



CrackingCHEM

GCSE | A-LEVEL

UNDERSTAND • APPLY • SUCCEED

AQA CHEMISTRY 7405

INTRODUCTION TO ORGANIC CHEMISTRY II

MECHANISMS • ELECTRON MOVEMENT • E/Z ISOMERISM



SPEC



CRACK IT



TEST IT



DONE WHEN

YOUR NEXT STEP AFTER ORGANIC I

AQA SECTION	YOU WILL MASTER
3.3.1.2	How mechanisms explain reactions; electron-pair curly arrows; radical notation and balanced steps.
Mechanism foundations	Reaction types, bond breaking, nucleophiles and electrophiles: the language needed to read mechanisms.
3.3.1.3, stereoisomerism	Why E/Z isomers exist; eligibility; CIP priorities; naming and drawing both arrangements.

YOUR ROUTE Learn the explanation, follow the worked example, then attempt the different TEST IT task. Use the complete answers to find the specific rule you need to practise.

BRING FORWARD Organic I: formulae, functional groups, names and connectivity. Bonding II: covalent bonds, lone pairs, electronegativity and partial charges.

Detailed reaction conditions and full topic mechanisms follow in Alkanes, Halogenoalkanes and Alkenes. Optical isomerism is outside this pack.

AQA specification checked 11 September 2026.

1. From an equation to a mechanism



SPEC 3.3.1.2 Explain what a mechanism adds to an equation and interpret electron notation.



CRACK IT An equation records the overall chemical change. A mechanism explains how bonds break and form through the movement of electrons.

TERM	LEARNABLE MEANING	EXAMPLE
Reaction mechanism	A step-by-step account of a reaction showing bond breaking, bond formation and electron movement.	An arrow from an O lone pair to H shows a new O-H bond forming.
Electron pair	Two electrons treated together when drawing an electron-pair mechanism.	A covalent bond contains a shared pair.
Lone pair	A pair of outer-shell electrons not involved in a covalent bond.	The nitrogen lone pair in NH ₃ .
Curly arrow	A curved arrow showing the movement of a pair of electrons.	Its tail begins at the pair or bond supplying those electrons.
Radical / free radical	A species containing an unpaired electron.	Cl•: the dot represents one unpaired electron.
Intermediate	A species formed in one step and used up in a later step of a mechanism.	It appears in the steps but cancels from the overall equation.

WORKED: read what the equation tells you



The carbon skeleton is retained. The C-Br bond is replaced by C-O bonding. The equation conserves every atom and has total charge -1 on both sides. It does not, by itself, show the electron movement that achieves this change.

TWO DIFFERENT ARROWS A straight reaction arrow means “forms”. A curly arrow tracks an electron pair within a mechanism. It does not show the path travelled by an atom.



TEST IT 1

- a) For $\text{CH}_3\text{CH}_2\text{Cl} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{Cl}^-$, identify the bond broken and the bond formed. [2 marks]
 b) State the total charge on each side, and explain one thing a mechanism adds to the equation. [2 marks]

.....

.....

.....

.....

✓ **DONE WHEN** you distinguish an overall chemical change from the electron movements explaining it.

2. Recognise the type of change



SPEC 3.3.1.2 Use the reaction pattern to recognise addition, substitution and elimination.



CRACK IT Compare the structures on both sides. Identify the change before trying to remember a reaction name. Conditions are deliberately not being learned here.

TYPE	QUICK BOND CHECK	WHAT CHANGES	WORKED PATTERN
Addition	Double → single C=C → C-C	Groups add across C=C. Its bond order decreases from two to one.	$\text{CH}_2=\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br}$
Substitution	Single → single C-Cl replaced by C-O	One single bond breaks and a different single bond forms as one atom or group replaces another.	$\text{CH}_3\text{Cl} + \text{OH}^- \rightarrow \text{CH}_3\text{OH} + \text{Cl}^-$
Elimination	Single → double C-C → C=C	Atoms or groups leave neighbouring carbons. The bond between those carbons becomes a double bond.	$\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_2=\text{CH}_2 + \text{H}_2\text{O}$

Use the bond check for the introductory reactions shown here. These are recognition patterns, not universal definitions of every addition, substitution or elimination reaction.

