SYSTEMIC ASSESSMENT AS A NEW TOOL FOR ASSESSING STUDENTS LEARNING IN HETEROCYCLIC CHEMISTRY

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ABSTRACT

Systemic Assessment [SA] has been shown to be highly effective new tool in raising the level of students academic achievements, improve their ability to learn by enhancing the process of teaching and learning, and converts students from surface to deep learning. It also allow teacher to monitor students learning throughout the course and gives him the ability to make necessary adjustments to improve learning. SA strategy changes assessment from linear bothering exams to enjoyable puzzle games by dealing with systemic assessment diagrams. The aim of the systemic assessment (SA) of learners in heterocyclic chemistry is to introduce an efficient evaluation of the systemic- oriented objectives of the [SATL-Heterocyclic Chemistry] model & effective tool for assessing students' meaningful understanding of heterocyclic chemistry topics in the tertiary level .Systemic Assessment Questions SAQ,s are the building unites of the systemic assessment .It measures the students' ability to correlate between hterocycles and to discover new relations between them. In this issue we use SA as a tool to assess the student achievement in heterocyclic chemistry by choosing five types of systemic assessment questions, namely Systemic Multiple Choice Questions (SMCQ,s), Systemic True False Questions (STFQ,s) ,Systemic Matching Questions (SMQ,s) ,Systemic Sequencing Questions (SSQ,s),and Systemic Synthesis Questions (SSynQ, s). *[African Journal of Chemical Education—AJCE 5(2), July 2015]*

INTRODUCTION

Heterocyclic chemistry appears to be hard to a large number of students due to the versatility and complexity of heterocyclic compounds, enormous amount and variety of information, abstract nature of many heterocyclic chemistry concepts, teaching styles applied in classes, and lack of new teaching aids... For this reasons and others the students find the following difficulties in learning heterocyclic chemistry (1); i) to remember the structural formulas of heterocyclic compounds and understand the chemical properties related to these structures, ii) to understand the reactivity of compounds due to enormous diversity of structures; iii) to understand the systemic effect of heteroatom on the reactivity of both heterocycles and the attached functional groups, iv) to synthesize systemic chemical relations between compounds of the same or different heterocycles , v) to follow up the theoretical bases connected to the complexity of heterocycles, vi) to design Synthesis of new target heterocyclic compounds via RSA..

For these reasons we use SA strategy is to enhance, support and improve both teaching and learning processes in heterocyclic chemistry via; (i) helping teachers to use evidence of student learning to assess student achievement against goals and standards to improve their performance, (ii) enable students to make feedback and feed forward during their study of any heterocyclic course materials, and helping them in making maximum connections between heterocyclic chemistry concepts, compounds, and reactions: iii) enable students to think systemically to solve complexity. Thus the student should be able to think in a systemic way when he is able to analyze a systemic to its fundamental components/subsystems and to synthesize these components into a meaningful whole, namely, to organize a systemic of interest (2-3). The students gain all these skills via solving different types of SAQ; s which is the building unites of the systemic assessment. By using SA we actually measure the change in cognitive structure of our students after each learning process.

Goals

Our goal of this issue is to make use of different types of SAQ,s :i) to build a new systemic assessment strategy in heterocyclic chemistry to assess students meaningful understanding which might lead to a better understanding of the systemic relations between heterocyclic compounds and their reactivity in chemical reactions: ii) to overcome the complexity of heterocyclic compounds structures and working memory limitation (as well as overload) by constructing cognitive schemas" combining simple elements into more complex ones" [4-5]. Cognitive schemas reduce working memory load, because even highly complex schema can be considered as a single element in the working memory [4-5]. Systemics which is the building unites of SAQ, s can be considered as closed cognitive schemas.

Discussion

Students organize their thinking in dealing with systemic diagrams of systemic assessment. By solving SAQ,s students use their critical thinking, problem solving and decision making abilities, demonstrate self-management skills, improve their perception by increasing their observation skills, and learn through creation and not through reproduction, therefore, they could increase their creativity (6). Also, SAQ schemes were used as a strategy for capturing students' systemic thinking skills in organic chemistry (7).

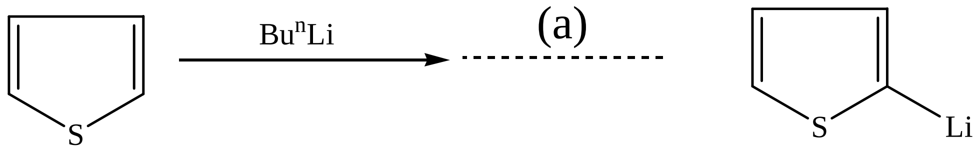
In this issue we will introduce SA of learners as an efficient evaluation of the systemic-oriented objectives of the [SATL-Heterocyclic Chemistry] model and effective tool for assessing students' meaningful understanding of heterocyclic chemistry topics in the tertiary level. A significant association was observed between students' performance on SAQ, s and on objective items designed for assessing their meaningful understanding. This association reveals that the students' systemic thinking level developed in organic chemistry is strongly related to a deeper understanding of the relevant chemistry concepts (7) .In this regards we will illustrate five types of SAQ,s in heterocyclic chemistry based on systemics to assess students at synthesis and analysis learning levels. We experiment some of these questions successfully on our 3ed year major chemistry students, faculty of science, Ain Shams University, Egypt. On the other hand the conventional (Linear) assessment questions (LAQ, s) in heterocyclic chemistry were designed to assess simple recall of knowledge which intensify rote learning and linear thinking.

Linear Assessment VS Systemic Assessment in Heterocyclic Chemistry

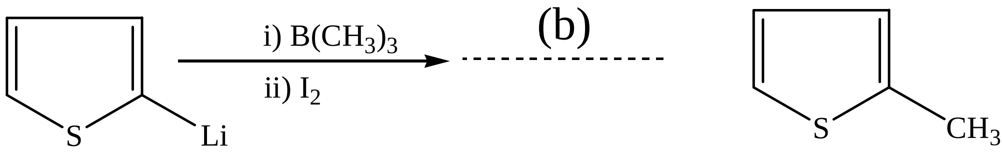
A-Linear Assessment in Heterocyclic Chemistry [LAHC]: [eg.Thiopene chemistry]

In the linear (Traditional) Assessment of heterocyclic chemistry [LAHC] we ask our students to represent the different types of reactions by chemical equations. The student can write the correct symbolic chemical equations, but, however, he couldn't correlate between reactants and resultants or between both and used reagents. So, the student just writes separate chemical equations without any comprehension or appreciating significance of these relationships representing the chemical reactions [rote learned materials]. According to Ausuble [8] rote learned materials are not anchored to existing concepts, it is more easily forgotten and consequently assesses our students at lower learning outcomes [memorization].

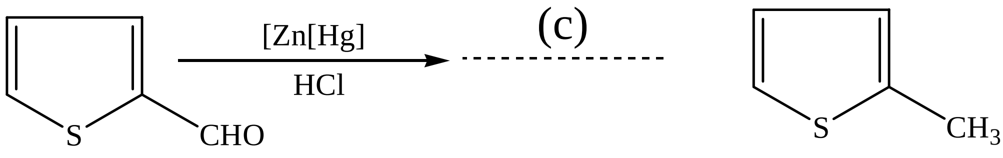
Q: Complete the following equations [1-6]: [eg.Thiopene chemistry]:



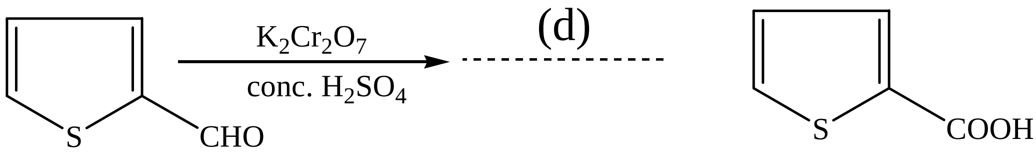
(Equation-1)



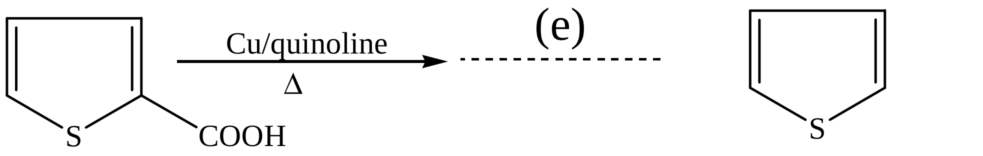
(Equation-2)



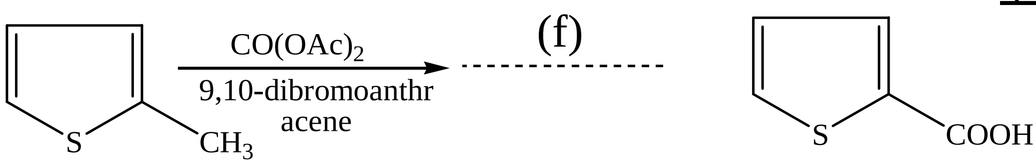
(Equation-3)



Equation4)



(Equation5)



(Equation6

B-Systemic assessment in heterocyclic chemistry [SAHC] [Thiophene chemistry]

