Topic 7 Fossil Fuels and Carbon Compounds

Unit 28 Addition polymers

Content

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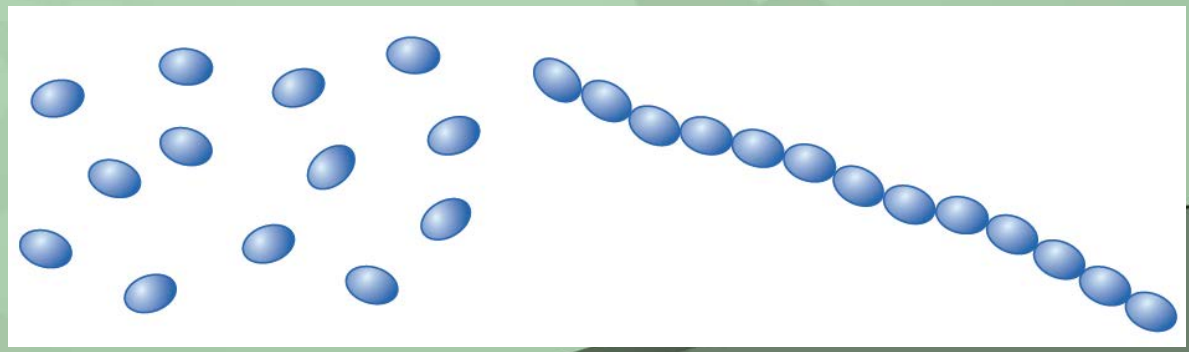
Content

28.1 Synthetic polymers all around you (p.136)

- Almost everywhere you look, you will see objects made of **plastic (塑膠)**.
- Plastics are examples of what chemists call **synthetic polymers (合成聚合物)**.
- A **polymer (聚合物)** is a compound consisting of very large molecules formed by joining together many small molecules repeatedly.



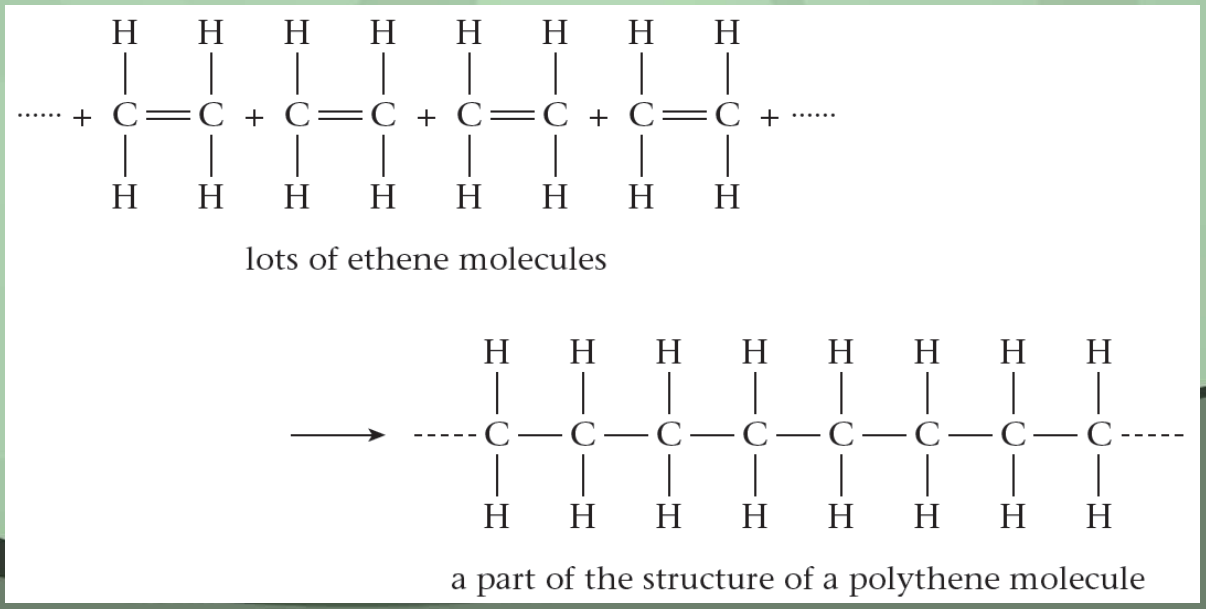
28.2 Why are synthetic polymers so useful? (p.138)

Synthetic polymers have many advantages. In general , they're

- lightweight;
- resistant to chemicals;
- strong;
- good thermal and electrical insulators;
- waterproof;
- can be easily moulded into different shapes;
- can be easily coloured;
- cost-effective.

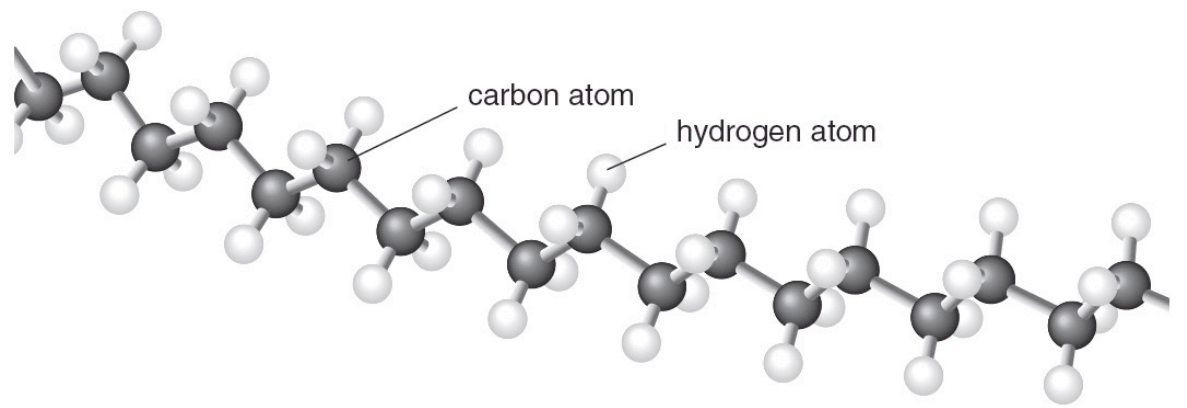
28.3 Addition polymerisation of ethene (p.139)

- The alkenes obtained from catalytic cracking of petroleum fractions are the starting compounds for making many common synthetic polymers.
- Part of C=C bond of each molecule breaks; other atoms add on.
- The two electrons of C=C may be used to join neighbouring ethene molecules to make a long chain of polymer polythene.



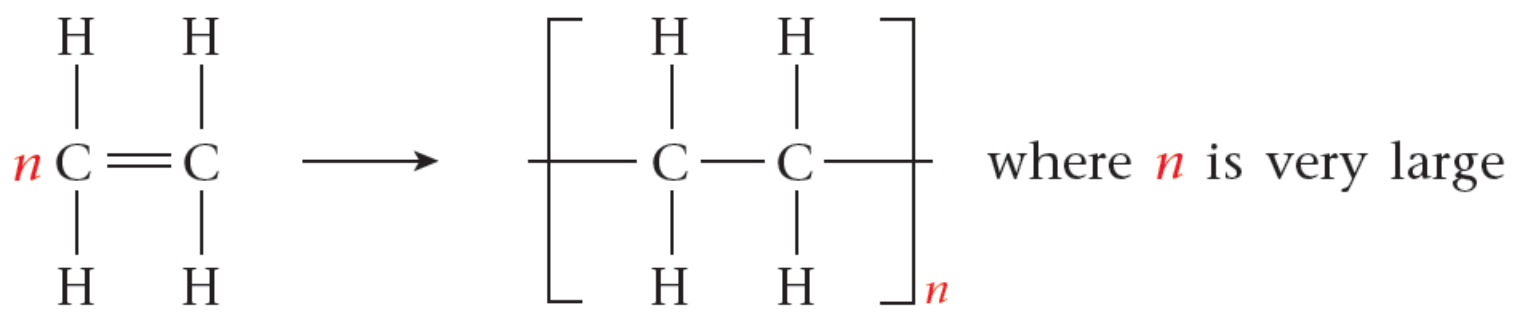
28.3 Addition polymerisation of ethene (p.139)

- This type of reaction is called **addition polymerisation (加成聚合作用)**—one in which monomer molecules join together repeatedly to form polymer molecules. No atoms are lost from the monomer molecules during the reaction.
- High temperature / high pressure / catalyst is used for addition polymerisation.
- Polythene is an **addition polymer (加成聚合物)**. The 'ene' ending is still used even though the polymer is saturated.

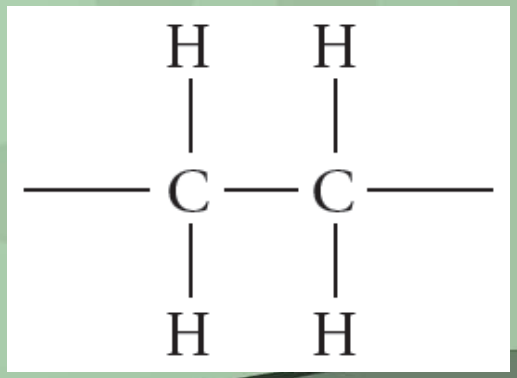


28.3 Addition polymerisation of ethene (p.139)

- The polymerisation of ethene can be shown by the equation below:



- The section inside the bracket is the **repeating unit (重複單位)**:
- A repeating unit is the smallest part of a polymer molecule, and the whole polymer molecule can be obtained by repeating it.
- *n* is often several thousands



28.3 Addition polymerisation of ethene (p.139)

Below are some features of addition polymers and addition polymerisation:

- Polymers consist of long-chain molecules formed by joining many monomer molecules together.
- Monomer molecules containing carbon-carbon double bonds can undergo addition polymerisation to give addition polymers.
- During addition polymerisation, part of the double bond of each monomer molecule is broken, and the molecule joins to neighbouring monomer molecules to make a molecule with a very long chain.

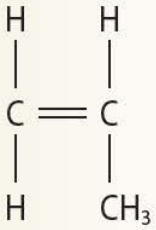
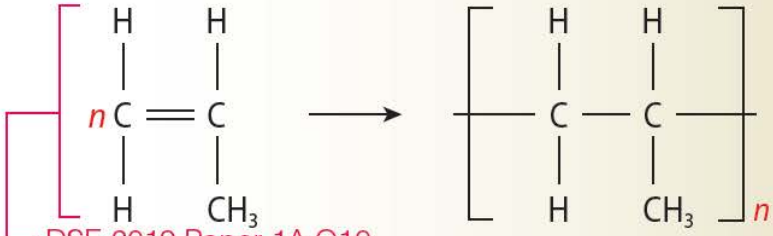
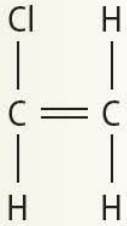
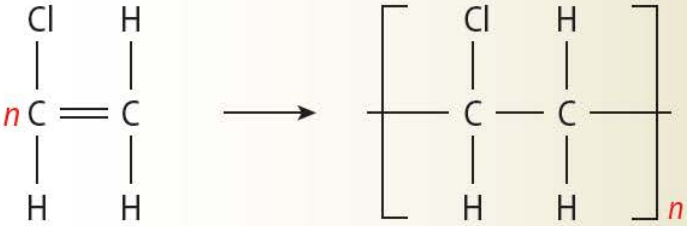
28.3 Addition polymerisation of ethene (p.139)

Two common types of polythene:

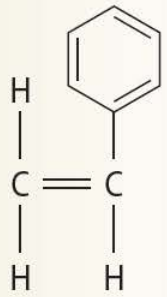
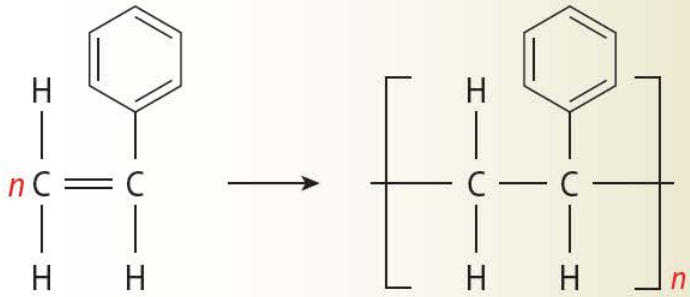
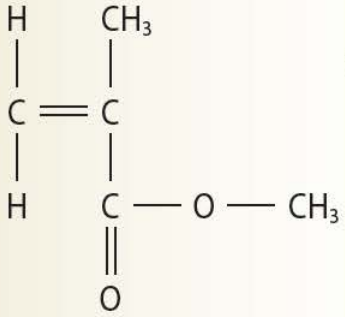
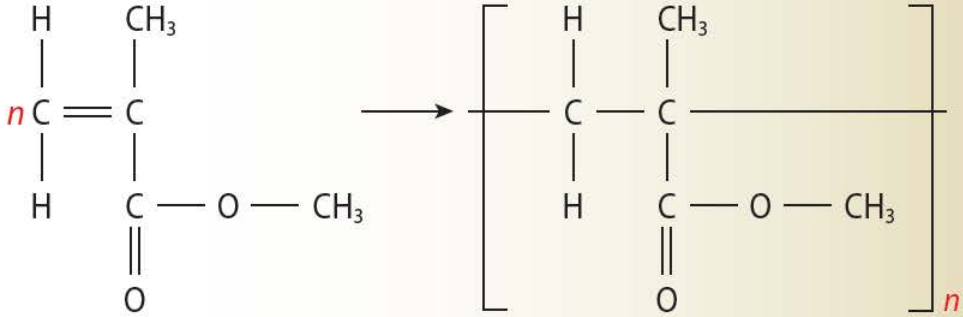
- **low density polythene, LDPE (低密度聚乙烯)**— heating ethene at high pressures and high temp. with **initiator (引發劑)** (often peroxides);
- **high density polythene, HDPE (高密度聚乙烯)**— manufactured at relatively low pressures and low temperatures with a special catalyst.

28.4 Making other synthetic polymers (p.142)

- Many other polymers can be made from monomers containing C=C bonds, but NOT from benzene.

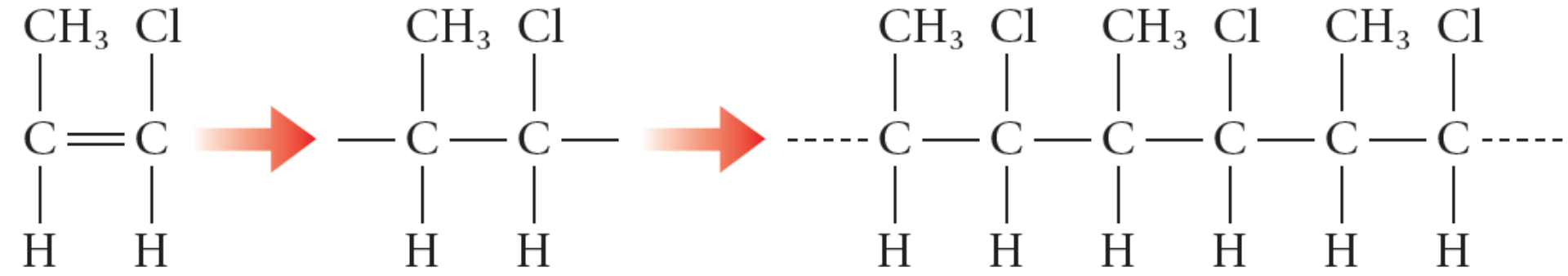
Propene		**polypropene** (PP)	 DSE 2019 Paper 1A Q10
Chloroethene (vinyl chloride)		**polyvinyl chloride** (PVC)	

28.4 Making other synthetic polymers (p.142)

Phenylethene (styrene)		**polystyrene** (PS)	
Methyl 2-methylpropenoate or methyl methacrylate		**poly(methyl 2-methylpropenoate)** (Perspex) or polymethyl methacrylate (PMMA)	

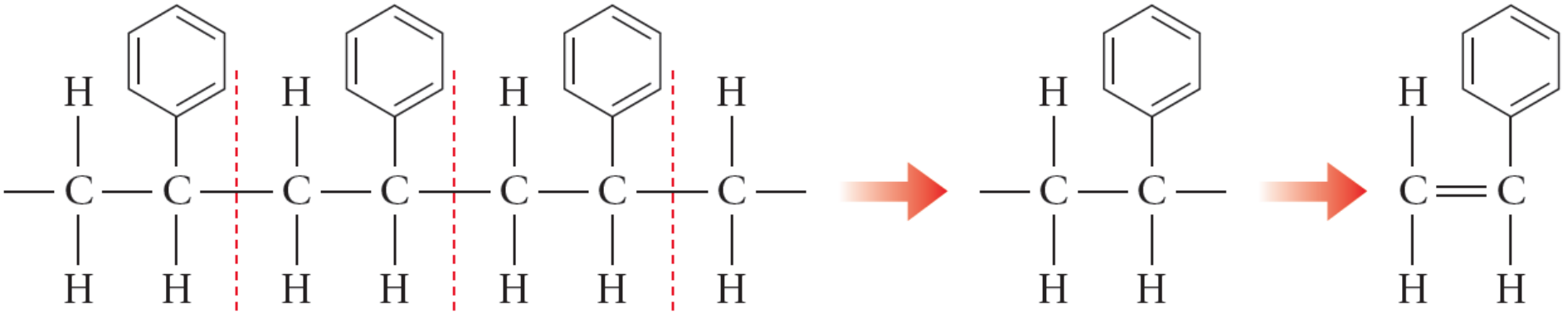
28.4 Making other synthetic polymers (p.142)

Deducing the structure of an addition polymer



28.4 Making other synthetic polymers (p.142)

Deducing the structure of a monomer

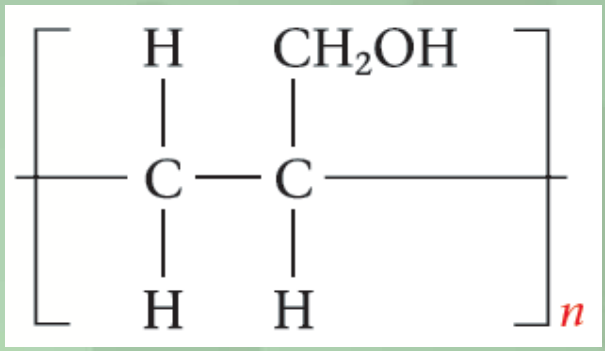


a part of the structure of an addition polymer → repeating unit → monomer

28.4 Making other synthetic polymers (p.142)

Q (Example 28.1)

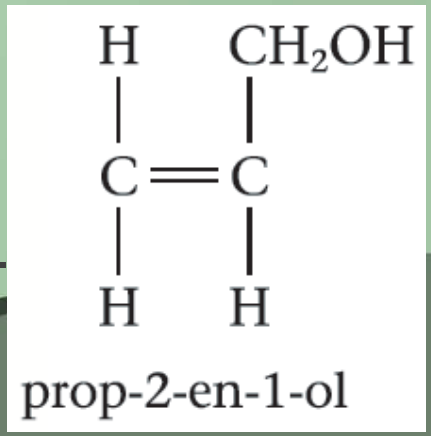
Polymer B shown below can be formed from the polymerisation of compound A.



a) Write the structural formula of compound A and give its systematic name.
b) State the type of polymerisation for the formation of B from A.
c) Suggest why the relative molecular mass of B is expressed using a range of values instead of a single fixed value.

