

CANADIAN CHEMISTRY CONTEST

CHEMISTRY

TOPIC QUESTIONS

King

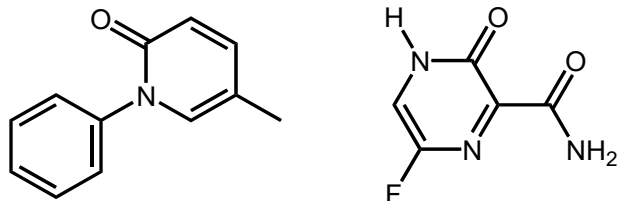


1. Organic Chemistry



KingCh

- 8) The COVID-19 pandemic triggered an intense effort worldwide to screen *existing* “small-molecule” drugs in the development of a treatment. The structures of two such compounds of interest are shown below. What is the difference in the molecular weight of the compounds in g mol^{-1} ?

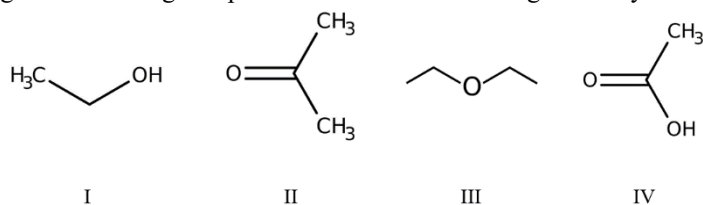


- A) 14.1 B) 26.1 C) 27.1 D) 28.1 E) no difference

- 9) Which statement is **TRUE** for the two compounds in Question 8?

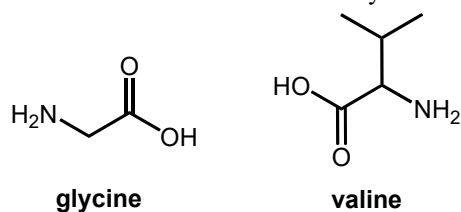
- A) only one compound contains one amide functional group
 B) both compounds have the same number of lone pair electrons
 C) both compounds contain one amide functional group
 D) both compounds contain a benzene ring
 E) only one compound contains one amine functional group

- 11) Arrange the following compounds in order of increasing volatility



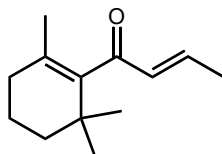
- A) IV, I, II, III D) IV, I, III, II
 B) I, III, II, IV E) III, II, IV, I
 C) I, IV, II, III

- 17) An equimolar mixture of two amino acids, glycine and valine, (structures below) underwent a condensation reaction. How many dipeptide products were formed which have different atom connectivity?

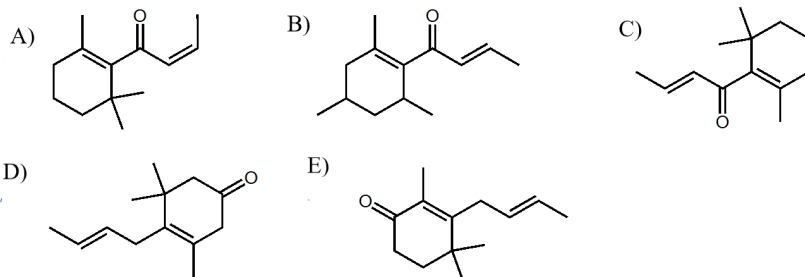


- A) 2 B) 3 C) 4 D) 5 E) 6

- 18) The organic substance below is a component of a variety of essential oils and belongs to a family of compounds known as “rose ketones”.

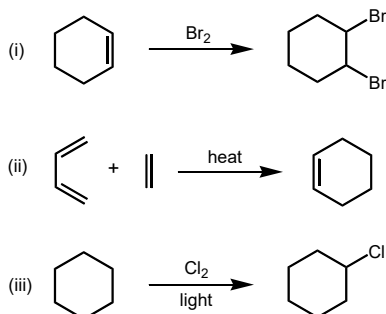


Which of the following compounds is **NOT** an isomer of this substance?



