

Ollscoil na hÉireann, Gaillimh  
THE NATIONAL UNIVERSITY OF IRELAND, GALWAY

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SUMMER EXAMINATIONS, 2002

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FIRST UNIVERSITY EXAMINATION  
in  
BIOMEDICAL SCIENCE, BIOTECHNOLOGY,  
ENVIRONMENTAL SCIENCE

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CHEMISTRY

Professor I. Fleming, FRS  
Professor R.N. Butler  
Dr. A.V. Savage  
Dr. F. Aldabbagh

Time allowed: *Three* hours

Use a separate answer book for *Section C*

Answer *five* questions of which no more than two may be from any one section.

All questions carry *equal* marks.

Atomic masses (a.m.u.): H = 1.008, C = 12.001, N = 14.007, O = 15.999.

Universal Gas Constant, R = 8.314 J mol<sup>-1</sup>K<sup>-1</sup>

Section A

1. The amino acid histidine is known to contain only carbon, hydrogen, oxygen, and nitrogen. The composition by weight of histidine is 46.45% C, 5.85% H, 27.08% N.
  - (a) What is the empirical formula of histidine? [5 marks]
  - (b) Draw the structure of histidine [5 marks]
  - (c) What approximate pH would a solution of histidine have? [3 marks]
  - (d) Calculate the freezing point of a solution made by adding 15.5 g histidine to 500 g water. [7 marks]  
Molecular weight histidine = 155 g mol<sup>-1</sup>, K<sub>f</sub> for H<sub>2</sub>O is 1.86 °C m<sup>-1</sup>
  
2. Draw graphs showing the Maxwell Boltzmann distribution of molecular speeds for any gas at two different temperatures. [4 marks]
  - (b) Under what experimental conditions do gases behave non-ideally? [4 marks]
  - (c) What properties of gas molecules cause them to behave nonideally? [4 marks]
  - (d) If 1.00 mol of an ideal gas were confined to 22.4 dm<sup>3</sup> at 0.0°C, it would exert a pressure of 101.325 kPa. Use the van der Waals equation to estimate the pressure exerted by 1.00 mol of Cl<sub>2(g)</sub> in 22.4 dm<sup>3</sup> at 0.0°C. Comment on your answer. [8 marks]  
For Cl<sub>2</sub> a = 657.6 dm<sup>6</sup>kPa mol<sup>-2</sup> and b = 0.0562 dm<sup>3</sup>mol<sup>-1</sup>

3.

- (a) Discuss the terms (i) rate of a reaction, (ii) activation energy, (iii) transition state. [9 marks]
- (b) A peroxide compound, P, decomposes above 373K. The decrease in concentration at 380K was measured over time and shown to be as follows.

Time (min)	0	15	30	45	60	75	90	120	150	180
[P] x 10 <sup>2</sup> mol dm <sup>-3</sup>	2.00	1.40	1.00	0.70	0.50	0.36	0.25	0.13	0.06	0.03

- (c) Using these data determine the order of this reaction. [5 marks]
- Calculate accurately the concentration of the compound remaining after 4 hours. [6 marks]

4.

- (a) Discuss the relationship between the standard Gibbs Free Energy change and the equilibrium constant. [6 marks]
- (b) Determine K at 298K for the reduction of ethene to ethane and comment on your answer. [6 marks]
- $\Delta G^\circ_f \text{C}_2\text{H}_{4(g)} = +68.4 \text{ kJmol}^{-1}$ ,  $\Delta G^\circ_f \text{C}_2\text{H}_{6(g)} = -32.0 \text{ kJmol}^{-1}$  at 298K.

## Section B

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- (a) Write notes on (i) isotopes of hydrogen, (ii) the Morse (potential energy) curve for hydrogen, (iii) hydrogen bonding, (iv) fuel cell [12 marks]
- (b) Write the ground state electronic configuration and four quantum numbers for the electrons in an atom of copper. [8 marks]

6 Discuss *each* of the following, including nuclear equations as appropriate

- (a) The radioactive decay of <sup>238</sup>U [4 marks]
- (b) The radioactive decay of <sup>14</sup>C [4 marks]
- (c) The radioactive decay of <sup>222</sup>Rn [4 marks]
- (d) Nuclear fission of <sup>235</sup>U [8 marks]

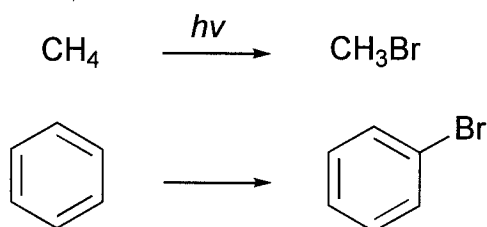
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- (a) Define, giving examples, what is meant by (i) strong acid, (ii) strong base, (iii) weak acid, (iv) weak base. [4 marks]
- (b) Predict whether each of the following salt's aqueous solution is acidic, basic, or neutral and explain your answer: [6 marks]
- (i) sodium acetate, (ii) ammonium chloride, (iii) potassium chloride
- (c) Define what is meant by a buffer and discuss the carbonate buffer system. [4 marks]
- (d) Predict whether each of the following pairs of substances could function as a buffer system in aqueous solution and explain your answers: [6 marks]
- (i) HCl and NaCl, (ii) HCN and KCN, (iii) HCl and HCN (iv) NaCN and KCN.

- 8 Write notes on *each* of the following, paying particular attention to the chemical reactions involved:
- (a) Acid rain: causes, consequences and controls [10 marks]
  - (b) Biological oxygen demand and eutrophication [10 marks]

### Section C

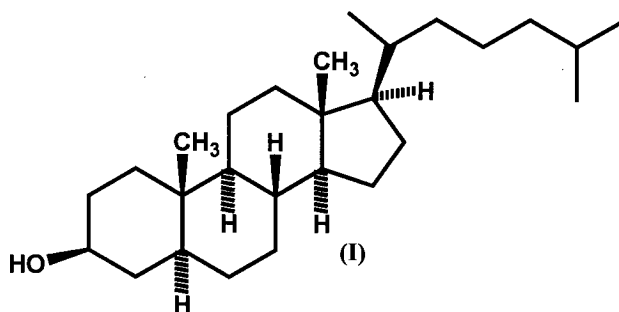
- 9 Provide a mechanism and reagents for the following transformations:



[2 x 10 marks]

10

- (a) Compare and contrast the bonding, conformation and electronic structure of benzene and cyclohexane. [12 marks]
- (b) Structural formula (I) represents cholestanol. Draw the most stable conformation of this molecule.



[8 marks]

11

- (a) Define the primary, secondary, tertiary and quaternary structure of a polypeptide. [12 marks]
- (b) Draw and name *any* dipeptide. [8 marks]