CAMPBELL UNIVERSITY
NORTH CAROLINA, U. S. A.

ACADEMIC YEAR 2017/2018

JANUARY/FEBRUARY EXAMINATION

CHEMISTRY BACH2253(B)
ENVIRONMENTAL CHEMISTRY AND ANALYSIS

MONDAY, 5 FEBRUARY 2018

TIME: 2.00 PM – 4.00 PM (2 HOURS)

BACHELOR OF SCIENCE DEGREE

Instructions to Candidates:

Answer ALL questions. All questions carry equal marks.

This question paper consists of 4 questions on 4 printed pages.
BACH2253(B) ENVIRONMENTAL CHEMISTRY AND ANALYSIS

Question 1

a) Montreal Protocol agreed to phase-out chemicals destroying the ozone layer in the Earth’s Stratosphere. However, according to sciencedaily.com, dichloromethane, which is a ozone-destroying substance that is not regulated by the Montreal Protocol due to its life is too short to reach the stratosphere in large quantities, is suspected to be carriable up into the stratosphere by the meteorological phenomenon of cold-air surges and therefore, deplete the ozone layer in East Asia. Assuming that you are an environmental researcher, propose three scientific techniques by including the sampling, analysis methodology and other necessary parameters or conditions to prove that whether dichloromethane has reached the Earth’s Stratosphere and is damaging the ozone layer. (10 marks)

b) Briefly describe how radon could be a significant natural source of radionuclides in the atmosphere. (6.5 marks)

c) Briefly describe how human can be exposed to radon. (8.5 marks)

[Total: 25 marks]

Question 2

A case study was carried out to investigate the carbon monoxide (CO) level in a city. In this investigation, an air sampling pump, which was operated at 2 L/min was used to draw 10 L of air sample from the atmospheric air through an impinger containing 50 mL 1% palladium(II) chloride (PdCl₂) trapping solution. After the sampling, the trapping solution in impinger was totally transferred to a vessel and 10 mL of 12%(w/v) potassium iodide (KI) solution was added into it before sent to a commercial laboratory for analysis. In the laboratory, the solution was diluted with acidic 1% potassium iodate (KIO₃) solution to 100 mL before titrated with 0.1 M sodium thiosulfate (Na₂S₂O₃) solution until dark blue colour caused by the present of starch indicator was discolourized. [Given atomic weight of Sulfur, S is 32.065 g/mole ; Oxygen, O is 15.9994 g/mole; Palladium, Pd is 106.42 g/mole; Chlorine, Cl is 35.453 g/mole; Carbon, C is 12.0107 g/mole, Hydrogen, H is 1.0079 g/mole, Potassium, K is 39.0983 g/mole and Iodine, I is 126.9045 g/mole]

a) Write a balanced chemical equation for the reaction between thiosulfate (S₂O₃²⁻) ions and triiodide (I₃⁻) in the 100 mL diluted trapping solution in the titration where tetrathionate (S₄O₆²⁻) and iodide (I⁻) ions are produced. (2 marks)

b) If the volume of the 0.1 M sodium thiosulfate (Na₂S₂O₃) solution, which is used to titrate the diluted 100 mL trapping solution until achieving end point, is 45.4 mL, calculate the amount in gram of the triiodide ions in the 100 mL diluted trapping solution. (6 marks)

c) Write a balanced chemical equation for the reaction between iodate (IO₃⁻) ions and iodide (I⁻) in the acidic condition when acidic 1% potassium iodate (KIO₃) solution is used to dilute 50 mL 1% palladium(II) chloride (PdCl₂) trapping solution containing potassium iodide (KI) to 100 mL. (2 marks)

d) Calculate the amount of the iodide ions present in the 100 mL diluted 1% palladium(II) chloride (PdCl₂) trapping solution. (3 marks)

