Answer Sheet

LABORATORY 3: ATMOSPHERE COMPOSITION, PRESSURE, AND CIRCULATION

Student Name ________________________________

Student Number ______________________________

QUESTION 1

Using the information in **Table 3.2**, interpolate the atmospheric pressure (in mb) for each of the following locations. Round off your answers to one decimal place.

Example: Dilworth Mountain Peak, Kelowna, British Columbia, Canada: 636 m.

Step 1: Find the pressure for known altitudes either side of the elevation of interest:

Pressure at 500 m = 954.6 mb

Pressure at 1000 m = 898.8 mb

Step 2: Calculate the per meter rate of pressure change between the two known altitudes:

954.6 - 898.8 = 55.8 mb

1000 - 500 = 500 m

55.8 /500 = 0.1116 mb m^{-1} (rate pressure drops with an increase in altitude)

Step 3: Find the height difference between the elevation of interest and the lower boundary of the known values:

636 - 500 = 136 m

Step 4: Calculate the pressure at the location using the values calculated in Steps 2 and 3:

Pressure at 636 m = 954.6 - (136 * 0.1116) = 939.4 mb

Table 3.2. Temperature and pressure characteristics of the standard atmosphere.

Altitude (m)	Temperature (°C)	Pressure (mb)	Altitude (m)	Temperature (°C)	Pressure (mb)
0	15.0	1,013.2	11,000	- 56.4	227.0
500	11.8	954.6	11,100	- 56.5	223.5
1,000	8.5	898.8	11,500	- 56.5	209.8
1,500	5.2	845.6	12,000	- 56.5	194.0
2,000	2.0	795.0	13,000	- 56.5	165.8
2,500	- 1.2	746.9	14,000	- 56.5	141.7
3,000	- 4.5	701.2	15,000	- 56.5	121.1
3,500	- 7.7	657.8	16,000	- 56.5	103.5
4,000	- 11.0	616.6	17,000	- 56.5	88.5
4,500	- 14.2	577.5	18,000	- 56.5	75.6
5,000	- 17.5	540.5	19,000	- 56.5	64.7
5,500	- 20.7	505.4	20,000	- 56.5	55.3
6,000	- 24.0	472.2	25,000	- 51.6	25.5
6,500	- 27.2	440.8	30,000	- 46.6	12.0
7,000	- 30.4	411.0	35,000	- 30.6	5.7
7,500	- 33.7	383.0	40,000	- 22.8	2.9
8,000	- 36.9	356.5	45,000	- 9.0	1.5
8,500	- 40.2	331.5	50,000	- 2.5	0.8
9,000	- 43.4	308.0	60,000	-17.4	0.225
9,500	- 46.7	285.8	70,000	- 53.4	0.055
10,000	- 49.9	265.0	80,000	- 92.5	0.010
10,500	- 53.1	245.4	90,000	- 92.5	0.002

1.1) What is the approximate atmospheric pressure of Victoria, British Columbia, Canada 23 meters above sea level in millibars?

1.2) What is the approximate atmospheric pressure of Kelowna, Canada 344 meters above sea level in millibars?

1.3) What is the approximate atmospheric pressure of Mt. Sidley, Antarctica 4181 meters above sea level in millibars?

1.4) What is the approximate atmospheric pressure of Mt. Everest, Nepal 8848 meters above sea level in millibars?

1.5) What is the approximate atmospheric pressure of Death Valley, U.S.A.: -86 meters below sea level in millibars?

1.6) What is the approximate atmospheric pressure of Big White Peak, Canada 2319 meters above sea level in millibars?

1.7) What is the approximate atmospheric pressure of Vail Ski Resort Peak, Colorado, USA 3527 meters above sea level in millibars?

QUESTION 2

Answer the following questions related to the structure and the chemical composition of the atmosphere.

2.1) Excluding the thermosphere, what atmospheric layer contains the warmest air temperatures? How are these temperatures affected by the ground surface of our planet?

2.2) Why are warm temperatures also found in the stratosphere? What process is creating the heat energy found here?

2.3) Using the data in Table 3.2, and information in Figure 3.1 derive the average lapse rate for the troposphere.

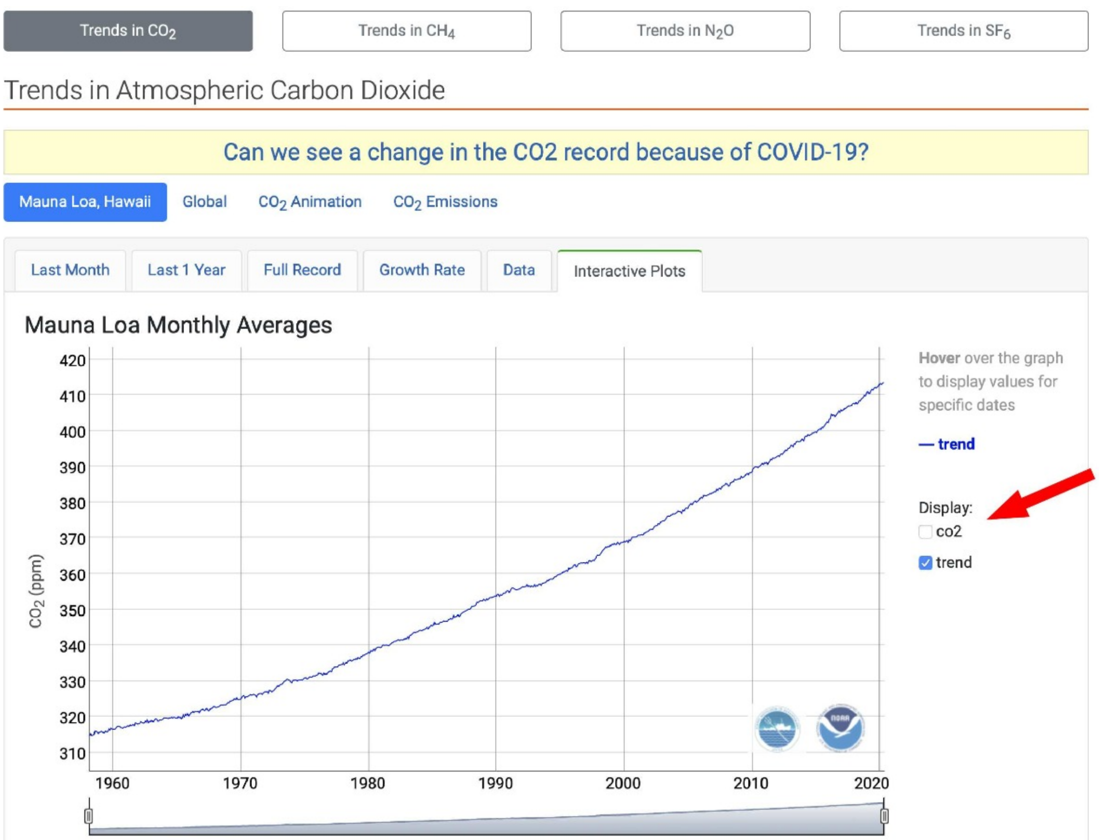
Average lapse rate = _______________ °C per km.

