NAME _____ DATE 2014

New Unit: METEOROLOGY 1

Meteorology is the study of the changing conditions of the atmosphere (due to movement of heat energy)
The movement of energy in our atmosphere creates what we know as "weather".

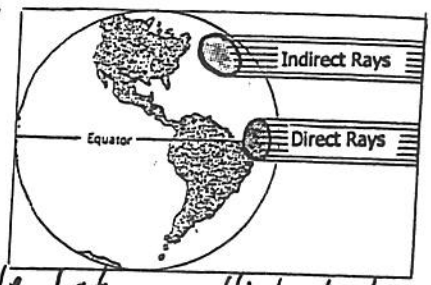
Weather is the local conditions of the atmosphere that change frequently (every few hours or even minutes)

What causes weather?

Weather is caused by CHANGES in atmospheric energy from place to place. This occurs because the energy the earth receives from the sun (Insolation) is Unevenly distributed over the earth. This causes the earth's atmosphere to become a giant engine moving heat energy around the world by Convection

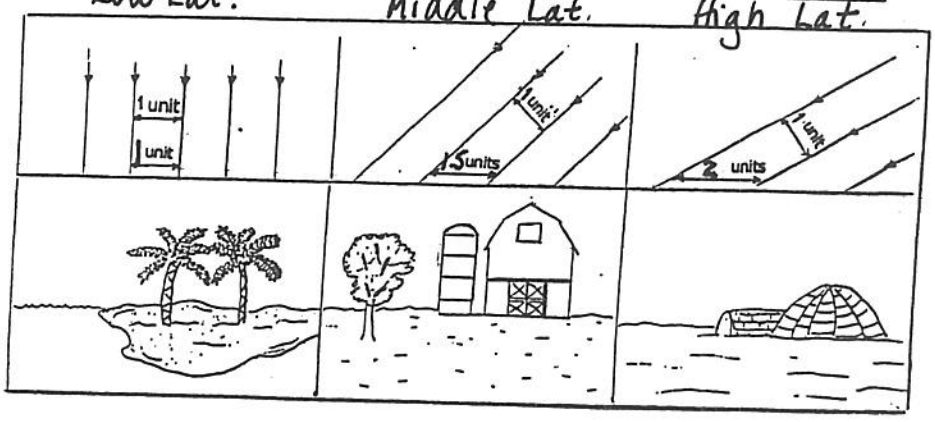
Energy from the Sun.

Through the seasons, it heats our world, some parts more and some less.



less than 90° ray

90° ray - most intense



more intense
Higher angle

less intense
Lower angle

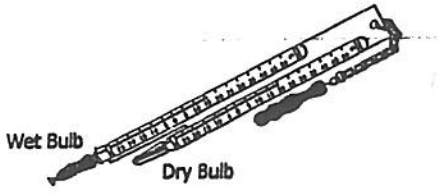
Weather is described by the action of Atmospheric Variables such as

1. temperature
2. air pressure
3. moisture content (humidity)
4. wind
5. cloud cover (atmospheric transparency)
6. precipitation

Weather Instruments:

thermometer
(temperature)

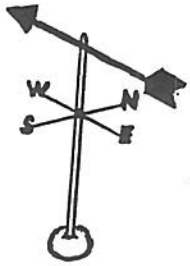
barometer
(air pressure)



sling psychrometer
(humidity)

rain gauge
(precipitation)

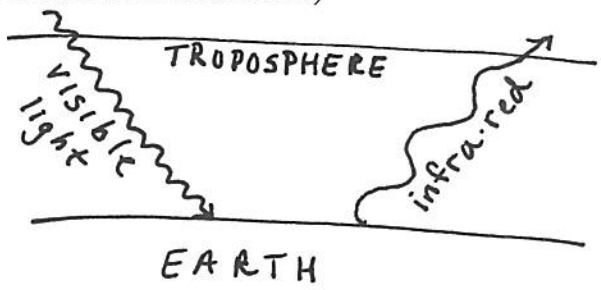
anemometer
(wind speed)



wind vane
(wind direction)

Weather Variable: Temperature

1. Definition: Air temp. is a measure of the 'average' kinetic energy of air molecules, measured with a thermometer
2. Air heats by infra-red heat energy re-radiated from the ground (Terrestrial Radiation)

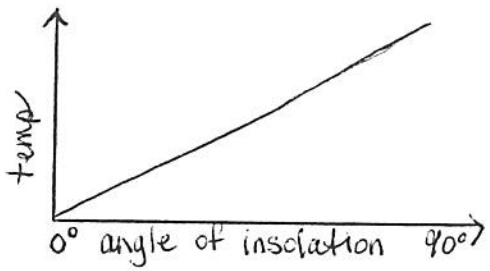


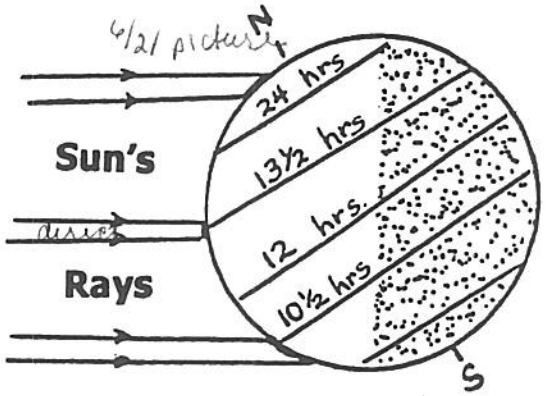
3. HEAT ENERGY is responsible for ALL changes in atmospheric variables

4. Temperature can be measured in 3 scales: °F, °C, °K
   Convert between scales using chart in ESRT p. 13
   10 °C = 50 °F
   250°K = -23 °C
   140 °F = 333° K

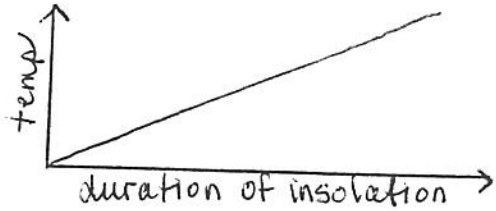
5. Changes in air temperature are caused by:

   a. Angle of Insolation (Incidence)= as angle increases, temp increases

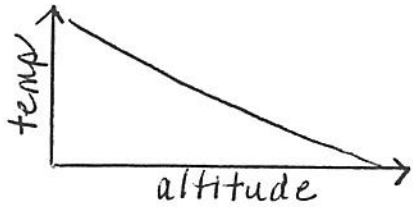




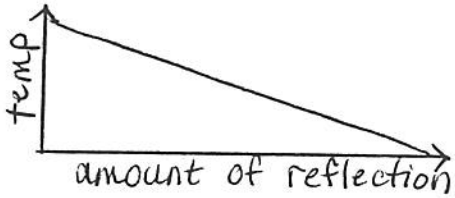
   b. Duration of insolation = as duration increases, temp increases (seasonal + daily cycles)



c. Altitude = as altitude increases, temp (in troposphere) decreases



d. Amount of reflection by clouds, pollution, etc. = as reflection increases, temp decreases



e. Closeness to a large body of water = locations closer to a large body of water have a smaller temp range (moderate)

