


VIT

 Vellore Institute of Technology
(Deemed to be University under section 3 of U.G.C. Act, 1956)
SCHOOL OF ADVANCED SCIENCES
Department of Chemistry
Fall Semester 2023-24
Continuous Assessment Test – 2
Course Code: BCHY101L

Duration: 90 Minutes

Slot: D1 +TD1

Course Name: Engineering Chemistry

Max. Marks : 50

Class Numbers: VL2023240106278, 6212, 6214, 6216, 6218, 6237, 6242, 6246, 6250, 6254, 6262, 6274, 6282, 6286, 6290

Faculty Names: Dr. Priyankar Paira, Dr. Sriraghavan K, Dr. Buvaneswari G, Dr. Loganathan Rangasamy, Dr. Satish Kumar G, Dr. Manish Kumar Mishra, Dr. Abir Sarbajna, Dr. Tapas Ghatak, Dr. Ganesh Babu S, Dr. Tamas Kumar Panda, Dr. Badal Kumar Mandal, Dr. Sasikumar S, Dr. Madhumitha G, Dr. Asharani I.V, Dr. Mausumi Goswami

| QN | Answer ALL the questions (5 X 10 = 50 Marks) | Marks | CO | BL |
|----|---|-------|-----|-----|
| 1 | How will you prove that the efficiency of an engine is determined by the temperature of the source and sink, not by the working substance? | 10 | CO2 | BL2 |
| 2 | <p>(a) 1.5 moles of an ideal monoatomic gas at 28 °C expands reversibly and adiabatically from a volume of 17 dm³ to 28 dm³. By considering $C_v = 1.5R$, calculate ΔH and ΔU.</p> <p>(b) What will happen to the kinetics of the following reaction if you add a small amount of sodium bromide to the reaction mixture?</p> $2\text{H}_2\text{O}_2(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$ | 5 + 5 | CO2 | BL3 |
| 3 | <p>(a) A first-order reaction takes 9 hours for its 80% completion. Calculate the time required for its 95% completion.</p> <p>(b) How will you prove that isothermal reversible and irreversible expansion processes are spontaneous in nature?</p> | 5 + 5 | CO2 | BL3 |
| 4 | <p>(a) Explain the use of acetic anhydride in making an analgesic drug that is readily absorbed from the gastrointestinal tract.</p> <p>(b) Why "Prussian blue" cannot be used in the textile industry for making blue jeans? Suggest a suitable method for making blue jeans.</p> | 5 + 5 | CO1 | BL2 |

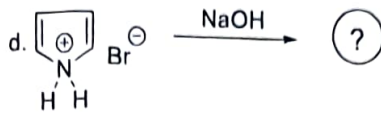
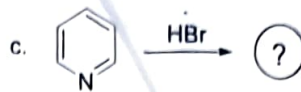
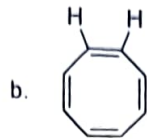
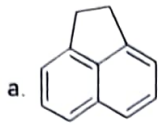
5

Identify the aromatic/anti-aromatic/non-aromatic character of the following compounds.

10

CO1

BL4



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KEY

1. How will you prove that the efficiency of an engine is determined by the temperature of the source and sink, not by the working substance?

Four processes of the Carnot cycle, with W1, W2, W3, and W4 with graph and formulas- 4x2.5= 10M.

$$\eta = \frac{\text{work performed}}{\text{heat absorbed from the hot source}} = \frac{W}{q_h} = 1 - q_c/q_h = 1 - T_c/T_h$$

2. a) 1.5 moles of an ideal monoatomic gas at 28 °C expands reversibly and adiabatically from a volume of 17 dm³ to 28 dm³. By considering Cv = 1.5R, calculate ΔH and ΔU.

