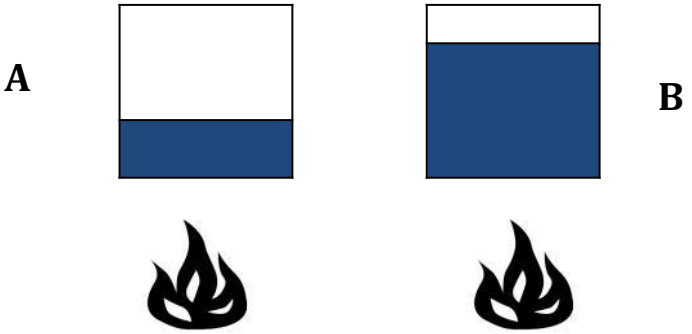
Unit 4: Heat


DID YOU HEAR ABOUT THE GUY THAT GOT FROZEN TO ABSOLUTE ZERO?
HE'S OK NOW.

Heat Inquiry

Heat is the flow of energy which changes the temperature of an object. Temperature is a measure of the average thermal energy of particles in a substance.

1. You place identical pots on the stove and heat them equally. Pot A contains 100. g of water; pot B contains 1000. g of water. Both pots start out at 20 C.

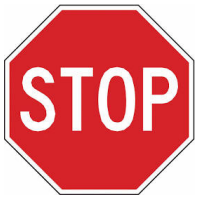


2. If you wanted to heat both pots of water until they boiled, which pot would boil first? Why?

3. When both pots are boiling, what is the temperature in A? B?

4. Compare the amount of heat contained by the water in each pot. Are they the same or different? If they are different, explain why and indicate which one you may think has more (or less).

5. Based upon these questions, indicate one factor involved in determining the heat content of a substance.



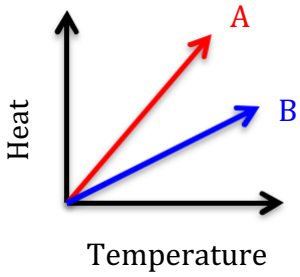
Now assume you have the identical pots of water on the stove but this time they both have exactly 1.00 gram of water. You heat pot A from 20°C to 50°C and pot B from 20°C to 90°C.

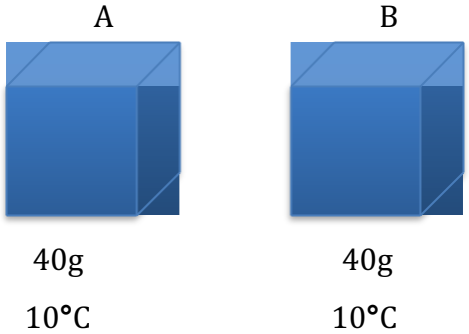
6. Which sample of water has the greater heat content? Why?

7. Use you answer to question 6 to indicate a second factor in determining the heat content of a substance.

Part II

Use the following models to answer the questions below. Block A and B are made of different substances but contain the same mass and are at the same initial temperature.





1. The same amount of heat (Q) is added to both blocks. Which block will end up at the higher temperature?

If you wanted to raise the temperature of 1g of water 1°C you would have to add 4.18J of heat energy (Q). So we can develop a constant for water where 4.18J per 1 gram causes a 1°C temperature change:

$$4.18\ \mathrm{g}\ \frac{\mathrm{J}}{°\mathrm{C}}$$

2. If you have 1g of water and you wanted to heat it from 10°C to 11°C how much heat energy (Q) would you need to add?

3. If you have 10 g of water and you wanted to heat it from 10°C to 11°C how much heat energy (Q) would you need to add?

4. If you have 10 g of water and you wanted to heat it from 10°C to 20°C how much heat energy (Q) would you need to add?

Application

If you wanted to heat a bucket containing 37g of water and you wanted to heat it up 25°C how much heat (Q) would you need to add?

Lesson 1: What is Heat?

Objective:

Determine the direction of heat flow

Determine the change in heat of a reaction

1.) Which statement is true?

(a) At a given temperature, the temperature value is a measure of the total kinetic energy of all the molecules.

