



**RAJARATA UNIVERSITY OF SRI LANKA**  
**FACULTY OF APPLIED SCIENCES**

B.Sc. (General) Degree  
 Third Year – Semester I Examination – April / May 2016

**PHY 3302 – APPLIED METEOROLOGY**

Answer **all** questions

Time allowed: **3** hours

Gravitational acceleration

$$g = 9.8 \text{ ms}^{-2}$$

Pressure at sea level

$$1 \text{ atm} = 1013 \text{ hPa}$$

Universal gas constant

$$R = 287 \text{ JK}^{-1}\text{kg}^{-1}$$

**Multiple Choice Questions** (Colour the letter of the correct answer in the answer sheet given):

1. The definition of a variable gas is a gas that varies significantly from time to time and place to place. The most significant variable gas by volume in the planetary boundary layer in the atmosphere is:
  - a. Ozone
  - b. Oxygen
  - c. Water vapor
  - d. Carbon dioxide
  
2. An isobar is a line of constant \_\_\_\_\_.
  - a. Pressure
  - b. Density
  - c. Temperature
  - d. Dew point
  
3. Which of the following best explains how pressure decreases with height in the Earth's atmosphere?
  - a. It decreases at a constant rate (linear decrease)
  - b. It decrease quickly at first then more gradually (exponential decrease)
  - c. It decreases at a rate of 9.8 millibars per kilometer
  - d. It decreases in the troposphere, increases in the stratosphere, then decreases to the top of the atmosphere

4. The seasons of Spring, Summer, Winter, and Fall are a direct result of which phenomenon?
  - a. The sun's energy output and the Earth's proximity to the sun
  - b. Shifting of ocean currents
  - c. The  $23.5^\circ$  tilt of the Earth from vertical
  - d. The jet stream
5. \_\_\_\_\_ refers to the horizontal transport of air while \_\_\_\_\_ is the vertical transport of air.
  - a. Advection, convection
  - b. Convection, advection
  - c. Radiation, convection
  - d. Advection, radiation
6. Which of the following has the highest albedo and thus more reflected solar radiation?
  - a. Fresh snow
  - b. Grass
  - c. Water
  - d. Blacktop
7. Which of the following is NOT a primary "control" of climate?
  - a. Altitude
  - b. Daily weather
  - c. Latitude
  - d. Ocean currents
8. A  $1^\circ$  temperature change on the Fahrenheit scale is equal a \_\_\_\_\_ degree change on the Celsius scale.
  - a. 0.56
  - b. 0.90
  - c. 1.8
  - d. 3.6
9. Unsaturated air rises at the dry adiabatic lapse rate which is \_\_\_\_\_  $^\circ\text{C}$  per kilometer. This is also the same numerical value as the gravitational force constant in meters per second squared.
  - a. 15.2
  - b. 9.8
  - c. 6.5
  - d. 5.5
10. Which of the following processes ABSORBS the most latent heat?
  - a. Melting
  - b. Freezing
  - c. Evaporation
  - d. Condensation

11. Which of the following processes will result in a GREATER dew point depression at the surface? The dew point depression is the difference between the temperature and the dew point.
- Wet-bulb cooling
  - Saturating previously unsaturated air
  - Radiational cooling
  - Solar heating
12. One saturated air parcel with a temperature of  $10^{\circ}\text{C}$  has a saturation mixing ratio of 7 grams per kilogram; A second air parcel with a temperature of  $20^{\circ}\text{C}$  has a saturation mixing ratio of 14 grams per kilogram; From this information, what is the most likely saturation mixing ratio of a parcel of air at  $30^{\circ}\text{C}$ ? Warmer air holds exponentially more water vapor, therefore the temperature/saturation mixing ratio relationship is not linear.
- 17.5 grams per kilogram
  - 19.0 grams per kilogram
  - 21.0 grams per kilogram
  - 26.5 grams per kilogram
13. In which air mass type would a rising parcel's slope at the moist adiabatic lapse rate be closest to the dry adiabatic lapse rate? The moist adiabatic lapse rate is NOT a constant. The moist adiabatic lapse rate has a smaller slope than the dry adiabatic lapse rate if a parcel contains moisture. The amount of latent heat release depends on the temperature and moisture content of the air.
- Maritime tropical (warm and moist)
  - Maritime polar (cool moist)
  - Continental tropical (hot and dry)
  - Continental polar (cold and dry)
14. Which of the following statements is FALSE:
- Cloud droplets freeze once temperature drops below  $0^{\circ}\text{C}$ .
  - The vapor pressure is higher over water than over ice
  - The typical raindrop is about 2 millimeters in diameter
  - Salt particles make good condensation nuclei
15. The geostrophic wind is a balance of the pressure gradient force and the \_\_\_\_\_ force. This balance causes air to flow nearly parallel to the height contours in the mid and upper levels of the atmosphere.
- Friction
  - Coriolis
  - Centrifugal
  - Gravity
16. This is the type of fog that forms on nights with light wind, clear skies, low dew point depressions, and moist soils.
- |                           |                    |
|---------------------------|--------------------|
| a. Warm air advection fog | c. Upslope fog     |
| b. Thermal fog            | d. Radiational fog |