Final temperature (Tf); 1.5 Ln(Tf/301)= Ln(17/28)= 215.82K

ΔU= 1.5x1.5x8.314x(215.82-301)= -1593.8J

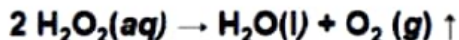
ΔH=ΔU+ΔPV= ΔU+nRT; -1593.8+1.5x8.314x(215.82-301)= -2656.8J

b) What will happen to the kinetics of the following reaction if you add a small amount of sodium bromide to the reaction mixture?

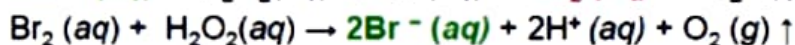
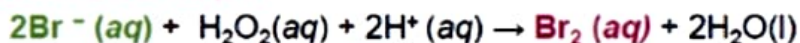


The rate of reaction will be faster due to the lowering of activation energy according to the following reaction, 2M+3M for the explanation.

The decomposition of aqueous hydrogen peroxide, H₂O₂(aq) , into water and oxygen:



In presence of catalyst:



3a. A first-order reaction takes 9 hours for 80% completion. Calculate the time required for 95% completion.

K=2.303/9 log(100/20)= 0.17885 s⁻¹; t(95%)= 2.303-0.17885xlog (100/5) = 16.75hours

Formulas, substitution, final answers= 2m+2m+1M

3b. How will you prove that isothermal reversible and irreversible expansion processes are spontaneous in nature?

Reversible process-2.5m and irreversible process-2.5m as detailed below.

> **Total Entropy change in irreversible (spontaneous) process of a perfect gas**

✓ example: **isothermal** expansion of an ideal gas at constant temperature into **vacuum**

As, $w = 0$, $\Delta U = 0 \Rightarrow q = 0$ [from 1st law]
 \Rightarrow no heat is absorbed by or removed from the surrounding,

Hence, $\Delta S_{\text{surrounding}} = 0$

$$\Delta S_m = R \ln(V_f/V_i)$$

As, $S_{\text{total}} = S_{\text{system}} + S_{\text{surrounding}}$

$$\begin{aligned} \therefore \Delta S_{\text{total}} &= \Delta S_{\text{system}} + \Delta S_{\text{surrounding}} \\ &= R \ln(V_f/V_i) + 0 \\ &= R \ln(V_f/V_i) \end{aligned}$$

\rightarrow As $V_f > V_i$, this spontaneous (irreversible) isothermal expansion of a gas is accompanied by the increase in entropy.

> **Isothermal Reversible expansion**

$$w = -p\Delta V \quad \& \quad q_{\text{rev}} = p\Delta V$$

$$\begin{aligned} \therefore S_{\text{total}} &= \Delta S_{\text{system}} + \Delta S_{\text{surrounding}} \\ &= \left(\frac{q_{\text{rev}}}{T}\right) + \left(-\frac{q_{\text{rev}}}{T}\right) \\ &= 0 \end{aligned}$$

> **Clausius inequality** $dS \geq \frac{dq}{T}$

▪ In an isolated system, there is no heat transfer and $dq = 0$, thus $dS \geq 0$

\Rightarrow **all natural processes are spontaneous & irreversible.**

▪ Reversible process:

$$dS_{\text{total}} = dS_{\text{system}} + dS_{\text{surrounding}} = 0$$

\Rightarrow spontaneous in neither direction and is at equilibrium

▪ Irreversible process

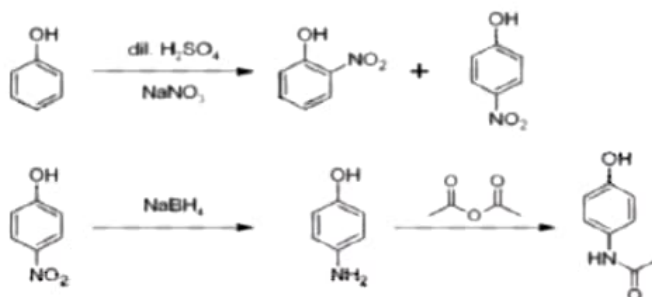
$$dS_{\text{total}} > dS_{\text{system}} + dS_{\text{surrounding}} > 0$$

