## Chem / Envsty L111: Spring 2007 Quiz 6

Name

1. Which conclusion is *not* supported by the Table of Bond Energies? a. A nitrogen-carbon single bond is about half as strong as a fluorinehydrogen single bond. b. Many elements make stronger single bonds to hydrogen than to any other atom. c. Triple bonds tend to be weaker than double bonds. 16/24 correct d. A carbon-carbon double bond is less than twice as strong as a carboncarbon single bond. A C-N single bond is worth 285 kJ/mole, while an HF bond is worth 566 – that's about half. The list of bond energies gets smaller to the right, confirming that X-H is often the strongest bond formed. A C-C bond is worth 356 kJ/mole, while a C=C bond is worth 598, which is less than twice as strong. But all of the triple bonds at the bottom of the table are stronger than their comparable double bonds. 2. The energy that flows from a warmer body to a colder body is called a. heat. 22/24 b. temperature. c. potential. d. work. 3. The energy stored in the chemical bonds of fossil fuels is a form of energy. a. heat b. light c. potential 21/24 d. kinetic 4. Thermal energy a. decreases as the temperature of a body increases. b. is characterized by the random motion of molecules. 15/24 c. is the only form of energy that can be transformed into work with 100% efficiency. d. causes the mass of a body to increase.

This is part of the definition of thermal energy – heat, unlike work, does not have a specified direction of motion of the molecules.

5. The conclusion that it is impossible to *completely* convert heat into work without making other changes in the universe is

- a. based on erroneous observations.
- b. the concept that increasing entropy characterizes all changes in the universe.
- c. another way of stating that all energy is either thermal energy or heat.
- d. the second law of thermodynamics.

This is a re-statement of the Second Law. A popular answer was b, indicating that people were on the right track. But entropy doesn't increase in **all** changes – just those that do not also involve work.

- 6. The energy needed to initiate a chemical reaction is called the
  - a. heat of combustion.
  - b. bond energy.
  - c. activation energy.
  - d. renewable energy.

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- 7. How is heat energy used to generate electricity in a modern power plant?
  - a. Heat warms wires causing electrons to move through them more rapidly.
  - b. Heat boils water to make steam which drives a turbine. 20/24
  - c. Heat warms the fins on a turbine, causing them to spin.
  - d. Heat generates strong magnetic fields through which the wires of a turbine move.
- 8. The following molecules contain only single bonds.

$$\mathsf{NH}_3(g) + 3\mathsf{F}_2(g) \to \mathsf{NF}_3(g) + 3 \mathsf{HF}(g)$$

Based upon the data in the Table of Bond Energies, the heat evolved or absorbed per mole of  $NH_3$  that reacts is

- a. +51 kJ/mol.
- b. +867 kJ/mol.
- c. –51 kJ/mol.

d. –867 kJ/mol.

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To break the bonds of the reactants, you must break 3 N-H bonds and 3 F-F bonds. That's 3 x 391 kJ/mole + 3 x 158 kJ/mole = 1647 kJ/mole. Making the bonds in the products gets you back 3 N-F bonds and 3 H-F bonds, which, changing the sign!!!, is worth 3 x -272 kJ/mole + 3 x -566 kJ/mole = -2514 kJ/mole. The energy change, then, is 1647 kJ/mole + (-2514 kJ/mole) = -867 kJ/mole. Half credit was awarded for answer b.

9. In the United States today, which two energy sources contribute almost equally to our total energy usage?

a. coal and natural gas

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- b. petroleum and natural gas
- c. petroleum and nuclear electric power
- d. coal and nuclear electric power

Wow. This question stumped almost everyone. Note what the question is asking – not which two sources are largest, or most important, but which two are most comparable to each other in terms of usage. Recall the bar graph showing the U.S. energy sources:



10. In which example is the entropy of the initial state *lower than* the entropy of the final state?

a. A pot of water boils to produce water vapor at 100 °C.

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- b. Librarians put library books back onto the shelves at the end of the day.
- c. A raw egg heated at 100 °C in boiling water becomes "hard boiled."
- d. Soldiers are called to attention when the general enters the room.

Liquid water is more organized, less chaotic than gas phase water, so a. is certainly a case where entropy **increases** during the "reaction". In b., the librarians are imposing order by doing work, and decreasing entropy. The same is true in d., where the arrival of the general **decreases** the entropy in the barracks. The egg is a little harder to see, but in a hard-boiled egg, the liquid yolk and white solidify and become fairly rigid – this, too, is a decrease in entropy compared to the original state.