NavApp: Common Chemical Equations in Naval Operations

Learning Objectives

- Be able to balance a given chemical equation
- Determine the limiting reaction in an equation
- Determine the percent composition of an element in a compound

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1. Introduction

In the military, officers and enlisted personnel operate in extreme environments. As a future Naval or Marine Corps officer, it is important to understand the chemical reactions that are occurring in those environments, as some are undesirable or miscalculations can have deadly consequences. Below, we will investigate why metal ships rust in the operating environment, why choosing the correct warhead will help determine its lethality, and how ships and aircraft combust kerosene derivatives to operate.

2. Chemistry in the Operating Force

Next time you are walking on the Yard Patrol (YPs) crafts, take a minute to locate spots of rust. Rust occurs when iron reacts with oxygen and water. Placing metal ships in water is a perfect environment for rust to occur. Aircraft fuels, like JP-5 and JP-8, are combusted to form the energy required to propel the aircraft to its destination. Finally, warheads in missiles decompose to gases to form the destructive pressure bubble formed in an explosion.

3. Scientific Practices

Navy ships are made of a high tensile strength steel alloy. Steel is an alloy of iron. An alloy is when a metal is combined with other metals, in this case it is iron combined with other elements to provide additional strength. The equation of iron rusting covered in the questions portion of this document is an example of a reduction-oxidation equation that will be covered further in SC112.

A common explosive in warheads is cyclonite, commonly referred to as RDX (Royal Demolition Explosive). RDX is an organic compound combined with other ingredients to form a powerful warhead in several anti-ship missiles. The chemical formula for RDX is $C_3H_6N_6O_6$. The reaction is an example of a decomposition reaction used in explosives.

JP-5 is a kerosene directive fuel used in military flight operations. A common component of kerosene is $C_{12}H_{26}$ that can combust in the presence of oxygen. This provides the needed energy for aircraft operations. Mixing a hydrocarbon with oxygen to produced carbon dioxide and water is an example of a combustion reaction.

4. Questions

Balance the equations below:

a. [A] Fe (s) + [B] O_2 (g) + [C] H_2O (l) → [D] $Fe(OH)_3$ (s)
b. Given the balanced equation for rusting, please indicate the limiting reactant given 26.00 grams of iron and 30.00 mL of water in excess oxygen.
c. How much of the excess reactant will remain (in grams) after depleting the limiting reactant?
d. [A] $C_{12}H_{26}$ (s) + [B] O_2 (g) → [C] H_2O (l) + [D] CO_2 (s) (Please use whole numbers only)
e. [A] $C_3H_6N_6O_6$ (s) → [B] N_2 (g) + [C] H_2O (g) + [D] CO (g)
f. What is the empirical formula of $C_3H_6N_6O_6$? What is the percent composition of nitrogen?

References and Additional Readings

References are given in the figure captions, where available/applicable. Additional readings can be found on the Chemistry Department's website: https://intranet.usna.edu/ChemDept/plebeChem/navapps.php