



University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II RESIT EXAMINATION - 2010

CHEM 10030
Chemistry For Engineers

Professor Wayne

Professor Waghorne

Dr. Sullivan *

Dr Quinn *

Time Allowed: 2 hours

Instructions for Candidates

Use a separate answer book provided for each question.

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

**ONLY STUDENTS SEEKING TO IMPROVE THEIR LABORATORY GRADE SHOULD ATTEMPT
QUESTION 3**

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 questions 1 and 2*

Students seeking to improve their laboratory grade should also answer question 3

Question 1

Answer any *three* of the following (a) – (e)

(a) Answer *all* sections (i) – (iii)

- (i) Draw a diagram of the apparatus used to generate a hydrogen emission spectrum. (10)
- (ii) Explain, at an atomic level, the processes taking place during the absorption and emission of energy during this experiment. (10)
- (iii) Determine the energy (in J) of the light emitted when an electron makes a transition from the $n = 4$ orbital to the $n = 3$ orbital in a hydrogen atom. (13.3)

$$\text{Rydberg constant} = 2.18 \times 10^{-18} \text{ J molecule}^{-1}$$

(b) Answer *all* sections (i) – (iii)

- (i) Order the following regions of the electromagnetic spectrum in increasing order of energy: γ Ray, Ultra Violet, Microwave, Infra red, X Ray, Radiowave. (10)
- (ii) Write an equation expressing the relationship between the wavelength of light and its energy. (5)
- (iii) Explain why electromagnetic radiation with a high frequency may be considered dangerous. (5)
- (iv) Microwave ovens operate at a frequency of 2.45 GHz (Giga = 10^9). What is the wavelength of this radiation? What is its energy per photon? (13.3)

The speed of light is $3 \times 10^8 \text{ m s}^{-1}$ and Planck's constant is $6.626 \times 10^{-34} \text{ J s}$.

(c) Answer **all** sections (i) – (ii)

- (i) The conversion of $\text{C}_6\text{H}_6 + \text{O}_2$ mixtures into $\text{CO}_2 + \text{H}_2\text{O}$ mixtures is an exothermic process. What does this suggest about the relative strengths of the C – C, C—H, C = O and O – H bonds in the C_6H_6 , O_2 , H_2O and CO_2 . (20)
- (ii) Determine the number of moles of H_2O and the mass of CO_2 formed following the combustion of 500kg of C_6H_6 . (13.3)

(d) Answer **all** sections

Draw Lewis structures and predict the shapes of the following molecules:

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|----------------------|-------|
| NH_3 | (5) |
| CH_4 | (5) |
| H_2O | (5) |
| PCl_5 | (5) |
| BrF_5 | (7) |
| SF_4 | (7.3) |

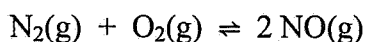
(e) Answer **all** sections (i) – (iii)

- (i) Draw a diagram showing the experiment that Rutherford performed using gold foil and α particles and explain how his conclusions following this experiment furthered the development of modern atomic theory. (20)
- (ii) Explain how Rutherford would have produced a stream of α particles for use in the experiment described in section (i). (13.3)

Question 2

Answer any *two* of the following (a) – (c)

- (a) For the endothermic reaction:



Write an expression for the equilibrium constant in terms of concentrations.

At 2010 K, the equilibrium constant, K_c for the reaction is 4.0×10^{-4} . If the equilibrium concentrations of N_2 and O_2 are 0.28 mol/L and 0.38 mol/L at 2010 K in a 1 L flask, what is the equilibrium concentration of NO?

Predict the effect on amount of NO in the system when the reaction temperature is increased. Explain your reasoning.

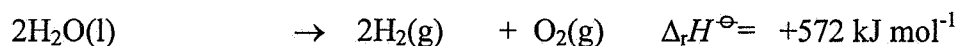
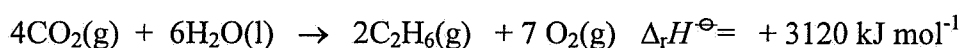
Would you expect the equilibrium constant to be the same for a 50 L flask? (50)

- (b) Answer *all* parts (i), (ii) *and* (iii).

(i) Define the standard enthalpy of formation of a compound ΔH_f^\ominus ;

(ii) State Hess's Law;

(iii) Given the following information:



Calculate the standard enthalpy of formation of ethane $\text{C}_2\text{H}_6(\text{g})$ (50)

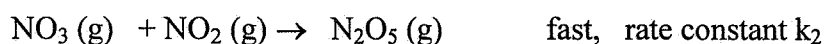
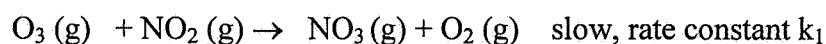
(c) Answer **all** parts (i), (ii) **and** (iii).

(i) Explain briefly the meaning of the following terms in chemical kinetics:

Rate equation Reaction half-life Rate determining step

(ii) The complex reaction: $\text{O}_3(\text{g}) + 2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_5(\text{g}) + \text{O}_2(\text{g})$

Is proposed to occur by the following two ELEMENTARY reactions:



Write the rate equation for the complex reaction.

(iii) Molecular iodine dissociates at 625 K with a first-order rate constant of 0.27 s^{-1} . What is the half-life of this reaction? (50)

Question 3

ONLY ANSWER THIS QUESTION IF YOU ARE SEEKING TO IMPROVE YOUR LABORATORY MARK FOR THE MODULE.

Design an experiment that will measure the concentrations of sodium carbonate and sodium bicarbonate in a solid sample of unknown composition.

Discuss the chemical principles behind the experiment, the chemicals and apparatus that you will require, as well as the modes of data collection and analysis that will yield a reasonable result. (50)

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