

Organic Chemistry

Question Paper 1

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Organic Chemistry
Booklet	Question Paper 1

Time Allowed: 60 minutes

Score: /50

Percentage: /100

Grade Boundaries:

Basic Principles

1. What is the total number of different chloroethanes, formula $C_2H_{6-n}Cl_n$, where n can be any integer from 1 to 4?

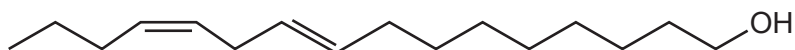
A 4 B 6 C 7 D 8

2. Hydrobromic acid reacts with ethene.

Which is a correct statement about the organic intermediate formed in the mechanism of this reaction?

- A It has a positive charge.
 B It has carbon, hydrogen and bromine atoms.
 C It is a free radical.
 D Its structure is planar.

3. The diagram shows the skeletal formula of the silkworm moth sex pheromone.



How many hydrogen atoms are present in one molecule of this pheromone?

A 26 B 28 C 29 D 30

4. The compound of molecular formula $C_3H_4Br_2$ has structural isomers.

How many of these **structural** isomers contain $C=C$ and how many do **not** contain $C=C$?

	structural isomers with $C=C$	structural isomers without $C=C$
A	4	0
B	4	2
C	5	0
D	5	2

5. Which molecule has the same number of atoms in a plane as a molecule of ethene, C_2H_4 ?

- A** BF_3 **B** IF_7 **C** PCl_5 **D** SF_6

6. Which type of formula will show butanone and butanal as different compounds?

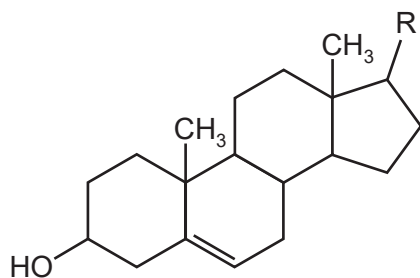
	empirical	molecular	structural	skeletal
A	x	x	x	✓
B	x	x	✓	✓
C	x	✓	✓	✓
D	✓	✓	✓	✓

key

✓ = shows difference

x = shows no difference

7. Cholesterol is the most common steroid alcohol. It has a molecular formula of $C_{27}H_{46}O$ and has the structure shown.

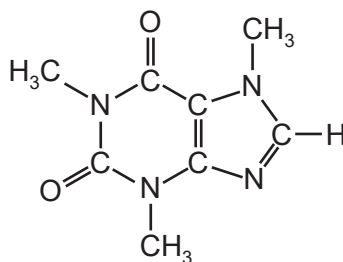


How many carbon atoms are in the hydrocarbon group R?

- A** 7 **B** 8 **C** 9 **D** 10

8. Caffeine is the stimulant found in tea and coffee.

The structure of caffeine is shown.



How many of its eight carbon atoms are at each of the functional group levels shown?

	alcohol	carbonyl	carboxylic acid	carbon dioxide
A	3	1	4	0
B	3	3	2	0
C	4	2	1	1
D	4	1	2	1

9. An organic molecule contains

only carbon, hydrogen and one oxygen atom;
 one carbon atom at the carbonyl functional group level;
 one asymmetric carbon atom.

What is the smallest number of carbon atoms such a molecule could possess?

- A** 4 **B** 5 **C** 6 **D** 7

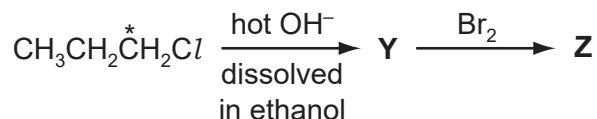
Functional Group Level

10. In the reaction of bromoethane with the cyanide ion, one carbon atom in bromoethane changes its functional group level.

Which statement correctly describes this change?

- A It changes from alcohol level to carbonyl level.
 - B It changes from alcohol level to carboxylic acid level.
 - C It changes from alcohol level to hydrocarbon level.
 - D It changes from hydrocarbon level to carboxylic acid level.
11. In terms of change in functional group level, which addition reaction does **not** involve oxidation?
- A $\text{CH}_2=\text{CH}_2 + \text{Br}_2 \rightarrow \text{CH}_2\text{BrCH}_2\text{Br}$
 - B $\text{CH}_2=\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br}$
 - C $\text{CH}_2=\text{CH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{CH}_2\text{Cl}$
 - D $\text{CH}_2=\text{CH}_2 + \text{H}_2 \rightarrow \text{CH}_3\text{CH}_3$

12. The diagram shows a reaction pathway.



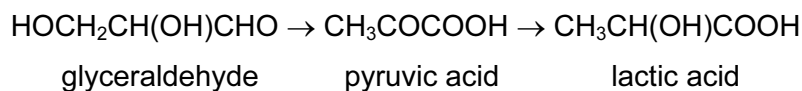
For this reaction pathway, what is the correct sequence of changes in the functional group level of the carbon atom shown by *?

