Week 23

IGCSE Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

11. Organic chemistry

Starter Quiz · 课前小测

IGCSE Chemistry Name: _____ Score: _____

1. Organic chemistry is the study of compounds containing:
   - ☐ carbon
   - ☐ only metals
   - ☐ only oxygen
   - ☐ noble gases
2. How many carbon atoms does the prefix ”prop-” indicate?
   - ☐ three
   - ☐ one
   - ☐ two
   - ☐ four
3. A hydrocarbon is a compound of:
   - ☐ hydrogen and carbon only
   - ☐ hydrogen and oxygen
   - ☐ carbon and nitrogen
   - ☐ metals
4. Alkanes are described as saturated because they have:
   - ☐ only single carbon-carbon bonds
   - ☐ a double bond
   - ☐ a triple bond
   - ☐ no carbon
5. Alkenes contain a:
   - ☐ carbon-carbon double bond
   - ☐ only single bonds
   - ☐ nitrogen atom
   - ☐ metal ion
6. Boiling points rise gradually as the chain length increases in a series.

   ☐ True ☐ False

7. How many carbon atoms are in butane?

   _____
8. Incomplete combustion can produce toxic carbon monoxide.

   ☐ True ☐ False
9. Alkanes burn well, which is why they are used as fuels.

   ☐ True ☐ False
10. Alkenes are unsaturated because of their double bond.

    ☐ True ☐ False

IGCSE Chemistry

1. **carbon**

   Organic compounds are carbon-based.

2. **three**

   meth-(1), eth-(2), prop-(3), but-(4).

3. **hydrogen and carbon only**

   Hydrocarbons contain only hydrogen and carbon.

4. **only single carbon-carbon bonds**

   Saturated = all single bonds.

5. **carbon-carbon double bond**

   The C=C double bond defines alkenes.

6. **True**

   Longer chains have higher boiling points.

7. **4**

   but- means 4 carbons.

8. **True**

   Too little oxygen makes CO and soot.

9. **True**

   Combustion releases lots of energy.

10. **True**

    The double bond can open to add atoms.

IGCSE CHEMISTRY • EXERCISE SHEET

11.1 Formulae, functional groups and terminology

Name: _____ Class: _____ Date: _____ **Total: 26 marks**

KEY WORDS molecular formula 分子式 • homologous series 同系物 • displayed formula 结构式 • structural formula 结构简式 • alcohols 醇

Objective

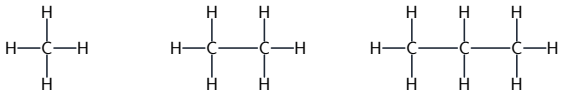
Build the skills to answer exam questions on **formulae, functional groups and terminology** 有机化学术语 — types of formula, the **homologous series** 同系物, saturated/unsaturated, and **structural isomers** 同分异构体.

You must be able to:

- use molecular, displayed, structural and general formulae
- describe a homologous series and its general formula
- recognise saturated/unsaturated and structural isomers

1 Worked examples

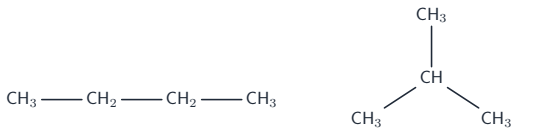
Homologous series & isomers



methane CH_4 | ethane C_2H_6 | propane C_3H_8

each step adds a CH_2 unit general formula C_nH_{2n+2}

A homologous series: same functional group, differ by CH_2, general formula C_nH_{2n+2} for alkanes



Structural isomers: same molecular formula, different structures

■ Naming, drawing and telling isomers apart

A **homologous series** 同系列 is a family with the same **functional group** 官能团, the same general formula, and neighbours differing by CH_2. Along a series the boiling point rises as the molecules get longer, because the intermolecular forces between the larger molecules are stronger.

Series	Functional group	General formula	First four
alkanes	none (all single bonds)	C_nH_{2n+2}	methane, ethane, propane, butane
alkenes	C = C	C_nH_{2n}	ethene, propene, butene
alcohols	−OH	$C_nH_{2n+1}OH$	methanol, ethanol, propanol
carboxylic acids	−COOH	$C_nH_{2n+1}COOH$	methanoic, ethanoic, propanoic

Three formulas, three jobs. The **molecular formula** counts the atoms (C_4H_{10}). The **structural formula** shows the order of the groups without drawing every bond ($CH_3CH_2CH_2CH_3$). The **displayed formula** 结构式 draws every atom and every bond, so each carbon must show four bonds and each hydrogen one.

Structural isomers 结构异构体 have the same molecular formula but different structures, so they have different physical properties (for example different boiling points) while sharing the same chemical family.

Worked example. Draw and name the two isomers of C_4H_{10}, and explain why they have different boiling points. Butane is a straight chain of four carbons; 2-methylpropane is a chain of three with a CH_3 branch on the middle carbon. Both must show every carbon with four bonds. Butane boils higher, because its unbranched molecules pack closer together, so the forces between them are stronger and more energy is needed to separate them.

2 Practice

2.1 State the general formula of the alkanes. [1]

2.2 Define a structural isomer. [1]

2.3 State the general formula of the alkenes and give the molecular formula of the alkene with four carbon atoms. [2]

2.4 State two features shared by all members of a homologous series. [2]

2.5 Explain why the boiling points rise as you go along a homologous series. [2]

3 Exam-style questions

3.1 A saturated hydrocarbon contains: [1]

- **A** a C=C double bond
- **B** only single C–C bonds
- **C** an –OH group
- **D** a –COOH group

3.2 Members of a homologous series have similar chemical properties.

(a) State why they have similar chemical properties. [1]

(b) State how consecutive members differ. [1]

3.3 Draw the two structural isomers of C_4H_{10} and name each. [3]

3.4 A hydrocarbon X has the molecular formula C_5H_{12}.

(a) Identify the homologous series X belongs to, and give its general formula. [2]

(b) Draw the displayed formula of the straight-chain isomer of X. [2]

(c) Draw the displayed formula of one branched isomer of X, and explain why it is described as a structural isomer of your answer to (b). [3]

(d) The straight-chain isomer boils at 36 °C and the branched one at 28 °C. Explain this difference. [2]

(e) A different compound, Y, has the molecular formula C_5H_{10} and decolourises bromine water. Identify the homologous series of Y and explain how the test shows this. [3]

Solutions

2.1 C_nH_{2n+2}.

2.2 compounds with the same molecular formula but different structural formulae.

2.3 C_nH_{2n}; C_4H_8.

2.4 Any two of: the same functional group; the same general formula; neighbouring members differ by CH_2; similar chemical properties; a gradual change in physical properties.

2.5 The molecules get longer as the series is climbed, so the intermolecular forces between them are stronger and more energy is needed to separate them.

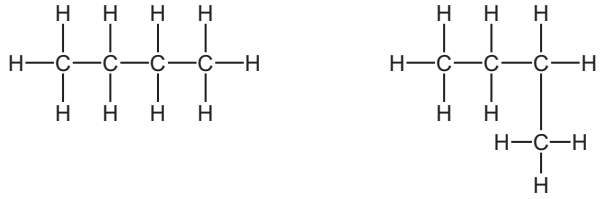
3.1 B. A saturated hydrocarbon has only single C–C bonds.

3.2 (a) they have the same functional group.
(b) by a CH_2 unit each step.

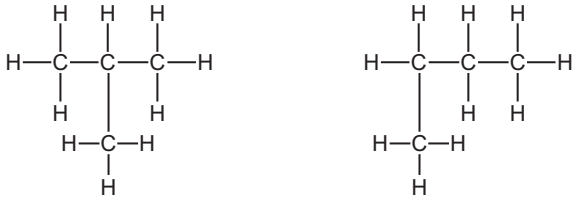
3.3 straight chain butane $CH_3CH_2CH_2CH_3$; branched 2-methylpropane; both named correctly.