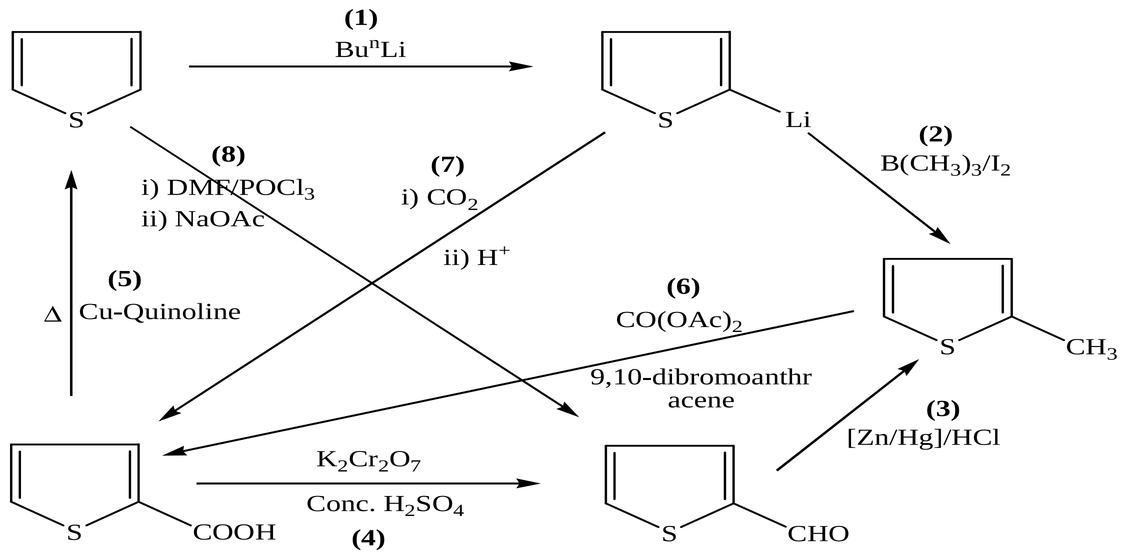
We can ask our students about the same chemical reactions 1-6 by using systemic assessment questions, based on systemic.

E.g.: Systemic Synthesis Question: [Sync]

Draw pentagonal systemic diagram illustrating the chemical relations between thiophene and its related compounds stated in the chemical equations 1-6.

A) In this type of question we assess our students' knowledge about chemical relations between (thiophene-2-Lithiothiophene-2-Methylthiopene-2-Formylthiophene-2-Carboxythiophene), beside the relations between the six chemical processes [Lithiationmethylation,-reduction [Zn [Hg]/HCl –oxidation-decarboxylation - reduction with Co (OAc) 2] and the used reagents.

The student synthesizes the following systemic pentagonal diagram which is considered as closed cognitive scheme.



In the above question ,we assess our student at the synthesis learning level by synthesizing the above pentagonal systemic diagram to show the relations between the five thiophene compounds and the chemical processes in equations 1-6 and. The student discovers another two possible chemical relations between the above thiophene compounds (Carboxylation-7, and formylation-8).

DESIGNING OF SYSTEMIC ASSESSMENT QUESTIONS IN HETEROCYCLIC CHEMISTRY

Systemic diagrams representing different types of systemic assessment questions [SAQ, s] in which the selected heterocyclic compounds of any reaction were located in the given systemic. SAQ, s have been designed in accordance with the guidelines sated by: Tzougraki (2), Golemi (6), Fahmy & Lagowski (9-11)

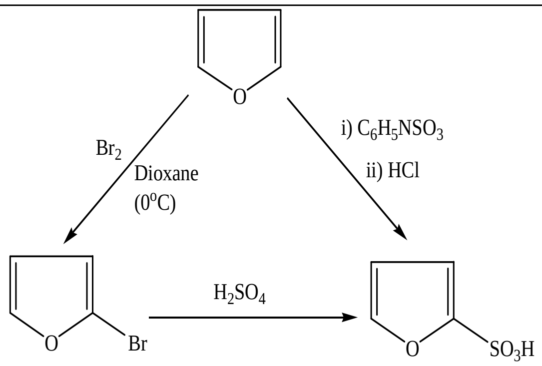
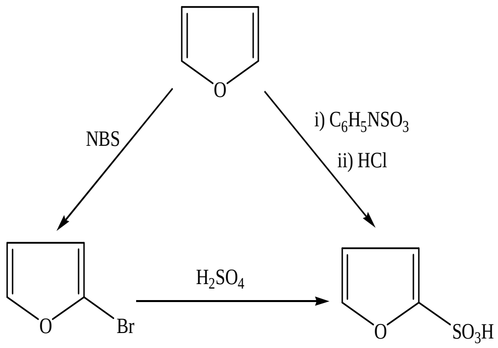
Here we continue our work on systemic assessment to assess student academic achievement in heterocyclic chemistry by using new different types of SAQ,s, namely, Systemic Multiple Choice Questions [SMCQ,s], Systemic True False Questions [STFQ, s], Systemic Matching Questions [SMQ,s], Systemic Sequencing Questions [SSQ, s], Systemic Synthesis Questions [SSynQ,s].

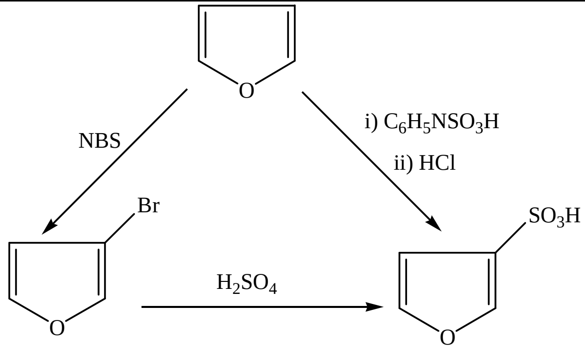
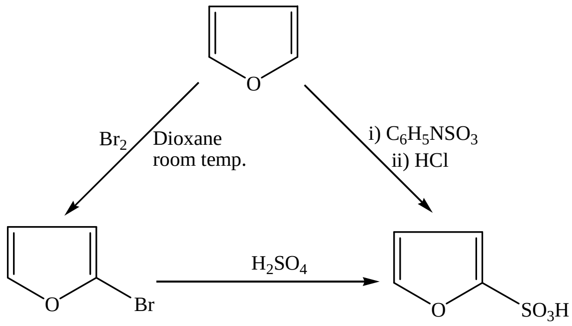
Type [I]: Systemic multiple choice questions [SMCQs] :(9)

SMCQs are choosing of one systemic from a list of possible systemic. Each systemic represents at least three chemical relations between three heterocyclic compounds. SMCQs are well suited for testing students' comprehension, synthesis, and analysis.

Put (✓) in front of the correct systemic diagram in each of the following questions:

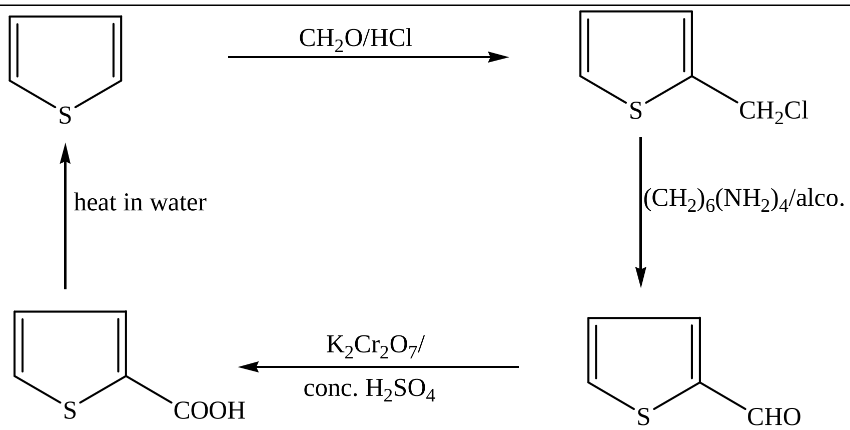
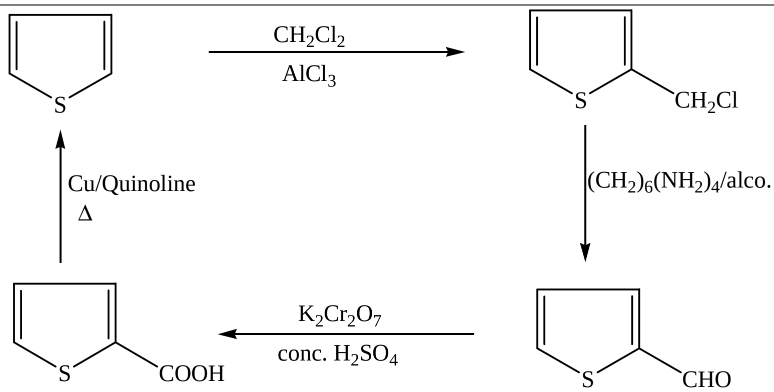
Q1)

<table>
<tr><th>(a)</th><th>(b)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>( )</td><td>( )</td></tr>
</table>

