

BINDURA UNIVERSITY OF SCIENCE EDUCATION
CHEMISTRY DEPARTMENT

COURSE: CH105 GENERAL CHEMISTRY

AUG 2024

PROGRAMME: BACHELOR OF SCIENCE EDUCATION HONOURS PART I

Time 2 Hours
ANSWER QUESTION 1 AND FOUR OTHERS, TWO FROM EACH OF SECTIONS A AND B. EACH QUESTION CARRIES 20 MARKS

1. (a) What do you understand by the following
- (i) Strong acid
 - (ii) Equivalence point
 - (iii) Lewis acid
 - (iv) End point
 - (v) Black body [10 marks]
- (b) (i) Draw the shapes of s and p-orbitals. [4 marks]
(ii) State the difference between the 1s and 2s orbitals. [2 marks]
- (c) Calculate the pH of:
- (i) 0.2M ethanoic acid, CH_3COOH . [$K_a = 1.78 \times 10^{-5} \text{ mol.dm}^{-3}$]
 - (ii) 0.1M NaOH. [4 marks]

SECTION B: ANSWER ANY TWO QUESTIONS FROM THIS SECTION

2. (a) Give a schematic representation of the energy changes that accompany the process; $\text{Na(s)} + \text{Cl(g)} \rightarrow \text{NaCl(s)}$. [6 marks]
- (b) Write the Lewis formula for
- (i) the carbonate ion, CO_3^{2-} . [2 marks]
 - (ii) phosphorus trifluoride, PF_3 , a covalent compound. [2 marks]
- (c) Each halogen can form single covalent bonds with other halogens, to form interhalogen compounds; some examples are ClF and BrF . Given that the electronegativity of F, Cl, Br and I are 4.0, 3.0, 2.8 and 2.5 respectively, rank the following single bonds from least polar to most polar: F-Cl, F-Br, Cl-Br, and Cl-I [4 marks]

- (d) The pK_a of hydrocyanic acid (HCN) is 9.31. Find the concentration of H_3O^+ ions in an aqueous solution of concentration $2.0 \times 10^{-2} \text{ mol dm}^{-3}$. [3 marks]
- (e) $HCOOH$ has a pK_a of 3.75. What is the pH of an aqueous solution of concentration $5 \times 10^{-3} \text{ M}$? [3 marks]
3. (a) A 0.1014-g sample of purified glucose was burned in a C-H combustion train to produce 0.1486 g of CO_2 and 0.0609 g of H_2O . An elemental analysis showed that glucose contains only carbon, hydrogen, and oxygen. Determine the masses of C, H, and O in the sample and the percentages of these elements in glucose.
- (i) Determine the mass of each element in the sample [6 marks]
- (ii) Calculate the percentage of each element. [6 marks]
- (b) What mass of sodium chlorate, $NaClO_3$, would contain 33.0 grams of oxygen? [4 marks]
- (c) Explain, giving reason for the trend in first ionization energy down a group [4 marks]
4. (a) Define the following terms as used in analytical measurements and briefly describe how each of them arises.
- (i) Systemic error [6 marks]
- (ii) Random error [6 marks]
- (b) Differentiate between accuracy and precision. [4 marks]
- (c) Find the mean and standard deviation for 821, 783, 834, and 855. [4 marks]

SECTION B: ANSWER ANY TWO QUESTIONS FROM THIS SECTION.

5. (a) A 30.0 mL sample of 0.20 M hydrochloric acid (HCl) is titrated with 0.20 M NaOH solution. Calculate the pH after the following volumes of base has been added:
- (i) 0 mL
- (ii) 15 mL
- (iii) 25 mL
- (iv) 30.0 mL [14 marks]
- (b) Calculate the K_a and pK_a of 0.100 M methanoic acid, $HCOOH$, which has a pH of 4. [5 marks]
- (c) Calculate the pH of 0.01M HCl. [1 marks]

6. (a) Use the Valence Bond Theory to explain shapes and bonding in SF_6 , H_2O , NH_3 and PCl_5 . [8 marks]

(b) Aspirin ($\text{C}_9\text{H}_8\text{O}_4$) is produced from salicylic acid ($\text{C}_7\text{H}_6\text{O}_3$) and acetic anhydride ($\text{C}_4\text{H}_6\text{O}_3$):



- (i) How much salicylic acid is required to produce 1.5×10^2 kg of aspirin? [3 marks]
- (ii) How much salicylic acid would be required if only 80% of the salicylic acid is converted to aspirin? [3 marks]
- (iii) What is the theoretical yield of aspirin if 185 kg of salicylic acid is allowed to react with 125 kg of acetic anhydride? [3 marks]
- (iv) If the situation described in part (iii) produces 182 kg of aspirin, what is the percentage yield? [3 marks]

7. (a) State Pauli's exclusion principle. [2 marks]

(b) Discuss the steps involved in the construction of sp , sp^2 and sp^3 , hybrid orbitals. [6 marks]

(c) What is the significance of electron spin for electronic configurations? [4 marks]

(d) State and explain the configurations of Cu and Cr. [4 marks]

(e) Suggest why Zn is not considered as a transition metal. [4 marks]

END OF PAPER