(b) At a given temperature, all the particles have the same amount of kinetic energy.

(c) At a given temperature, the average kinetic energy of the molecules is constantly changing.

(d) At a given temperature, the temperature value is a measure of the average kinetic energy of all the molecules.

2.) In which sample do the particles have the highest average kinetic energy?

(a) $H_2O(l)$ @55$_o$C (b)Br_2 (l) @75$_o$C (c) NaCl(aq) @30$_o$C (d) Mg(s) @17$_o$C

3.) Which sample has particles with the *lowest* average kinetic energy? (a) 1.0g of I_2 at 50.°C (b) 2.0g of I_2 at 30.°C (c) 7.0g of I_2 at 40.°C (d) 9.0g of I_2 at 20.°C

4.) Object *A* at 40.°C and object *B* at 80.°C are placed in contact with each other. Which statement describes the heat flow between the objects?

(a) Heat flows from object *A* to object *B.*

(b) Heat flows from object *B* to object *A.*

(c) Heat flows in both directions between the objects.

(d) No heat flow occurs between the objects.

5.) What occurs when a 35-gram aluminum cube at 100.°C is placed in 90. grams of water at 25°C in an insulated cup?

(1) Heat is transferred from the aluminum to the water, and the temperature of the water decreases.

(2) Heat is transferred from the aluminum to the water, and the temperature of the water increases.

(3) Heat is transferred from the water to the aluminum, and the temperature of the water decreases.

(4) Heat is transferred from the water to the aluminum, and the temperature of the water increases.

6.) A person with a body temperature of 37°C holds an ice cube with a temperature of 0°C in a room where the air temperature is 20.°C. The direction of heat flow is

(a) from the person to the ice, only

(b) from the person to the ice and air, and from the air to the ice

(c) from the ice to the person, only

(d) from the ice to the person and air, and from the air to the person

Table I Practice:

7. Are the following endo or exothermic?

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ _____

$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O + 1452kJ$ _____

$H_2 + I_2 \rightarrow 2HI$ _____

The dissolving of NaOH _____

$25.69kJ + NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$ _____

The dissolving of LiBr _____

8. Circle the more stable compound in each pair: (Exothermic reactions are more stable)

The formation of: $H_2O_{(g)}$ ***OR*** $H_2O_{(l)}$

The formation of: NH_3 ***OR*** Al_2O_3

The formation of: HI ***OR*** NO

The formation of: C_2H_6 ***OR*** C_2H_4

9. Circle the compound which is more likely to form in each pair: (Exothermic reactions occur more readily)

CO_2 from elements ***OR*** CO_2 from CO

NO ***OR*** NO_2

C_2H_6 ***OR*** C_2H_2

NH_3 ***OR*** HI

10. Will the following feel hot or cold?

Dissolving KNO_3 _____

Dissolving LiBr _____

Burning CH_4 in O_2 _____

Forming Al_2O_3 _____

11. Draw a model to describe what happens to the heat energy when a container of water at 10C is placed in a room at 24C.

REGENTS PRACTICE

1. A cube of iron at 20.°C is placed in contact with a cube of copper at 60.°C. Which statement describes the initial flow of heat between the cubes?

   A) Heat flows from the copper cube to the iron cube.
   B) Heat flows from the iron cube to the copper cube.
   C) Heat flows in both directions between the cubes.
   D) Heat does not flow between the cubes.

2. Given samples of water:
   Sample 1: 100. grams of water at 10.°C
   Sample 2: 100. grams of water at 20.°C

   Compared to sample 1, sample 2 contains

   A) molecules with a lower average kinetic energy
   B) molecules with a lower average velocity
   C) less heat energy
   D) more heat energy

3. In a laboratory where the air temperature is 22°C, a steel cylinder at 100.°C is submerged in a sample of water at 40.°C. In this system, heat flows from

   A) both the air and the water to the cylinder
   B) both the cylinder and the air to the water
   C) the air to the water and from the water to the cylinder
   D) the cylinder to the water and from the water to the air