Work through the evidence, not just the number of products

Addition: the C=C becomes C-C and H/Br attach to its carbons. Substitution: C-Cl becomes C-O while the single-carbon skeleton stays. Elimination: loss of H and OH from adjacent carbons makes C=C and water.

A USEFUL DISTINCTION "Substitution" describes the structural change. "Nucleophilic" or "electrophilic" tells you about the attacking species and electron movement. Those terms are introduced in section 4.

The equations below are supplied so you can classify the changes. You are not expected to recall their reagents or conditions at this stage.



TEST IT 2

a) Classify each change as addition, substitution or elimination, and give one structural reason for each: (i) $\text{CH}_3\text{CH}=\text{CH}_2 + \text{H}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_3$; (ii) $\text{CH}_3\text{CH}_2\text{Br} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{Br}^-$; (iii) $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 \rightarrow \text{CH}_3\text{CH}=\text{CH}_2 + \text{H}_2\text{O}$. [6 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you classify a supplied equation by the bonds and groups that change.

3. Breaking a covalent bond



SPEC 3.3.1.2 Explain where the bonding electrons go and distinguish radicals from ions.



CRACK IT Bond fission means bond breaking. A bond contains two electrons: they can separate equally or both go to one atom. These terms help explain the AQA arrow and radical conventions.

PROCESS	ELECTRON ALLOCATION	RESULT
Homolytic fission	One electron from the bond goes to each atom.	Radicals: each receives an unpaired electron.
Heterolytic fission	Both electrons from the bond go to one atom.	For a neutral molecule splitting into two fragments, a positive ion and a negative ion form.

WORKED: homolytic fission



Each bromine atom receives one bonding electron. Both products are neutral radicals; a dot is not a negative charge. AQA requires balanced radical equations, not curly arrows for radical mechanisms.

WORKED: heterolytic fission



The curly arrow begins at the H-Cl bond and ends at Cl. Chlorine receives both bonding electrons: Cl^- forms and H^+ remains. Other lone pairs are omitted for clarity; the gained pair is shown.



TEST IT 3

- Write the equation for homolytic fission of I_2 , including radical dots. [2 marks]
- For heterolytic fission of H-I in which I receives the bonding pair, state both products and their charges. [2 marks]
- State the difference in electron allocation between the two types of fission. [2 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you use dots for unpaired electrons and charges for ions, with electron allocation explained.

4. Electron-pair donors and acceptors



SPEC 3.3.1.2 Define nucleophile and electrophile and locate the reacting electron source or electron-deficient atom.



CRACK IT Begin with electrons. A nucleophile supplies an electron pair. An electrophile accepts that pair to form a covalent bond.

TERM	FULL-MARK DEFINITION	EXAMPLES AND REASON
Nucleophile	An electron-pair donor.	OH^- : an O lone pair is available. NH_3 : an N lone pair is available despite the molecule being neutral.
Electrophile	An electron-pair acceptor.	H^+ can accept a pair. A δ^+ carbon in a polar C-X bond can also be attacked.
Partial charge, δ	Unequal sharing of bonding electrons; δ^+ and δ^- are not full ionic charges.	In C-Br, C is δ^+ and Br is δ^- .
Carbocation	An organic ion containing a positively charged carbon atom.	CH_3^+ has a carbon that can accept an electron pair.

WORKED: identify the source and the destination

SPECIES / BOND	REASONING
$\text{NH}_3 + \text{H}^+$	N in ammonia has a lone pair. H^+ can accept it. The new bond forms between N and H.
OH^- approaching C-Br	O supplies a lone pair; δ^+ carbon is electron deficient. The new bond is C-O, not C-H or O-Br.

EXAM TRAP A nucleophile need not be negatively charged: a neutral molecule can have a lone pair. An electrophilic centre need not carry a full + charge: δ^+ can be enough.



TEST IT 4

- a) Define nucleophile and electrophile. [2 marks]
 b) Water reacts with H^+ to form H_3O^+ . Explain why water can be the nucleophile even though it is neutral, and identify its donating atom. [2 marks]
 c) In $\text{CH}_3\text{CH}_2\text{Cl}$, chlorine is more electronegative than carbon. State which atom of the C-Cl bond is δ^+ and which atom an electron-pair donor attacks. [2 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you identify the donating pair and accepting atom instead of guessing from charge alone.

