00136

The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme

Department	: Physics
Level	: 5
Name of the Examination	: Final Examination
Course Code and Title	**: PHU5302 - Atmospheric Physics**
Academic Year	: 2024/2025
Date	: 30th November 2024
Time	: 9.30 a.m. -11.30 a.m.
Duration	: Two (2) hours

General Instructions

1. Read all the instructions carefully before answering the questions.
2. This question paper consists of **6** questions in **4** pages.
3. Answer any **4** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary
5. Relevant log tables are provided where necessary.
6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense.
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered on the front cover of your answer script.
9. Clearly state your index number in your answer script

$\varepsilon = 0.622$

$g_0 = 9.8\ m/s^2$

R_d=287 J /kg K

R_v=461 J /kg K

R* =0.08205 *l atm /mol K* =8.314 *J /mol K*

C_p =1004 *J/ kg*

$e_0 = 611\ Pa\ \ at\ T_0 = 273\ K,$

$L_v = 2.5 \times 10^6\ J\ kg^{-1}$

The speed of light =3×10^8 m / s

Stefan-Boltzmann constant = $5.67 \times 10^{-8}\ W\ /\ m^2\ K^4$.

Air density =1.225 $kg\ /\ m^3$

Wien' s displacement constant = 2.897×10^{-3} W m K

Answer 4 questions only.

01.

(a) The Earth's atmosphere is a mixture of gases that surrounds the planet. If the atmosphere around the Earth disappeared, briefly explain three possible consequences that would happen to Earth?

(3 marks)

(b) The thermosphere and the ionosphere are two layers identified in the upper atmosphere of Earth.

i. What causes the high temperature gradient with height seen in the thermosphere?

ii. Why would an astronaut in the thermosphere feel cold, even though the layer temperature is so high?

iii. What are the main characteristics of the ionosphere? With an aid of a diagram, explain the diurnal variations of the layers occur at ionosphere.

(9 marks)

(c) Explain how air pollution is often trapped within the atmospheric boundary layer

(3 marks)

(d) Coriolis force is known as an apparent force.

i. Define the horizontal component of the Coriolis force (F_{Co}) and Coriolis parameter (f).

ii. Why is the Coriolis force zero at the equator and maximum at the poles?

(7 marks)

(e) What is meant by gradient wind balance?

(3 marks)

02.

(a) The gauge pressure of the air in a rubber tube is 1450 hPa at 0^0C temperature. Its initial volume is 1.32×10^{-2} m^3 and atmospheric pressure is 1013 hPa. If the temperature rises to 35^0C and its volume increases to 1.77×10^{-2} m^3, determine what is the new gauge pressure of the air in the tube? (Gauge pressure is the difference between the actual pressure and atmospheric pressure.).

(4 marks)

(b) Starting from the hydrostatic equation, derive following equations for an isothermal atmosphere. H denotes the scale height.

i. the equations for the change in pressure (P) with altitude (z), $P = P_0 e^{-\left(\frac{z}{H}\right)}$ where P_0 is pressure at z = 0.

ii. the equations for the change in density (ρ) with altitude (z), $\rho = \rho_0 e^{-\left(\frac{z}{H}\right)}$ where ρ_0 is density at z = 0.

(10 marks)

(c)

i. A 200 J of work is done on an air parcel and 70 J is extracted from that system as heat. If the heat released at constant pressure, estimate the change in internal energy (including algebraic sign) and the change in enthalpy of the system.

ii. In a certain atmospheric system, the temperature and pressure of a parcel of air at a height of 5 km had been observed as -18.5^{0}C and 640.0 mb, respectively. Determine the potential temperature of that parcel of air.

(5 marks)

(d)

i. What is an adiabatic process? Briefly explain why many atmospheric thermodynamic processes closely approximate as adiabatic processes.

ii. Explain why a building made of bricks has smaller entropy than the same bricks in a disorganized pile.

(6 marks)

03.