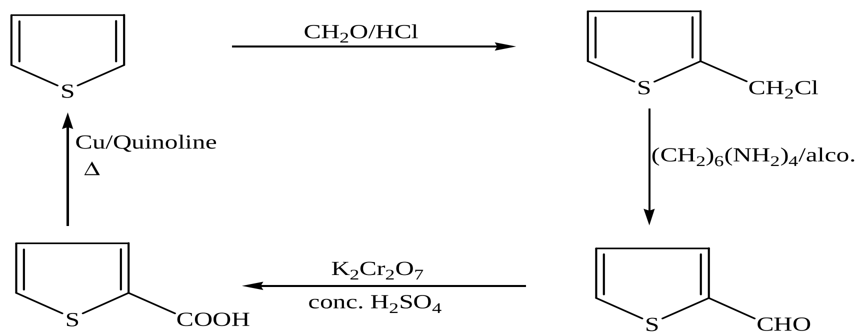
<table>
<tr><th>(c)</th><th>(d)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>( )</td><td>( )</td></tr>
</table>

A :(✓

Q2:

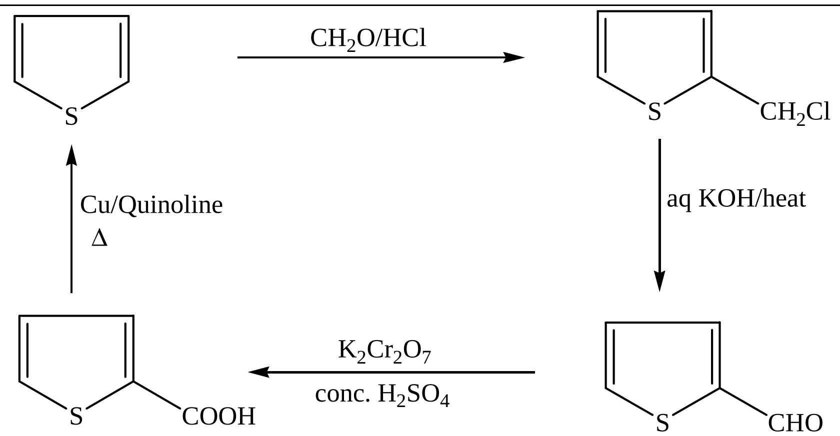
<table>
<tr><th>(a)</th></tr>
<tr><td>
</td></tr>
<tr><td>( )</td></tr>
<tr><th>(b)</th></tr>
<tr><td>
</td></tr>
<tr><td>( )</td></tr>
</table>

(c)


CH2O/HCl
CH2Cl
Cu/Quinoline
Δ
(CH2)6(NH2)4/alco.
K2Cr2O7
conc. H2SO4
COOH
CHO
S

(   )

(d)

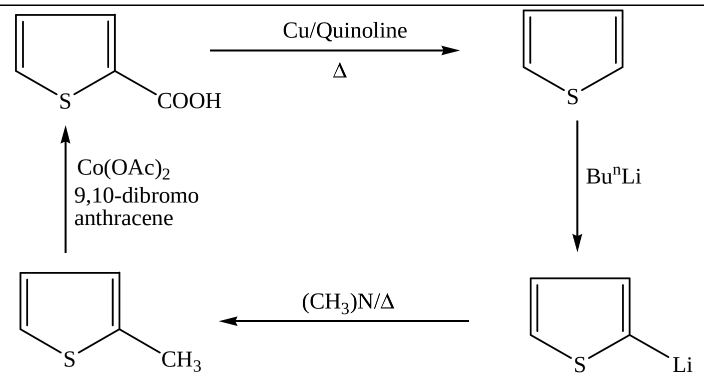

CH2O/HCl
CH2Cl
Cu/Quinoline
Δ
aq KOH/heat
K2Cr2O7
conc. H2SO4
COOH
CHO
S

(   )

<u>c :</u>(✓)

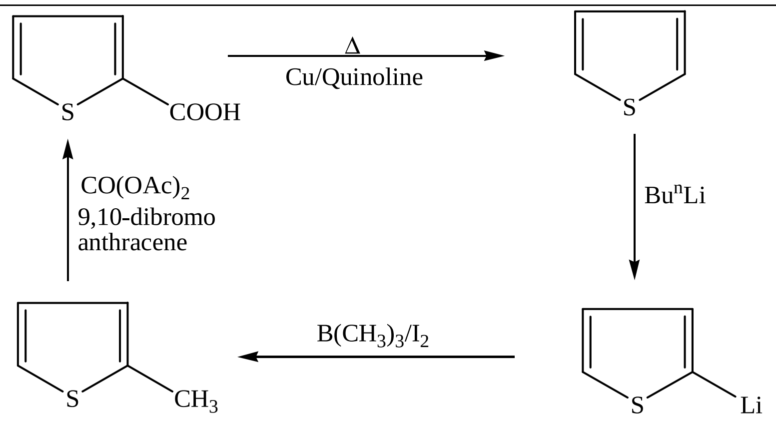
<u>Q3:</u>

(a)


Cu/Quinoline
Δ
COOH
Co(OAc)2
9,10-dibromo
anthracene
BunLi
(CH3)N/Δ
CH3
Li
S

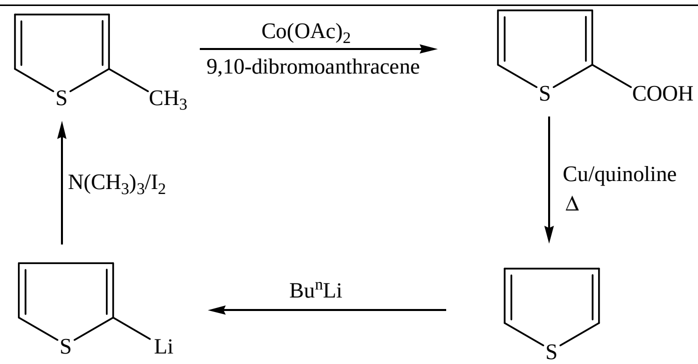
(   )

(b)


Δ
Cu/Quinoline
COOH
S
Bu^nLi
CO(OAc)2
9,10-dibromo
anthracene
B(CH3)3/I2
CH3
Li

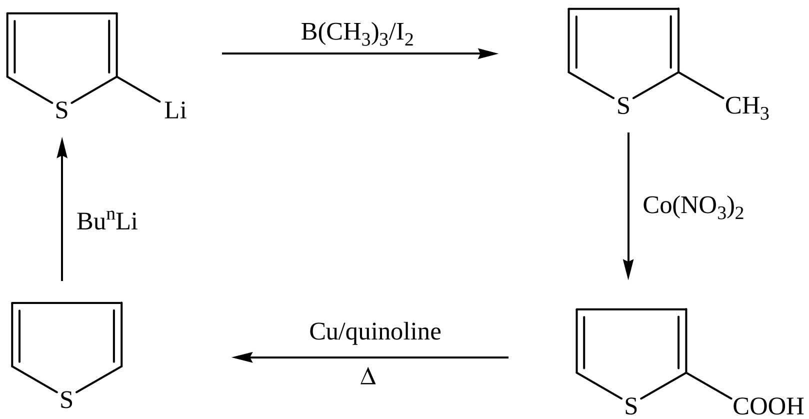
( )

(c)


Co(OAc)2
9,10-dibromoanthracene
CH3
COOH
S
N(CH3)3/I2
Cu/quinoline
Δ
Bu^nLi
Li

( )

(d)


B(CH3)3/I2
Li
CH3
S
Bu^nLi
Co(NO3)2
Cu/quinoline
Δ
COOH

( )

b: (✓)

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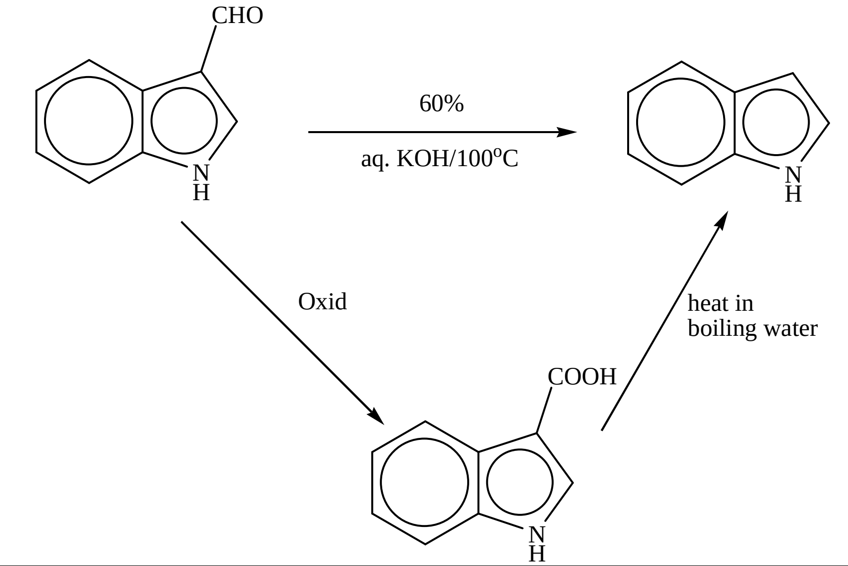
Type [II]: Systemic True False questions (STFQ, s): (6, 10)

STFQs require a student to assess whether a systemic_is true or false. This means that the student assess systemic relations between concepts, rather than concepts. STFQ, s are well suited for testing students' comprehension, synthesis, and analysis.

