Thermochemistry Class Notes

Thermochemistry concerns itself with how much energy is absorbed or released in a chemical reaction, or in a phase change. Since we just learned about phases, we'll start with them first, then move to chemical reactions.

Physical changes, or Phase changes can be either exo or endothermic, depending if they either release or emit heat energy, or if they absorb it.

Emit = Release heat

Absorb = Add heat

1. Exothermic means to _____ heat energy.

2. Endothermic means to _____ heat energy.

3. To melt solids into liquids you need to _____ heat energy.

4. To freeze liquids into solids you need to _____ heat energy.

5. To vaporize a liquid into a gas you need to _____ heat energy.

6. To condense a gas into a liquid you need to _____ heat energy.

7. For sublimation, when a solid turns directly into a gas you need to _____ heat energy.

8. For deposition, when a gas turns directly into a solid you need to _____ heat energy.

9. When substances are hotter, their particles are moving _____

10. The hotter particles have _____ Kinetic energy than colder ones.

11. Colder substances have _____ moving particles.

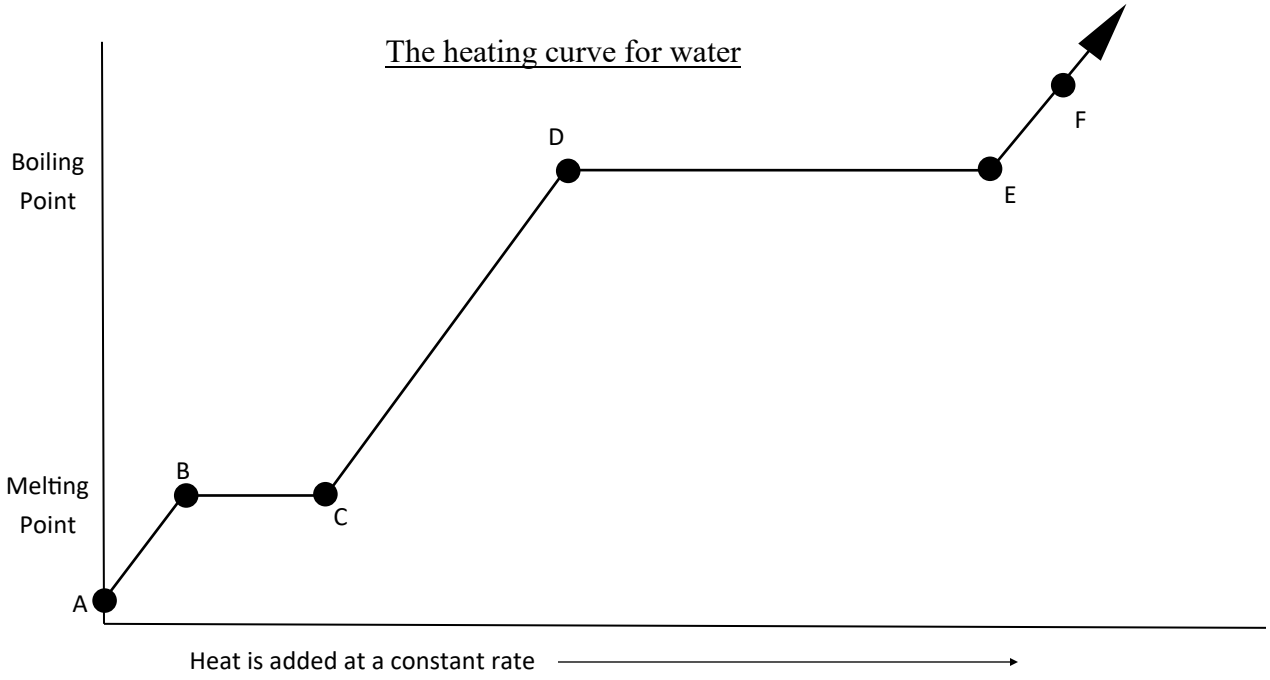
12. Colder substances have _____ Kinetic energy than hotter ones.