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Question 2 (Continued)

c) Write a balanced chemical equation for the reaction between palladium(II) chloride (PdCl₂) and potassium iodide (KI) in the vessel containing 50 mL 1% palladium(II) chloride (PdCl₂) trapping solution transferred from impinger after 10 mL of 12%(w/v) potassium iodide (KI) solution was added into it. (2 marks)

f) Calculate the amount of palladium(II) chloride (PdCl₂) that has been reacted with potassium iodide (KI) in the vessel. (2 marks)

g) Write a balanced chemical equation for the reaction between palladium(II) chloride (PdCl₂) and carbon monoxide (CO) in the impinger containing 50 mL 1% palladium(II) chloride (PdCl₂) trapping solution. (2 marks)

h) Calculate the concentration in ppm of the carbon monoxide level in the city if the sampling conditions are as follows:

Temperature in the city during sampling = 30 °C  
Atmospheric pressure in the city during sampling = 1 atm  
Sampling pump air flow rate = 0.5 L/min  
Sampling duration = 8 hours  
Impinger trapping efficiency = 90%  
Gas constant, R = 0.08206 L.atm.mol⁻¹K⁻¹  

[Total: 25 marks]

Question 3

a) Oxygen sag curve resulting from the addition of oxidizable pollutant material to a stream is shown in the figure below:

(Sources: Environmental Chemistry, Stanley E. Manahan, Lewis Publishers)

Briefly explain the changes of the level of the dissolved oxygen shown in figure above. (9.5 marks)
Question 3 (Continued)

b) Discuss briefly why 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is a stable, persistent environmental pollutant and hazardous waste constituent of considerable concern.  
   (7.5 marks)

c) By including its disadvantages, briefly discuss what is BOD and how it is measured.  
   (8 marks)  
   [Total: 25 marks]

Question 4

30 g of soil sample containing 3,3',4,4',5-pentachlorobiphenyl (C₁₂H₁₀Cl₅) was collected and analyzed according to EPA Method 8080. 100 mL of 1:1 methylene chloride:acetone extraction solvent was added to the collected soil sample in a sampling bottle before extracted ultrasonically in a heated sonicator bath for 30 minutes. The extraction solvent was decanted and filtered before passed through a drying column containing anhydrous sodium sulfate. The eluted extraction solvent was concentrated to 1 mL using Kuderna-Danish (K-D) apparatus before analyzed using gas chromatograph (GC) coupling with electron capture detector (ECD). The obtained detector response signal in peak area was calibrated using a calibration curve established by a series of standard solutions containing known amount of 3,3',4,4',5-pentachlorobiphenyl in 1:1 methylene chloride:acetone.

a) Calculate the concentration of 3,3',4,4',5-pentachlorobiphenyl in the 1 mL concentrated extraction solvent in the unit of mg/L, if the obtained peak area for the GCECD analysis is 125456.46 μV-min and the peak areas for two calibration points at concentrations of 15 and 50 mg/L in the five-points calibration curve are 168594.23 and 512468.74 μV-min.  
   (10 marks)

b) Same soil sample containing 3,3',4,4',5-pentachlorobiphenyl was sent to the other laboratory and the quantity of 3,3',4,4',5-pentachlorobiphenyl in the sample was determined using other validated method and the final determined recovery-corrected concentration in 10 g soil sample is 0.375 mg/kg, calculate the percentage recovery of the 3,3',4,4',5-pentachlorobiphenyl in the soil sample using EPA Method 8080.  
   (5 marks)

c) Calculate the concentration of 3,3',4,4',5-pentachlorobiphenyl in the 100 mL of 1:1 methylene chloride:acetone extraction solvent after sonication.  
   (3 marks)

d) Given that the density of the 3,3',4,4',5-pentachlorobiphenyl stock solution is 1.182 g/cm³ with 93 % (w/w) purity, calculate the volume of 3,3',4,4',5-pentachlorobiphenyl liquid in μL that is necessary to be transferred into a 100 mL volume flask using micropipette in order that the 1000 ppm of 3,3',4,4',5-pentachlorobiphenyl can be prepared in the 100 mL 1:1 methylene chloride:acetone.  
   (7 marks)  
   [Total: 25 marks]

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