- 21) The “atom economy” of a chemical reaction is the fraction of starting material atoms that end up in a desired product. It is important for both sustainable development and economic reasons to use reactions with high atom economy as much as possible.

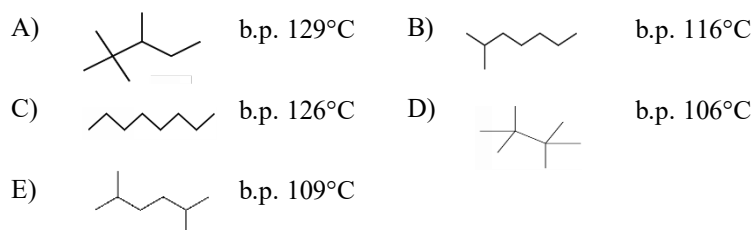
Which of the following three reactions occur with 100% atom economy, based on forming the desired product shown?



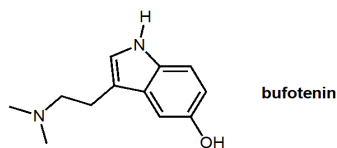
- A) i only B) ii only C) iii only D) i and ii E) i, ii & iii

CCC 2021

- 4) A student drew structural diagrams for some of the isomers of octane and wrote down each isomer’s boiling point (b.p.). There is an error in the student’s work. For which structure did the student **incorrectly** record the boiling point?



- 7) Bufotenin (structure below) is a substance found in the skin of certain species of toads. In large quantities, it can have a psychoactive effect on humans, changing brain function and altering behaviour. What is the correct molecular formula of bufotenin?

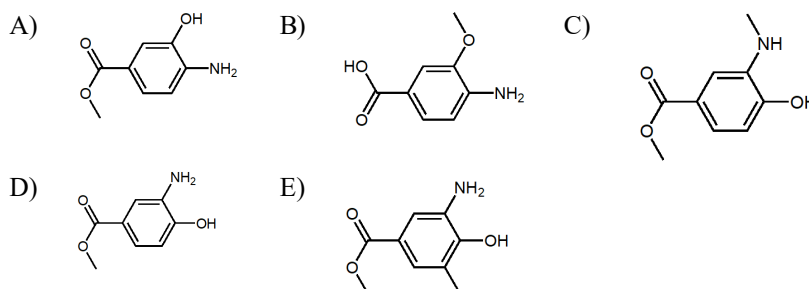


- A) $C_{12}H_{16}N_2O$ B) $C_{10}H_{12}N_2O$ C) $C_{11}H_{14}N_2O$
 C) $C_{12}H_{18}NO$ E) $C_{12}H_{14}N_2O$

- 8) How many constitutional isomers and how many stereoisomers does the organic molecule with the formula C_3H_9N have?

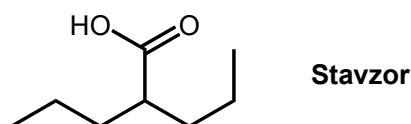
	constitutional isomers	stereoisomers		constitutional isomers	stereoisomers
A)	2	2	D)	4	0
B)	3	2	E)	3	0
C)	4	2			

- 14) The organic compound orthocaine is a local anesthetic developed over one hundred years ago to treat pain. The chemical name of orthocaine is methyl 3-amino-4-hydroxybenzoate. Which of the following structures represents a molecule of orthocaine?

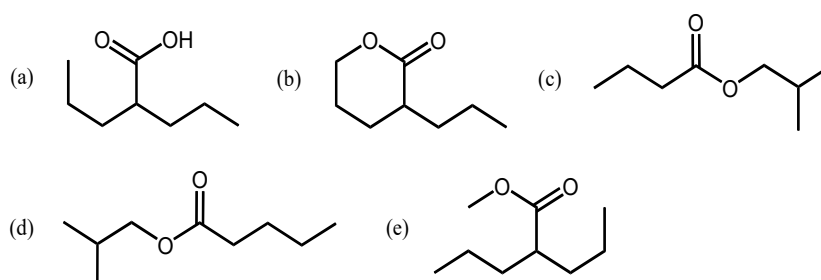


CCC 2020

- 10) Stavzor (structure below) is a medication primarily used to treat epilepsy and bipolar disorder.