3.4 (a) The alkanes; C_nH_{2n+2}.
(b) A chain of five carbon atoms, each single-bonded, with every carbon showing four bonds and every hydrogen one, giving 12 hydrogens in total.
(c) A correct branched structure, for example 2-methylbutane: a four-carbon chain with a CH_3 group on the second carbon, drawn with all bonds shown; it is a structural isomer because it has the same molecular formula, C_5H_{12}, but the atoms are joined in a different order.
(d) The straight-chain molecules pack more closely together, so the intermolecular forces between them are stronger; more energy is needed to separate them, so its boiling point is higher.
(e) The alkenes; an alkene contains a carbon-carbon double bond, and bromine adds across that double bond, so the orange bromine water is decolourised, which an alkane would not do.

34 Which structures are structural isomers of each other?



1 2



3 4

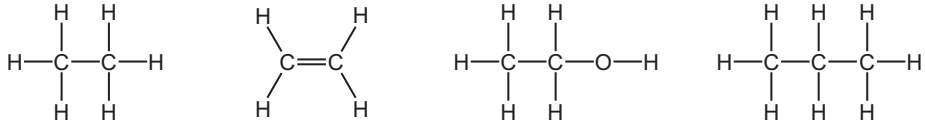
A 1, 2, 3 and 4

B 1, 2 and 4 only

C 1 and 3 only

D 2 and 4 only

37 The structures of four compounds are shown.



1 2 3 4

Which compounds are members of the same homologous series?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 4 **D** 2 and 4

5 This question is about the homologous series of alkanes.

Three general characteristics of alkanes are:

- they are generally unreactive because they do **not** have a functional group
- they show trends in their physical properties, such as melting points and boiling points
- they have similar chemical properties.

(a) Describe **two other** general characteristics of the homologous series of alkanes.

1.....

2.....

[2]

(b) **(i)** State the trend in the boiling points of the alkanes as the carbon chain length increases.

..... [1]

(ii) Name **one other** physical property of alkanes that shows a trend, other than melting points and boiling points.

Describe this trend as the carbon chain length of alkanes increases.

name .....

description .....

[2]

(c) State why alkanes are described as saturated.

..... [1]

(d) Propane has the structural formula $CH_3CH_2CH_3$.

When propane undergoes a monosubstitution reaction with chlorine at room temperature, **two** organic products can be formed.

(i) State **one** condition needed for this substitution reaction to take place.

..... [1]

(ii) Give the structural formula and state the name of each organic product formed.

- structural formula of product 1

name of product 1 .....

- structural formula of product 2

name of product 2 .....

[4]

(iii) The two products formed are structural isomers of each other.

Define the term structural isomers.

.....

..... [1]

[Total: 12]

6 Compound **E** shown in Fig. 6.1 is an ester.

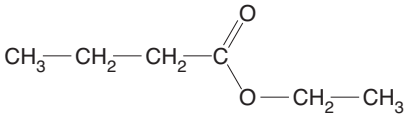


Fig. 6.1

(a) **On Fig. 6.1**, draw a circle around all the atoms which make up the ester linkage. [1]

(b) Name compound **E**.

..... [1]

(c) Deduce the empirical formula of compound **E**.

..... [1]

(d) Compound **E** is produced when two different compounds react together in the presence of a catalyst.

(i) Name the **two** compounds that react together to produce compound **E**.

1 .....

2 .....

[2]

(ii) Suggest a suitable catalyst for this reaction.

..... [1]

(e) Determine the number of unbranched esters which have the molecular formula $C_5H_{10}O_2$.

..... [1]

(f) All unbranched esters with the molecular formula $C_5H_{10}O_2$ combust completely to form carbon dioxide and water only.

Write the symbol equation for the complete combustion of $C_5H_{10}O_2$.

..... [1]

[Total: 8]

The Periodic Table of Elements

Group	I	II											III	IV	V	VI	VII	VIII
																		2 He helium 4
													5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
													13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
										29 Cu copper 64	30 Zn zinc 65		31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
										47 Ag silver 108	48 Cd cadmium 112		49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
										79 Au gold 197	80 Hg mercury 201		81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
										111 Rg roentgenium –	112 Cn copernicium –		113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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11 Na sodium 23	12 Mg magnesium 24																													
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59																					
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106																					
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195																					
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –																					

Key

atomic number
atomic symbol
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relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

6 This question is about organic compounds.

(a) Organic compound **Q** has the following composition by mass.

C, 50.00%; H, 5.56%; O, 44.44%

Calculate the empirical formula of compound **Q**.

empirical formula = ... [3]

(b) Organic compound **R** has the empirical formula CHO and a relative molecular mass of 116.

Determine the molecular formula of compound **R**.

molecular formula = ... [1]

(c) Carboxylic acids react with alcohols to form esters.

(i) Name the other product that is formed when a carboxylic acid reacts with an alcohol.

..... [1]

(ii) Name the **type** of catalyst that is used when a carboxylic acid reacts with an alcohol.

..... [1]

(iii) Ester **S** has the structural formula $CH_3CH_2COOCH_2CH_2CH_2CH_3$.

Name the carboxylic acid and the alcohol which react together to form ester **S**.

carboxylic acid .....

alcohol ....

[2]

(d) Fig. 6.1 shows part of a polymer structure.

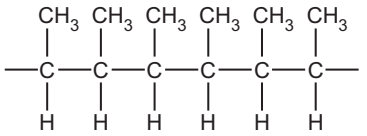

Fig. 6.1

(i) Name the type of polymerisation that is used to produce this polymer.

..... [1]

(ii) Suggest why it is **not** possible to write the molecular formula of this polymer.

..... [1]

(iii) State the number of monomer units that are needed to make the part of the polymer structure shown in Fig. 6.1.

..... [1]

(iv) Draw the displayed formula of the monomer used to make this polymer.

[2]

(e) Fig. 6.2 shows part of the general structure of an amino acid.

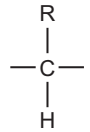

Fig. 6.2

(i) Complete Fig. 6.2 to show all the atoms and all the bonds in the two functional groups of the amino acid. [2]

(ii) Part of a natural polyamide structure is shown in Fig. 6.3.

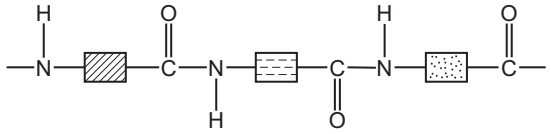

Fig. 6.3

On Fig. 6.3, draw a circle around **one** amide linkage. [1]

(iii) State the name given to natural polyamides made from amino acids.

..... [1]

[Total: 17]

The Periodic Table of Elements

Group I	II											III	IV	V	VI	VII	VIII
																	2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
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19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
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Key

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lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

33 The structural formula of methyl ethanoate is CH_3COOCH_3.

Which compounds are structural isomers of methyl ethanoate?

1 $HCOOCH_2CH_3$

2 CH_3CH_2COOH

3 $HOCH_2CH_2CH_2OH$

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 3 only

34 Which row describes two characteristics of members of the same homologous series?

	characteristic 1	characteristic 2
A	same functional group	trend in physical properties
B	same physical properties	same functional group
C	same general formula	different chemical properties
D	differing from one member to the next by a CH_3 unit	similar chemical properties

6 The structural formulae of two compounds, **A** and **B**, are shown.

A	**B**
$CH_2=CHCH_3$	$CH_3CH=CHCH_3$

A and **B** are members of the same homologous series.

(a) Give **two** reasons why the structural formulae of **A** and **B** show they are members of the same homologous series.

1 .....

2 .....

[2]

(b) Explain why **A** and **B** are both hydrocarbons.

..... [1]

(c) Write the symbol equation for the complete combustion of **A**.

..... [2]

(d) Deduce the empirical formula of **A**.

..... [1]

(e) Name compound **B**.

..... [1]

(f) A structural isomer of **B** is a member of the same homologous series.

Draw the displayed formula of this structural isomer of **B**.

[1]

(g) Compound **B** reacts with aqueous bromine at room temperature to form product **C**.
The equation is shown.

$$\underset{\textbf{B}}{CH_3CH{=}CHCH_3} + Br_2 \rightarrow \underset{\textbf{C}}{CH_3CHBrCHBrCH_3}$$

(i) State why this is an addition reaction.

..... [1]

(ii) Describe the colour change in aqueous bromine during this reaction.

from ..... to ..... [1]

(iii) Name product **C**.