Coastal locations

Water has high C_p so water heats + cools slowly

= cooler summers, warmer winters } moderate temps

Continental (Inland) locations

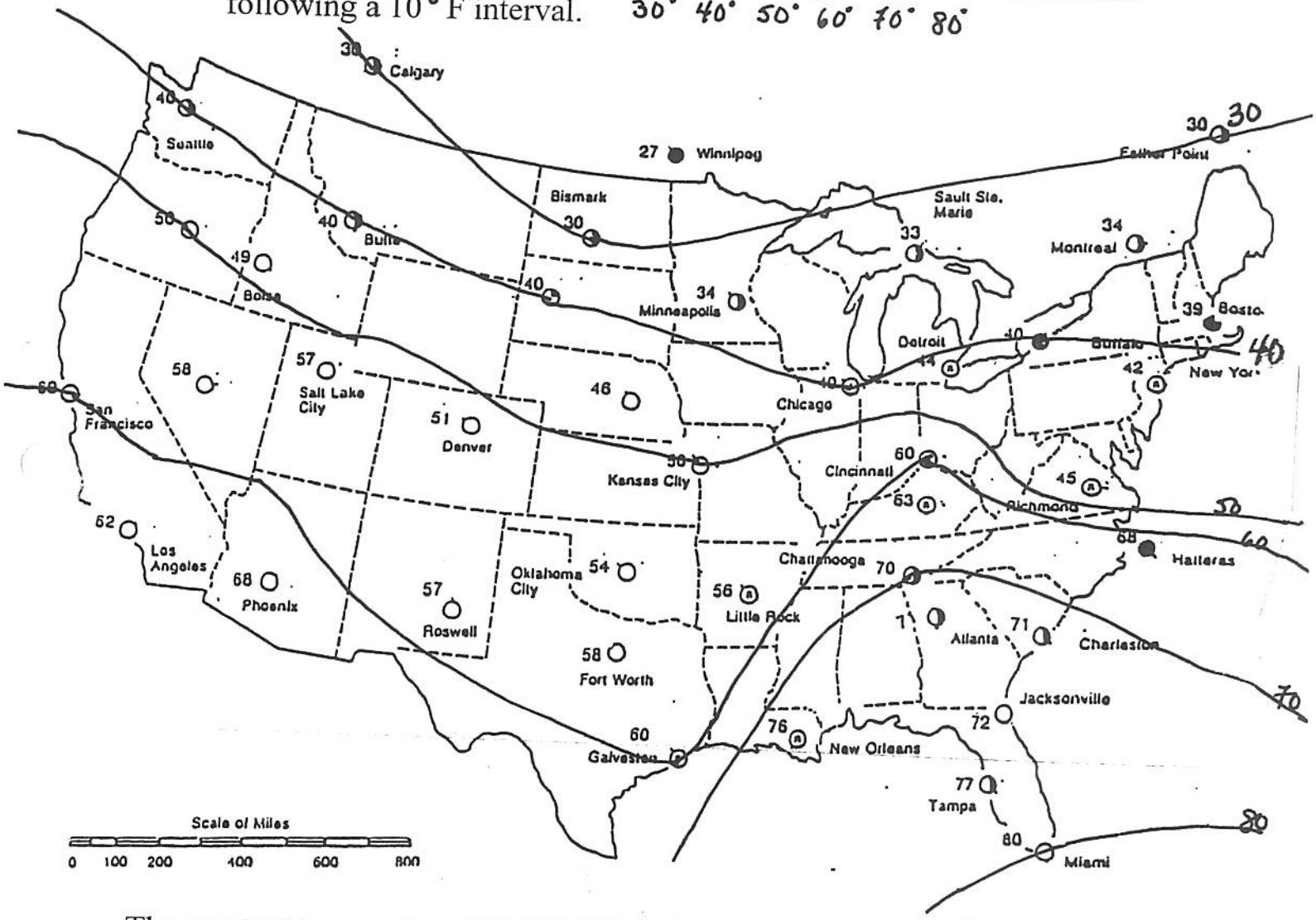
land has low C_p so land heats + cools fast

= hotter summers, colder winters } extreme temps

N.H location

Temperatures are shown on a WEATHER MAP by lines connecting points of equal temperature called Isotherms. The same rules for drawing all isolines must be followed.

On the map below, draw isotherms beginning with the 30 ° F line and following a 10 ° F interval. 30° 40° 50° 60° 70° 80°



The greatest temperature GRADIENT is found between Richmond and Hatteras because the isotherms are close together

Calculate the temperature gradient between Cincinnati and Chicago below:

$g = \frac{\text{chg in field value}}{\text{distance}}$

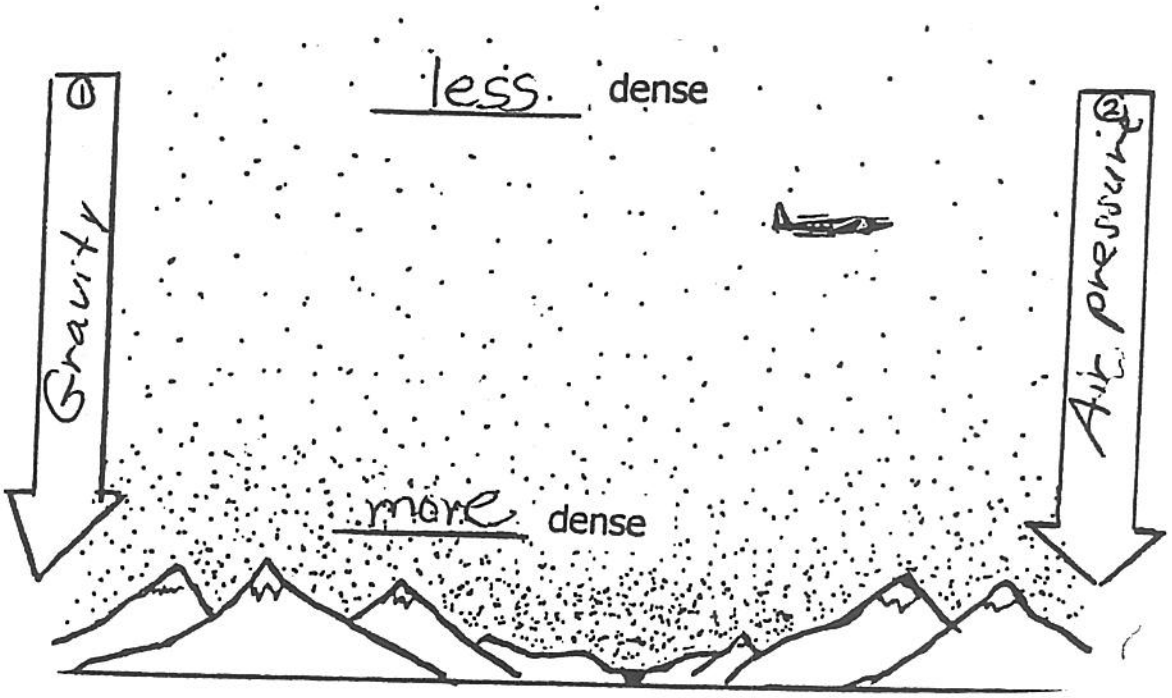
$= \frac{60\,^\circ F - 40\,^\circ F}{250\ mi} = \frac{20\,^\circ F}{250\ mi} = .08\,^\circ F/mi = .1\,^\circ F/mi$

