



University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II EXAMINATION - 2009

CHEM 10030
Chemistry For Engineers

Professor Cole-Hamilton

Professor Graetzel

Professor Waghorne

Dr. Sullivan *

Professor Sidebottom *

Time Allowed: 2 hours

Instructions for Candidates

All questions carry equal marks; the approximate assignment of marks to parts of a question is indicated (as a percentage) in parentheses.

Use a separate answer book provided for each question.

No rough work sheets are to be used. The rough work for each question should be included in the answer book for that question.

Instructions for Invigilators

The use of electronic calculators is permitted
A Periodic Table of the Elements is attached to these sheets
Graph paper should be provided

Answer *both* question 1 *and* question 2.

ONLY ANSWER QUESTION 3 IF YOU ARE SEEKING TO IMPROVE YOUR PRACTICAL MARK!

1. Answer *either* part (a) *or* part (b) and *any four* parts (c) – (h).

- (a) Draw a diagram showing the experiment that Curie performed using radioactive Radium and explain how her conclusions following this experiment furthered the development of modern atomic theory. (40)
- (b) Discuss the experiment Rutherford performed using α particles and gold foil. Explain how his results disproved the atomic theory previously proposed by Thompson. (40)

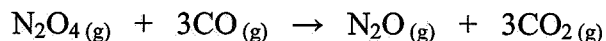
Answer *any four* parts (c) – (h).

- (c) Chlorine has two stable isotopes, ^{35}Cl with a mass of 34.97 (and abundance of 75.77%) and ^{37}Cl with a mass of 36.95. What is the relative atomic mass of chlorine? (15)
- (d) For a hydrogen atom, calculate the wavelength of a photon that results from the transition of an electron from $n = 4$ to $n = 2$. The Rydberg constant is $-2.18 \times 10^{-18} \text{ J}$, the speed of light is $3 \times 10^8 \text{ ms}^{-1}$ and Planck's constant is $6.626 \times 10^{-34} \text{ Js}$. (15)
- (e) Write the electronic configurations of the following atoms and ions, He, Na, Na^+ , O, O^{2-} , Mg^{2+} . (15)
- (f) Draw an approximate potential energy diagram (Energy V Inter nuclear distance) for the formation of a molecule of Br_2 from two Br atoms, given that the Bond Length of a Br_2 molecule is 229 pm and the bond energy is 224 kJ mol^{-1} . (15)
- (g) Draw Lewis structures of the following molecules, H_2S , PH_3 and CBr_4 . Use VSEPR theory to determine their shapes. (15)
- (h) Determine the % C in C_6H_6 . What mass of CO_2 and what number of moles of H_2O are produced from the combustion of 1 mole of C_6H_6 ? (15)

2. Answer **all** parts (a) – (d).

(a) Answer **both** parts (i) **and** (ii). (25)

(i) Use the data given below to calculate the enthalpy change at 298 K for the reaction:



$$\Delta H_f^0 (\text{N}_2\text{O}_{(g)}) = 81 \text{ kJ mol}^{-1}$$

$$\Delta H_f^0 (\text{CO}_{2(g)}) = -393 \text{ kJ mol}^{-1}$$

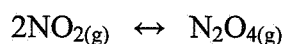
$$\Delta H_f^0 (\text{N}_2\text{O}_{4(g)}) = 10 \text{ kJ mol}^{-1}$$

$$\Delta H_f^0 (\text{CO}_{(g)}) = -110 \text{ kJ mol}^{-1}$$

(ii) Draw the enthalpy diagram for the reaction including the elements in their standard states

(b) Answer **both** parts (i) **and** (ii). (25)

(i) Write an expression for the equilibrium constant for the reaction:



Initially, 1.0 mol of NO_2 and 1.0 mol of N_2O_4 were present in a 1L flask. When equilibrium was reached the concentration of N_2O_4 was 0.75 mol L^{-1}

(ii) Calculate the concentration of NO_2 at equilibrium and hence the equilibrium constant for the reaction.

(c) The decomposition of a compound A to give products gave the following kinetic data: (25)

[A], mol L ⁻¹	Time, s
0.583	0.0
0.303	9.0
0.123	17.0
0.063	25.0
0.029	35.0

Determine the order of the reaction and calculate the rate constant.

- (d) Calculate the activation energy for a reaction which doubles in rate when the temperature is increased from 298 K to 398 K. (25)
- (Gas constant, $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$)

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3. Answer *any* part (a) – (c).

- (a) Describe an experiment used to measure the strength of a hydrogen bond using infra red spectroscopy. (40)
- (b) Describe an experiment which separates, identifies and quantifies the chemical components of a mixture. (40)
- (c) Describe an experiment that measures the rate of the chemical reaction between I_2 and $(\text{CH}_3)_2\text{CO}$. (40)

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Group (new notation)	13	14	15	16	17	18
Group (old notation)	III	IV	V	VI	VII	VIII

Lanthanides

Actinides