..... [1]

(h) Under certain conditions, **one** mole of **B** reacts with oxygen to form **two** moles of carboxylic acid **D**.

Carboxylic acid **D** has **two** carbon atoms.

(i) Draw the displayed formula of carboxylic acid **D**.

[1]

(ii) Name carboxylic acid **D**.

..... [1]

(iii) Complete the symbol equation for this reaction.

$CH_3CH{=}CHCH_3$ + ... → .....

[1]

[Total: 14]

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actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

IGCSE CHEMISTRY • EXERCISE SHEET

11.2 Naming organic compounds

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS ethanoic acid 乙酸 • ethanol 乙醇 • naming organic compounds 有机物命名 • ethene 乙烯 • structural isomers 同分异构体

Objective

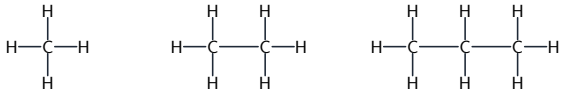
Build the skills to answer exam questions on **naming organic compounds** 有机物命名 — using the ending (family) and the stem (number of carbons).

You must be able to:

- use the ending to identify the family (-ane, -ene, -ol, -oic acid)
- use the stem for the number of carbons (meth-, eth-, prop-, but-)
- name simple compounds and use position numbers

1 Worked examples

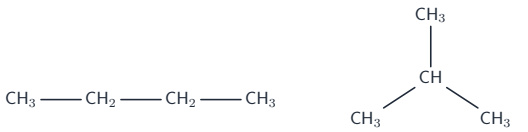
■ **Stems and endings**



methane CH_4 | ethane C_2H_6 | propane C_3H_8

each step adds a CH_2 unit general formula C_nH_{2n+2}

Stem = carbons (meth-1, eth-2, prop-3, but-4); ending = family



butane (straight chain) 2-methylpropane (branched)

both have the formula C_4H_{10}: same formula, different structure (structural isomers)

Naming distinguishes structural isomers

Ending	Family
-ane	alkane
-ene	alkene
-ol	alcohol
-oic acid	carboxylic acid

2 Practice

2.1 State the family of a compound whose name ends in -ol. [1]

2.2 State how many carbon atoms 'prop-' means. [1]

3 Exam-style questions

3.1 Which compound is an alkene? [1]

- **A** ethane
- **B** ethene
- **C** ethanol
- **D** ethanoic acid

3.2 Name each compound from its description: [3]

(a) a 2-carbon alcohol

(b) a 1-carbon alkane

(c) a 2-carbon carboxylic acid

3.3 Explain why both but-1-ene and but-2-ene need a number in the name. [2]

Solutions

2.1 an alcohol.

2.2 three.

3.1 B. The ending -ene shows ethene is an alkene.

3.2 (a) ethanol
(b) methane
(c) ethanoic acid.

3.3 the number shows the position of the C=C double bond; the double bond can be in different places along the chain, giving different compounds.

IGCSE CHEMISTRY • EXERCISE SHEET

11.3 Fuels

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS petroleum 石油 • hydrogen 氢气 • fractions 馏分 • hydrocarbon 碳氢化合物 • fractionating column 分馏塔

Objective

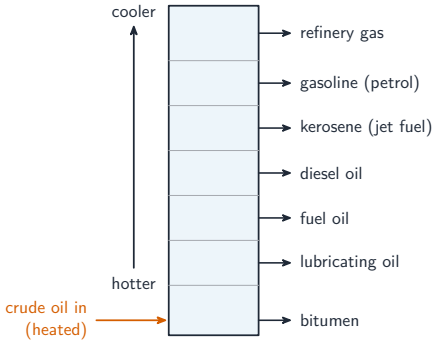
Build the skills to answer exam questions on **fuels** 燃料 — **fossil fuels** 化石燃料, **hydrocarbons** 碳氢化合物, and the **fractional distillation** 分馏 of petroleum.

You must be able to:

- name the fossil fuels and define a hydrocarbon
- describe fractional distillation and the trends up the column
- match fractions to their uses

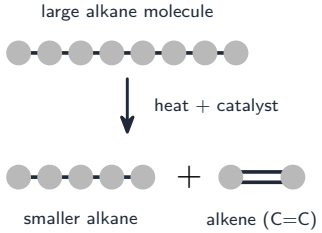
1 Worked examples

■ Fractional distillation



up the column: smaller molecules, lower boiling points, more volatile

Hot at the bottom, cool at the top; each fraction condenses at a different height



Cracking turns long fractions into useful fuels

- going **up** the column: shorter chains, higher volatility, lower boiling point, lower viscosity.
- fractions: refinery gas, gasoline, naphtha, kerosene, diesel, fuel oil, bitumen.

2 Practice

2.1 Define a hydrocarbon. [1]

2.2 Name the fraction used as fuel for cars. [1]

3 Exam-style questions

3.1 Going up the fractionating column, the boiling point of the fractions: [1]

- **A** increases
- **B** decreases
- **C** stays the same
- **D** increases then decreases

3.2 Petroleum is separated by fractional distillation.

(a) Explain why the different fractions separate. [2]

(b) State one use of bitumen. [1]

3.3 Explain why a fraction near the top of the column flows more easily than one near the bottom. [2]

Solutions

2.1 a compound containing hydrogen and carbon only.

2.2 gasoline / petrol.

3.1 B. Boiling point decreases up the column.

3.2 (a) the fractions have different boiling points; they condense at different heights as the column cools towards the top.
(b) making roads.

3.3 fractions near the top have smaller molecules / lower viscosity; so they flow more easily than the larger molecules near the bottom.

Name: IGCSE Chemistry: **w25 21**

32 Petroleum is separated by fractional distillation.

Which statement about the fractions produced is correct?

A Bottled gas for heating and cooking is obtained from the naphtha fraction.

B Diesel oil is used as a fuel for jet aircraft.

C Substances used to make polishes are obtained from the lubricating fraction.

D The kerosene fraction contains many useful waxes.

IGCSE Chemistry: **w25 22**

36 Which row shows the products obtained by the cracking of a large alkane?

	alkene	hydrogen	water
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✓
D	✗	✓	✓

key
✓ = yes
✗ = no

IGCSE Chemistry: **s25 22**

34 Petroleum can be separated into useful fractions by fractional distillation.

Which row shows a correct use of the named fraction?

	fraction	use
A	bitumen	lubricant
B	naphtha	fuel for home heating
C	kerosene	jet fuel
D	refinery gas	making chemicals

IGCSE CHEMISTRY • EXERCISE SHEET

11.4 Alkanes

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS ultraviolet light 紫外线 • substitution 取代 • alkanes 烷烃 • combustion 燃烧 • hydrogen 氢气

Objective

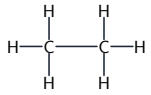
Build the skills to answer exam questions on **alkanes** 烷烃 — saturated hydrocarbons, **combustion** 燃烧, and **substitution** 取代 with chlorine.

You must be able to:

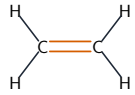
- describe alkanes as saturated and generally unreactive
- write combustion equations (complete/incomplete)
- describe the photochemical substitution with chlorine

1 Worked examples

Alkane reactions



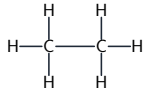
ethane C_2H_6
saturated: single C–C bond



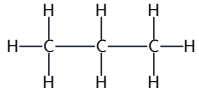
ethene C_2H_4
unsaturated: C=C double bond

Alkanes are saturated (single bonds only), so they are generally unreactive

methane
CH_4



ethane
C_2H_6



propane
C_3H_8

each step adds a CH_2 unit general formula C_nH_{2n+2}

Alkanes form a homologous series

- **combustion (complete):** alkane + $O_2 \rightarrow CO_2 + H_2O$.
- **substitution:** $CH_4 + Cl_2 \xrightarrow{UV} CH_3Cl + HCl$ (needs UV light).