13. Skip this one, okay?

14. During a phase change the temperature is steady, so what energy changes? _____

15. The _____ energy _____ during melting.

16. The _____ energy _____ during condensing.



	Segment	Temperature and Kinetic Energy INC or DEC or STEADY?	Phase or Phases Present	Potential Energy INC or DEC or STEADY?
17	AB			
18	BC			
19	CD			
20	DE			
21	EF			

22. Why is BC shorter than DE? _____

_____.

23. To melt ONE GRAM of SOLID ICE into one gram of liquid water requires the _____

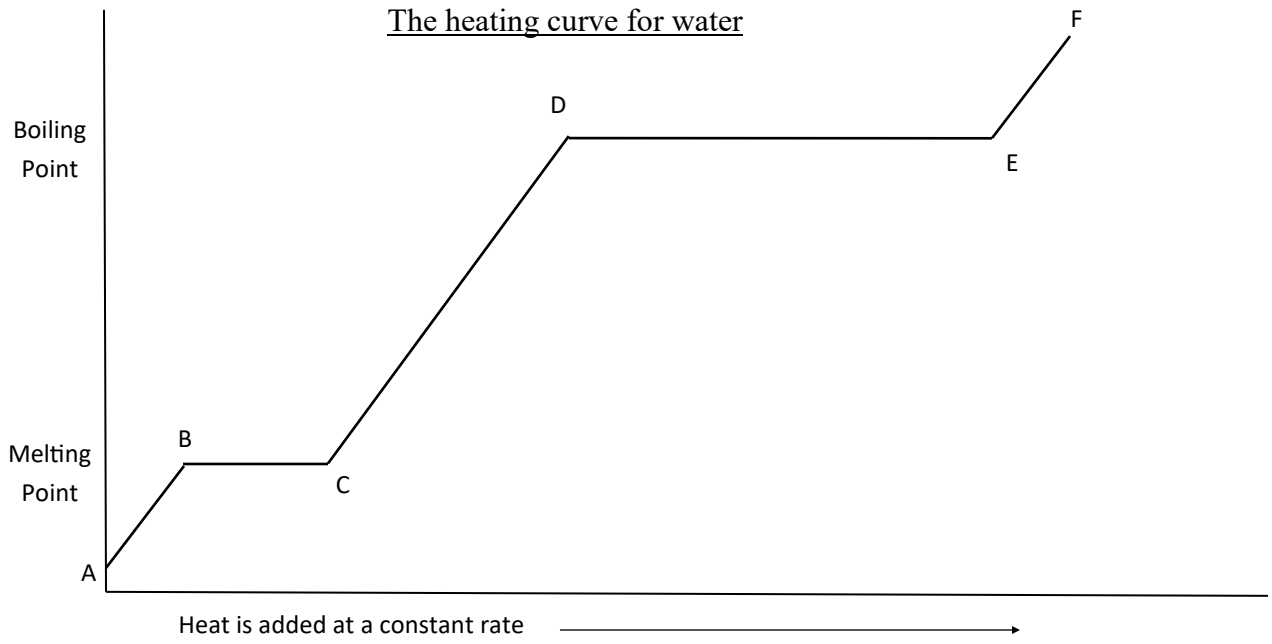
of _____ energy, for H_{2O} that is _____.

24. To vaporize ONE GRAM of liquid water into STEAM gas requires the _____ of

_____ energy, for H_2O that is _____.

25. Table B has three important physical constants for water. Fill in this chart now.

Constant	Value with units	Will make one gram of H_2O...
Heat of Fusion		
Heat of Vaporization		
Specific Heat Capacity		



26. To move from B to C on this graph, we would need to ADD _____ of energy.

27. To move from D to E on this graph, we would need to ADD _____ of energy.

28. Moving from B to C is _____thermic.

29. The energy requirement to move along the BC segment is _____.

30. How much energy does it take to melt a real sized ice cube of 73.5 grams?

31. How much energy does it take to freeze 125 grams of pure water into ice if the water starts at 0°C?

32. How much energy does it take to vaporize 73.5 grams of water into steam? (no ΔT)

33. If you stick your finger into the steam coming out of a tea kettle, and 2.75 grams of steam condenses into 2.75 grams of water on your hand, how much energy do you absorb?