Weather Variable: Air Pressure

1. Definition : the force or weight of atmosphere on objects

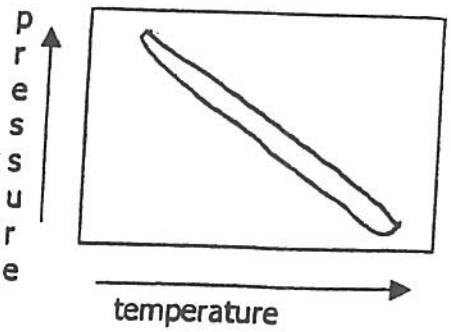
The force of Gravity causes the air to have weight - This creates air pressure.

Denser air has more weight and force and so has higher air pressure

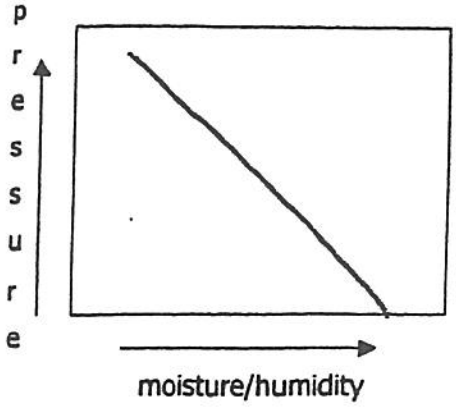


2. Changes in air pressure are caused by the SAME factors that change air density:

   a. Temperature = as temp. increases (air molecules move farther apart + become less dense), air pressure decreases



b. Moisture (or Humidity) = Moist air is lighter, less dense + lower pressure than dry air. As water vapor is added to air, air pressure decreases.

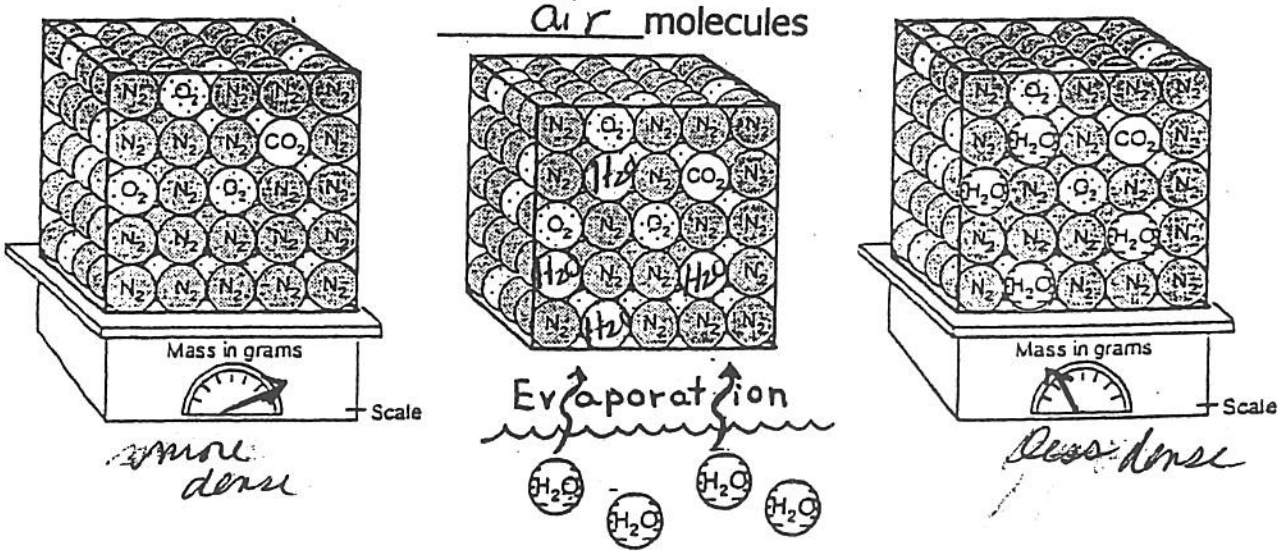


The diagrams represent a specific volume of air in three different circumstances. They show how the density or mass of this volume of air changes when water vapor enters the air.

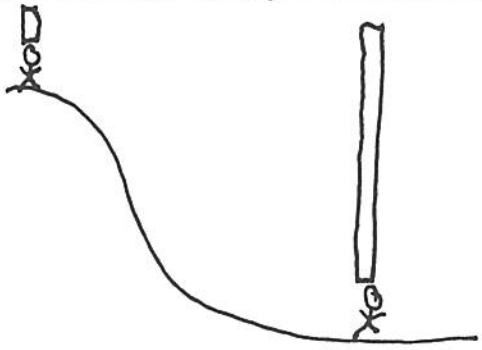
DATA TABLE

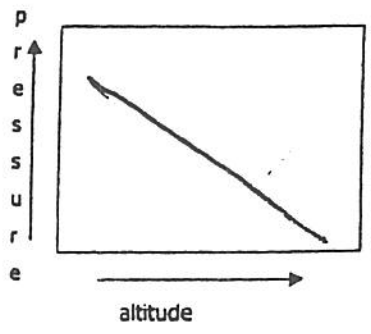
Molecule Symbol	Gas	Mass
N_2	Nitrogen	28 g
O_2	Oxygen	32 g
CO_2	Carbon Dioxide	44 g
H_2O	Water Vapor	18 g

1. DRY 2. Water vapor molecules replace air molecules 3. Humid

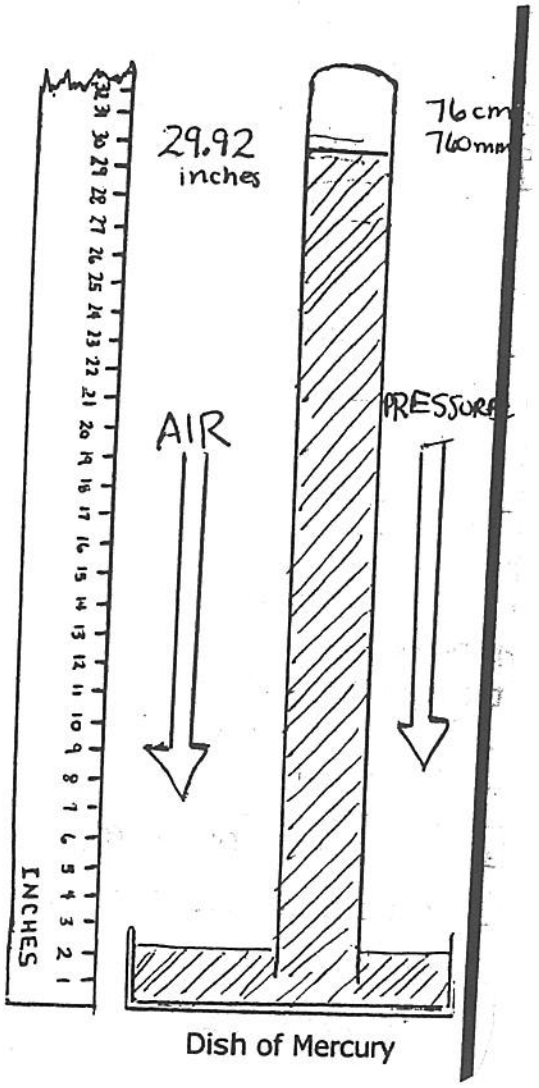


c. Altitude = As altitude increases, air pressure decreases (less air is above AND air is less dense)