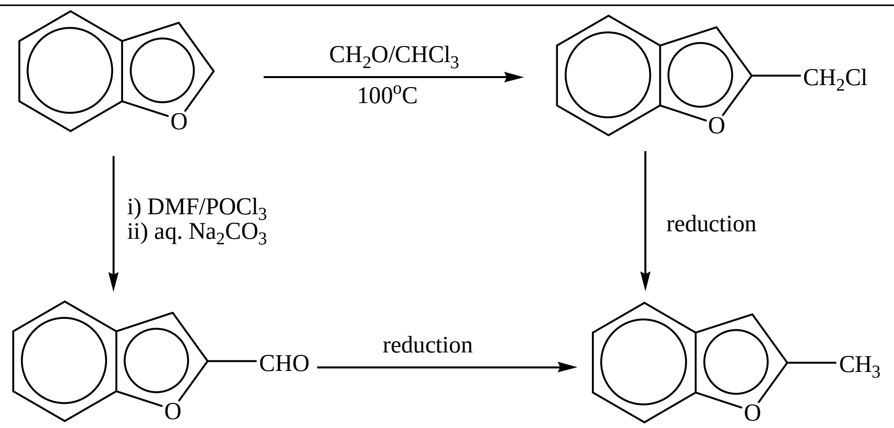
Q1: Which of the following systemics are true and which are false?

(a)



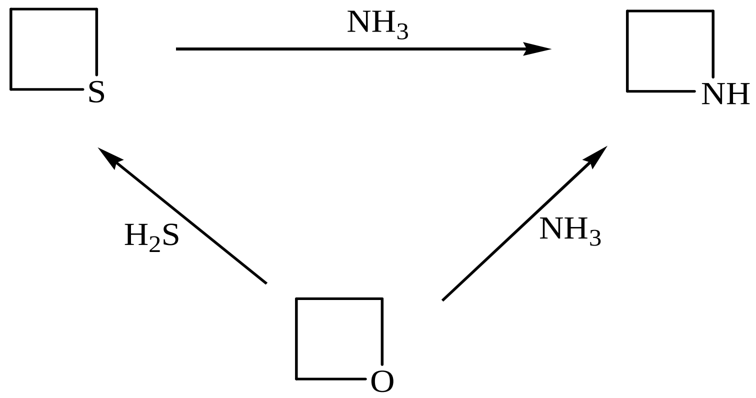
( )

(b)



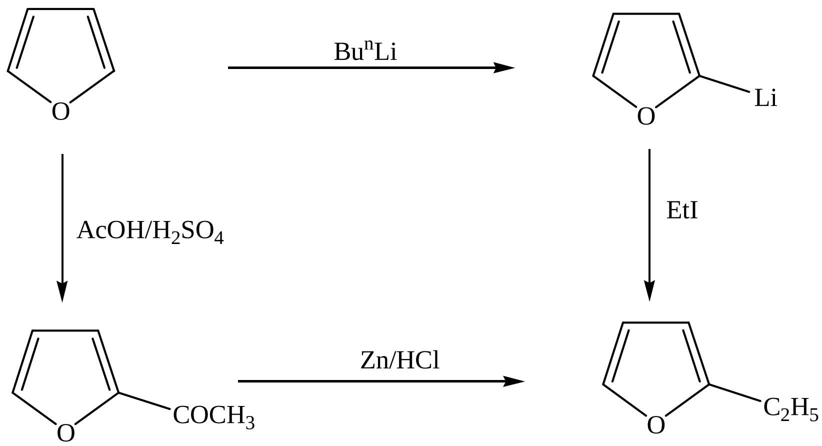
( )

(c)


NH3
S
NH
H2S
NH3
O

(   )

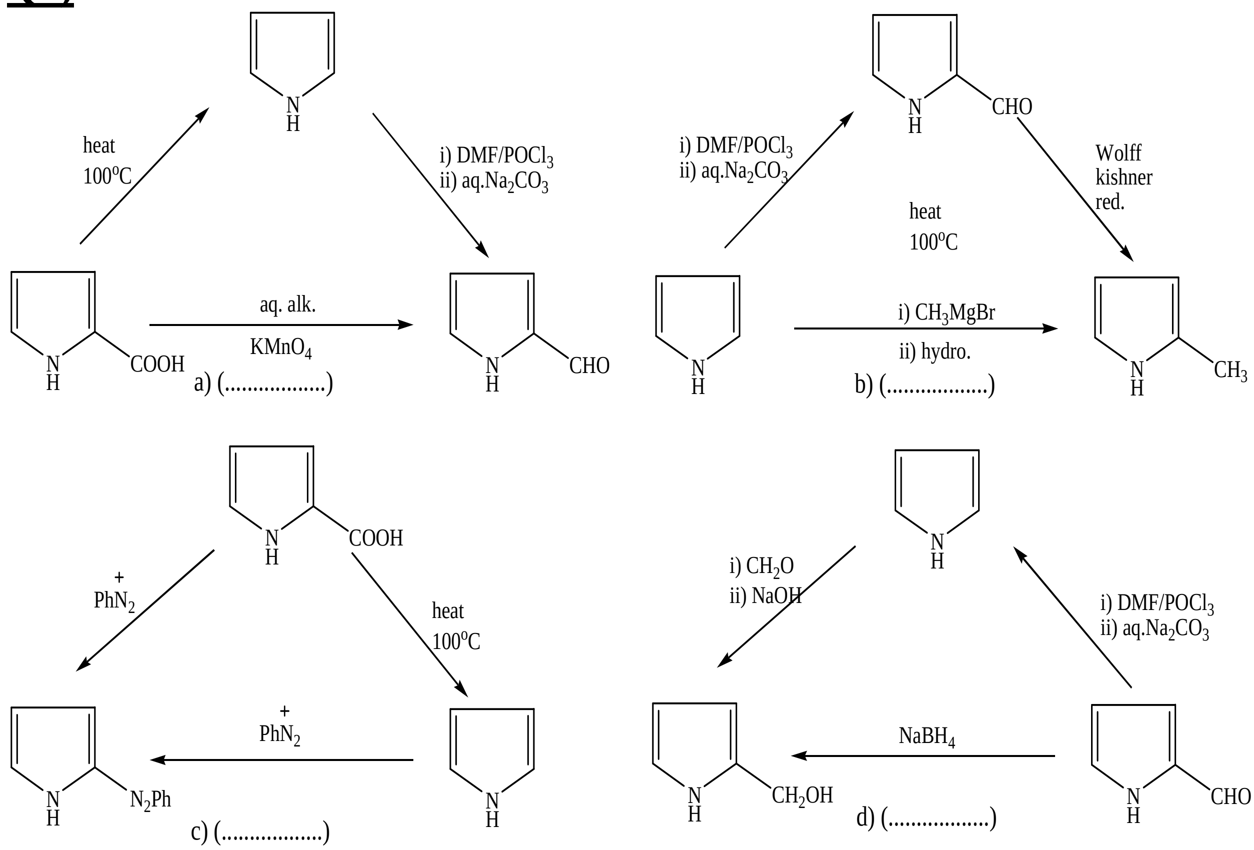
(d)


BunLi
O
Li
O
AcOH/H2SO4
EtI
Zn/HCl
O
COCH3
O
C2H5

(   )

A) (a) (✓) , (b) (✗) , (c) (✓) , (d) (✗)

<u>Q2)</u>



<u>A</u>) a: (x), b: (✓), c: (✓) , d: (x)

<u>III: Systemic matching Questions (SMQ):</u> (6, 11)

Systemic Matching Questions assess students learning outcomes at synthesis level. The given systemic diagram could be triangular, quadrilateral or Pentagonal.