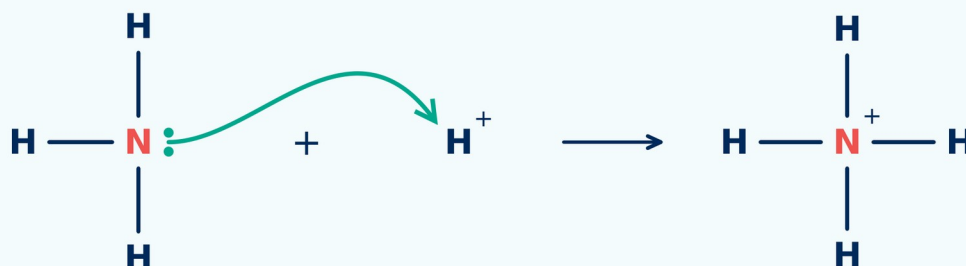
5. Start a curly arrow at a lone pair



SPEC 3.3.1.2 Draw a curly arrow for covalent bond formation from a lone pair.



CRACK IT Start the tail midway between the two lone-pair dots without covering either dot. The head points to the atom receiving the pair, where the new bond will form.



WORKED: $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$. The coloured dots are the reacting lone pair.

STEP	WHY IT IS DRAWN THIS WAY
1. Find the source	N has a lone pair. Start there, not at the N-H bond or the positive charge.
2. Find the destination	H^+ accepts the pair. Point the arrowhead towards H.
3. Check the product	N now has four N-H bonds and no lone pair. The ion has overall charge +1.
4. Check conservation	Four H atoms and one N occur on each side; total charge remains +1.

HOW TO DRAW IT Use a smooth curve with a full arrowhead to represent a pair of electrons. Leave space around labels. Show the reacting lone pair and all required charges.



TEST IT 5

- a) The ion NH_2^- accepts H^+ to form NH_3 . Draw N bonded to two H atoms, show a lone pair and the negative charge, and add the curly arrow for the new N-H bond. Draw the NH_3 product, including its remaining lone pair. [4 marks]
- b) State the total charge before and after this step. [1 mark]

Written answers for 5(b): use the lines below.

5(a) Draw NH_2^- and H^+ , the curly arrow and the NH_3 product here.

NH_2^- has two lone pairs; show at least the reacting pair. This is an electron-movement exercise, not a reaction to memorise.

✓ **DONE WHEN** your arrow begins on a pair and your product has the correct bond count and charge.

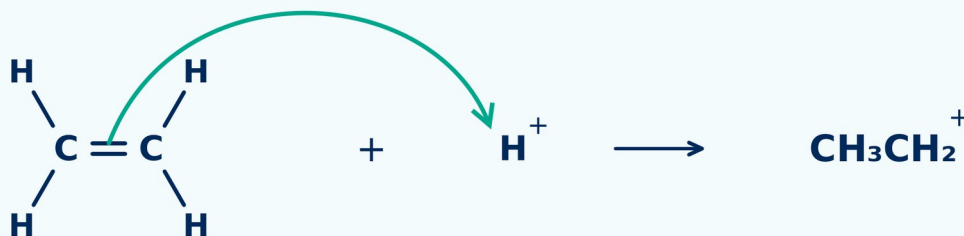
6. A bond can supply the electron pair



SPEC 3.3.1.2 Draw a curly arrow from the C=C bond in an alkene to H⁺ to show a new C-H bond forming.



CRACK IT A lone pair is not the only source. The electrons in an existing bond can be used to form a new bond. Start the arrow on the bond line itself.



WORKED MECHANISM: $\text{CH}_2=\text{CH}_2 + \text{H}^+ \rightarrow \text{CH}_3\text{CH}_2^+$

The arrow tail touches one line of C=C. That electron pair forms a new C-H bond to H⁺. The C=C becomes C-C. One carbon gains H and becomes CH₃; the other is CH₂⁺. Its carbon has three bonds and a positive charge.

ARROW PURPOSE	TAIL	HEAD
Form a bond using a lone pair	On that lone pair	At the atom that accepts it
Form a bond using a bonding pair	On the supplying bond	At the atom that accepts it
Break a bond heterolytically	On the bond being broken	At the atom receiving both electrons

KEEP THE SCOPE CLEAR The equation tells you which product to draw. Here, practise the arrow from C=C to H⁺. The full addition mechanism and rules for choosing products follow in Alkenes.



