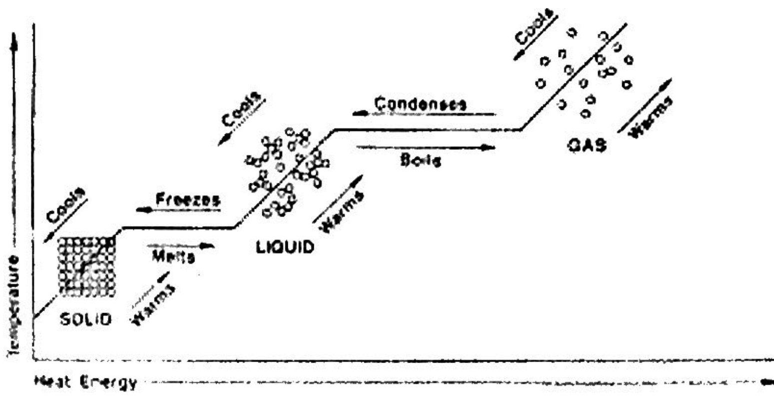
Heating and Cooling Curves

Heating and cooling curves illustrate the changes that occur when a sample of matter is subjected to a change in temperature. A typical heating curve is illustrated to the right.



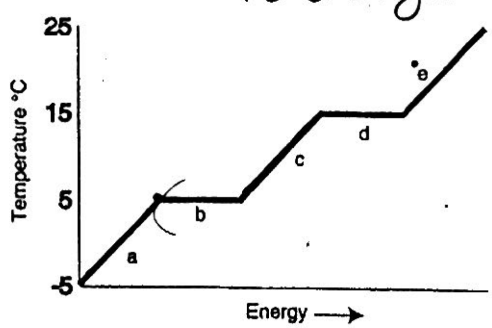
During a phase change there is a change in potential energy while kinetic energy remains constant as evident by the fact that there is no change in temperature. The heat being absorbed or released during a phase change is working on the intermolecular forces that hold the substance together. In the case of the heating curve, these forces must be weakened in order for the substance to change phase. In the case of a cooling curve, the forces need to be strengthened.

When heat is applied to a sample of matter in a single phase, there is a change in Kinetic energy as observed by the change in temperature.

PRACTICE:

- sloping lines = in a phase, warming or cooling -KE changes
- horizontal lines = -phase changes -PE changes

Answer Questions 1 – 9 using the heating curve provided.



5°C 1. What is the freezing point (temp) of the substance?

15°C 2. What is the boiling point (temp) of the substance?

a 3. What letter represents the range where the solid is being warmed?

c 4. What letter represents the range where the liquid is being warmed?

e 5. What letter represents the range where the vapor is being warmed?

d 6. What letter represents the vaporization of the liquid?

b, d 7. What letter(s) shows a change in potential energy?

a, c, e 8. What letter(s) shows a change in kinetic energy?

b 9. What letter represents where both the solid and liquid phases are present?

3 Ps

a 10. During which process is potential energy decreasing and average kinetic energy remaining the same? (cooling curve; plateau, phase change)

a. A liquid is converted to a solid at its freezing point.

b. A solid is converted to a liquid at its melting point.

c. A gas is cooled from a temperature of 120°C to 115°C.

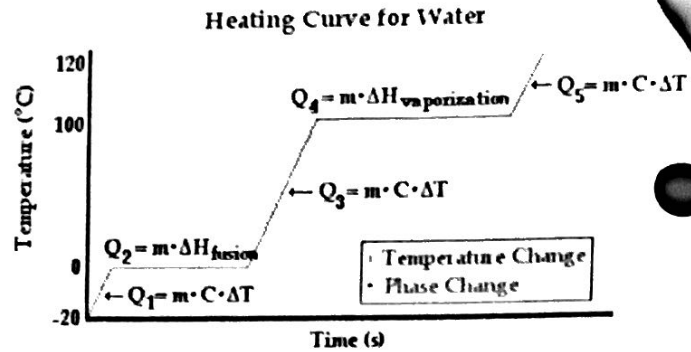
d. A liquid is heated from 38°C to 58°C.

horizonal line / plateau = phase change = PE change

b 11. Which phase change is exothermic? → releases energy / goes to a lower energy state

a. Melting b. Freezing c. Vaporizing d. Sublimation

Heat Calculations Review



The change in energy during can be calculated using the heat equations represented on Table T of the reference tables. These equations allow scientists to determine the amount of heat absorbed or released during a temperature change or a phase change. The diagram to the right illustrates the proper use of each of the equations.

The values for the Specific Heat (C), Heat of fusion(H_f) and Heat of Vaporization (H_v) of water can be located on Table B of the reference tables. The constants for other substances are either given or calculated for in the problem.

⊛ use $q = mC\Delta T$ during a temp change/heating/cooling
⊛ use $q = mH_f$ when melting or freezing

PRACTICE: For each of the following problems, circle key words that help to determine the equation used. Then write the appropriate equation, substitute values and solve.

⊛ use $q = mH_v$ when vaporizing or condensing

1) A sample of water as a solid at its melting point requires 3865 Joules of energy to change completely to a liquid. How many grams of water are present?