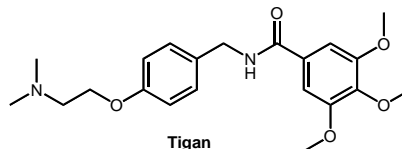
- A well-known substance with a characteristic odour of bananas (**A**) is a constitutional isomer of Stavzor. Which of the following is a possible structure for **A**?



CCC 2019



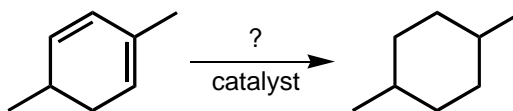
- 10) Tigan (structure below) is an antiemetic drug used to prevent nausea and vomiting. It is often prescribed for patients with gastroenteritis, medication-induced nausea, and other illnesses.



Which of the following functional groups are present within Tigan?

- A) amine, ether, amide B) amine, ketone, ether, alcohol
C) ether, aldehyde, amine D) alcohol, amine, ether, amide
E) ketone, amine, ether
- 11) How many carbon (C) and hydrogen (H) atoms are present in a molecule of Tigan?
- A) 21 C and 28 H atoms B) 21 C and 27 H atoms
C) 16 C and 28 H atoms D) 20 C and 28 H atoms
E) 21 C and 29 H atoms

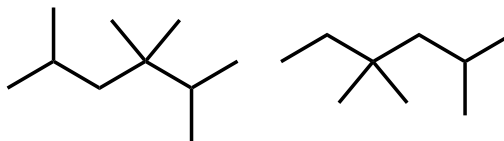
- 18) Consider the following reaction, where the starting compound is treated with an unknown reagent over a catalytic surface to form the product:



Which two terms can be used to describe this process?

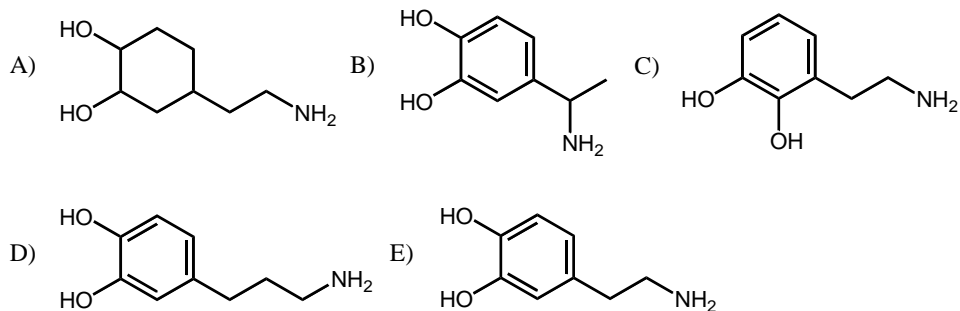
- A) hydrogenation, elimination B) hydration, addition
C) hydrogenation, substitution D) hydrogenation, addition
E) hydration, substitution

13) What is the correct relationship between the following two organic substances?



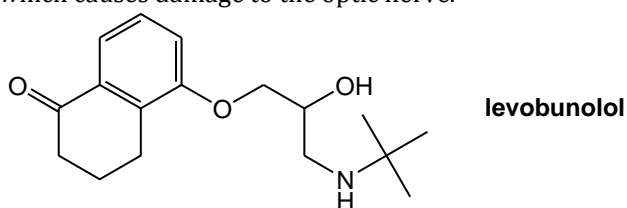
- A) non-superimposable mirror images
- B) identical
- C) Structural, non-geometric isomers
- D) hydrocarbons with different molecular formulae
- E) geometric isomers

in motor control. The IUPAC name for dopamine is 4-(2-aminoethyl)benzene-1,2-diol. Which of the following structures represents a molecule of dopamine?