4. When NH_4NO_3 is dissolved in water, the temperature of the water decreases. When NaOH is dissolved in a separate water sample, the temperature of the water increases. Based on these observations, it can be concluded that the dissolving of

   A) both salts is endothermic
   B) both salts is exothermic
   C) NH_4NO_3 is endothermic and the dissolving of NaOH is exothermic
   D) NH_4NO_3 is exothermic and the dissolving of NaOH is endothermic

5. Given the equation:

   $$I + I \rightarrow I_2 + 35 \text{ kcal}$$

   This equation shows that the formation of an iodine molecule is an

   A) exothermic process in which energy is absorbed
   B) exothermic process in which energy is released
   C) endothermic process in which energy is absorbed
   D) endothermic process in which energy is released

6. According to Reference Table I, which gas is formed from its elements as a result of an endothermic reaction?

   A) CO_2 B) NO_2 C) H_2O D) C_2H_6

ASSESS YOURSELF ON THIS LESSON:

If you missed any regents practice questions you should see me for extra help and/or re-watch the lesson video assignment

Lesson 2: Calculating Heat

Objective:

Calculate heat, specific heat mass and change in temperature of a reaction

Specific heat is defined as the amount of heat (in _____) needed to raise ____ gram of a substance ____˚C.

Every substance has its own specific heat depending on the bonds and forces it has.

1. At the park, why do you tend to steer clear of metal benches and prefer wooden picnic benches? Which has a lower specific heat?

2. Explain in terms of specific heat why during the month of October on Long Island the air temperature fluctuates between 60 ˚F during the day and 40 ˚F at night yet the ocean water temperature is consistently 65 ˚F?

Define the following terms with units: **q: _____** **c: _____**

m: _____ **T: _____**

Answer the following questions using the heat formula. Show work with units and significant figures.

3. A 5.00 gram sample of water is heated so that its temperature increases from 10.0°C to 15.0°C. What is the total amount of energy absorbed by the water?

4. When a sample of 25.0 g of water is cooled from 20.0°C to 10.0°C, what is the number of Joules of energy released?

5. A sample of water is heated from 10.0°C to 15.0°C by adding 125.58 Joules of heat. What is the mass of the water?

6. How many joules of heat energy are released when 50.0 grams of water are cooled from 70.0 °C to 60.0 °C?

7. What is the total number of joules of heat energy absorbed when the temperature of 200.0 grams of water is raised from 10.0 °C to 40.0 °C?

8. When 418. joules of heat energy are added to 10.0 grams of water at 20.0 °C, what will the final temperature of the water be?

9. How many kJ of heat energy are absorbed when 100.0 g of water are heated from 20.0 °C to 30.0 °C?

10. The temperature of a sample of water in the liquid phase is raised 30.0 °C by the addition of 3762 J. What is the mass of the water?

REGENTS PRACTICE

1. The temperature of a sample of water changes from 10.°C to 20.°C when the water absorbs 420 Joules of heat. What is the mass of the sample?

   A) 1.0 g B) 10. g
   C) 100 g D) 1000 g

2. An 80.0-gram sample of water at 10.0°C absorbs 1680 Joules of heat energy. What is the final temperature of the water?

   A) 50.0°C B) 15.0°C
   C) 5.00°C D) 4.00°C

3. The temperature of a sample of water changes from 10°C to 20°C when the sample absorbs 418 joules of heat. What is the mass of the sample?

   A) 1 g B) 10 g
   C) 100 g D) 1000 g

4. A 36-gram sample of water has an initial temperature of 22°C. After the sample absorbs 1200 joules of heat energy, the final temperature of the sample is

   A) 8.0°C B) 14°C C) 30.°C D) 55°C

5. When 200 grams of water cools from 50.°C to 25°C, the total amount of heat energy released by the water is

   A) 42 kJ B) 21 kJ C) 34 J D) 17 J

6. What is the total number of Joules of heat energy absorbed by 15 grams of water when it is heated from 30.°C to 40.°C?