A

a)

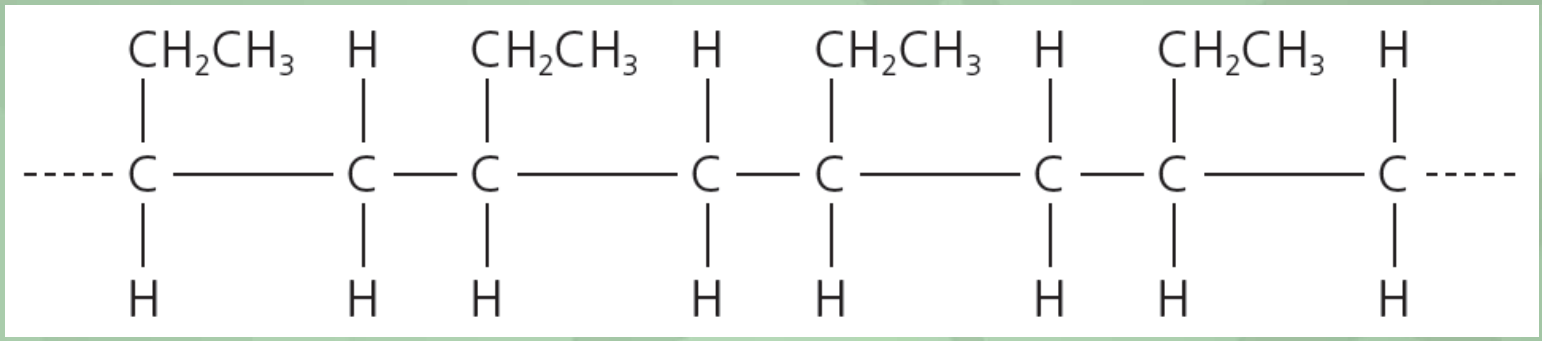


b) Addition polymerisation
c) B is a mixture of polymeric molecules with different lengths.

28.4 Making other synthetic polymers (p.142)

Practice 28.1

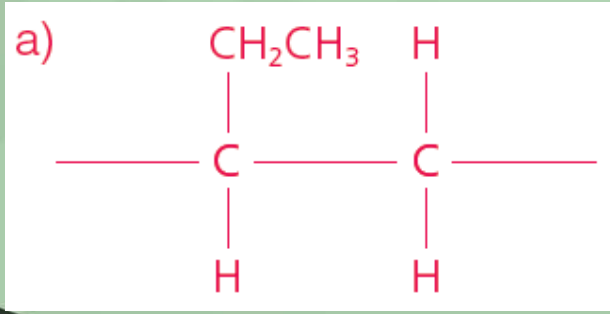
1 Compound X can form a polymer with the structure shown below.



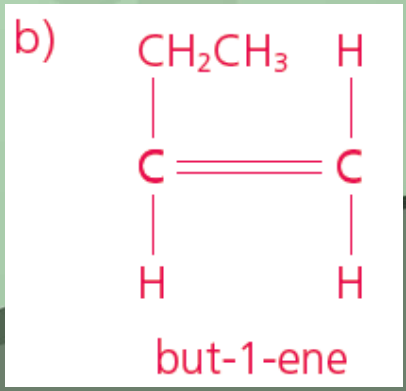
a) Draw the repeating unit of the polymer.

b) Write the structural formula of compound X and state its systematic name.

a)

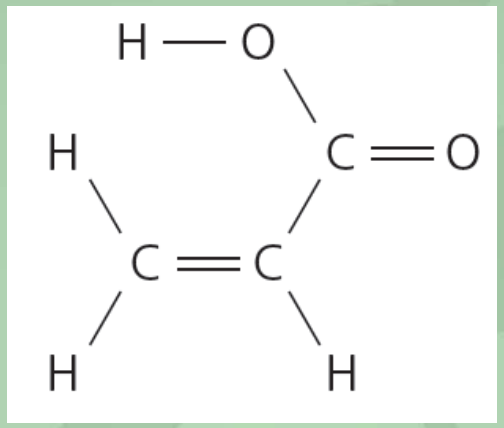


b)



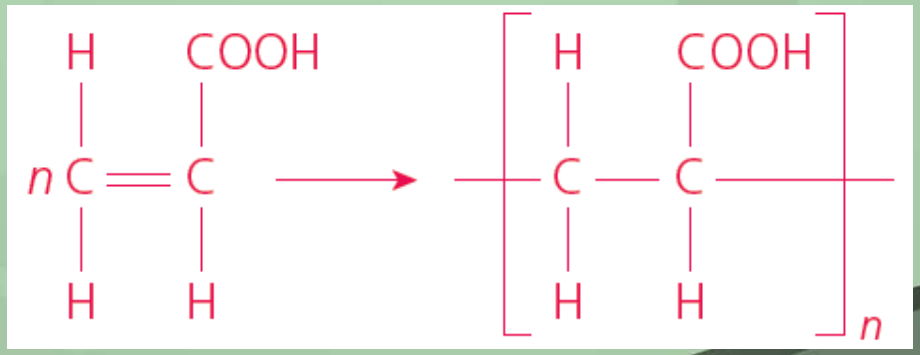
28.4 Making other synthetic polymers (p.142)

2 Compound A shown below can polymerise to form an addition polymer.



a) State the systematic name of compound A. Propenoic acid

b) Write the chemical equation for the polymerisation of compound A.



28.5 Uses of some common addition polymers (p.145)

- Polymers have different uses as they have different properties.

Structure of LDPE

- shorter average chain length
- highly branched

Structure of HDPE

- longer average chain length
- not highly branched

28.5 Uses of some common addition polymers (p.145)

Table 28.2 Differences between LDPE and HDPE

Property or use	LDPE	HDPE
Density	lower	higher
Melting point	about 130 °C	about 160 °C
Strength	lower	higher
Flexibility	very flexible	much stiffer
Uses	packaging films and bags	bottle caps

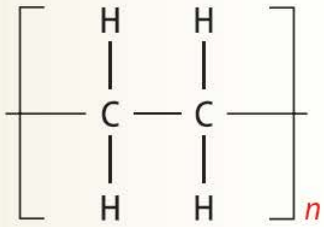
The strength of a material is its ability to resist an applied force without breaking.

A flexible material is easy to bend.

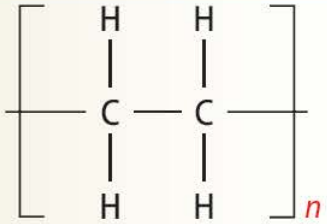
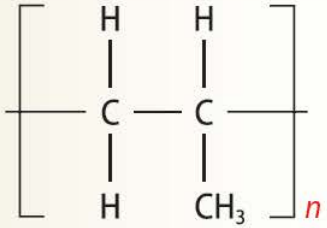
A stiff material is difficult to bend.

28.5 Uses of some common addition polymers (p.145)

Table 28.3 Structures, properties and uses of six synthetic polymers

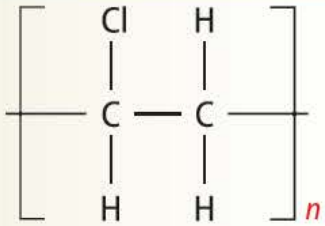
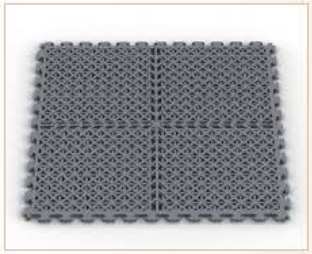
Name	Structure of polymer	Properties of polymer	Uses of polymer
Low density polythene (LDPE)		• lightweight • flexible • fairly soft • good electrical insulator • good barrier to moisture	• packaging films, bags • garbage bags • squeezable bottles 

28.5 Uses of some common addition polymers (p.145)

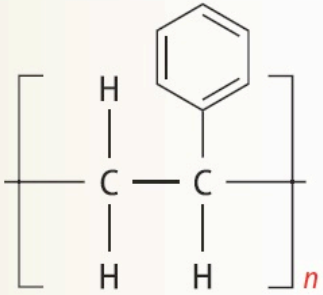
High density polythene (HDPE)		• stiffer and stronger than low density polythene • chemical and moisture resistant	• milk, water and juice containers • liquid detergent bottles 
Polypropene (PP)		• hard • strong • chemical and moisture resistant	• ketchup bottles • margarine tubs • medicine bottles • bottle crates  

A hard material can resist wear, scratching and indentation.

28.5 Uses of some common addition polymers (p.145)

Polyvinyl chloride (PVC)		• hard • strong • chemical resistant PVC with plasticiser • more flexible	• drain pipes • floor tiles • table cloths • wire and cable insulation  

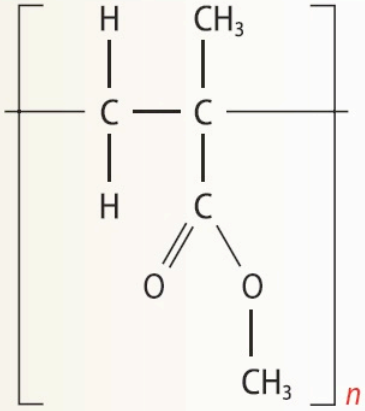
28.5 Uses of some common addition polymers (p.145)

Polystyrene (PS)		• hard • rigid • transparent • brittle Expanded polystyrene • lightweight solid foam • good insulator of heat • excellent shock absorbent	• disposable cups and lunch boxes • packing materials 

A brittle material fractures upon the application of a small force, impact or shock.

Expanded polystyrene can be produced by blowing gases through molten polystyrene and then allowing it to cool. Expanded polystyrene is made up of 98% air. This trapped air enhances the heat insulating property of expanded polystyrene.

28.5 Uses of some common addition polymers (p.145)

Perspex		• highly transparent • strong • rigid	• signs • covers for car lights • shower screens • aircraft windows

Preparing polystyrene

Investigating the properties of some polymers

28.5 Uses of some common addition polymers (p.145)

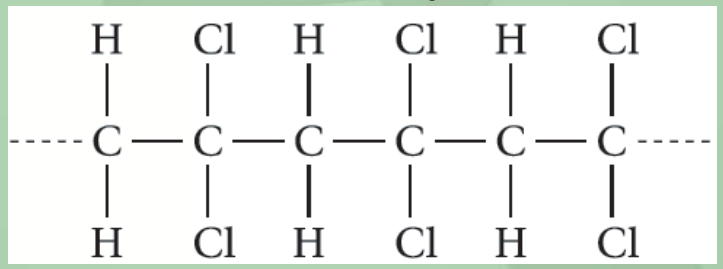
Q (Example 28.2)

Polythene can be used to make food wrap.

a) Explain, in terms of bonding, why objects made of polythene are resistant to chemical attacks.

b) Explain why ethene can form a polymer, but ethane CANNOT.

c) 'Saran' can also be used to make food wrap. A section of a polymer chain of 'Saran' is shown below.



i) In terms of intermolecular forces, explain why 'Saran' is more suitable than polythene in making food wrap for use in microwave ovens.

ii) Incineration of 'Saran' waste produces hydrogen chloride which causes air pollution. State ONE harmful effect of the discharge of hydrogen chloride into the atmosphere.

28.5 Uses of some common addition polymers (p.145)

A

a) Polythene is a hydrocarbon with strong C—C and C—H bonds. These bonds are not readily attacked by chemicals.

b) An ethene molecule contains a carbon-carbon double bond whereas an ethane molecule does not.

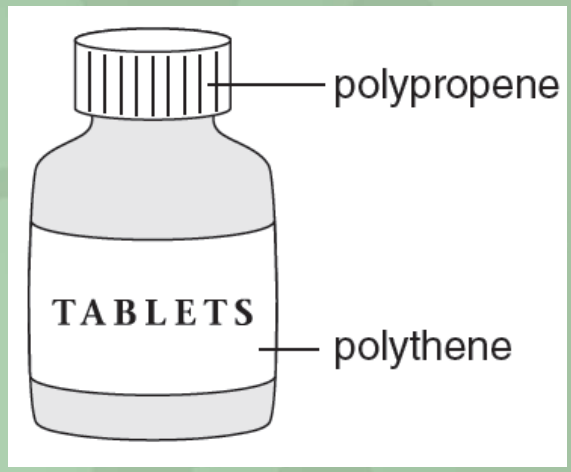
c) i) 'Saran' is more heat resistant. It has polar C—Cl bonds. The polar attractive forces between 'Saran' molecules are stronger than the attractive forces between non-polar polythene molecules.

ii) Hydrogen chloride causes acid rain when discharged into the atmosphere.

28.5 Uses of some common addition polymers (p.145)

Practice 28.2

1 The tablet container shown is made from two different synthetic polymers.



a) These are two common types of polythene (PE).

i) Name the TWO common types of PE.

Low density polythene and high density polythene

ii) Suggest which type of PE is more suitable in making this container. Explain your choice.

As the bottle is hard, high density polythene is more suitable.

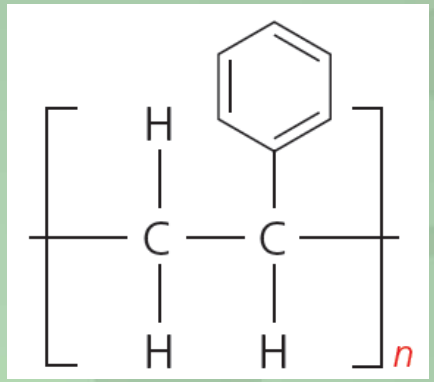
b) State ONE property of polypropene which makes it suitable for making caps of tablet containers.

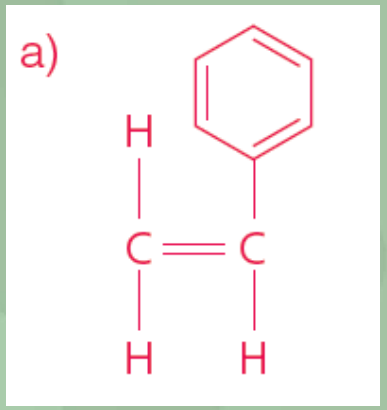
Any one of the following:

- Chemical resistant
- Good barrier to moisture
- Non-toxic

28.5 Uses of some common addition polymers (p.145)

2 Polystyrene (PS) is a commonly used synthetic polymer. The structure of PS is shown.



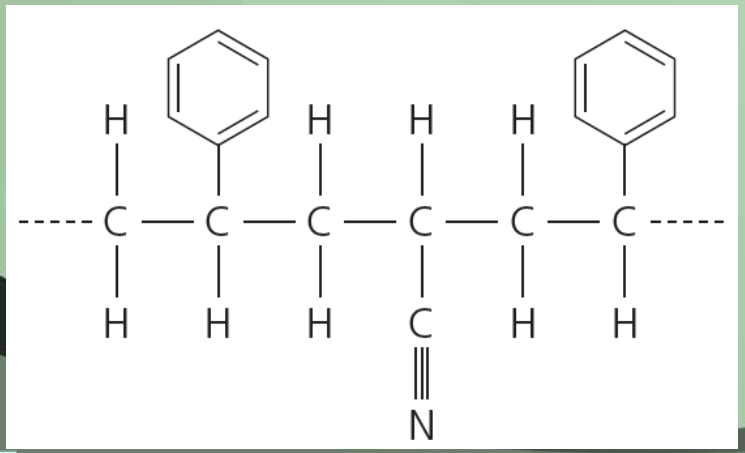


a) Write the structural formula of the monomer of PS.

b) Suggest why PS does NOT have a constant relative molecular mass.

PS is a mixture of polymer molecules of different lengths.

c) SAN is a plastic material made from the copolymerisation of styrene with acrylonitrile (CH_2=CHCN). A part of the structure of SAN is shown below.



Acrylonitrile has polar –C≡N group. The –C≡N groups hold the polymer molecules of SAN by stronger polar attractive forces.

Key terms (p.152)

plastic	塑膠	low density polythene	低密度聚乙烯
synthetic polymer	合成聚合物	high density polythene	高密度聚乙烯
polymer	聚合物	initiator	引發劑
monomer	單體	polypropene	聚丙烯
polymerisation	聚合作用	polyvinyl chloride	聚氯乙烯
addition polymerisation	加成聚合作用	polystyrene	聚苯乙烯
addition polymer	加成聚合物	low density polythene	低密度聚乙烯
repeating unit	重複單位	poly(methyl 2-methylpropenoate)	聚(2-甲基丙烯酸甲酯)

Summary (p.153)

1 A polymer is a compound consisting of very large molecules formed by joining together many small molecules repeatedly.

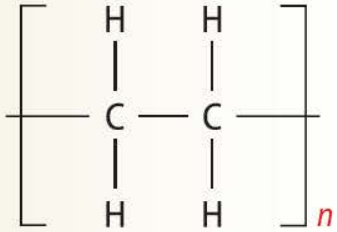
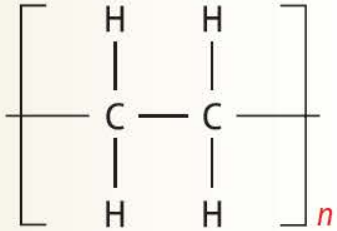
2 Addition polymerisation is a reaction in which monomer molecules join together repeatedly to form polymer molecules. No atoms are lost from the monomer molecules during the reaction.

