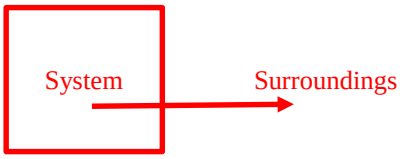
Chapter 16 WS

Intro to Thermodynamics & Specific Heat

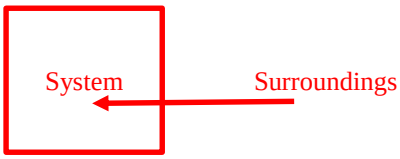
Name: _____

Period: _____ **Date:** _____

1) In an exothermic reaction, is heat gained or lost in the system? Is heat gained or lost in the surroundings? Draw a diagram that shows the transfer of energy between the two in an exothermic reaction.
Exothermic = Heat lost by the system and gained by the surroundings.



2) In an endothermic reaction, is heat gained or lost in the system? Is heat gained or lost in the surroundings? Draw a diagram that shows the transfer of energy between the two in an endothermic reaction.
Endothermic = Heat gained by the system and lost by the surroundings



3) ΔH is known as the ____enthalpy_____ or the ____heat____ __of__ ___reaction___. If a reaction is exothermic, the value of ΔH will be _____negative_____, but if a reaction is endothermic, the value of ΔH will be _____positive_____.

4) List three examples of an exothermic reaction
- Condensation
- Freezing
- Deposition
- Any reaction that gets colder

5) List three examples of an endothermic reaction
- Vaporization (Boiling)
- Melting
- Sublimation
- Any reaction that gets warmer

6) When you get a small cut, you can disinfect it by placing hydrogen peroxide in the wound. How much energy will be transferred if 34.0 g of hydrogen peroxide decomposes by the following reaction? Is it endothermic or exothermic?

$$2H_2O_{2\,(l)} \rightarrow 2H_2O_{(l)} + O_{2\,(g)} + 200\ kJ$$

$$34.0\ g\ H_2O_2 \left|\frac{1\ mol\ H_2O_2}{34.0\ g\ H_2O_2}\right| \left|\frac{-200\ kJ}{2\ mol\ H_2O_2}\right| = -100\ kJ$$

Heat is product = Negative Answer = Exothermic

7) How much heat will be transferred when 5.494 g of manganese reacts with hydrochloric acid according the following equation? Is it endothermic or exothermic?

$$Mn_{(s)} + 2HCl_{(aq)} \rightarrow MnCl_{2\,(aq)} + H_{2\,(g)} + 221\ kJ$$

$$5.494\ g\ Mn \left|\frac{1\ mol\ Mn}{54.94\ g\ Mn}\right| \left|\frac{-221\ kJ}{1\ mol\ H_2O_2}\right| = -22.1\ kJ$$

Heat is product = Negative Answer = Exothermic

8) How much heat will be transferred in the decomposition of 10.8 g of dinitrogen pentoxide? Is it endothermic or exothermic?

$$2N_2O_{5\,(g)} + 110.\ kJ \rightarrow 4NO_{2\,(g)} + O_{2\,(g)}$$

$$10.8\ g\ N_2O_5 \left|\frac{1\ mol\ N_2O_5}{108\ g\ N_2O_5}\right| \left|\frac{+110.\ kJ}{2\ mol\ N_2O_5}\right| = +5.5\ kJ$$

Heat is reactant = Positive Answer = Endothermic

9) Phosphorus burns to produce a thick white cloud of tetra phosphorus decaoxide gas. This gas reacts with water in the air to produce acid rain composed of phosphoric acid. How much energy is transferred when 14.2 g of the gas reacts with water? It is endothermic or exothermic?

$$P_4O_{10\,(g)} + H_2O_{(l)} \rightarrow 4H_3PO_{4\,(aq)} + 424\ kJ$$

$$14.2\ g\ P_4O_{10} \left|\frac{1\ mol\ P_4O_{10}}{284\ g\ P_4O_{10}}\right| \left|\frac{-424\ kJ}{1\ mol\ P_4O_{10}}\right| = -21.2\ kJ$$

Heat is product = Negative Answer = Exothermic

10) Methane gas is used as a fuel for heating hot water in many of our homes. It is also used to cook our food in our gas stoves as well as in our Bunsen Burners in our chemistry lab. Write the thermochemical equation with ΔH, for the combustion of methane gas if it is an exothermic reaction that produces 890 kJ/mol of CH_4.

$$CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{(l)} \qquad \Delta H = -890\ kJ$$