   A) 42 J B) 63 J C) 130 J D) 630 J

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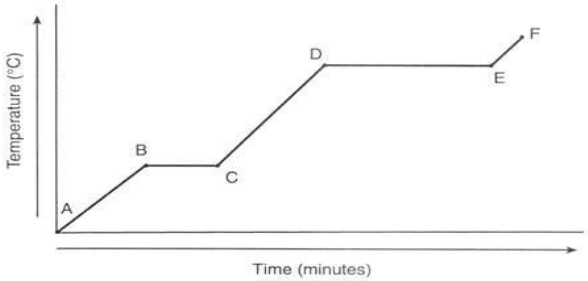
LESSON 3: PHASE CHANGES AND HEAT

Objective:

Differentiate between endothermic and exothermic

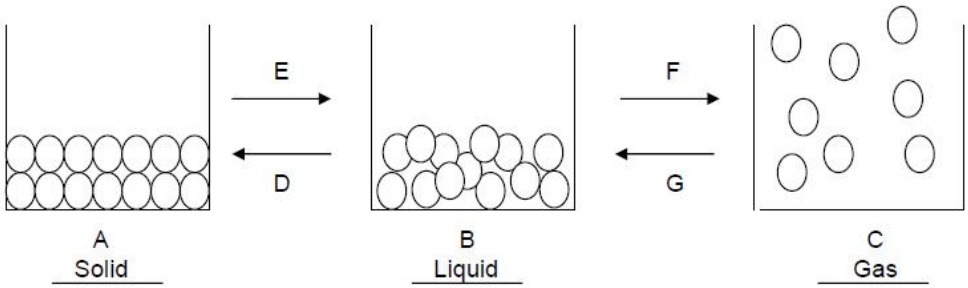
Identify a phase change as either endothermic or exothermic

1. Identify the phase(s) represented by the following line segments in the diagram below:
   a. AB _____ d. DE _____
   b. BC _____ e. EF _____
   c. CD _____



2. What line segment(s) represent the melting point? _____
3. What line segment(s) represent the boiling point? _____
4. What takes more energy: to melt this substance or to vaporize it? Give evidence to support your answer. _____
5. What type of energy is being used during the line segments AB, CD, EF? _____
6. What type of energy is being used during the line segments BC & DE? _____
7. At what point will the particles be moving the slowest? _____
8. If this substance were water, at what temperature would segment BC occur? _____ ^{o}C
9. If this substance were water, at what temperature would segment DE occur? _____ ^{o}C

Use the diagram below to answer questions 10-14.



10. Which arrows in Model 1 indicate the addition of energy? _____ and _____

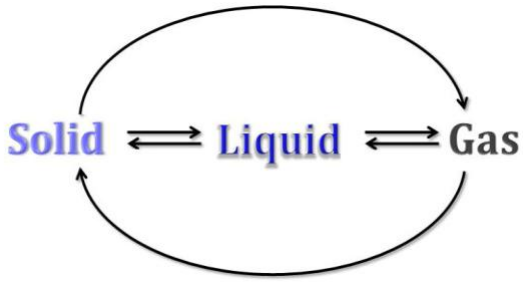
11. Which term, endothermic or exothermic, is used to describe the situation when energy is added into a system from the surroundings? _____

12. Which arrows in Model 1 indicate the release of energy? _____ and _____

13. What are the names of the phase changes that involve a release of energy to the surroundings by the system? _____ and _____

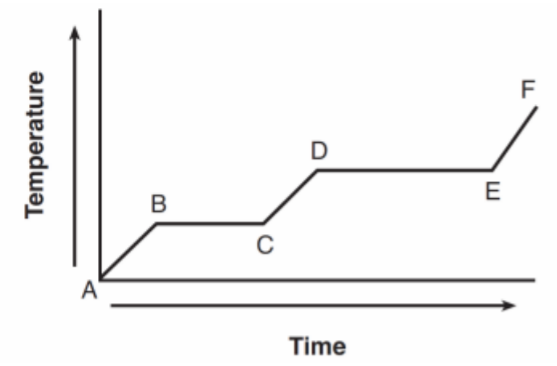
14. If a substance is a gas at room temperature, does it have strong or weak Intermolecular forces of attraction?