3. Instrument used to measure air pressure is the Barometer



A Mercury Barometer is a scale that balances the weight of air against a column of mercury.

A 36 inch tube of mercury is filled and inverted into a dish. Mercury runs out of the tube into the dish until the weight of the air pressing on the mercury in the dish supports the height of the mercury in the tube.

As the air becomes Heavier (=denser), less mercury flows out of the tube supporting a HIGHER column = HIGHER pressure air reading.
As the air becomes Lighter (=less dense), more mercury flows out of the tube supporting a LOWER column = LOWER pressure air reading.

4. Air pressure can be measured in different units: inches of mercury, millibars, atmospheres, pounds/square inch

Sea Level air pressure is:
29.92 inches of mercury = 1 atm = 1013.2 mb = 14.7 lbs/sq in

Convert between scales using chart in ESRT p. 13 999 mb = 29.5 in

997 mb = 29.44 in.
1006 mb = 29.71 in.
1019 mb = 30.09 in
1000 mb = 29.53 in

1021 mb = 30.15 in
979 mb = 28.91 in

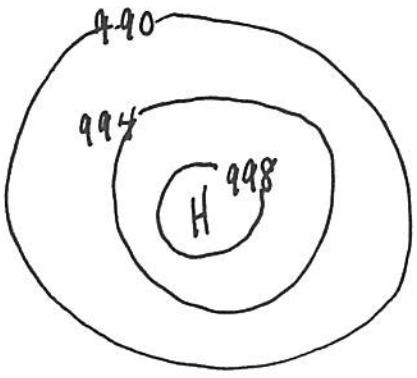
Falling Barometer Reading = Lowering air pressure
Generally means warmer temps
higher elevation
moist air (rainy/stormy)

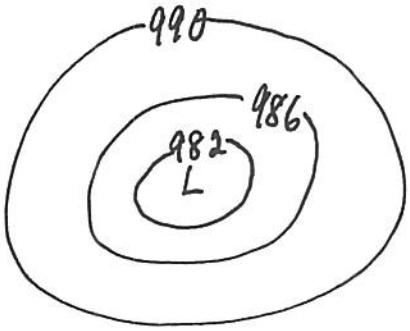
Rising Barometer Reading = Higher air pressure
Generally means cooler temps
lower elevation
dry air (clear skies)

Air pressure is shown on a WEATHER MAP by lines connecting points of equal air pressure called Isobars. The same rules for drawing isolines must be followed.

a. A standard isobar interval of 4mb is used on weather maps.

b. The common pattern for isobars on weather maps is closed circles enclosing a pressure system. The type of system is NAMED by the values in the center of the system.
A "L" is placed in the center circle of a LOW pressure system;
A "H" is placed in the center circle of a HIGH pressure system.

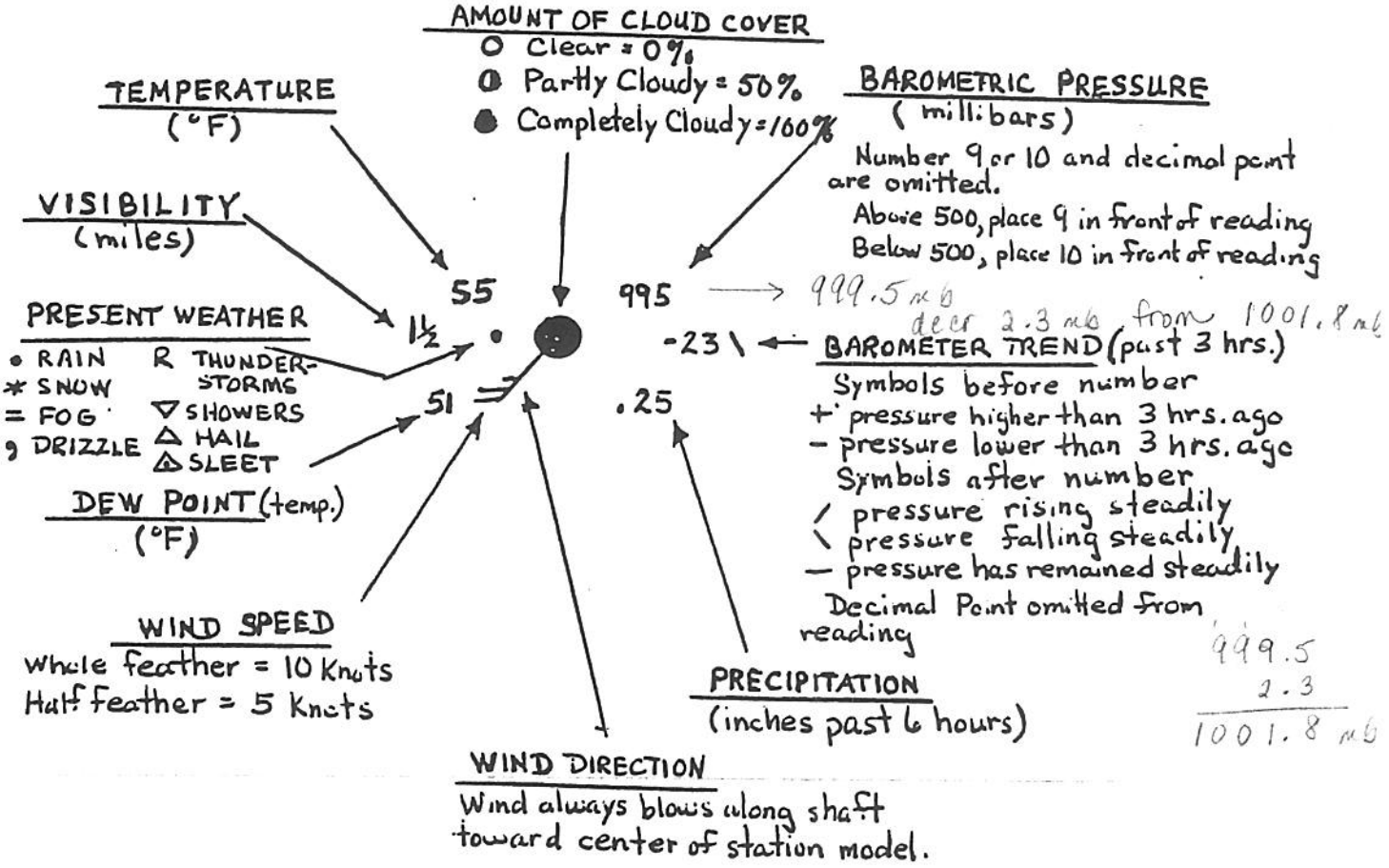




How is weather data for cities placed on a weather map?

