



UNIVERSITY OF TECHNOLOGY, JAMAICA  
DEPARTMENT OF SCIENCE AND MATHEMATICS

SEMESTER 1: EXAMINATION

GROUP: BENG - 2

Date:

Module: PHYSICAL CHEMISTRY (CHY2018)

Duration: 2 hours

Instructions: Answer any four questions. Each question is worth twenty (20) marks.

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1} = 0.0821 \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$$

**Question 1**

Adsorption of a gas to a solid surface can occur either with or without dissociation.

a) What are the assumptions and essential features of the monolayer adsorption (chemisorption and physisorption)? [5]

b) The following data list volumes of ammonia (reduced to STP) adsorbed by a sample of activated charcoal at 273 K.

P/kPa	6.8	13.5	26.7	53.1	79.4
V/cm <sup>3</sup> g <sup>-1</sup>	78	111	147	177	189

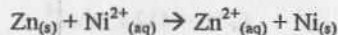
Show that the data fit a Langmuir adsorption isotherm and evaluate the constants. [15]

[Total 20 marks]

**Question 2**

a) Derive Nernst Equation to calculate cell potential. Define each term in the equation and state what condition is it applicable. [6]

b) Given the redox reaction, determine the following:



(i) What is the emf of this cell under standard conditions given that the standard reduction potentials of  $\text{Zn}^{2+}_{(aq)}/\text{Zn}_{(s)}$  and  $\text{Ni}^{2+}_{(aq)}/\text{Ni}_{(s)}$  are -0.73 V and -0.23 V respectively? [3]

(ii) What is emf of the cell when  $[\text{Ni}^{2+}] = 2.50 \text{ M}$  and  $[\text{Zn}^{2+}] = 0.250$ ? [3]

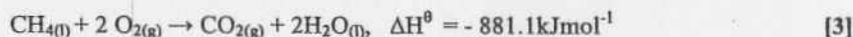
c) Given that  $H = U + pV$ . Derive an equation for the following:

(i) When pressure is constant

(ii) When volume is constant

Note: DEFINE each term in the equation. [5]

(iii) Calculate  $\Delta U^\theta$  for the following combustion reaction:



[Total 20 marks]

### Question 3

Answer all parts.

- a) Given that  $PV = nRT$  and  $\Delta S = q/T$ . **Derive** the equation for the entropy of mixing of gases ( $\Delta S_{\text{mix}}$ ). [10]

$$\Delta S_{\text{mix}} = -nR(X_1 \ln X_1 + X_2 \ln X_2).$$

- b) The composition of dry air is approximately 78 %  $N_2$ , 21 %  $O_2$ , and 1 % Ar by volume (which is the same as mole percent). What is the molar entropy of mixing of air? [5]
- c) With aid of a diagram, discuss the changes of a pure substance through different phases. [5]

[Total 20 marks]

### Question 4

- a) When a mole of propane, at room temperature is burnt and the products are collected and brought to room temperature, the heat released is  $890.4 \text{ kJ mol}^{-1}$ .

- (i) Determine the change in internal energy for this process, assuming pressure is constant throughout at 1 atmosphere.
- (ii) If it is true that energy is conserved in chemical reactions then the energy released must have been present in the system before the reaction. Explain.

[3 + 2]

- b) Using the bond dissociation enthalpies given below:

- (i) Make an estimate of the standard enthalpy of formation of toluene vapour i.e.  $\{\Delta H_f^\circ(\text{C}_6\text{H}_5\text{CH}_3(g))\}$ . The enthalpy of sublimation of graphite is  $716.7 \text{ kJ mol}^{-1}$  and the enthalpy of atomization of hydrogen is  $436.0 \text{ kJ mol}^{-1}$ . [5]



- (ii) Compare your result with the experimentally determined value of  $+100 \text{ kJ mol}^{-1}$  and explain why they are very different. [3]

- c) Discuss Raoult's Law and how it applies to solutions in which the solute is non-volatile. The limitation of Raoult's Law. [7]

[Total = 20 marks]

### Question 5

Answer all parts.

- a) With the aid of Maxwell-Boltzmann distribution of energy diagram, discuss the collision theory and the effects of temperature and catalysis on the rate of reaction. [10]

- b) For a reaction:  $2A + 3B \rightarrow A_2B_3$

Based on the data below, determine each of the following:

- (i) The order of the reaction.  
(ii) The overall order of the reaction.  
(iii) The specific rate constant including the correct units

Experiment	Molarity (mol dm <sup>-3</sup> )		Rates (mol dm <sup>-3</sup> / min)
	[A]	[B]	
1	0.30	0.05	1.50
2	0.30	0.10	6.00
3	0.45	0.05	2.25

[10]

[Total 20 marks]

### Question 6

Answer all parts.

- a) Complete the diagram below and show that for a Carnot engine  $\epsilon = 1 - (T_c/T_h)$ . Why  $\epsilon = 100\%$  cannot be achieved. [8]



- b) Discuss the fraction distillation of nitric acid. Sketch the appropriate diagram to illustrate this. [8]
- c) When 0.500 g of hydrogen and 63.45 g of iodine are allowed to reach equilibrium in 250 cm<sup>3</sup> flask at 450 °C and 1 atm, the amount of HI at equilibrium is 0.390 g. Calculate  $K_p$  at 450 °C. [4]

[Total = 20 marks]

END OF EXAMINATION

