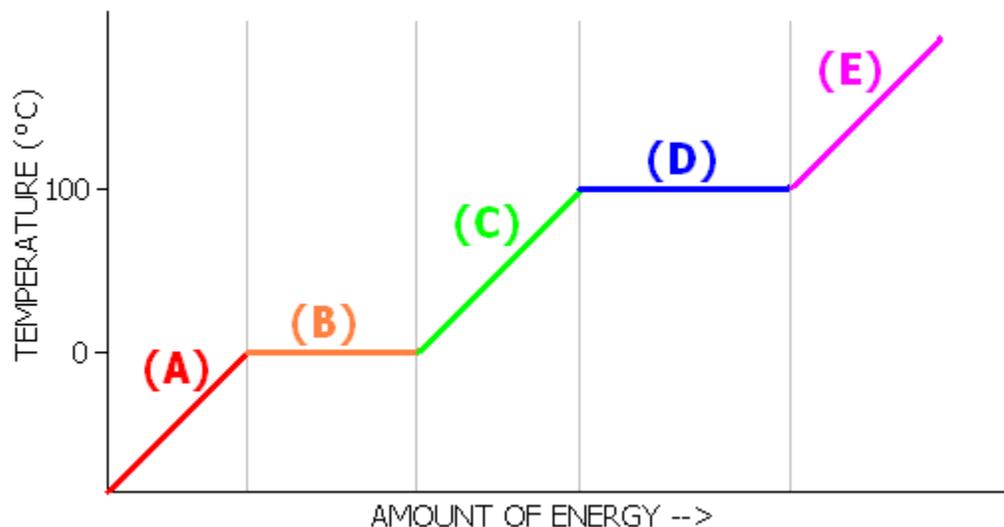


HEAT ENERGY NOTES



SECTION (A): same temp or change?
phase(s) of matter =

SECTION (B): same temp or change?
phase(s) of matter =
temp is called the
energy difference at same temp =

SECTION (C): same temp or change?
phase(s) of matter =

SECTION (D): same temp or change?
phase(s) of matter =
temp is called the
energy difference at same temp =

SECTION (E): same temp or change?
phase(s) of matter =

HEAT & ITS MEASUREMENT NOTES

* Heat (or energy) can be measured in units of calories or Joules. When there is a temperature change (ΔT), heat (q) can be calculated using this formula:

$$q = m \cdot C_p \cdot \Delta T$$

q = heat (Joules)

m = mass (g)

C_p = specific heat (J/g°C)

ΔT = change in temp. (°C)

UNIT 11 - SOLIDS, LIQUIDS, & PHASE CHANGES

* During a phase change, there is no change in temperature. So, the heat used to change the phase of matter can be calculated using this formula:

$Q = m \cdot H_f \text{ (or } H_v)$	
$Q = \text{heat (J)}$	$H_f = \text{heat of fusion (J/g)}$
$m = \text{mass (g)}$	$H_v = \text{heat of vaporization (J/g)}$

~ Here are some of these values for water (given on reference tables):

Specific Heat (C_p) of water = 4.18 J/g $^{\circ}$ C

Heat of Fusion for H₂O = 334 J/g

Specific Heat (C_p) of steam = 2.02 J/g $^{\circ}$ C

Heat of Vaporization for H₂O = 2260 J/g

Specific Heat (C_p) of ice = 2.05 J/g $^{\circ}$ C

EXAMPLE 1: How many Joules of heat are needed to change the temperature of 25.0 grams of steam from 105 $^{\circ}$ C to 135 $^{\circ}$ C?

EXAMPLE 2: How many Joules of heat are required to boil 35.0 grams of ice at 100.0 $^{\circ}$ C?

EXAMPLE 3: How many Joules of heat energy are required to change a 13.5 gram ice cube at -11.4 $^{\circ}$ C to liquid water at 45.9 $^{\circ}$ C?

UNIT 11 - SOLIDS, LIQUIDS, & PHASE CHANGES

HEAT & ITS MEASUREMENT WORKSHEET

- 1.) How many Joules of heat are given off when 5.00 grams of water cool from 75.0°C to 25.0°C?
- 2.) If 575 Joules of heat are added to 45.0 grams of water at 25.0°C, what will the new temp. be?
- 3.) How many Joules does it take to boil 15.0 g of water at 100.0°C?
- 4.) When 1550 Joules of heat are added to a 30.7 gram sample of H₂O, the temperature changes by 25.0°C. Is the H₂O in solid, liquid, or gas form?
- 5.) How many Joules of heat are necessary to raise the temperature of 25.0 grams of steam from 110.0°C to 160.0°C?
- 6.) How many Joules are given off when 55.0 grams of water at 0.00°C freezes?
- 7.) In a lab experiment, students were given a sample of water at 22.5°C. The students added 935 Joules of heat to the sample, and the temperature increased to 49.2°C. What is the mass of the sample of water?
- 8.) If 4,550 Joules of heat are added to 17.5 grams of water, by how many degrees Celsius would the water increase?
- 9.) How many Joules of heat are required to change 25.0 grams of water at 83.2°C to steam at 100.0°C?
- 10.) How much heat (in Joules) is required to change a 23.0 gram ice cube from -12.7°C to liquid water at 19.4°C?