A Station Model is a group of *standardized* symbols used on a weather map to record atmospheric information taken at the same time (synoptic) in a known location.

All information MUST be placed in the same spot and follow the same symbols in the station model. See ESRT p. 13 for key to symbols.



Practice air pressure millibars to 3 digit symbol conversion:

1012.6 mb = 126
996.2 mb = 962
1010 mb = 100
1003.5 mb = 035
989.9 mb = 899

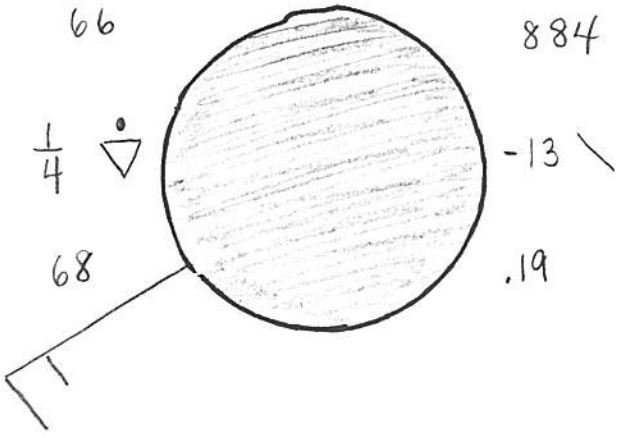
982 = 998.2 mb
401 = 1040.1 mb
876 = 987.6 mb
001 = 1000.1 mb
678 = 967.8 mb

Station Model Practice:

(A)

air temp 19°C = 66°F
air pressure 988.4 mb
dew point 20°C = 68°F
southwest wind at 15 knots
visibility 1/4 mile
cloud cover 100%
air pressure (3hr ago) 989.7mb
present weather rain showers
precipitation past 6 hr .19 inches

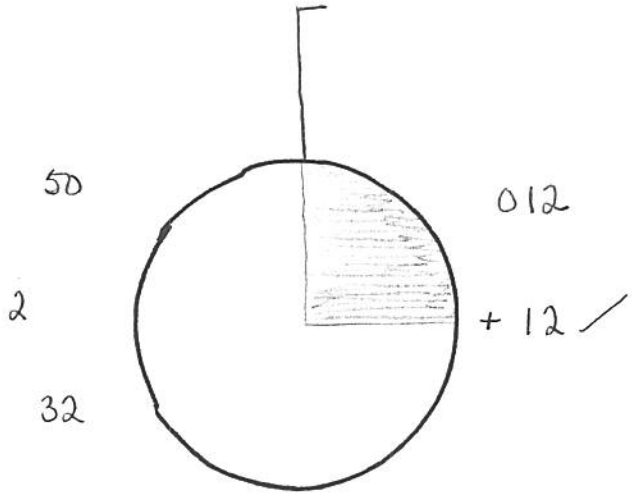
989.7 mb
- 988.4 mb
1.3 mb



(B)

air temp 10°C = 50°F
air pressure 1001.2 mb
dew point 0°C = 32°F
north wind at 5 knots
visibility 2 miles
cloud cover 25%
air pressure (3 hr ago) 1000 mb
present weather clear & fair
precipitation past 6 hr 0 inches

1001.2 mb
- 1000.0 mb
1.2 mb

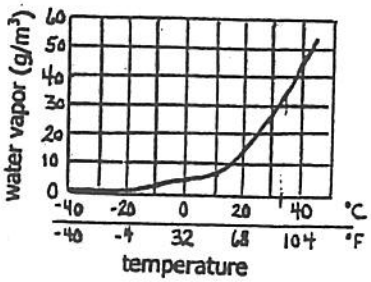


Weather Variable: Humidity

1. Definition:

   Air can hold moisture as a solid (snow, ice), liquid (rain, water droplets), or gas (water vapor)

2. The amount of water that air can hold is DIRECTLY related to Temperature. The higher the temperature, the more moisture the air can hold.



   When air is holding ALL the moisture it can hold at a specific temperature, it is Saturated (= filled to capacity)
   That temperature at which air is saturated is called Dew Point Temperature

3. The saturation point is an equilibrium. Changing Temperature can cause the air to either RELEASE moisture through Condensation or to ADD moisture through Evaporation

   ***When air temperature cools below Dew Point, the capacity of the air to hold moisture decreases (→ air is overfull) and condensation occurs (It rains or snows! = higher humidity)

   ***When air temperature warms above Dew Point, the capacity of the air to hold moisture increases (→ air is less full) and evaporation occurs (Air becomes drier! = lower humidity)

4. On a station model, when air temperature and dew point temperature become more similar, the probability of condensation increases and the humidity of the air increases

19
*
20

= snow

45
32

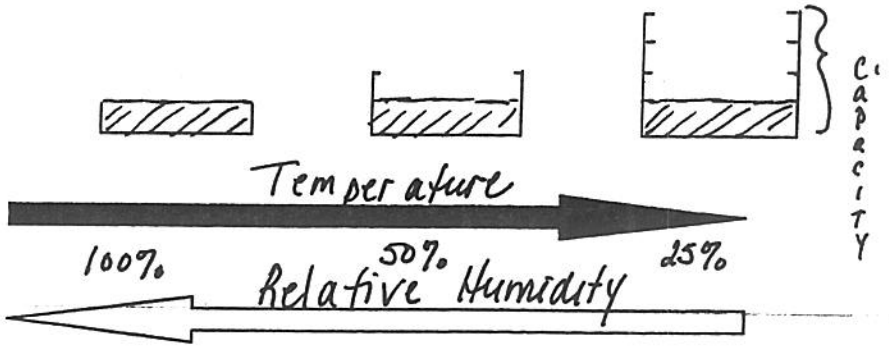
= clear

42
•
43

= rain

5. *Relative* Humidity is a comparison of the amount of moisture in air with its saturation amount at that temp.
It is a measure of how full of moisture the air is at that temperature.