17. Which of the following reasons explains why the stratosphere is absolutely stable.
- Air temperatures are too cold
  - Air pressure is too low
  - The absorption of radiant energy by ozone
  - The wind speed is too strong
18. These clouds have some vertical development and are located in the upper levels of the atmosphere. The clouds have a lumpy appearance and are made of ice crystals. When viewed from the surface, each cloud element is about the size of a thumbnail.
- Nimbostratus
  - Fair weather cumulus
  - Altostratus
  - Cirrocumulus
19. Many of the world's desert regions are located:
- Just north and south of the equator
  - West coast regions along the Tropics of Capricorn and Cancer
  - At 60 ° North and 60 ° South
  - On the east coast of most continents
20. The sun is closest to the Earth in \_\_\_\_\_, this is known as \_\_\_\_\_ and has a \_\_\_\_\_ effect on seasons. Assume you are in the Northern Hemisphere.
- Summer; Aphelion; large
  - Summer; Perihelion; small
  - Winter; Aphelion; large
  - Winter; Perihelion; small
21. When comparing the moisture content in the air between two locations it is best to use?
- The dew point
  - Relative humidity
  - The wet bulb temperature
  - The dry bulb temperature
22. Suppose a parcel of air at the surface has a temperature of 50 ° F with a dew point of 30 ° F. As it begins to rain heavily into the parcel, what is the wet-bulb temperature most likely to be after complete evaporational cooling?
- |           |           |
|-----------|-----------|
| a. 55 ° F | c. 37 ° F |
| b. 43 ° F | d. 32 ° F |
23. When there is a balance between the upward pressure gradient force and the downward force of gravity, the atmosphere is said to be in \_\_\_\_\_ balance.
- Geostrophic
  - Hydrostatic
  - Baroclinic
  - Hypsometric

24. Which of the following air masses is the densest?

- a. Cold and moist
- b. Cold and dry
- c. Warm and moist
- d. Warm and dry

25. The dew point is greater than the temperature:

- a. When the relative humidity is 100%
- b. When clouds form
- c. When it is raining
- d. Never

[1 x 25]

---

### Essay Questions (Answer all the Questions):

Previous analyses of global temperature trends during the first decade of the 21st century seemed to indicate that warming had stalled. This allowed critics of the idea of global warming to claim that concern about climate change was misplaced. *Karl et al* now show that temperatures did not plateau as thought and that the supposed warming "hiatus" is just an artifact of earlier analyses. Warming has continued at a pace similar to that of the last half of the 20th century, and the slowdown was just an illusion.

*Science*, Vol. 348, Issue 6242, 26 Jun 2015

- a) What is global warming? (Hint: Explain the physics behind global warming) [5]
  - b) What are the **primary sources** for global warming? How do they contribute to global warming? [5]
  - c) The atmospheric gases responsible for global warming ironically contribute to make the Earth a livable place for its inhabitants. Explain. [5]
  - d) Why do most climate models predict that the earth's average surface temperature will increase by an additional 3.0°C (5.4°F) by the end of this century? [5]
2. Titan is a moon shrouded in mystery. Despite multiple flybys and surface exploration conducted in the past few decades, this Cronian moon still manages to surprise us from time to time. In addition to having a dense atmosphere rich in hydrocarbons, which scientists believe may be similar to what Earth's own atmosphere was like billions of years ago, it appears that methane on Titan is similar to what water is to planet Earth. I.e. methane on Titan is subject to the same transfer process as water is here on Earth. Basically, liquid methane on the surface evaporates and is exchanged with the atmosphere, where it condenses to form fog banks and rain clouds.