3 Monomer molecules containing carbon-carbon double bonds can undergo addition polymerisation to give addition polymers.

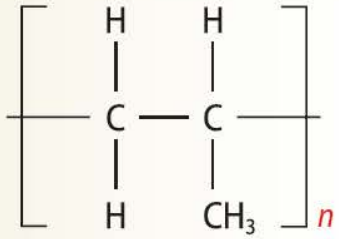
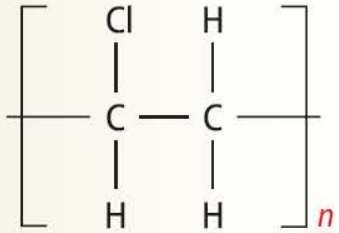
4 A repeating unit is the smallest part of a polymer molecule, and the whole polymer molecule can be obtained by repeating it.

Summary (p.153)

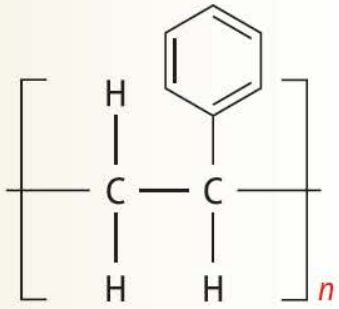
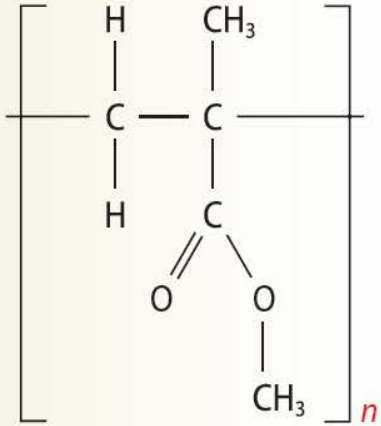
5 The structures, properties and uses of some common addition polymers are shown below:

Name	Structure of polymer	Properties of polymer	Uses of polymer
Low density polythene (LDPE)		• lightweight • flexible • fairly soft • good electrical insulator • good barrier to moisture	• packaging films, bags • garbage bags • squeezable bottles
High density polythene (HDPE)		• stiffer and stronger than low density polythene • chemical and moisture resistant	• milk, water and juice containers • liquid detergent bottles

Summary (p.153)

Polypropene (PP)		• hard • strong • chemical and moisture resistant	• ketchup bottles • margarine tubs • medicine bottles • bottle crates
Polyvinyl chloride (PVC)		• hard • strong • chemical resistant PVC with plasticiser • more flexible	• drain pipes • floor tiles • table cloths • wire and cable insulation

Summary (p.153)

Name	Structure of polymer	Properties of polymer	Uses of polymer
Polystyrene (PS)		• hard • rigid • transparent • brittle Expanded polystyrene • lightweight solid foam • good insulator of heat • excellent shock absorbent	• disposable cups and lunch boxes • packing materials
Perspex		• highly transparent • strong • rigid	• signs • covers for car lights • shower screens • aircraft windows

Unit Exercise (p.155)

Note: Questions are rated according to ascending level of difficulty (from 1 to 5):

 **question targeted at level 3 and above;**
 **question targeted at level 4 and above;**
 **question targeted at level 5.**
‘ * ’ indicates 1 mark is given for effective communication.

Unit Exercise (p.155)

PART I KNOWLEDGE AND UNDERSTANDING

1 Complete the following concept map.

a) addition
b) addition
c) polythene
d) polypropene
e) polyvinyl chloride
f) polystyrene
g) Perspex

synthetic polymers

that are made by

(a) polymerisation

are called

(b) polymers

examples

(c) repeating unit is (h)

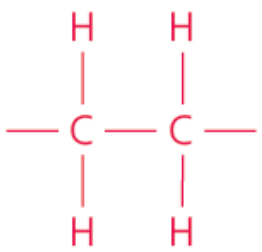
(d) repeating unit is (i)

(e) repeating unit is (j)

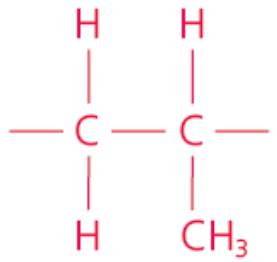
(f) repeating unit is (k)

(g) repeating unit is (l)

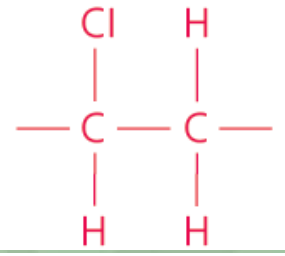
h)



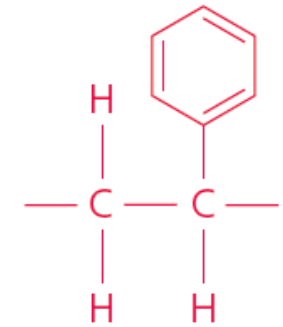
i)



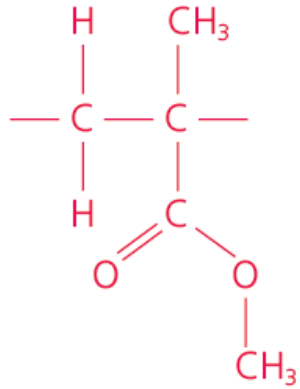
j)



k)



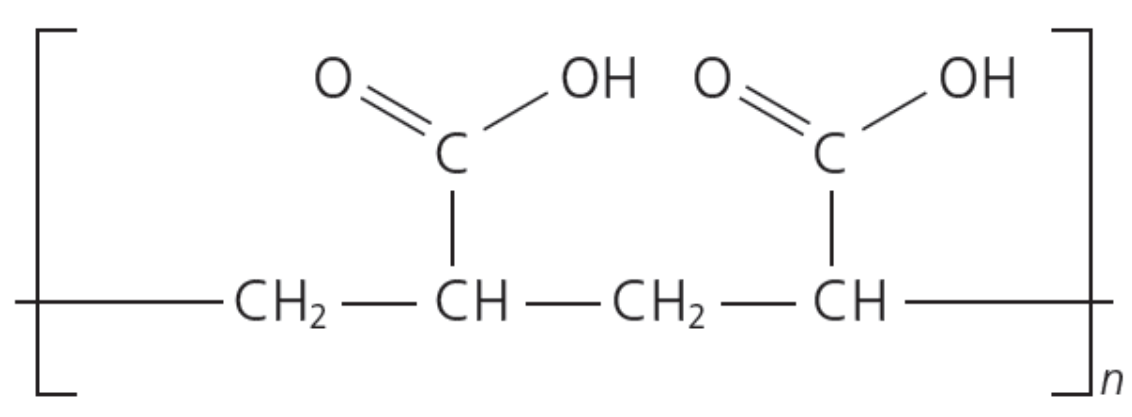
l)



Unit Exercise (p.155)

PART II MULTIPLE CHOICE QUESTIONS

2 A polymer made from acrylic acid (CH_2=CHCOOH) is shown below.



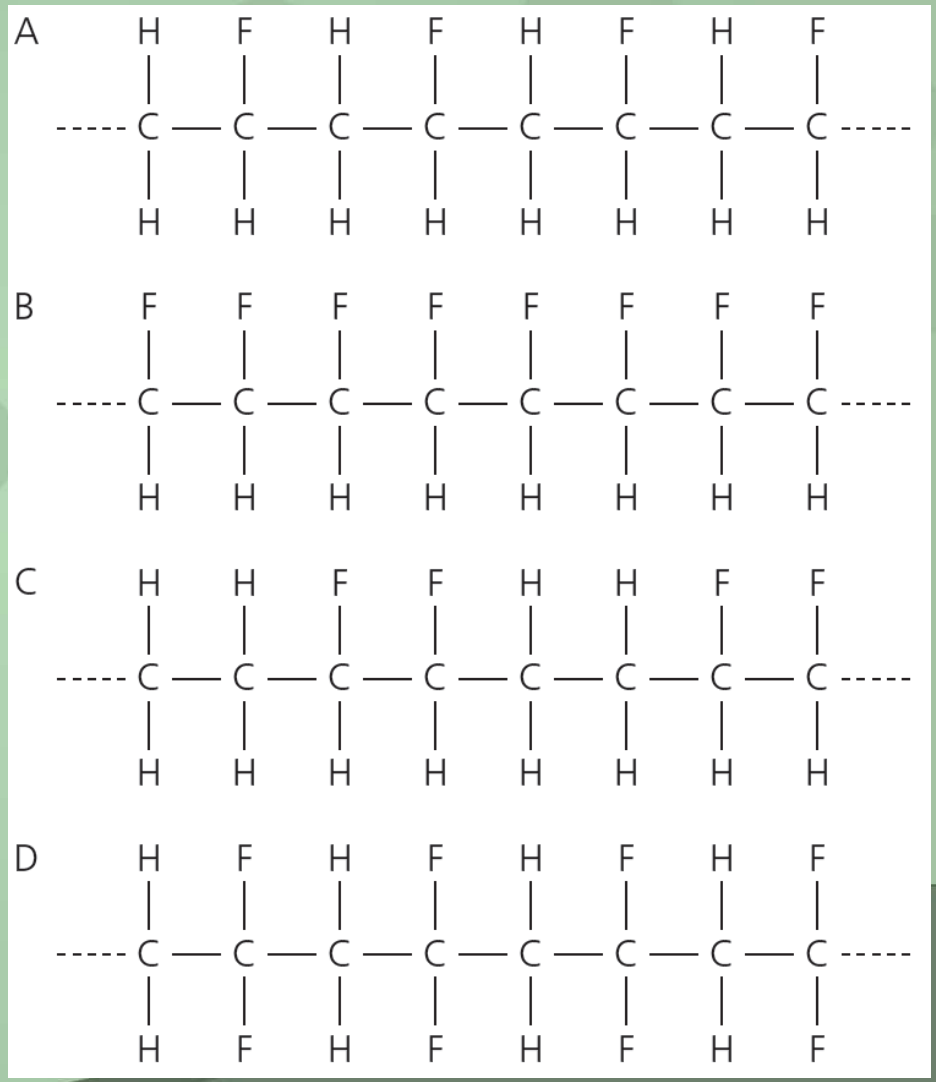
Which type of reaction results in the formation of this polymer?

A Addition
B Hydration
C Oxidation
D Substitution

Answer: A

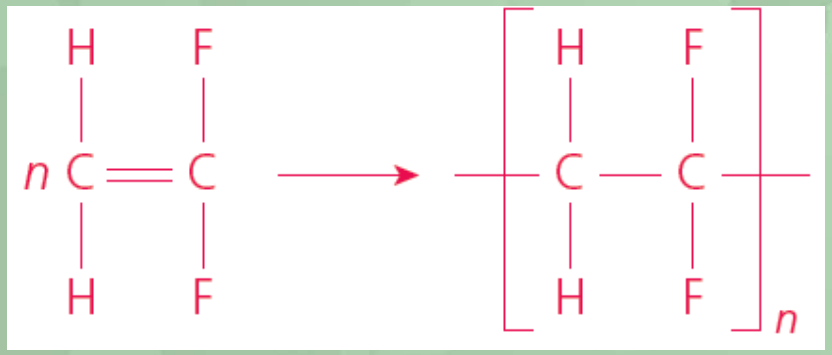
Unit Exercise (p.155)

3 1,1-difluoroethene can form a polymer. Which of the following can represent a part of the structure of the polymer?



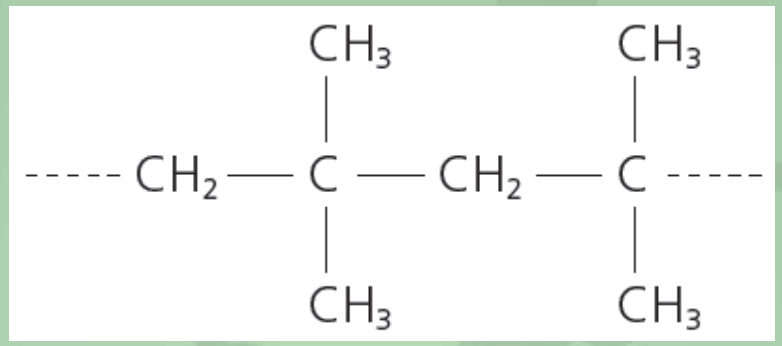
Answer: D

Explanation:

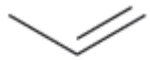


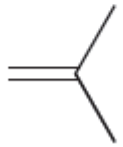
Unit Exercise (p.155)

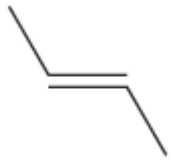
4 A section of the structure of an addition polymer is shown below:



What is the monomer of the polymer?

A 

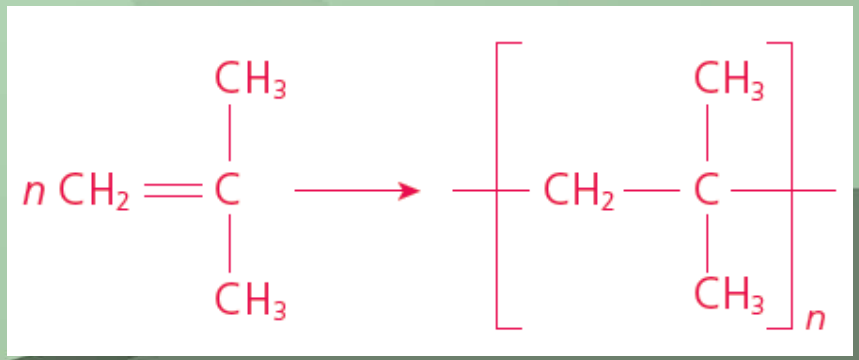
B 

C 

D 

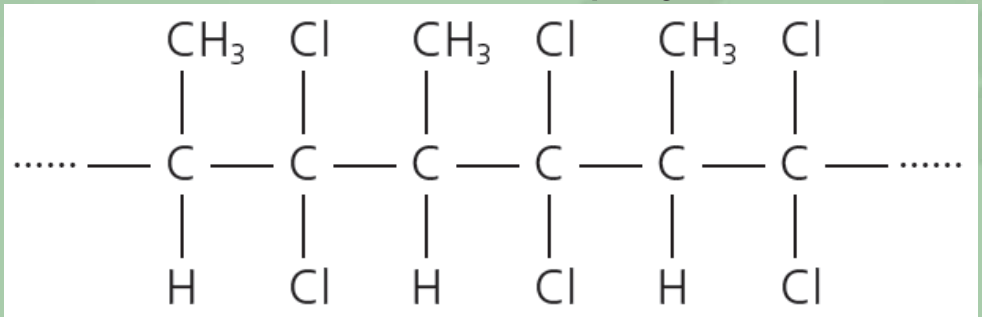
Answer: B

Explanation:



Unit Exercise (p.155)

5 A portion of the structure of an addition polymer X is shown below:



Which of the following is the systematic name of the monomer of X based on the given structure?

A 1,1-dichloro-2-methylethene
B 1,1-dichloropropene
C 1,2-dichloropropene
D 3,3-dichloropropene

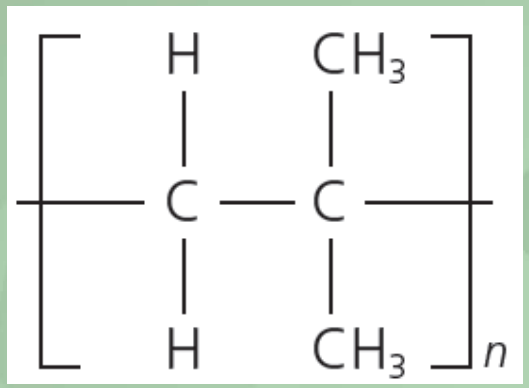
Answer: B

(HKDSE, Paper 1A, 2013, 14)

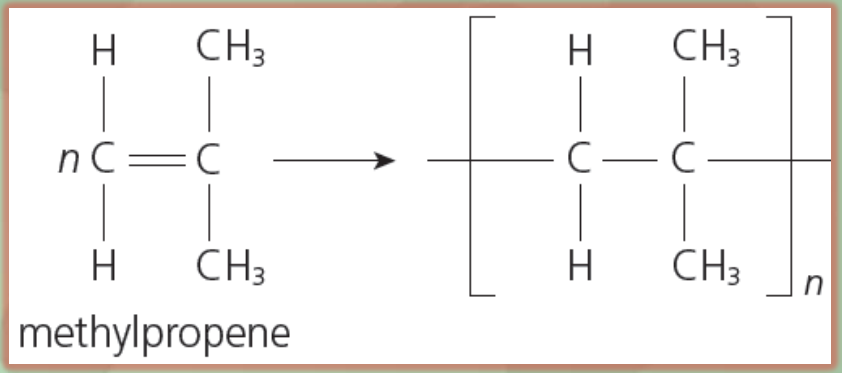
Unit Exercise (p.155)

Answer: D

6 Polymer X has the structure shown below.



Explanation: Option B—



Which of the following statements concerning X is INCORRECT?

A X is an addition polymer.
B The monomer of X is methylpropene.
C Van der Waals' forces exist between the polymer chains of X.
D X belongs to the alkene homologous series.

Unit Exercise (p.155)

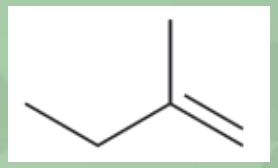
7 Which of the following items can be made from low density polythene?

A Bottle crates
B Margarine tubs
C Car bumpers
D Wash bottles

Answer: D

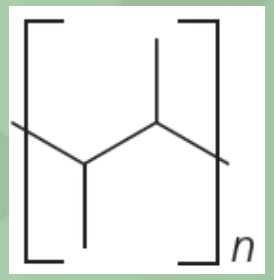
Unit Exercise (p.155)

8 Consider the carbon compound shown below.



Which of the following statements concerning this carbon compound is / are correct?