CCC 2017

10) Levobunolol (structure below) is used topically to treat glaucoma, an eye disorder which causes damage to the optic nerve.

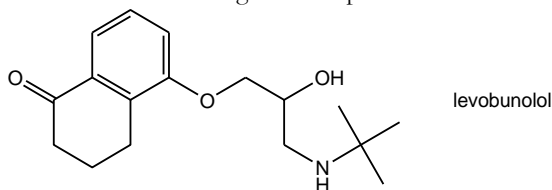


Which of the following functional groups are contained within the structure of levobunolol?

- A) amine, ketone, ether, phenol
- B) amide, ketone, ether, alcohol
- C) amine, ketone, ester, alcohol
- D) amine, ketone, ether, alcohol
- E) amine, aldehyde, ether, alcohol

CCC 2016

16. Levobunolol (structure below) is used topically to treat glaucoma, an eye disorder which causes damage to the optic nerve.

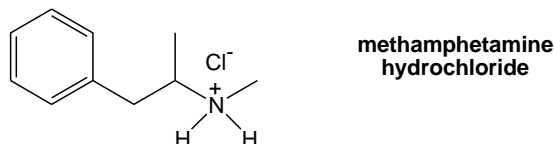


Which of the following functional groups are contained within the structure of levobunolol?

- A) amine, ketone, ether, phenol
 B) amide, ketone, ether, alcohol
 C) amine, ketone, ester, alcohol
 D) amine, aldehyde, ether, alcohol
 E) amine, ketone, ether, alcohol

CCC 2015

9. In the television series *Breaking Bad*, Walter White and Jesse Pinkman synthesize methamphetamine (*N*-methyl-1-phenyl-2-propanamine) which is marketed as methamphetamine hydrochloride, or “crystal meth”.

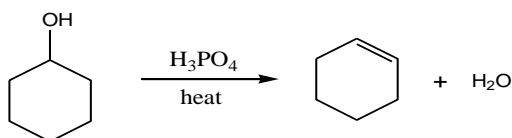


What is the molecular formula of methamphetamine hydrochloride?

- A) $C_8H_{16}ClN$ B) $C_{10}H_{10}ClN$ C) $C_{10}H_{16}ClN$
 D) $C_{10}H_{14}ClN$ E) $C_9H_{16}ClN$

CCC 2013

20. Consider the following reaction, where cyclohexanol reacts with concentrated phosphoric acid to form cyclohexene. Cyclohexene is a precursor to adipic acid, one of the important compounds used in the industrial preparation of nylon.

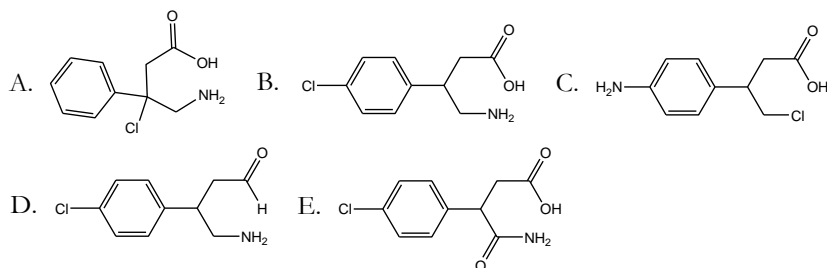


Which two terms can be used to appropriately describe this type of reaction?

- A. addition, dehydration B. elimination, hydration
 C. substitution, dehydration D. elimination, dehydration
 E. substitution, hydration

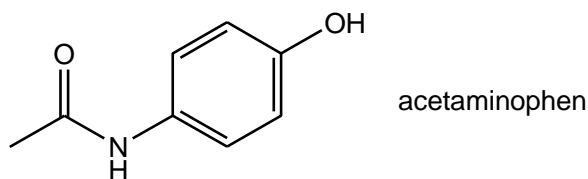
10. To how many isomers does the molecular formula C_3H_8O correspond?
 A. 4 constitutional (structural) isomers including one which has 2 stereoisomers
 B. 4 constitutional isomers and no stereoisomers
 C. 3 constitutional isomers including one which has 2 stereoisomers
 D. 3 constitutional isomers and no stereoisomers
 E. 2 constitutional isomers and no stereoisomers

14. Baclofen is a muscle relaxant which is also effective in the treatment of alcohol dependence and withdrawal. The IUPAC name of baclofen is 4-amino-3-(4-chlorophenyl)butanoic acid. Which of the following structures correctly represents this molecule?