TEST IT 6

- a) For $\text{CH}_2=\text{CHCH}_3 + \text{H}^+ \rightarrow \text{CH}_3\text{CH}^+\text{CH}_3$, draw propene with its C=C bond and show H⁺ beside it. Add one curly arrow from the C=C bond to H⁺ to show formation of the new C-H bond. [2 marks]
- b) State what happens to the C-C bond order and the total charge in this step. [2 marks]

Written answers for 6(b): use the lines below.

6(a) Draw propene and H⁺, then add the curly arrow from C=C to H⁺.

✓ **DONE WHEN** you can begin an arrow at a bond and account for the new bond, bond order and charge.

7. Show bond making and breaking together



SPEC 3.3.1.2 Draw the two curly arrows for $\text{OH}^- + \text{HCl} \rightarrow \text{H}_2\text{O} + \text{Cl}^-$: O lone pair to H, and H-Cl bond to Cl.



CRACK IT When H already has one covalent bond, making a new bond to it requires the old bond to break. Show both electron-pair movements.



WORKED: $\text{OH}^- + \text{HCl} \rightarrow \text{H}_2\text{O} + \text{Cl}^-$. Only the reacting lone pair is shown.

MOVEMENT	CORRECT ARROW	CONSEQUENCE
New O-H bond	From the O lone pair to H of H-Cl	O becomes bonded to two H atoms.
H-Cl bond breaking	From H-Cl to Cl	Cl receives the bonding pair and becomes Cl^- .

Check the whole step: the reactants have net charge -1 , and the products have net charge -1 . A lone pair is converted to a bond; the old H-Cl bonding pair becomes a lone pair on chloride.

COMMON MISSING ARROW Drawing only the attack arrow would leave H with two bonds. Drawing only the bond-breaking arrow would not show the new O-H bond forming.



TEST IT 7

a) Draw the mechanism for $\text{CH}_3\text{O}^- + \text{HBr} \rightarrow \text{CH}_3\text{OH} + \text{Br}^-$. Show the C-O and H-Br bonds, a lone pair on O and all full charges. Add two curly arrows to show O-H bond formation and H-Br bond breaking, then draw the products. [4 marks]

b) Explain why the second curly arrow must begin at H-Br and end at Br. [2 marks]

Written answers for 7(b): use the lines below.

7(a) Draw the reactants, both curly arrows and the products for the equation above.

✓ **DONE WHEN** you account for every bond made and broken without giving H more than one bond.

8. Radical dots and balanced steps



SPEC 3.3.1.2 Represent unpaired electrons and write balanced equations for radical-mechanism steps.



CRACK IT A radical dot represents one unpaired electron. Use the dot consistently on every radical, and balance atoms in every individual step.

CONVENTION	USE IT ACCURATELY
$\text{Cl}^\bullet$ versus Cl^-	$\text{Cl}^\bullet$ is a neutral chlorine radical. Cl^- is a chloride ion with a full negative charge.
$\text{CH}_3^\bullet$	A methyl radical: its carbon has three bonds and one unpaired electron.
AQA arrow convention	Curly arrows are not required for radical mechanisms. Balanced step equations and clear radical dots are required.

WORKED 1: take a hydrogen atom from a molecule



Cl takes one H atom. The original molecule loses H and becomes $\text{CH}_3^\bullet$. Counts on both sides are $\text{C}_1\text{H}_4\text{Cl}_1$. One radical is used and one is formed; the species are neutral.

WORKED 2: combine two radicals



The two unpaired electrons form a new C-C bond. The product is ethane, not another radical. Both sides contain C_2H_6 . Do not leave a dot on the stable product.

METHOD Write the carbon skeleton, count C/H/halogen atoms, then check radical dots and total charge. Full initiation/propagation/termination chains are developed in Alkanes.



TEST IT 8

- Complete the balanced equation $\text{Br}^\bullet + \text{C}_2\text{H}_6 \rightarrow \text{HBr} + \underline{\hspace{2cm}}$. Write the missing product formula with its radical dot. [2 marks]
- Write a balanced equation for combination of $\text{C}_2\text{H}_5^\bullet$ and $\text{Cl}^\bullet$. [2 marks]
- State what the dot means and whether AQA requires curly arrows for radical mechanisms. [2 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** your radical equations conserve atoms and put a dot only on species with an unpaired electron.

