

BINDURA UNIVERSITY OF SCIENCE EDUCATION
SCIENCE AND MATHEMATICS EDUCATION DEPARTMENT

COURSE: CH105 GENERAL CHEMISTRY

JAN 2025

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) Systematic error
 - (ii) Arrhenius base
 - (iii) Lewis base
 - (iv) Bronsted-Lowry base [8 marks]
- (b) Distinguish between the terms end point and equivalence point. [4 marks]
- (c) Distinguish between precision and accuracy [4 marks]
- (d) Determine the number of unpaired electrons in an atom of tellurium, Te. [2 marks]
- (e) Giving reasons, arrange the following ions in order of increasing ionic radii: [2 marks]
- Ca^{2+} , K^+ , Al^{3+} ;

SECTION A: ANSWER ANY TWO QUESTIONS FROM THIS SECTION.

2. (a) Calculate $[\text{OH}^-]$, pOH , $[\text{H}_3\text{O}^+]$ and pH for a 0.015 M $\text{Ca}(\text{OH})_2$ solution. [8 marks]
- (b) Nicotinic acid is a weak mono-protic organic acid that we can represent as HA.



A dilute solution of nicotinic acid was found to contain the following concentrations at equilibrium at 25°C.

$$[\text{HA}] = 0.049 \text{ M}; [\text{H}_3\text{O}^+] = 8.4 \times 10^{-4} \text{ M}.$$

What is the value of K_a ? [4 marks]

- (c) In what proportions should ammonia and ammonium chloride be mixed in solution to give a buffer solution of pH 10.0? $\text{p}K_a$ for NH_4^+ is 9.25. [4 marks]

- (d) Calculate the pH of 1.00M ammonia solution and 0.4M ammonium chloride if K_a for the ammonium ion is 5.62×10^{-10} mol.dm⁻³. [4 marks]

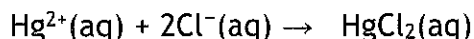
3. (a) Provide explanations of the following phenomena:
 (i). The electron configuration of Cr is [Ar] 4s¹ 3d⁵ rather than [Ar] 4s² 3d⁴.
 (ii). The electron configuration of Ti is [Ar] 4s² 3d², but that of Cr²⁺ is [Ar] 3d⁴. [6 marks]
- (b) Three isotopes of magnesium occur in nature. Their abundances and masses as determined by mass spectrometry, are listed in the following table. Use this information to calculate the atomic weight of magnesium [4 marks]

Isotope	% Abundance	Mass (amu)
$^{24}_{12}\text{Mg}$	78.99	23.98504
$^{25}_{12}\text{Mg}$	10.00	24.98584
$^{26}_{12}\text{Mg}$	11.01	25.98259

- (c) (i) An atomic orbital has a principal quantum number 5, what are the possible values of l ? [4 marks]
 (ii) What are the subshells present in the atom? [4 marks]
 (iii) Why is the first ionization energy for phosphorus 1060 kJ/mol, and that for sulfur 1005 kJ/mol? [2 marks]
4. (a) Use the VSEPR model to predict the shapes of the following:
 ClF₃, BrO₃⁻, SOF₂, PCl₅ [8 marks]
- (b) State and explain
 (i) The variation in ionic radii of elements across period 3. [4 marks]
 (ii) The variation in ionic radii of the first row transition elements [4 marks]
- (c) Use Slater's rules to calculate the effective nuclear charge (Z^*) for the 4s electron in K. [4 marks]

SECTION B: ANSWER ANY TWO QUESTIONS FROM THIS SECTION

5. (a) Chloride (Cl^-) in blood serum can be measured by titration with mercuric ion:



When the reaction is complete excess Hg^{2+} react with the indicator diphenylcarbazone, which forms a violet blue color.

- (i) Mercuric nitrate was standardized by titrating solution containing 1.48 g of NaCl (Formula weight 58.44), which required 28.06 ml of $\text{Hg}(\text{NO}_3)_2$ solution. Find the molarity of $\text{Hg}(\text{NO}_3)_2$. [6 marks]
- (ii) When this same $\text{Hg}(\text{NO}_3)_2$ solution was used to titrate 20.00 mL of blood serum, 22.83 mL was required. Find the concentration of Cl^- (in mol/L) in the blood serum. [4 marks]
- (b) (i) Define an outlier [3 marks]
(ii) How can one decide that a given result is an outlier? [2 marks]
- (c) To investigate the reproducibility of a method from the determination of selenium in foods, eight measurements were made on a single batch of brown rice with the following results:

0.07; 0.08; 0.07; 0.07; 0.08; 0.08; 0.09; 0.04.

- (i) Is the last measurement an outlier? Explain [3 marks]
(ii) What type of error could have resulted in this type of measurement? Explain [2 marks]
6. (a) A 50.0 mL sample of 0.150 M KOH is titrated with 0.150 M nitric acid (HNO_3) solution. Calculate the pH after the following volumes of base have been added:
- (i) 0 mL
(ii) 20 mL
(iii) 40 mL
(iv) 50.0 mL [14 marks]
- (b) When potassium hydrogen carbonate (KHCO_3) is heated it decomposes to K_2CO_3 , CO_2 , and H_2O .
- (i) Write the balanced equation for this reaction. [2 marks]
(ii) What volume (in litres) of CO_2 gas at 115°C and 101kPa pressure will be produced from 42.8g of KHCO_3 ? [4 marks]

7. (a) What do the terms *reasonance* and *hybridization* mean? [6 marks]
- (b) Discuss the steps involved in the construction of sp , sp^2 and sp^3 , hybrid orbitals. [6 marks]
- (c) Use the band theory to explain why
- (i) Al is a metallic conductor.
 - (ii) Si is a semiconductor [8 marks]

END OF PAPER