Show your calculations:

2.4) The following web address takes you to **[NOAA's Global Monitoring Laboratory](https://www.esrl.noaa.gov/gmd/ccgg/trends/)** for atmospheric carbon dioxide (CO_2).

https://www.esrl.noaa.gov/gmd/ccgg/trends/

Using the Mauna Loa, Hawaii data, select the **tab** "Interactive Plots". On the top graph, turn off the **display** for CO_2. This should leave you with just a blue trend line (see image below).



2.4a) Select the blue trend line and determine the quantity of carbon dioxide (ppm) on January, 1960. Record your answer to 2 decimal points.

2.4b) Select the blue trend line and determine the quantity of carbon dioxide (ppm) on December, 1969. Record your answer to 2 decimal points.

2.4c) What was the net increase in atmospheric carbon dioxide from January, 1960 to December, 1969 in ppm (record your answer to 2 decimal points)?

2.4d) Select the blue trend line and determine the quantity of carbon dioxide (ppm) on January, 2010. Record your answer to 2 decimal points.

2.4e) Select the blue trend line and determine the quantity of carbon dioxide (ppm) on December, 2019. Record your answer to 2 decimal points.

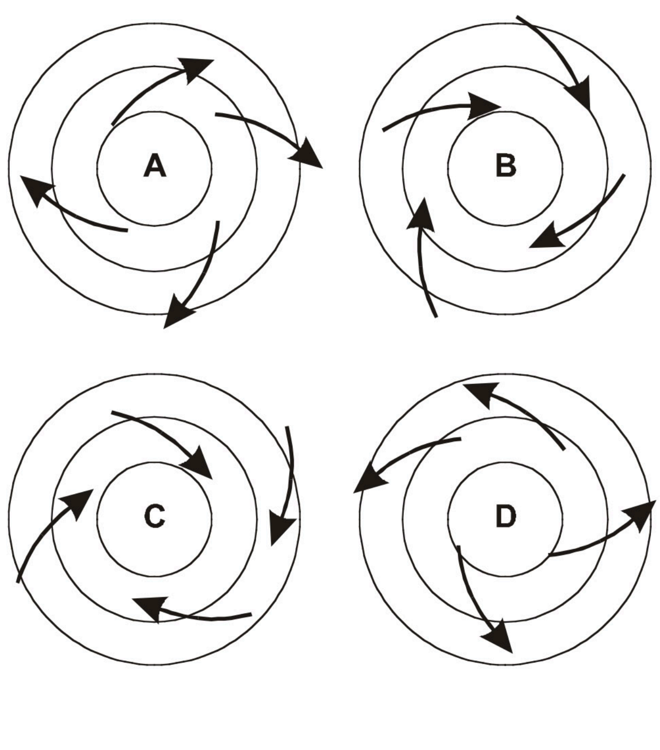
2.4f) What was the net increase in atmospheric carbon dioxide from January, 2010 to December, 2019 in ppm (record your answer to 2 decimal points)?

2.4g) From your calculations, would you conclude the rate of increase of atmospheric carbon dioxide from 1960 is

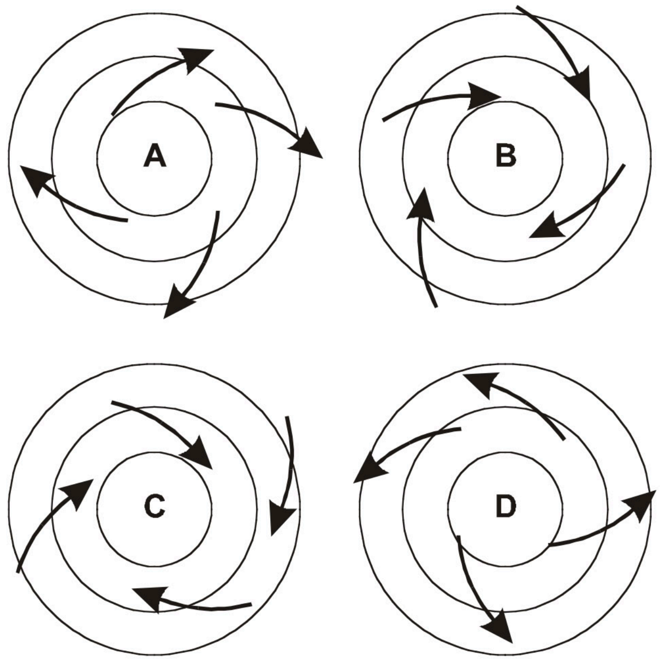
A the same.
B now about two times greater.
C now about three times greater.

