BENG2

UNIVERSITY OF TECHNOLOGY, JAMAICA

DEPARTMENT OF SCIENCE & MATHEMATICS

Engineering Dept.

SEMESTER II RESIT EXAMINATION

GROUPS: B.ENG-2 **DATE: JULY 2005**

MODULE CODE: CHY 2018 **DURATION: 2 HOURS**

MODULE NAME: PHYSICAL CHEMISTRY

INSTRUCTIONS : Answer **ALL** Questions From Section A and any **TWO** From Section B

Constants: R = 8.314 J/mol.K or 0.08206 L.atm/mol.K

F = 9.649×10^4 C/mol; 1 atm = 760 torr = 760 mmHg = 101,325 Pa

Vapor pressure of water at 25°C = 4.24 Kpa

Section A (Answer all Questions from this section)

Question #1

(a) Define the following terms using appropriate equations.

(i) Zeroth Law of Thermodynamics
(ii) First Law of thermodynamics
(iii) Hess's Law
(iv) Gibbs free energy **[4 marks]**

(b) Distinguish between each of the following:

(i) Internal energy and enthalpy
(ii) Heat and work
(iii) Adiabatic and Isothermal process **[3 × 2 marks]**

(c) The equilibrium constant for the reaction below is 2.45×10^5 at 298 K and 6.15×10^4 at 500 K:

$$H_2O(g) + O_3(g) \rightleftharpoons H_2O_2(g) + O_2(g)$$

What is the ΔH° for the reaction over the given temperature range? **[5 marks]**

(d) The vapor pressure of water at 373 *K* is 760 torr and the average heat of vaporization over the temperature range 363 *K* to 373 *K* is 40 .8 kJ/mol. Calculate the vapor pressure of water at 363 *K*. **[5 marks]**

Total = 20 marks

Question #2

(a) State Hess's Laws. Why are these laws so useful? **[3 marks]**

(b) From the following enthalpies of reaction:

$H_2(g) + F_2(g) \longrightarrow 2\,HF(g)$ $\quad \Delta H = -537$ kJ

$C(s) + 2\,F_2(g) \longrightarrow CF_4(g)$ $\quad \Delta H = -680$ kJ

$2\,C(s) + 2\,H_2(g) \longrightarrow C_2H_4(g)$ $\quad \Delta H = +52.3$ kJ

Calculate ΔH for the reaction of ethylene (C_2H_4) with F_2:

$C_2H_4(g) + 6\,F_2(g) \longrightarrow 2\,CF_4(g) + 4\,HF(g)$ **[5 marks]**

(c) (i) What is the difference between internal energy change ΔE and enthalpy change ΔH? Under what circumstances are ΔE and ΔH nearly equal?

(ii) A gas is compressed from 10.00 L to 5.00 L at a constant pressure of 0.500 atm. During the course of the compression, the gas gives off 400 J of heat. Calculate the work done on the gas and the change in the internal energy (ΔE) of the gas.

[4 + 4 marks]

(d) During a constant volume process, 0.500 kJ of heat was transferred to 2.0 mol of helium (He) gas that was initially at 25 °C. Under these conditions C = 12.4 J/mol.K. Calculate:

(i) The work done *by* the gas

(ii) The final temperature of the gas **[2 + 2 marks]**

Total = 20 marks

Section B

(Answer ANY TWO Questions from this Section)

Question # 3

(a) A closed vessel contains $COCl_{2\,(g)}$ at 0.250 atm, $CO_{(g)}$ at 0.320 atm and $Cl_{2\,(g)}$ at 0.410 atm at 373 K. The equilibrium constant K_p for the react on at this temperature is 2.4.

$$COCl_{2\,(g)} \rightleftharpoons CO_{(g)} + Cl_{2\,(g)} \qquad \Delta H = \text{negative}$$

(i) Calculate K_c for this reaction. **[3 marks]**

For each of the following describe the resulting effect on the equilibrium system:

(ii) Using a smaller reaction vessel

(iii) Decreasing the temperature of the system

(iv) Removal of some $Cl_{2\,(g)}$ from the system

(v) Adding $CO_{(g)}$ to the system **[4 marks]**

(b) For the following reaction: $2\,A + 3\,B \longrightarrow A_2B_3$,
Based on experimental data below, determine each of the following:

(i) The order with respect to each component.