$q = mH_f$ (m = x)
Table B 334 J/g → $H_f = 334$ J/g
q = 3865 J
m = x
$q = mH_f$
$3865 = (x)(334\ J/g)$
$\frac{3865}{334\ J/g} = x$
11.6 g = x

2) 17 grams of an unknown liquid is heated from -24°C to 5°C. If this change requires 9871 J of energy, what is the specific heat capacity of this substance?

q = 9871 J
m = 17 g
C = x
$\Delta T = T_f - T_i = 5 - -24 = 29°C$
$q = mC\Delta T$
$9871\ J = (17g)(x)(29°C)$
$\frac{9871\ J}{493} = \frac{(493\ g \cdot °C)\ x}{493}$
20.0 J/g°C = x

3) The heat of vaporization of nitrogen is 5560 J/g. How much energy is absorbed when 55 grams of nitrogen vaporizes at its boiling point?

q = x
m = 55g
H_v = 5560 J/g
$q = mH_v$
$q = (55g)(5560\ J/g)$
q = 305800 J -OR- 305.8 kJ

4) When 25.0 g of water are cooled from 20.0°C to 10.0°C the number of joules of heat energy released is

a) 42 b) 105 c) 840 d) 1050

C of water = 4.18 J/g·K (Table B)
$q = mC\Delta T$
$q = (25.0g)(4.18\ J/g \cdot K)(10.0 - 20.0°C)$
q = -1045 J → -1050 J

5) Use the following data about tellurium to answer the question below:

If you have one mole of tellurium as a solid at 449.51 °C, how much energy is required to melt it? (HINT: How many grams in 1 mole?)

Melting Point	449.51 °C
Boiling Point	988.0 °C
Specific Heat Capacity	0.20 J/g°C
Heat of Fusion	138 J/g
Heat of Vaporization	820 J/g

Te: gfm = 127.6 g/mol
1 mole Te = 127.6 g
$q = mH_f$
$q = (127.6g)(138\ J/g)$
q = 17600 J

If the sample of Te is heated from 460°C to 899°C how much energy is absorbed?

m = 127.6 g
q = x
m = 127.6 g
C = 0.20 J/g°C
ΔT = 899 - 460°C = 439°C
$q = mC\Delta T$
$q = (127.6g)(0.20\ J/g \cdot °C)(439°C)$
q = 11200 J

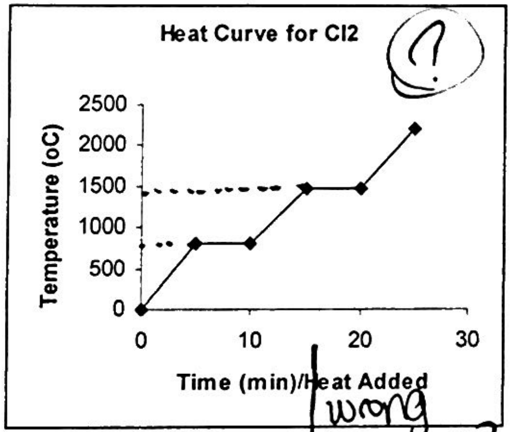
Which has stronger intermolecular forces, water of tellurium? Justify your response with evidence from the data provided and your knowledge of water.

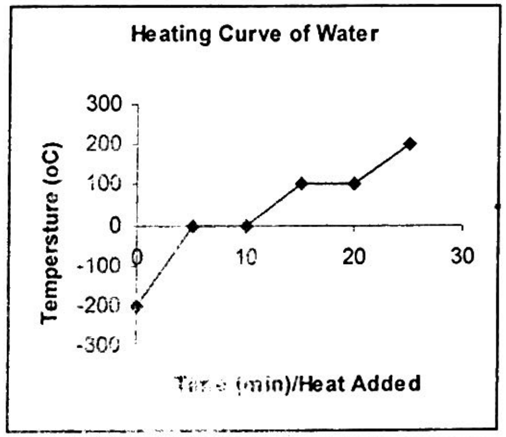
Tellurium, as its melting point of 449.51°C is higher than water's (0°C). Also, its boiling point (988.0°C) is higher than that of water (100°C).

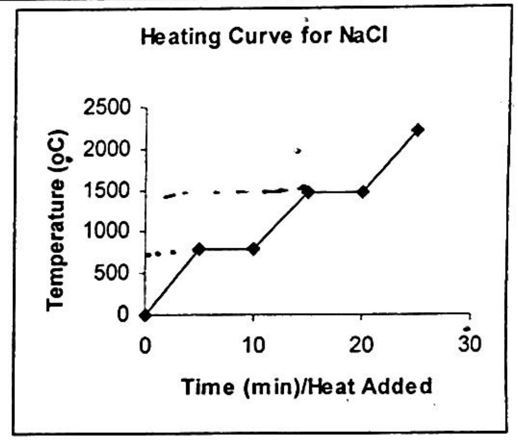
Name: Date:

Relationship between Bond Types and Phase

Use the three heating curves below to fill in the data table below







Substance	Cl_2	H_2O	NaCl
Dot Diagram	:Cl:Cl:	H–O–H	[Na]$^{+1}$ [:Cl:]$^{-1}$
Bond Between Atoms	nonpolar covalent	polar covalent	ionic
Force of attraction	dipole-dipole	H-bonds	molecule-ion
Phase at Room Temperature	gas	liquid	solid
Melting Point	-30 ~700°C	0°C	~700°C
Boiling Point	~1500°C	100°C	~1500°C

-101

How are intermolecular forces related to the phases of matter, melting point and boiling point?

strongest IMF weakest IMF
solid > liquid > gas

The stronger the IMF, the higher the mp & bp because it takes more energy to break the forces holding the molecules together so they can move into the next phase of matter.