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The Open University of Sri Lanka
Faculty of Natural Sciences
Department of Chemistry

Level	: 5
Name of the Examination	: Final Examination
Course Code and Title	: **CYU5309- Environmental Chemistry**
Academic Year	: 2024/25
Date	: 26.11.2024
Time	: 9.30 a.m. – 11.30 a.m.
Duration	: 02 Hours

1. Read all instructions carefully before answering the questions.
2. This question paper consists of four **(04)** questions in **five (05)** pages.
3. **Answer all four (04) questions.** All questions carry equal marks.
4. The answer to each question should commence from a new page.
5. Draw fully labelled diagrams where necessary.
6. Having any unauthorized documents / mobile phones in your possession is a punishable offence.
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

1.a. The atmosphere is categorized into layers based on temperature. It is an extraordinary mixture of gases varying in reactivity and quantity.

i. Draw and explain the temperature profile of the troposphere.

ii. What is meant by the term 'thermal inversion'?

iii. Briefly explain how air pollution is influenced by thermal inversion. Give the name of **one (01)** event (air pollution) that occurs due to temperature inversion.

(30 marks)

b. Many gases from motor vehicles, industries, and power plants are being emitted continuously to the atmosphere due to anthropogenic activities which have an impact on the environment.

i. List **three (03)** main gaseous pollutants that are emitted from motor vehicle exhaust.

ii. Show by chemical equations how these poliutants are produced in motor vehicles.

iii. A catalytic converter is a device incorporated in the exhaust system of a motor vehicle, containing a catalyst for converting pollutant gases into less harmful ones. How do catalytic converters convert the pollutants in the exhaust into harmless components?

(20 marks)

c. Photochemical smog is a type of air pollution due to the reaction of solar radiation with airborne pollutants.

i. Write the conditions necessary for photochemical smog other than solar radiation.

ii. Write equations for the formation of the chemical constituents of smog.

iii. Identifying each of the constituents, briefly describe their adverse effects.

(20 marks)

d. The ozone layer is a thin part of the that absorbs harmful UV radiation. Ozone depletion in the stratosphere is a critical issue that poses significant risks to life on Earth. This depletion is primarily caused by human activities releasing harmful chemicals like chloroflourocarbons (CFCs).

i. Show by chemical equations the destruction of ozone in the stratosphere by CFC.

ii. What properties of CFCs make it an environmental concern and that should be addressed in finding a replacement for CFC.

iii. What are the essential features an ideal CFC replacement compound must have?

iv. What is meant by the term ozone depleting potential (ODP)?

v. Explain why the ODP value of CH_2FCF_3 (0) is less than that of CCl_3F (1.0).

(30 marks)

2.a. Explain the concept of thermal stratification in a lake located in a temperate region and the impact this process can have on dissolved oxygen profile.

(18 marks)

b. Calculate the pH of natural rainwater at 25° C, given that the partial pressure of CO_2 in air is 3.5×10^{-4} atm, and that for carbon dioxide, the Henry's Law constant $K_H = 3.4 \times 10^{-2}$ mol L^{-1} atm^{-1} and K_a for H_2CO_3 has a value of 4.5×10^{-7} mol L^{-1}.

[Assume that the reaction, $H_2CO_3(aq) \rightarrow HCO_3^-(aq) + H^+(aq)$ is the only significant source of acidity].

(22 marks)

c. Hard water is a nuisance because of mineral buildup on plumbing fixtures and poor performance of soap and detergent.

i. What is meant by water hardness?

ii. Distinguish between temporary hardness and permanent hardness of water.

iii. The hardness of a water sample is determined by titrating 50.00 mL of sample against 0.05 M EDTA solution at pH 10.00. The Eriochrome Black T end point occurs at 11.20 mL EDTA solution. Calculate the hardness of the water sample in mg $CaCO_3$ /L. [Relative atomic weight; C = 12; Ca = 40; O = 16]

(30 marks)

d. i. Briefly describe the terms 5day-Biochemical Oxygen Demand (BOD_5) and ultimate Biochemical Oxygen Demand (uBOD).