34. Which phase change takes more energy, COLD freezing/melting or HOT condensing/vaporizing?

35. If heat is added AT A CONSTANT RATE, why is BC shorter than DE on the heating curve for water?

36. Freezing water into ice or melting ice into water takes _____

37. Vaporizing water into steam or condensing steam into water takes _____

38. To change the temperature of liquid water it takes _____

To warm up one gram H_2O by 1°C takes 4.18 Joules. To cool down one gram H_2O by 1°C takes 4.18 Joules.

The change in temperature is the same in Centigrade or Kelvin: _____

39. The amount of energy need to change the temperature of one gram of pure water from

275 Kelvin to 276 Kelvin means we must add _____ Joules of energy.

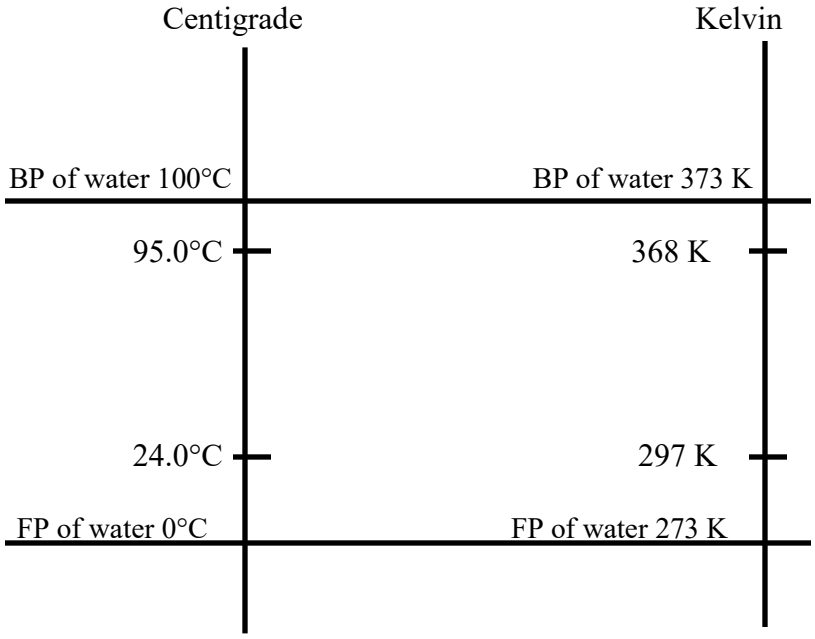
40. To change the temp. of 2 grams of H_2O from 365 K to 366 K, you need to add _____ (8.36 J)

41. If you let one gram of hot water, at 368 Kelvin, to cool down to 367 Kelvin, how much heat is radiated out

of this water? _____

42. How many joules of energy must be removed from 375 grams of water at 294 K to cool it to 275 K?

43. The temperature of 95.0°C = 368 K The temperature of 24.0°C = 297 K



44. The ΔT in °C = _____

45. The ΔT in K = _____

46. The hot temps have different numbers, and so do the cold temps, but the ΔT is always going to be

_____

47. There are _____ units of energy between freezing and boiling in Celsius: _____

48. There are _____ units of energy between freezing and boiling in Kelvin: _____

49. The _____ = _____

50. A pot has 650. grams of water at room temp, or 24.0°C. You think to make some mac & cheese and turn on the stove to heat the water. Your BFF shows up with pizza, so you turn off the stove. The water is at 95.0°C. How much energy would your Dad say you <u>wasted</u> by heating up this water for nothing?

51. You want some mac & cheese, so you put 650. grams of water at 24.0°C onto the stove top. You begin to text your BFF and "forget" about the pot. Your Mom yells "Who left this pot boiling on the stove?!" You realize that you foolishly vaporized 35.0 grams of your water while being distracted. You turn off the stove and decide to eat out instead. How much total energy did you waste?

52. Take out table T (the bottom of the back page of your reference table. Copy this:

The most important thing in doing phase change thermomchem problems it to always use the right formula, always use the right constants, and to always use units. Challenge time...