- A It moves down one level, followed by moves up one level.
- B It moves down one level, followed by stays the same.
- C It stays the same, followed by moves up one level.
- D It stays the same, followed by stays the same.

13. A non-cyclic compound has the molecular formula $C_4H_9O_2N$.
Which pair of functional groups could **not** both be present in this molecule?

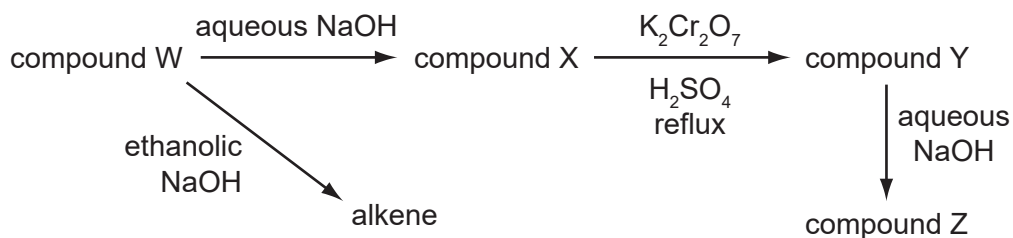
- A amide and alcohol
- B amine and carboxylic acid
- C amine and ester
- D carboxylic acid and nitrile

14. Lactic acid builds up in muscles when there is a deficiency of oxygen. Part of the reaction sequence is shown.



Which statement is correct?

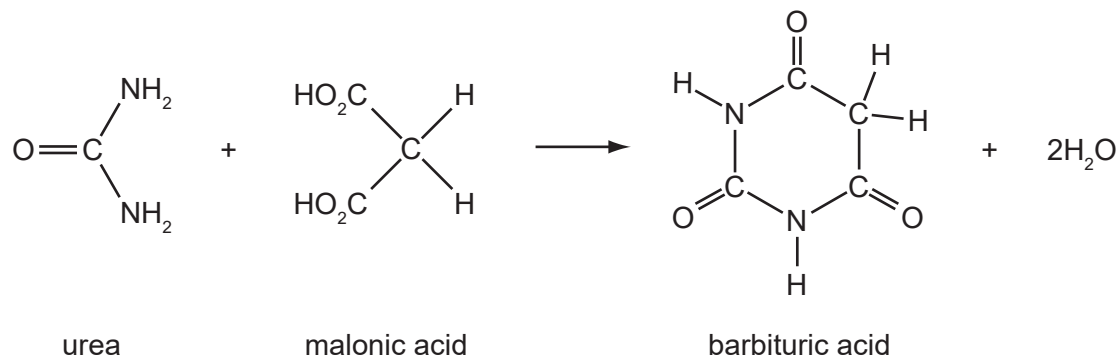
- A All three molecules involved have a carbon atom at the carbonyl functional group level.
 - B All three molecules involved have a chiral carbon atom.
 - C Both steps in the reaction sequence involve oxidation.
 - D In the reaction sequence, one of the carbon atoms increases then decreases its functional group level.
15. The flow chart shows a series of reactions.



Which class of compound are W, X, Y and Z?

	W	X	Y	Z
A	halogenoalkane	primary alcohol	aldehyde	carboxylic acid
B	halogenoalkane	primary alcohol	carboxylic acid	salt of carboxylic acid
C	primary alcohol	aldehyde	carboxylic acid	salt of carboxylic acid
D	primary alcohol	halogenoalkane	aldehyde	carboxylic acid

16. Barbituric acid, the basis for synthesising barbiturates, can be made by the reaction shown.



In this reaction, how many carbon atoms change their functional group level?

