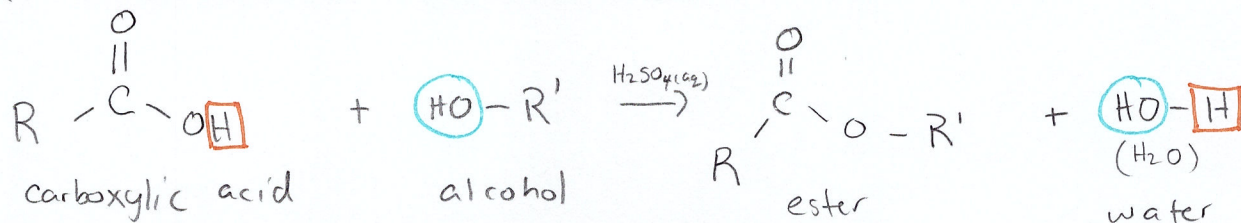


## ESTERIFICATION REACTIONS

- An **esterification reaction** is when an **alcohol** reacts with a **carboxylic acid** to produce an **ester** and **water**.

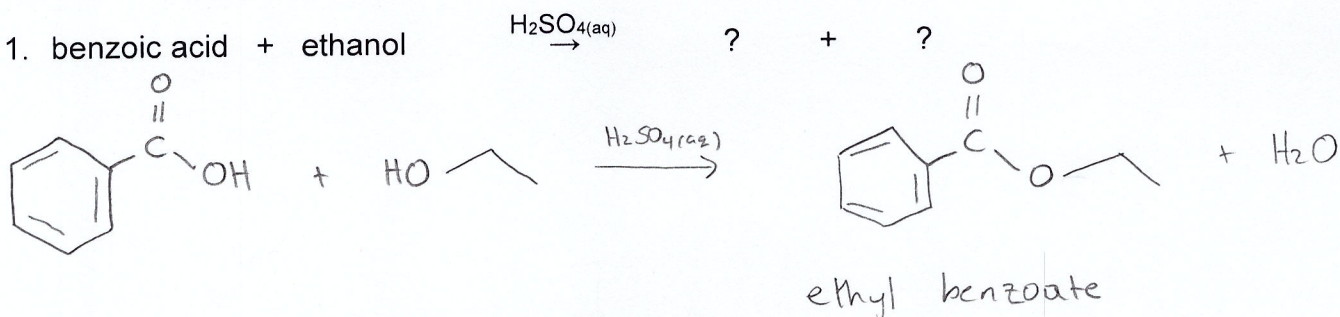
\* Esterification reactions require an acid catalyst (usually  $\text{H}_2\text{SO}_4(\text{aq})$ )



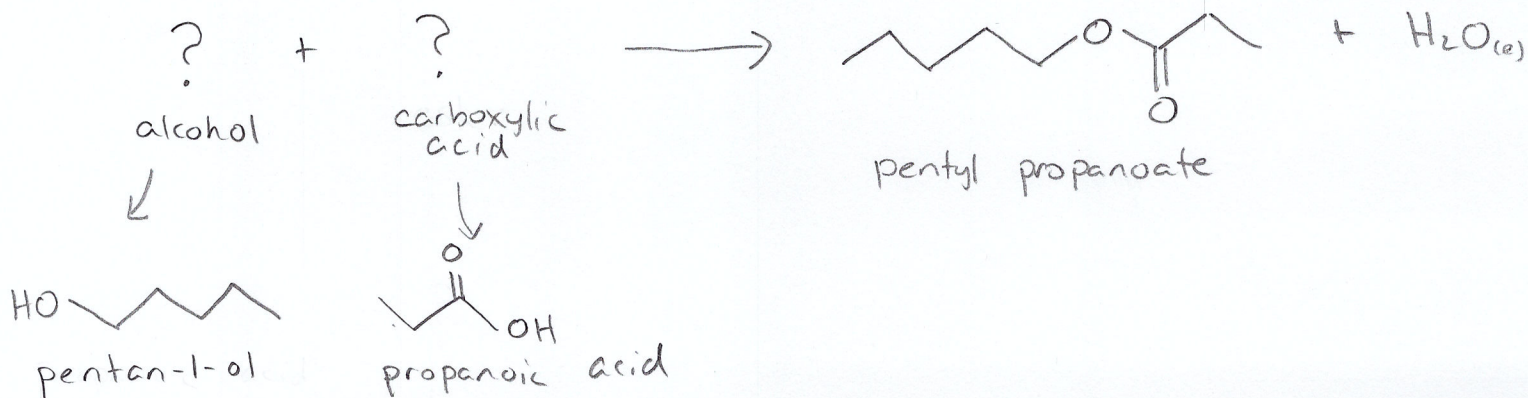
- Esterification is a type of a **condensation reaction**
  - A **condensation reaction** is a reaction in which two molecules combine to form a larger molecule and also producing a second smaller, stable molecule (usually water)

EXAMPLES: Predict the reactants or products of each reaction by writing/drawing out the complete organic reaction.

