ST. JOSEPH'S UNIVERSITY, BENGALURU-27
B.Sc. - 2nd SEMESTER
SEMESTER EXAMINATION: APRIL 2024
(Examination conducted in May/June 2024)
BCH221 - Physical and Organic Chemistry
(For current batch students only)

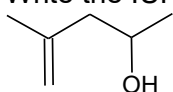Time: 2 hours   Max. marks: 60

This paper contains 4 printed pages and 4 parts.

Part A

Answer any ELEVEN questions of the following: Each question carries 1 mark.   **(11x1=11)**

1. Write the IUPAC name of the following:

2. Write the bond line formula of 1,2-dichlorocyclohexene.

3. Which is the device used for measuring the effect of optically active compounds on plane-polarized light?

4. The internal energy of a perfect gas does not change when the gas undergoes isothermal expansion. What is the change in enthalpy?

5. Write the important resonance structures for the following:
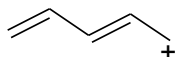
6. Which reagent in each pair would be a more reactive nucleophile in a polar aprotic solvent?
   i) CH_3NH^- or CH_3NH_2 ii) CH_3SH or CH_3OH

7. Which alkyl halide would you expect to react more rapidly by an S_N2 mechanism?
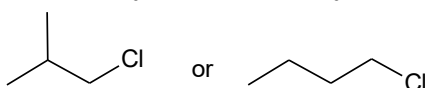

8. How is the oxygen saturation curve of haemoglobin different from that of myoglobin?

9. The re-formation of a DNA double helix is given by the following:
   Strand + complementary strand → double helix
   The rate equation for this process is v = k [strand] [complementary strand]. What is the order of the reaction?

10. Name the law that is applicable in making carbonated beverages.

11. Name a device that is used to study the thermal denaturation of biological macromolecules.

12. Give an example of a system that shows upper critical solution temperature.

13. What is an emulsion?

Part B

Answer any NINE questions of the following: Each question carries 2 marks.   **(9x2=18)**
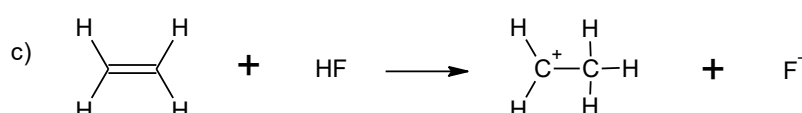
14. Why is a freezing mixture formed when a salt such as KCl is added to ice?

15. State Nernst distribution law.

16. What are gels? How are they classified?
17. Chloroacetic acid has a lower pK_a value compared to acetic acid. Explain
18. What are the limiting conformations of ethane? Why is there a potential energy difference between them?
19. Sketch the free-energy diagram for a S_N2 reaction.
20. The equilibrium constant for the hydrolysis of the dipeptide alanylglycine by a peptidase enzyme is $K = 8.1 \times 10^2$ at 310 K. Calculate the standard reaction Gibbs energy for the hydrolysis. (R= 8.31447 J K^{-1} mol^{-1}).
21. List the substituents in each of the following sets in order of priority, from highest to lowest as per Cahn-Ingold-Prelog rules.
    a) –OH, –SH, –H, –I   b) –CH$_3$, –CH$_2$OH, –COOH, –CHO
22. Define the terms i) plane of symmetry   ii) racemic mixture
23. The half-life of pyruvic acid in the presence of an aminotransferase enzyme (which converts it to alanine) was found to be 221 s. How long will it take for the concentration of pyruvic acid to fall to $1/64$ of its initial value in this first-order reaction?
24. Write the major product for each of the following reactions:

a)

$$\xrightarrow[\text{EtOH, 50}^0\text{C}]{\text{EtO}^-} \ ?$$

b)

$$\xrightarrow[\textit{t}\text{-BuOH, 50}^0\text{C}]{\textit{t}\text{-BuO}^-} \ ?$$
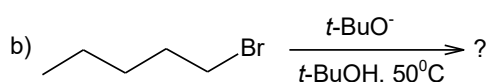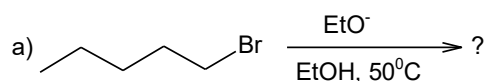
Part C

Answer any SEVEN questions of the following: Each question carries 3 marks.   **(7x3=21)**