9. Check a mechanism before you submit it



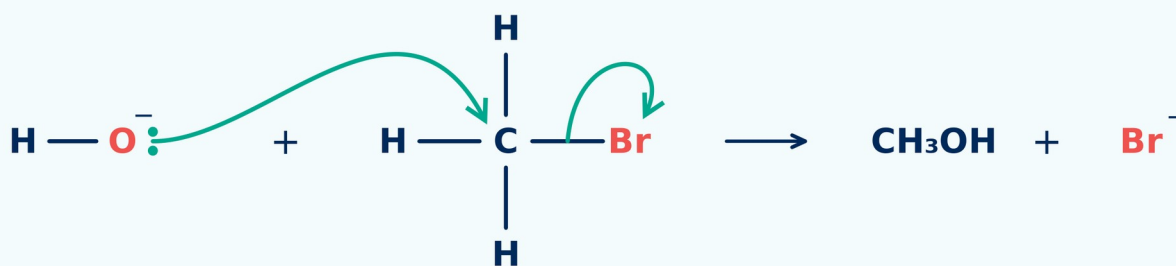
SPEC 3.3.1.2 Check the start and end of each curly arrow, the bonds in the products and the total charge.



CRACK IT Read each curly arrow as a sentence: "This electron pair moves from here to there." Then redraw the consequences and check the product.

CHECK	ASK YOURSELF
Source	Does each tail begin between the lone-pair dots, or on a bond line, in the reactant?
Destination	Does each head reach the atom that receives the electrons?
Product	Did every arrow produce the expected bond change?
Charge	Is the total charge the same before and after?
Valency	Is H singly bonded? Does neutral C have four bonds? Are three-bond carbocations, radicals and charged O/N clearly labelled?
Notation	Are dots, lone pairs, partial charges and full charges being used for different meanings?

WORKED REPAIR "The arrow starts at H^+ and points to the ammonia lone pair" is reversed. H^+ has no electron pair to donate. Begin at the N lone pair and point towards H^+ .



WORKED MECHANISM: $\text{OH}^- + \text{CH}_3\text{Br} \rightarrow \text{CH}_3\text{OH} + \text{Br}^-$

The new C-O bond and the breaking C-Br bond need separate arrows. Carbon keeps four bonds in the product, and net charge remains -1 . This diagram practises the conventions; the full reaction topic follows later.



TEST IT 9

- Water reacts with H^+ to form H_3O^+ . Draw the structures, a reacting O lone pair, the correct curly arrow and the product charge. Show any remaining lone pair on the product. [4 marks]
- A student says "a curly arrow shows the movement of a hydrogen atom". Correct this statement. [1 mark]
- Another student draws $\text{CH}_3^\bullet$ with a $-$ charge instead of a dot. Explain why this changes the species. [1 mark]

Written answers for 9(b) and 9(c): use the lines below.

9(a) Draw H_2O and H^+ , the curly arrow and the H_3O^+ product here.

✓ **DONE WHEN** you can explain a correction using electrons, rather than saying only that an arrow is wrong.

10. Same connectivity, different arrangement

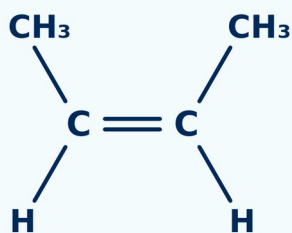


SPEC 3.3.1.3 Define stereoisomers and explain the origin of E/Z isomerism.

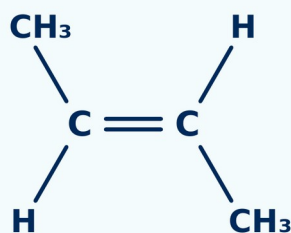


CRACK IT Organic I changed which atoms were connected. Here the connectivity stays the same and the arrangement in space changes.

TERM	FULL-MARK WORDING / MEANING
Stereoisomers	Compounds with the same structural formula but a different arrangement of atoms in space.
Structural isomers: retrieval	Compounds with the same molecular formula but different structural formulae.
E/Z isomerism	A form of stereoisomerism caused by restricted rotation about a planar carbon-carbon double bond, when each double-bond carbon has two different attached groups.