1. benzoic acid + ethanol



2. Pentyl propanoate and water are the products of an organic reaction.



\*\*\*Now try pg. 596 #2e, 5 & pg. 602 #2b,g & Practice Problems\*\*\*

## Practice Problems

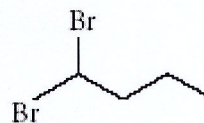
- Which one of the following statements best describes an elimination reaction?
  - Carbon atoms in the organic product are bonded to fewer atoms than the carbon atoms in the organic reactant.
  - A hydrogen atom or functional group is replaced with a different atom or functional group.
  - Atoms are added to a double or triple carbon-carbon bond.
  - Two molecules are combined and a small molecule, such as water, is produced as a second product.
  
- The addition of a catalyst is required for the conversion of propan-2-ol to propene. An appropriate catalyst for this reaction is
  - $\text{KMnO}_4$
  - $\text{H}_2\text{SO}_4$
  - $\text{NaOH}$
  - $\text{H}_2$

- Which of the following compounds could be formed in the addition reaction of  $\text{Br}_2$  and but-1-ene?

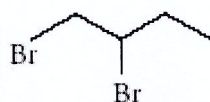
(a)



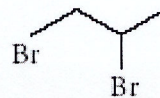
(b)



(c)

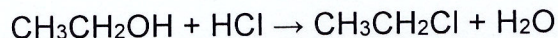


(d)





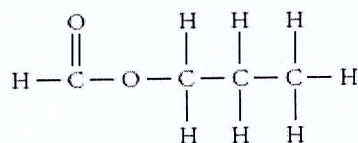
4. What type of reaction is shown below?



- a. Substitution
- b. Elimination
- c. Esterification
- d. Addition

5. In a reaction between hex-2-ene and hydrochloric acid, name all possible products that could be produced.

6. What compounds would you need to react together to produce the molecule below?



*Use the following information below the answer the next question.*

To help identify two unknown hydrocarbons, a student adds potassium permanganate aqueous solution ( $\text{KMnO}_4(\text{aq})$ ) to each hydrocarbon. Potassium permanganate as an aqueous solution is purple in color. When  $\text{KMnO}_4$  is added to hydrocarbon X, a brown precipitate forms. When  $\text{KMnO}_4$  is added to hydrocarbon Y, a purple layer forms on top of the hydrocarbon solution. Based on the observations, the student can conclude that hydrocarbon X is   i   and hydrocarbon Y is an   ii  .

7. The statement is correctly completed by row

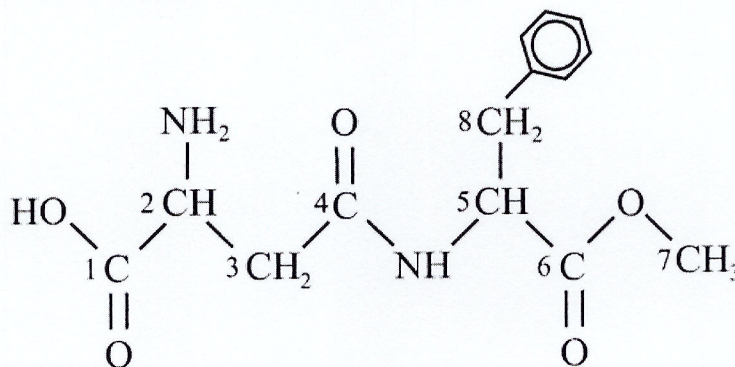
Row	i	ii
a.	saturated	alkane
b.	saturated	alkene or alkyne
c.	unsaturated	alkane
d.	unsaturated	alkene or alkyne



8. Four numbered reactions are given below. When the reactions are listed in order of addition, substitution, esterification, and elimination, the number sequence that corresponds is \_\_\_\_, \_\_\_\_, \_\_\_\_, \_\_\_\_.