1)



(2) If temp increases + moisture in air remains same, Relative Humidity will decrease

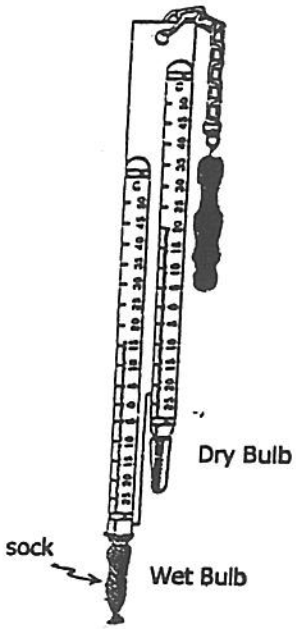
(3) Time of Day:

(a) Highest Relative Humidity = coolest time of day 5 am

(b) Lowest Relative Humidity = warmest time of day 3 pm

How are Dew Point Temperature and Relative Humidity determined?

A instrument called a Sling Psychrometer is used to determine both dew point and relative humidity.



A sling psychrometer consists of two thermometers: a dry bulb and a wet bulb placed side by side. The dry bulb measures normal air temperature. The wet bulb has a wet piece of material or "sock" on it. The instrument is then swung through the air for a minute. The temperature readings from each thermometer will differ.

The wet bulb thermometer will always register a LOWER temperature because the evaporation of the water from the "sock" draws heat energy away from the bulb of the thermometer. The dew point temperature and relative humidity are then determined by using the two temperature readings and the chart on p. 12 of the ESRT.

Earth Science Reference Tables: page 12

Determine the dew point temperature for the following data:

DRY BULB TEMP.	22°C	22°C	20°C	15°C	9°C	8°C	17°C
WET BULB TEMP.	20°C	13°C	14°C	12°C	3°C	6°C	17°C
dew point	19°C	5°C	10°C	10°C	-7°C	3°C	17°C

air temp = dew pt = 100% R.H. saturated air

Determine the relative humidity for the following data:

Dry Bulb Temp.	20°C	8°C	22°C	22°C	15°C	15°C	3°C
Wet Bulb Temp.	14°C	6°C	13°C	20°C	12°C	15°C	-1°C
Relative Humidity	51%	74%	33%	83%	70%	100%	39%

dry bulb	12°C	21°C	6°C	28°C	
wet bulb	6°C	16°C	2°C	21°C	
difference	6°C	5°C	4°C	7°C	
relative humidity	38%	59%	46%	53%	
dew point temp.	-2°C	13°C	-4°C	17°C	

How does moisture enter and leave the atmosphere?

1. Moisture enters the atmosphere by two processes:

   Evaporation = changing liquid water from oceans (most important), rivers, streams, etc. into water vapor

   Transpiration = plants release water vapor to atmosphere through their leaves.

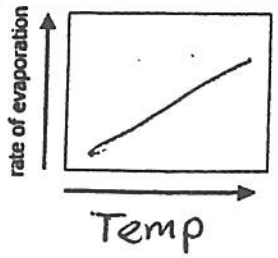
   Evapo-Transpiration is the term used to describe all water vapor added to the atmosphere through evaporation and transpiration.

2. Adding moisture to the atmosphere ALSO adds Energy

   in the form of more energized molecules (2260 J/g = Latent Heat H_v

3. The Rate of Evaporation is affected by:

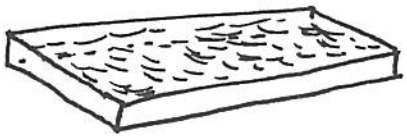
   a. Temperature = The greater the temp, the more + faster the evaporation can occur (b/c greater heat energy is available.



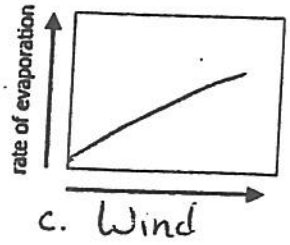
   b. Exposed surface area of the water = the more exposed surface area of water, the more + faster evaporation can occur

less /slow evaporation

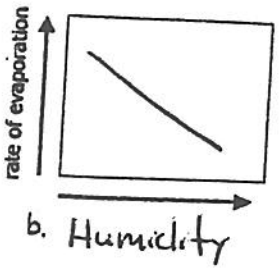
more/fast evaporation



c. Wind = the more air molecules that pass over the surface, the greater the evaporation



d. Humidity = as humidity increases, the rate of evaporation decreases



4. Moisture leaves the atmosphere by two processes:

   a. Condensation = water vapor changes to liquid water at temperatures above 0 °C

   b. Sublimation = water vapor changes to solid (ice crystals or snow) at temperatures below 0 °C

5. Removing moisture from the atmosphere ALSO removes Energy in the form of less energized molecules (2260 J/g Latent Heat) H_v This is the energy that drives many storms systems (ex. Hurricanes).
6. For condensation to occur, a solid surface for the vapor to condense on MUST be present. This solid surface may be dust, dirt, pollen, pollution, aerosols, etc. and is called Condensation Nuclei. No condensation can occur in perfectly clean air.

7. Clouds are collections of tiny water droplets or ice crystals suspended in the atmosphere.

Clouds are visible therefore they are NOT made of gases, but are made of liquids or solids.

Clouds form when: warm moist air rises
it cools below dew point
condensation occurs
"poof" a cloud!

8. When water droplets and/or ice crystals become large enough to fall down to the ground, Precipitation occurs.

Precipitation cleans the atmosphere by removing dirt and aerosols (condensation nuclei) from the atmosphere by bringing them down to the ground.

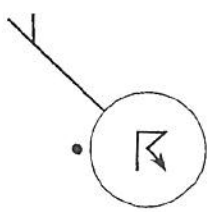
Name Key

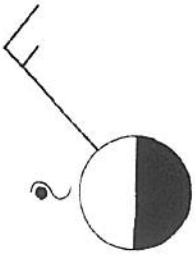
Date SAMPLE

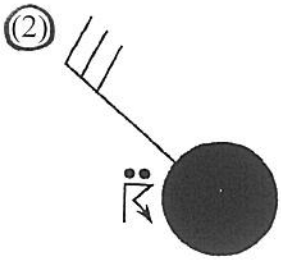
Part 1: Multiple Choice. (3 points each, total 84 points)

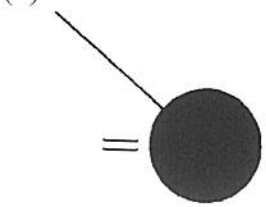
1. Base your answer to the following question on the *Earth Science Reference Tables*.

Which station model correctly shows the weather conditions of a thunderstorm with heavy rain?

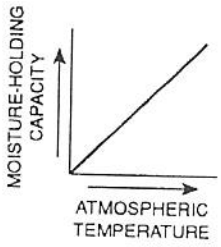
(1) 

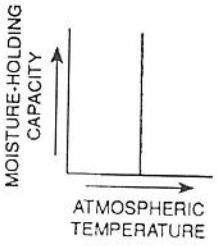
(3) 

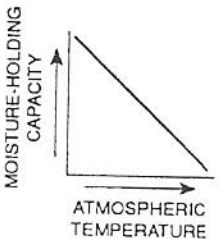
(2) 

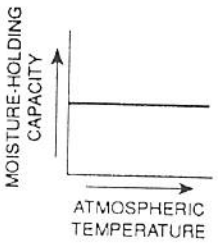
(4) 

2. Which graph best represents the relationship between the moisture-holding capacity (ability to hold moisture) of the atmosphere and atmospheric temperature?

