

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

SUMMER EXAMINATIONS 2002

FIRST YEAR ENGINEERING
CHEMISTRY 1/2 (CH106)

Professor I. Fleming, FRS
Professor R.N. Butler
Dr. N.W.A. Geraghty

Time allowed: Three hours
Answer five questions

Answer five questions of which not more than two may be chosen
from any one section.

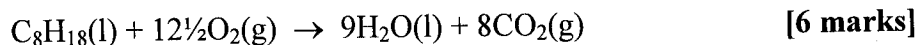
Section A

1. Name the following equation and explain the significance of each of the terms in it:

$$\Delta G = \Delta H - T\Delta S \quad [6 \text{ marks}]$$

Use the thermodynamic data provided below to calculate the following for the fuels hydrogen and octane:

- (a) the enthalpy of combustion of octane and the energy released when 1 litre of octane is burned:



- (b) the enthalpy of combustion of hydrogen gas [4 marks]

- (c) the mass of hydrogen that would have to be burned to produce the same amount of energy as 1 litre of octane. [4 marks]

$$\Delta H^\circ_f \text{C}_8\text{H}_{18}(\text{l}) = -210 \text{kJ} \cdot \text{mol}^{-1}$$

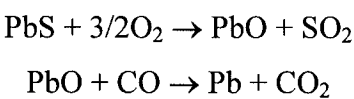
$$\Delta H^\circ_f \text{CO}_2(\text{g}) = -390 \text{kJ} \cdot \text{mol}^{-1}$$

$$\Delta H^\circ_f \text{H}_2\text{O}(\text{l}) = -240 \text{kJ} \cdot \text{mol}^{-1}$$

$$\text{Density C}_8\text{H}_{18}(\text{l}) = 0.703 \text{kg} \cdot \text{l}^{-1}$$

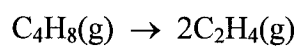
2. Answer (i) and (ii)

- (i) The metal lead (Pb) is produced from its oxide (PbO) by a two step process which involves roasting the ore and the subsequent reduction of the lead oxide (PbO) thus formed



- (a) What weight of lead is obtained from 1 tonne (1000kg) of the ore? **[4 marks]**
- (b) What volume of SO₂ is produced, at 1atm and at 30°C, in processing this amount of ore? **[3 marks]**
- (c) What volume of carbon monoxide at STP is required to process 1 tonne of the ore? **[3 marks]**

- (ii) Cyclobutane decomposes at high temperature to give ethene:



The half-life of the reaction is constant and when cyclobutane at an initial concentration of 0.00150M is heated for 455s, the concentration is reduced to 0.00119M.

- (a) Find the rate constant, k **[5 marks]**
- (b) Determine the concentration of cyclobutane after 968s. **[5 marks]**

- 3.** Draw a phase diagram for water (triple point: 0.01°C and 0.006atm) and for a material X whose triple point occurs at 6.0atm and 4°C, but whose phase diagram is otherwise very similar to that of water. **[6 marks]**

Use the phase diagrams to explain the following:

- (a) what happens when ice is heated at 0.5atm to 150°C **[3 marks]**
- (b) what happens when a gaseous sample of X is cooled at 1atm **[3 marks]**
- (c) how the removal of water from a sample by freeze drying works **[4 marks]**
- (d) how a pressure cooker can be used to accelerate the cooking of food **[4 marks]**

- 4.** (a) The ionization energies (kJ.mol⁻¹) of the elements in the first row of the Periodic Table are as follows:

Li, 519; Be, 900; B, 799; C, 1090; N, 1400; O, 1310; F, 1680; Ne, 2080

- Account for the general trend and for any departures from this trend. **[5 marks]**
- (b) Describe the experiment carried out by Rutherford which played a key role in determining the structure of the atom, and explain its significance. **[5 marks]**
- (c) Explain, using examples, what information is provided by each of the four quantum numbers. **[5 marks]**
- (d) Explain, in detail, how a detergent solubilizes oil in water. **[5 marks]**

Section C

8. Discuss the chemistry of the alkenes under the following headings:

(a) structure and isomerism

[10 marks]

(b) chemical reactions

[10 marks]

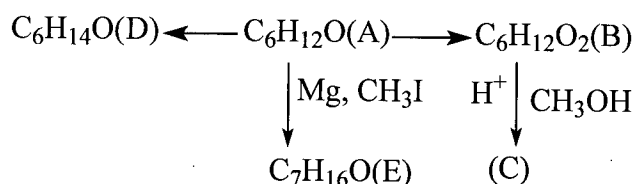
9. (a) Explain why it proved very difficult to work out the molecular structure of benzene (C_6H_6) and explain how this was eventually done using the concept of resonance. [5 marks]

(b) Explain why carboxylic acids are acidic and why fluoroacetic acid is a stronger acid than acetic acid. [5 marks]

(c) Explain using **two** examples what is meant by a substitution reaction. [5 marks]

(d) Explain, using an example, why and how a nucleophile reacts with a ketone. [5 marks]

10.



A contains a straight chain of carbon atoms with the functional group at one end.

D and **E**: have the same functional group and react with sodium metal to give hydrogen.

C has a pleasant smell.

(a) Provide structures for (A) – (E); the functional group should be named and clearly labelled in each case. [10 marks]

(b) Describe two other reactions of (D). [5 marks]

(c) Suggest reagents (where they are not given) that could be used to carry out these transformations. [5 marks]

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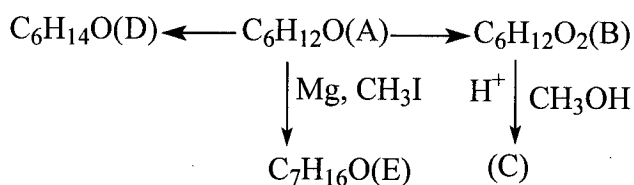
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