Please answer **ALL** questions.

Each question carries different marks.

You can use either **ENGLISH** or **CHINESE** to answer the questions.

1. What is "dry adiabatic lapse rate"? Describe the temperature profile (as a function of height) and dispersion of air pollutants under neutral, stable, and unstable atmospheric conditions. (20%)

2. Explain the significance of the following terms: (10%)
   (a) Chemical Oxygen Demand
   (b) Trophic Pyramid

3. A field study of the spatial and temporal variation of wild rabbit populations in Forest A and Forest B was carried out between 1970 and 2005. Key results are summarized in Table 1 and Figure 1 below.

Table 1. Comparison between Forest A and Forest B.

	Forest A	Forest B
Environment	Similar to Forest B	Similar to Forest A
Climate	Similar to Forest B	Similar to Forest A
Predators of wild rabbits	Absent	Grey wolves

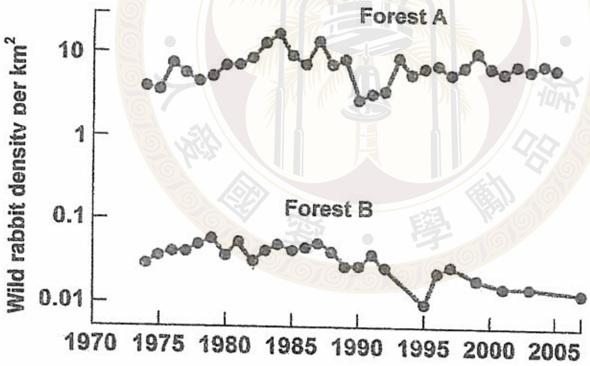

Figure 1. Predation impact of grey wolves on wild rabbit density in Forest A and B from 1970 to 2005.

In Forest B, the number of wild rabbits is determined by the predation of grey wolves. However, the wild rabbit population in Forest A instead of showing exponential increase, it remained fairly constant over time even without the predation impact from grey wolves. **Explain** this pattern in details with **an appropriate ecological concept** (20%).

4. Calculate the answers for the following questions.
   A. Dragonfly species Y has one annual breeding season and a lifespan of one year. If the population size at generation-0 is 100 and the net reproductive rate is 1.5. Calculate the **population size at generation-5** (10%).
   B. Lake A and Lake B are two freshwater lakes of the same size. Calculate the **Shannon-Wiener diversities of Lake A** and **Lake B**, according to the species data from Table 2 below (10%):

Table 2. Abundance of three fish species at Lake A and Lake B.

	Total abundance (Number of individuals)		
	Fish species 1	Fish species 2	Fish species 3
Lake A	50	100	20
Lake B	40	40	40

5. This question tries to derive mathematical model which is able to estimate how population grows. This topic is the typical field called population ecology. The following exponential growth model is a differential equation which can be used to calculate unlimited population growth scenario: $\frac{dN_t}{dt} = r \times N_t$

where N_t is population at time t and parameter r is the net growth rate. Notice that the initial population is N_0 at time $t = 0$.

Solve the differential equation by taking the integral. Prove how you obtain $N_t = N_0 \times e^{r \times t}$ and please show all detail of your calculation (10%).

6. This problem assumes that the population grows slowly if the population is near its population upper bound. On the other hand, if it is far below the limit, the population grows rapidly. Here, the population upper bound is called carry capacity K. As mentioned before, N_t is population at time t and parameter r is the net growth rate. Hence, the following logistic model is derived to determine the limited population growth scenario: $\frac{dN_t}{dt} = r \times N_t \times \frac{(K - N_t)}{K}$. Two hints are given as follows.

(a) Rescale the equation by using $P_t = \frac{N_t}{K}$

(b) Integrating the equation $\frac{dP_t}{dt} = r \times P_t \times (1 - P_t)$ yields $P_t = \frac{P_0}{(1 - P_0) \times e^{-r \times t} + P_0}$.

Use these two hints to solve the differential equation. Prove $N_t = \frac{K \times N_0 \times e^{r \times t}}{K + N_0 \times (e^{r \times t} - 1)}$ and remember to show all your calculation (10%).

7. The problem considers interaction between two species. This predator-prey model describes the predator lives by hunting prey for food.

$$\frac{dx_t}{dt} = x_t \times (\alpha - \beta \times y_t)$$

$$\frac{dy_t}{dt} = y_t \times (\gamma \times x_t - \delta)$$

where x_t is predator population and y_t is prey population at time t. Additionally, α, β, γ, and δ are parameters representing the interaction between two species.

Population equilibrium occurs when the population is not changing in the system. Solve the population equilibrium equations. Show the population equilibrium and explain your result (10%).