CCC 2012

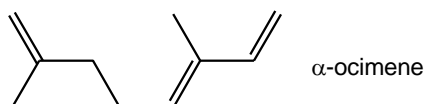
12. Acetaminophen (structure below) is marketed in North America as an analgesic (to relieve pain) and an antipyretic (to reduce fever) under the tradename Tylenol®.



Which of the following statements concerning acetaminophen is **TRUE**?

- A. It is not classed as an aromatic compound.
- B. It has an amide functional group.**
- C. Its chemical formula is $C_7H_9NO_2$.
- D. It has a ketone functional group.
- E. It does not contain any polar covalent bonds.

18. α -Ocimene (structure below) is a monoterpene substance found within a variety of flowers and fruits. It has a characteristic citrus scent and can exist as geometric isomers.



Ignoring any isomerism, which of the following represents the correct IUPAC name of α -ocimene?

- A. 2,6-dimethylocta-2,6,8-triene
- B. 3,7-dimethylocta-2,4,8-triene
- C. 2-methylene-6-methylocta-5,7-diene
- D. 2,6-dimethylocta-1,5,7-triene
- E. 3,7-dimethylocta-1,3,7-triene**



19. PETN was the explosive used by the Christmas Day bomber on Northwest Airline flight 253 to Detroit in 2009. The portability of PETN is one of the reasons that security on airlines in North America are so much more stringent today than they were 10 years ago. A sample of 0.2000 mol of PETN weighs 63.23 g and has the following percent composition by mass:

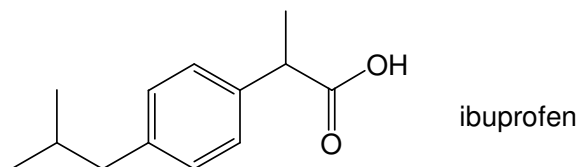
carbon	hydrogen	nitrogen	oxygen
18.99%	2.56%	17.72%	60.73%

The molecular formula of PETN is:

- A. CH_5NO_2 B. $\text{C}_5\text{H}_2\text{N}_7\text{O}_{12}$ C. $\text{C}_6\text{H}_4\text{N}_4\text{O}_{11}$
D. $\text{CH}_8\text{N}_7\text{O}_{15}$ E. $\text{C}_5\text{H}_8\text{N}_4\text{O}_{12}$
16. Valeric (pentanoic) acid, $\text{C}_5\text{H}_{10}\text{O}_2$, is found naturally in the perennial flowering plant *Valeriana officinalis*, from which it gets its name. Including valeric acid itself, how many five-carbon compounds exist that contain a carboxylic acid functional group and are constitutional isomers of one another?
- A. 2 B. 3 C. 4 D. 5 E. 6

CCC 2011

24. Ibuprofen (structure below) is a non-steroidal anti-inflammatory drug initially prescribed for treatment of rheumatoid arthritis. It is now marketed in North America as a general painkiller under the trade name Advil[®].

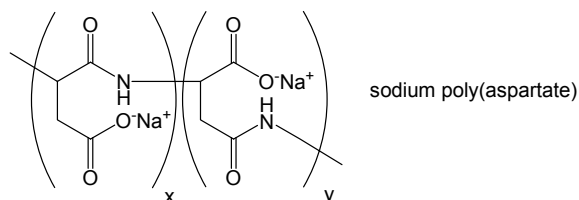


- Which **one** of the following statements concerning ibuprofen is **FALSE**?
- A. It contains a carboxylic acid functional group.
B. It contains a benzene ring.
C. It contains twelve carbon atoms.
D. It can be reacted with a base to form a water-soluble salt.
E. It is classified as an aromatic compound.
25. How many constitutional isomers exist of formula $\text{C}_5\text{H}_{12}\text{O}$ that contain an ether functional group?
- A. 3 B. 4 C. 5 D. 6 E. 7