- A** 0 **B** 1 **C** 2 **D** 3

17. Partial hydrolysis of an animal protein produces a dipeptide with the structure shown.



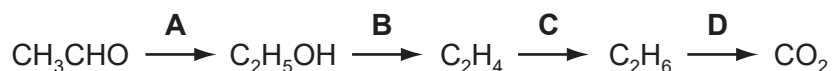
How many carbon atoms, at the functional group levels shown, does this molecule possess?

	alcohol	carbonyl	carboxylic acid
A	1	1	2
B	2	0	2
C	2	1	1
D	3	0	1

18. How many of the structural isomers of dibromopropane will react with aqueous sodium hydroxide to produce a compound with a carbon atom at the carbonyl functional group level?

- A** 0 **B** 1 **C** 2 **D** 3

19. Which conversion involves an increase in bond angle in the molecule involved and a decrease in functional group level of a carbon atom?

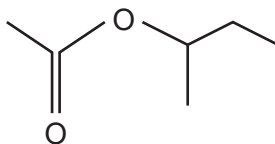


20. Which sequence shows an **overall** change that moves a carbon atom up one functional group level?

- A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
B $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
C $\text{CH}_3\text{CH}_2\text{CH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$
D $\text{CH}_3\text{CH}_2\text{CH}_3 \rightarrow \text{CH}_3\text{CH}=\text{CH}_2 \rightarrow 3\text{CO}_2 + 3\text{H}_2\text{O}$

Alcohols

21. An ester has the skeletal formula shown.



Which alcohol would combine with ethanoic acid to produce this ester?

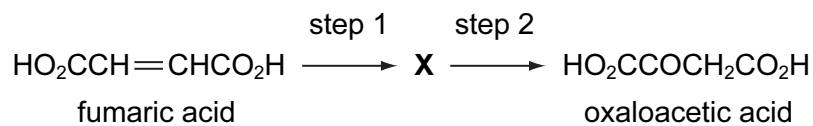
- A butan-1-ol
 - B butan-2-ol
 - C propan-1-ol
 - D propan-2-ol
22. A carbonyl compound, **X**, with the molecular formula $C_5H_{10}O$ can be oxidised with a $Cr_2O_7^{2-}/H^+$ mixture to form 3-methylbutanoic acid.

X can be reduced by $NaBH_4$ to form an alcohol, **Y**.

What is the structure of compound **Y**?

- A $CH_3CH(CH_3)CH_2CH_2OH$
 - B $CH_3CH_2CH_2CH(OH)CH_3$
 - C $CH_3CH(CH_3)CH(OH)CH_3$
 - D $CH_3CH_2CH(CH_3)CH_2OH$
23. Which statements about the reaction of butan-2-ol heated under reflux with acidified potassium dichromate(VI) are correct?
- 1 The organic product contains a π -bond in its molecule.
 - 2 The organic product contains a chiral carbon atom in its molecule.
 - 3 One carbon atom in butan-2-ol increases its functional group level by one.
- A 1, 2 and 3 B 1 and 2 only C 1 and 3 only D 2 and 3 only

24. In the Krebs cycle, fumaric acid is converted to oxaloacetic acid by a two step process involving an intermediate compound **X**.



What is the identity of **X**?

- A** $\text{HO}_2\text{CCH}_2\text{CH}_2\text{CO}_2\text{H}$
- B** $\text{HO}_2\text{CCHBrCH}_2\text{CO}_2\text{H}$
- C** $\text{HO}_2\text{CCH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$
- D** $\text{HO}_2\text{CCH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H}$
25. An organic compound X is reacted with an ethanolic solution of cyanide ions to form compound Y. Y is hydrolysed in acid solution to form compound Z, a carboxylic acid.

Which statement is correct?

- A** X is an alcohol with the same number of carbon atoms in one molecule as Z.
- B** X is an alcohol with fewer carbon atoms in its molecule than Z.
- C** X is a halogenoalkane with the same number of carbon atoms in one molecule as Z.
- D** X is a halogenoalkane with fewer carbon atoms in its molecule than Z.

Carbonyl

26. X is $\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$

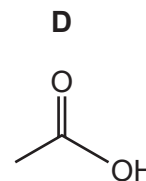
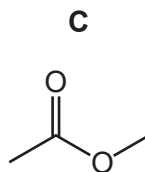
Y is $\text{HOCH}_2\text{COCH}_2\text{OH}$

Which statement about X and Y is correct?

- A X can be directly oxidised to Y.
- B X and Y have different empirical formulae.
- C X and Y both react with Tollens' reagent.
- D X and Y can both be reduced to $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$.

27. An organic compound produced a silver mirror when warmed with Tollens' reagent.

What is a possible structure for the organic compound?