(ii) The overall order of the reaction.

(iii) The specific rate constant including the correct unit.

Experiment	Molarity, M		Rate (M/min)
	[A]	[B]	
1	0.3	0.05	1.5×10^{-3}
2	0.3	0.10	6.0×10^{-3}
3	0.6	0.05	3.0×10^{-3}

[6 marks]

(c) The table below contain a set of experimental rate constant for the first-order decomposition of a compound.

Temperature (°C)	Rate constant (s^{-1})
25	2.15×10^{-4}
50	4.25×10^{-3}

Determine the activation energy and calculate the half-life for the reaction at 20 °C.

[7 marks]

Total = 20 marks

Question #4

(a) With the aid of a fully labeled diagram, describe in detail how a catalyst affects (i) activation energy and (ii) rate constant, and hence its impact on the rate of a given reaction. **[6 marks]**

(b) If concentration versus time data is collected for a given reaction, show how would you determine if the reaction is zero, first or second order? **[4 marks]**

(c) $C_2H_{5\,(aq)} + OH^-_{(aq)} \rightarrow C_2H_5OH_{(aq)} + I^-_{(aq)}$

The above reaction has a specific rate constant of 3.25×10^{-3} $M^{-1}s^{-1}$ at 298 K and activation energy of 7.95×10^4 J/mol. What is the value of the frequency factor *A*? **[4 marks]**

(d) Discuss the following with the assistance specific examples:
(i) absorption versus adsorption
(ii) physisorption versus chemisorption **[6 marks]**

Total = 20 mark

Question #5

(a) List three types of intermolecular forces and discuss their effects on boiling point and latent heat of vaporization **[6 marks]**

(b) Calculate the value of ΔG° at 350 K for which ΔH° is -2150 kJ/mol and ΔS° is -275 J/mol.K. State whether the reaction is spontaneous under standard conditions at this temperature. **[3 marks]**

(c) Use the pressure-temperature phase diagram to illustrate the phase changes of pure water. **[7 marks]**

(d) A gas is allowed to expand from 5.00 L to 12.00 L at a constant pressure of 0.500 atm. During the course of the expansion the gas gives off 370 J of heat. Calculate the work done on the gas and the change in the internal energy (ΔE) of the gas. **[4 marks]**

Total = 20 marks

Question #6

(a) Briefly discuss the following:
(i) electrolysis and electrolytic process
(ii) electrochemical and galvanic cells

[4 marks]

(b) The overall reaction for a certain galvanic cell is:

$$Mn(s) + Pb^{2+}(aq) \longrightarrow Mn^{2+}(aq) + Pb(s)$$

Given that the E° values: $Mn^{2+}(aq)/\,Mn(s) = -1.18\ V$

$Pb^{2+}(aq)/\,Pb(s) = -0.126\ V$

i. Write the anode and cathode half-cell reactions.

ii. Calculate the standard potential (E°) of the overall cell reaction.

iii. Sketch the experimental setup, label the anode and cathode with their signs and indicate the direction of **electrons** and **ions** flow.

iv. What is the function of the salt-bridge? **[2+2+2+1 marks]**

(c) Determine the equilibrium constant at 298 K for the reduction of V^{2+} by Cr^{2+} according to the following reactions and using the data below.

$$V^{2+}(aq) + 2\,Cr^{2+}(aq) \longrightarrow V(s) + 2\,Cr^{3+}(aq)$$

$V^{2+}/V = -1.19V$; and $Cr^{3+}/Cr^{2+} = -0.41\ V$

[4 marks]

(d) Calculate the composition of vapor in equilibrium with a solution containing 4.0 mol of toluene and 2.0 mol of benzene. Assume ideal behavior. At 293 K the vapor pressure of pure toluene is 22 torr and that of benzene is 75 torr.

[5 marks]

Total = 20 marks

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