BINDURA UNIVERSITY OF SCIENCE EDUCATION
BACHELOR OF SCIENCE PHYSICS WITH SPECIALISATION
ENGINEERING AND PHYSICS DEPARTMENT

HPH214/HPH421-ATMOSPHERIC PHYSICS

INSTRUCTIONS TIME: 3 HOURS

Answer ALL parts of the question in Section A and any THREE questions from Section B. Section A carries 40 marks and each question in Section B carries 20 marks.

Physical Constants

R = 8.31 J/(K·mol)

JAN 2025

Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1}

Permeability of free space, $\mu_0 = 4\pi x10^{-7}$ Hm^{-1}

Mass of electron, $m_e = 9.11 \times 10^{-31}$ kg

Mass of proton, $m_p = 1.67 \times 10^{-27}$ kg

Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol^{-1}

Universal Gravitation Constant, $G = 6.7 \times 10^{-11}$ Nm^{2}kg^{-2}

Acceleration due to gravity, $g = 9.8$ ms^{-2}

SECTION A

1.

(a) How do we know what the make-up of air was like in the past? [5]

(b) How does haze in the air affect global temperatures? [5]

(c) How do scientists work out what the climate is going to be like in future? [5]

(d) In a certain mountain range, water boils at 92°C. What is the atmospheric pressure under these conditions? The enthalpy of vaporization of water at 100°C is 40.7 kJ/mol. [4]

(e) Air flows over a rectangular plate having dimensions 0.5 m x 0.25 m. The free stream temperature of the air is 300°C. At steady state, the plate temperature is 40C. If the convective heat transfer coefficient is 250 W/m^2.K, determine the heat transfer rate from the air to one side of the plate. [4]

(f)

stratosphere,making them regarded as different parts of the atmosphere? [3]

(ii) Is vertical motion most common in the troposphere or the stratosphere? Why?

[3]

(iii) The global average height of the tropopause is 14 km. Calculate the pressure at that altitude, assuming constant atmospheric temperature of 250 K. [4]

(iv) Assume that the global air flow from the troposphere to the stratosphere is equal to the opposite flow (from the stratosphere to the troposphere), being 5.9 1017 kg/year in each of the two directions. Calculate the residence times
of air in the troposphere and the stratosphere. The pressure at the stratopause is 1 hPa. [5]

(v) Explain why the residence times of stratospheric and tropospheric air differ. [3]

SECTION B

2 (a) What does global warming have to do with severe weather, like storms, heat waves, droughts, and hurricanes? [10]

b) If global warming is real, why is it so cold and snowy in winter? (The difference between climate and weather. [10]

3. (a) The atmospheric concentration of CO_2 is since a long time increasing. Which are the main reasons for the increase? [4]

(b) Fig. 1 shows the change in CO_2 concentration from year 1960 to present at Mauna Loa,Hawaii. What is causing the annual variation (*årstidsvariation*)?

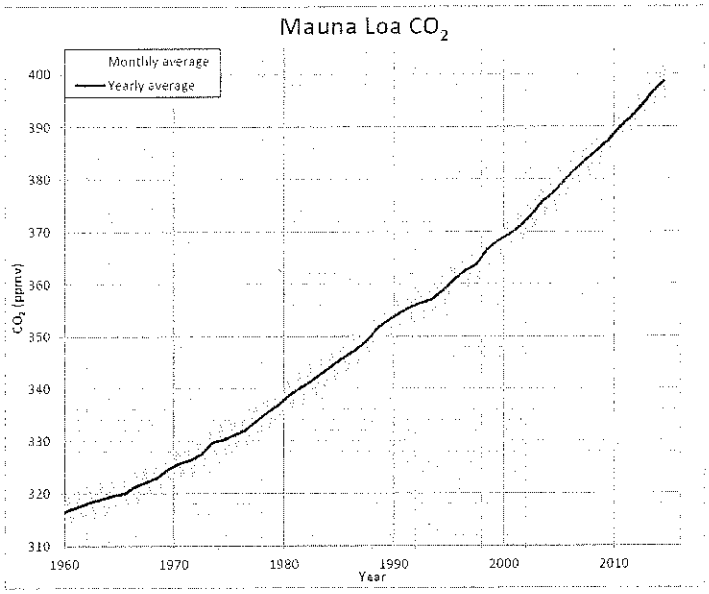
[3]

(c) The yearly average concentration at Mauna Loa is a good estimate of the global yearly average. Why can we use data from one place for a global estimate?

[3]

(d) Use the data in Fig. 1 to calculate the increase of carbon mass in the atmosphere during the industrial era (i.e. the increase from pre-industrial concentration to the concentration year 2014). The pre-industrial CO_2

concentration was 280 ppmv. [10]



4. (a) Which are the two main natural sources of aerosol particles, and which is the main human activity behind particles in the atmosphere? [4]

(b) Which of these sources produce mainly particles smaller or larger than 1 μm diameter, respectively? [3]

(c) Compare these three sources with respect to hygroscopic growth (water uptake). Discuss their importance in cloud formation with respect to particle size and composition. [5]

(d) Why is hygroscopic growth of aerosol particles important for the climate? [3]

(e) Volcanic eruption induces an aerosol layer in the stratosphere of the earth with the globally averaged optical depth $\delta = 0.05$. The backscattered fraction $\beta = 0.2$. Calculate the radiative forcing induced by the eruption. [5]

5(a).

- The mixing ratio of oxygen in the atmosphere is 20.95%. Calculate the concentration in mol L^{-1} and in g m^{-3} at P° (101 325 Pa, 1.00 atm) and 25°C. [7]

ii Calculate the atmospheric pressure at the stratopause. What are the concentrations (mol m^{-3}) of dioxygen and dinitrogen at this altitude? How do these concentrations compare with the corresponding values at sea level? [5]

iii What is the total mass of the stratosphere (the region between 15 and 50 km above the Earth's surface)? What mass fraction of the atmosphere does this make up? [8]

6. (a) What does climate change have to do with health? [10]

(b) What is the United Nations doing to combat climate change? [10]

THE END