol Fe\_{2}O\_{3}×\frac{159.7 g Fe\_{2}O\_{3}}{1 mol Fe\_{2}O\_{3}}=1.1 g Fe\_{2}O\_{3} remain unreacted $$

$$\% yield=\left(\frac{actual yield}{theoretical yield}\right)×100=\left(\frac{19.44 g}{23.85 g}\right)×100=81.51\%$$

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Quiz 3b (20 points) February 20, 2013

1. (7 points) Titanium occurs in the magnetic mineral ilminite (FeTiO3), which is often found mixed up with sand. The ilmenite can be separated from the sand with magnets. The titanium can then be extracted from the ilmenite by the following set of reactions:

FeTiO3*(s)* + 3Cl2*(g)* + 3 C*(s)* 🡪 3CO*(g)* + FeCl2*(s)* + TiCl4*(g)*

TiCl4*(g)* + 2 Mg*(s)* 🡪 2MgCl2*(l)* + Ti*(s)*

Suppose that an ilmenite-sand mixture contains 26.8% ilmenite by mass and that the first reaction is carried out with a 90.8% yield. If the second reaction is carried out with an 85.9% yield, what mass (in grams) of titanium can be obtained from 4.50 kg of the ilmenite-sand mixture?

0.00795 kmol

1.21 kg

$$?g Ti=4.50 kg sand mix×\frac{26.8 kg FeTiO\_{3}}{100 kg sand}×\frac{1 kmol FeTiO\_{3}}{151.73 kg FeTiO\_{3} }×\frac{1 kmol TiCl\_{4}(theor)}{1 kmol FeTiO\_{3}}×\frac{90.8 kmol TiCl\_{4}(act)}{100 kmol TiCl\_{4}(theor)}×\frac{1 kmol Ti}{1 kmol TiCl\_{4}}×\frac{85.9 kmol Ti (act)}{100 kmol Ti(theor)}×\frac{47.88 kg Ti}{1 kmol Ti}×\frac{1000 g Ti}{1 kg Ti}=297 g Ti$$

0.00620 kmol

1. (6 points) Calculate the molarity of sodium and phosphate ions in a solution formed by dissolving 68.3 g of sodium phosphate to a final volume of 750.0 mL?

$$?M Na\_{3}PO\_{4}=\frac{68.3 g Na\_{3}PO\_{4}}{0.7500 L soln}×\frac{1 mol Na\_{3}PO\_{4}}{163.9 g Na\_{3}PO\_{4}}=0.556 M Na\_{3}PO\_{4}$$

$$\left[Na^{+}\right]=\frac{0.4167 mol Na\_{3}PO\_{4}}{1 L}×\frac{3 mol Na^{+}}{1 mol Na\_{3}PO\_{4}}=1.67 M Na^{+} $$

$$\left[PO\_{4}^{3-}\right]=\frac{0.4167 mol Na\_{3}PO\_{4}}{1 L}×\frac{1 mol PO\_{4}^{3-}}{1 mol Na\_{3}PO\_{4}}=0.556 M PO\_{4}^{3-} $$

1. (7 points) Iron(III) oxide reacts with carbon monoxide according to the equation

Fe2O3*(s)* + 3CO*(g)* 🡪 2Fe*(s)* + 3CO2*(g)*

A reaction mixture initially contains 42.69 g Fe2O3 and 19.38 g CO. Calculate the final mass of all reactants and products expected. Once the reaction has occurred as completely as possible, 21.84 g of metallic iron is formed. Calculate the percent yield for the reaction.

$$42.69 g Fe\_{2}O\_{3}×\frac{1 mol Fe\_{2}O\_{3}}{159.7g Fe\_{2}O\_{3}}=0.2673 mol Fe\_{2}O\_{3}$$

$$19.38 g CO×\frac{1 mol CO}{28.01 g CO}=0.6919 mol CO$$

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | x=0.2673 |  | x=0.2306 |  |  |  |  |
|  | Fe2O3 | + | 3CO | 🡪 | 2Fe | + | 3CO2 |
| I | 0.2673 mol |  | 0.6919 mol |  | 0 mol |  | 0 mol |
| D | -x |  | -3x |  | +2x |  | +3x |
| E | 0.2673-x=0.2673-0.2306=0.0367 mol |  | 0.6919-3x=.6919-3(0.2306)=0 mol |  | 2x=2(0.2306)=0.4613 mol |  | 3x=3(0.2306)=0.6919 mol |
|  |  |  |  |  |  |  |  |

$$0.4613 mol Fe×\frac{55.85 g Fe}{1 mol Fe}=25.76 g Fe$$

$$0.6919 mol CO\_{2}×\frac{44.01 g CO\_{2}}{1 mol CO\_{2}}=30.45 g CO\_{2}$$

$$0.0367 mol Fe\_{2}O\_{3}×\frac{159.7 g Fe\_{2}O\_{3}}{1 mol Fe\_{2}O\_{3}}=5.86 g Fe\_{2}O\_{3} remain unreacted $$

$$\% yield=\left(\frac{actual yield}{theoretical yield}\right)×100=\left(\frac{21.84 g}{25.76 g}\right)×100=84.78\%$$