53. How many joules of energy are required to freeze 355 mL of water at 273K?

54. How many joules required to melt a snowball of 415 g?

55. How many joules does it take to warm up 375 grams of water at 285.0 K to 292.5 K?

Sometimes in thermochem problems you need to solve for H_F or H_V or C or even ΔT. To do this you must put the numbers in their proper place and remember it's not always water we're talking about.

56. What is the specific heat capacity constant for GOLD if it takes 271 joules to warm up a ring with mass of 34.2 g from 294.0 K to a "too hot to wear" 355.5 Kelvin?

57. What is the specific heat capacity constant of copper, if it takes 951 joules to warm up 41.63 grams of copper from 294.5 K up to 352.9 Kelvin?

58. What is the heat of fusion constant for an unknown metal if it takes 6750 Joules to melt 28.0 grams of it?

59. How many grams of ice can be melted when you add 87,500 joules of heat to it?

60. If 92.0 grams of a substance absorbs 27,496 Joules and the temperature increased from 12.3°C to 83.8°C, what is the specific heat capacity constant of this unknown?

61. You put a 155. gram snowball at –4.00°C into the back of your friend's jacket. It ultimately warms up to his body temperature of 37.0°C. How much energy did that take? (think) Look back in notes 2 pages.

step	called	formula	Do the math
1		$q = mC\Delta T$	
2		$q = mH_F$	
3		$q = mC\Delta T$	
		Total Joules required →	

62. You allow 5.75 grams of steam to condense onto your kitchen window, then it cools to room temperature of 23.5°C. How much energy is emitted in this process?

step	called	formula	Do the math
1			
2			
		Total Joules required →	

Let's look at Table I.

63. The title to table I is _____

64. Which means _____.

65. *There are 6 combustion reactions, then 12 synthesis (or decomp) reactions, and 6 phase changes (from solid salts ionizing into AQ solution).* All have what is called the ΔH. What is that?

ΔH means the _____

66. Some of the ΔH are negative, like the top reaction. What does that little asterisk* mean at the top of the table, next to ΔH?

— ΔH means that this reaction is _____

+ ΔH means that this reaction is _____

67. Can energy be positive or negative? _____

68. These signs are just indicators as to energy being absorbed: ____ ΔH

69. Or if it is energy being emitted: ____ ΔH

Time for a really, really cool demo…

70. $Ba(OH)_2 \cdot 8H_2O_{(S)}$ is _____

71. $NH_4SCN_{(S)}$ _____

72. Look at the first reaction in Table I. What type of reaction is that? _____

73. What is kJ? _____

74. 1 kJ = _____

75. 1 km = _____

76. 1 kg = _____

77A. Table I shows many chemical reactions & physical or phase changes (S → AQ) and the amount of energy associated with each, how exothermic or endothermic.

77B. $+\Delta H$ means that energy is _____ (endo)

77C. $-\Delta H$ means that energy is _____ (exo)

77D. The H stands for CHANGE IN HEAT ENERGY, and it's measured in _____ (kJ).

78. 1000 joules = 1 kilojoule _____ = _____

79A. _____

79B. Which means that when ONE mole of NaOH dissolves into water, exactly _____ of energy gets released, exothermically. Making this solution creates a lot of HEAT!

79C. The MOLES are in _____ (remember stoich?). The _____ is in ratio too!

80A. How many <u>joules</u> are released when one mole of NaOH dissolves into water?

80B. How many <u>joules</u> are absorbed when one mole of NaCl dissolves into water?

80C. How many kJ of energy are released when one mole of LiBr is dissolved into water?

80D. When you dissolve 11.9 moles of LiBr into water, how many kJ are released?

81. How much energy is JOULES is absorbed when 52.61 moles of KNO_3 is dissolved into water?

82. What is the unit of energy that food is measured as? _____(capital C)

83. There is a scientific value of energy called _____ ! (lower case c)

84A. Food Calories are really _____ or "C" capital C Calories.