QUESTION 3

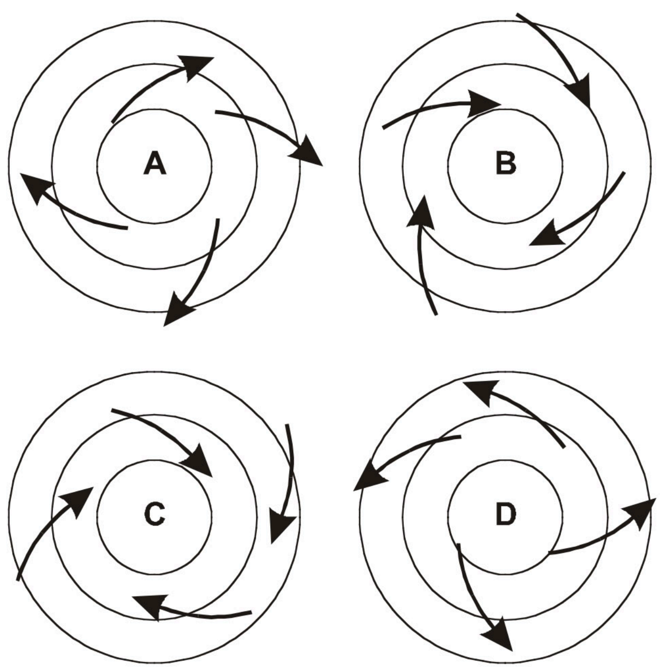
3.1) Which of the following circulation patterns represents a low pressure system in the Southern Hemisphere?



3.2) Which of the following circulation patterns represents a high pressure system in the Southern Hemisphere?



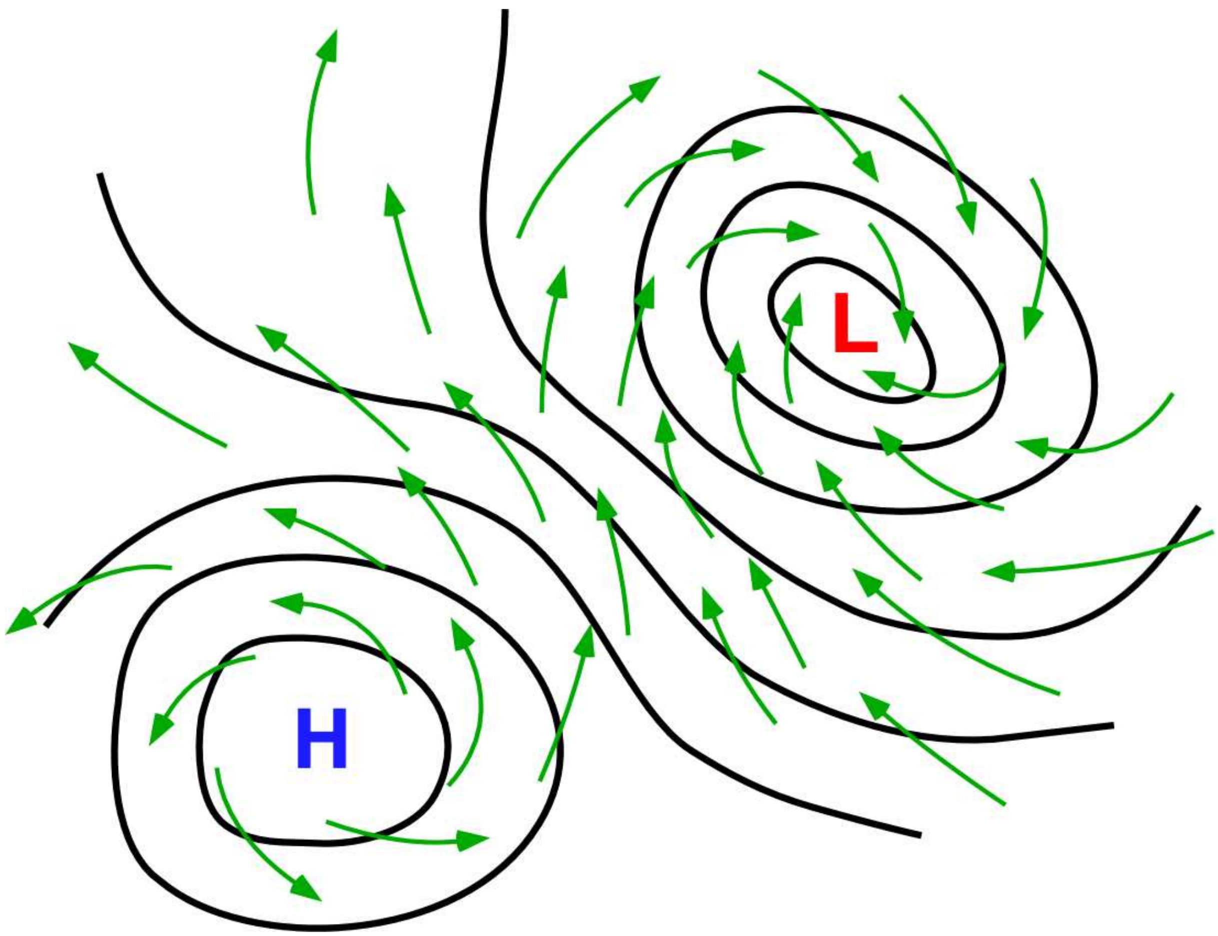
3.3) Which of the following circulation patterns represents a high pressure system in the Northern Hemisphere?