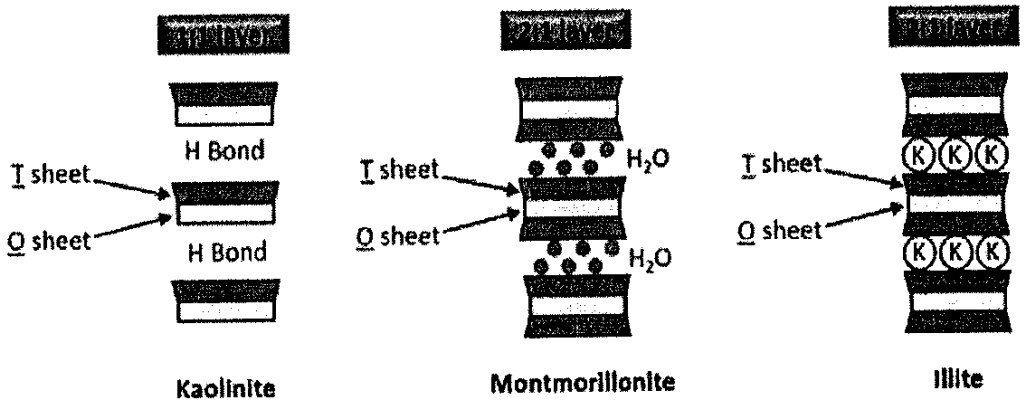
ii. It was found that the BOD_5 of wastewater sample was 359 mg L^{-1}. Find out the ultimate BOD of the wastewater sample. Also, find out the value of BOD_{10}. It is given that k = 0.23 per day.

[Hint: $BOD_t = y_t = L_o(1 - e^{-kt})$]

Where k is the first order rate of BOD removal

(30 marks)

3.a. Clay minerals are secondary minerals. The structure of the three most common clay minerals is given below.



Kaolinite Montmorillonite Illite

Describe their structure and features in terms of expanding, swelling properties and ion exchange capacity.

(30 marks)

b. Weathering is a general term that describes all the changes that result from the exposure of rock material to the atmosphere.

i. What is meant by chemical weathering?

ii. Explain how each type of the following chemical weathering works.

α. Complete dissolution

β. Oxidation

γ. Hydrolysis

(40 marks)

c. Cation Exchange Capacity (CEC) is an inherent characteristic property and is a useful indicator of soil fertility

i. Define the term "Cation Exchange Capacity" of soil.

ii. Name **four (04)** factors and briefly explain how they affect the CEC of soil.

iii. Briefly explain how CEC maintains soil fertility.

(30 marks)

4. a. Environmental chemists use the concept of pE to characterize the extent to which natural waters are chemically reduced in nature.

i. Define the term pE of an aquatic system.

ii. Calculate the pE value of sea water with respect to the following half reaction.

$H^+(aq) + O_2(g) \leftrightarrow H_2O(l)$ $\quad E^0 = 1.23\ V$

[Assume pH = 8.1 and partial pressure of oxygen is 0.21 atm in sea water]

(30 marks)

b. Soil pH is an important property that influences chemical and biological processes occurring in soil. Acidification of soil can occur due to acid rain.

i. Explain the term acid rain.
ii. Discuss the effect of acid rain on soil.
iii. Give **two (02)** compounds that are commonly used to neutralize acid soils.

(30 marks)

c. i. State the possible water treatment process/ technique that could be used to treat the following contaminants.

1. Pathogens

2. Organic carbon

3. Phosphate

4. Oils and Grease

(20 marks)

d. i. What is meant by the threshold limit value (TLV) of indoor air pollutants?

ii. How does it relate to the nature of pollutants? Comment on the TLV (mg m^{-3}) of toluene (375) and benzene (30).

iii. Give **three (03)** examples of indoor air pollutants.

(20 marks)

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