CCC 2010



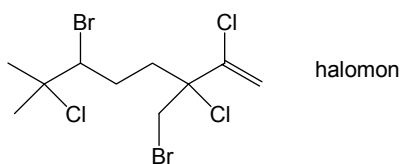
16. The polymer sodium poly(aspartate) (used as an anti-scaling agent) is manufactured by initially heating the amino acid known as aspartic acid at 180°C , causing a condensation polymerization to occur. This is followed by reaction with sodium hydroxide to form the final polymer, which has two repeating units (structure below).



What type of polymer is sodium poly(aspartate)?

- A. a polyamide B. a polyester C. a rubber
D. polynucleotide E. a polysaccharide

23. Halomon (structure below) is a polyhalogenated hydrocarbon initially isolated from *Portieria hornemannii*, a red algae. This substance has cytotoxic properties and has important potential as an anti-cancer drug.

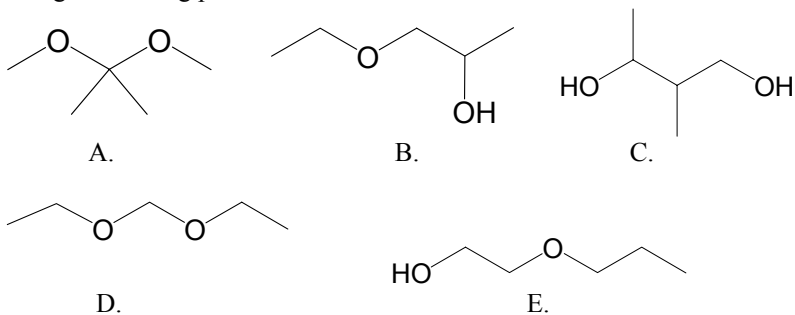


Which of the following represents the correct IUPAC name of halomon?

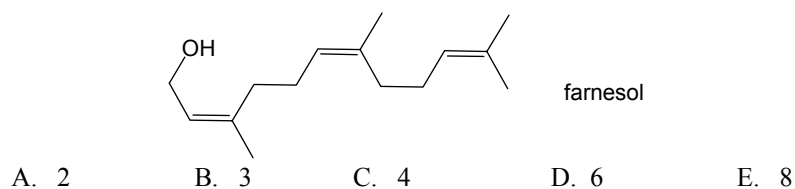
- A. 6-bromo-3-(bromomethyl)-2,3,7-trichloro-7-methyloct-1-ene
B. 3-bromo-6-(bromomethyl)-2,6,7-trichloro-2-methyloct-7-ene
C. 6-bromo-3-(bromomethyl)-7-methyl-2,3,7-trichlorooct-1-ene
D. 6-bromo-3-(bromoethyl)-2,3,7-trichloro-7-methyloct-1-ene
E. 3,6-dibromo-2,6,7-trichloro-2-methyloct-7-ene



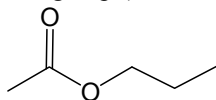
24. Each of the following organic substances has the chemical formula $C_5H_{12}O_2$ and is a liquid at room temperature and pressure. Which one has the highest boiling point?



25. Farnesol (structure below) is an organic substance used in perfumery to emphasise the odours of floral fragrances, and is a natural pesticide for mites. How many different stereoisomeric (geometric) structures of farnesol are possible?