Q) Choose heterocyclic compounds from column (A) and reaction conditions from column (B) to construct the systemic diagrams in column (C):

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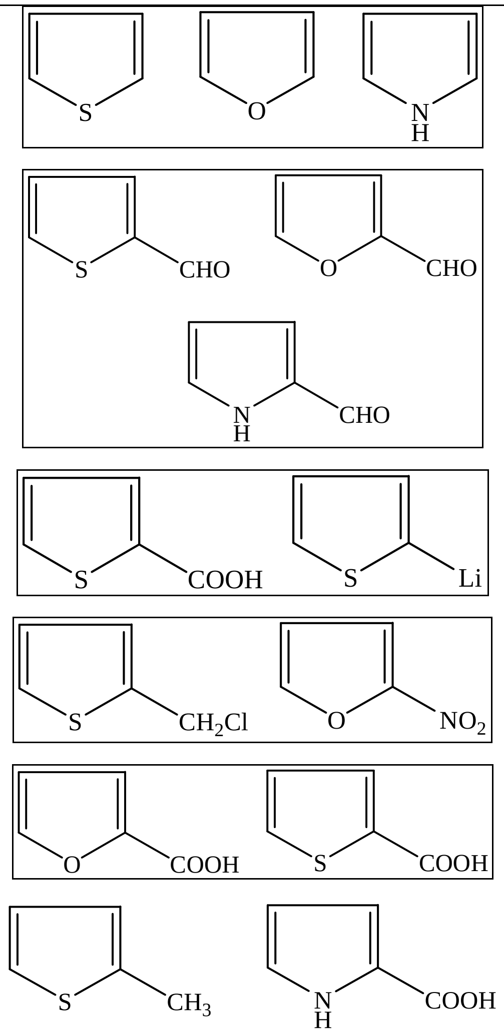
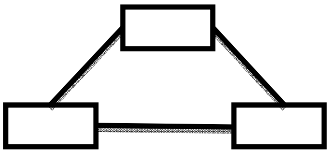
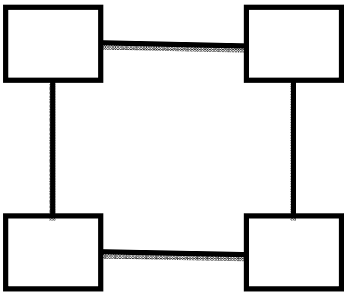
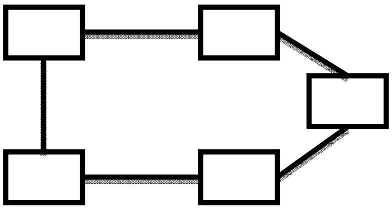
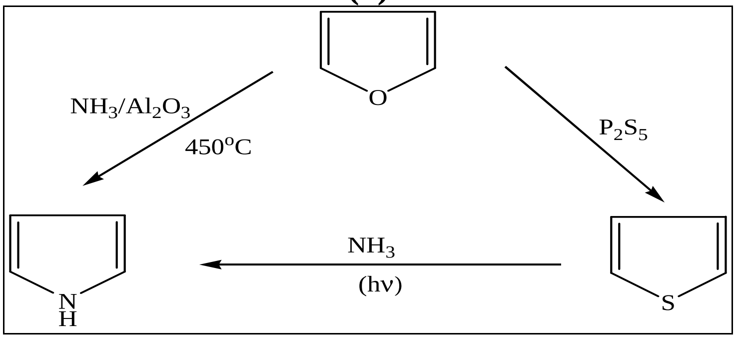
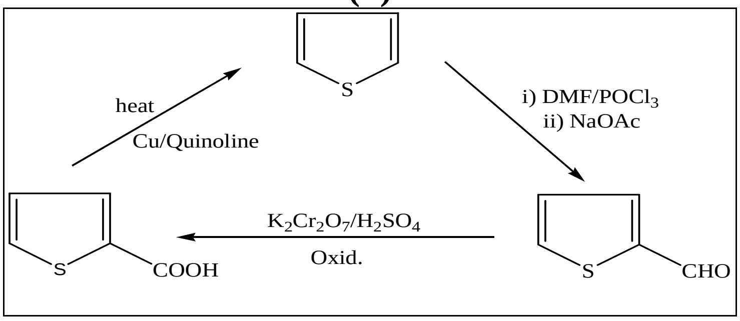
(A)	**(C)**	**(B)**
	  	**$CO(OAC)_2$** **$AcNO_3$** **BuLi** **$DMF/POCl_3$, NaOAc** **Cu/Quinoline, Δ** **$(CH_3)_3B/I_2$** **$CH_3I/FeCl_3$** **Zn[Hg]/HCl** **CH_2O/HCl** **$(CH_2)_6(NH_2)_4$/alc.** **P_2S_5** **NH_3 (hν)** **$K_2Cr_2O_7/H_2SO_4$** **Heat 200°C** **HNO_3 [conc.]** **CH_3MgBr, H_2O** **$NaNO_2/HCl$** **NaN3** ---------------------------------- **NH3/Al2O3/450°C**

1- Answers in a triangular systemic chemical relations

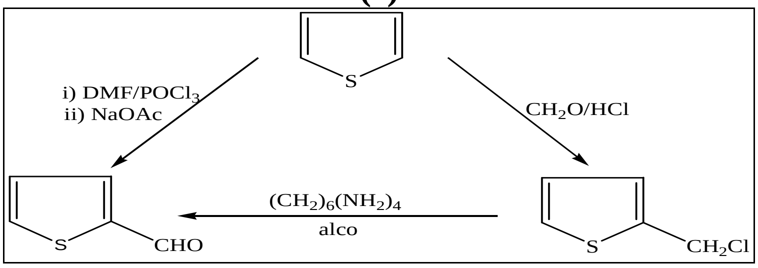
(a)



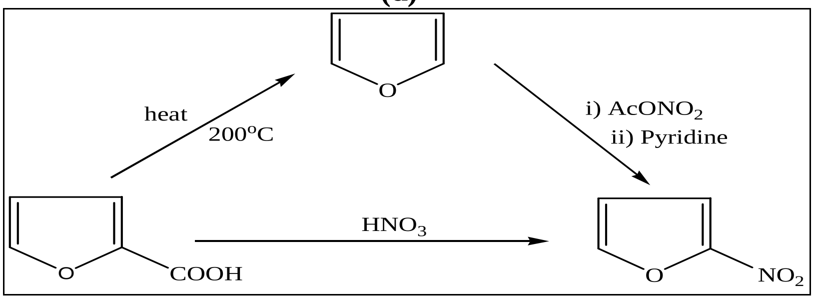
(b)



(c)

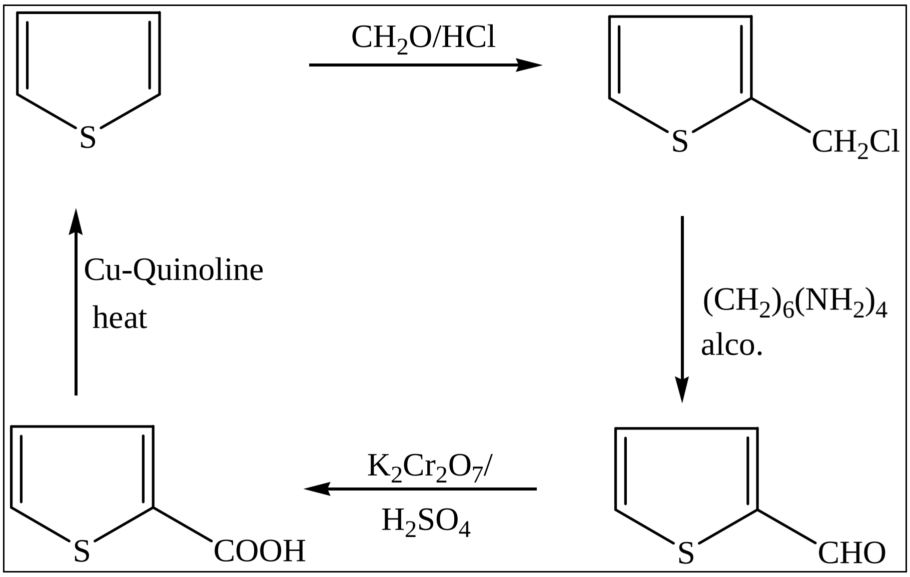


(d)

