Enthalpy, Energy, Heat Worksheet

1. Two beakers of water, one containing 50 mL and the other containing 250 mL, are heated to 75°C. Using these beakers as your examples, explain the difference between heat and temperature.

2. A quantity of gas was cooled from 323 K to 273 K. Express this temperature difference in degrees Celsius and Kelvins. What do these temperatures represent about the gas particles? Which temperature scale is a more accurate depiction of this representation? Explain briefly.

3. In the following chemical reactions, identify the system and the surroundings.

   a. Addition of sodium to a beaker of water.
   b. The blast furnace production of iron from Fe_2O_3 and CO.

4. Are the following reactions exothermic or endothermic?$_2$

   a. $CH_4\ (s) + O_2\ (g) \longrightarrow CO_2\ (g) + 2\ H_2O\ (\ell)$ $\quad \Delta H = -890$ kJ
   b. $2\ HCl\ (g) \longrightarrow H_2\ (g) + 2\ Cl_2\ (g)$ $\quad \Delta H = +185$ kJ
   c. $4\ NH_3\ (g) + 5\ O_2 \longrightarrow 4\ NO\ (g) + 6\ H_2O\ (\ell)$ $\quad \Delta H = -1169$ kJ

5. Question 4 above shows one way of representing the enthalpy of reaction. Pick one of the reactions above and show two other ways to represent the enthalpy of reaction.

6. Are the following processes exothermic or endothermic?

   a. ice cubes solidify in freezer
   b. water evapourates from a glass left on windowsill
   c. dew forms on grass overnight.

7. Using the concept of bond energies, explain why an overall reaction is endothermic or exothermic.

8. When potassium nitrate dissolves in water, the beaker containing the solution gets cooler. Is dissolving this salt an exothermic or an endothermic process?

9. Using the example of the burning of piece of paper, explain how chemical reactions follow the law of conservation of energy.

10. Is ΔH positive or negative for the chemical reaction occurring when oil burns? Explain briefly.

11. Explain why the process involved in freezing a substance is exothermic.

12. Adding Drano to a clogged sink causes the drain pipe to get warm. What is the sign of ΔH for this process?

13. When 1.5×10^3 J of heat energy is absorbed by a beaker of water, its temperature rises 3.1°C. What is the heat capacity of the beaker of water? (Hint: heat capacity is mass times specific heat capacity)

14. If 10.5 g of iron, at 25°C, absorbs 128 J of heat, what will be the final temperature of metal? (The specific heat of iron is 0.449 J g^{-1} $°C^{-1}$)

15. Calculate the molar heat capacity of ethanol, C_2H_5OH (ℓ). The specific heat of ethanol is 2.46 J g^{-1} $°C^{-1}$) (Hint: this is simply a unit conversion of grams to moles)

16. A 50.0 g piece of aluminum is heated to 100°C and then put into a beaker containing 150 mL of water at 20.0°C. Assuming no loss of heat to the surroundings, calculate the final temperature of the water. (The specific heat capacity of aluminum is 0.903 J g^{-1} $°C^{-1}$ and for water is 4.184 J g^{-1} $°C^{-1}$)

17. A 4.05 g sample of sulfur is burned in excess oxygen. The heat produced raises the temperature of 1.00 L of water from 23.15°C to 32.03°C. From this information calculate the ΔH of the reaction.

18. Calculate the amount of energy released when 1.0 kg of water freezes. (ΔH = 6.02 kJ/mol)

19. Using a coffee cup calorimeter, 150 mL of 1.00 mol L^{-1} hydrochloric acid are mixed with 150 mL of 1.00 mol L^{-1} sodium hydroxide solution. The initial temperature of the solutions was 22.6°C and the temperature after mixing was 29.5°C. Calculate the molar enthalpy change of the neutralization reaction.

20. A 24.6 g sample of nickel is heated to 110.0°C and then placed in a coffee cup calorimeter containing 125 g of water at a temperature of 23.00°C. After the nickel cools, the final temperature of the metal and water is 24.83°C. Assuming no heat has escaped to the surroundings or been absorbed by the calorimeter, calculate the specific heat of nickel.

Answers:

2. 50 K and 50°C.
3. system – Na, H_2O, and the products;
   surroundings – beaker, air system – Fe_2O_3, CO and products; surroundings – furnace, air
4. exothermic, endothermic, exothermic
5. show using an enthalpy diagram; show the enthalpy directly as part of the reaction equation as either a product or reactant
6. exothermic, endothermic, exothermic
7. endothermic
11. negative
12. 4.80×10^2 J $°C^{-1}$
13. 52°C
14. 113 J mol^{-1} K^{-1}
15. 25.3°C
16. -295 kJ mol^{-1}
17. 3.3×10^2 kJ released
18. -57.8 kJ mol^{-1}
19. 0.457 J g^{-1} $°C^{-1}$