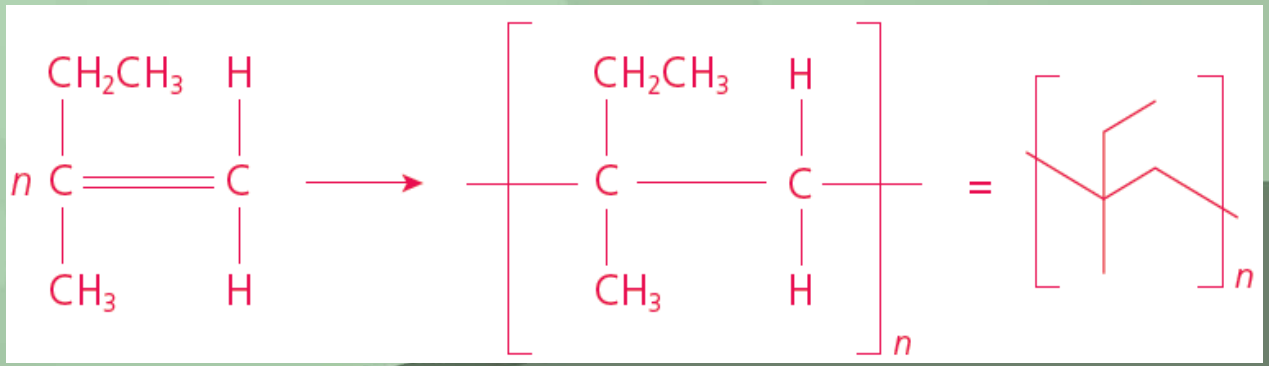
(1) Its systematic name is 2-methylbutene.
(2) It can turn Br2 (in CH_3CCl_3) solution colourless quickly.
(3) It can form a polymer with structure shown below:



A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

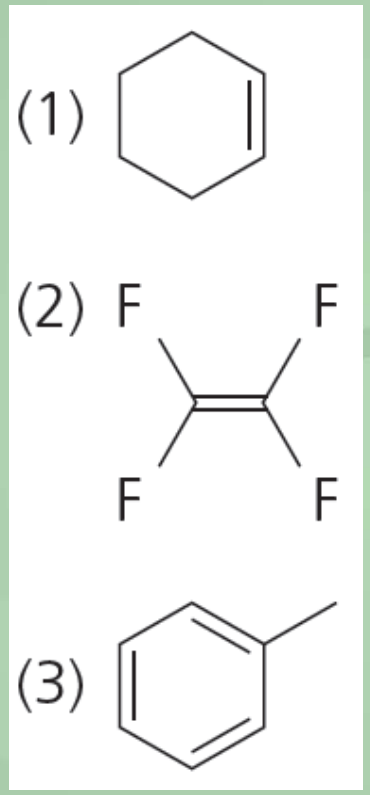
Answer: B

Explanation:
(1) Its systematic name is 2-methylbut-1-ene
(3)



Unit Exercise (p.155)

9 Which of the following compounds can undergo addition polymerisation?



A (1) and (2) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

Answer: A

Explanation:
(3) The C=C bonds in the benzene ring of an aromatic compound do NOT undergo addition polymerisation.

Unit Exercise (p.155)

10 Which of the following items can be made from polyvinyl chloride (PVC)?

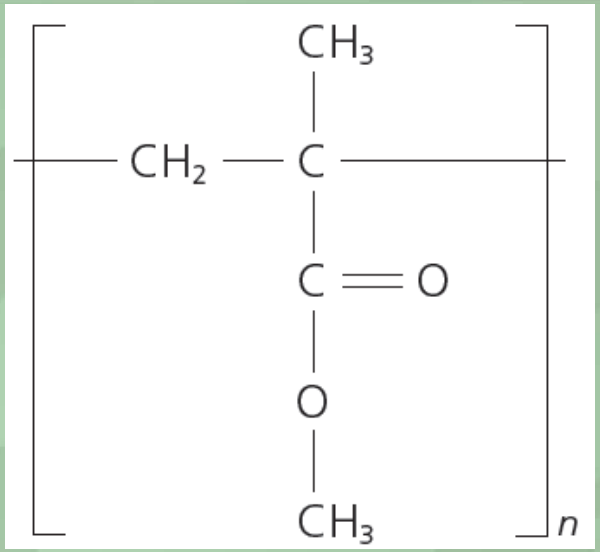
(1) Drain pipes
(2) Table clothes
(3) Window frames

A (1) and (2) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

Answer: D

Unit Exercise (p.155)

11 A polymer has the following structure:



Which of the following statements concerning the polymer are correct?

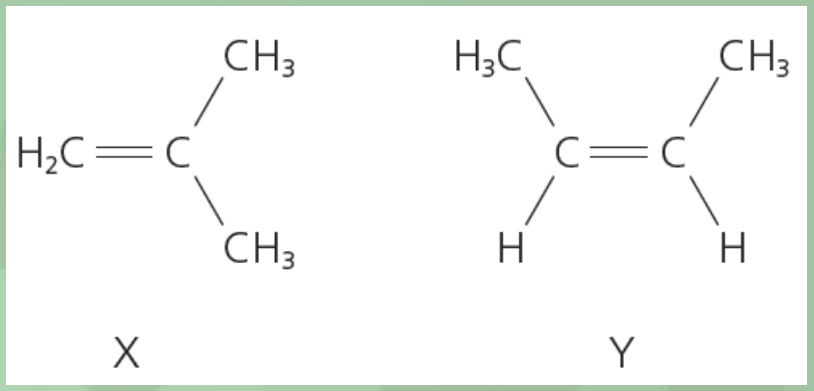
(1) It contains carboxyl groups.
(2) Its monomer can decolourise acidified $KMnO_4(aq)$.
(3) It can be used to make aircraft windows.

A (1) and (2) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

Answer: C

Unit Exercise (p.155)

12 Consider the two hydrocarbons shown.



Which of the following statements concerning the hydrocarbons is / are correct?

(1) Both have the same molecular formula.
(2) X and Y react separately with cold acidified $KMnO_4(aq)$ to give the same organic product.
(3) Both the polymerisation of X and that of Y give the same addition polymer.

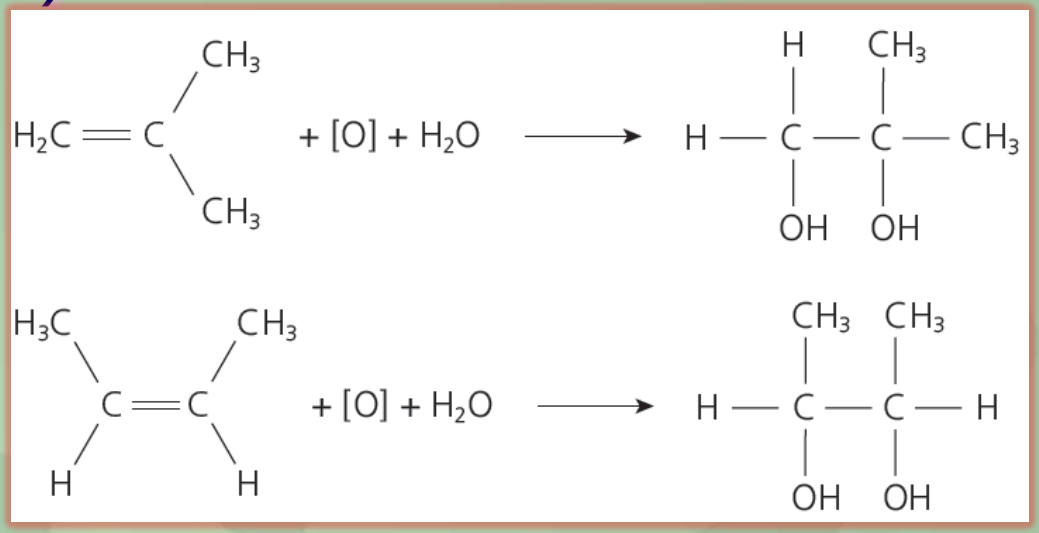
A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

Answer: A

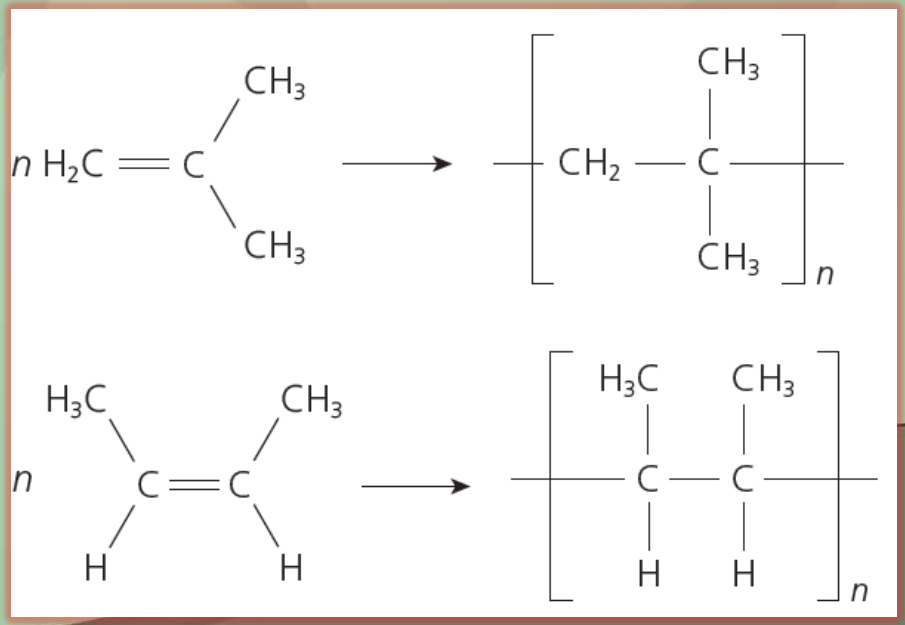
Unit Exercise (p.155)

Explanation:

(2) X and Y react separately with cold acidified $KMnO_4(aq)$ to give different organic products.



(3) Polymerisation of X and that of Y give different additional polymers.



Unit Exercise (p.155)

13 Which of the following pairs of substances can be distinguished by using acidified $KMnO_4(aq)$?

(1) Pent-1-ene and pent-2-ene
(2) Cyclohexane and cyclohexene
(3) Polyethene and poly(chloroethene)

A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

Answer: B

(HKDSE, Paper 1A, 2015, 19)

Unit Exercise (p.155)

PART III STRUCTURED QUESTIONS

14 Synthetic polymers are very useful materials. Many objects previously made of metals are now made of synthetic polymers. For each of the following objects, suggest ONE advantage of using synthetic polymers over using metals in making the object.

a) The casing for an electric rice cooker

b) Gear wheel

c) Storage tank for cold water

Electricity leakage can be prevented. (1)

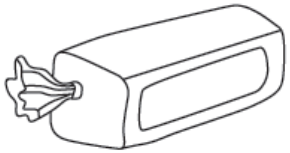
b) Any one of the following:
- More corrosion resistant (1)
- Needs no lubricant (1)
- Strong but light in weight (1)
- Can be moulded to different shapes more easily (1)

c) Any one of the following:
- More corrosion resistant (1)
- Lighter / less dense (1)
- Can be moulded to different shapes more easily (1)
- Good insulator / keep the water cold (1)

Unit Exercise (p.155)

15 The following diagrams show four items made of synthetic polymers.

a)

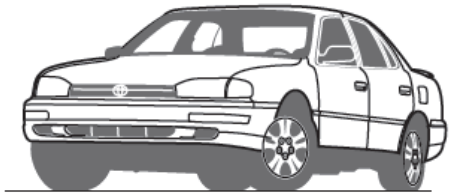


bread bag

b)

raincoat

c)



car light cover

d)

margarine tub

For each of the items,

i) suggest ONE synthetic polymer which is suitable to make the item;

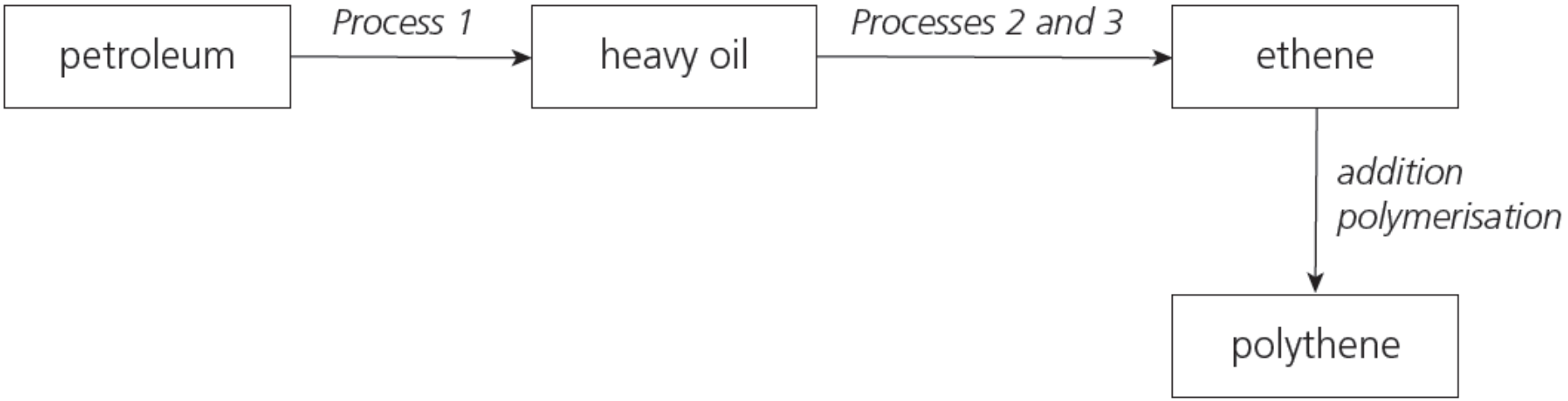
ii) give TWO properties of the suggested synthetic polymer which make it suitable for making the item.

Unit Exercise (p.155)

Item	Synthetic polymer suitable for making the item	TWO properties of the synthetic polymer which make it suitable
a) bread bag	polythene (1)	• soft and flexible (1) • waterproof (1)
b) raincoat	polyvinyl chloride (1)	Any two of the following: • flexible (1) • waterproof (1) • easily coloured (1)
c) car light cover	Perspex (1)	Any two of the following: • transparent (1) • strong (1) • rigid (1)
d) margarine tub	polypropene (1)	Any two of the following: • chemical resistant (1) • moisture resistant (1) • non-toxic (1) • does not flavour the food (1)

Unit Exercise (p.155)

16 Large quantities of ethene are manufactured every year. Ethene is produced by the following procedure:



a) Name *Processes 1*, *2* and *3*.

Process 1: fractional distillation (1)
Process 2: cracking (1)
Process 3: fractional distillation (1)

Unit Exercise (p.155)

b) Explain why ethene can form a polymer, but ethane CANNOT.

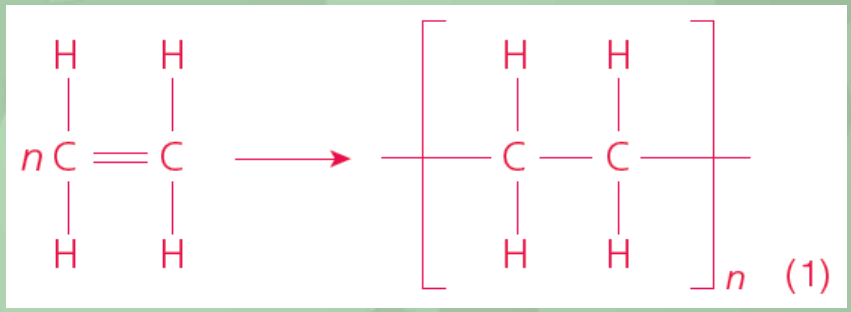
An ethene molecule contains a carbon-carbon double bond while an ethane molecule does not. (1)

c) Explain the meaning of the term 'addition polymerisation'.

Addition polymerisation is a reaction in which monomer molecules join together repeatedly to form polymer molecules. (1)

No atoms are lost from the monomer molecules during the reaction. (1)

d) Write a chemical equation for the addition polymerisation.



(1)

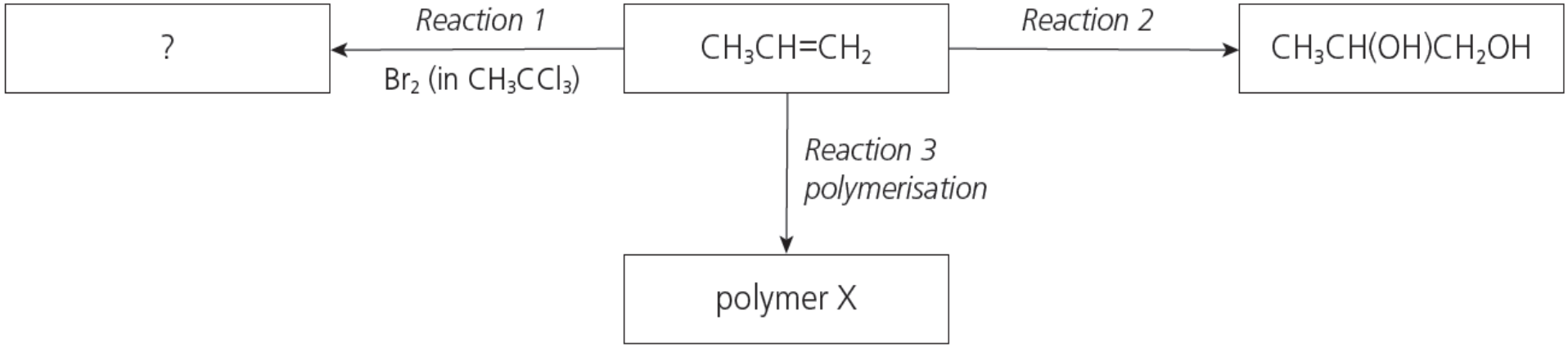
e) A steel storage tank for concentrated hydrochloric acid has an inner lining of polythene. Explain the function of the lining of polythene in terms of the chemistry concept involved.

Polythene lining is chemically inert / does not react with acid. (1)

It can prevent the acid from reacting with the steel storage tank.