UNIT 11 - SOLIDS, LIQUIDS, & PHASE CHANGES

PHASE DIAGRAMS NOTES

~ just a fancy graph that tells you what state of matter a substance is in at a particular temperature and pressure

WHAT DO THESE POINTS REPRESENT?

A =

B =

C =

D =

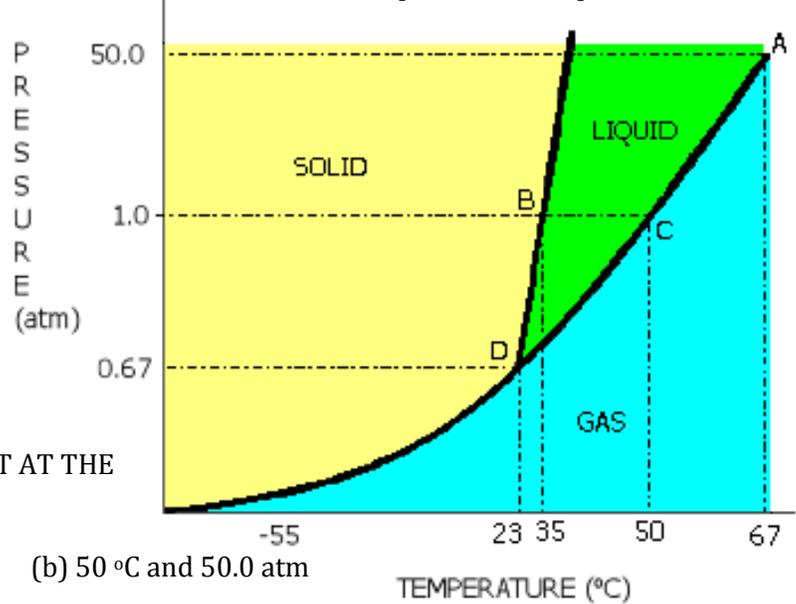
WHAT STATE(S) OF MATTER ARE PRESENT AT THE FOLLOWING CONDITIONS?

- (a) 35 °C and 1.0 atm
- (b) 50 °C and 50.0 atm
- (c) 23 °C and 0.67 atm
- (d) 50 °C and 1.0 atm
- (e) 68 °C and 51.0 atm
- (f) -50 °C and 0.75 atm

CRITICAL POINT: point where critical temperature and critical pressure intersect

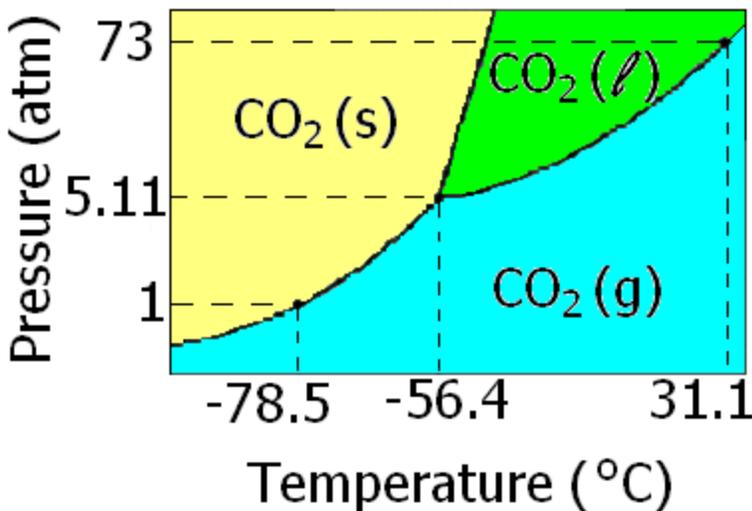
CRITICAL TEMPERATURE:

CRITICAL PRESSURE:



PHASE DIAGRAMS WORKSHEET

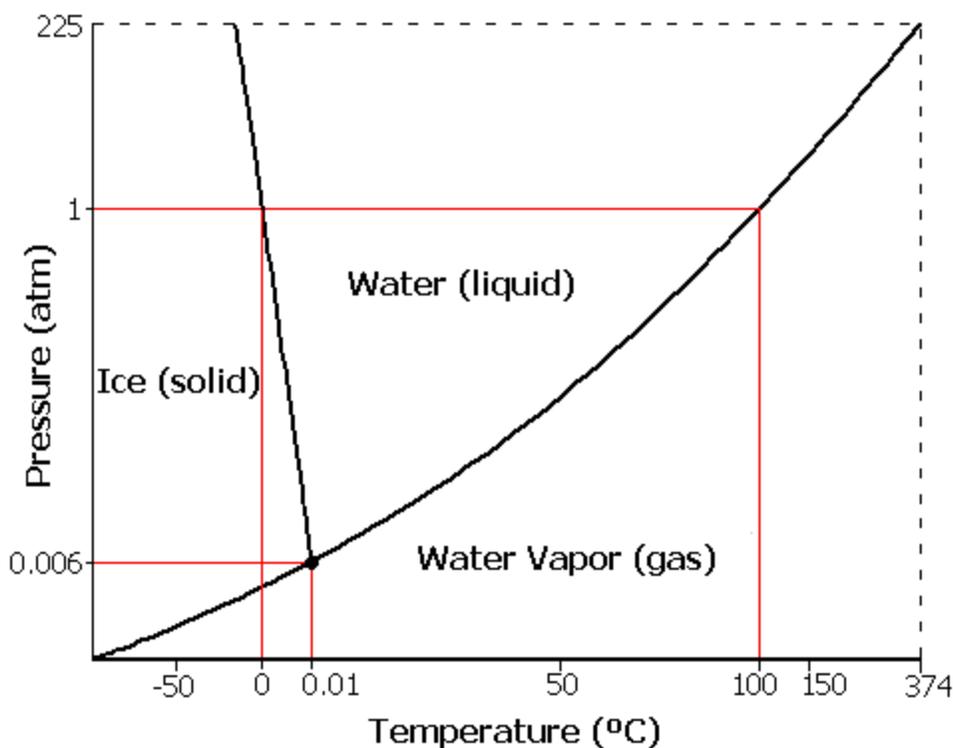
PHASE DIAGRAM FOR CO₂



UNIT 11 - SOLIDS, LIQUIDS, & PHASE CHANGES

- Label the following on the phase diagram:
 - critical temperature
 - critical pressure
 - triple point
 - sublimation line
 - freezing/melting point line
 - boiling point line
- What are the critical temperature and critical pressure of carbon dioxide?
- What is the triple point of carbon dioxide?
- Identify the state or states of matter that CO_2 would exist under the following conditions:
 - (A) $-78.5\text{ }^\circ\text{C}$ and 1 atm _____
 - (B) $-80\text{ }^\circ\text{C}$ and 2 atm _____
 - (C) $-40\text{ }^\circ\text{C}$ and 6 atm _____
 - (D) $32\text{ }^\circ\text{C}$ and 75 atm _____
 - (E) STP conditions _____
- Can CO_2 ever be a liquid at room temperature? Explain why or why not.
- When dry ice (solid carbon dioxide) is exposed to room temperature conditions, what process describes its phase change? How does the phase diagram explain why CO_2 does not "melt"?

Water - Phase Diagram



- Study the phase diagram of water. What two units are plotted against each other in a phase diagram graph?

UNIT 11 - SOLIDS, LIQUIDS, & PHASE CHANGES

8. Give the state or states of matter present at each of the following conditions:
- | | |
|-------------------------|--------------------------|
| (A) 100°C and 1 atm | (F) 150°C and 225 atm |
| (B) 0°C and 1 atm | (G) 400°C and 240 atm |
| (C) 100°C and 225 atm | (H) 375°C and 230 atm |
| (D) 50°C and 1 atm | (I) -50°C and 0.006 atm |
| (E) 50°C and 0.0060 atm | (J) 0.01°C and 0.006 atm |
9. After a substance passes a certain temperature (critical temperature), it cannot be liquefied. Regardless of the amount of pressure applied, the substance will remain a gas. What is the critical temperature of water?
10. When a substance reaches its critical temperature, it can be liquefied if enough pressure is applied. The pressure necessary to do this is called critical pressure. What is the critical pressure of water?
11. Give the temperature and pressure for the triple point of water.
12. What unique condition occurs at the triple point?

PROPERTIES OF LIQUIDS NOTES

- Definite _____ (like _____); maximum closeness
- No definite _____ (like gases); _____
- Incompressibility (like _____); _____ not affected by pressure
- _____ (like _____); but much slower
- Evaporation: molecules with enough kinetic energy escape the surface and become gases

VAPOR PRESSURE NOTES

- Definition:
- A liquid in a closed container will _____. If the container remains closed,
- The pressure of the _____ over the liquid is called
It will continue to build over the liquid until _____ is reached.
- At _____, the _____ of the evaporating molecules is _____ to the rate of _____ of molecules.
- _____ and _____ are still occurring, so the system is said to be in _____.

MORE LIQUIDS NOTES

- Consider three liquids: cooking oil, water, and butane
 - ~ Which evaporates fastest?
 - ~ Which has the lowest boiling point?
 - ~ Which has the highest vapor pressure?
 - ~ What makes a liquid evaporate faster than another? Or boil quicker?
 - The difference can be explained by looking at the properties of individual molecules.