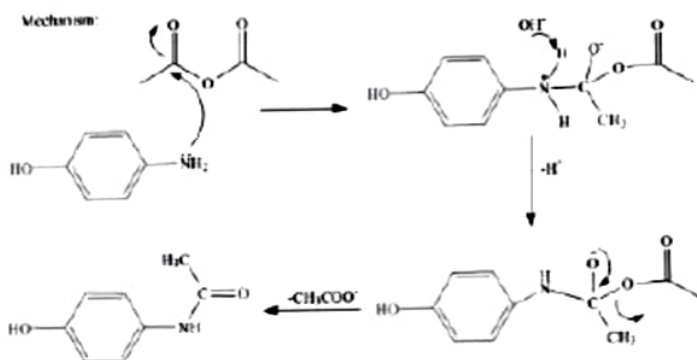
\Rightarrow **All spontaneous process occurring in Nature are irreversible and entropy of the universe is increasing continuously.**

4a. Explain the use of acetic anhydride in making an analgesic drug that is readily absorbed from the gastrointestinal tract.

Paracetamol with structure-2M

Preparation and Mechanism-3M





4b. Why "Prussian blue" cannot be used in the textile industry for making blue jeans? Suggest a suitable method for making blue jeans.

Prussian blue – Mixture of hexacyanoFe(II) and Fe(III) - $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ is not suitable due to its solubility in water-2M+ Indigo dye details as mentioned below, 3M

- ❖ Indigo dye is widely used to color blue jeans.
- ❖ The chemical in indigo which is responsible for the blue colour is indigotin, which is a dark blue powder at room temperature and is insoluble in water and ethanol.
- ❖ It is most soluble in chloroform, nitrobenzene and sulphuric acid. It has a fused nitrogen heterocyclic structure.
- ❖ To overcome the solubility problem, the dye is reduced to soluble leucoindigo (known as 'white indigo'), and applied to clothes in this form. When exposed to atmospheric oxygen it re-oxidises to the insoluble form and regains its colour..
- ❖ Once the dye is applied to the fabrics, the dye will not be leached out even after several washings due to its insolubility in water.

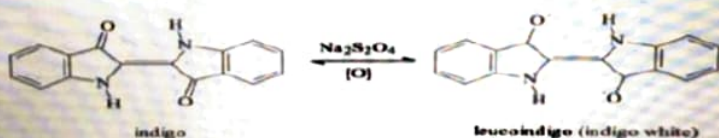
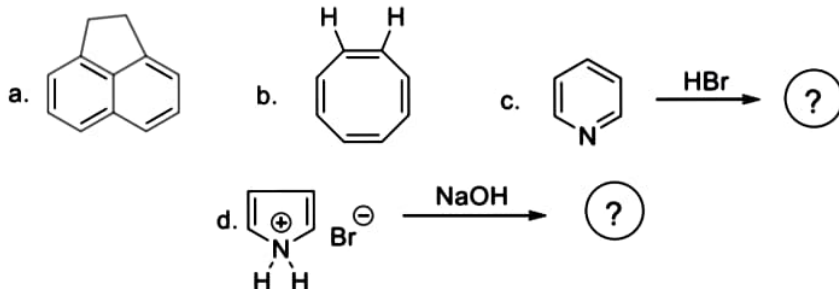


Figure 2: The reaction showing the conversion of the insoluble blue indigo dye to the clear yellow, water soluble leucoindigo or indigo white.

5. Identify the aromatic/anti-aromatic/non-aromatic character of the following compounds.



a. Non-aromatic, with four rules, cyclic, no conjugation, non-planar, $4n+2$, $n=2$, $-2M$

b. Non-aromatic, with four rules and tub shaped stuture-2M

c. Pyridinium cation- aromatic, with four rules-2M

d. Pyrrole- aromatic, with four rules-Reaction 1M+1M for the following reaction