QUESTION 4

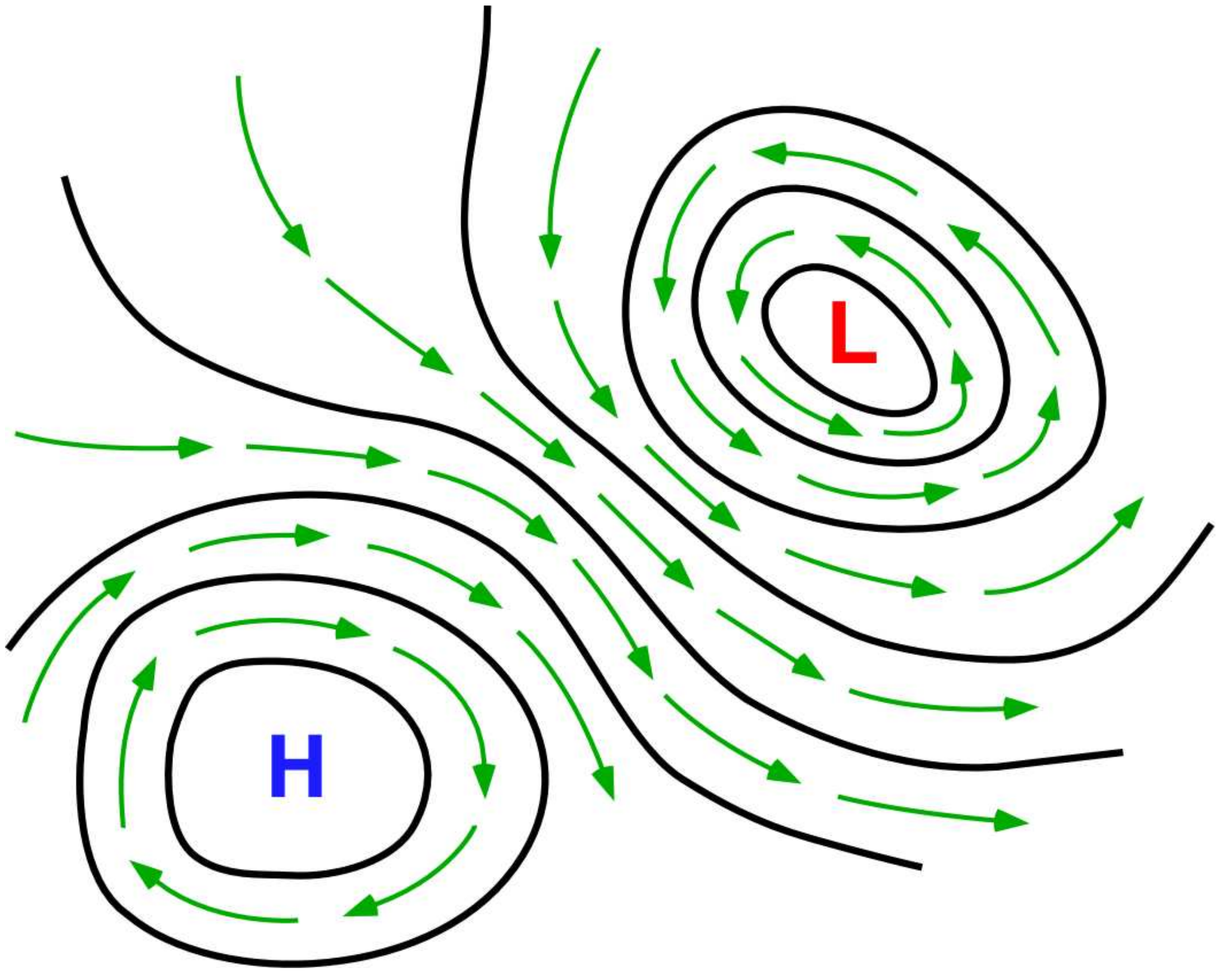
The next four questions will show you wind patterns at the Earth's surface and in the upper atmosphere. Also determine if the patterns are from the Northern Hemisphere of the Southern Hemisphere.

