



राष्ट्रीय प्रौद्योगिकी संस्थान जमशेदपुर
National Institute of Technology Jamshedpur
Jamshedpur - 831014, India

An Institute of National Importance established by Ministry of Education, Govt.

Department of Chemistry
I. B.Tech. ME, MM, PI, ECM / Mid Sem Exam / Spring Semester 2023-24

Course & Code: Engineering Chemistry. & CH1201

Duration: 2 Hours

Date: 18/03/2024

Day: Monday

Shift : B

Time: 03:00 – 05:00 pm

Course Instructors: Dr. S. K. Prasad, Dr. Moumita Mondal, Dr. Subrata Mahanta & Dr. S. Sakthivel

Answer all questions

Max. Marks: 30

Part A

- Find out magnetic moment of $[\text{Ru}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Ag}(\text{CN})]^-$ $\mu_m = \sqrt{n(n+2)} BM$
 $n = \text{no. of unpaired } e^-$ $2 M$
- Draw molecular orbital diagram of O_2 and find out O–O bond order in O_2 and O_2^+ $e^- 3+2 M$
- Arrange the following octahedral complexes in increasing order of Jhan-Teller distortion with reason
(a) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ (b) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ and (c) $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ $3 M$

Part B

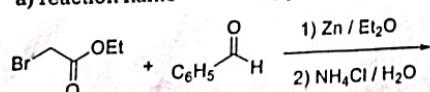
- 2.0 mol of an ideal gas diatomic gas at 300K and 0.507 MPa are expanded adiabatically to a final pressure of 0.203 MPa against a constant pressure of 0.101 MPa. Calculate the final temperature, q, w, ΔE and ΔH $3 M$
- Show mathematically that enthalpy (H) is a state function $3 M$
- Show that Joule-Thomson coefficient for a van der Waal's gas $4 M$

$$\mu_{J,T} = \frac{1}{C_p} \left(\frac{2a}{RT} - b \right)$$

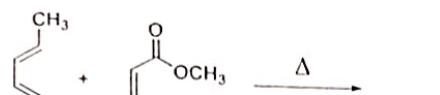
Part C

- Arrange the following chemical species in the order of increasing nucleophilicity in 1 M hydroxylic solvents: $\text{CH}_3\text{COO}^- ; \text{CH}_3\text{S}^- ; \text{HO}^- ; \text{H}_2\text{O}$ $1 M$

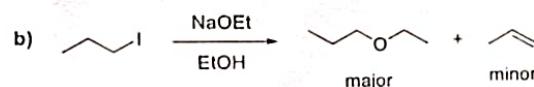
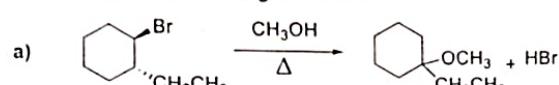
- For the following reaction, identify the $2 M$
 - reaction name
 - product formed with the complete reaction steps.



- Predict the major and minor products in the following Diels-Alder reaction and explain its formation $3 M$



- Provide the reaction mechanism in stepwise manner which accounts for the product(s) formation in the following reactions $4 M$





Department of Chemistry

B.Tech. (1st) End Semester Exam [CE, CS, EC & EE] 2024-25

Course: Engineering Chemistry

Code: CH1101

Max. Marks: 50

Date: Dec 09, 2024

Duration: 03 h

Day: Monday

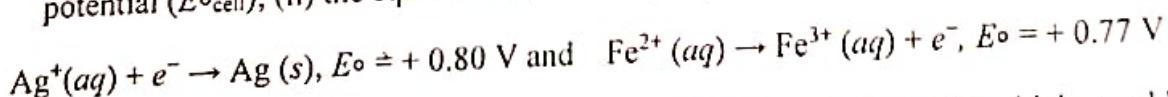
- Attempt all the parts of a particular question at one place.
- Marks of the question are indicated in the square brackets.
- Symbols and notations carry usual meaning, unless otherwise stated.
- Assume suitable data, if considered necessary, and indicate it clearly.

1. Answer the following questions. [3 × 4 = 12]

- The molar heat capacity of a solid metal is given by the following equation in the temperature interval 300 K to 600 K. $C_p = 25.94 + 5.44 \times 10^{-3}T \text{ J K}^{-1} \text{ mol}^{-1}$. What is the change in enthalpy, internal energy and entropy at constant volume, when 1 mol of this metal is heated from 300 K to 600 K.
- Derive expressions for work done by a gas following ideal gas law expanding from V_1 to V_2 , isothermally and (i) reversibly and (ii) irreversibly and show that during compression, work done in reversible process is less than that of irreversible process.
- Deduce the expression for the entropy of mixing of pure gases A, B and C having "a", "b" and "c" moles occupying V_A , V_B and V_C at a particular temperature T, respectively; and calculate the entropy of mixing for hydrogen, oxygen and nitrogen gases having weights 0.2g, 3.2 g and 2.8 g, respectively.
- A Carnot engine operating under reversible conditions between 630 and 300 K and absorbs 4184 J from the source in one cycle. What is the efficiency of the engine? How much heat is rejected to the sink? How much work is done per cycle?