2 Practice

2.1 State why alkanes are described as saturated. [1]

2.2 Name the products of the complete combustion of an alkane. [2]

3 Exam-style questions

3.1 The reaction of methane with chlorine requires: [1]

- **A** a nickel catalyst
- **B** ultraviolet light
- **C** steam
- **D** high pressure only

3.2 Methane reacts with chlorine in ultraviolet light.

(a) Write the equation for the reaction. [2]

(b) Name this type of reaction. [1]

3.3 Write a balanced equation for the complete combustion of ethane, C_2H_6. [2]

3.4 Methane, CH_4, is the first member of the alkanes.

(a) State what is meant by a *saturated hydrocarbon*, and give the general formula of the alkanes. [3]

(b) Write the balanced equation for the complete combustion of methane, and state one danger of **in**complete combustion. [3]

(c) Methane reacts with chlorine in ultraviolet light. Name the type of reaction, write the equation for the first step, and state why light is needed. [3]

(d) Draw the displayed formula of ethane, and explain why alkanes are generally unreactive. [3]

Solutions

2.1 they have only single carbon–carbon bonds.

2.2 carbon dioxide; water.

3.1 B. The substitution needs ultraviolet light.

3.2 (a) $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$.
(b) substitution.

3.3 $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$.

3.4 (a) It contains only carbon and hydrogen (a hydrocarbon), with only **single** bonds between the carbon atoms — no double bonds; the general formula is C_nH_{2n+2}.
(b) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$; incomplete combustion produces **carbon monoxide**, a toxic gas that is colourless and has no smell, so it cannot be detected without an alarm.
(c) **Substitution**; $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$; ultraviolet light supplies the energy to break the Cl–Cl bond and start the reaction.
(d) Two carbons joined by a single bond, each with three hydrogens, all bonds drawn. The C–C and C–H bonds are strong and are not polar, so there is no partial charge to attract an attacking particle — a great deal of energy is needed before anything reacts.

34 Ethane reacts with chlorine.

Which row identifies the type of reaction and the formulae of the products formed?

	reaction	products
A	addition	CH_3CH_2Cl + H_2
B	addition	CH_3CH_2Cl + HCl
C	substitution	CH_3CH_2Cl + HCl
D	substitution	CH_3CH_2Cl + H_2

31 Which type of reaction takes place when methane reacts with chlorine in the presence of ultraviolet light?

A addition

B cracking

C polymerisation

D substitution

5 This question is about the homologous series of alkanes.

Three general characteristics of alkanes are:

- they are generally unreactive because they do **not** have a functional group
- they show trends in their physical properties, such as melting points and boiling points
- they have similar chemical properties.

(a) Describe **two other** general characteristics of the homologous series of alkanes.

1.....

2.....

[2]

(b) **(i)** State the trend in the boiling points of the alkanes as the carbon chain length increases.

..... [1]

(ii) Name **one other** physical property of alkanes that shows a trend, other than melting points and boiling points.

Describe this trend as the carbon chain length of alkanes increases.

name .....

description.....

[2]

(c) State why alkanes are described as saturated.

..... [1]

(d) Propane has the structural formula $CH_3CH_2CH_3$.

When propane undergoes a monosubstitution reaction with chlorine at room temperature, **two** organic products can be formed.

(i) State **one** condition needed for this substitution reaction to take place.

..... [1]

(ii) Give the structural formula and state the name of each organic product formed.

- structural formula of product 1

name of product 1.....

- structural formula of product 2

name of product 2.....

[4]

(iii) The two products formed are structural isomers of each other.

Define the term structural isomers.

.....

..... [1]

[Total: 12]

34 What is the **total** number of covalent bonds in one molecule of propane?

A 8 **B** 9 **C** 10 **D** 11

Name: IGCSE Chemistry: **s25 22**

35 Ethane reacts with chlorine in the presence of ultraviolet light.

Which products are formed?

A $Cl CH_2CH_2Cl$ and H_2

B $2CH_3Cl$ and H_2

C C_2H_5Cl and HCl

D $CH_2{=}CH_2$ and $2HCl$

IGCSE Chemistry: **s25 23**

35 Compound W is a hydrocarbon that contains single bonds only.

Which homologous series contains W?

A alkenes

B alkanes

C carboxylic acids

D alcohols

36 Methane forms chloromethane in a photochemical reaction using ultraviolet light.

Which statement about this reaction is correct?

A Methane is mixed with hydrogen chloride gas, and ultraviolet light prevents a combustion reaction.

B Methane is mixed with hydrogen chloride gas, and ultraviolet light provides the activation energy for the reaction.

C Methane is mixed with chlorine gas, and ultraviolet light prevents a combustion reaction.

D Methane is mixed with chlorine gas, and ultraviolet light provides the activation energy for the reaction.

IGCSE Chemistry: **m25 22**

36 The structural formula of methyl propane is $CH_3CH(CH_3)CH_3$.

The equation represents the reaction of methyl propane with chlorine.

$$C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$$

How many structural isomers with the molecular formula C_4H_9Cl can be formed from this reaction?

A 1 **B** 2 **C** 3 **D** 4

IGCSE CHEMISTRY • EXERCISE SHEET

11.5 Alkenes

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS bromine 溴 • saturated 饱和的 • unsaturated 不饱和的 • nickel 镍 • catalyst 催化剂

Objective

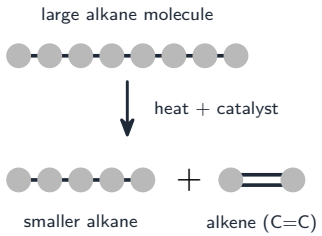
Build the skills to answer exam questions on **alkenes** 烯烃 — unsaturated hydrocarbons, **cracking** 裂化, **addition reactions** 加成反应, and the **bromine water test** 溴水检验.

You must be able to:

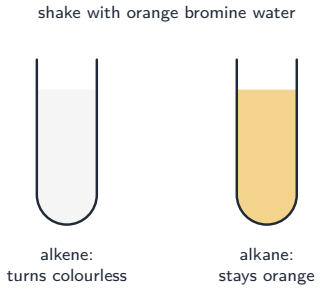
- describe alkenes as unsaturated (C=C) and reactive
- describe cracking and its products
- describe addition reactions and the test for unsaturation

1 Worked examples

■ Cracking & the bromine water test



Cracking breaks large alkanes into smaller alkanes + alkenes (heat + catalyst)



Test for unsaturation: an alkene turns orange bromine water colourless; an alkane does not

- − H_2 (Ni) → alkane; + steam (acid catalyst) → alcohol.

■ Cracking, addition, and the test that tells them apart

Cracking 裂化 breaks a long-chain alkane into a shorter alkane plus an **alkene** 烯烃, using heat (about 600–700 °C) and a catalyst. It is done because the long fractions from crude oil are in surplus while the short ones — petrol, and the alkenes needed to make polymers — are in demand. Every cracking equation must balance:

$$C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$$

Count the carbons and hydrogens on each side: $10 = 8 + 2$ and $22 = 18 + 4$. An unbalanced equation loses the mark even when the products are right.

Why alkenes react and alkanes do not. An alkane is **saturated** 饱和的 — all single bonds — so it can only substitute. An alkene is **unsaturated** 不饱和的: its C = C double bond can open, and a molecule **adds across** it without anything being lost.

Reagent	Conditions	Product
bromine, Br_2	room temperature	1,2-dibromoethane — orange bromine water is **decolourised**
hydrogen, H_2	nickel catalyst, ~150 °C	the alkane, ethane
steam, H_2O	phosphoric acid catalyst, high pressure	the alcohol, ethanol

The test for unsaturation is the bromine-water one: shake the sample with orange aqueous bromine. An **alkene decolourises it**; an alkane leaves it orange. State the colour BOTH before and after — "it goes colourless" without the starting colour is only half the mark.

Worked example. Explain why $C_{12}H_{26}$ is cracked, and write one possible equation. It is cracked because a 12-carbon molecule is a poor fuel and is in surplus, while shorter molecules and alkenes are in demand. One possibility: $C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$, which balances at 12 carbons and 26 hydrogens.