But-2-ene: arrangement A



But-2-ene: arrangement B

Both structures have $\text{CH}_3\text{CH}=\text{CHCH}_3$ connectivity and molecular formula C_4H_8 . The atoms attached directly to the $\text{C}=\text{C}$ carbons lie in a plane. Rotation about $\text{C}=\text{C}$ is restricted: converting one arrangement into the other requires disrupting the double bond.

WHAT "PLANAR" MEANS HERE The two double-bond carbons and the four atoms directly attached to them lie in one plane. Larger attached groups need not all lie in that plane.



TEST IT 10

- Define stereoisomers. [2 marks]
- Explain why suitable alkenes can have two persistent arrangements around $\text{C}=\text{C}$. [2 marks]
- Pent-1-ene and pent-2-ene differ in double-bond position. State whether this is structural isomerism or stereoisomerism, and explain. [2 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you distinguish different connections from a different arrangement around unchanged connections.

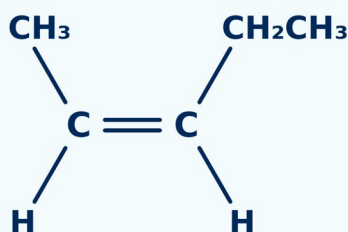
11. Decide whether E/Z is possible



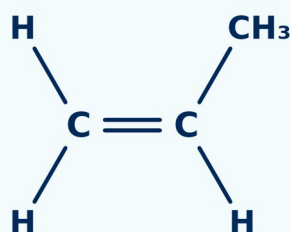
SPEC 3.3.1.3 Check both C=C carbons for two different attached groups.



CRACK IT Cover one half of the double bond and compare the two groups on the other carbon. Repeat on the second carbon. Both comparisons must contain different groups.



Pent-2-ene: E/Z possible



Propene: E/Z not possible

WORKED DECISION	REASON
Pent-2-ene: yes	One C carries H/CH ₃ ; the other carries H/CH ₂ CH ₃ . Each pair is different.
Propene: no	The CH ₂ carbon has H/H. Interchanging those identical H atoms does not give a different stereoisomer.
(CH ₃) ₂ C=CHCH ₃ : no	One double-bond carbon has two CH ₃ groups. Different groups on the other carbon cannot rescue it.

EXAM TRAP The molecule does not need four different groups in total. It needs two different groups on each individual double-bond carbon. But-2-ene can show E/Z even though both sides contain H and CH₃.



TEST IT 11

a) For each structure, state whether E/Z is possible and explain by comparing the groups on the C=C carbons: (i) CH₃CH₂CH=CHCH₂CH₃; (ii) CH₂=C(CH₃)CH₂CH₃; (iii) CH₃CH=C(Cl)CH₃. [6 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you test both ends of C=C before trying to assign E or Z.

12. CIP priorities: start at the attached atom



SPEC 3.3.1.3 Apply Cahn-Ingold-Prelog priority rules using atomic number.



CRACK IT Assign priorities separately at each carbon of C=C. Compare the atoms directly bonded to that carbon first. Higher atomic number gives higher priority.

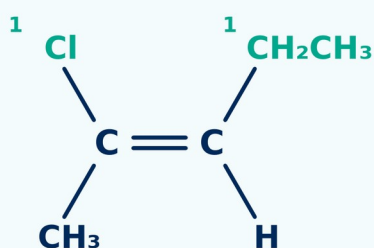
ATOM	H	C	N	O	F	Cl	Br	I
ATOMIC NUMBER	1	6	7	8	9	17	35	53

WORKED 1: chlorine versus a methyl group

Compare Cl with the C directly attached in CH₃. Atomic numbers: 17 > 6. Cl has higher priority. The three hydrogens in CH₃ do not outweigh chlorine because they are not compared at this stage.

WORKED 2: OH versus CH₂CH₂CH₃

The directly attached atoms are O and C. Since 8 > 6, OH has higher priority even though the carbon group is larger. Stop as soon as a difference decides the order.



Local priorities: Cl on the left; CH₂CH₃ on the right

PRIORITY IS LOCAL Select one higher-priority group on the left and one on the right. Do not rank all four groups in a single list to choose the two heaviest.



