BINDURA UNIVERSITY OF SCIENCE EDUCATION
CHEMISTRY DEPARTMENT

COURSE: CH105 GENERAL CHEMISTRY AUG 2023

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) Weak acid
   (ii) Arrhenius base
   (iii) Lewis acid
   (iv) Black body [8 marks]

   (b) Draw the shapes of s and p-orbitals. [4 marks]

   (c) Distinguish between equivalence point and end point. [4 marks]

   (d) Calculate the pH of:
   (i) 0.2M ethanoic acid, CH_3COOH. [$K_a=1.78\times10^{-5}mol.dm^{-3}$]
   (ii) 0.1M H_2SO_4. [4 marks]

SECTION A: ANSWER ANY TWO QUESTIONS FROM THIS SECTION.

2. (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]

3. (a) A 30.0 mL sample of 0.20 M nitric acid (HNO_3) is titrated with 0.20 M KOH solution. Calculate the pH after the following volumes of base has been added and derive the titration curve:

(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 butanoic acid, $CH_3CH_2CH_2COOH$, which has a pH of 4. [4 marks]

(c) Calculate the pH of 0.01M NaOH. [2 marks]

4. (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 ($C_9H_8O_4$) is produced from salicylic acid ($C_7H_6O_3$) and acetic anhydride ($C_4H_6O_3$):

$$C_7H_6O_3 + C_4H_6O_3 \longrightarrow C_9H_8O_4 + HC_2H_3O_2$$

(i) How much salicylic acid is required to produce 1.5×10^2 kg of aspirin? [4 marks]
(ii) How much salicylic acid would be required if only 80% of the salicylic acid is converted to aspirin? [2 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? [4 marks]
(iv) If the situation described in part (iii) produces 182 kg of aspirin, what is the percentage yield? [2 marks]

SECTION B: ANSWER ANY TWO QUESTIONS FROM THIS SECTION

5. (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]

6. (a) Give a schematic representation of the energy changes that accompany the process; $K(g) + F(g) \rightarrow KF(s)$. [6 marks]

(b) Write the Lewis formula for
(i) the carbonate ion, CO_3^{2-}. [2 marks]
(ii) phosphorus trichloride, PCl_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 ICl. 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 most polar to least polar: F-Cl, F-Br, Cl-Br, and Cl-I [3 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 $2.0\times 10^{-2}\,\text{moldm}^{-3}$. [3 marks]

(e) CH_3COOH has a pK_a of 3.75. What is the pH of an aqueous solution of concentration 5×10^{-3}M? [4 marks]

7. (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 potassium chlorate, $KClO_3$, would contain 40.0 grams of oxygen? [4 marks]

(c) Explain, giving reason for the trend in first ionization energy down a group [4 marks]

END OF PAPER