2 Practice

2.1 State the functional group in an alkene. [1]

2.2 State what cracking does. [1]

2.3 Write a balanced equation for cracking $C_{14}H_{30}$ to give octane, C_8H_{18}, and one alkene. [2]

2.4 State the reagent and the catalyst used to convert ethene into ethanol. [2]

2.5 Explain, in terms of bonding, why ethene decolourises bromine water but ethane does not. [2]

3 Exam-style questions

3.1 When ethene is shaken with bromine water, the bromine water: [1]

- **A** stays orange
- **B** turns colourless
- **C** turns blue
- **D** turns purple

3.2 Cracking breaks decane ($C_{10}H_{22}$) into octane (C_8H_{18}) and one other product.

(a) Name the type of compound formed as the other product. [1]

(b) Give the molecular formula of the other product. [1]

3.3 Describe how you could use bromine water to tell an alkene from an alkane. [2]

3.4 A refinery cracks decane, $C_{10}H_{22}$.

(a) State two conditions used for cracking. [2]

(b) Explain why a refinery cracks long-chain alkanes. [2]

(c) Decane is cracked to give one molecule of octane and one other product. Write the balanced equation and name the second product. [3]

(d) Describe a test that would distinguish the second product from octane, giving the result for each. [3]

(e) The alkene product is reacted with steam. Name the product, state the catalyst, and give the type of reaction. [3]

(f) Explain why the alkene can take part in addition reactions but octane cannot. [2]

Solutions

2.1 the C=C carbon–carbon double bond.

2.2 it breaks large alkane molecules into smaller, more useful molecules (alkanes and alkenes).

2.3 $C_{14}H_{30} \rightarrow C_8H_{18} + C_6H_{12}$.

2.4 Steam; a phosphoric acid catalyst, at high pressure.

2.5 Ethene contains a carbon–carbon double bond, which can open so that bromine adds across it; ethane has only single bonds and is saturated, so it has no double bond for the bromine to add to.

3.1 B. The alkene decolourises the bromine water.

3.2 (a) an alkene.
(b) C_2H_4.

3.3 add bromine water to each and shake; the alkene turns it colourless while the alkane leaves it orange.

3.4 (a) A high temperature, about 600–700 °C; a catalyst, for example aluminium oxide or silica.
(b) The long-chain fractions are produced in surplus and make poor fuels; cracking converts them into shorter molecules such as petrol, and into alkenes needed for making polymers, which are in high demand.
(c) $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$; the second product is ethene.
(d) Shake each with aqueous bromine, which is orange; ethene decolourises it; octane leaves it orange.
(e) Ethanol; a phosphoric acid catalyst; addition, or hydration.
(f) The alkene has a carbon–carbon double bond that can open, so atoms add across it with nothing lost; octane is saturated, with only single bonds, so it can only react by substitution.

Name: IGCSE Chemistry: **w25 21**

36 Ethene reacts with hydrogen in an addition reaction to form ethane.

Which catalyst is used for this reaction?

A iron

B nickel

C vanadium(V) oxide

D yeast

IGCSE Chemistry: **w25 22**

32 The alkenes are a homologous series.

Which statement about the members of the homologous series of the alkenes is correct?

A They have the same functional group.

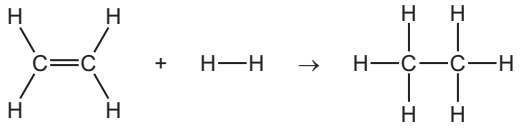
B They have the same relative molecular mass.

C They have different chemical properties.

D They have different general formulae.

IGCSE Chemistry: **w25 23**

17 Ethene reacts with hydrogen to form ethane.



The bond energies are shown in the table.

bond	bond energy in kJ / mol
C–C	+350
C–H	+410
H–H	+436
C=C	+614

What is the enthalpy change for the reaction?

A –290 kJ / mol

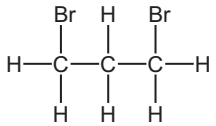
B –120 kJ / mol

C +120 kJ / mol

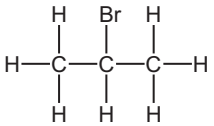
D +290 kJ / mol

36 Propene undergoes addition reactions with bromine, hydrogen and steam.

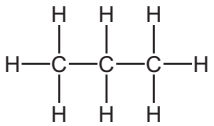
Which structures represent a product of these reactions?



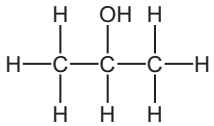
1



2



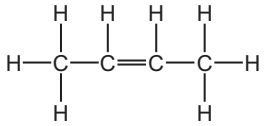
3



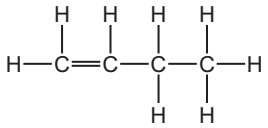
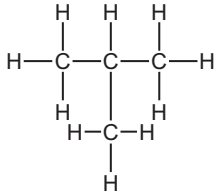
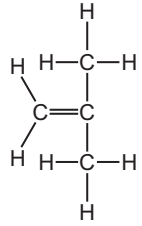
4

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

33 The displayed formula of but-2-ene is shown.



Which displayed formulae represent structural isomers of but-2-ene?

		
1	2	3

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

6 Ethene, C_2H_4, is the first member of a family of similar compounds which contains the alkene functional group.

(a) State the term for a family of similar compounds which contain the same functional group.

..... [1]

(b) Determine the difference in relative molecular mass between C_2H_4 and the next member in this family of similar compounds.

..... [1]

(c) Write the symbol equation for the complete combustion of C_2H_4.

..... [2]

(d) C_2H_4 reacts with steam to form ethanol.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\,kJ/mol$$

The process happens in a closed system and the reaction reaches an equilibrium.
The conditions for this process are 300 °C and 60 atm pressure. H_3PO_4 is used as a catalyst.

(i) Complete Table 6.1 to show the effect, if any, on the concentration of $C_2H_4(g)$ when the following changes to the conditions are applied.

Only use the words **increases**, **decreases** or **no change**.

Table 6.1

change to condition	effect on the concentration of $C_2H_4(g)$ at equilibrium
temperature is decreased	
some $C_2H_5OH(g)$ is removed	
pressure is increased	
a more effective catalyst is used	

[4]

(ii) Explain, in terms of collision theory, why the rate of the forward reaction increases if the temperature increases.

.....

.....

.....

....

..... [3]

(e) Compound **B** has the displayed formula shown in Fig. 6.1.

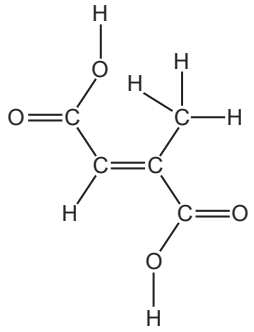


Fig. 6.1

(i) Deduce the molecular formula of compound **B**.

..... [1]

(ii) State why compound **B** is unsaturated.

..... [1]

(iii) Draw the structure of **one** repeat unit of the polymer formed when compound **B** undergoes addition polymerisation.

[2]

(iv) Explain why 1 mol of compound **B** reacts with 2 mol of sodium hydroxide, NaOH.

.....

..... [1]

(v) Calculate the volume, in cm^3, of 0.250 mol / dm^3 NaOH that reacts with 0.100 mol of compound **B**.

volume = ... cm^3 [2]

[Total: 18]

The Periodic Table of Elements

Group I	II											III	IV	V	VI	VII	VIII
																	2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

6 The structural formulae of two compounds, **A** and **B**, are shown.

A	B
$CH_2=CHCH_3$	$CH_3CH=CHCH_3$

A and **B** are members of the same homologous series.

(a) Give **two** reasons why the structural formulae of **A** and **B** show they are members of the same homologous series.

1 .....

2 .....

[2]

(b) Explain why **A** and **B** are both hydrocarbons.

..... [1]

(c) Write the symbol equation for the complete combustion of **A**.

..... [2]

(d) Deduce the empirical formula of **A**.

..... [1]

(e) Name compound **B**.

..... [1]

(f) A structural isomer of **B** is a member of the same homologous series.

Draw the displayed formula of this structural isomer of **B**.

[1]

(g) Compound **B** reacts with aqueous bromine at room temperature to form product **C**.
The equation is shown.

$$\underset{\textbf{B}}{CH_3CH=CHCH_3} + Br_2 \rightarrow \underset{\textbf{C}}{CH_3CHBrCHBrCH_3}$$

(i) State why this is an addition reaction.

..... [1]

(ii) Describe the colour change in aqueous bromine during this reaction.

from ..... to ..... [1]

(iii) Name product **C**.