4.1) The wind pattern shown in the following map is



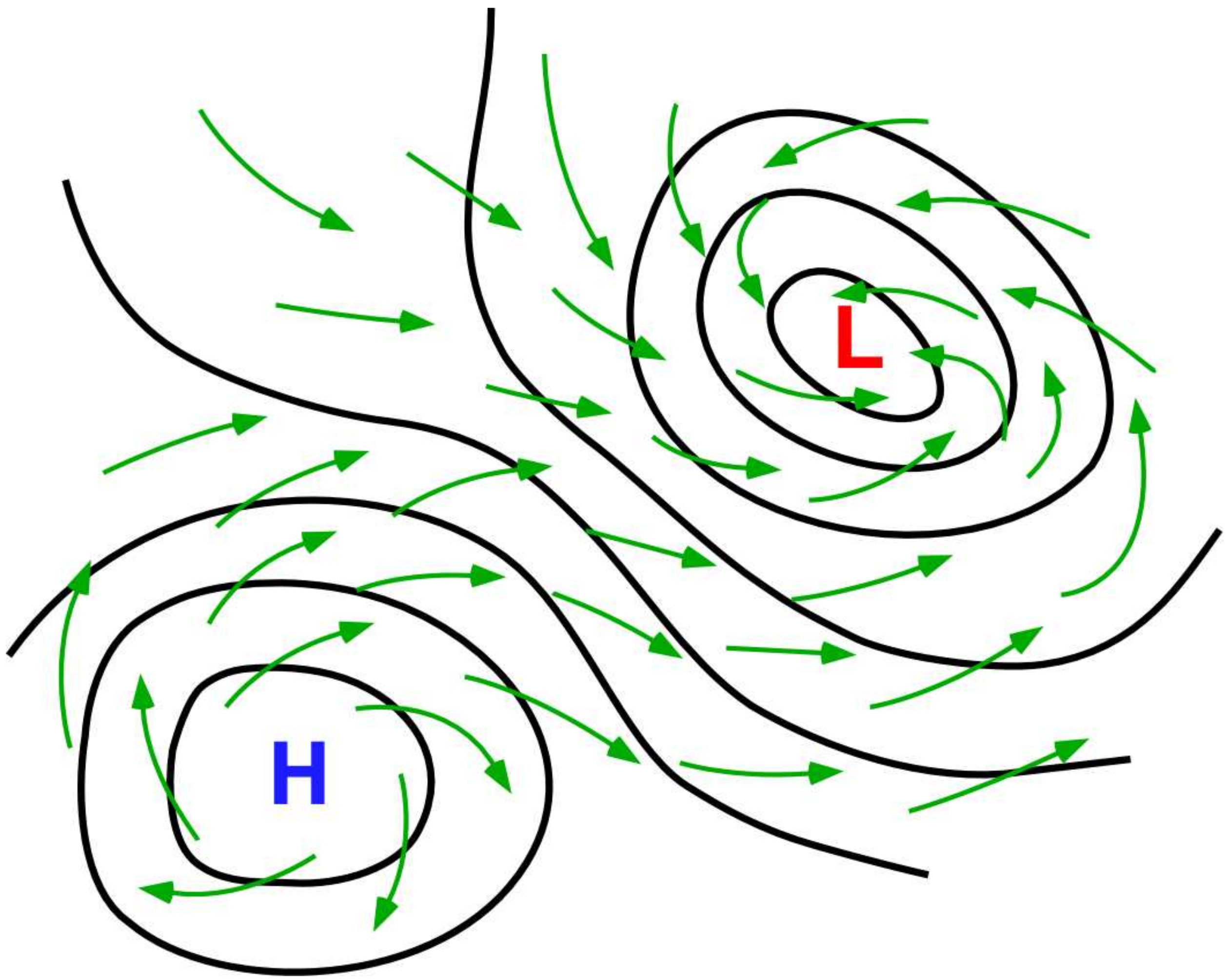
A surface winds in the Northern Hemisphere.
B surface winds in the Southern Hemisphere.
C upper air winds in the Northern Hemisphere.
D upper air winds in the Southern Hemisphere.

4.2) The wind pattern shown in the following map is



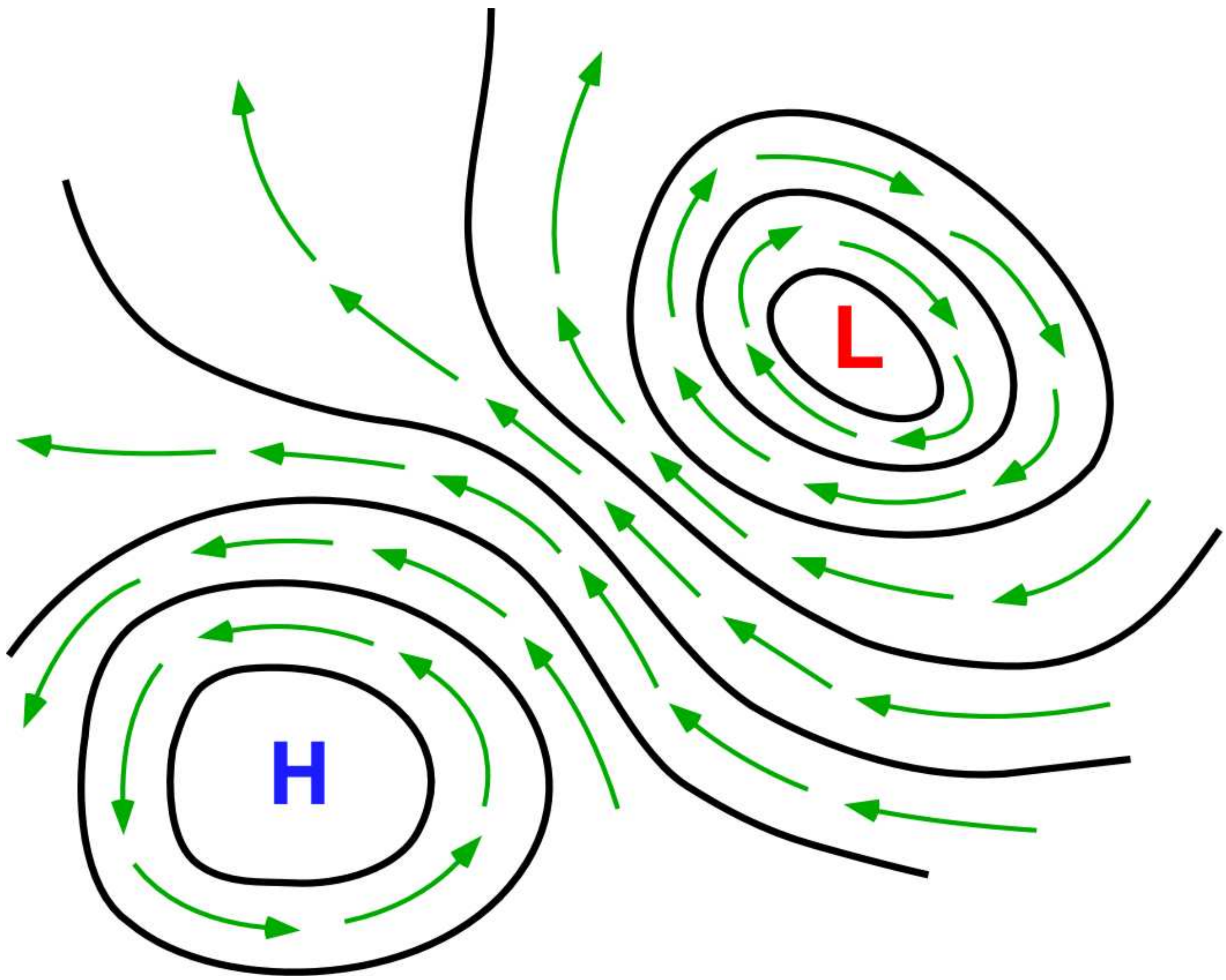
A surface winds in the Northern Hemisphere.
B surface winds in the Southern Hemisphere.
C upper air winds in the Northern Hemisphere.
D upper air winds in the Southern Hemisphere.