15. Fill in the following phase change diagram indicating the following: Melting, freezing, evaporation, condensation, sublimation, deposition



REGENTS PRACTICE

1. The graph below represents the uniform heating of a substance from the solid to the gas phase.



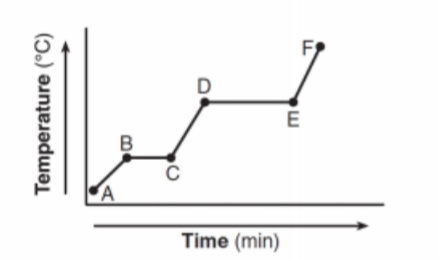
Which line segment of the graph represents boiling?

A) $\overline{AB}$ B) $\overline{BC}$ C) $\overline{CD}$ D) $\overline{DE}$

2. Which equation represents sublimation?

A) $I_2(s) \rightarrow I_2(g)$ B) $I_2(s) \rightarrow I_2(\ell)$
C) $I_2(\ell) \rightarrow I_2(g)$ D) $I_2(\ell) \rightarrow I_2(s)$

3. The graph below represents the uniform heating of a sample of a substance starting as a solid below its melting point.



Which statement describes what happens to the energy of the particles of the sample during time interval *DE*?

A) Average kinetic energy increases, and potential energy remains the same.
B) Average kinetic energy decreases, and potential energy remains the same.
C) Average kinetic energy remains the same, and potential energy increases.
D) Average kinetic energy remains the same, and potential energy decreases

4. Which physical changes are endothermic?

A) melting and freezing
B) melting and evaporating
C) condensation and sublimation
D) condensation and deposition

ASSESS YOURSELF ON THIS LESSON:

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Specific Heat

Specific heat is defined as the amount of heat (in ____) needed to raise ____ gram of a substance ___˚C.

Every substance has its own specific heat depending on the bonds and forces it has.

1. When you wake up in the morning and touch the floor, at first the carpet feels warm. The wood floor in the hallway is a bit chilly, but the tile floor in the bathroom is FREEZING! However, your whole house is probably 68˚F. What quality is different about each of these surfaces? Which has the highest specific heat?

2. At the park, why do you tend to steer clear of metal benches and prefer wooden picnic benches? Which has a lower specific heat?

3. Water has a high specific heat due to its hydrogen bonds. Explain why the fish is so happy in the picture below.

4. Based on the specific heat values in the table below, why do Al, Cu, Au, Fe and Hg have very low values? (What do they have in common?)

Substance	Specific Heat
Air	1.01
Aluminum	0.902
Copper	0.385
Gold	0.129
Iron	0.450
Mercury	0.140
NaCl	0.864
Ice	2.03
Water	4.18

5. Based on your answer to question 2 do you expect wood to have a higher or lower specific heat than these substances and why?

6. Glass is often called an insulator because it has a _____ specific heat.

Lesson 4: Calculating Heat of Phase Changes

Objective:

Calculate heat of phase changes using q=mHf and q=mHv

Directions: Read and answer each of the following questions. Make sure to show all work, include proper units, report the answer to the correct number of significant figures, and box your answers.

1. What is the total number of joules required to freeze a 10 g sample of water at 0 C?

2. How much energy is required to vaporize 10.00 g of water at its boiling point?

3. What is the total number of joules of heat needed to change 25 g of ice to water at 0 C?

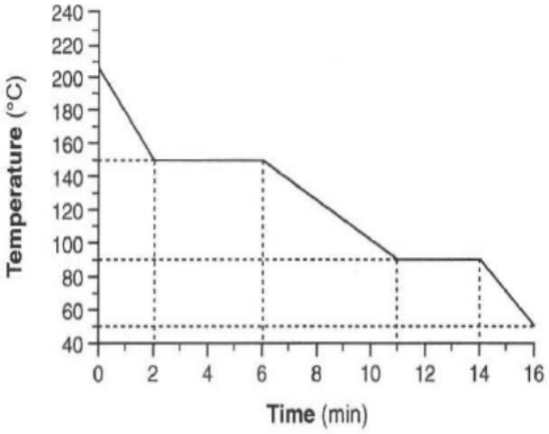
4. Calculate the amount of energy required to heat **100. g** to the following:

    a. $H_2O(s)$ changes to $H_2O(l)$ at 0 C

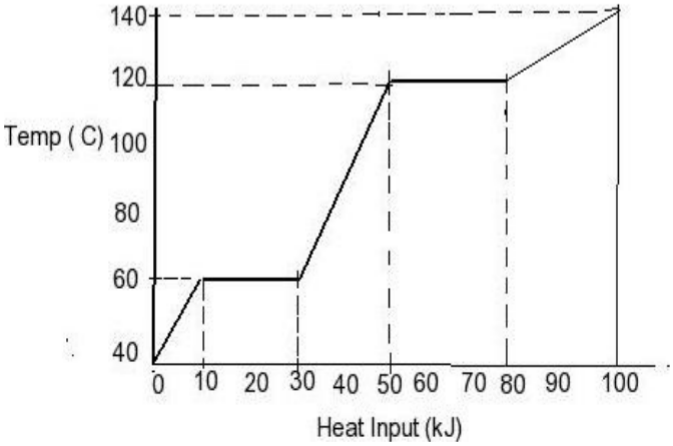
    b. $H_2O(l)$ changes to H_2O (s) at 0 C

    c. $H_2O(l)$ at 10 C changes to $H_2O(l)$ at 20 C

5. Label the line segments with their phase(s).
6. What is this substance's melting point? _____
7. What is this substance's boiling point? _____
8. Does this represent an endothermic or exothermic reaction?



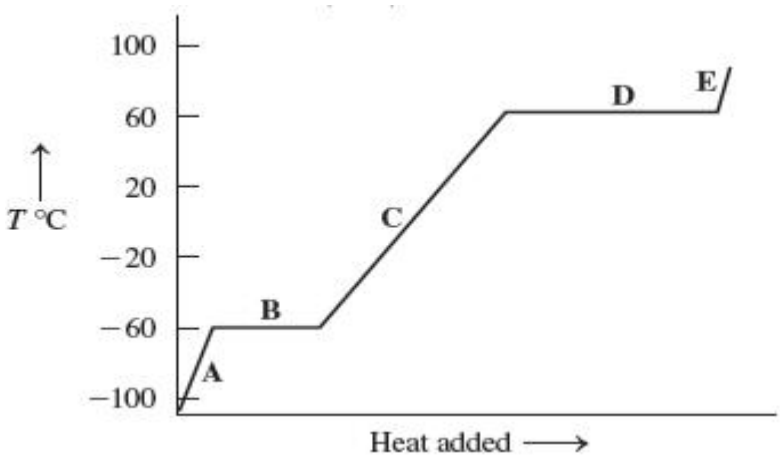
9. Draw six particles of this substance as it looks for the first line segment in the box below.



10. Draw six particles of this substance as it looks for the last line segment in the box below.

11. What is the boiling point of this substance? _____
12. What is the melting point of this substance? _____
13. What would you expect the graph to do if the substance continued to be heated?

14. Label each letter in the heating curve with the appropriate formula ($q=mc\,T$ $q=mH_f$ $q=mH_v$) that would be used to calculate the amount of heat for that portion of the graph.



REGENTS PRACTICE

1. What is the total amount of heat required to completely melt 347 grams of ice at its melting point?

   A) 334 J B) 1,450 J
   C) 116,000 J D) 784,000 J

2. What is the amount of heat required to completely melt a 200.-gram sample of $H_2O(s)$ at STP?

   A) 334 J B) 836 J
   C) 66800 J D) 452000 J

3. How much energy is required to vaporize 10.00 grams of water at its boiling point?

   A) 2.26 kJ B) 3.34 kJ
   C) 4.2 kJ D) 22.6 kJ

4. What is the total number of kiloJoules required to boil 100. grams of water at 100°C and 1 atmosphere?

   A) 22.6 kJ B) 33.4 kJ
   C) 226 kJ D) 334 kJ

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