

## NATIONAL UNIVERSITY OF SINGAPORE

**ESE2001 – ENVIRONMENTAL PROCESSES**

(Semester 1: AY2016/2017)

Time Allowed: 2 Hours

**INSTRUCTIONS TO CANDIDATES**

1. Please write your student number only. **Do not write your name.**
2. This assessment paper contains **THREE** questions and comprises **TEN** printed pages.
3. Answer **ALL** questions. All questions **DO NOT** carry equal marks.
4. Please start each question on a new page.
5. This is a “**CLOSED BOOK**” assessment.
6. **You have been given linear graph paper and a reference booklet (memo).**  
Please return the memo after the exam and do not write on it so that it can be reused.
7. Programmable calculator is not permitted for this exam.
8. The total maximum mark is **FORTY (40).**

**Please write your matriculation number below:**

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Question	Score
1	
2	
3	
Total	

**Question 1 [10 marks]**

**Answer the following questions [1 mark each].**

1) Which of the following statements can be explained by the first law of thermodynamics? (Choose all that apply)

- A. After exercising, I get hungry
- B. It is impossible to recycle all our waste
- C. No matter how hard I try, my room is always messy
- D. We will eventually run out of fossil fuels
- E. When living things die, they decompose

2) If you double the kinetic energy of the atoms in an object, its rate of energy loss by blackbody radiation

- A. remains the same
- B. doubles
- C. quadruples
- D. goes up by a factor of 16

3) The battery of the biosphere consists of

- A. igneous rocks and  $\text{CO}_2$
- B.  $\text{CaCO}_3$  rocks and  $\text{CO}_2$
- C. organic carbon and  $\text{O}_2$
- D. organic carbon and  $\text{CO}_2$

4) Our primary source of energy today is

- A. Chemical
- B. Solar
- C. Nuclear
- D. Electrical

5) Which process is responsible for the buildup of  $\text{O}_2$  in the atmosphere?

- A. Dead plankton and plants in mud
- B. Trees growing
- C. Volcanoes
- D. Loss of hydrogen to space

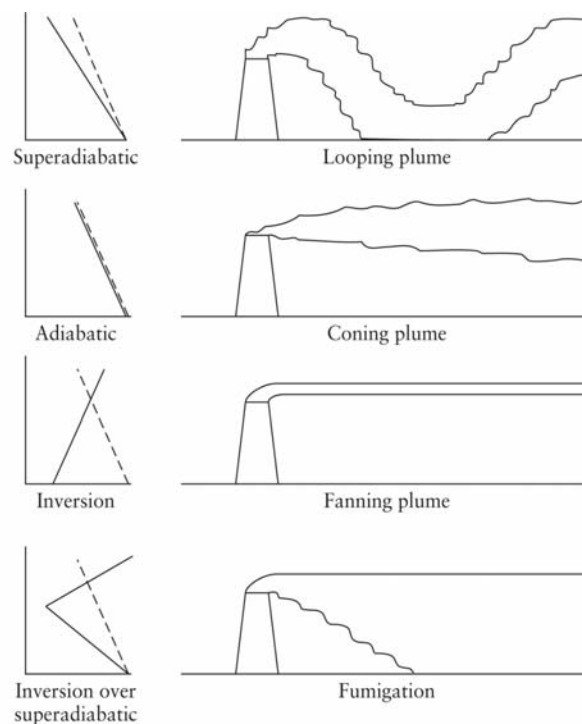
6) On long time scales, fluctuations in atmospheric  $\text{CO}_2$  are driven by the exchange with

- A. The land surface
- B. The solid Earth
- C. The oceans

7) Where do the nutrients from wastewater treatment facilities generally end up?

- A. Into the soil
- B. Into rivers, streams, and oceans
- C. Into the atmosphere
- D. Wastewater treatment facilities don't output nutrients

- 8) The oceans, through the glacial / interglacial climate fluctuations, have acted as a
- A. Positive feedback to climate forcing
  - B. Negative feedback to climate forcing
  - C. It depends
- 9) About how much has the temperature of the Northern hemisphere varied over the past thousand years?
- A. 1 °C
  - B. 2 °C
  - C. 3 °C
  - D. 4 °C
  - E. 5 °C
- 10) The four plumes shown below differ by their mode of
- A. Advection
  - B. Diffusion
  - C. Dispersion



**Figure 13.10** Prevailing lapse rates produce signature plumes (temperature versus elevation).

Prevailing lapse rates produce signature plumes (temperature versus elevation)

**Question 2 [8 marks]**

Given the following temperature readings:

Elevation (m)	Temperature (°C)
0	20
50	15
100	10
150	15
200	20
250	15
300	20

What type of plume would you expect if the exit temperature of the plume is 10°C and the smoke stack is

(a) 50 m tall?

[4 marks]



(b) 150 m tall?

[4 marks]

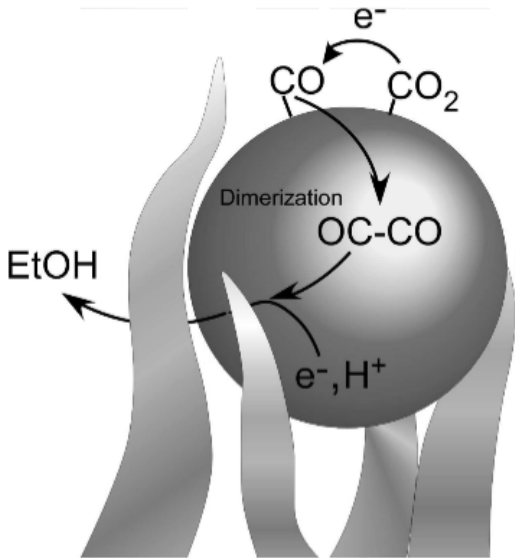
**Question 3** [22 marks]

- (a) Explain the concept and applications of carbon sequestration in fewer than 200 words. [6 marks]

(b) On 19 October 2016, it was reported that scientists just accidentally discovered a process that turns CO<sub>2</sub> directly into ethanol. The abstract of the paper is given below.



**FULL PAPERS**



*Dr. Y. Song, Dr. R. Peng, D. K. Hensley, Dr. P. V. Bonnesen, Dr. L. Liang, Dr. Z. Wu, Dr. H. M. Meyer, III, Dr. M. Chi, Dr. C. Ma, Dr. B. G. Sumpter, Dr. A. J. Rondinone\**

1 – 8

**High-Selectivity Electrochemical Conversion of CO<sub>2</sub> to Ethanol using a Copper Nanoparticle/N-Doped Graphene Electrode**

A nanostructured catalyst achieves one-pot electrochemical conversion of carbon dioxide to ethanol. The catalyst is comprised of copper nanoparticles imbedded in N-doped carbon nanospikes. Carbon dioxide is

electrochemically reduced on copper particles to carbon monoxide, which dimerizes. Electrochemical reduction of the dimer yields ethanol with an overall Faradaic efficiency of 63%.

In no more than 150 words, explain why this discovery is significant.

[6 marks]



- (c) Compare this new process to that of other environmental processes in terms of energy efficiency. [4 marks]



(d) In your final year of study, as part of your final year project, you decide to test this new process mentioned in (b). You conduct the experiment in a batch reactor and report the evolution of CO<sub>2</sub> concentration as a function of the experimental time in the table below:

Time (hrs)	Concentration of CO <sub>2</sub> . (mg/L)
0	900
10	720
20	570
40	360
80	230

What should the volume of your reactor be in order to achieve a treatment capacity of 2 L/d and an effluent CO<sub>2</sub> concentration of 50 mg/L?

[6 marks]