2. All the questions are mandatory. [4+4+3+2]

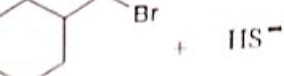
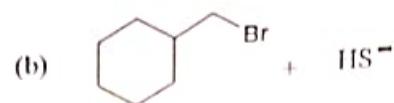
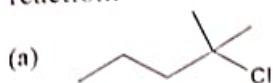
- Describe the functioning of a pH meter with the help of a neat sketch. Explain how the pH meter utilizes cell potential measurements to determine the pH of a solution, referencing the Nernst equation in your explanation.
- Consider a galvanic cell consisting of the following half-reactions, calculate (i) the standard cell potential (E°_{cell}); (ii) the equilibrium constant (K_{eq}) for the cell reaction at 25 °C:



- Based on the knowledge acquired in the course, which type of electric vehicle would you choose to purchase: a lithium-ion battery electric car or a hydrogen fuel cell electric car? Discuss your choice in terms of energy efficiency, environmental impact, cost, infrastructure availability, and long-term sustainability.
- What are the advantages of Li-ion batteries in comparison with Lead-acid and Ni-Cd batteries?

3. Answer the following questions [2 + 2 + 2 + 2 + 2 + 3]

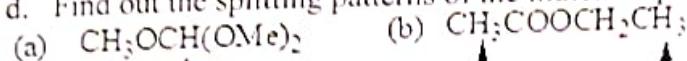
a. Draw the product of nucleophilic substitution and determine the likely mechanism (S_N1 or S_N2) for each reaction.



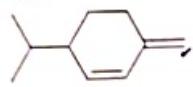
b. How will you prove the completion of reduction of *cyclohexanone* to *cyclohexanol* through IR spectroscopy?

c. The base peak in the mass spectrum of 2,2,4-trimethylpentane occurs at m/z = 57. What ion is responsible for this peak and why is this ion the most abundant fragment?

d. Find out the splitting patterns of the indicated protons in the ¹H NMR spectra.



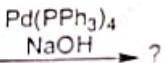
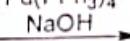
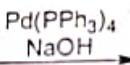
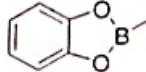
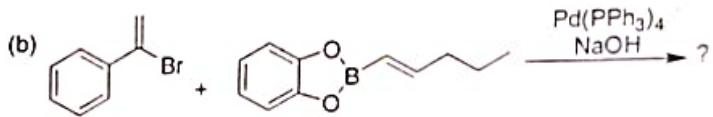
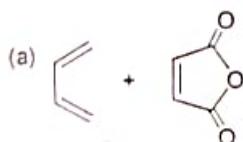
e. Determine the wavelength of maximum absorption (λ_{max}) of the following compounds based on the given data.



- (i) base value for butadiene system: 214 nm
- (ii) alkyl substituents or ring residue attached to the parent diene: 5 nm
- (iii) double bond extending conjugation: 30 nm
- (iv) exocyclic double bond: 5 nm



f. Draw the products of the following reactions with stereochemistry.



4. Answer the following questions 4 + 2 + 2 + 4

a. Derive the expression for rate constant for a second order reaction where the initial concentrations of the reactants are (i) same: $[A]_0 + [B]_0 \rightleftharpoons P$ (ii) different: $[A]_0 + [B]_0 \rightleftharpoons P$, where the rate of the reaction is first order with respect to each reactant. Show in which condition the reaction behaves as a first order.

b. The half-life period of a first order decomposition of H₂O₂ is 360 min at 380 °C. The energy of activation of the reaction is 200 kJ/mole. Calculate the time required for 75% decomposition at 450 °C.

c. Explain why the molecular mass of acetic acid in Benzene determined by any Colligative property is higher than its actual molecular mass.

d. A certain solution of 1 m benzoic acid in benzene has a freezing point of 3.1 °C and normal BP of 82.6 °C. The freezing point of benzene is 5.5 °C and its boiling point is 80.1 °C. Analyze the state of the solute (benzoic acid at two temperatures and comment).

~Good Luck~

