

# University of Information Technology & Sciences (UITS)

## Faculty of Science and Engineering

### Department of CSE

Mid-Term Examination, Spring-2024

Course Title: Engineering Chemistry

Course Code: CHEM 0531175

Marks: 20

Time: 1 Hour

Answer all the questions. Assume necessary data/values if missing

1. (a) Explain Aufbau principle. Consider an elemental zoo where each element is a unique animal with different electron configuration. What would be your idea to group them in different cage. 2+2

- (b) Discuss briefly the postulates of Bohr's atomic model. 3

- (c) For  $n=3$ , list all the possible quantum numbers of electron associated with that orbit. 3

2. (a) Draw the orbital diagram of  $d_{xy}$ ,  $d_{yz}$ ,  $d_{zx}$ ,  $d_{x^2-y^2}$  and  $d_{z^2}$ . Explain their reason for orbital splitting. Why d-block elements form colorful compounds. Discuss with example. 2+1+1

- (b) Explain the periodic trend of ionization potential and atomic radius of atoms. 3

- (c) Fill the table with appropriate values. 3

Nuclide	$p^+$	$n^0$	$e^-$	Mass #
Oxygen -		10		
-	33	42		
- 31	15			

or, Find out the isotopes, isotones and isobars from the list:

$^{12}_6\text{C}$ ,  $^{14}_7\text{N}$ ,  $^{14}_6\text{C}$ ,  $^{40}_{19}\text{K}$ ,  $^{16}_8\text{O}$ ,  $^{40}_{20}\text{Ca}$ ,  $^{40}_{18}\text{Ar}$ ,  $^{13}_6\text{C}$ ,  $^{15}_7\text{N}$

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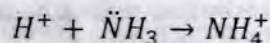
Marks: 50

Time: 3 Hours

*Answer all the questions. Assume necessary data/values if missing*

1. (a) Most of the times, we assume that half-life of any reaction is dependent 4  
on initial concentration of the reactants. Sometimes, it appears to be false.  
Identify the half-life of a first-order and a second-order reaction and show  
that one of them is not dependent on initial concentration of reactant.

- (b) You are assigned to design programming codes for a sensor to detect 3  
acids and bases. Hence, you require theoretical explanation of acid-base to  
test your codes. Now, describe Brønsted–Lowry and Lewis Acid-Base  
using the following reaction:



- (c) Discuss  $sp^3$  hybridization in  $H_2O$  molecule with electronic configuration 3  
and diagram.

2. (a) A researcher is synthesizing semiconductor materials where he requires 4  
constant pH environment. He used buffer solution. Describe the reaction  
mechanisms of acidic and basic buffer solutions to fulfill his purpose.

- (b) You need 0.5M HCl for a laboratory experiment but you have found 4M 3  
HCl in the lab. Therefore, you need to dilute the solution before use.  
Determine the volume of water needed to dilute 200 mL of a 4 M solution  
to a final concentration of 0.5M.

- (c) Red cabbage juice turns red in acidic solutions and green in basic 3  
solutions. You have three unknown solutions. By mixing a small amount  
of each solution with red cabbage juice, you observe following changes:  
Solution A + cabbage juice  $\rightarrow$  pink, Solution B + cabbage juice  $\rightarrow$  dark  
purple, Solution C + cabbage juice = teal blue. Knowing that a neutral  
solution with cabbage juice turns purple, can you analyze the solutions  
from strongest acid to strongest base?



3. (a) Discuss the Effect of temperature on an exothermic and endothermic reaction at equilibrium. 4
- (b) Describe the factors that can affect chemical equilibrium. 3
- (c) You are working in a production engineering team where you are assigned to design a vessel structure to sustain at the highest pressure. Therefore, the partial pressure is required to be calculated. The equilibrium constant ( $K_p$ ) for the reaction  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$  is  $10^2$  at a certain temperature. If the partial pressures of  $\text{SO}_2$  and  $\text{O}_2$  are 0.2 atm and 0.4 atm, respectively. Determine the partial pressure of  $\text{SO}_3$  at equilibrium. 3
4. (a) Derive rate equation of first order reaction with half-life 4
- (b) A first order reaction takes 20 min for 15% completion. Determine the rate constant and how long it takes to 60% completion. 3
- (c) One day you have found a reagent bottle containing  $\text{OH}^-$  where it labeled as  $1 \times 10^{-4} \text{ M}$ . You want to write the pH on the label for convenience. Determine the pH of a solution with a hydroxide ion concentration of  $1 \times 10^{-4} \text{ M}$ . 3
5. (a) Explain Lewis dot structure of  $\text{CH}_2\text{O}$  and  $\text{NH}_3$ . 4
- (b) Stability of compound can be evaluated using their bond order. Show the order of stability of  $\text{H}_2$ ,  $\text{H}_2^-$ ,  $\text{H}_2^+$  using that concept. 4
- (c) Assume that you are working as programming engineer at chemical industry. There is a boiler in which pressure should be below 70 kPa. Suggest any code in programming language for controller so that sensor detects the pressure and when pressure is above 70 kPa, the vent should be opened automatically; after the pressure reduced down to 70 kPa, the vent should be closed again. 2