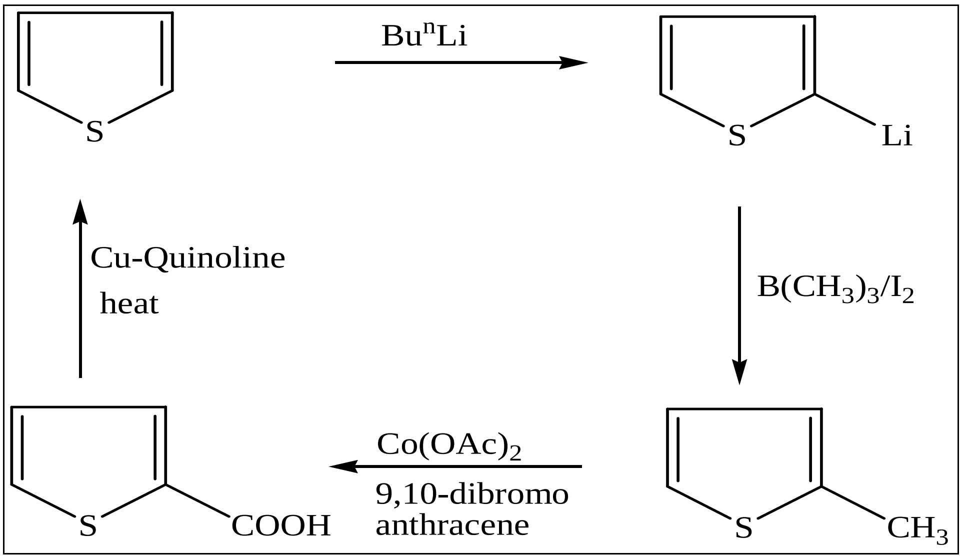


2- Answers in a quadrilateral systemic chemical relations

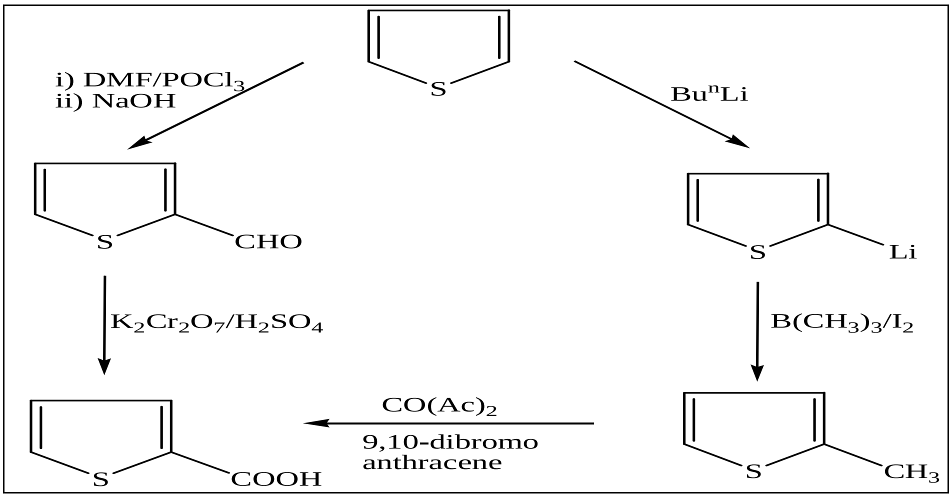
(a)



(b)



3- Answers in a pentagonal systemic chemical relations

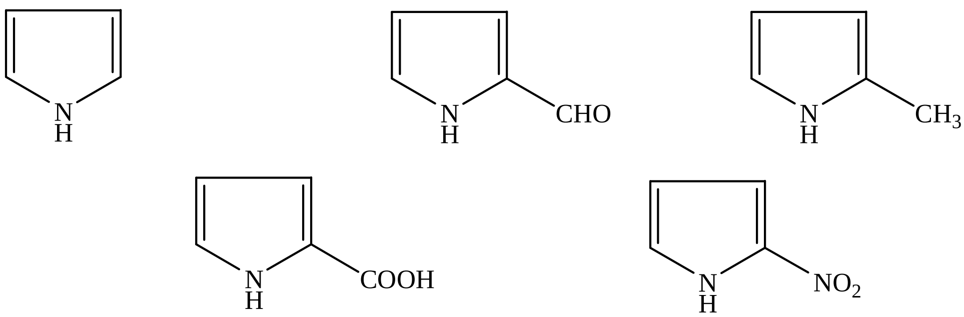


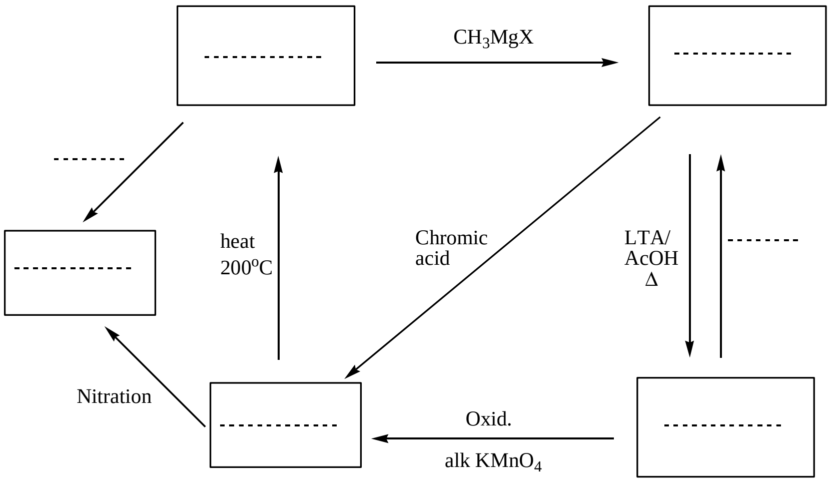
Type [IV]: Systemic Sequencing Questions [SSQ, s] :(9)

SSQs require the student to position molecule, or text or graphic objects in a given systemic sequence and assess the student learning outcomes at synthesis level.

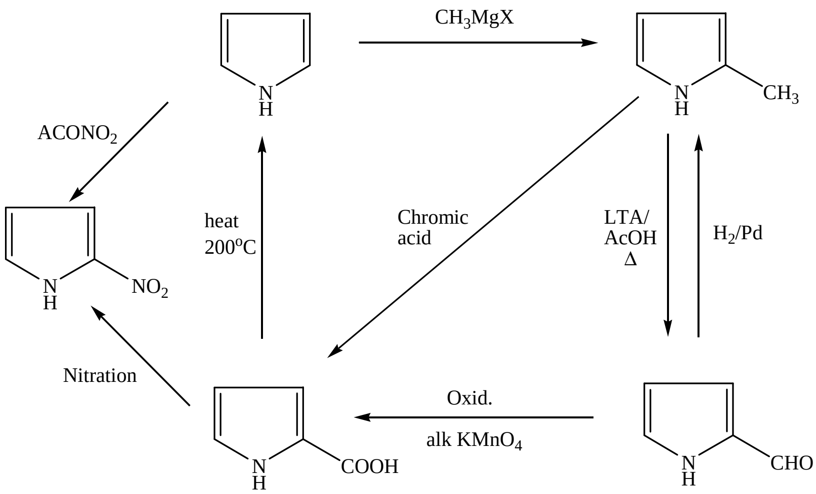
Example:

Q) Arrange the following pyrrole compounds in the right places in the following (SD):





A)

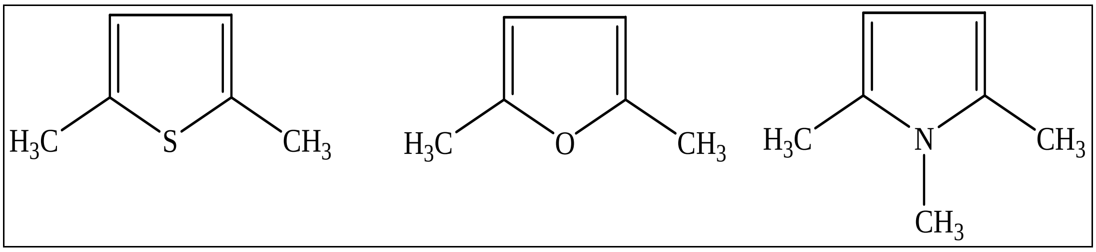


Type [V]: Systemic Synthesis Questions [SSynQs]: (6, 11)

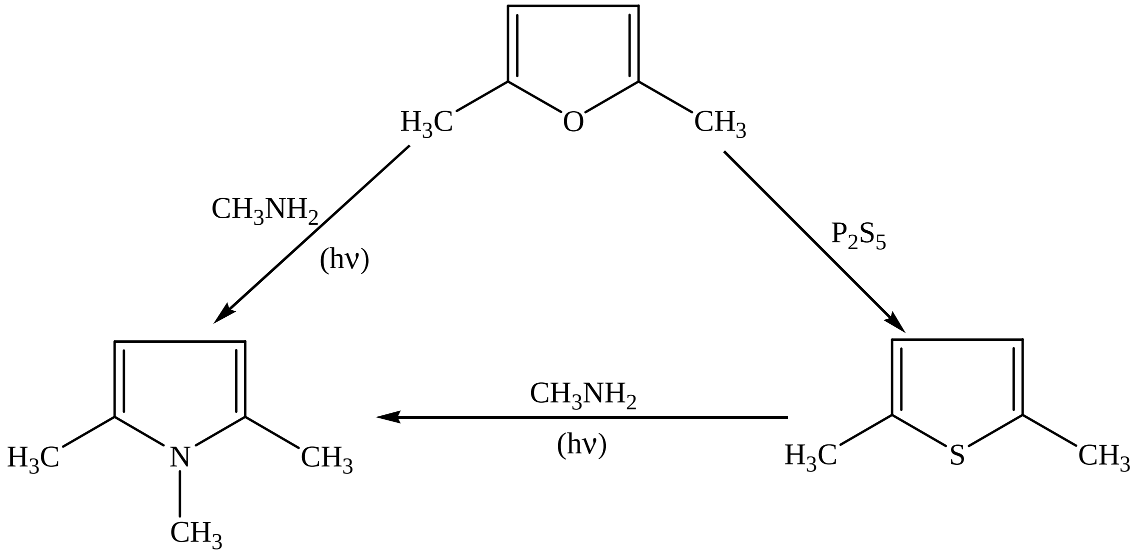
Requires the student to synthesize systemic from the given chemicals and assess the student learning outcomes at synthesis level. It measures various kinds of knowledge, including students' ability to correlate between concepts, formula, or reactions.