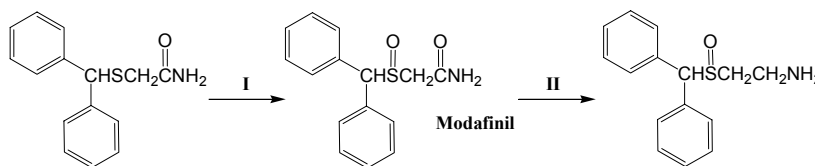
21. Propyl ethanoate (below) is an organic substance with a characteristic odour of pears. How many constitutional isomers of propyl ethanoate exist that contain an ester functional group (not counting the one shown)?



propyl ethanoate

- A. 2 B. 3 C. 4 D. 6 E. 8

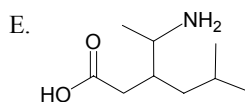
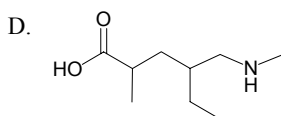
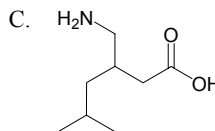
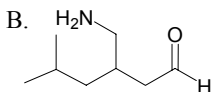
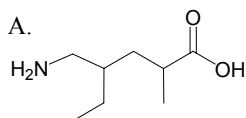
22. Modafinil (shown below) is an anti-narcoleptic drug that will reportedly suppress the need for sleep for up to 40 hours.



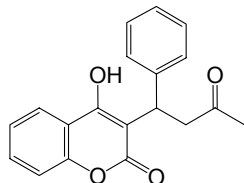
Identify which type of reaction is taking place during **I** and **II** and the nature of the nitrogen-containing functional group in modafinil.

	I	II	Functional Group
A.	reduction	Oxidation	Amide
B.	Oxidation	Reduction	Amide
C.	oxidation	Substitution	Amide
D.	oxidation	Elimination	Amine
E.	Oxidation	Reduction	Amine

24. Lyrica[®] is marketed by the pharmaceutical company Pfizer as an anticonvulsant drug used to treat generalised anxiety disorder. Lyrica[®] is also known by the chemical name 3-(aminomethyl)-5-methylhexanoic acid. Which of the following represents a molecule of Lyrica[®]?

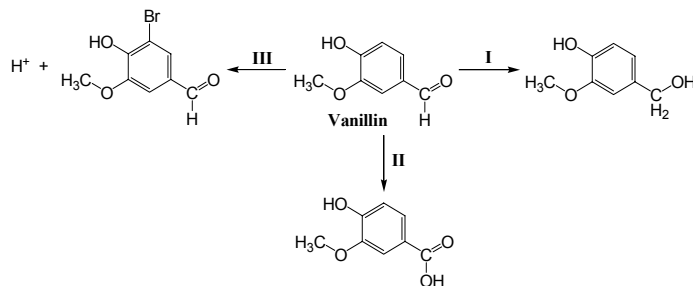


16. Warfarin is an anticoagulant used to decrease the clotting ability of blood so that thrombosis is prevented, while avoiding spontaneous bleeding. The structural formula of Warfarin is given below:



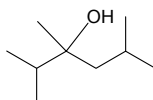
Four of the functional groups present in Warfarin are:

- A. ether, alkene, ketone, ester
 B. ether, alkene, ester, alcohol
 C. ester, alkene, alcohol, ketone
 D. ether, ketone, alkene, alcohol
 E. ester, alcohol, alkene, aldehyde
24. Vanillin, the primary component of the extract of the vanilla bean, undergoes several chemical reactions as shown below:



Identify which type of reaction is taking place during steps **I**, **II** and **III**.

- | I | II | III |
|--------------|-----------|--------------|
| A. reduction | oxidation | substitution |
| B. oxidation | reduction | substitution |
| C. reduction | oxidation | elimination |
| D. reduction | oxidation | addition |
| E. oxidation | reduction | addition |
25. Treatment of the organic substance 2,3,5-trimethyl-3-hexanol (structure below) with aqueous sulfuric acid causes a dehydration reaction. Three alkene products are formed in unequal amounts: 2,3,5-trimethyl-2-hexene (**I**), 2-isopropyl-4-methyl-1-pentene (**II**), and 2,3,5-trimethyl-3-hexene (**III**).



Which of these three alkenes can exist as geometric isomers?

- A. **I** only B. **I** and **II** only C. **I**, **II** and **III**
 D. **II** and **III** only E. **III** only