4.3) The wind pattern shown in the following map is



A surface winds in the Northern Hemisphere.
B surface winds in the Southern Hemisphere.
C upper air winds in the Northern Hemisphere.
D upper air winds in the Southern Hemisphere.

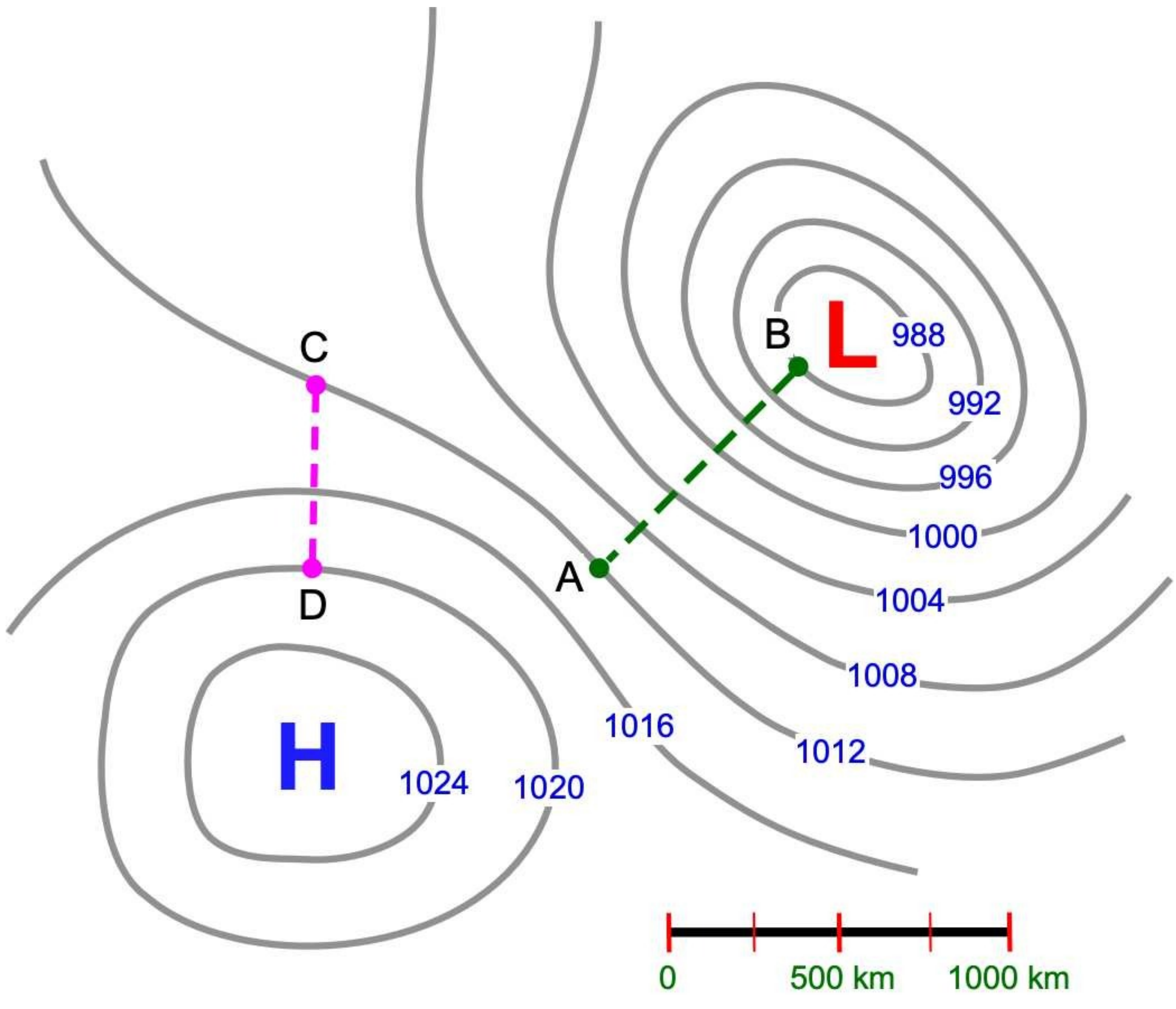
4.4) The wind pattern shown in the following map is



A surface winds in the Northern Hemisphere.
B surface winds in the Southern Hemisphere.
C upper air winds in the Northern Hemisphere.
D upper air winds in the Southern Hemisphere.

QUESTION 5

The following map shows sea level pressure over a region. This region is dominated by a low and high pressure system. Isobars are drawn around these pressure centers at a 4 millibar (mb) interval.



Calculate the **pressure gradient** (difference in pressure between stations divided by the distance between them) between **A** - **B** and **C** - **D**. Express the pressure gradient to 3 decimal places, in units of **mb km^{-1}** (millibars per kilometer). Answer the following questions.

