**ID4212 – Principles of Atmospheric Science**
End-Semester Examination: 3rd May 2019
**Total marks: 50; Time allotted: 2 hours 30 min**
Calculations must be shown for numerical problems.

1) Does scale height vary for individual chemical species in the lower atmosphere? Explain. (2)

2) Consider a city that has a higher (homogeneous) surface air temperature ($T_{city}$ = 303 K) compared to a surrounding rural area ($T_{rural}$ = 298 K) as a consequence of the urban heat island effect. What is the buoyant acceleration of air over the city? (3)

**OR**

2) Atmospheric $CO_2$ mixing ratios have increased from 280 ppmv in the pre-industrial era to 410 ppmv at present. What is the corresponding increase in the mass of atmospheric carbon? Assume $CO_2$ is homogeneously distributed in the atmosphere; total mass of the atmosphere = $5.2 \times 10^{18}$ kg; molecular weight of air = 29 g $mol^{-1}$. (3)

3) With the help of a diagram, describe subsidence inversion. (3)

4) Describe the Brewer-Dobson circulation. (3)

**OR**

4) Microbial processes at the earth's surface release NO, $NO_2$, $N_2O$ and $N_2$ as a result of denitrification. Which of these species contribute to stratospheric $O_3$ depletion and how? Explain with equations. (3)

5) Describe the role of polar stratospheric clouds in the formation of the Antarctic $O_3$ hole. (4)

6) Considering a hydrocarbon RH, describe the formation of tropospheric $O_3$ in the presence of NO (you can ignore the CO oxidation pathway). (3)

**OR**

6) Briefly discuss how the photolysis rate constant (k) of a molecule depends on the actinic flux, the absorption cross-section, and the quantum yield. (3)

7) Kolkata and Mohanpur have VOC/$NO_X$ ratios of 3 and 15, respectively. Comment on the potential effect the following policies might have on tropospheric $O_3$ levels at each of these two locations: i) a reduction in VOC levels keeping $NO_X$ constant; ii) reducing both VOCs and $NO_X$; iii) a reduction in $NO_X$ levels keeping VOCs constant. Explain your answers. (2+2+2)

8) The scavenging coefficient of wet deposition is inversely proportional to the falling velocity of the raindrop and the raindrop diameter. Explain. (3)

**OR**

8) What are rain-out and wash-out? (3)

9) Consider a lake directly downwind of a thermal power plant cluster. What effects (increase/decrease/no change) on the following lake parameters are strict controls on $SO_2$ emissions from the power plant cluster likely to have? i) lake water pH; ii) concentration of mobile inorganic Al; iii) acid neutralizing capacity (ANC) of the lake; iv) concentration of $SO_4^{2-}$ in the lake watershed area (2)

10) What is binary homogeneous nucleation? (2)

11) What are primary and secondary aerosols? Give examples. (3)

12) What is secondary organic aerosol (SOA)? How does it differ from secondary organic carbon (SOC)? Name a natural and an anthropogenic SOA precursor. (3)

**OR**

12) Briefly discuss seasonal (summer vs winter) factors that affect atmospheric SOA levels. (3)

13) Provide a diagram for the structure of a typical aerosol particle based on the core-shell theory. Clearly label the species and processes involved. (4)

14) How do high (e.g., cirrus) and low (e.g., stratus) clouds affect the earth's radiation balance? (2+2)

15) For an air pollutant, define deterministic and stochastic health effects. Briefly describe how atmospheric pollutant concentrations are converted into a cumulative Air Quality Index (AQI). (2+3)