1) One reasonable explanation is that more (thermal) energy is produced when we condense gaseous water to liquid water. Another way of saying this is that it takes energy to perform the following reaction:

\[ \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g) \]

That is, it takes energy to boil water. (That part is a real ‘no duh’.)

2) First, we should convert 20 tons of coal into grams. Here we go:

\[ ? \text{ grams} = 20 \text{ tons} \left( \frac{2000 \text{ lbs}}{1 \text{ ton}} \right) \left( \frac{453.6 \text{ grams}}{1 \text{ lbs}} \right) = 18,144,000 \text{ grams} \]

which, at 30 kJ/gram, yields thermal energy of: 18,144,000 grams(30 kJ/gram) = \(5.44 \times 10^{11}\) J.

Now for the nuclear part of this: 6.72 mg = \(6.72 \times 10^{-6}\) kg which we can substitute into \(E = mc^2\) to get: \(E = (6.72 \times 10^{-6}\) kg)(3.0 \(\times 10^8\))^2 = \(6.048 \times 10^{11}\) J which is more than the 20 tons of coal gave us. (Just for interest, you would need: 22.22 tons of coal to match this.)

3) a) \(2 \text{ } ^{3}\text{He} \rightarrow ^{4}\text{He} + 2 ^{1}\text{H} \) is the requested equation.

b) \(^{1}\text{H} + ^{2}\text{H} \rightarrow ^{4}\text{He} + ^{0}\text{n} \) is the requested equation.

4a) \[ \text{Pb}_{(s)} + \text{SO}_4^{2-}_{(aq)} \rightarrow \text{PbSO}_4(s) + 2 \text{ e}^- \]

\[ \text{PbO}_2(s) + 4 \text{ H}^+_{(aq)} + \text{SO}_4^{2-}_{(aq)} + 2 \text{ e}^- \rightarrow \text{PbSO}_4(s) + 2 \text{ H}_2\text{O}(l) \]

b) \[ \text{Pb}_{(s)} + \text{SO}_4^{2-}_{(aq)} \rightarrow \text{PbSO}_4(s) + 2 \text{ e}^- \] is the oxidation reaction;

\[ \text{PbO}_2(s) + 4 \text{ H}^+_{(aq)} + \text{SO}_4^{2-}_{(aq)} + 2 \text{ e}^- \rightarrow \text{PbSO}_4(s) + 2 \text{ H}_2\text{O}(l) \]

is the reduction reaction

c) The lead electrode is the anode and the lead dioxide electrode is the cathode?

d) \[ \text{Pb}_{(s)} + \text{PbO}_2(s) + 4 \text{ H}^+_{(aq)} + 2 \text{ SO}_4^{2-}_{(aq)} \rightarrow 2 \text{ PbSO}_4(s) + 2 \text{ H}_2\text{O}(l) \]

5) a) From the balanced equation, 2 moles of sodium produce one mole of hydrogen so we need 2(22.99 g) = 45.98 g of sodium.

b) The production of one mole of liquid water produces 286 kJ of energy. In order to produce \(1.1 \times 10^6\) kJ of energy we need: \[ \frac{1.1 \times 10^6 \text{ kJ}}{286 \text{ kJ/mol}} = 3850 \text{ moles} \text{ H}_2\text{O}, \] which is also how much hydrogen gets consumed. If 45.98 g Na is needed for 1 mole \text{ H}_2, then 3850(45.98 g) = \(177,000\) g of Na is needed. (This is also 177 kg of Na.)
c) The cost would be $177 \times \frac{\$94}{1 \text{ kg Na}} = \$16,638$ which seems awfully expensive.