Solve each of the following story problems involving specific heats

11) 5.0 g of copper was heated from 20°C to 80°C. How much energy in calories and joules was used to heat Cu? (Specific heat capacity of Cu is 0.092 cal/g °C)

$$q = mC\Delta T$$
$$q = (5.0\ g)(0.092\ \frac{cal}{g°C})(80°C - 20°C)$$
$$q = 27.6\ cal$$
$$q = 27.6\ cal \left|\frac{4.184\ J}{1\ cal}\right| = 115\ J$$

12) How much heat in calories and joules is absorbed by 20g granite boulder as energy from the sun causes its temperature to change from 10°C to 29°C? (Specific heat capacity of granite is 0.10 cal/g°C)

$$q = mC\Delta T$$
$$q = (20.\ g)(0.10\ \frac{cal}{g°C})(29°C - 10°C)$$
$$q = 38\ cal$$
$$q = 38\ cal \left|\frac{4.184\ J}{1\ cal}\right| = 160\ J$$

13) How much heat is released in calories and joules when 30. g of water at 96°C cools to 25°C? The specific heat of water is 1.0 cal/g°C.

$$q = mC\Delta T$$
$$q = (30.\ g)(1.0\ \frac{cal}{g°C})(96°C - 25°C)$$
$$q = 2130\ cal$$
$$q = 2130\ cal \left|\frac{4.184\ J}{1\ cal}\right| = 8910\ J$$

14) If a 3.1g ring is heated using 10.0 calories, its temperature rises 17.9°C. Calculate the specific heat capacity of the ring.

$$C = \frac{q}{m\Delta T} = \frac{10.0\ cal}{(3.1\ g)(17.9°C)} = 0.18\ \frac{cal}{g°C}$$
$$C = 0.18\ \frac{cal}{g°C}\left|\frac{4.184\ J}{1\ cal}\right| = 0.75\ \frac{J}{g°C}$$

15) The temperature of a sample of water increases from 20.0°C to 46.6°C as it absorbs 5650 calories of heat. What is the mass of the sample? (Specific heat of water is 1.0 cal/g °C)

$$q = mC\Delta T$$
$$5650\ cal = (m)(1.0\ \frac{cal}{g°C})(46.6°C - 20.0°C)$$
$$5650\ cal = 26.6\frac{cal}{g}(m)$$
$$m = 212\ g\ H_2O$$

16) The temperature of a sample of iron with a mass of 10.0 g changed from 50.4°C to 25.0°C with the release of 47 calories of heat. What is the specific heat of iron in calories and joules?

$$C = \frac{q}{m\Delta T} = \frac{47.0\ cal}{(10.0\ g)(50.4°C - 25.0°C)} = 0.185\frac{cal}{g°C}$$
$$C = 0.185\ \frac{cal}{g°C}\left|\frac{4.184\ J}{1\ cal}\right| = 0.774\ \frac{J}{g°C}$$

17) A 4.50 g coin of copper absorbed 54 calories of heat. What was the final temperature of the copper if the initial temperature was 25°C? The specific heat of copper is 0.092 cal/g°C.

$$q = mC\Delta T$$
$$54\ cal = (4.5\ g)(0.092\ \frac{cal}{g°C})(T_f - 25°C)$$
$$54\ cal = 0.414\frac{cal}{°C}(T_f - 25°C)$$
$$130 = T_f - 25 \qquad T_f = 160°C$$

18) A 155 g sample of an unknown substance was heated from 25.0°C to 40.0°C. In the process, the substance absorbed 569 calories of energy. What is the specific heat of the substance in calories and joules?

$$C = \frac{q}{m\Delta T} = \frac{569\ cal}{(155\ g)(40.0°C - 25.0°C)} = 0.245\frac{cal}{g°C}$$
$$C = 0.245\ \frac{cal}{g°C}\left|\frac{4.184\ J}{1\ cal}\right| = 1.03\ \frac{J}{g°C}$$

19) What is the specific heat in calories and joules of an unknown substance if a 2.50 g sample releases 12 calories as its temperature changes from 25.°C to 20.°C?

$$C = \frac{q}{m\Delta T} = \frac{12\ cal}{(2.5\ g)(25.°C - 20.°C)} = 0.18\frac{cal}{g°C}$$
$$C = 0.18\ \frac{cal}{g°C}\left|\frac{4.184\ J}{1\ cal}\right| = 0.75\ \frac{J}{g°C}$$

20) You find a rod that looks like platinum laying on the ground and want to test to see if it is. If it requires 2170 J of energy to change the 221 g rod from 43°C to 121°C, is the rod made of platinum (C_{Pt} = 0.126 J/g°)?

$$C = \frac{q}{m\Delta T} = \frac{2170\ J}{(221\ g)(121°C - 43°C)} = 0.126\frac{J}{g°C}$$

Yes it is Platinum because the specific heat matches, and since specific heat is an intensive property, it identifies the metal of the pipe.