Indian Institute of Science Education and Research, Tirupati

ABHIPRAJNA 2023 (Prelims)

CHEMISTRY QUESTION PAPER

Date: September 17, 2023 Maximum points: 30

Instructions:

- *All questions are mandatory*
- *The question paper consists of 7 questions in total, spread over 4 pages.*
- *Answers must be written in legible and readable handwriting, failing which that question shall not be considered for evaluation.*
- *All Questions are Mandatory*
- *Question 3 (marked with a star) is the hint question, whose answer will be the solution to the puzzle round.*
- *Click this link for submitting your solution PDF:* https://forms.gle/aTVAvpL764NTrYTZ8

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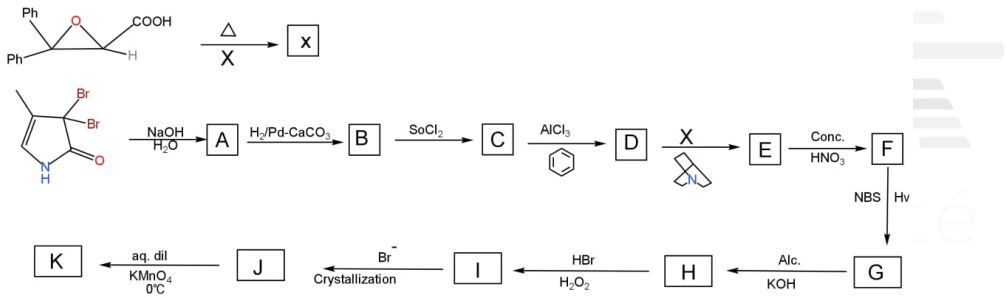
1. **(12 * 0.5 = 6 points)**



Find the Final Product of the Reaction:

2. **(3 points)**

DUAL REACTIONS: SAME PRODUCT

Suppose you have been given six chemicals:

1. Chlorobenzense
2. 1,4 - diphenyl but-3-en-2-one

3. 4-hydroxy-1,4-diphenyl butan-2-one
4. phenol
5. 3-Hydroxy-1,4- diphenyl butanone
6. salicylic acid

and the following reagents

1. NaOH
2. Triethylamine
3. HCl
4. silyl esters

Provide two chemical reactions involving two of the chemicals provided and using the appropriate reagents such that both the reactions produce the same product. Also, write the mechanism

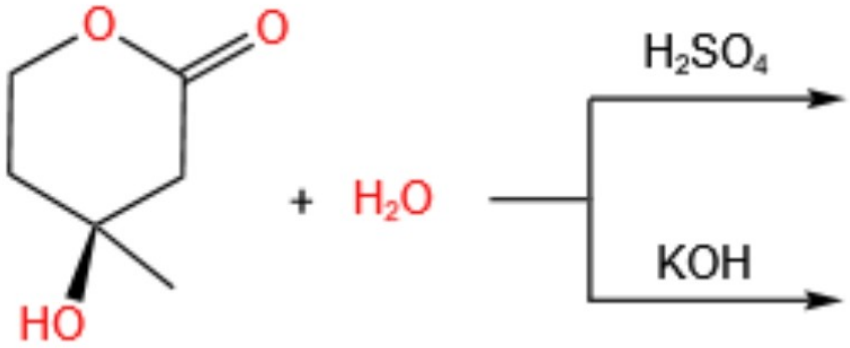
3. **(2 + 2 = 4 points) ***

MULTIPLE PATHWAYS

Complete the following reactions and provide a detailed reaction mechanism :

(Hint: Both yield the same products, yet entirely different reaction mechanisms)

Puzzle Question Hint: Find the common name of the product formed.



4. **(3 points)**

LET'S DO SOME CALCULATIONS

Tris is a weak base frequently used to prepare buffers for bio-chemical use. Its full name is tris-(hydroxymethyl) aminomethane, Pka = 8.08. A volume of $500cm^3$ of a buffer at PH 8.2 is required, and we have available a $0.2000mol\ dm^-3$ solution of

tris. What volume of $2.000 mol\, dm^{-}3\ HCl$ must be added to what volume of tris to achieve this?

5. **(3 + 2 = 5 points)**

The auto-protolysis of water is given by the chemical equation:

$$2H_2O_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

As the reaction returns to equilibrium after the temperature jump, the relaxation time was measured to be $37\mu s$ at $298K$ and pH = 7

1. What is the order of the forward and the reverse reaction in this case? Given that the equilibrium constant to be 1.008×10^{-14}, calculate the rate constants for the forward and the reverse reactions.
2. Would the Kw change if we use heavy water (D2O) instead of H2O? If yes, explain why, how it changes and if not, explain why not. With this, comment on the pD of the heavy water compared to the pH of water. Explain.

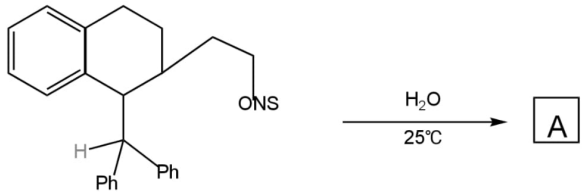
6. **(1+1+1+1+1+1 = 6 points)**

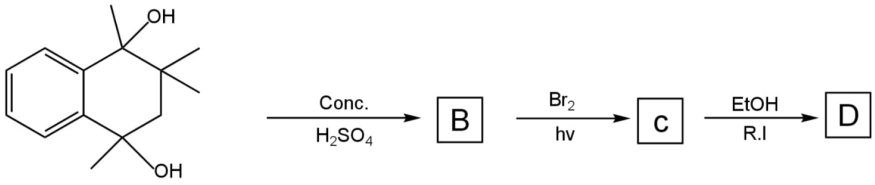
COLORIMETRIC INDICATOR SYNTHESIS:

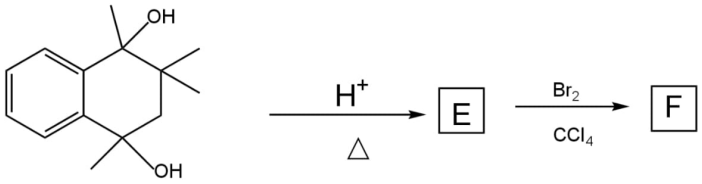
Subh is facing a problem of discoloration and staining (mainly getting a yellow or reddish-brown color to the solution), affecting the aesthetic appearance of his industrial product. He assumed ferric or thiocyanate ion impurity in his industrial solution. So, he thought to make a particular indicator (colorimetric reagent), which would help him to find the concentration of that specific impurity in his solution. So he goes through the process - He takes "A," which is a colorless solid, by heating, gives a colorless gas (C) with a brown residue(D), and by dissolving in water, gives a yellow solution(B). This yellow solution reacting with barium chloride provides barium sulfate. In the presence of sodium hydroxide, this yellow solution gives a reddish brown ppt (E) [which is insoluble in NaOH]. Now he reacts "E" with concentrated HCl followed by thiocyanate ion; it gives him the blood red color desired compound (P). Identify A, B, C, D, E, and p.

7. **(3 points)**

Decide the no of transition state formed during A, B, E product formation. And write down all the products from A to F.







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