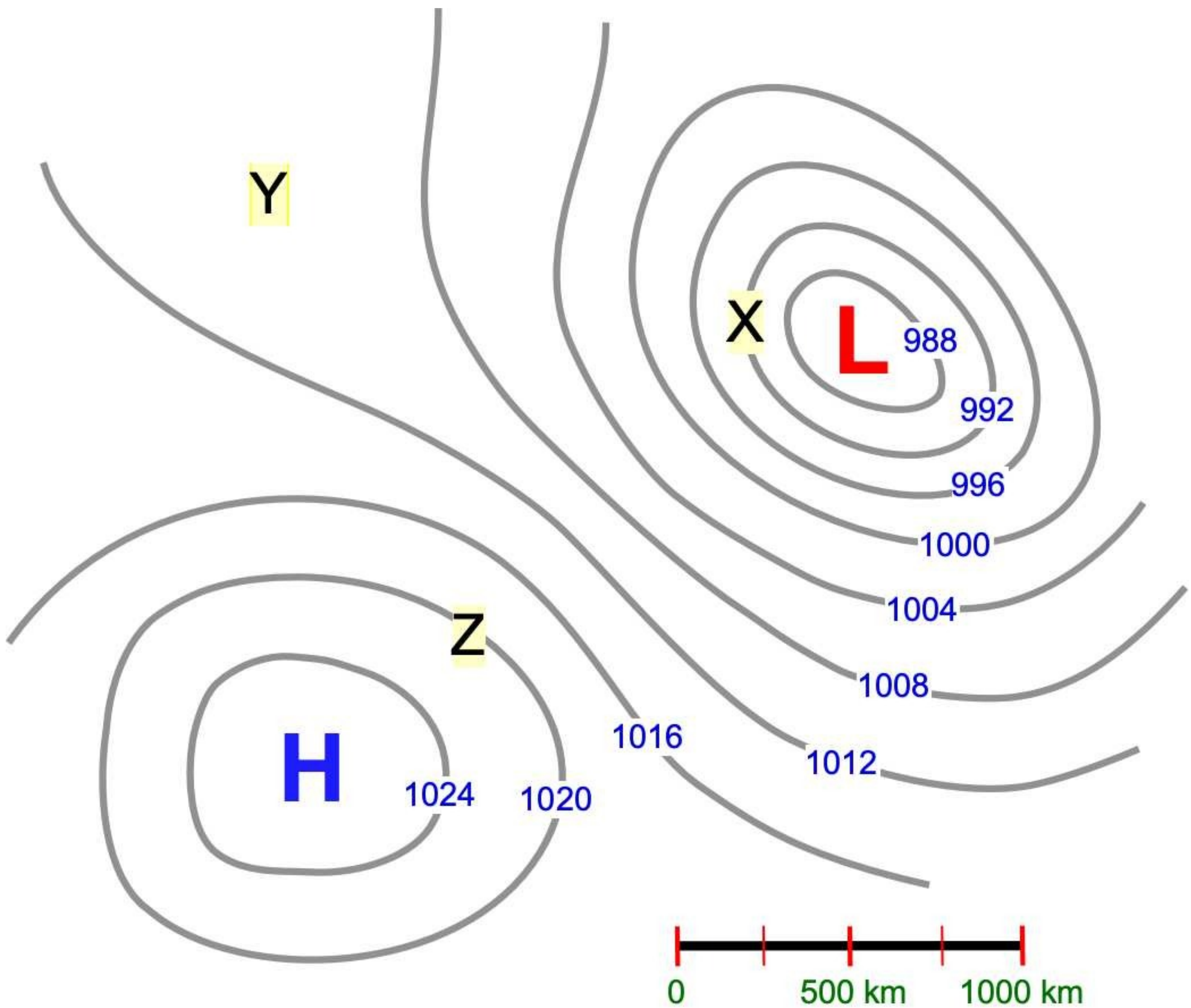
5.1) The calculated pressure gradient for A - B which has a distance of 750 kilometers between points is

5.2) The calculated pressure gradient for C - D which has a distance of 500 kilometers between points is

5.3) How much faster are the winds in A - B relative to C - D?

A 0.5 times.
B 2 times.
C 3 times.
D 4 times.

Here is the sea level pressure map again with some slight modifications. Drawn on it are three locations - X, Y, and Z. Answer the following questions.



5.4) Which location would have the fastest wind speed?

A X
B Y
C Z

5.5) Which location would have the slowest wind speed?

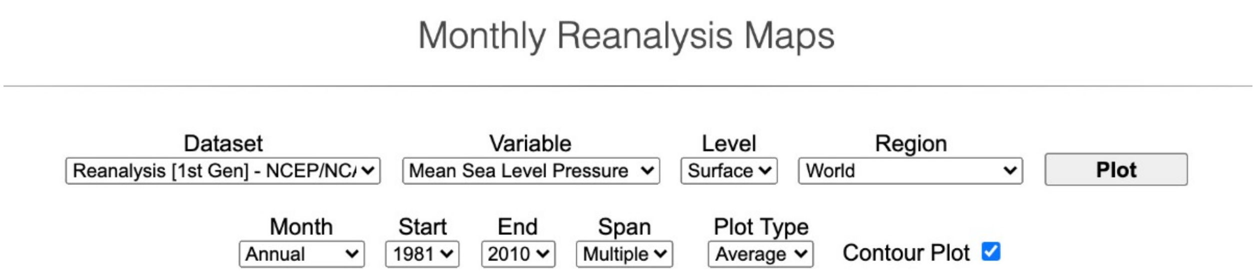
A X
B Y
C Z

QUESTION 6

Use the following web link to go to **Climate Reanalyzer**, Monthly Reanalysis Maps.

http://climatereanalyzer.org/reanalysis/monthly_maps/

Create a global map showing **annual** average mean sea level pressure for the 30-year period 1981-2010 with the following inputs.



Answer the following questions.

6.1) Atmospheric pressure along the equator averages about

A 990 mb.
B 1000 mb.
C 1010 mb
D 1020 mb.

