Chemistry Worksheet
Heating-Cooling Curves and Calorimetry

Name: KEY
Block: _____

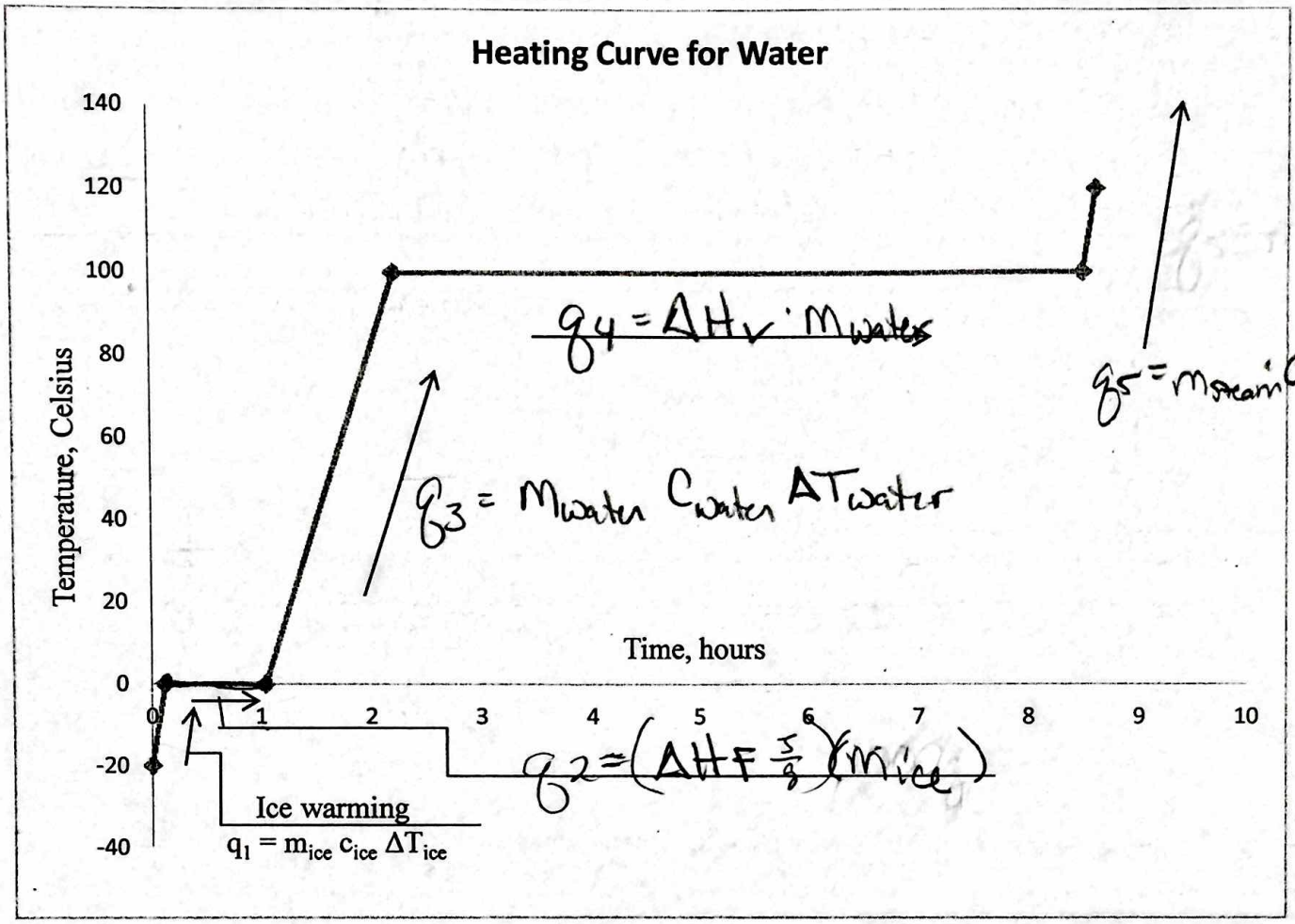

Figure 1

Figure 1shows the temperature of 1.00 kilograms of ice (H_2O) starting at −20 °C that is heated at a constant rate of 100 Joules per second (100 J/s). After about 8.6 hours, the ice has become water vapor (still H_2O!) at 120 °C. There are five distinct regions in the curve, each of which has an arrow nearby.

1. Above each arrow *write what is happening* to the H_2O in that region. (See the example for the first region.)
2. Below each line, *write the algebra equation that is used to calculate the heat* (q) for that region. Label the heat (q_2, q_3, q_4, q_5) in order from left to right. (See the example for the first region.)
3. For each of the five regions, use your equation and the information provided in the figure 1 caption and in table 1 to calculate the heat for each region using the *numerical information*. Complete your calculations on the next page – be sure to show your work and include all units with each calculation. Record your results in the appropriate answer blank. Use a separate piece of paper if you need more space. Keep the paper with this worksheet.

Table 1: Key thermochemical data for water					
C_{ice} =	2.11	J/(g C)	ΔH_f =	333.6	J/g
C_{water} =	4.18	J/(g C)	ΔH_v =	2256	J/g
C_{steam} =	2.08	J/(g C)	$q_{total} = q_1 + q_2 + q_3 + q_4 + q_5$		

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Show calculations here:

$q_1 = 1000\,g \cdot 2.11\ \frac{J}{g°C}\ (20°C - 0°C) = 42200\,J$

$q_2 = 333.6\ \frac{J}{g}\ (1000\,g) = 333600\,J$

$q_3 = 1000\,g \cdot 4.18\ \frac{J}{g°C} \cdot (100°C - 0°C) = 418000\,J$

$q_4 = 2256\ \frac{J}{g}\ (1000\,g) = 2256000\,J$

$q_5 = 1000\,g \cdot 2.08\ \frac{J}{g°C}\ (120°C - 100°C) = 41600\,J$

a. q_1 = 42.2 KJ

b. q_2 = 333.6 KJ

c. q_3 = 418 KJ

d. q_4 = 2256 KJ

e. q_5 = 41.6 KJ

f. q_{total} = 3091.4 KJ

4. Which segment represents the largest amount of energy? Explain why.

phase change from liquid → gas b/c it requires the most amount of energy for the same amount of water.

5. Which phase (solid, liquid, or gas) takes the most energy to warm up by 20°C?
   a. Explain how you can tell by looking at the graph.

liquid b/c it has the highest specific heat.

   b. Explain how you can tell by looking at the values of specific heat.

the value indicates the amount of energy needed to raise 1g of the substance 1°C

6. In an experiment, 2.0 grams of NaOH are dissolved in 100 g of water. The temperature of the water goes from 21°C to 25°C.
   a. Is the reaction endothermic or exothermic? b/c the water temp goes up.
   b. Calculate the following:
      i. mass of the ~~solution~~ water = m = 100 g
      ii. change in temperature = ΔT = 25°C − 21°C = 4°C
      iii. heat = q = $100\,g \cdot 4.18\ J/g°C \cdot 4°C = 1672\,J$ > $q_{calorimeter}$
      Given that the specific heat of the solution = 4.18 J/g°C.
      iv. moles of NaOH = $2.0\,g\ NaOH \times \frac{1\ mole\ NaOH}{40\,g\ NaOH} = 0.05\ mol\ NaOH$
      v. enthalpy for the reaction in units of kJ/mol = ΔH =

$q_{cal} = -q_{rxn}$ $\Delta H_{rxn} = \frac{-1672\,J}{0.05\,mol} = 33440\ J/mol = -33.4\ KJ/mol$