28. Which reagent reacts with ethanal to give an organic product **without** a π bonded carbon atom?

- A acidified dichromate(VI) ions
- B bisulfite ions
- C hydrogen cyanide
- D Tollens' reagent

29. A compound of formula $C_5H_6Cl_2O$ has the following features.
- geometric isomers
 - no optical isomers
 - two carbon atoms at the carbonyl functional group level

What is the compound?

- A $CHCl_2COCH=CHCH_3$
 B $CH_2ClCOCH=CHCH_2Cl$
 C $CH_3CHClCCl=CHCHO$
 D $CH_3CH_2COCH=CCl_2$

30. A **straight chain** organic compound X, $C_4H_8Br_2$, undergoes hydrolysis with aqueous sodium hydroxide to produce a compound which reacts with Tollens' reagent to form a silver mirror.

In X, the bromine atoms are joined to carbon atoms numbered

- A 1,1. B 1,2. C 1,4. D 2,2.

31. X is $HOCH_2CH(OH)CHO$

Y is $HOCH_2COCH_2OH$

Which statement about X and Y is correct?

- A X can be directly oxidised to Y.
 B X and Y have different empirical formulae.
 C X and Y both react with Tollens' reagent.
 D X and Y can both be reduced to $HOCH_2CH(OH)CH_2OH$.

32. Grignard reagents react with compounds containing the carbonyl functional group.

Which compound would react with Grignard reagent CH_3CH_2MgBr to produce an organic product with a chiral carbon atom?

- A ethanal
 B methanal
 C propanal
 D propanone

33. The compound $C_4H_6O_2$ gives butter its distinctive flavour.

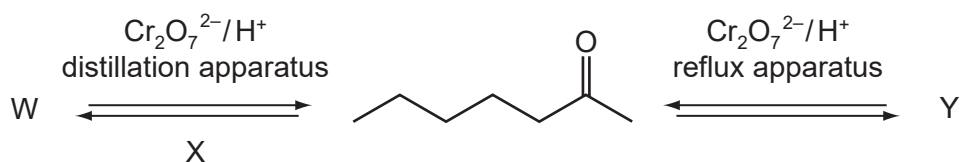
It reacts with hydrogen cyanide to produce the compound $C_6H_8N_2O_2$ but does not react with Tollens' reagent.

What is the structural formula of this compound in butter?

- A CH_3COCH_2CHO
- B $CH_3COCOCH_3$
- C $CH_3COCH=CHOH$
- D $CH_2=CHCOCH_2OH$

34. One of the chemicals giving blue cheese its unique aroma is heptan-2-one.

The diagram shows reactions involving heptan-2-one.



Which row correctly identifies compound W, reagent X and compound Y?

	compound W	reagent X	compound Y
A	heptane	$NaBH_4$	heptanoic acid
B	heptan-2-ol	$NaBH_4$	heptanoic acid
C	heptanal	C_2H_5MgBr	heptan-2-one
D	heptan-2-ol	$NaBH_4$	heptan-2-one

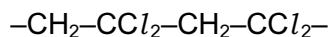
Additions and Eliminations

35. An amine $\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$, and an acid $\text{HO}_2\text{C}(\text{CH}_2)_3\text{CO}_2\text{H}$ react to form a condensation polymer **P**.

What is the formula of the repeat unit in **P**?

- A** $\text{C}_9\text{H}_{20}\text{N}_2\text{O}_2$
B $\text{C}_{10}\text{H}_{19}\text{NO}$
C $\text{C}_{11}\text{H}_{18}\text{N}_2\text{O}_2$
D $\text{C}_{11}\text{H}_{20}\text{N}_2\text{O}_2$

36. Two repeat units of a polymer are shown.

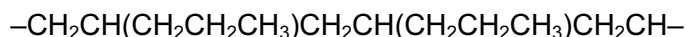


What is the product when the monomer used to make this polymer is reacted with chlorine in an organic solvent?

- A** $\text{CCl}_2=\text{CCl}_2$ **B** CCl_3CCl_3 **C** $\text{CH}_2\text{ClCCl}_3$ **D** $\text{CHCl}_2\text{CCl}_3$

37. Certain polymers are added to engine oil to improve its viscosity.

A portion of the chain of one such polymer is shown.



A molecule of this polymer contains 40 carbon atoms.

How many monomer units are incorporated in one molecule of this polymer?