..... [1]

(h) Under certain conditions, **one** mole of **B** reacts with oxygen to form **two** moles of carboxylic acid **D**.

Carboxylic acid **D** has **two** carbon atoms.

(i) Draw the displayed formula of carboxylic acid **D**.

[1]

(ii) Name carboxylic acid **D**.

..... [1]

(iii) Complete the symbol equation for this reaction.

$CH_3CH=CHCH_3$ + ... → .....

[1]

[Total: 14]

The Periodic Table of Elements

Key: atomic number / **atomic symbol** / name / relative atomic mass

Group: I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
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37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
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The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

IGCSE CHEMISTRY • EXERCISE SHEET

11.6 Alcohols

Name: ____________ Class: ________ Date: __________ **Total: 9 marks**

KEY WORDS ethanol 乙醇 • fermentation 发酵 • glucose 葡萄糖 • alcohols 醇 • yeast 酵母

Objective

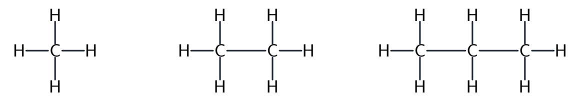
Build the skills to answer exam questions on **alcohols 醇** — the –OH group, **ethanol 乙醇**, the two ways to make it (**fermentation 发酵** and addition of steam to ethene), and its uses.

You must be able to:

- describe alcohols (–OH group) and ethanol
- compare fermentation with the catalytic addition of steam to ethene
- state the uses of ethanol

1 Worked examples

Making ethanol



methane CH_4 ethane C_2H_6 propane C_3H_8

each step adds a CH_2 unit general formula C_nH_{2n+2}

Alcohols contain the –OH functional group; ethanol is the key example

Method	Conditions	Notes
fermentation of glucose	yeast, 25–35 °C, no air	renewable, slow, impure
steam + ethene	300 °C, 60 atm, acid catalyst	fast, pure, non-renewable

2 Practice

2.1 State the functional group in an alcohol. [1]

2.2 Name the two products of fermentation of glucose. [2]

3 Exam-style questions

3.1 A use of ethanol is as a: [1]

- **A** metal
- **B** solvent and fuel
- **C** fertiliser
- **D** catalyst

3.2 Ethanol can be made by fermentation or by adding steam to ethene.

(a) Give one advantage of making ethanol by fermentation. [1]

(b) Give one advantage of making ethanol from ethene. [1]

3.3 State the conditions needed for fermentation. [3]

Solutions

2.1 –OH (the hydroxyl group).

2.2 ethanol; carbon dioxide.

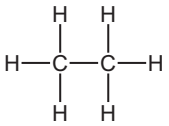
3.1 B. Ethanol is used as a solvent and a fuel.

3.2 (a) it uses renewable sugar.
(b) it is fast and gives pure ethanol.

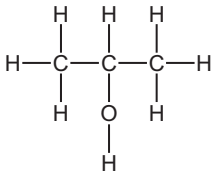
3.3 yeast; a temperature of about 25–35 °C; in the absence of air/oxygen.

33 Which structure represents a compound in the alcohol homologous series?

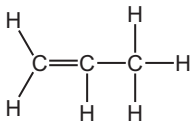
A



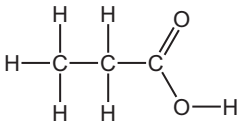
B



C



D



37 Ethanol is produced by the fermentation of aqueous glucose or by the catalytic addition of steam to ethene.

Which row shows some advantages and disadvantages of these processes?

	fermentation of aqueous glucose		catalytic addition of steam to ethene	
	advantage	disadvantage	advantage	disadvantage
A	fast reaction	ethanol produced continuously	almost pure ethanol formed	renewable raw material
B	ethanol produced in batches	slow reaction	fast reaction	ethanol produced continuously
C	renewable raw material	ethanol produced in batches	almost pure ethanol formed	slow reaction
D	renewable raw material	dilute aqueous ethanol formed	fast reaction	non-renewable raw material

5 This question is about the homologous series of alcohols.

(a) A homologous series is a family of organic compounds whose members have the same general formula.

(i) State the general formula for alcohols.

..... [1]

(ii) Give **one other** characteristic that is the same for all members of a homologous series.

..... [1]

(b) Ethanol can be manufactured by two methods:

- **method 1** uses glucose as the starting material
- **method 2** uses ethene as the starting material.

(i) Complete Table 5.1.

Table 5.1

	method 1 glucose as starting material	**method 2** ethene as starting material
typical temperature used / °C		
two other essential conditions	1	1
	2	2

[6]

(ii) Write the symbol equation for the reaction in **method 1**.

..... [2]

(iii) Write the symbol equation for the reaction in **method 2**.

..... [2]

(c) Butane-1,4-diol has the structural formula $HO—CH_2—CH_2—CH_2—CH_2—OH$.

(i) Deduce the molecular formula of butane-1,4-diol.

..... [1]

(ii) Butane-1,4-diol reacts with ethanoic acid.

Determine the number of moles of ethanoic acid which react fully with **one** mole of butane-1,4-diol.

..... [1]

(d) Butanedioic acid has the structural formula HOOC—CH_2—CH_2—COOH.

(i) Deduce the empirical formula of butanedioic acid.

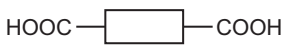
..... [1]

(ii) Name the gas formed when butanedioic acid reacts with sodium.

..... [1]

(e) Butane-1,4-diol can be represented as shown.

Butanedioic acid can be represented as shown.



Butane-1,4-diol reacts with butanedioic acid to form a polymer.

(i) Draw **two** repeat units of the polymer formed from the reaction of butane-1,4-diol with butanedioic acid.

Show all the atoms and all the bonds in the ester linkages.

[3]

(ii) State the type of polymerisation when butane-1,4-diol reacts with butanedioic acid.

..... [1]

[Total: 20]

The Periodic Table of Elements

Group I	II											III	IV	V	VI	VII	VIII
																	2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
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Key

atomic number
atomic symbol
name
relative atomic mass

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The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

17 Ethanol is warmed with acidified aqueous potassium manganate(VII).

Which row describes the type of reaction of the ethanol and the colour change observed in the reaction mixture?

	type of reaction	colour change
A	oxidation	colourless to purple
B	oxidation	purple to colourless
C	reduction	colourless to purple
D	reduction	purple to colourless

35 Industrially, ethanol is produced by fermentation or by the reaction of ethene with steam.

Which row is correct?

	fermentation	ethene + steam
A	uses a temperature of 100 °C	uses a temperature of 350 °C
B	needs the presence of yeast	does **not** need a catalyst
C	slow reaction	fast reaction
D	high yield of ethanol	low yield of ethanol

32 What is the structural formula of butan-2-ol?

A $CH_3CH_2CH_2OH$

B $CH_3CH(OH)CH_3$

C $CH_3CH_2CH_2CH_2OH$

D $CH_3CH_2CH(OH)CH_3$

36 Ethanol can be made by the fermentation of aqueous glucose and by the catalytic addition of steam to ethene.

What are two advantages of making ethanol by the catalytic addition of steam to ethene rather than by the fermentation of aqueous glucose?

A faster reaction and renewable raw materials

B purer product and faster reaction

C renewable raw materials and continuous process

D uses more energy and forms a purer product

37 Which statements describe disadvantages of manufacturing ethanol by fermentation?

1 The process uses a renewable resource.

2 The process produces impure ethanol.

3 The process requires a high temperature.

4 The process is slow.

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

IGCSE CHEMISTRY • EXERCISE SHEET

11.7 Carboxylic acids

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS ester 酯 • ethanoic acid 乙酸 • carboxylic acids 羧酸 • carbonates 碳酸盐 • oxidation 氧化

Objective

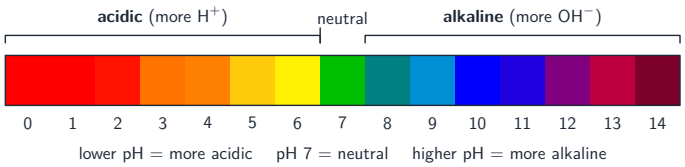
Build the skills to answer exam questions on **carboxylic acids** 羧酸 — the –COOH group, the reactions of **ethanoic acid** 乙酸, making it by **oxidation** 氧化 of ethanol, and **esters** 酯.

