

BENGZ

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: $R = 8.314 \text{ J/mol.K}$ or $0.08206 \text{ L.atm/mol.K}$

$F = 9.649 \times 10^4 \text{ C/mol}$; $1 \text{ atm} = 760 \text{ torr} = 760 \text{ mmHg} = 101,325 \text{ Pa}$

Vapor pressure of water at $25^\circ\text{C} = 4.24 \text{ Kpa}$

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

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[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:



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

BOB

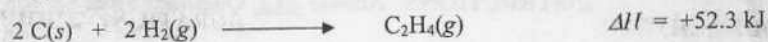
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Question #2

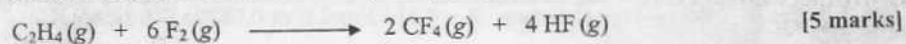
(a) State Hess's Laws. Why are these laws so useful?

[3 marks]

(b) From the following enthalpies of reaction:



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



(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 $C = 12.4 \text{ J/mol.K}$. 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 $\text{COCl}_2(\text{g})$ at 0.250 atm, $\text{CO}(\text{g})$ at 0.320 atm and $\text{Cl}_2(\text{g})$ at 0.410 atm at 373 K. The equilibrium constant K_p for the reaction at this temperature is 2.4.



- (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 $\text{Cl}_2(\text{g})$ from the system
 (v) Adding $\text{CO}(\text{g})$ to the system

[4 marks]

- (b) For the following reaction: $2\text{A} + 3\text{B} \longrightarrow \text{A}_2\text{B}_3$,
 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.

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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}

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

[6 marks]

Temperature ($^{\circ}\text{C}$)	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) $\text{C}_2\text{H}_5\text{(aq)} + \text{OH}^-\text{(aq)} \rightarrow \text{C}_2\text{H}_5\text{OH}\text{(aq)} + \text{I}^-\text{(aq)}$
 The above reaction has a specific rate constant of $3.25 \times 10^{-3} \text{ M}^{-1}\text{s}^{-1}$ at 298 K and activation energy of $7.95 \times 10^4 \text{ J/mol}$. 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:



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

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

- Write the anode and cathode half-cell reactions.
- Calculate the standard potential (E°) of the overall cell reaction.
- Sketch the experimental setup, label the anode and cathode with their signs and indicate the direction of **electrons** and **ions** flow.
- 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.



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

[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 298 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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(a) Determine the equilibrium constant K_c for the reaction at 200°C, assuming that the initial concentration of H_2 is 0.100 M and the initial concentration of I_2 is 0.100 M.

10.00

$$K_c = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]}$$

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- (b) Calculate the equilibrium constant K_c for the reaction at 200°C, assuming that the initial concentration of H_2 is 0.100 M and the initial concentration of I_2 is 0.100 M.
- (c) Calculate the equilibrium constant K_c for the reaction at 200°C, assuming that the initial concentration of H_2 is 0.100 M and the initial concentration of I_2 is 0.100 M.

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