(1) 

(3) 

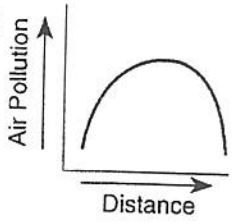
(2) 

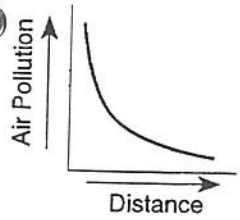
(4) 

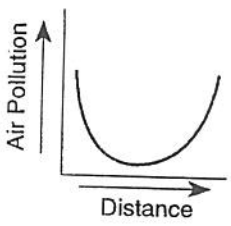
3. The change from the vapor phase to the liquid phase is called

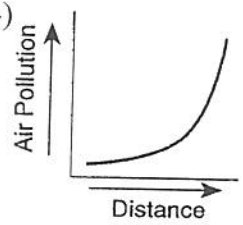
(1) condensation
(2) evaporation
(3) transpiration
(4) precipitation

4. Which graph best represents the most common relationship between the amount of air pollution and the distance from an industrial city?

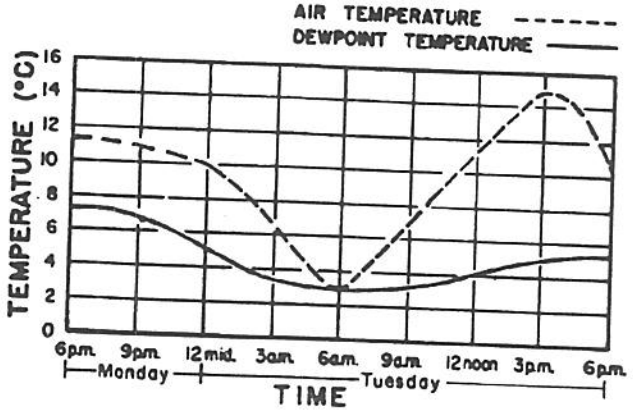
(1) 

(3) 

(2) 

(4) 

Base your answers to question 5 on The graph below which shows the air temperature and dewpoint temperature over a 24-hour period for a location in New York State.



5. When was the air at ground level saturated with water vapor?

(1) 6 p.m. Monday
(2) 6 a.m. Tuesday
(3) 3 p.m. Tuesday
(4) 12 noon Tuesday

6. Base your answer to the following question on the *Earth Science Reference Tables*.

At which temperature could water vapor in the atmosphere change directly into solid ice crystals?

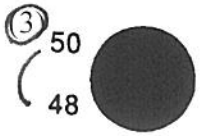
(1) 20°F
(2) 40°F
(3) 10°C
(4) 100°C

below freezing

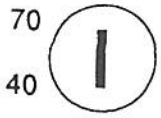
7. Which weather station model represents the location with the greatest probability of precipitation?

(1)

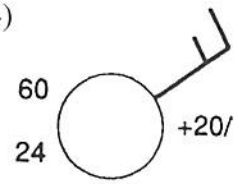
(3)



(2)



(4)



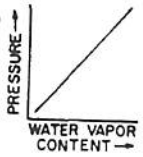
8. Which graph best shows the relationship between atmospheric pressure and water vapor content at the Earth's surface?

(1)

(3)

(2)

(4)



9. The highest air temperature ever recorded in Albany, New York, was 104°F, which occurred on July 4, 1911. This temperature is equal to

(1) 50°C
(2) 45°C
(3) 40°C
(4) 35°C

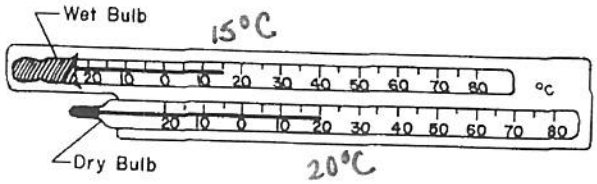
10. Why are temperature variations usually not as great on Long Island as they are in central New York State?

(1) Central New York State has a higher elevation.
(2) Central New York State is more heavily wooded.
(3) Long Island has a more southerly latitude.
(4) Long Island is surrounded by a large body of water.

11. Which statement best explains why the wet-bulb thermometer of a sling psychrometer usually shows a lower temperature than the dry-bulb thermometer?

(1) Water evaporates from the wet-bulb thermometer.
(2) Water vapor condenses on the wet-bulb thermometer.
(3) The air around the wet bulb prevents absorption of heat.
(4) The air around the dry bulb prevents absorption of heat.

12. According to the *Earth Science Reference Tables* and the thermometer readings below, what is the approximate dewpoint?



(1) 16°C
(2) 20.°C
(3) 5.0°C
(4) 12°C

13. As warm, moist air moves into a region, barometric pressure readings in the region will generally

(1) decrease
(2) increase
(3) remain the same

14. The primary source of moisture for the atmosphere is the Earth's

(1) rivers and lakes
(2) oceans
(3) ground water
(4) vegetation

15. An observer reports the following data for a location in New York State:

Air temperature = 35° C = 96°F
Pressure = 996 mb
Relative humidity = 84 %

The weather conditions at this location would best be described as

(1) cool and humid
(2) cool and dry
(3) hot and humid
(4) hot and dry

16. Base your answer to the following question on the *Earth Science Reference Tables*.

When the dry-bulb temperature is 14°C and the wet-bulb temperature is 8°C, the relative humidity is

(1) 6%
(2) 22%
(3) 25%
(4) 41%

17. According to the *Earth Science Reference Tables*, an atmospheric pressure of 1,019 millibars is equal to

(1) 30.15 inches of mercury
(2) 31.05 inches of mercury
(3) 30.00 inches of mercury
(4) 30.09 inches of mercury

18. Condensation will most likely occur in a given volume of air when the air is

(1) saturated and contains no condensation nuclei
(2) saturated and contains condensation nuclei
(3) unsaturated and contains no condensation nuclei
(4) unsaturated and contains condensation nuclei

19. Which gas in the atmosphere has the most influence on day-to-day weather changes?

(1) carbon dioxide
(2) water vapor
(3) oxygen
(4) ozone

20. Which processes provide the greatest amount of moisture to the atmosphere?

(1) evaporation and transpiration
(2) evaporation and infiltration
(3) condensation and transpiration
(4) condensation and infiltration

21. Which atmospheric condition will cause the greatest amount of evaporation from the surface of a lake?

(1) calm, dry, cold
(2) moist, cold, windy
(3) calm, moist, hot
(4) dry, hot, windy

22. Which event usually occurs when air is cooled to its dewpoint temperature?

(1) evaporation
(2) freezing
(3) transpiration
(4) condensation

23. Which atmospheric variable usually increases before precipitation occurs?

(1) insolation
(2) air pressure
(3) visibility
(4) relative humidity

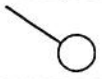
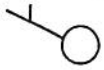
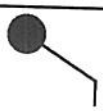
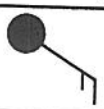
24. By which process are clouds, dew, and fog formed?