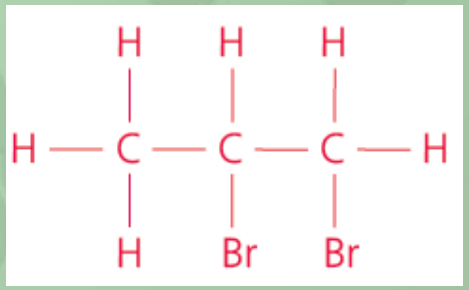
Unit Exercise (p.155)

17 Heavy fractions from petroleum can produce propene via cracking. Some of the reactions of propene are shown below.



a) Consider *Reaction 1*.

i) Write the structural formula of the product.



ii) Give the systematic name of the product.
1,2-dibromopropane

iii) State the expected observation in the reaction.
The orange solution of bromine becomes colourless quickly. (1)

Unit Exercise (p.155)

b) Consider *Reaction 2*.

i) Suggest the reagent required.
Cold acidified dilute potassium permanganate solution (1)

ii) Name the type of reaction involved. Addition reaction (1)

iii) Give the systematic name of the product. Propane-1,2-diol (1)

iv) State the expected observation in the reaction.
The purple solution of potassium permanganate becomes colourless quickly. (1)

c) Consider *Reaction 3*.

Describe how propene molecules react with each other to form polymer X.

Compounds with carbon-carbon double bonds can undergo addition polymerisation. (1)

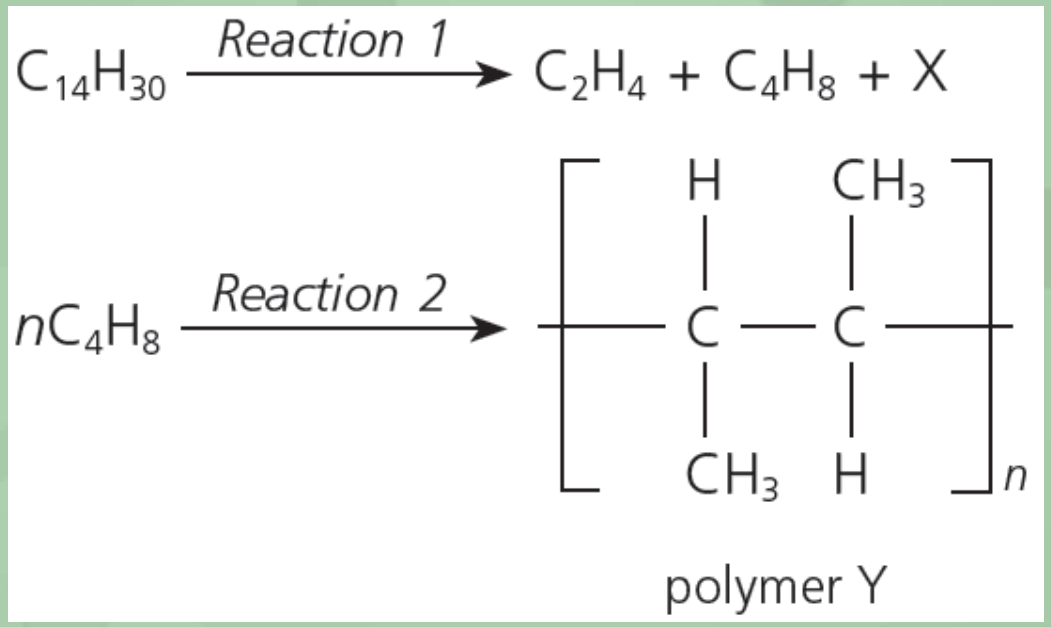
During addition polymerisation, part of the double bond of each propene molecule is broken, and the molecule joins to neighbouring propene molecules to make a molecule with a very long chain. (1)

No atoms are lost during the reaction.

High temperature / high pressure / catalyst is used. (1)

Unit Exercise (p.155)

18 Tetradecane ($C_{14}H_{30}$) is a hydrocarbon found in the naphtha fraction of petroleum. Tetradecane can be used as a starting material to produce a wide variety of useful products. The scheme below shows how one such product, polymer Y, can be produced from tetradecane.



Unit Exercise (p.155)

a) Explain, from molecular level, why naphtha can be obtained from petroleum by fractional distillation.

Components with different boiling points can be separated from each other by fractional distillation. (1)

The longer the carbon chain in a hydrocarbon molecule, the higher the boiling point of the hydrocarbon is. (1)

b) Name the homologous series to which both C_2H_4 and C_4H_8 belong.

Alkenes (1)

c) Identify compound X.

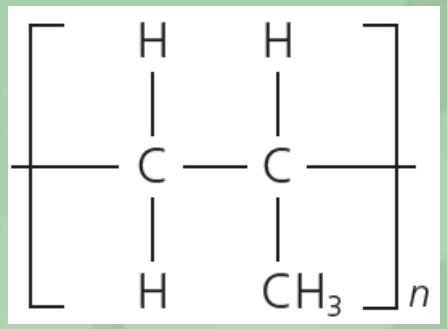
C_8H_{18} (1)

d) Name polymer Y.

Polybut-2-ene (1)

Unit Exercise (p.155)

19 The structure of polypropene is shown below.



a) The monomer of polypropene is propene. Suggest a chemical test to show that propene is an unsaturated hydrocarbon.

a) Any one of the following:

- Add an orange solution of bromine dissolved in 1,1,1-trichloroethane to propene. (1)
  The orange solution of bromine becomes colourless quickly. (1)
- Add a purple solution of cold acidified dilute potassium permanganate solution to propene. (1)
  The purple solution of potassium permanganate becomes colourless quickly. (1)

Unit Exercise (p.155)

b) Explain, in terms of bonding, why objects made of polypropene are resistant to chemical attacks.

Polypropene is a hydrocarbon with strong C-C and C-H bonds. These bonds are not readily attacked by chemicals. (1)

c) Polypropene is used to make sandwich boxes. Suggest TWO properties, other than resistant to chemical attacks, needed by polypropene to be suitable for making a sandwich box.

Any two of the following:

- Waterproof (1)
- Non-toxic (1)
- Non-biodegradable (1)

Unit Exercise (p.155)

20 Compound R has the following condensed structural formula:

$(CH_3)_2CHCH_2CH=CH_2$

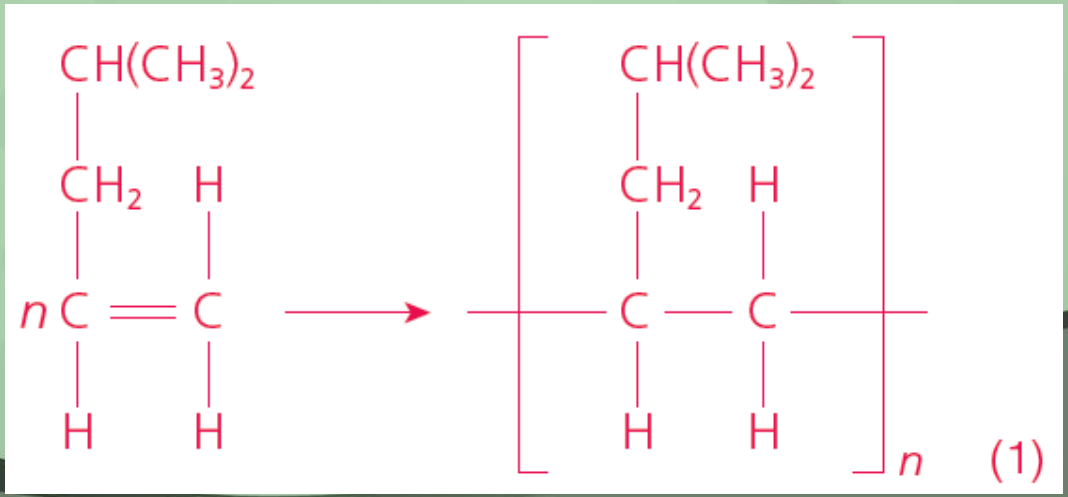
a) Give the systematic name of R. 4-methylpent-1-ene (1)

b) Compound R undergoes addition polymerisation to form a polymer.

i) Explain the meaning of the term 'addition polymerisation'.

Addition polymerisation is a reaction in which monomer molecules join together repeatedly to form polymer molecules. (1)
No atoms are lost from the monomer molecules during the reaction. (1)

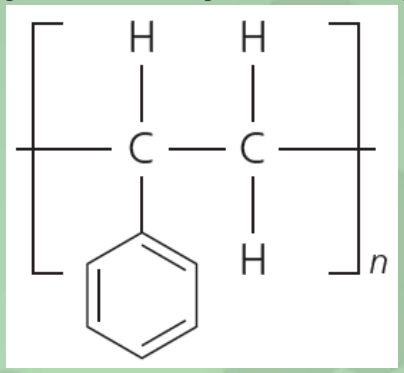
ii) Write a chemical equation for the polymerisation.



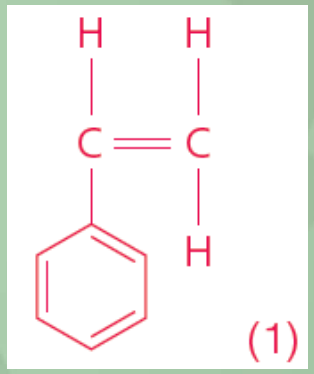
(1)

Unit Exercise (p.155)

21 Polystyrene (PS) is a commonly used synthetic polymer. The structure of PS is represented as follows:



a) Write the structural formula of the monomer of PS.



(1)

b) Suggest why the relative molecular mass of PS is expressed using a range of values instead of a single fixed value.

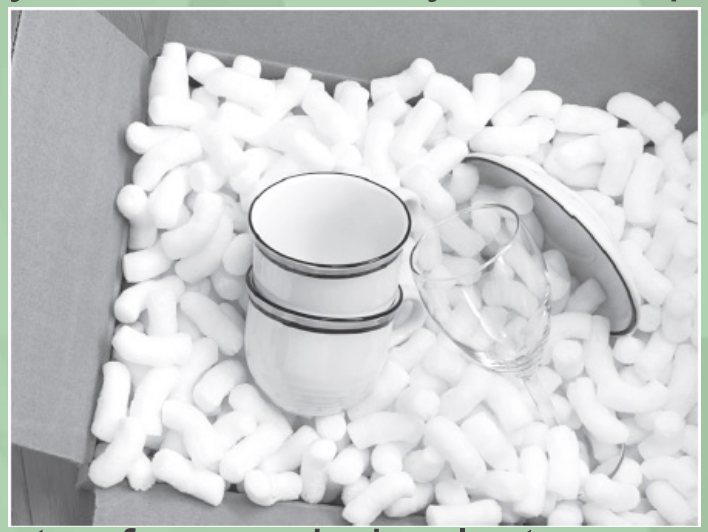
PS is a mixture of polymer molecules with different lengths. (1)

Unit Exercise (p.155)

c) Expanded polystyrene has good heat insulating properties. Suggest why.

Air is a good insulator of heat. (1)
Trapping air in expanded polystyrene enhances the heat insulating properties.

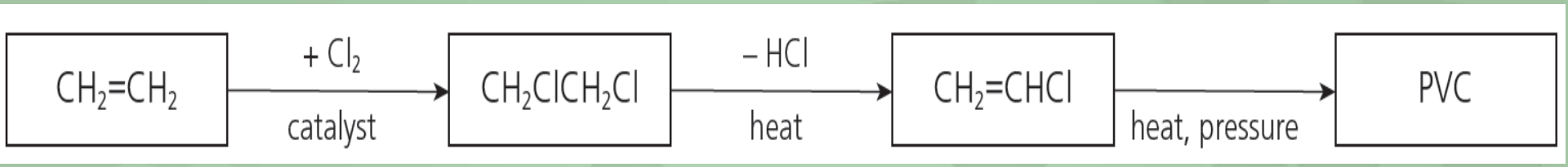
d) Expanded polystyrene is commonly used as packing materials for delicate articles.



State ONE property of expanded polystyrene associated with this usage.
It is light but still quite rigid. / It is an excellent shock absorbent. (1)

Unit Exercise (p.155)

22 Ethene is obtained from the cracking of naphtha. Polyvinyl chloride (PVC) can be obtained from ethene as shown below.



a) What is 'cracking'?

Cracking is the breaking down of large hydrocarbon molecules with heat or in the presence of a catalyst to produce smaller hydrocarbon molecules. (1)

b) What is the systematic name of CH_2ClCH_2Cl?

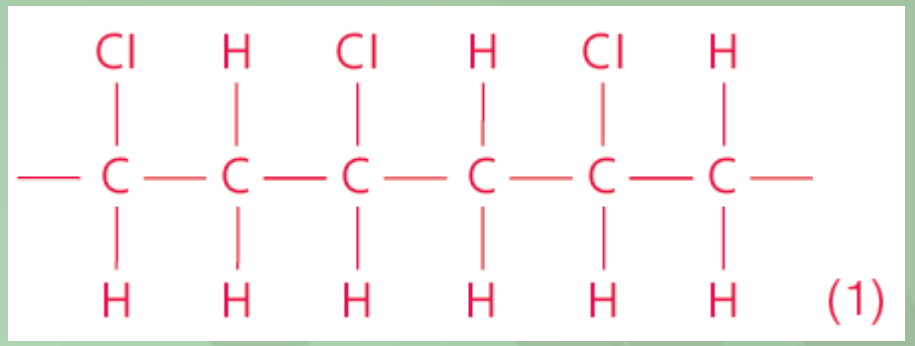
1,2-dichloroethane (1)

c) Name the type of polymerisation that produces PVC.

Addition polymerisation (1)

Unit Exercise (p.155)

d) Draw the structure of PVC, showing at least THREE repeating units.



e) Products made of PVC may vary greatly in rigidity. Give ONE rigid product made of PVC.

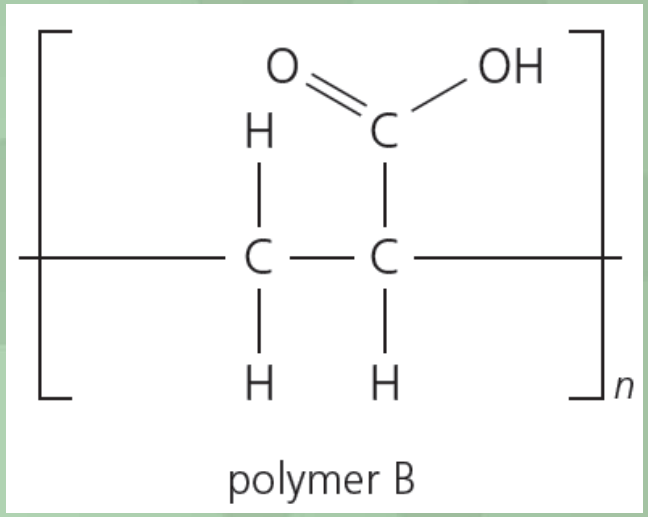
Any one of the following:
- Bottles (1)
- Drain pipes (1)
- Window / door frames (1)

f) Both polythene (PE) and polyvinyl chloride (PVC) can be used to make food wrap.
When incinerated, why would food wrap made from PVC cause more serious pollution problem than food wrap made from PE?

Incineration of food wrap made from PVC will produce toxic gases / hydrogen chloride / chlorine / dioxins while food wrap made from PE will not. (1)

Unit Exercise (p.155)

23 Polymer B shown below can be used as water absorbing material in diapers. It can be formed from the polymerisation of compound A.



polymer B

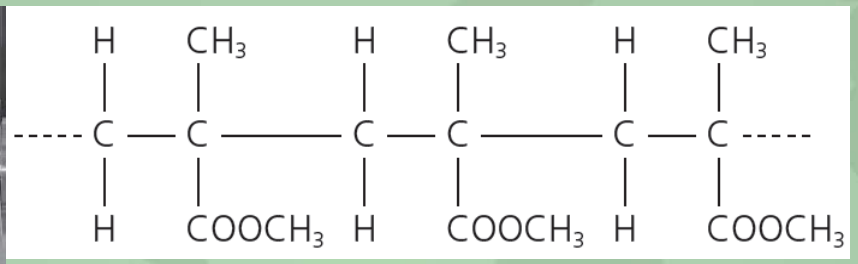
a) Draw the structure of compound A and state its systematic name.
b) State the type of polymerisation for the formation of B from A.
c) Suggest why the relative molecular mass of B is expressed using a range of values instead of a single fixed value.

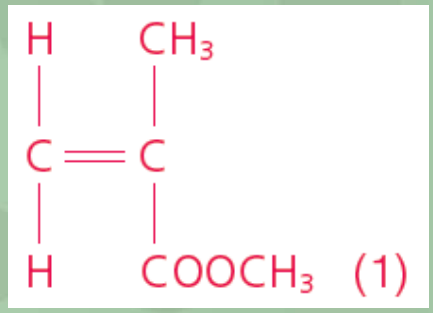
(HKDSE, Paper 1B, 2016, 5(a)–(c))

Answers for the questions of the public examinations in Hong Kong are not provided (if applicable).

Unit Exercise (p.155)

24 Perspex can be used to make riot shields used by police. A section of the structure of Perspex is shown below.





a) Write the structure formula of the monomer of Perspex. (1)

b) Suggest TWO properties of Perspex which make it suitable for making riot shields. Any two of the following: • Transparent (1) • Strong (1) • Rigid (1)

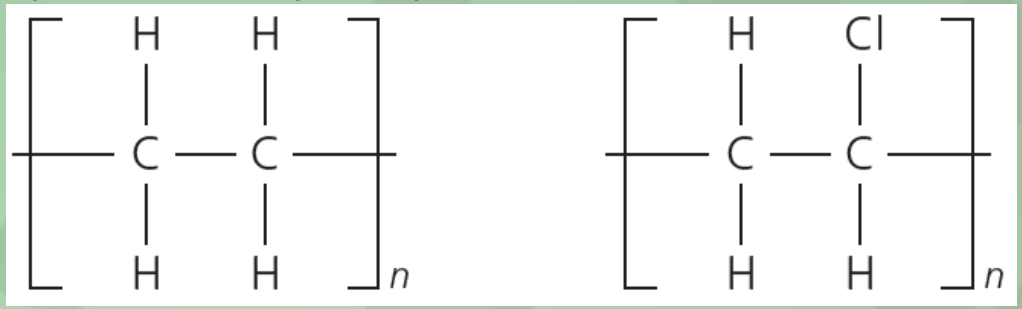
c) Perspex can be used instead of glass to make camera lenses. State ONE advantage and ONE disadvantage of using Perspex instead of glass to make camera lenses.