25. What is the principle of steam distillation?
26. Sketch the vapour pressure-composition curves for the three types of completely miscible binary solutions.
27. Rewrite each of the following reactions using curved arrows and show all nonbonding electron pairs.

a) $H_3C{-}OH$ **+**   HI $\longrightarrow$ $H_3C{-}\overset{+}{O}H_2$ **+** I^-

b) $H_3C{-}NH_2$ **+**   HCl $\longrightarrow$ $H_3C{-}\overset{+}{N}H_3$ **+** Cl^-

c)

   +   HF $\longrightarrow$

   + F^-

28. Write the structure of the two chair conformers of methylcyclohexane? Which one is more stable? Why?
29. What is the principle of the diastereomeric method of resolution of enantiomers?
30. Write the mechanism for E1 reaction using *tert*-butyl chloride as substrate.
31. The product of an S_N2 reaction gives inversion in configuration whereas an S_N1 reaction gives a racemic mixture. Explain.

32. In a particular biological reaction taking place in the body at 37°C, the change in enthalpy was −125 kJ mol^{-1} and the change in entropy was −126 J K^{-1} mol^{-1}.
(a) Calculate the change in Gibbs energy. (b) Is the reaction spontaneous?
(c) Calculate the total change in entropy of the system and the surroundings.

33. A rate constant is 1.78 x 10^{-4} L mol^{-1} s^{-1} at 19°C and 1.38 x 10^{-3} L mol^{-1} s^{-1} at 37°C. Evaluate the Arrhenius parameters of the reaction given R= 8.31447 J K^{-1} mol^{-1}.

Part D

Answer any TWO questions of the following: Each question carries 5 marks.　　　**(2x5=10)**

34. Consider the phase diagram for iodine (a one component system) shown below and answer the following questions.
    a. What is the normal boiling point for iodine?
    b. What is the melting point for iodine at 1 atmosphere?
    c. What is the critical temperature and pressure of iodine?
    d. Determine the number of phases and degree of freedom along the curve AO.
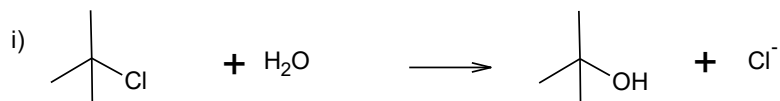   e. What is the degree of freedom at point O?
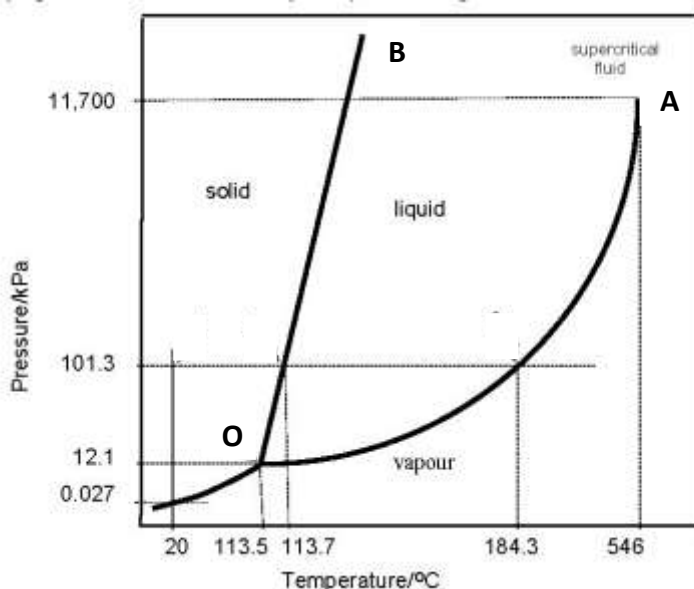
35. Identify the relationship between the following pairs of structures by describing them as representing enantiomers, diastereomers, constitutional isomers, or two molecules of the same compound.
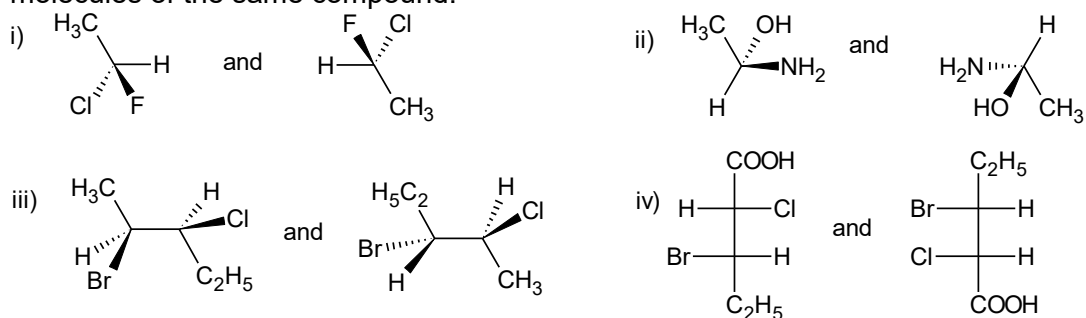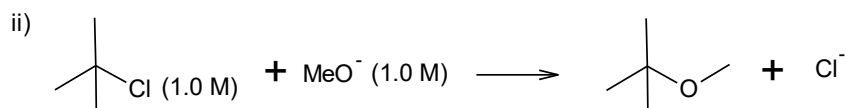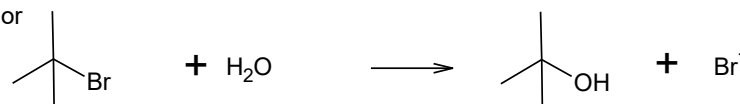
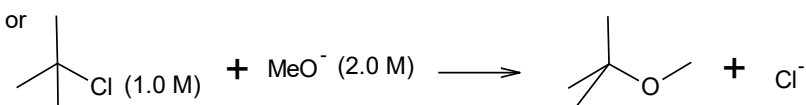36. a) Which S_N1 reaction of each pair would you expect to take place more rapidly? Explain your answer.

