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

AUTUMN EXAMINATIONS, 2002

FIRST MEDICAL EXAMINATION

CHEMISTRY

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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 (amu): H = 1.008, C = 12.001, N = 14.007, O = 15.99

Section A

1

(a) The alkaloid nicotine, a component of tobacco, contains 74.1% C, 8.6% H, and 17.3% N. Determine the empirical formula of nicotine. **[8 marks]**

(b) If the moleculare weight of nicotine is 162 $gmol^{-1}$, determine the molecular formula. **[4 marks]**

(c) Draw a structure for nicotine. (Hint: it contains a pyridine ring and a heterocyclic five-membered ring). **[5 marks]**

(d) Is nicotine considered to be an acid or a base? Explain your answer. **[3 marks]**

2

(a) Briefly discuss Boyle's Law and Charles's Law and give practical examples of each. **[6 marks]**

(b) If 200 cm^3 of N_2 at 25°C and a pressure of 35 kPa are mixed with 350 cm^3 of O_2 at 25°C and a pressure of 45 kPa so that the resulting volume is 330 cm^3, what would be the final pressure of the mixture at 25°C? **[10marks]**

(c) Under what experimental conditions do gases deviate from ideal behaviour? **[4marks]**

3

(a) Draw a heating curve for gases, liquids and solids, and compare their properties. **[6marks]**

(b) Write a note on X-ray diffraction of solids and the Bragg equation. **[8marks]**

(c) Discuss the crystal structure of NaCl. **[6marks]**

4

(a) Discuss the following terms (i) enthalpy change, (ii) entropy change, (iii) Hess' Law. **[9 marks]**

(b) Calculate ΔH for the reaction:

$NO_{(g)} + O_{(g)} \rightarrow NO_{2(g)}$ given the following information:

(i) $NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$ $\Delta H = -198.9kJ$

(ii) $O_{3(g)} \rightarrow 3/2\ O_{2(g)}$ $\Delta H = -142.3kJ$

(iii) $O_{2(g)} \rightarrow 2\ O_{(g)}$ $\Delta H = +495.0kJ$ **[11 marks]**

Section B

5. Answer each of the following and discuss your answer in each case:

(a) Arrange each set of atoms in order of increasing atomic size: C, O, Be **[3 marks]**

(b) Arrange each set of atoms in order of increasing ionisation energy: N, B, Ne **[3 marks]**

(c) Arrange each set of atoms in order of increasing metallic character: Ca, Rb, S **[2 marks]**

(d) Indicate whether each of the following atoms or ions are diamagnetic, paramagnetic, or ferromagnetic in their ground state:

Si, Be, Fe, V^{3+}, Co^{3+}, Ag^{+} **[12 marks]**

6

(a) Complete each of the following nuclear equations:

(i) $^{226}Ra \longrightarrow {}^{222}Rn +$ **[2 marks]**

(ii) $^{90}Mo \longrightarrow {}^{90}Nb +$ **[2 marks]**

(iii) $^{38}K \longrightarrow {}^{38}Ar +$ **[2 marks]**

(iv) $^{234}Th \longrightarrow {}^{234}Pa +$ **[2 marks]**

(v) $^{235}U + {}^{1}_{0}n \longrightarrow$ **[4marks]**

(d) Given that the half-life of ^{239}Pu is 24,000 years, how many years will it take for the level of radioactivity from plutonium in a sample of it to decrease to 1% of its original value? **[8 marks]**

7

(a) Discuss the neutralization of phosphoric acid by a strong base. **[6 marks]**

(b) Calculate the pH of a solution made by mixing 20 cm^3 0.5M H_2SO_4 with 30 cm^3 0.3M NaOH. **[6 marks]**

(c) A solution is prepared that is 0.025M CH_3COOH and 0.02M CH_3COONa. Show that this is a buffer solution and calculate the pH.
K_a for acetic acid is 1.8×10^{-5} **[8 marks]**

8

Write an essay on the importance of hydrogen bonding in biological systems **[20 marks]**

Section C

9

(a) Draw structural formulae showing all of the atoms of each of the following: dichloromethane, acetone, ethanoic acid and nitrobenzene. **[12 marks]**

(b) Using resonance structures, discuss the following statement; *phenols are much stronger acids than aliphatic alcohols.*

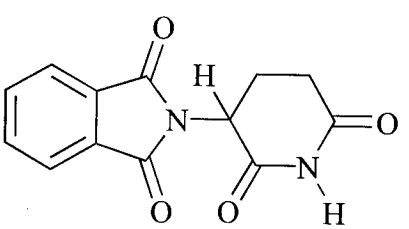
[8 marks]

10

(a) Draw the three constitutional isomeric alkanes of formula C_5H_{12}. **[6 marks]**

(b) Draw the two geometric (*cis* and *trans*) isomers of 1,2-dichloroethene. **[4 marks]**

(c) Briefly explain why (*R*)-thalidomide and (*S*)-thalidomide have different biochemical effects in the human body. **[4 marks]**



thalidomide

Draw the *R* and *S* forms of thalidomide. **[6 marks]**

11

Compare and contrast the chemical structures of DNA and RNA. **[20 marks]**