84B. Science calories are really _____, or "c" lower case c calories

84C. _____

84D. The names are nuts, but they are. We will fix this now.

84E. Food calories will be called _____ (or kilocalories).

85. How many science calories are in a Big Mac? (it's called Le Big Mac in France!)

86 we have four units for energy now…		

87. Three equalities we can make (then copy Under Table B!) are…

87. Write out the specific heat capacity constant for water here: _____

88. What does that mean?

89. It takes _____ joules to make one gram of water change temp by 1°C or 1 K.

1 cal = 4.18 J

90. It takes _____ cal to make one gram of water change temp by 1°C or 1 K.

91. It takes 354 calories to make 354 g H_2O at 7°C to warm to 8°C. How many joules is 354 cal?

92. Convert 3429 cal into kilojoules.

93. When 1.0 moles of NaCl dissolve into water the ΔH is _____. That energy is absorbed. Convert that amount of energy into joules, then into cals, and then into Calories.

94. When one mole of methane combusts, how many kilojoules are released? _____

95. Convert that amount of kJ into joules, then into cals, and then into Calories.

97. If you combust 8.44 moles of methane, how many kilojoules are released?

98. If you combust 40.8 moles of glucose, how many kJ are released?

99. Liquid octane (reaction #3) combusts in car engines. If you burn up 12.890 moles of C_8H_{18}, how many kilojoules are released?

100. What is the mole ratio of this third reaction on table I? _____

101. What is the THERMOCHEMICAL mole ratio of this reaction? _____

102. When 7.50 moles of aluminum oxide form, how many kJ are released?

103. How many calories are removed when 45.8 grams of ice forms from water at 273K?

104. What is the HEAT OF FUSION for candle wax if it takes 3388 Joules to melt a whole birthday candle with mass of 23.04 grams?

105. When a 355 mL can of seltzer, is warmed from a temperature of 293 K by adding 64,000 Joules of energy to it, what is the final temperature? Assume the seltzer is just water.

106. How many grams of water can be heated by 25.5 K when it absorbs 17,500 joules?

107. When 51.1 g Cu cools, it emits 1788 Joules, to cools down. If it starts at 381.5 Kelvin, what is its final temperature if the C_{Cu} = 0.391 J/g·K ? (this one is the hardest so far!) Think!

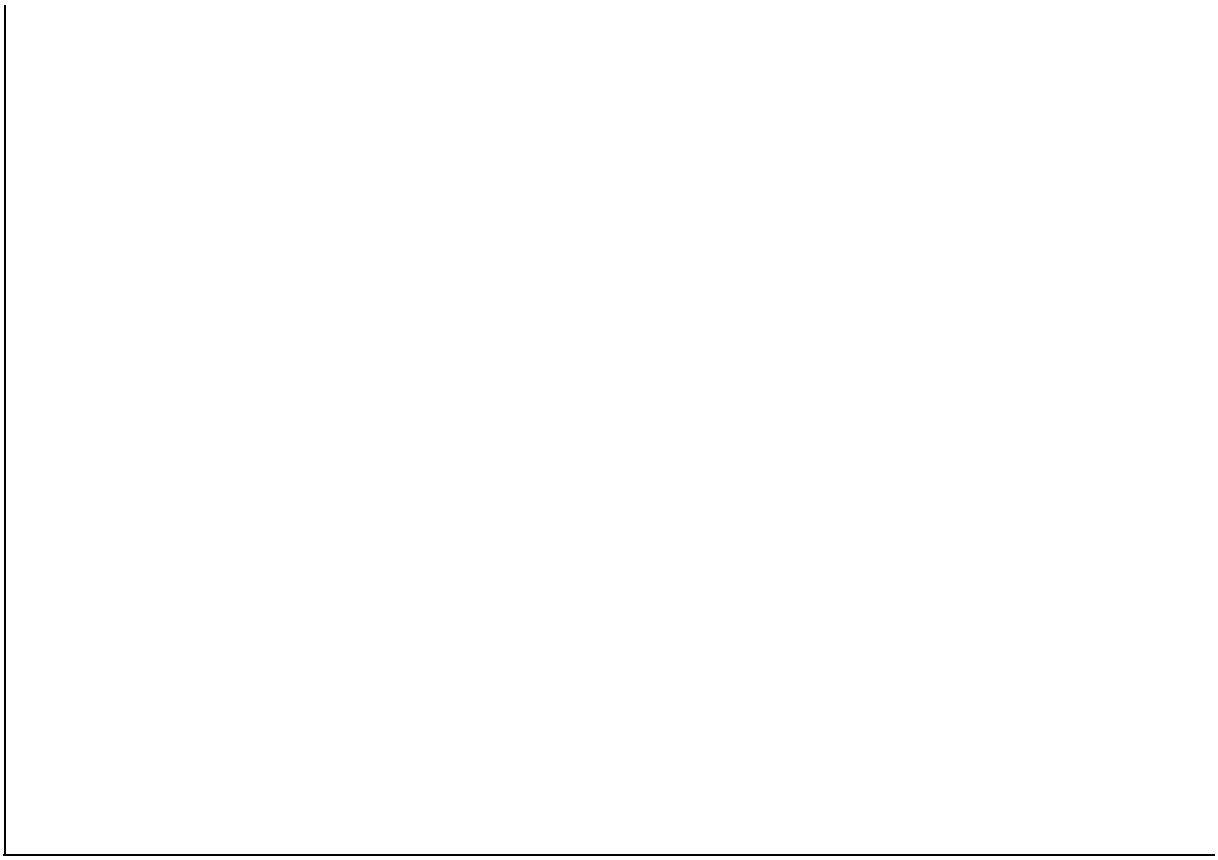
108. A 246.4 gram snowball at 273.0 K first melts, then warms to 26.55°.
How many joules did it take to do that?