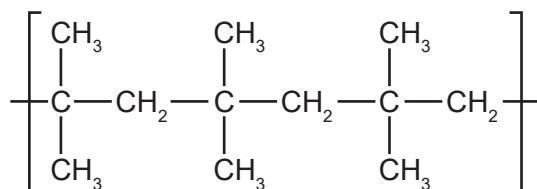
- A** 4 **B** 5 **C** 8 **D** 10

38. Elimination occurs when 2,4-dibromoheptane reacts with hot alcoholic sodium hydroxide, producing a mixture of dienes with the molecular formula C_7H_{12} .

Which diene would **not** be produced in this reaction?

- A** $\text{CH}_2=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}_3$
B $\text{CH}_2=\text{CHCH}=\text{CHCH}_2\text{CH}_2\text{CH}_3$
C $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_3$
D $\text{CH}_3\text{CH}=\text{CHCH}=\text{CHCH}_2\text{CH}_3$

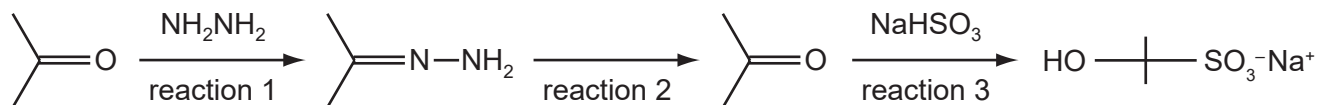
39. Patches used to administer drugs contain pressure-sensitive adhesives that stick to the skin. The diagram shows part of the structure of one such adhesive.



Which monomer could be used to make this polymer?

- A $\text{CH}_3\text{CH}=\text{CHCH}_3$
 B $(\text{CH}_3)_2\text{C}=\text{CHC}(\text{CH}_3)_3$
 C $(\text{CH}_3)_2\text{C}=\text{CH}_2$
 D $(\text{CH}_3)_2\text{CHC}(\text{CH}_3)_2\text{CH}_2\text{CH}_3$

40. The diagram shows a reaction sequence.



How can the three reactions be classified?

	reaction 1	reaction 2	reaction 3
A	addition	hydrolysis	reduction
B	addition	oxidation	reduction
C	condensation	hydrolysis	addition
D	condensation	oxidation	addition

41. A bromine-containing organic compound, **T**, undergoes an elimination reaction when treated with hot ethanolic sodium hydroxide solution.

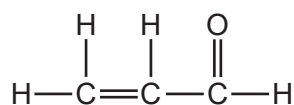
What is **T**?

- A CH_3Br
 B C_2Br_6
 C $(\text{CH}_3)_2\text{C}=\text{CBr}_2$
 D $\text{CH}_3\text{CH}_2\text{CBr}_3$

42. Which pair of reactions could **not** regenerate the original organic reactant?

- A addition followed by elimination
- B addition followed by substitution
- C hydrolysis followed by substitution
- D substitution followed by hydrolysis

43. The diagram shows a molecule of propenal, which is used to make many polymers.

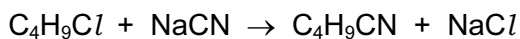


When CH_3MgBr reacts with propenal, which bond in the above molecule is broken?

- A the σ bond in $\text{C}=\text{O}$
- B the σ bond in $\text{C}=\text{C}$
- C the π bond in $\text{C}=\text{O}$
- D the π bond in $\text{C}=\text{C}$

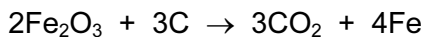
Environmental Impact

44. What is the atom economy of the following synthesis of C_4H_9CN ? (C_4H_9CN is the only utilised product.)



- A** 59% **B** 88% **C** 90% **D** 100%
45. Which aim is consistent with the principles of green chemistry?
- A** avoiding catalysts that are heterogeneous
B solventless reactions
C using cheaper reagents
D using substitution rather than addition reactions

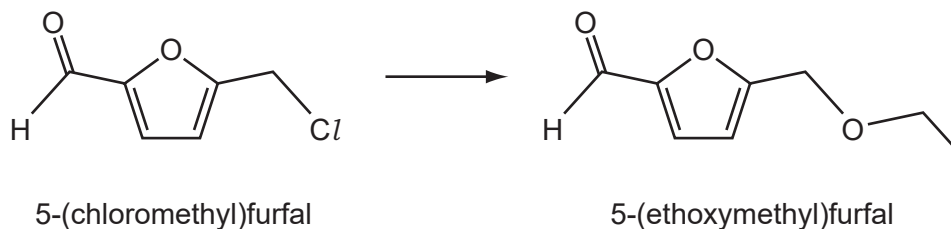
46. Iron can be extracted from the ore haematite, Fe_2O_3 , using carbon.