(a) If the temperature and pressure of an air parcel are 21°C and 50 kPa respectively, determine the moisture parameters below.

i. the saturation vapor pressure

ii. the saturation mixing ratio

(8 marks)

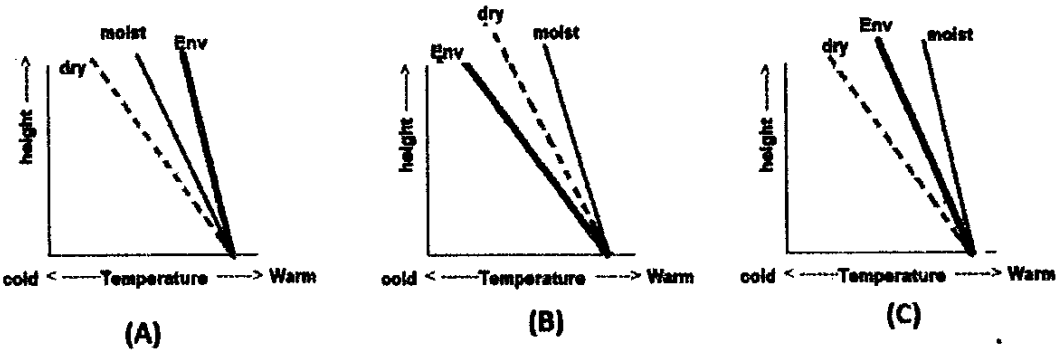
(b) Briefly explain why the frost point temperature is higher than the dew point temperature.

(4 marks)

(c)

i. Identify the stability conditions for following A, B and C situations.

ii. If we push some saturated and unsaturated air parcels upwards in each situation, briefly explain whether those parcels would rise or sink.



(9 marks)

(d) State 4 main characteristics of a tephigram

(4 marks)

04.

(a) Define or explain the following terms used in radiation

i. Diffuse radiation

ii. Monochromatic radiance

(4 marks)

(b) The microwave sounding units operating on NOAA polar-orbiting satellite platforms were the principal sources of satellite temperature profiles in the last two decades. It made measurements of microwave radiance ranging from 50.3 to 57.95 GHz on the lower shoulder of the Oxygen absorption band. Calculate the wavelengths of these frequency limits.

(2 marks)

(c)

i. Determine the total radiative flux emitted from the blackbody Earth at temperature 255 K, and the wavelength of peak emission.

ii. If the temperature increases by 1.5°C due to global warming, what is the percentage increase of total radiative flux?

(6 marks)

(d) If 700 W m^{-2} of visible light strikes a translucent object that allows 150 W m^{-2} to shine through and 200 W m^{-2} to bounce off, determine the transmissivity, reflectivity, absorptivity, and emissivity. Consider that the sum of all three fractions transmissivity, reflectivity, and absorptivity are equal to 1. The term translucent body implies partly transparent, and partly absorbing body.

(4 marks)

(e) Briefly describe the physical causes of the following atmospheric phenomena.

i. Sun pillars

ii. Haze

iii. Looming

(9 marks)

05.

(a) Briefly explain the necessary and sufficient conditions required for condensation.

(4 marks)

(b)

i. State four significant factors that determine the rain formation by collision-coalescence process.

ii. What is sleet and briefly explain how sleet is formed?

(8 marks)

(c)

i. Briefly explain the main reasons that cause downdrafts in a thunderstorm.

ii. State two key factors that lead to form a tropical cyclone.

(6 marks)

(d)

i. Which kind of ions are most important in the atmospheric system and why?

ii. What is the role of thunderstorms in the global electric circuit?

(7 marks)

06.

(a) Describe the mountain breeze circulation and discuss the mechanism responsible for its formation.

(3 marks)

(b) What is the difference between inertial and non-inertial reference frames?

(4 marks)

(c) Briefly explain the working principle of weather radar.

(5 marks)

(d) Compare the differences of climate variability and climate change.

(4 marks)

(e) Briefly explain three main characteristics of climate change that are observed during past century.

(9 marks)

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