Advantage: It does not break easily. / It is lighter. (1)

Disadvantage: It can be quite easily scratched. (1)

Unit Exercise (p.155)

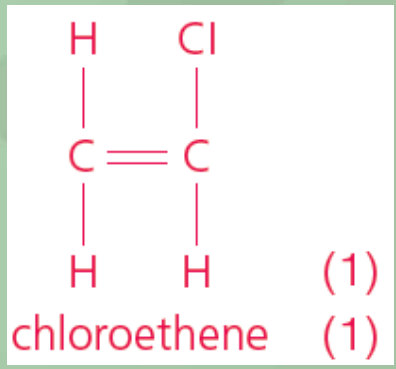
25 Polythene (PE) and polyvinyl chloride (PVC) are two of the most commonly used synthetic polymers.



a) Suggest reaction conditions for the formation of PE from its monomer.

Any one of the following:

- Peroxide; heat; high pressure (1)
- Catalyst; moderate pressure (1)



b) Write the structural formula of the monomer of PVC.
Give the systematic name of the monomer. (1)

c) Explain why PVC is more rigid than PE.

chloroethene (1)

PVC has polar C−Cl bonds. The polar attractive forces between PVC molecules are stronger than the attractive forces between non-polar PE molecules. (1)

Unit Exercise (p.155)

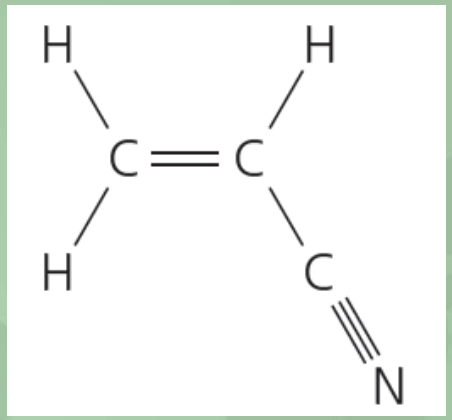
26 Poly(propenenitrile) is an addition polymer. It can be made from propene.

a) Alkanes in petroleum can be used to manufacture propene. Two stages are required.
Name the TWO stages.

Fractional distillation (1)
Cracking (1)

Unit Exercise (p.155)

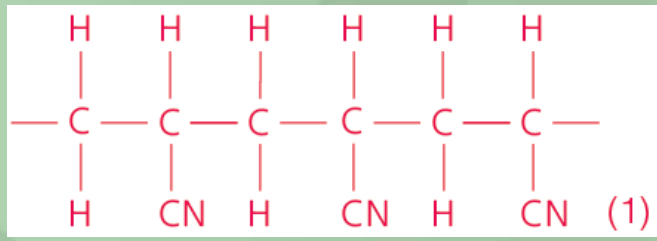
b) Look at the structural formula of propenenitrile:



i) Propenenitrile is an unsaturated compound.
How can you tell from the structural formula?

Propenenitrile has carbon-carbon double bond. (1)

ii) Draw the structure of poly(propenenitrile), showing at least THREE repeating units.



iii) The polymerisation of propene gives polypropene.
The strength of poly(propenenitrile) is higher than that of polypropene.
Explain why.

Poly(propenenitrile) has polar −C N groups. The polar attractive forces between the poly(propenenitrile) molecules are stronger than the attractive forces between non-polar polypropene molecules. (1)

Unit Exercise (p.155)

*27 Tetrafluoroethene undergoes polymerisation to form a polymer called 'Teflon'. Using this example, describe this type of polymerisation.

(HKDSE, Paper 1B, 2018, 9)

Answers for the questions of the public examinations in Hong Kong are not provided (if applicable).

Topic Exercise (p.164)

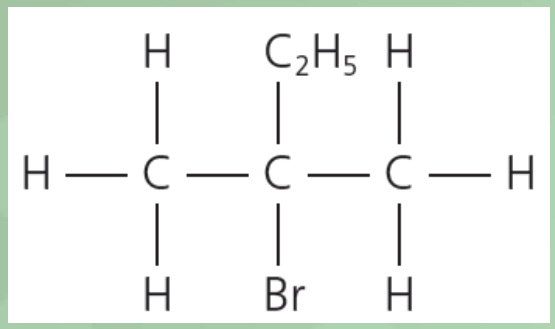
Note: Questions are rated according to ascending level of difficulty (from 1 to 5):

 **question targeted at level 3 and above;**
 **question targeted at level 4 and above;**
 **question targeted at level 5.**
‘ * ’ indicates 1 mark is given for effective communication.

Topic Exercise (p.164)

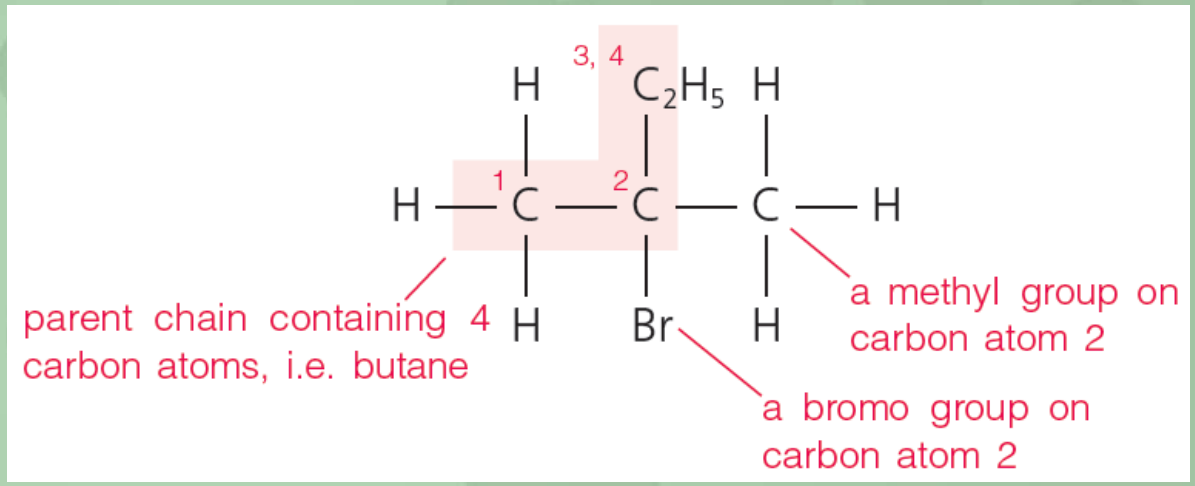
PART I MULTIPLE CHOICE QUESTIONS

1 What is the systematic name of the following compound?



Answer: D

Explanation:



A 1-bromo-2-ethylpropane
B 2-bromo-2-ethylpropane
C 1-bromo-2-methylbutane
D 2-bromo-2-methylbutane

Thus, the systematic name of this compound is 2-bromo- 2-methylbutane.

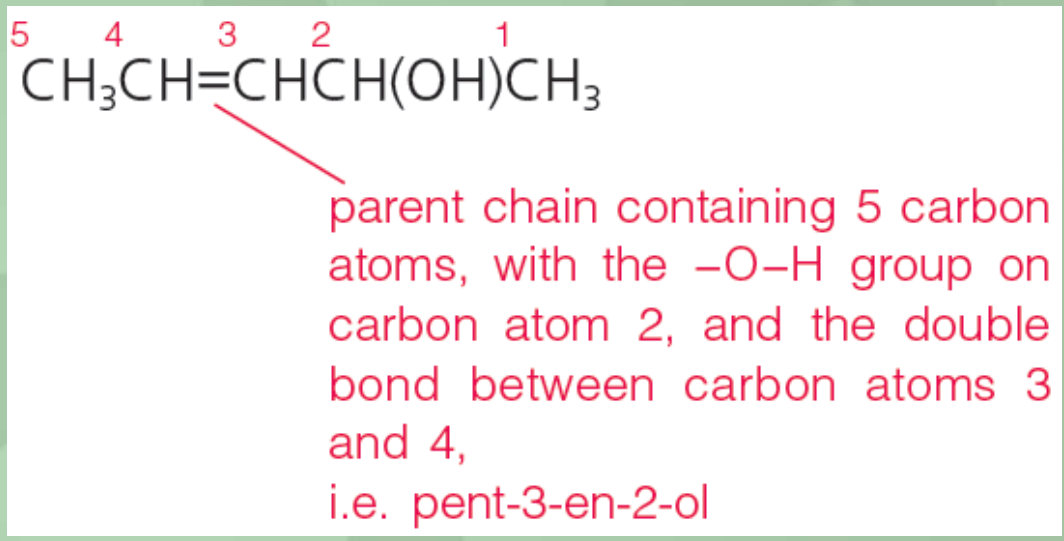
Topic Exercise (p.164)

2 What is the systematic name of the following compound?
$CH_3CH=CHCH(OH)CH_3$

A 2-hydroxypent-3-ene
B 3-hydroxypent-1-ene
C pent-2-en-4-ol
D pent-3-en-2-ol

Answer: D

Explanation:



Topic Exercise (p.164)

3 The diagram below shows an apparatus:

Answer: C

Which of the following mixtures can be separated by this apparatus?

A rock salt and sand

B propan-2-ol and water

C hexane (C_6H_{14}) and water

D methanoic acid and ethanoic acid

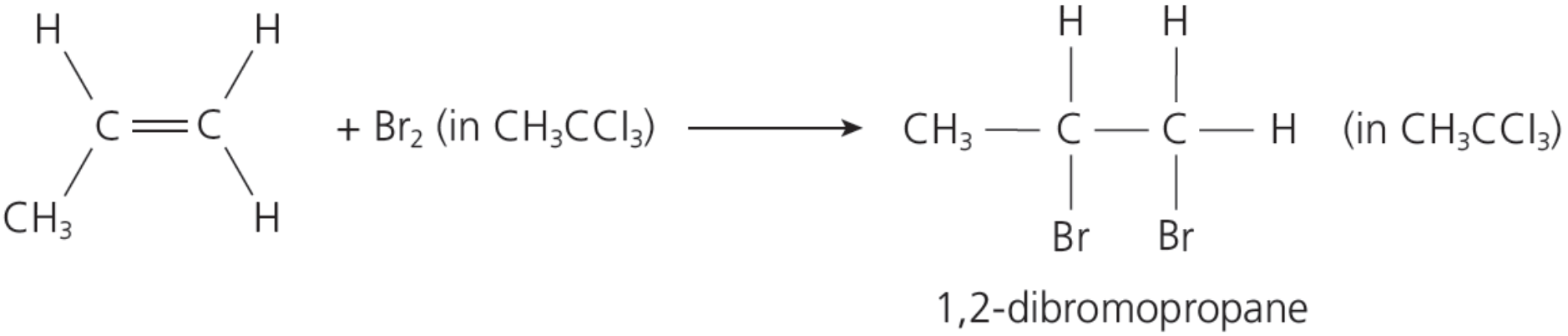
(HKDSE, Paper 1A, 2018, 15)

Topic Exercise (p.164)

4 Which of the following would be formed when propene reacts with Br_2 (in CH_3CCl_3) solution? Answer: B

A 1,2-dibromopropene
B 1,2-dibromopropane
C A mixture of 1-bromopropene and 2-bromopropene
D A mixture of 1-bromopropane and 2-bromopropane

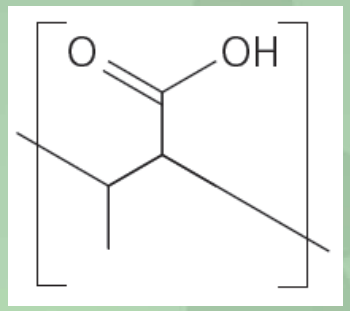
Explanation:



1,2-dibromopropane

Topic Exercise (p.164)

5 Monomer X undergoes addition polymerisation to give a polymer with the repeating unit shown below.

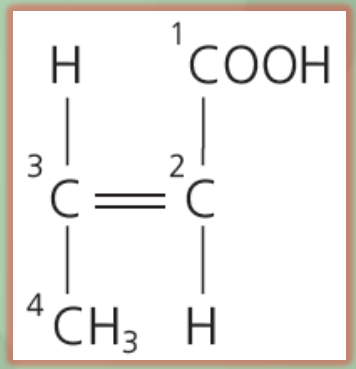


What is monomer X?

A but-2-enoic acid
B but-3-enoic acid
C 1-methylpropenoic acid
D 3-methylpropenoic acid

Answer: A

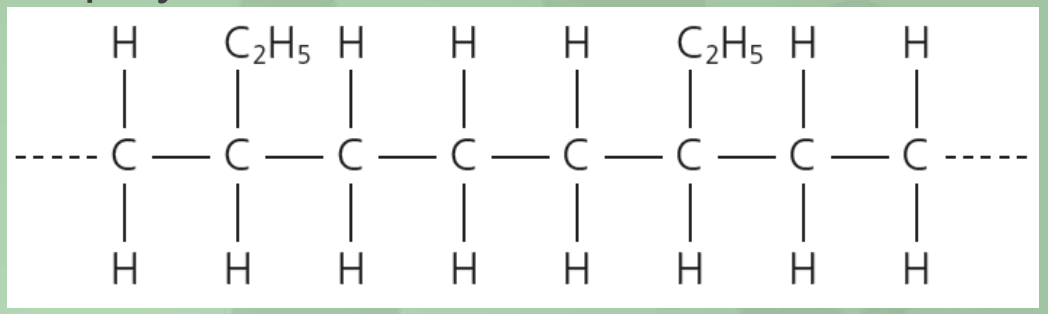
Explanation:
The structure of monomer X is shown.



The acid contains 4 carbon atoms, and the double bond between carbon atoms 2 and 3, i.e. but-2-enoic acid.

Topic Exercise (p.164)

6 Part of the structure of an addition polymer is shown below. It is made using two different monomers.

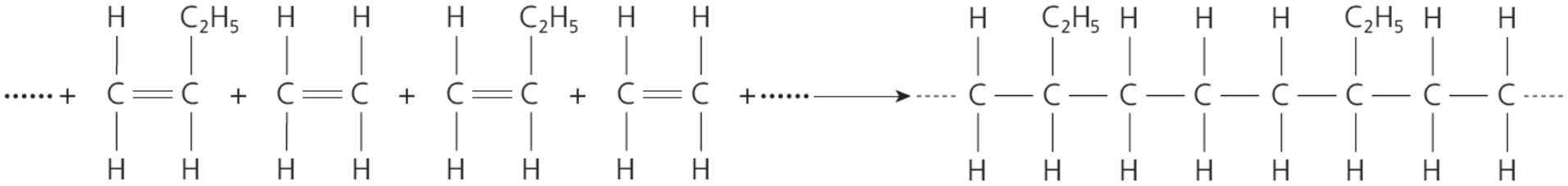


What is monomer X?

A but-2-enoic acid
B but-3-enoic acid
C 1-methylpropenoic acid
D 3-methylpropenoic acid

Answer: B

Explanation:
The polymer is made using ethene and but-1-ene.



Topic Exercise (p.164)

7 Which of the following statements concerning petroleum is / are correct?

(1) It is a source of aliphatic hydrocarbons.
(2) It can be separated into liquids of different viscosity by a separating funnel.
(3) It is a fossil fuel derived from ancient marine organisms.

A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

Answer: C

(HKDSE, Paper 1A, 2016, 17)

Topic Exercise (p.164)

8 Which of the following statements concerning the measures to reduce air pollutants is / are correct?

(1) Catalytic converters can be used to reduce carbon dioxide.
(2) Scrubbers can be used to reduce sulphur dioxide.
(3) Electrostatic precipitators can be used to reduce unburnt hydrocarbons.

Answer: B

A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

Explanation:
(1) Catalytic converters are used to reduce carbon monoxide, oxides of nitrogen and unburnt hydrocarbons.
(3) Electrostatic precipitators are used to reduce particulates.

Topic Exercise (p.164)

9 Which of the following processes increase global warming?

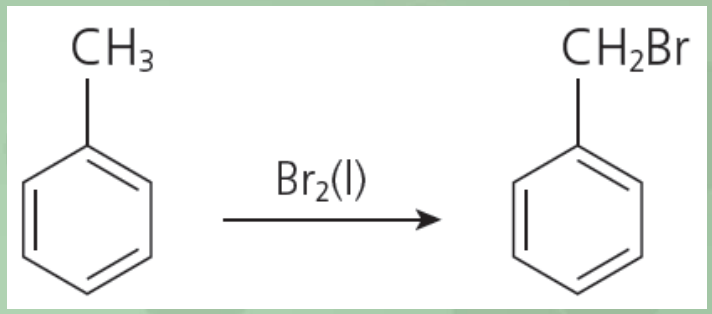
(1) Burning fossil fuel
(2) Decay of organic waste
(3) Farming cattle for beef

A (1) and (2) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

Answer: D

Topic Exercise (p.164)

10 Consider the following reaction of a hydrocarbon:



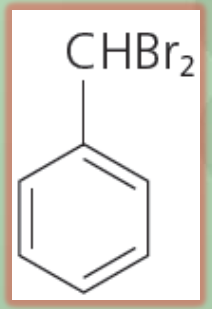
Which of the following statements about the reaction is / are correct?

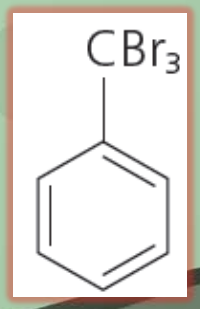
(1) Excess $Br_2(l)$ should be used.
(2) Light is needed.
(3) The reaction gives a single product.

A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

Answer: B

Explanation:

(1) If excess $Br_2(l)$ is used, dibromo and tribromo compounds (i.e. 

and 

) would be the major products.

Topic Exercise (p.164)

11 Which of the following processes is / are exothermic?

(1) Combustion of methane
(2) Cracking of heavy oil
(3) Melting of wax

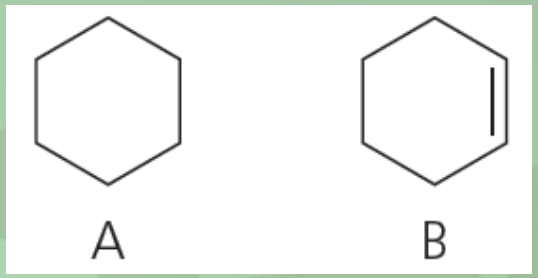
A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

Answer: A

Explanation:
(2) and (3) Cracking of heavy oil and melting of wax take in heat. They are NOT exothermic processes.

Topic Exercise (p.164)

12 The structures of organic compounds A and B are shown below:



Which of the following statements concerning the two compounds is / are correct?