You must be able to:

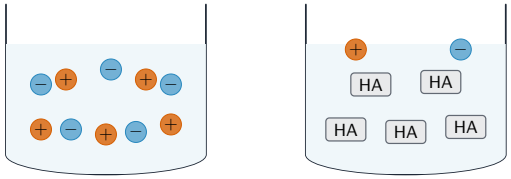
- give the reactions of carboxylic acids (with metals, bases, carbonates)
- describe making ethanoic acid by oxidising ethanol
- describe the formation of an ester

1 Worked examples

Reactions of ethanoic acid



Carboxylic acids contain –COOH and behave as (weak) acids



strong acid
fully split into ions (e.g. HCl)

weak acid
mostly molecules, few ions (e.g. ethanoic acid)

Carboxylic acids are weak acids

- – metal → ethanoate salt + hydrogen.
- – base → salt + water; + carbonate → salt + water + CO_2.
- **made by:** oxidising ethanol (acidified $KMnO_4$, or bacteria → vinegar).
- – alcohol (acid catalyst) → an **ester**.

2 Practice

2.1 State the functional group in a carboxylic acid. [1]

2.2 Name the type of compound formed when a carboxylic acid reacts with an alcohol. [1]

3 Exam-style questions

3.1 Ethanoic acid reacts with a carbonate to give a salt, water and: [1]

- **A** hydrogen
- **B** oxygen
- **C** carbon dioxide
- **D** chlorine

3.2 Ethanoic acid can be made by oxidising ethanol.

(a) Name a reagent that oxidises ethanol to ethanoic acid. [1]

(b) Name the everyday product made when ethanol is oxidised by bacteria. [1]

3.3 Magnesium reacts with ethanoic acid. Name the two products. [2]

3.4 Ethanoic acid, CH_3COOH, is a weak acid.

(a) Draw the displayed formula of ethanoic acid and circle the functional group, naming it. [3]

(b) Give the observation and name the products for ethanoic acid reacting with (i) magnesium, (ii) sodium carbonate. Write a balanced equation for (ii). [5]

(c) Ethanoic acid is warmed with ethanol and a little concentrated sulfuric acid. Name the type of reaction, name the organic product, and state what the sulfuric acid does. [3]

(d) Explain why ethanoic acid is described as a *weak* acid, and state how its pH compares with hydrochloric acid of the same concentration. [3]

Solutions

2.1 –COOH (the carboxyl group).

2.2 an ester.

3.1 C. Acid + carbonate → salt + water + carbon dioxide.

3.2 (a) acidified potassium manganate(VII).
(b) vinegar.

3.3 magnesium ethanoate; hydrogen.

3.4 (a) CH_3 joined to a carbon carrying a double-bonded O and an $-O-H$, with every bond shown; the circled $-COOH$ is the **carboxyl** group.
(b) (i) Effervescence; the magnesium disappears and hydrogen is given off, leaving magnesium ethanoate. (ii) Effervescence, and the gas turns limewater milky — carbon dioxide; $2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$.
(c) **Esterification**; the product is **ethyl ethanoate**, which has a sweet fruity smell; the sulfuric acid is a catalyst.
(d) A weak acid only **partly** ionises in water, so a solution of it contains far fewer hydrogen ions than the same concentration of a strong acid; its pH is therefore **higher** — around 3 to 4, compared with about 1 for hydrochloric acid.

37 What is produced by the bacterial oxidation of ethanol?

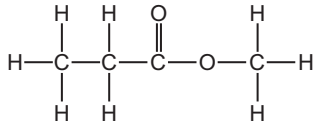
A ethene

B sodium ethanoate

C ethyl ethanoate

D vinegar

35 The structure of an ester is shown.



What is the name of this ester?

A ethyl methanoate

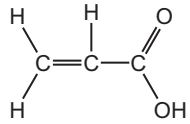
B methyl ethanoate

C propyl methanoate

D methyl propanoate

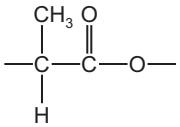
38 Propenoic acid is an organic compound that is both an alkene and a carboxylic acid.

The structure of propenoic acid is shown.

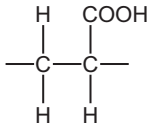


Which structure represents one repeat unit of the addition polymer formed from propenoic acid?

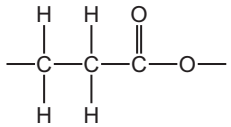
A



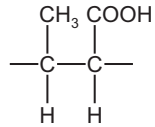
B



C



D



38 Which statement about ethanoic acid is correct?

A Ethanol is reduced by bacteria to produce ethanoic acid.

B Ethanoic acid reacts with magnesium to produce a salt of formula CH_3COOMg.

C Ethanoic acid and methanol react in the presence of an acid catalyst to produce ethyl methanoate.

D Ethanol reacts with acidified aqueous potassium manganate(VII) to produce ethanoic acid.

6 Compound **E** shown in Fig. 6.1 is an ester.

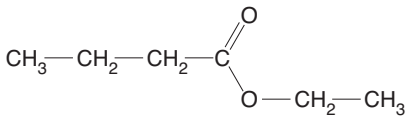


Fig. 6.1

(a) **On Fig. 6.1**, draw a circle around all the atoms which make up the ester linkage. [1]

(b) Name compound **E**.

..... [1]

(c) Deduce the empirical formula of compound **E**.

..... [1]

(d) Compound **E** is produced when two different compounds react together in the presence of a catalyst.

(i) Name the **two** compounds that react together to produce compound **E**.

1 .....

2 .....

[2]

(ii) Suggest a suitable catalyst for this reaction.

..... [1]

(e) Determine the number of unbranched esters which have the molecular formula $C_5H_{10}O_2$.

..... [1]

(f) All unbranched esters with the molecular formula $C_5H_{10}O_2$ combust completely to form carbon dioxide and water only.

Write the symbol equation for the complete combustion of $C_5H_{10}O_2$.

..... [1]

[Total: 8]

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr ontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

anthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
ctinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

6 This question is about organic compounds.

(a) Organic compound **Q** has the following composition by mass.

C, 50.00%; H, 5.56%; O, 44.44%

Calculate the empirical formula of compound **Q**.

empirical formula = ... [3]

(b) Organic compound **R** has the empirical formula CHO and a relative molecular mass of 116.

Determine the molecular formula of compound **R**.

molecular formula = ... [1]

(c) Carboxylic acids react with alcohols to form esters.

(i) Name the other product that is formed when a carboxylic acid reacts with an alcohol.

..... [1]

(ii) Name the **type** of catalyst that is used when a carboxylic acid reacts with an alcohol.

..... [1]

(iii) Ester **S** has the structural formula $CH_3CH_2COOCH_2CH_2CH_2CH_3$.

Name the carboxylic acid and the alcohol which react together to form ester **S**.

carboxylic acid .....

alcohol ..... [2]

(d) Fig. 6.1 shows part of a polymer structure.

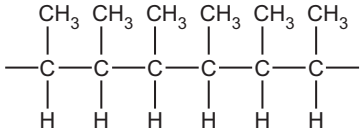


Fig. 6.1

(i) Name the type of polymerisation that is used to produce this polymer.

..... [1]

(ii) Suggest why it is **not** possible to write the molecular formula of this polymer.

..... [1]

(iii) State the number of monomer units that are needed to make the part of the polymer structure shown in Fig. 6.1.

..... [1]

(iv) Draw the displayed formula of the monomer used to make this polymer.

[2]

(e) Fig. 6.2 shows part of the general structure of an amino acid.

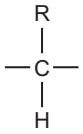


Fig. 6.2

(i) Complete Fig. 6.2 to show all the atoms and all the bonds in the two functional groups of the amino acid. [2]

(ii) Part of a natural polyamide structure is shown in Fig. 6.3.

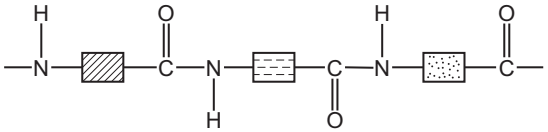


Fig. 6.3

On Fig. 6.3, draw a circle around **one** amide linkage. [1]

(iii) State the name given to natural polyamides made from amino acids.