109. There is no easy way to directly measure the energy that is in food. An indirect way has been well figured out, using a machine called a _____

110. Let's draw and label a bomb calorimeter now.

111. Let's assume that there is exactly 2120. mL of water in our bomb calorimeter and it's at exactly 295.0 K. After burning up our food sample, the temperature of the water rises to 354.5 K.
How many Calories of energy are in this food sample?

112. Copy the simple Cooling Curve for Chromium, labels, titles, axis labels, etc.



A. What temps are 1 + 2?

B. What's PE doing BC and CD?

C. What's KE doing AB and DE

D. Why is BC longer than DE?

E. Which thermochem formula do you use for BC?

F. Which thermochem formula do you use for EF?

113. Propane gas, C_3H_8 combusts according to Table I.
How much energy (in kJ) is released when 5.75 moles C_3H_8 combusts?
(find this - Table I, it's the 2nd reaction)

114. How much energy is absorbed by the reaction of 99.0 moles of $HI_{(G)}$ forming?

115. When 45.0 g of an unknown metal absorbs 1.51 kJ of heat. The temperature changes from 268 K to 345 K. What is the specific heat capacity constant for this metal? Note: KILOJOULES!

116. The Law of Conservation of Matter (or mass)

117. The Law of Conservation of Energy

118. Which takes more energy? Melting 50.0 g of ice or vaporizing 50.0 g of water into steam?

119. Which takes more energy? Heating 23.0 mL of water from 274 K to 299 K

Or Heating 23.0 mL of water from 299 K to 323 K?

120. Which takes more energy? Vaporizing 21.0 g water from 373 K liquid to gas

or Changing the temp of 100.0 g H_2O by 97.0 K?

121. Which has the LOWEST AVERAGE KINETIC ENERGY?

A. 100 mL water at 51.0°C
B. 100 mL water at 50.0°C
C. 175 mL water at 49.0°C
D. 175 mL water at 23.0°C

122. This horse has a boo boo. That's an ICE PACK on his leg. Describe the thermochemistry.

A. Heat flows from ice pack → leg
B. Cold flows from ice pack → leg
C. Heat flows from leg → ice pack
D. Cold flows from leg → ice pack

123. The old chemistry adage goes like this:

When bonds form _____.

124. A good example of this is…

125. The _____ = _____ even though the temperatures are different numbers!