(1) A and B belong to the same homologous series.
(2) A and B can be distinguished by acidified KMnO4(aq).
(3) Complete combustion of 1.0 g of A and complete combustion of 1.0 g of B would form the same mass of $CO_2(g)$.

A (1) only
B (2) only
C (1) and (3) only
D (2) and (3) only

Answer: B

(HKDSE, Paper 1A, 2017, 18)

Topic Exercise (p.164)

Directions : Each question (Questions 13–16) consists of two separate statements. Decide whether each of the two statements is true or false; if both are true, then decide whether or not the second statement is a correct explanation of the first statement. Then select one option from A to D according to the following table :

A Both statements are true and the 2nd statement is a correct explanation of the 1st statement.

B Both statements are true but the 2nd statement is NOT a correct explanation of the 1st statement.

C The 1st statement is false but the 2nd statement is true.

D Both statements are false.

Topic Exercise (p.164)

	1st statement	2nd statement
13	When using a Bunsen burner with the air hole fully open, the burner gives a luminous flame.	When using a Bunsen burner with the air hole fully open, the fuel undergoes complete combustion.

Answer: C

Explanation: When using a Bunsen burner with the air hole fully open, the burner gives a non-luminous flame.

14	In Hong Kong, natural gas is a common domestic fuel.	Natural gas is a renewable energy source.

Answer: D

Explanation: Natural gas is NOT a common domestic fuel.
Natural gas is a non-renewable energy source.

15	Both pent-1-ene and pent-2-ene can decolourise a solution of bromine in 1,1,1-trichloroethane.	Both pent-1-ene and pent-2-ene have the same molecular formula.

Answer: B

Topic Exercise (p.164)

	1st statement	2nd statement
16	Compared with hexane, hexene gives more dark smoke when burnt.	Hexene has a higher carbon to hydrogen ratio than hexane. Answer: A

Topic Exercise (p.164)

PART II STRUCTURED QUESTIONS

17 a) i) Coal is solid fossil fuel.
Name another fossil fuel. Petroleum / natural gas (1)

ii) Explain what is meant by the term 'fossil fuel'.

Burn to release energy. (1)
Formed from the remains of dead organisms that lived millions of years ago. (1)

Topic Exercise (p.164)

b) The burning of fossil fuels is largely responsible for the formation of acid rain. Two of the acids in acid rain are sulphuric acid and nitric acid.

i) Explain how the combustion of coal can form sulphuric acid.

Oxygen / air and sulphur (from coal) react to form sulphur dioxide. (1)
Sulphur dioxide reacts with oxygen / air to form sulphur trioxide. (1)
Sulphur trioxide reacts with water to form sulphuric acid. (1)

ii) High temperatures generated by the combustion of fossil fuels can lead to the formation of nitric acid. Explain.

Oxygen and nitrogen react to form oxides of nitrogen. (1)
Oxides of nitrogen react with water, making nitric acid. (1)

(Cambridge IGCSE, 0620/33, Paper 3, Jun. 2015, 4(a),(b)(i)–(ii))

Topic Exercise (p.164)

18 Some regions tend to generate electricity more by natural gas but less by coal. Give TWO reasons from environmental protection consideration.

(HKDSE, Paper 1B, 2015, 8(c))

Answers for the questions of the public examinations in Hong Kong are not provided (if applicable).

Topic Exercise (p.164)

19 Three common pollutants in the air are carbon monoxide, the oxides of nitrogen, NO and NO_2, and unburnt hydrocarbons. They are all emitted by motor vehicles.

a) Describe how the oxides of nitrogen are formed.

Nitrogen and oxygen react at high temperatures in the engine. (1)

b) Describe how a catalytic converter reduces the emission of these three pollutants.

Carbon monoxide reacts with nitrogen monoxide as they pass through the catalyst in the catalytic converter. Less harmful carbon dioxide and nitrogen are formed. (1)

The excess carbon monoxide and unburnt hydrocarbons are oxidised by air to carbon dioxide and water. (1)

(Cambridge IGCSE, 0620/31, Paper 3, Nov. 2014, 5(a)–(b))

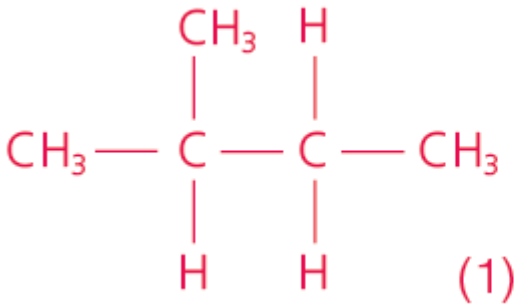
Topic Exercise (p.164)

20 Both pentane (C_5H_{12}) and octane (C_8H_{18}) are members of the same homologous series.

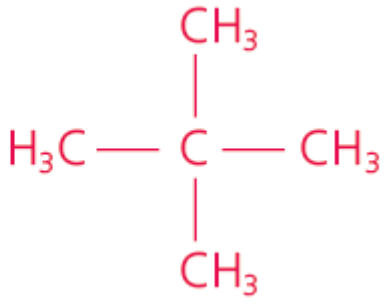
a) Which compound, pentane or octane, will burn with a more sooty flame? Explain your answer.

Octane will burn with a more sooty flame.
The octane molecule has a higher carbon to hydrogen ratio than the pentane molecule. (1)

b) Write the structural formulae of TWO other alkanes which have the same molecular formula as pentane.

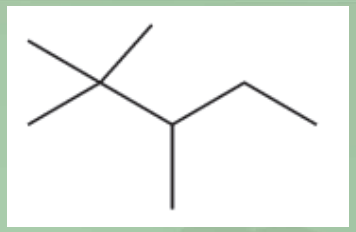


(1)



(1)

Topic Exercise (p.164)



2,2,3-trimethylpentane

c) The skeletal formula of compound A is shown.
It has the same molecular formula as octane.

i) Give the systematic name of compound A.

ii) Which compound, octane or A, has a higher boiling point? Explain your answer.

Octane has a higher boiling point.
The octane molecule is longer and somewhat spreadout. The molecule has a larger surface area, allowing a greater area of contact with neighbouring molecules. (1)

In contrast, the molecule of A is more compact, adopting a roughly spherical shape. The molecule has a smaller surface area for coming into contact with neighbouring molecules. (1)

Thus, the van der Waals' forces among octane molecules are stronger than those among molecules of A. (1)

Topic Exercise (p.164)

21 An oil company refines crude oil into different fractions. This table shows the volume of each fraction made from a barrel of crude oil in litres. It also shows the range of the number of carbon atoms in the molecules in each fraction.

	Fraction	Fraction in one barrel of crude oil in litres	Number of carbon atoms in molecules
top of barrel	Liquefied fuel gas	3	1–4
	Petrol	40	5–10
	Making chemicals	8	6–12
	Fuel oil	88	13–25
	Lubricants	8	20–22
bottom of barrel	Bitumen for roads	13	25+

Explain, using data from the table, why the boiling points change from one fraction to the next.

(OCR GCSE (Higher Tier), Chemistry A (21st Century Science), A172/02, Jun. 2014, 4)

Topic Exercise (p.164)

The boiling points of the fractions increase from the top to the bottom. (1)
The sizes of molecules in the fractions increase from the top to the bottom. (1)
Thus, the strength of van der Waals' forces among molecules increases from the top to the bottom. (1)
Communication mark (1)

Topic Exercise (p.164)

22 'Lava lamps' have become popular in recent years. These lamps contain two immiscible liquids of slightly different densities. When switched on, the heat of the bulb causes one of the liquids to rise up and then cool down at the top and fall in a bubble through the other liquid.

A substance that is used in lava lamps is the liquid 'ethylene glycol'. Ethylene glycol contains carbon, hydrogen and oxygen only. Its relative molecular mass is 62.0. Complete combustion of 1.24 g of ethylene glycol gives 1.76 g of carbon dioxide and 1.08 g of water.

a) Deduce the molecular formula of ethylene glycol.
(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0)

b) Given that ethylene glycol has two functional groups, draw a possible structure of ethylene glycol.

a) Mass of carbon in 1.24 g of ethylene glycol = $1.76 \text{ g} \times \frac{12.0}{44.0}$

$= 0.480 \text{ g}$

Mass of hydrogen in 1.24 g of ethylene glycol = $1.08 \text{ g} \times \frac{2.0}{18.0}$

$= 0.120 \text{ g}$

Mass of oxygen in 1.24 g of ethylene glycol = $(1.24 - 0.480 - 0.120) \text{ g}$

$= 0.640 \text{ g}$

	Carbon	Hydrogen	Oxygen	
Mass of element	0.480 g	0.120 g	0.640 g	
Number of moles of atoms	$\frac{0.480 \text{ g}}{12.0 \text{ g mol}^{-1}} = 0.0400 \text{ mol}$	$\frac{0.120 \text{ g}}{1.0 \text{ g mol}^{-1}} = 0.120 \text{ mol}$	$\frac{0.640 \text{ g}}{16.0 \text{ g mol}^{-1}} = 0.0400 \text{ mol}$	(1)
Mole ratio of atoms	$\frac{0.0400 \text{ mol}}{0.0400 \text{ mol}} = 1$	$\frac{0.120 \text{ mol}}{0.0400 \text{ mol}} = 3$	$\frac{0.0400 \text{ mol}}{0.0400 \text{ mol}} = 1$	(1)

∴ the empirical formula of ethylene glycol is CH_3O.

Let $(CH_3O)_n$ be the molecular formula of ethylene glycol.

Relative molecular mass of ethylene glycol = $n(12.0 + 3 \times 1.0 + 16.0)$

$= 31n$

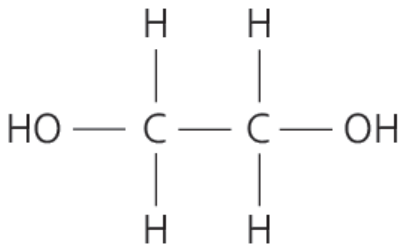
i.e. $31n = 62.0$

$n = 2$

∴ the molecular formula of ethylene glycol is $C_2H_6O_2$. (1)

Topic Exercise (p.164)

b)



(1)

Topic Exercise (p.164)

23 Chloromethanes, such as dichloromethane and trichloromethane, are produced in industry as they have many uses.

Trichloromethane ($CHCl_3$) has been used in the manufacture of the refrigerant chlorodifluoromethane.

Chlorine can react with dichloromethane (CH_2Cl_2) to form trichloromethane.

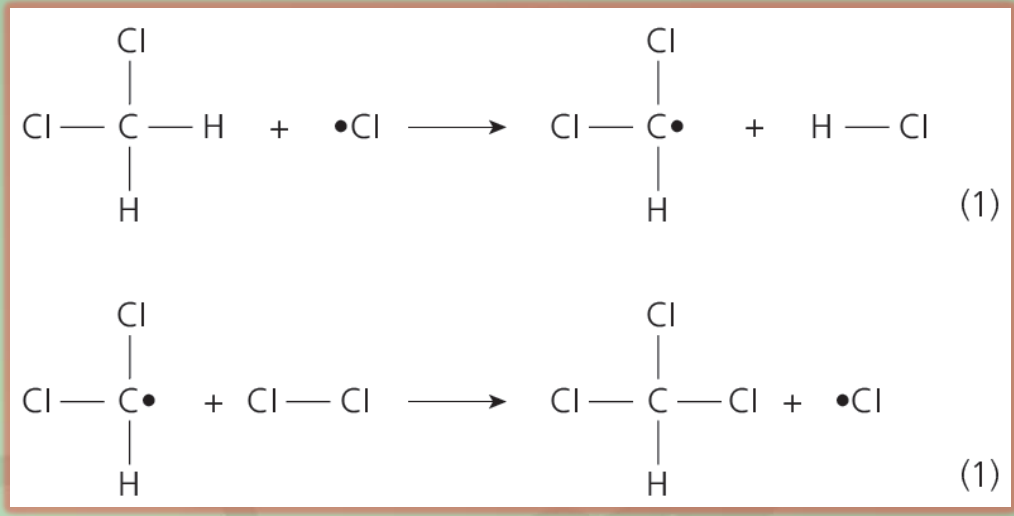
The reaction may be represented by a mechanism involving three stages — initiation, propagation and termination.

a) Show the initiation step of the reaction between chlorine and dichloromethane.

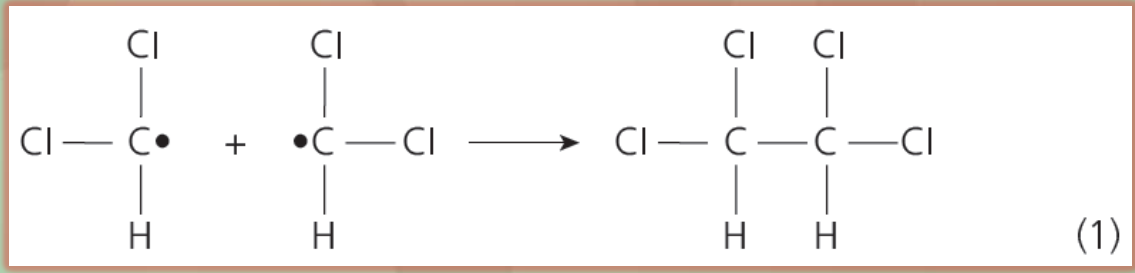
Cl–Cl → Cl• + •Cl (1)

Topic Exercise (p.164)

b) Give the TWO propagation steps of the reaction between chlorine and dichloromethane to form trichloromethane.



c) Show the termination step which leads to the formation of tetrachloroethane.



d) Give ONE essential condition for this reaction and name the type of reaction involved.

Ultraviolet light / heat / radical initiator (1)
Substitution reaction (1)

Topic Exercise (p.164)

24 Organic wastes can be used as an alternative energy source. Under suitable conditions, the wastes can be digested by bacteria to give a gaseous mixture containing a high proportion of methane. Methane can be used as a fuel.

a) Suggest ONE organic waste that can be used for this purpose.
Food waste / animal waste (1)

b) Write the chemical equation for the complete combustion of methane.
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ (1)

c) Methane is one of the greenhouse gases.
Describe how greenhouse gases help to maintain temperatures on the Earth.
The Earth absorbs the radiation from the sun and also emits infrared radiation back into space when it cools down. (1)
Greenhouse gases absorb some of the infrared radiation emitted from the Earth and re-emit them in all directions. This keeps the atmosphere warm for life to sustain on Earth. (1)

Topic Exercise (p.164)

25 Alkenes can be made from alkanes by cracking.

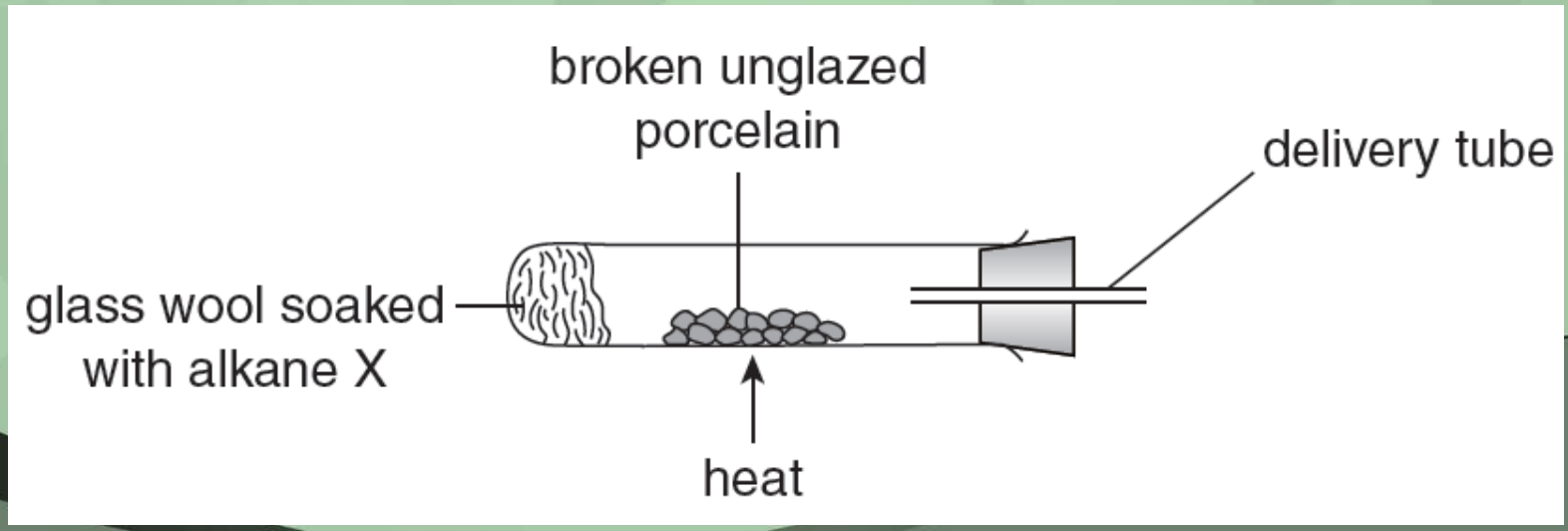
a) Explain the term 'cracking'.

Cracking is the breaking down of large hydrocarbon molecules with heat or in the presence of a catalyst to produce smaller hydrocarbon molecules. (1)

b) Suggest TWO importance of cracking in industry.

- To produce alkenes which can make a huge range of other compounds. (1)
- To convert heavy oil to petrol. (1)

c) The cracking of alkane X was studied in a school laboratory using the set-up shown below.



Topic Exercise (p.164)

During the experiment, one molecule of alkane X produced one molecule of hexane (C_6H_{14}) and two molecules of ethene.

i) What is the molecular formula of alkane X? $C_{10}H_{22}$ (1)

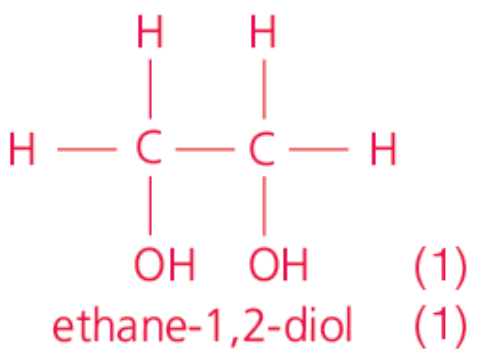
ii) Complete the diagram to show how the gaseous product could be collected.

iii) The gaseous product (ethene) was shaken thoroughly with a few drops of cold acidified dilute KMnO4(aq).