..... [1]

[Total: 17]

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
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37 Rb rubidium 85	38 Sr ontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
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Key

atomic number
atomic symbol
name
relative atomic mass

anthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
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The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

14 The equation represents the reaction between ethanoic acid and ethanol.

$$CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$$

Which type of reaction does this show?

A addition
B neutralisation
C reduction
D reversible

36 Some properties of an organic compound, J, are listed.

- It is a liquid at room temperature.
- It is soluble in water.
- A solution of J reacts with calcium carbonate to form carbon dioxide.
- A solution of J has a pH of 3.

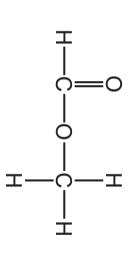
In which homologous series does J belong?

A alkane
B alkene
C alcohol
D carboxylic acid

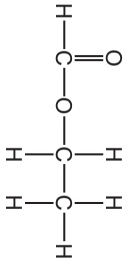
33 Methanol reacts with ethanoic acid to form an ester.

What is the displayed formula for this ester?

A



B



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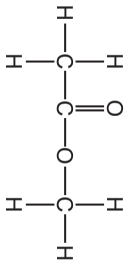
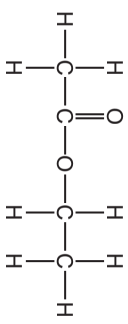


D



IGCSE CHEMISTRY • EXERCISE SHEET

11.8 Polymers

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS polymer 聚合物 • polyamides 聚酰胺 • polyesters 聚酯 • monomers 单体 • repeat unit 重复单元

Objective

Build the skills to answer exam questions on **polymers** 聚合物 — **addition** 加聚 and **condensation** 缩聚 polymerisation, the **repeat unit** 重复单元, and plastics in the environment.

You must be able to:

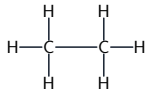
- describe addition polymerisation and draw a repeat unit
- compare addition with condensation polymerisation (polyamides, polyesters)
- discuss the disposal problems of plastics

1 Worked examples

Addition polymerisation

ethene (monomer) poly(ethene) repeat unit

In addition polymerisation the C=C bonds open and monomers join — no other product



ethane C_2H_6
saturated: single C–C bond

ethene C_2H_4
unsaturated: C=C double bond

Addition polymers form from unsaturated monomers

- **monomer:** small unit; **polymer:** the long chain; **repeat unit:** the part that repeats.
- **condensation:** monomers join and a small molecule (water) is lost — polyamides (nylon), polyesters (PET).

2 Practice

2.1 Define a polymer. [1]

2.2 Name the monomer used to make poly(ethene). [1]

3 Exam-style questions

3.1 In addition polymerisation, the number of products formed is: [1]

- **A** one (the polymer only)
- **B** two
- **C** three
- **D** none

3.2 Poly(ethene) is made from ethene.

(a) State what happens to the C=C double bonds during polymerisation. [1]

(b) Draw the repeat unit of poly(ethene). [2]

3.3 Many plastics are not biodegradable. State two problems this causes for the environment. [2]

Solutions

2.1 a very large molecule made from many small molecules (monomers) joined together.

2.2 ethene.

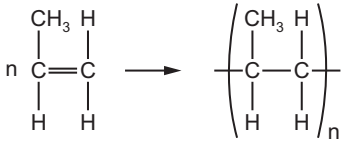
3.1 A. Addition polymerisation makes only the polymer (no other product).

3.2 (a) the double bonds open up so the monomers can join together.
(b) $-(CH_2 - CH_2)-$ shown in brackets with the continuation bonds.

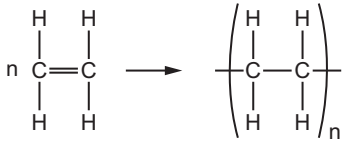
3.3 any two of: they build up in landfill; they collect in oceans and harm sea life; burning them releases toxic gases.

35 Which equation represents the formation of poly(propene) from propene?

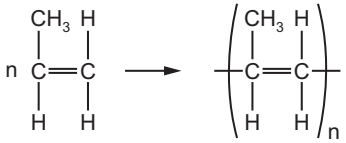
A



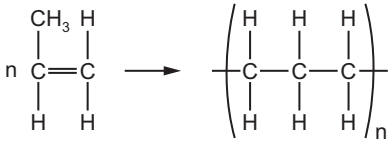
B



C



D



38 Which statement about addition polymers or condensation polymers is correct?

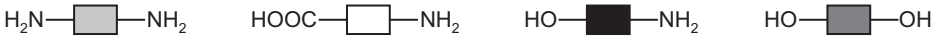
A Addition polymers only contain carbon and hydrogen atoms.

B One of the monomers used to make a polyester is a diamine.

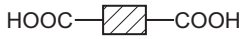
C Addition polymers contain carbon–carbon double bonds in the main chain.

D Water is an additional product in the formation of a protein from amino acids.

35 The diagrams represent four monomers.



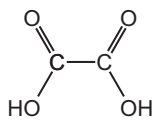
The monomers each react in a 1 : 1 ratio with the dicarboxylic acid shown.

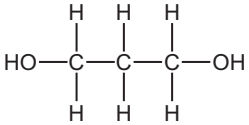


How many of the four monomers shown can react with the dicarboxylic acid to form a polymer?

A 1 **B** 2 **C** 3 **D** 4

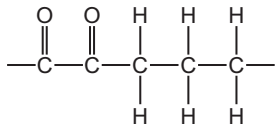
37 The structures of two monomers that are used to make a condensation polymer are shown.



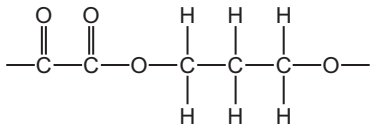


Which structure represents one repeat unit of the condensation polymer formed?

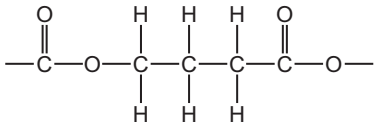
A



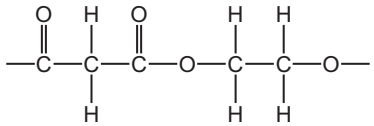
B



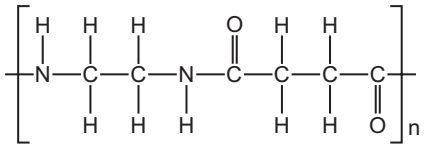
C



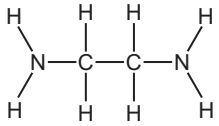
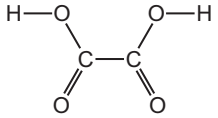
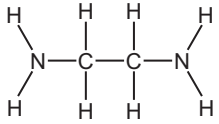
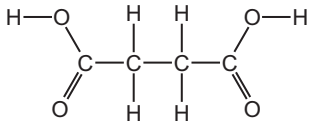
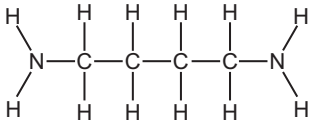
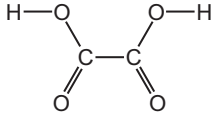
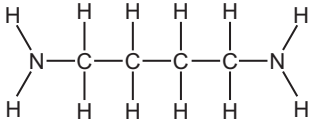
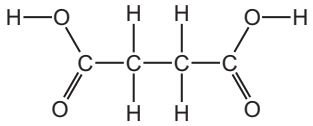
D



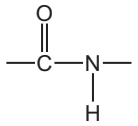
37 The structure of a polymer repeat unit is shown.



Which pair of monomers is used to make this polymer?

	monomer 1	monomer 2
A		
B		
C		
D		

37 Which statement about polymers is correct?

A Nylon contains the  linkage.

B Nylon is a polyester.

C Propane can be polymerised by addition polymerisation.

D The linkage in PET contains a carbon–carbon double bond.

38 Nylon is made in a polymerisation reaction.

Which row describes the type of polymerisation and identifies the other product of the reaction?

	type of polymerisation	other product
A	addition	water
B	addition	none
C	condensation	water
D	condensation	none