1.  $\text{CH}_3\text{CH}_2\text{COOH} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{COOCH}_3 + \text{H}_2\text{O}$
2.  $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_2\text{CH}_2 + \text{H}_2\text{O}$
3.  $\text{CH}_3\text{CCH} + \text{HBr} \rightarrow \text{CH}_3\text{CBrCH}_2$
4.  $\text{CH}_3\text{CH}_2\text{C}(\text{OH})\text{HCH}_3 + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{CBrHCH}_3 + \text{H}_2\text{O}$

9. The artificial sweetener aspartame is about 180 times as sweet as table sugar. The figure below illustrates the structure of aspartame. The carbons of aspartame are numbered from 1 to 8.



A student identifies three features of the aspartame molecule—a phenyl group attached to a carbon, an ester bond, and a carboxyl group. Match the structural feature to the numbered carbon that it is associated with. Record all four digits of your answer.

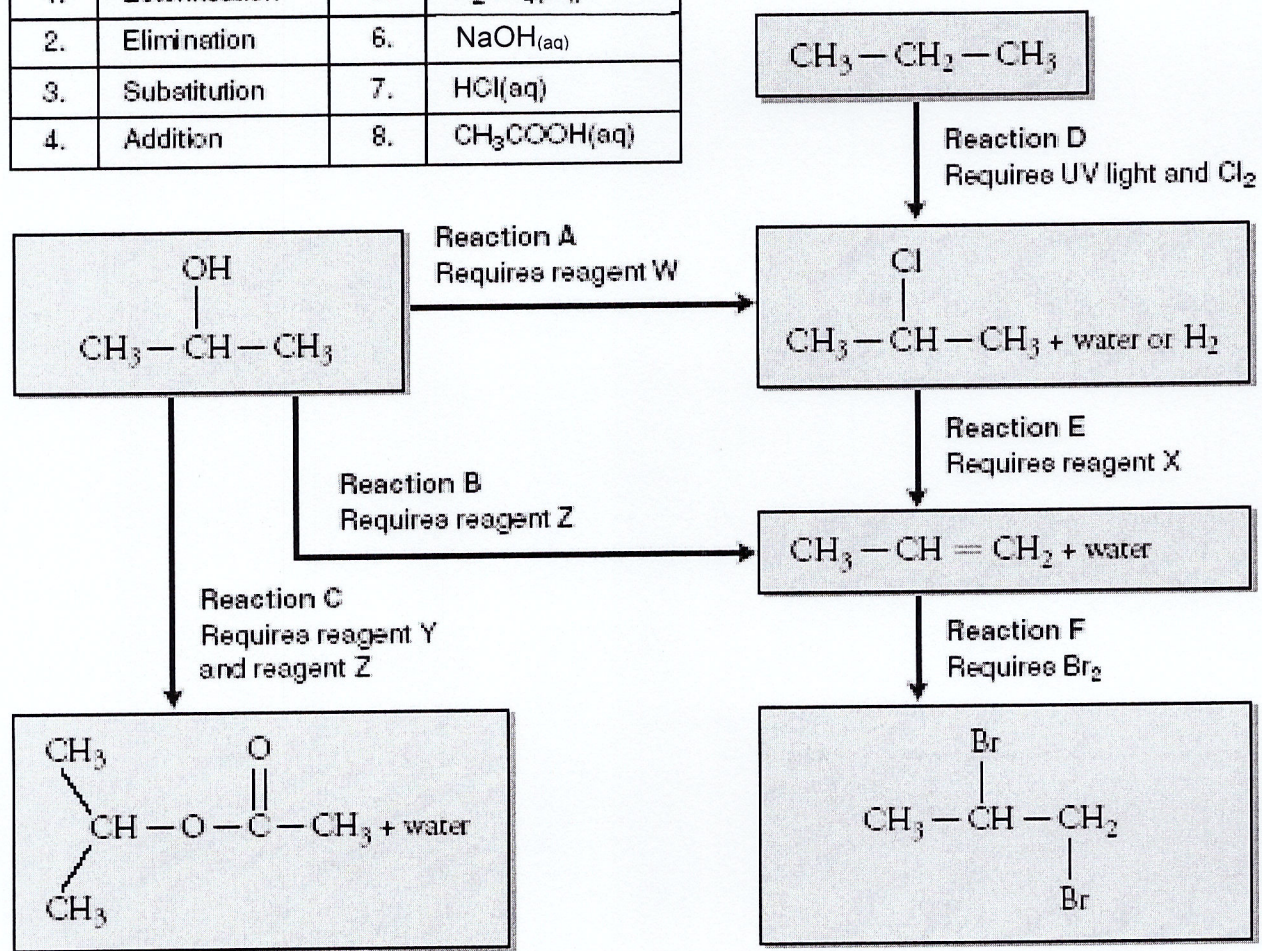
Structural Feature	Carbon Number
phenyl group	
ester bond	
carboxyl group	



Use the following information to answer the next 3 questions.