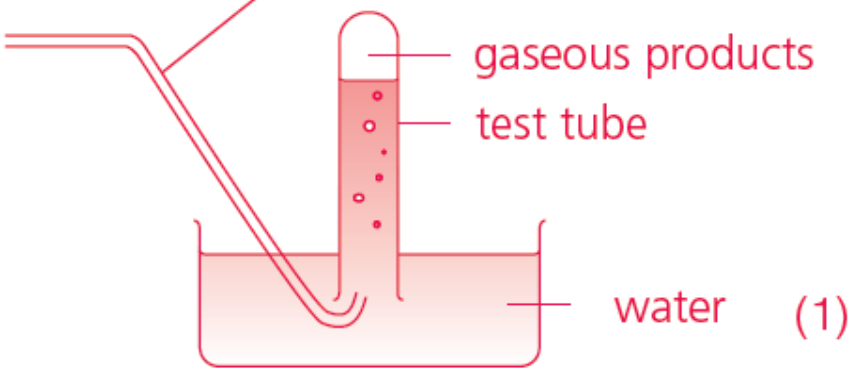
(I) State the expected observation.

The purple solution of potassium permanganate becomes colourless quickly. (1)

(II) Write the structural formula of the product formed in the reaction. Give its systematic name.

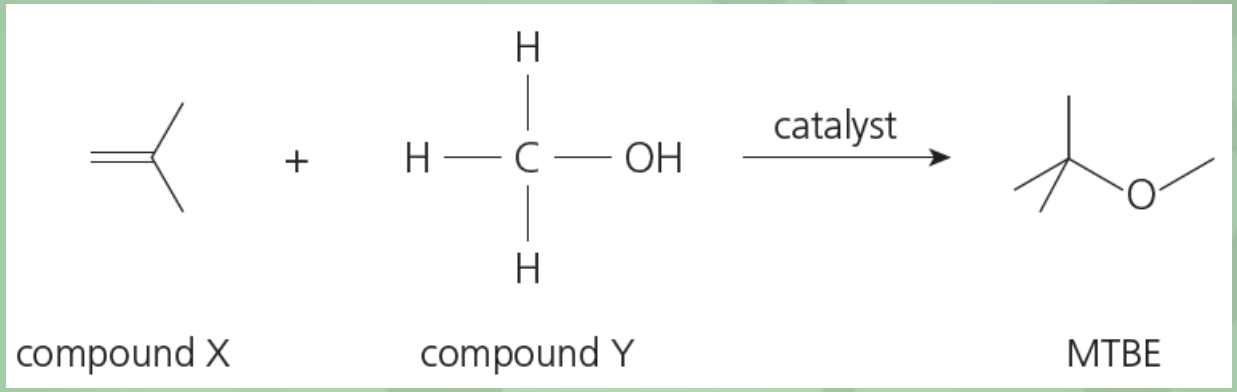


c) ii)



Topic Exercise (p.164)

26 Oxygenates are often blended in petrol to reduce carbon monoxide and soot that are produced during the combustion of petrol.
MTBE, an oxygenate, is manufactured according to the equation below.



a) Give the systematic names of compounds X and Y.
Compound X: methylpropene (1)
Compound Y: methanol (1)

b) Name the homologous series of which compound Y is a member.
Alkanols (1)

c) Name the type of formula used to represent compound X and MTBE. Skeletal formula (1)

Topic Exercise (p.164)

d) Compound X can be obtained by cracking a larger hydrocarbon $C_{15}H_{32}$.

i) Write the chemical equation for the cracking of C15H32 to produce compound X and one other product.

$C_{15}H_{32} \rightarrow C_4H_8 + C_{11}H_{24}$ (1)

ii) A catalyst is one condition needed to crack a hydrocarbon. State ONE other condition needed to crack a hydrocarbon.

Heat / high temperature (1)

Topic Exercise (p.164)

27 Ethene, propene and but-1-ene are members of the alkene homologous series.

a) Describe THREE features of a member of a homologous series.

Any three of the following:

Members

- have the same general formula. (1)
- differ from the next by a $-CH_2-$ unit. (1)
- have similar chemical properties. (1)
- have physical properties showing a trend. (1)

b) State and explain which of the compounds has the highest boiling point.

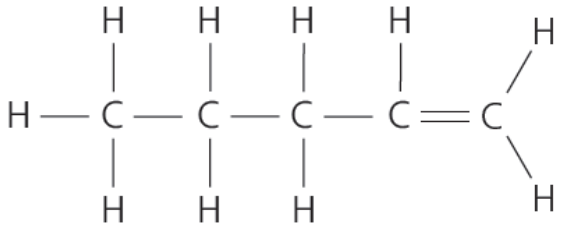
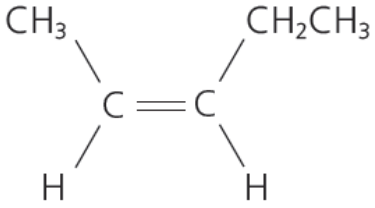
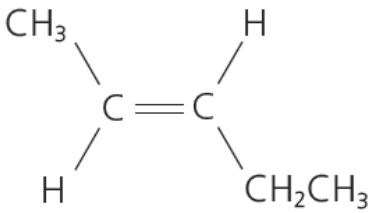
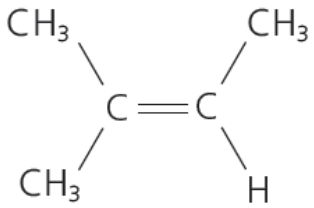
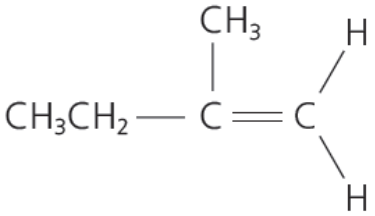
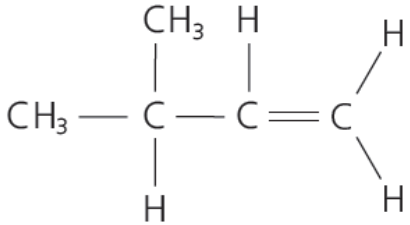
But-1-ene has the highest boiling point.

The molecular size is the greatest for but-1-ene. (1)

Thus, the strength of van der Waals' forces among but-1-ene molecules is the greatest. (1)

Topic Exercise (p.164)

c) Write the structural formula and systematic name of an alkene containing five carbon atoms per molecule. Any one of the following:

-  pent-1-ene (1) (1)
-  or  pent-2-ene (1) (1)
-  2-methylbut-2-ene (1)
-  2-methylbut-1-ene (1)
-  3-methylbut-1-ene (1)

Topic Exercise (p.164)

d) Describe a chemical test to distinguish between an alkane and an alkene, giving the expected observation in each case.

Any one of the following:

- Add an orange solution of bromine dissolved in 1,1,1-trichloroethane to alkane and alkene separately. (1)
  The orange solution of bromine becomes colourless quickly when added to alkene.
  The orange solution of bromine becomes colourless slowly when added to alkane in the presence of ultraviolet light / heat. (1)

- Add a purple solution of cold acidified dilute potassium permanganate solution to alkane and alkene separately. (1)
  The purple solution of potassium permanganate becomes colourless quickly when added to alkene.
  Alkane gives no observable change. (1)

Topic Exercise (p.164)

28 a) Cracking of alkanes gives alkenes.

Write a chemical equation for the cracking of $C_{21}H_{44}$ in which ethene and propene are produced in a 3:2 mole ratio together with one other product. $C_{21}H_{44} \rightarrow 3C_2H_4 + 2C_3H_6 + C_9H_{20}$ (1)

b) Propene undergoes addition polymerisation to form polypropene.

i) Explain the meaning of the term 'addition polymerisation'.

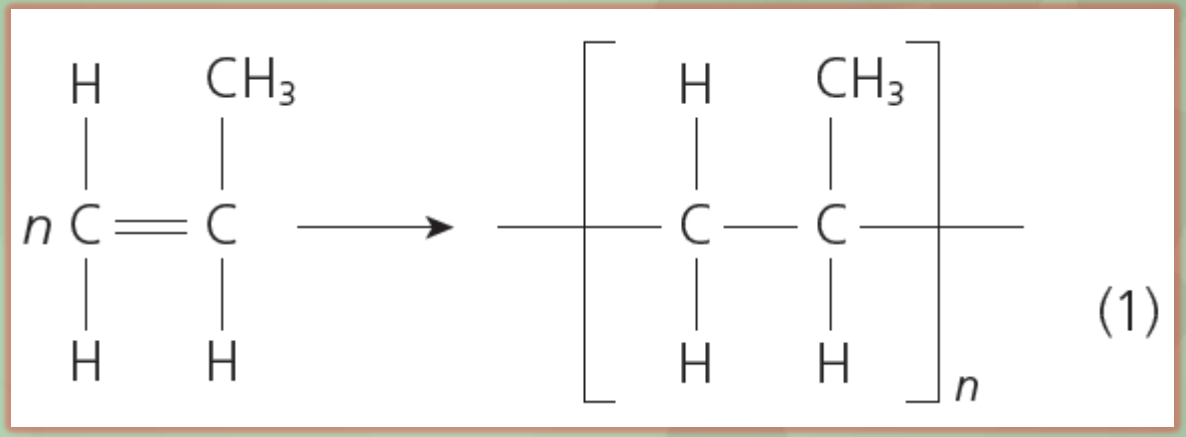
Addition polymerisation is a reaction in which monomer molecules join together repeatedly to form polymer molecules. (1)
No atoms are lost from the monomer molecules during the reaction. (1)

Topic Exercise (p.164)

ii) Explain why propene can form a polymer, but propane CANNOT

$C_{21}H_{44} \rightarrow 3C_2H_4 + 2C_3H_6 + C_9H_{20}$ (1)

iii) Write the chemical equation for the formation of polypropene from propene.



iv) Explain why polypropene is a solid at room conditions.

Polypropene has long-chain molecules. (1)

The van der Waals' forces among the molecules are strong. (1)

Topic Exercise (p.164)

29 Ethene and ethane are hydrocarbons.

a) Suggest how ethene can be converted to ethane.

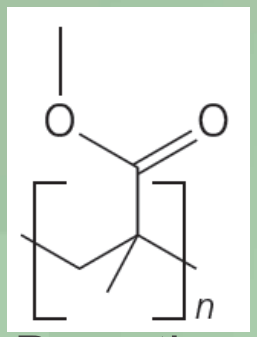
b) Suggest a chemical test to distinguish between ethane and ethene.

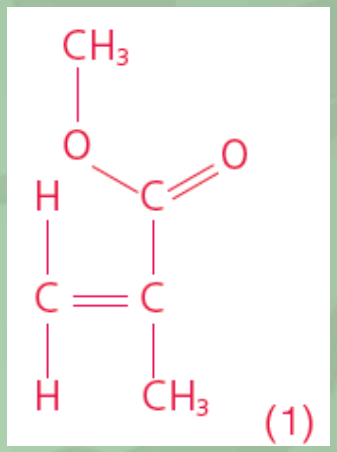
(HKDSE, Paper 1B, 2018, 4(c))

Answers for the questions of the public examinations in Hong Kong are not provided (if applicable).

Topic Exercise (p.164)

30 The structure of Perspex is shown below.





a) Draw the structure of the monomer of Perspex.

b) Perspex can be used to make aircraft windows. One of the properties that make Perspex suitable for making aircraft windows is its transparency. Suggest TWO other properties of Perspex which make it suitable for this use.

Any two of the following:

- Does not break when hit (1)
- Not degraded by sunlight (1)
- Durable (1)
- Strong (1)
- Does not corrode / does not react with moist air (1)
- Lightweight (1)
- High melting point (1)
- Rigid (1)

Topic Exercise (p.164)

31 Allyl chloride, $CH_2=CHCH_2Cl$, is used in the production of polymers.

a) Allyl chloride is a member of a homologous series.

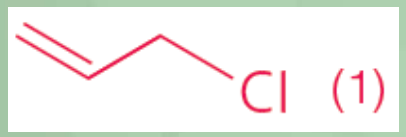
i) What is meant by the term 'homologous series'?

A 'family' of compounds that have a common functional group, with each successive member differing by a $-CH^2-$ unit, is called a homologous series. (1)

ii) What is the general formula of the homologous series of which allyl chloride is a member?

$C_nH_{2n-1}Cl$ (1)

iii) Write the skeletal formula of allyl chloride.

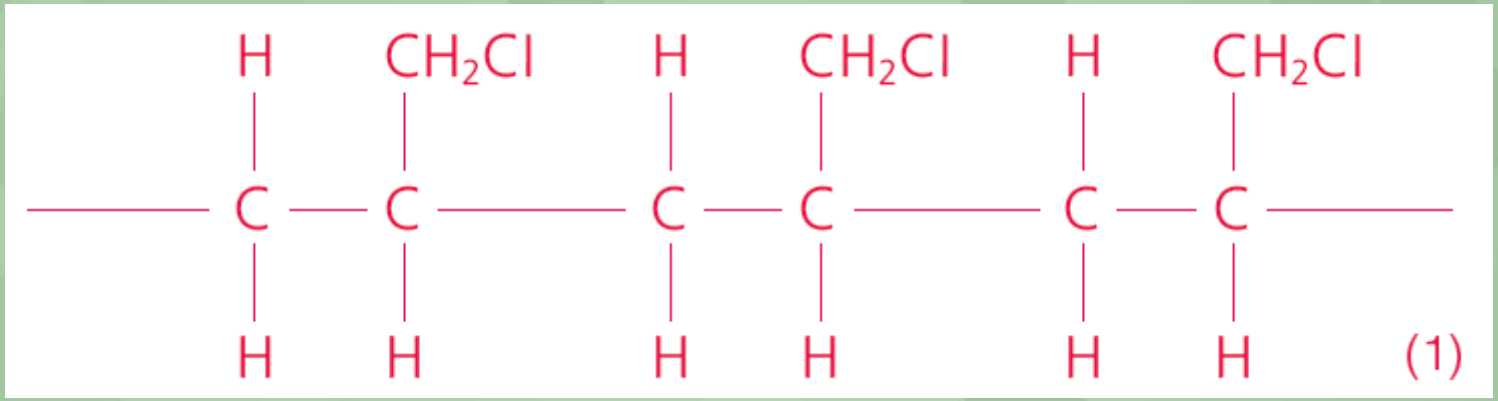


(1)

Topic Exercise (p.164)

b) i) State the type of polymerisation for the formation of polymer from allyl chloride. Addition polymerisation (1)

ii) Draw the structure of the polymer, showing at least THREE repeating units.



Topic Exercise (p.164)

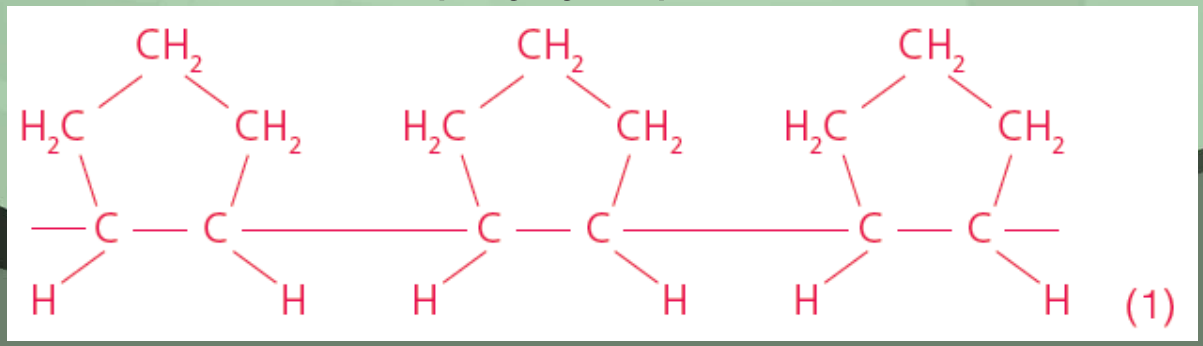
32 The cyclic carbon compounds shown below are members of the same homologous series and have the same general formula.

a) What is the functional group in these compounds?
Carbon-carbon double bond (1)

b) Why are these compounds described as hydrocarbons?
They contain only hydrogen atoms and carbon atoms. (1)

c) State the general formula for members of this series. C_nH_{2n+2} (1)

d) Cyclopentene can be polymerised to give polycyclopentene.
Draw a section of polycyclopentene to show THREE repeating units.



Topic Exercise (p.164)

e) Both cyclohexene and cyclohexane contain six carbon atoms per molecule. Suggest a chemical test to distinguish cyclohexene from cyclohexane. State your expected observations.

Any one of the following:

- Add an orange solution of bromine dissolved in 1,1,1-trichloroethane to cyclohexene and cyclohexane separately. (1)
  The orange solution of bromine becomes colourless quickly when added to cyclohexene.
  The orange solution of bromine becomes colourless slowly when added to cyclohexane in the presence of ultraviolet light / heat. (1)
- Add a purple solution of cold acidified dilute potassium permanganate solution to cyclohexene and cyclohexane separately. (1)
  The purple solution of potassium permanganate becomes colourless quickly when added to cyclohexene.
  Cyclohexane gives no observable change. (1)

Topic Exercise (p.164)

33 Both polythene (PE) and 'Saran' can be used to make food wrap, but 'Saran' is more suitable than PE in making food wrap for use in microwave ovens.

a) The monomer of PE is ethene. Suggest a chemical test to show that ethene is an unsaturated compound.

b) 'Saran' can be formed from the polymerisation of the compound shown below:

i) State the systematic name of this compound.

ii) Name the type of polymerisation involved in forming 'Saran'.

iii) Draw the structure of 'Saran', showing at least THREE repeating units.

Topic Exercise (p.164)

c) In terms of intermolecular force, explain why 'Saran' is more suitable than PE in making food wrap for use in microwave ovens.

d) When incinerated, why would food wrap made from 'Saran' cause more serious pollution problem than food wrap made from PE?

(HKDSE, Paper 1B, 2014, 3)

Answers for the questions of the public examinations in Hong Kong are not provided (if applicable).