



University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I Examinations 2010

CHEM 10030

Chemistry for Engineers

Professor Wayne

Professor Powell

Professor Waghorne

Dr. Sullivan*

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Time Allowed: 2 Hours

Instructions for Candidates

The assignment of marks to each part of a question is indicated.

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.

Instructions for Invigilators

The use of electronic calculators is permitted

A Periodic Table of the Elements is also attached to these sheets

Answer **both** questions.

Q1. A separate answer book must be used for each question.

Answer any **three** sections (a) – (e).

(a) Answer **all** parts (i) – (iii).

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

Planck's constant = $6.626 \times 10^{-34} \text{ Js}$

$c = 3 \times 10^8 \text{ ms}^{-1}$.

- (i) Discuss, with appropriate diagrams, the hydrogen emission spectrum in terms of the Bohr model of an atom. (15)
- (ii) What is the maximum number of emission lines that can be expected if electrons relax from the $n = 3$ level of the H atom. Use an energy-level diagram to illustrate your answer. (10)
- (iii) For a hydrogen atom, calculate the wavelength of the line in the hydrogen emission spectrum that results from the transition $n = 6$ to $n = 2$. (8)

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

- (i) Draw and label the apparatus Marie Curie used when she studied the radioactive decomposition of uranium. Clearly label the component parts and **explain** the results of the experiment. (20)
- (ii) Describe the effect of magnetic or electric fields on the movement of a charged particle. Use diagrams to illustrate the different features you discuss. (13)

Sections (c) to (e) of question 1 are continued on the following pages...

(c) Answer **both** parts (i) and (ii).

- (i) Given the following data, **roughly** sketch (on one plot) the potential-energy curves for the formation of C–O, C=O and C≡O bonds (carbon–oxygen single, double and triple bonds).

	Bond length / pm	Bond strength / kJ mol ⁻¹
C–O	141	358
C=O	132	745
C≡O	119	1046

Comment on the relationship between bond order, bond length and bond strength and explain each part of one of the energy profiles in terms of the changes in the attractive and repulsive forces experienced by the components of the atoms as a function of the inter-nuclear distance. (20)

- (ii) Explain, in terms of total bond energies of reactants and products, why certain reactions are exothermic and others endothermic. (13)

(d) Answer **all** parts (i) – (iv).

$$1 \text{ a.m.u.} = 1.661 \times 10^{-27} \text{ kg}$$

1 neutron has a mass of 1.008665 a.m.u.

1 proton has a mass of 1.007276 a.m.u.

$$c = 3 \times 10^8 \text{ m s}^{-1}$$

$$1 \text{ kg m}^2\text{s}^{-2} = 1 \text{ J}$$

- (i) Explain, with relevant diagrams, the principle of operation of a mass spectrometer. (10)
- (ii) An element consists of two isotopes. The abundance of one isotope is 95.72% and its atomic mass is 114.9041 a.m.u. The atomic mass of the second isotope is 112.9043 a.m.u. Name the element and determine its average mass? (5)
- (iii) Discuss the force which holds the nucleus of an atom together. (10)
- (iv) Determine the binding energy (BE) of a Carbon 12 nucleus (in J) assuming its mass is 12.00 a.m.u. (8)

(e) Answer **both** parts (i) and (ii).

- (i) Draw the Lewis structures and predict the shapes and the bond angles of the following molecules and ions: (20)



- (ii) High levels of the aromatic organic compound benzene C_6H_6 are found in unleaded gasoline.

(A) What is the weight % of carbon and hydrogen in benzene? (4)

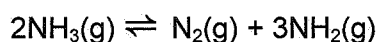
(B) Write a balanced equation for the combustion of C_6H_6 that takes place in a gasoline engine. (4)

(C) What mass of CO_2 and how many moles of H_2O are formed from the complete combustion of 2 kg of benzene? (5)

Q2. A separate answer book must be used for each question.

Answer **all** sections (a) – (c).

- (a) Determine the equilibrium constant K_p of the following reaction:



at 400 °C given that, at $T = 400\text{ °C}$, 1 mole of $\text{NH}_3(\text{g})$ placed in a 5 L reactor produces an $\text{N}_2(\text{g})$ concentration of 0.086 mol dm^{-3} at equilibrium. (40)

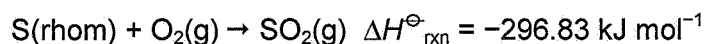
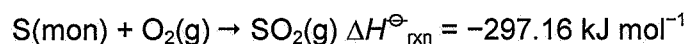
$$(R = 8.205 \times 10^{-2} \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1})$$

Sections (b) and (c) of question 2 are continued on the following page...

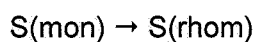
(b) Answer **both** parts (i) and (ii).

(40)

The standard enthalpy change, $\Delta H^{\ominus}_{\text{rxn}}$, for the combustion of monoclinic sulphur, S(mon), to sulphur dioxide SO₂(g) is -297.16 kJ mol⁻¹ while the standard enthalpy change, $\Delta H^{\ominus}_{\text{rxn}}$, for the combustion of rhombic sulphur, S(rhom) to SO₂(g) is -296.83 kJ mol⁻¹.



- (i) Determine the heat (gained or lost) from the transformation of 1.345 g of monoclinic sulphur if the reaction below takes place (assume constant pressure).



- (ii) Is this an endothermic or an exothermic reaction?

(c) Answer **both** parts (i) and (ii).

(20)

Given the general reaction



Determine

- (i) The initial rate of the reaction, v_i , given that:

$$[\text{A}] \text{ (at } t = 0 \text{ s)} = 0.187 \text{ mol L}^{-1}$$

$$[\text{A}] \text{ (at } t = 0.44 \text{ s)} = 0.183 \text{ mol L}^{-1}$$

- (ii) The average reaction rate in the time period between 60.2s and 80.3s, given that:

$$[\text{A}] \text{ (} t = 60.2 \text{)} = 0.55 \text{ mol L}^{-1}$$

$$[\text{A}] \text{ (} t = 80.3 \text{ s)} = 0.54 \text{ mol L}^{-1}$$

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