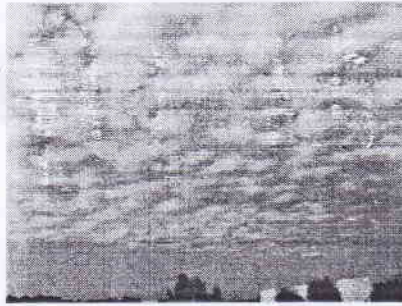
(Matt Williams, *Universe today, Space and Astronomy news*, 4<sup>th</sup> April 2016)

- a) Describe and distinguish between the formation of dew and wet haze? [4]
- b) What are the two primary ways of forming fog? Explain types of fog form under each category. [6]
- c) The air temperature during the night cools to the dew point in a deep layer, producing fog. Before the fog is formed, the air temperature cools each hour by about 2°C. After the fog is formed, the air temperature cools by only 0.5°C each hour. Give *two* reasons as to why the air is cooled more slowly after the fog is formed. [4]

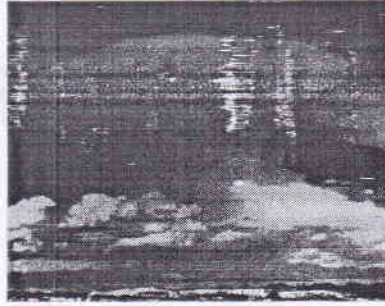


- d) Give the name of each of the type of clouds below. Also indicate whether they are convective or stratiform. Explain. [6]

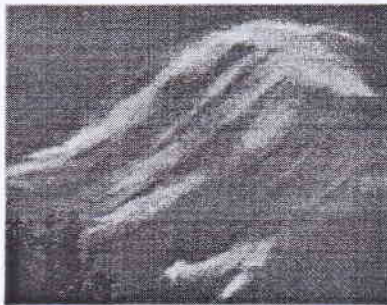
(I)



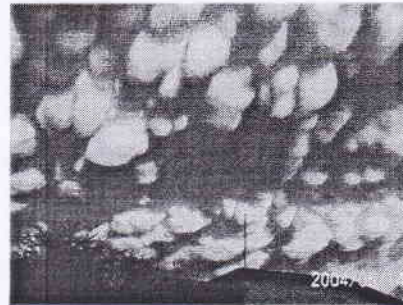
(II)



(III)



(IV)

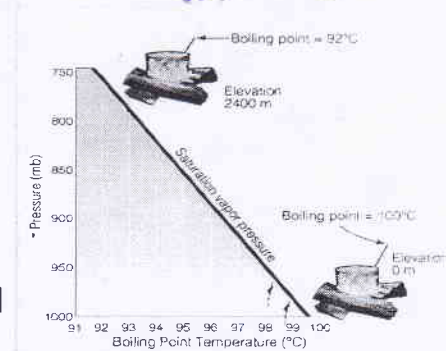


3. If you camp in the mountains, you may have noticed that, the higher you camp, the longer it takes vegetables to cook in boiling water. To understand this observation, we need to examine the relationship between vapor pressure and boiling.

- a) How are evaporation and condensation related to saturated air above a *flat water surface*? [3]

- b) In a volume of air, how does the actual vapor pressure differ from the saturation vapor pressure? When are they the same? [4]

- c) Explain why does it take longer to cook vegetables in the mountains than at sea level. [4]



Library  
Faculty of Applied Science  
Sri Lanka  
University  
Kandy

3. (i) Define relative humidity. [3]
- (ii) Explain two ways the relative humidity may be changed. [4]
- c) In Yellowstone National Park, there are numerous ponds of boiling water. If Yellowstone is about 2200 m (7200 ft) above sea level (where the air pressure is normally about 775 mb), what is the normal boiling point of water in Yellowstone? [2]
4. a) Explain why on a map, closely spaced isobars (or contours) indicate strong winds, and widely spaced isobars (or contours) indicate weak winds. [3]
- b) What is a geostrophic wind? Why would you *not* expect to observe a geostrophic wind at the equator? [3]
- c) If the wind aloft is blowing parallel to curved isobars, with the horizontal pressure gradient force being of greater magnitude than the Coriolis force, would the wind flow be cyclonic or anticyclonic? In this example, what would be the relative magnitude of the centripetal acceleration, and how would it be directed? [3]
- d) Describe four methods of forecasting the weather and give an example for each one. [8]
- e) Explain how the phrase "sensitive dependence on initial conditions" relates to the final outcome of a computer-based weather forecast. [3]