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.**

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

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/$cm^3\ g^{-1}$	78	111	147	177	189

Show that the data fit a Langmuir absorption 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:

$$Zn_{(s)} + Ni^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Ni_{(s)}$$

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

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

c) Given that $\mathbf{H = U + pV}$. **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 ΔU^{θ} for the following combustion reaction:

$CH_{4(l)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$, $\Delta H^{\theta} = -881.1 kJmol^{-1}$ **[3]**

[Total 20 marks

Question 3

Answer all parts.

a) Given that PV = nRT and ΔS = q/T. **Derive** the equation for the entropy of mixing of gases (ΔS_{mix}). **[10]**

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

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 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. $\{\Delta H^{\theta}_f (C_6H_5CH_{3(g)})\}$ The enthalpy of sublimation of graphite is 716.7 kJ mol^{-1} and the enthalpy of atomization of hydrogen is 436.0 kJ mol^{-1}. **[5]**

C-C = 348 kJ mol^{-1}, C=C = 612 kJ mol^{-1}

C≡C = 812 kJ mol^{-1}, C-H = 412 kJ mol^{-1}

(ii) Compare your result with the experimentally determined value of +100 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: $2\,A + 3\,B \longrightarrow A_2B_3$

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^{-3})		Rates (mol dm^{-3}/ 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 $\epsilon = 1 - (T_l/T_h)$. 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^3 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

The Periodic Table of Elements

IA	< Group																VIIIA
	IIA			Atomic number Symbol Atomic mass			Metals Transition Metals Metalloids Nonmetals					IIIA	IVA	VA	VIA	VIIA	
												5 B 10.81					
		IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB		14 Si 28.09				
		21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.38		32 Ge 72.59	33 As 74.92			
		39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40			51 Sb 121.75	52 Te 127.60		
		57 La* 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59						
		89 Ac* (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Uun (269)	111 Uuu (272)	112 Uub (277)	113 Uut (282)					

*Lanthanide series:	58 Ce 140.11	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
*Actinide series:	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)