Worked answers to Assignment 10

1) a) NH₃  ammonia
    b) N₂H₄  hydrazine
    c) HNO₃  nitric acid
    d) NF₃  nitrogen trifluoride

2) +5 \( \text{HNO}_3, \text{NO}_3^- \) nitric acid, nitrate anion
   +4 \( \text{NO}_2, \text{N}_2\text{O}_4 \) nitrogen dioxide, dinitrogen tetraoxide
   +3 \( \text{HNO}_2, \text{NO}_2^- \) nitrous acid, nitrite anion
   +2 \( \text{NO} \) nitric oxide
   +1 \( \text{N}_2\text{O} \) nitrous oxide
   0 \( \text{N}_2 \) dinitrogen
   \( \text{NH}_2\text{OH} \) hydroxylamine
   \( \text{N}_2\text{H}_4 \) hydrazine
   \( \text{NH}_3 \) ammonia

3) \( \text{N}_2 \) product is gas and very stable. This leads to a very exothermic reaction that produces lots of gas.

4) In the “Star Wars” experiment the combustion relied on diffusion of \( \text{O}_2 \) from the air. In the “\( \text{H}_2 \) balloon experiment the oxidant was pre-mixed with the fuel.

5) NO does not form under normal atmospheric conditions because it is endothermic, and because there is a high activation energy. NO forms in a car engine by the reaction of \( \text{N}_2 \) and \( \text{O}_2 \) because the temperature in the engine is sufficiently hot that the activation energy is overcome.

\( \text{N}_2 + \text{O}_2 \rightarrow 2 \text{NO} \)

(This process is similar to the production of NO in the atmosphere by lightning)

6) NO, NO₂

7) a) \( \text{C}_2\text{H}_2\text{N}_2\text{O}_4(s) + 1.5 \text{O}_2(g) \rightarrow 3 \text{CO}_2(g) + 3 \text{N}_2(g) + 3 \text{H}_2\text{O}(g) \)
    b) Oxidant is carried in the molecular formula. If you remove 1.5 \( \text{O}_2 \) from the left hand side you must remove 3 x \( \text{O} \) atoms from the RHS. The most likely way to do this is to produce 3 CO rather than 3 \( \text{CO}_2 \); so.

\( \text{C}_2\text{H}_2\text{N}_2\text{O}_4(s) \rightarrow 3 \text{CO}_2(g) + 3 \text{N}_2(g) + 3 \text{H}_2\text{O}(g) \)
    c) Exothermic, lots of oxidant in compound, all products are gases.
    d) MW(\text{RDX}) = 222.15

100 g of RDX = 0.45 mol RDX

\( \Delta H_f = 3 \times \Delta H_f^\circ(\text{CO}_2) + 3 \times \Delta H_f^\circ(\text{N}_2(g)) + 3 \times \Delta H_f^\circ(\text{H}_2\text{O}(l)) - \Delta H_f^\circ(\text{RDX(s)}) - \Delta H_f^\circ(\text{O}_2(g)) \)

\( = 3 \times (-394) + 3 \times (0) + 3 \times (-242) - (65) - (0) \)

\( = -1973 \text{ kJ/mol} \)

Therefore the heat released for 0.45 mol is 888 kJ.

8) \( \text{NH}_4\text{NO}_2(s) \rightarrow \text{N}_2(g) + 2\text{H}_2\text{O}(g) \)

MW = 64 g/mol

1 g = 1/64 = 1.56 × 10⁻² mol

therefore 1.56 × 10⁻² mol \( \text{N}_2 \) produced

\( PV = nRT \)

\( 1 \times V = 1.56 \times 10^{-2} \times 0.0821 \times (273+250) = 0.65 \text{ L} \)

Yes. Likely to be explosive because fuel and oxidant are pre-mixed in chemical compound.

9) a) \( \text{CH}_3\text{(CH}_3)_2\text{C}\text{COOH(s)} + 23\text{O}_2(g) \rightarrow 16\text{CO}_2(g) + 16\text{H}_2\text{O(l)} \)
    b) \( \Delta H_f = 16\Delta H_f^\circ(\text{CO}_2) + 16\Delta H_f^\circ(\text{H}_2\text{O}(l)) - \Delta H_f^\circ(\text{F},\text{ac}) \)

\( = 9980 = 16(-393.5) + 16(-285.8) - (-889) \text{ kJ/mol} \)

\( \Delta H_f^\circ(\text{F},\text{ac}) = -889 \text{ kJ/mol} \)

\( \text{MW(\text{ac}) = 256 amu} \). Therefore energy value = 9980 / 256 = 39 kJ/g fat

10) From lectures: \( \frac{|(1-R) F|}{4 \sigma} = T^4 \)

where \( R = \text{reflectivity of planet} \), \( F = \text{solar energy} \), \( T = \text{temp.}, \sigma = \text{Stefan-Boltzmann constant} \)

\( \frac{71\% \times 609}{4 \times 5.67 \times 10^{-12}} = T^4 \)

\( T^4 = 1.91 \times 10^9 \)

\( T = 209 \text{ K} \)

Greenhouse effect on Mars is very small (4°C). This makes sense as Mars has a thin atmosphere.