

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

SPRING EXAMINATIONS, 1999

FIRST MEDICAL EXAMINATION

CHEMISTRY

Professor R.C.F. Jones
Professor R.N. Butler
Dr. A.V. Savage

Time allowed: *Three* hours

Answer *five* questions of which no more than two may be from any one section.
All questions carry equal marks. For a question with a choice between parts, all parts of that question carry equal marks.

Atomic masses (a.m.u.): H = 1.008, C=12.001, N =14.006, O = 15.999.

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.
- (b) If the molecular weight of nicotine is 162 g mol^{-1} , determine the molecular formula.
- (c) Draw a structure for nicotine. (Hint: it contains a pyridine ring and a heterocyclic five-membered ring).
- (d) Is nicotine considered to be an acid or a base? Explain your answer.

2

- (a) Outline the main points of the kinetic-molecular theory of gases.
- (b) Discuss *either* Boyle's Law *or* Charles' Law in terms of this theory.
- (c) An unknown gas composed of homonuclear diatomic molecules effuses at a rate that is only 0.355 times that of O_2 at the same temperature. What is the identity of the unknown gas?
- (d) Write a chemical equation for any reaction which this gas might undergo.

3

- (a) Write a note on Gibbs Free Energy
- (b) Discuss the effect of temperature on reaction spontaneity
- (c) Predict the direction in which ΔG^0 will change with an increase in temperature for the equilibrium



- (d) Calculate ΔG^0 at 500°C , assuming that ΔH^0 and ΔS^0 do not change with temperature.
- (e) Discuss your answers in relation to the industrial production of ammonia.
- Given: $\Delta H^0 = -92.38 \text{ kJ}$, $\Delta S^0 = -198.3 \text{ JK}^{-1}$

4

- (a) "Some physical properties of solutions differ in important ways from those of pure solvent". Discuss.
- (b) The average osmotic pressure of blood is 780 kPa at 25°C . What concentration of glucose will be isotonic with blood?
- (c) Arrange the following aqueous solutions in order of their expected freezing points:
- (i) 0.050 m calcium nitrate, (ii) 0.15 m sodium chloride, (iii) 0.10 m hydrochloric acid, (iv) 0.050 m acetic acid, (v) 0.10 m sucrose.

Section B

5. Complete each of the following nuclear equations:

- (a) $^{14}\text{C} \rightarrow ^{14}\text{N} + \quad t_{1/2} = 5570 \text{ y}$
- (b) $^{212}\text{Po} \rightarrow ^{208}\text{Pb} + \quad t_{1/2} = 3 \times 10^{-7} \text{ s}$
- (c) $^{90}\text{Mo} \rightarrow ^{90}\text{Nb} + \quad t_{1/2} = 5.7 \text{ h}$
- (d) $^{239}\text{Np} \rightarrow ^{239}\text{Pu} + \quad t_{1/2} = 2.3 \text{ d}$
- (e) $^{235}\text{U} + ^1_0\text{n} \rightarrow$
- (f) $^3_1\text{H} + ^2_1\text{H} \rightarrow$

Discuss each reaction with respect to

- (i) Stability of parent radionuclide,
- (ii) particle(s) produced,
- (iii) significance of the reaction, and
- (iv) biological effects, if any, of the reaction.

- 6 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
 - (b) Arrange each set of atoms in order of increasing ionisation energy: N, B, Ne
 - (c) Arrange each set of atoms in order of increasing metallic character: Ca, Rb, S
 - (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^+

- 7 "Enzymes are biological catalysts". Discuss

- 8
- (a) Discuss each of the following, giving examples in each case: (i) buffer, (ii) buffer range, (iii) buffer capacity, (iv) buffer dilution, (v) the carbonate buffer system.
 - (b) What is the effect of adding (i) 20 cm^3 0.30M HCl and (ii) 10 cm^3 0.60M NaOH on the pH of 0.300 dm^3 of a buffer solution that is 0.250 M in acetic acid and 0.550 M in sodium acetate. K_a for acetic acid = 1.8×10^{-5} .

Section C

- 9 Discuss *each* of the following:

- (a) Keto-enol tautomerism
- (b) Reactions of aldehydes
- (c) The structure of glycogen

- 10 Discuss *each* of the following:

- (a) structure of an α -amino acid at different pH values
- (b) titration curve and pI of any α -amino acid
- (c) peptide linkage
- (d) secondary structure of protein
- (e) tertiary structure of protein
- (f) quaternary structure of protein

- 11 Answer *each* of the following:

- (a) Write a brief note on steroids.
- (b) Draw the chemical structure for any steroid
- (c) Write a brief note on estrogen mimics in the environment.