Chart 1

Key	Reaction Type	Key	Reagents
1.	Esterification	5.	$\text{H}_2\text{SO}_4(\text{aq})$
2.	Elimination	6.	$\text{NaOH}(\text{aq})$
3.	Substitution	7.	$\text{HCl}(\text{aq})$
4.	Addition	8.	$\text{CH}_3\text{COOH}(\text{aq})$



10. When Reactions A, B, and C are classified according to the key given in Chart 1, the number sequence that would correspond to ABC is \_\_\_\_, \_\_\_\_, \_\_\_\_.

11. When Reactions D, E, and F are classified according to the key given in Chart 1, the number sequence that would correspond to DEF is \_\_\_\_, \_\_\_\_, \_\_\_\_.

12. When the reagents W, X, Y, and Z are classified according to the key given in Chart 1, the number sequence that would correspond to WXYZ is \_\_\_\_, \_\_\_\_, \_\_\_\_, \_\_\_\_.



13. The primary component of the gasoline that you purchase to fuel your automobile is 2,2,4-trimethylpentane. The combustion of automobile fuel is one factor linked to the accelerated greenhouse effect.

a) Provide the condensed structural formula and molecular formula for 2,2,4-trimethylpentane.

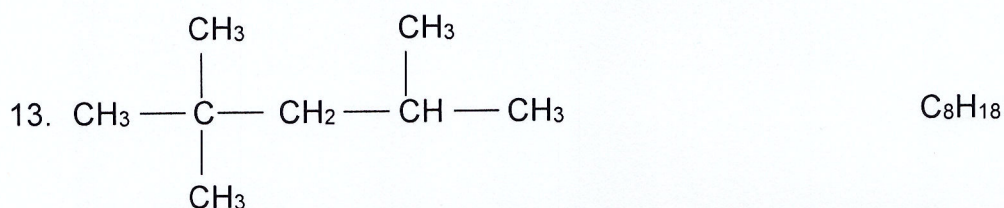
b) Write a balanced equation for the complete combustion of 2,2,4-trimethylpentane.

14. What series of reactions would you carry out to produce ethyl methanoate from chloroethane? Draw condensed structural formulas for all organic reagents and products. Identify any necessary inorganic reagents and indicate the types of reactions that are carried out.



## Answers

- |                                      |          |
|--------------------------------------|----------|
| 1. A                                 | 7. C     |
| 2. B                                 | 8. 3412  |
| 3. C                                 | 9. 861   |
| 4. A                                 | 10. 321  |
| 5. 2-chlorohexane and 3-chlorohexane | 11. 324  |
| 6. propan-1-ol and methanoic acid    | 12. 7685 |

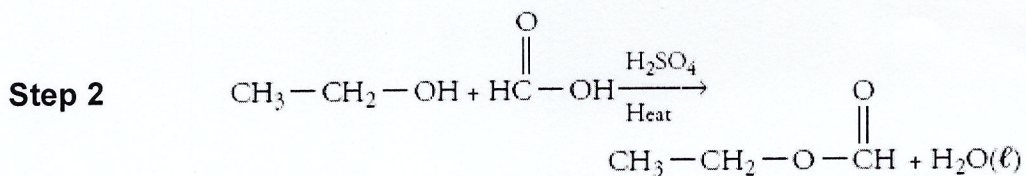
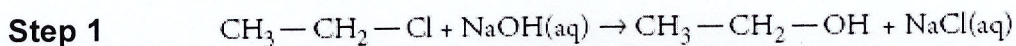


$\text{C}_8\text{H}_{18}$

**Condensed structural formula**

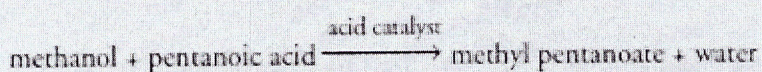
**Molecular formula**

14. Step 1 is a substitution reaction replacing the chloride from chloroethane with a hydroxyl group to form ethanol. Step 2 is an esterification reaction of the ethanol from step 1 with methanoic acid to form ethyl methanoate and water.



### Student Textbook pages 602

#### (b) Esterification reaction



#### (g) Esterification reaction