6.2) The pressure patterns seen at the equator are related directly to the

A Intertropical Convergence Zone.
B Tropical Low Pressure Zone.
C Zone of Hurricane Enhancement.
D Subtropical High Pressure Zone.

6.3) The high pressure patterns located over the oceans at 30° N and S are called the

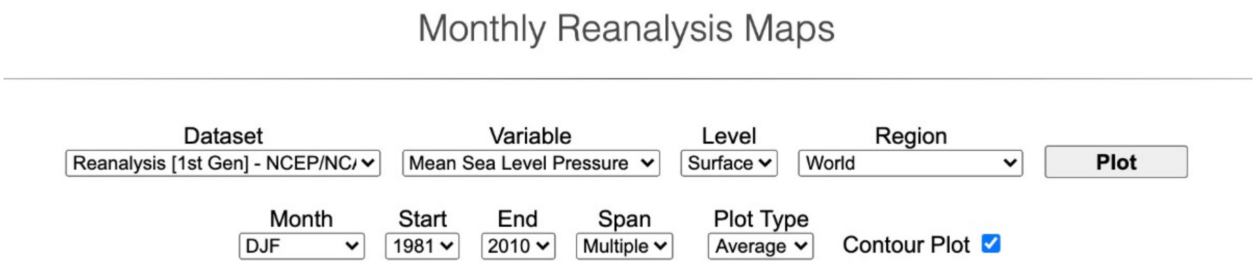
A Intertropical Convergence Zone.
B Oceanic Highs.
C Zone of Hurricane Enhancement.
D Subtropical High Pressure Zone.

6.4) In the Northern Hemisphere, the Subpolar Lows can be found in the following locations.

A Southern Alaska and around the Aleutian Islands.
B Around the tip of Greenland and over Iceland.
C Southern Canada.
D Western Europe.

6.5) Why are the Subpolar Lows so intense and continuous in the Southern Hemisphere?

Do not close your global map showing **annual** average mean sea level pressure. Now create a SECOND global map showing **Winter (DJF - December/January/February)** average mean sea level pressure for the 30-year period 1981-2010 with the following inputs. Create this map in a separate window so you can make comparisons to the annual average. January is the winter season in the Northern Hemisphere and the landmasses are cooling much more than the ocean bodies. In the Southern Hemisphere summer is occurring and the landmasses are heating up more than the ocean bodies.



http://climatereanalyzer.org/reanalysis/monthly_maps/

Answer the following questions.

6.6) How does the location of area of low pressure (ITCZ) along the equator change from the annual plot to the Winter plot?

> **A** It moves south mainly below the equator.
> **B** It moves north mainly above the equator.

6.7) Explain what happened in question 6.6.

6.8) How does the subtropical high pressure zone in the Northern Hemisphere change from the annual plot to the Winter plot?

> **A** It intensifies and becomes more prominent over the continents that are now much cooler in temperature.
> **B** It weakens and becomes less prominent over the continents that are now much cooler in temperature.

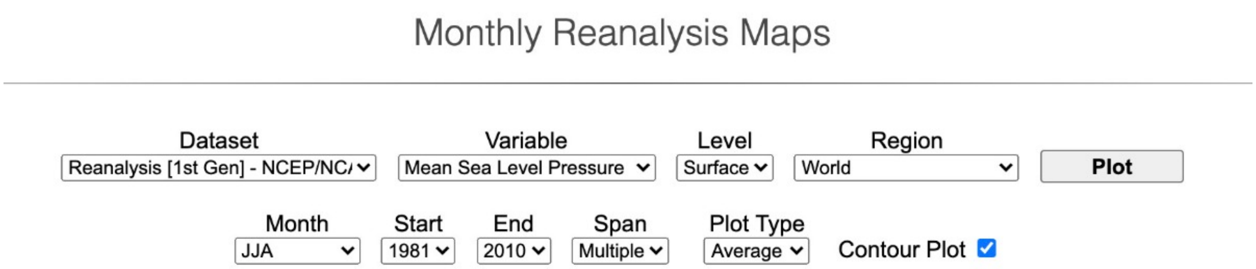
6.9) Explain what happened in question 6.8.

6.10) How does the subpolar low pressure zone in the Northern Hemisphere change from the annual plot to the January plot?

> **A** It intensifies and becomes more prominent over the oceans.
> **B** It weakens and becomes less prominent over the oceans.

6.11) Explain what happened in question 6.10.

Once again, do not close your global map showing **annual** average mean sea level pressure. Create a THIRD global map showing **Summer (JJA - June/July/August)** average mean sea level pressure for the 30-year period 1981-2010 with the following inputs. Create this map in a separate window so you can make comparisons to the annual average. July is the summer season in the Northern Hemisphere and the landmasses are heating up faster than the ocean bodies. In the Southern Hemisphere winter is occurring and the landmasses are cooling a lot more than the ocean bodies.



http://climatereanalyzer.org/reanalysis/monthly_maps/

Answer the following questions.

6.12) How does the location of area of low pressure (ITCZ) along the equator change from the annual plot to the Summer plot?

> **A** It moves south mainly below the equator.
> **B** It moves north mainly above the equator.

6.13) Explain what happened in question 6.12.

6.14) How does the subtropical high pressure zone in the Northern Hemisphere change from the annual plot to the Summer plot?

A It intensifies and becomes more prominent over the continents that are now much warmer in temperature.
B It weakens and becomes less prominent over the continents that are now much warmer in temperature.

6.15) Explain what happened in question 6.14.

6.16) How does the subpolar low pressure zone in the Northern Hemisphere change from the annual plot to the Summer plot?

A It intensifies and becomes more prominent over the oceans.
B It weakens and becomes less prominent over the oceans.

6.17) Explain what happened in question 6.16.