What is the atom economy for this process where iron is the only utilised product?

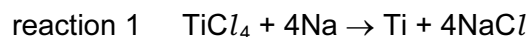
- A** 15.7% **B** 32.5% **C** 35.0% **D** 62.8%
47. Which type of reaction must have the greatest atom economy?
- A** addition
B condensation
C elimination
D substitution

48. Huge research efforts are going into biofuel production. Scientists have managed to break down cellulose into 5-(chloromethyl)furfal and convert it into 5-(ethoxymethyl)furfal, potentially useful in biofuel production.



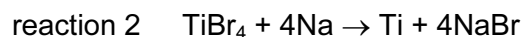
Which reagent is required for this transformation?

- A** chloroethane
B ethanol
C ethene
D water
49. Titanium is used to replace arthritic hip joints that have become too painful. The final step in its extraction is shown.



$$M_r(\text{TiCl}_4) = 189.9; A_r(\text{Na}) = 23.0; A_r(\text{Ti}) = 47.9$$

A research chemist decides to replace the titanium(IV) chloride with titanium(IV) bromide. The new equation is shown.



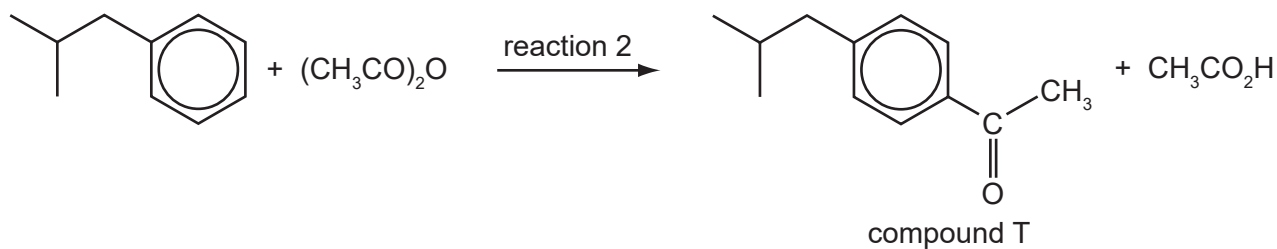
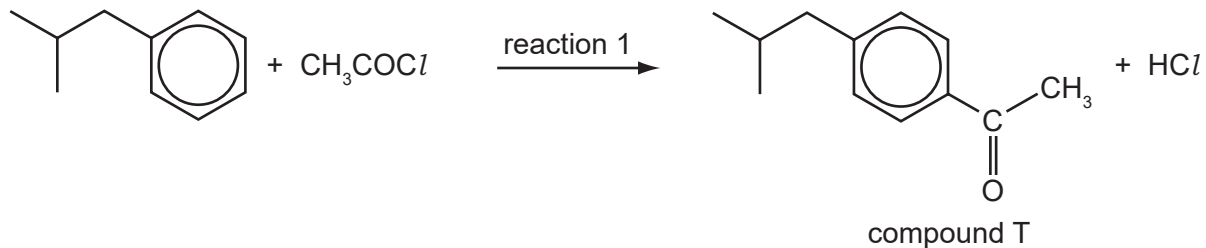
$$M_r(\text{TiBr}_4) = 367.5; A_r(\text{Na}) = 23.0; A_r(\text{Ti}) = 47.9$$

What will be the effect of substituting bromine for chlorine on the atom economy of the process where Ti is the only utilised product?

- A** Reaction 1 has a higher atom economy than reaction 2 by 6.6%.
B Reaction 1 has a higher atom economy than reaction 2 by 12.2%.
C Reaction 1 has a lower atom economy than reaction 2 by 6.6%.
D Reaction 1 has a lower atom economy than reaction 2 by 12.2%.

50. Ibuprofen is an over-the-counter pain killer. There are a number of ways to synthesise the drug.

The first step in the synthesis of ibuprofen involves the production of compound T by either reaction 1 or reaction 2.



Assuming compound T is the only utilised product, which statement is correct?

- A Adding a catalyst to either reaction will increase its atom economy.
- B Reaction 1 has a higher atom economy than reaction 2.
- C Reaction 2 has a higher atom economy than reaction 1.
- D Since both reactions use the same starting material, and the utilised product is the same in both cases, there is no difference in atom economy.