(1) evaporation
(2) condensation
(3) melting
(4) precipitation

25. Which natural process best removes pollutants from the atmosphere?

(1) convection
(2) condensation
(3) precipitation
(4) evaporation

Base your answers to questions **26** through **28** on the *Earth Science Reference Tables* and the data table below. The table shows weather conditions for 4 consecutive days at a location in New York State. Each reading was taken at 1 p.m.

Day	Temperature (°F)	Wind Speed, Wind Direction, Cloud Cover	Barometric Pressure (mb)	Present Weather
Monday	6		1,028.0	Clear
Tuesday	4		1,029.0	Sunny
Wednesday	24		1,017.0	Light snow
Thursday	26		1,011.0	Light snow

26. On which day was the wind speed at 1 p.m. the greatest?
(1) Monday (2) Tuesday (3) Wednesday (4) Thursday

27. Which symbol best indicates the weather conditions at 1 p.m. on Wednesday?
(1)  (2)  (3)  (4) 

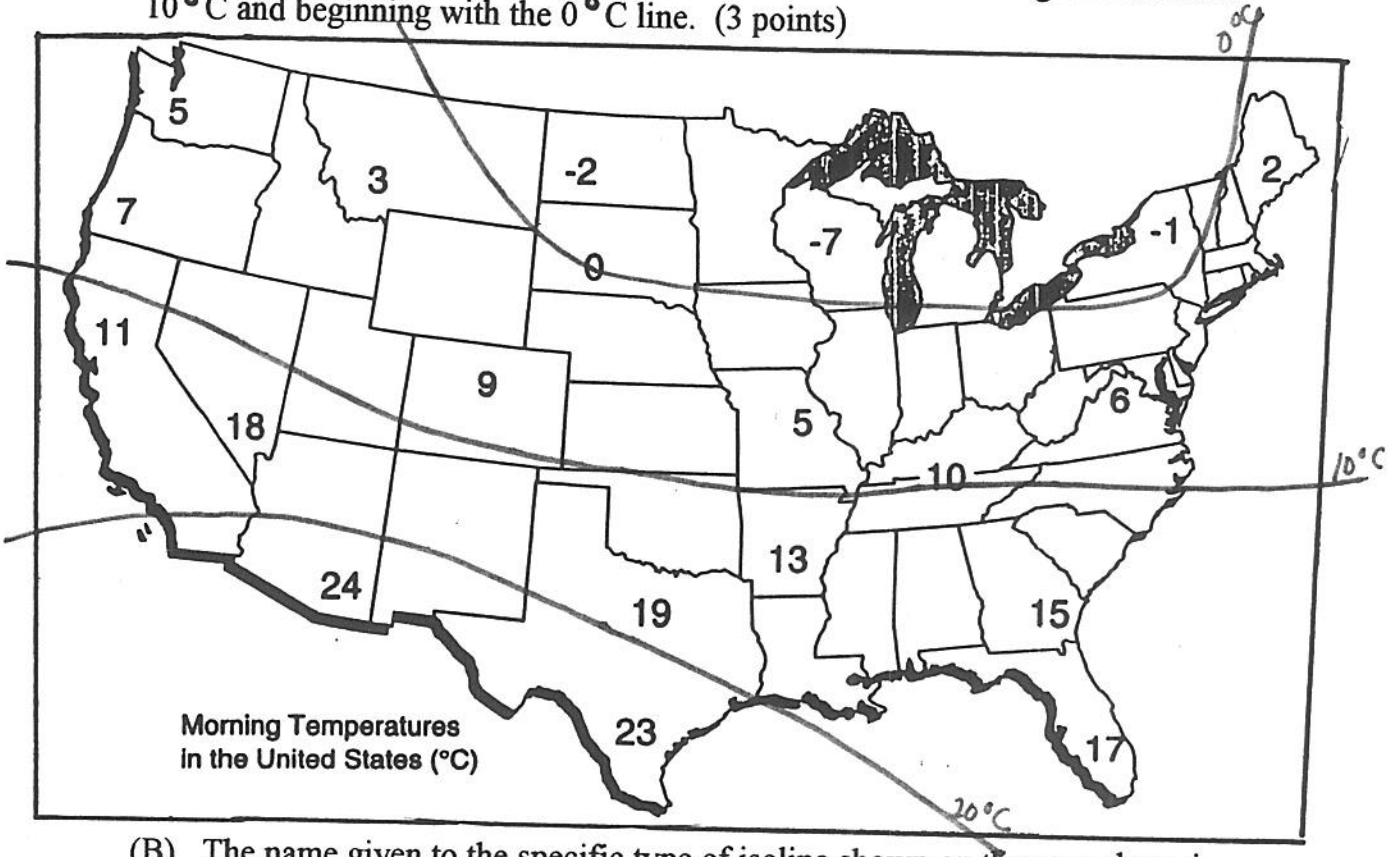
28. If the weather trend continues, the most probable air temperature for 1 p.m. on Friday is
(1) 20°F (2) 28°F (3) 36°F (4) 4°F

Part 2. Answer each question in the space provided. (16 points total)

1 pt each line

1. (A) Use the data shown on the map below to draw isolines using an interval of 10 °C and beginning with the 0 °C line. (3 points)

0° C
10° C
20° C



(B) The name given to the specific type of isoline shown on the map above is

1 pt isotherm.

2. The interiors of continents (inland areas) become centers of High Air Pressure in the Winter. Explain why this High Air Pressure occurs. (2 points)

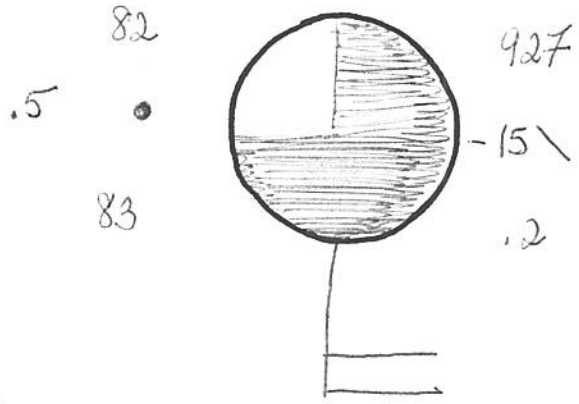
① Centers of continents get very cold in winter b/c land cools fast due to (low Cp of land) - ½

① Cold air is high pressure air

3. Correctly complete the station model drawing using the information given at the left (10 points).

Air temperature	82 ° F
Air Pressure	992.7 mb
Cloud Cover	75%
Dew Point Temperature	83 ° F
South wind at 20 knots	
Visibility	.5 miles

Air Pressure fell 1.5mb over the past 3 hours
and continues to fall



Precipitation is currently falling. Name the form of this precipitation rain .

On the model, indicate the current weather mentioned in the question above. drizzle ,
thunderstorms
rain showers

.2 inches of precipitation fell over the past 6 hours