Type [V-A]: Synthesis of triangular systemic chemical relations:

Q1) <u>Draw triangular systemic diagram illustrating the systemic chemical relations between the following heterocyclic compounds:</u>

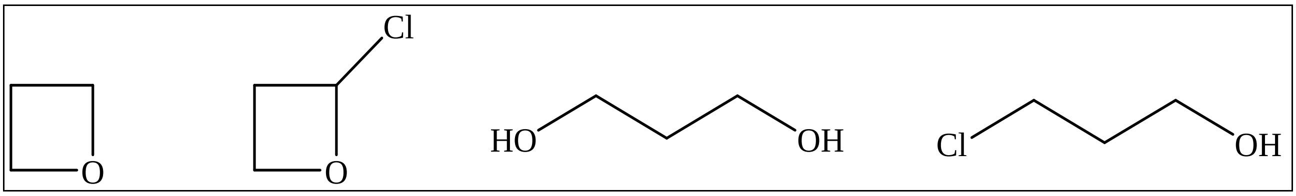


A1:

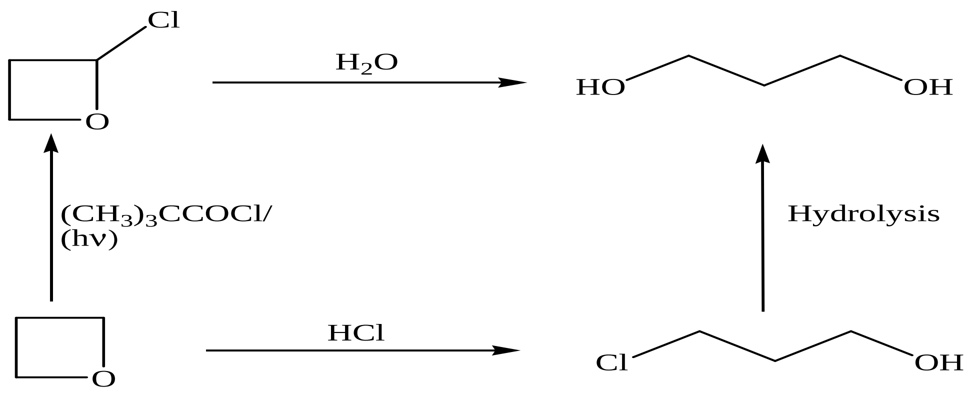


Type [V-B]: Synthesis of quadrilateral systemic chemical relations:

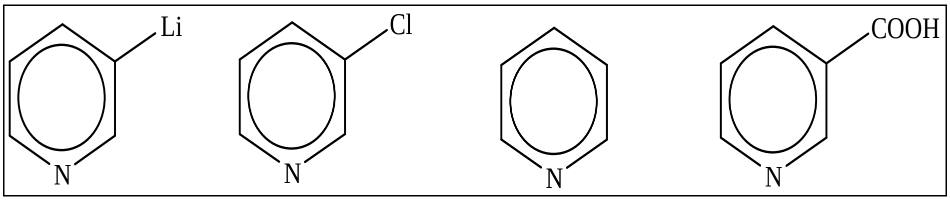
Q2: Draw quadrilateral systemic diagram illustrating the systemic chemical relations between the following compounds:



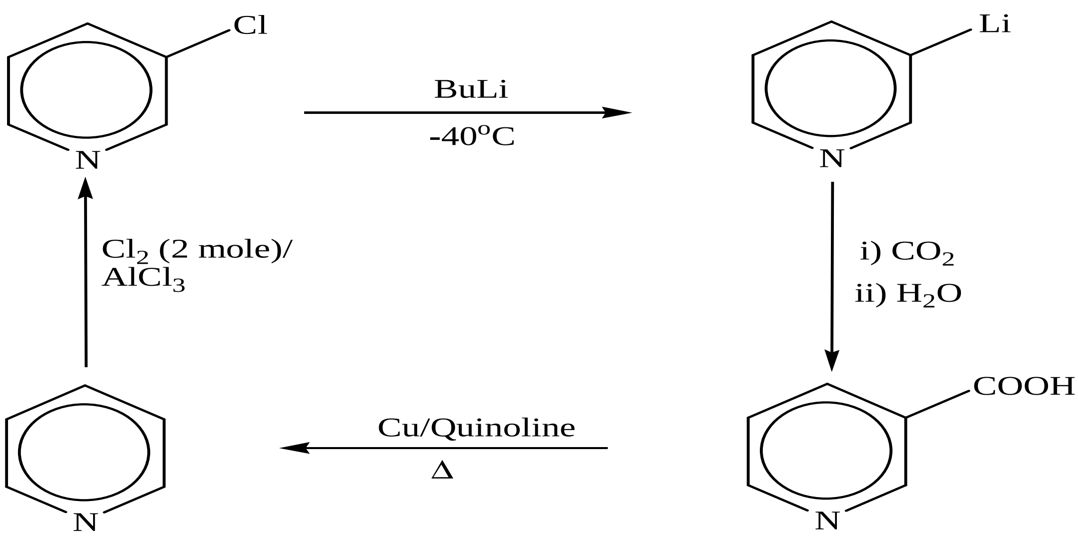
A2



Q3: Draw quadrilateral systemic diagram illustrating the systemic chemical relations between pyridine and the following related compounds:

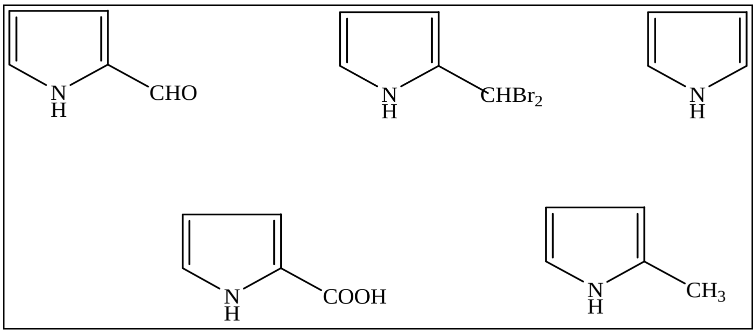


A3

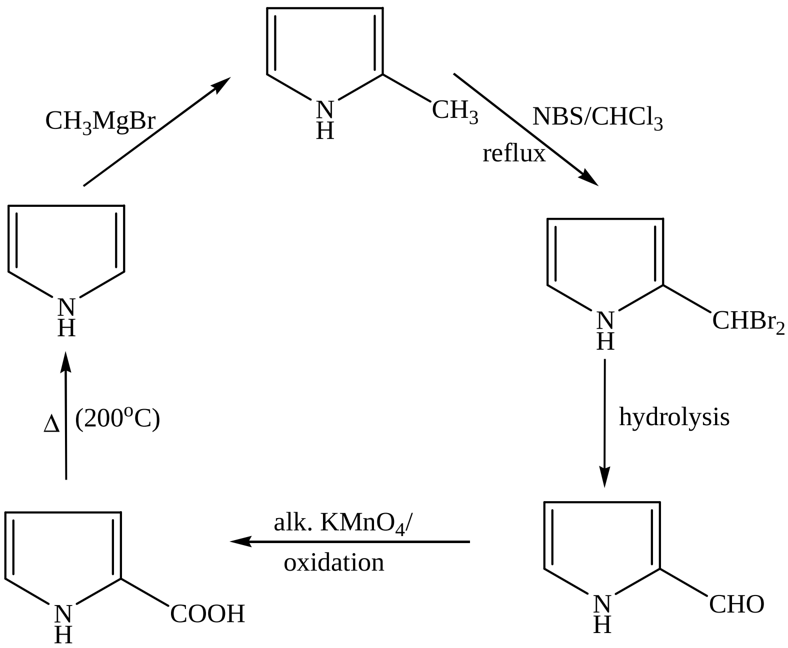


Type [V-C]: Synthesis of pentagonal systemic chemical relations:

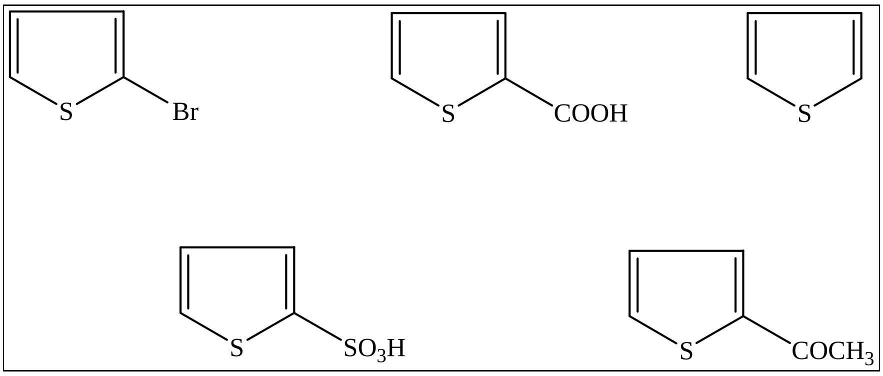
Q4) Draw pentagonal systemic diagram illustrating the systemic chemical relations between Pyrrole and the following related compounds:



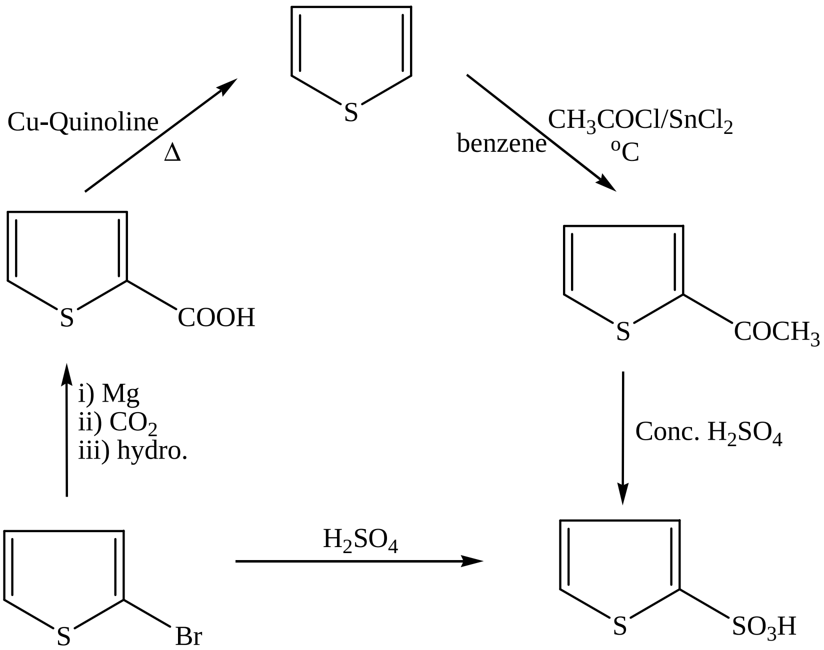
A4



Q5: Draw pentagonal systemic diagram illustrating the systemic chemical relations between thiophene and the following related compounds:

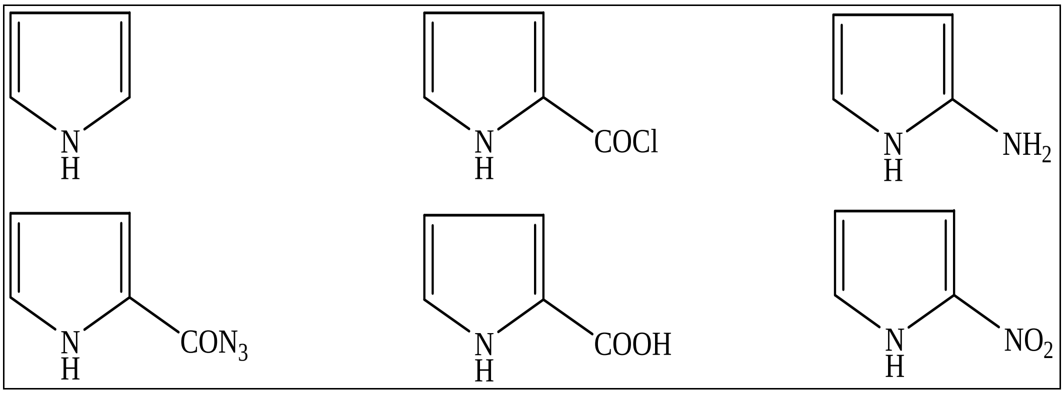


A5

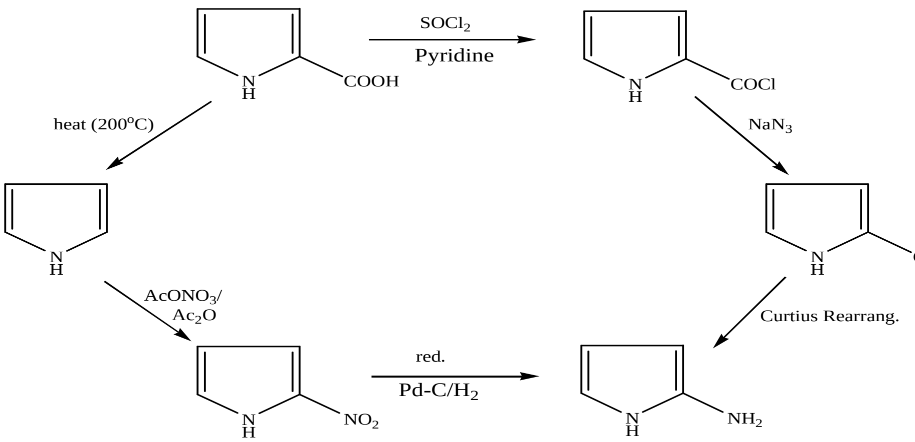


Type [V-D]: Synthesis of hexagonal systemic chemical relations:

Q6: Draw hexagonal systemic diagram illustrating the systemic chemical relations between pyrrole and the following related compounds:



A6:

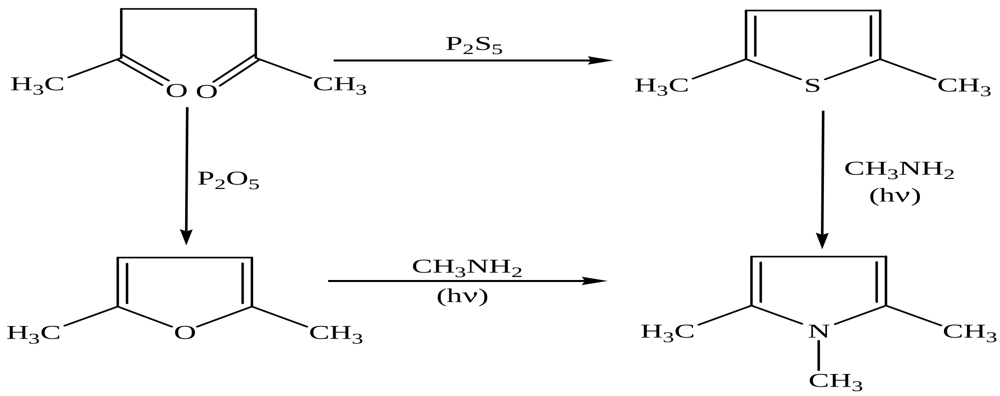


Type [V-E]: Open synthesis of systemic diagrams:

Q7: <u>From your study in Heterocyclic chemistry draw systemic diagrams illustrating the systemic chemical relations between each of the following:</u>

1) **Any four compounds.**
2) **Any five compounds.**
3) **Any six compounds**.

<u>Answer (2):</u>



CONCLUSION

By using Systemic Assessment in heterocyclic chemistry, we expect from our students making maximum connections between different heterocycles, view the pattern of pure and applied heterocyclic chemistry rather than synthesis and reactions of heterocycles, synthesize the given target heterocyclic compound by making use of different synthetic strategies , develop their skills and abilities to recognize problems and to participate in their solution, find systemic solutions for any problems in heterocyclic chemistry (Analytic, Synthetic), become more enthusiastic towards learning of heterocyclic chemistry and enter exams with minimum exam anxiety.

REFERENCES

1. Fahmy,A.F.M.,(2015). Systemic assessment as a new tool to assess student learning outcomes, 13 Ibn Sina International conference on pure and applied heterocyclic chemistry, Hurghada, Egypt, 14-17 Feb.
2. Vachlioti, T., Salta, k., Tzo ugri, C. (2013) .Meaningful understanding and systemic thinking in Organic chemistry: Validating measurement and exploring relationships, Res Sci Educ, published online 12 September.

3. Vachliotis,T, Salta,K., Vasiliou,P., Tzougraki,C (2011). Exploring novel tools for assessing high School students' meaningful understanding of organic reactions, J.Chem. Educ. 88 (3),337-345.
4. Miller, G. A. (1956). The Magical Number Seven Plus or Minus Two: Some Limits on our Capacity for Processing Information. The Psychological Review, 63, 81-97.
5. Van Merriënboer, J. J. G., Clark, R. E., & De Croock M. B. M. (2002). Blueprints for Complex Learning: the 4C/ID-Model. Educational Technology Research and Development, 50(2), 39-64.
6. Golemi,S.,Medja N.,and Lacej,D.(2014).Systemic Objective test in Medical Biochemistry: PART 1- Metabolism of Carbohydrates, AJCE, 2014, 4(1) 43-55.
7. Tzougraki,C., Salta,Vachliotis,T.(2014). Development and Evaluation of Systemic Assessment Framework in Organic Chemistry. AJCE, 2014, 4(2), 101-121.
8. Ausubel, D. P.; Novak, J. D.; and Hariesian H.(1968) ;. Educational Psychology:' A Cognitive View" Reinhart and Winston, New York.
9. Fahmy, A.F.M.and Lagowski, J.J. (2006/2008). Systemic Multiple Choice Questions in Chemistry, Chemical Education International Vol. 3 (2006/2008).http://www.iupac.org/publications/cei.
10. Fahmy, A.F.M., and .Lagowski, J.J. (2012).Systemic assessment as a new tool for assessing students learning in Chemistry using SATL methods: Systemic true false [STFQs] and systemic sequencing [SSQs] question types, AJCE. 2(2)66-78.
11. Fahmy, A.F.M., and .Lagowski, J.J. (2014). Systemic assessment as a new tool for assessing students learning in Chemistry using SATL methods: Systemic Matching questions [SMQs] ,Systemic synthesis questions [SSynQs],Systemic analysis questions[SAnQ,s],and Systemic Synthetic-Analytic questions[SSyn-AnQ,s] as new systemic questions types, AJCE 4(4)35-55.