UNIT 11 - SOLIDS, LIQUIDS, & PHASE CHANGES

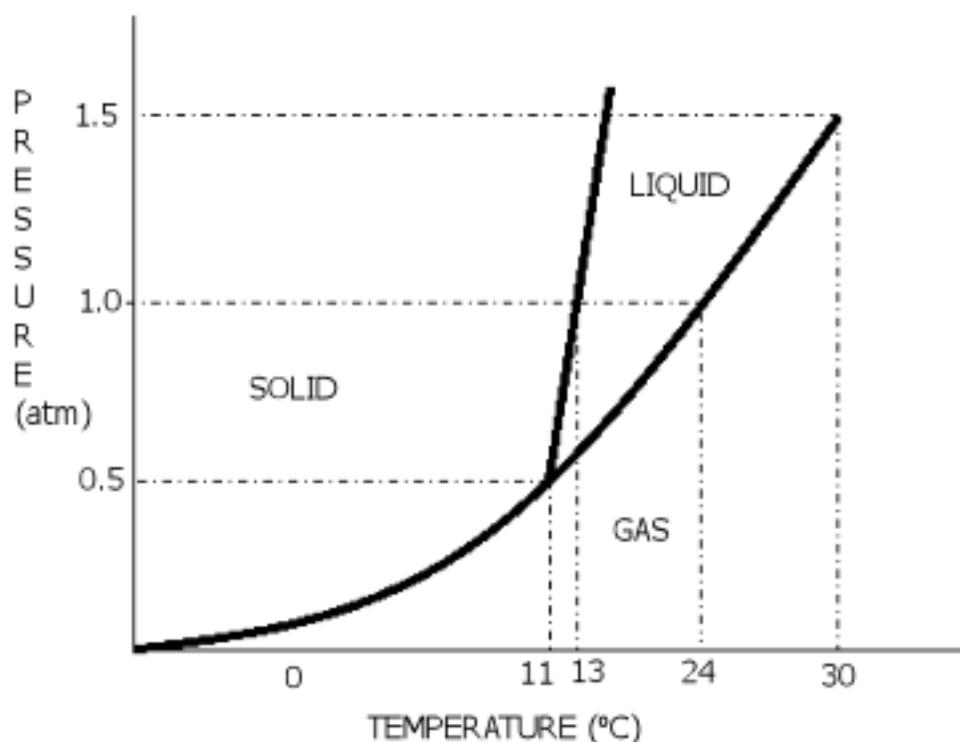
Two factors help determine the rate of evaporation, boiling point, or heat of vaporization.

- o Molar mass of the molecule: Molecules with _____ molar masses (such as _____ above) tend to require _____ energy to evaporate or boil. They form _____ over their liquids. _____ molecules tend to evaporate faster (like _____ above)

- o Intermolecular (IM) attraction between molecules: _____ molecules (with slightly ___ and ___ ends) attract each other much more than _____ molecules (_____; no ___ and ___ ends). Therefore, _____ molecules (such as _____ above) are more difficult to evaporate, boil, etc. than _____ (such as _____ above)

UNIT 11 REVIEW WORKSHEET

Part 1 - Phase Diagram - Use the following phase diagram to answer questions 1 - 5.



1. What are the temperature and pressure at the triple point?
2. What is the critical temperature of this substance?
3. What is the normal melting point for this substance? The normal boiling point?
4. At 1.0 atm pressure (standard pressure), does this substance undergo sublimation?
5. Indicate the state(s) of matter present at:
 - (A) 32°C and 1.5 atm
 - (B) 11°C and 0.5 atm
 - (C) 13°C and 1.0 atm
 - (D) 0°C and 0.75 atm
 - (E) 22°C and 1.05 atm
 - (F) 24°C and 1.0 atm

UNIT 11 - SOLIDS, LIQUIDS, & PHASE CHANGES

Part 2 – Heat Calculations – Use the data given on the Reference Tables to solve the following problems.

6. How many Joules of heat are required to boil a 29.3 gram sample of water at 100.0°C?
7. How many Joules of heat are required to heat a 29.3 gram sample of steam from 100.0°C to 117.3°C?
8. How many Joules of heat are required to heat a 15.75 gram sample of water from 95.0°C to steam at 117.3°C?

Duncan

Heat and Its Measurement Worksheet

Answers: 1.) 1045 J (1050J) 2.) 28.06°C (28.1°C) 3.) 33,900 J 4.) Gas 5.) 2525 J (2530 J)
6.) 18,370 J (18,400 J) 7.) 8.38 g 8.) 62.2°C 9.) 58,255.6 J (58,300 J)
10.) 10,145.921 J (10,100 J)