i)

$+ \; H_2O \longrightarrow$ (t-Bu)OH $+ \; Cl^-$

or

(t-Bu)Br $+ \; H_2O \longrightarrow$ (t-Bu)OH $+ \; Br^-$

ii)

(t-Bu)Cl (1.0 M) $+$ MeO$^-$ (1.0 M) $\longrightarrow$ (t-Bu)OMe $+ \; Cl^-$

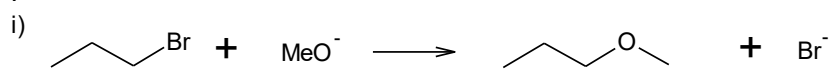or

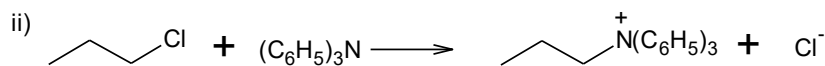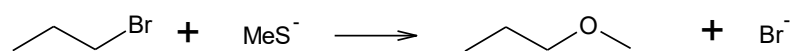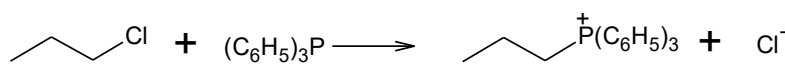(t-Bu)Cl (1.0 M) $+$ MeO$^-$ (2.0 M) $\longrightarrow$ (t-Bu)OMe $+ \; Cl^-$

b) Which S_N2 reaction of each pair would you expect to take place more rapidly in a protic solvent?

i)

CH$_3$CH$_2$CH$_2$Br $+$ MeO$^- \longrightarrow$ CH$_3$CH$_2$CH$_2$OMe $+ \; Br^-$

or

CH$_3$CH$_2$CH$_2$Br $+$ MeS$^- \longrightarrow$ CH$_3$CH$_2$CH$_2$OMe $+ \; Br^-$

ii)

CH$_3$CH$_2$CH$_2$Cl $+$ $(C_6H_5)_3N \longrightarrow$ CH$_3$CH$_2$CH$_2\overset{+}{N}(C_6H_5)_3$ $+ \; Cl^-$

or

CH$_3$CH$_2$CH$_2$Cl $+$ $(C_6H_5)_3P \longrightarrow$ CH$_3$CH$_2$CH$_2\overset{+}{P}(C_6H_5)_3$ $+ \; Cl^-$

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