TEST IT 12

a) Give the higher-priority group in each pair and justify it using the directly attached atoms: (i) Br and Cl; (ii) NH₂ and CH₂CH₃; (iii) F and OH. [6 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you use atomic number at the point of attachment, not molecular mass or group size.

13. CIP priorities: resolve a first-atom tie



SPEC 3.3.1.3 Compare the next attached atoms when the first atoms are identical.



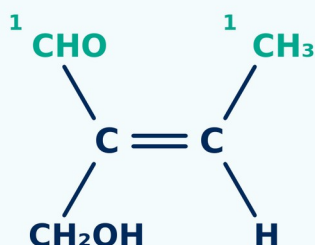
CRACK IT If the first atoms tie, list the atoms attached to each, excluding the C=C carbon you came from. Put each list in decreasing atomic number and compare the first difference.

WORKED PAIR	NEXT-ATOM LISTS	DECISION
CH ₂ CH ₃ versus CH ₃	[C,H,H] versus [H,H,H]	C beats H: ethyl has higher priority.
CH ₂ OH versus CH ₂ CH ₃	[O,H,H] versus [C,H,H]	O beats C: CH ₂ OH has higher priority.
CH(CH ₃) ₂ versus CH ₂ CH ₂ CH ₃	[C,C,H] versus [C,H,H]	First C ties; the second C beats H. CH(CH ₃) ₂ has higher priority.

Do not add atomic numbers together. Compare the highest entry, then the next, then the next, stopping at the first difference. If an entire layer ties, continue outward until a difference is found.

MULTIPLE-BOND COMPARISONS For CIP comparison, treat a double bond as attachment to two copies of the bonded atom and a triple bond as attachment to three. These are comparison copies, not extra atoms in the actual molecule.

Example: a directly attached -CHO carbon is compared as [O,O,H]. A -CH₂OH carbon is [O,H,H]. The first O ties, then O beats H, so -CHO has higher priority.



Priority 1: CHO on the left; CH₃ on the right



TEST IT 13

a) Give the higher-priority group in each pair and show the ordered comparison that decides it: (i) CH₂Cl versus CH₂OH; (ii) CH₂CH₂CH₃ versus CH₃; (iii) CHO versus CH₂CH₃. [6 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you resolve a tie by ordered comparisons, not by choosing the longest-looking group.

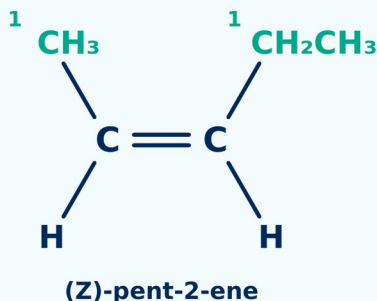
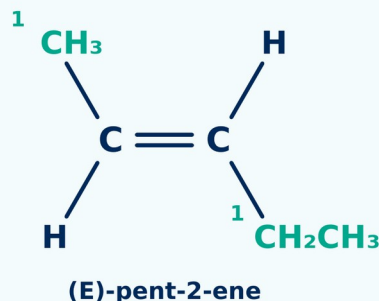
14. Assign E or Z after choosing priorities



SPEC 3.3.1.3 Apply CIP priorities to name the E or Z arrangement.



CRACK IT Mark one higher-priority group at each double-bond carbon. Compare their positions across C=C: same side is Z; opposite sides is E.



WORKED STEP	PENT-2-ENE
1. Confirm eligibility	Left: CH ₃ /H. Right: CH ₂ CH ₃ /H. Each pair differs.
2. Apply CIP independently	C beats H on both sides, so the carbon group wins at each carbon.
3. Compare the priority groups	Both above the C=C: Z. One above and one below: E.
4. Write the name	Put (E)- or (Z)- before the complete IUPAC name.

MEMORY AID Z: zusammen, together. E: entgegen, opposite. The comparison always uses the higher-priority groups, not whichever groups look most alike.

REFERENCE STRUCTURES FOR TEST IT 14

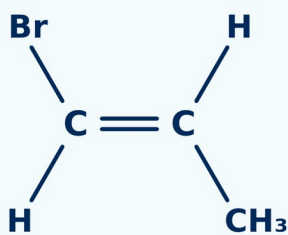


Figure 14A

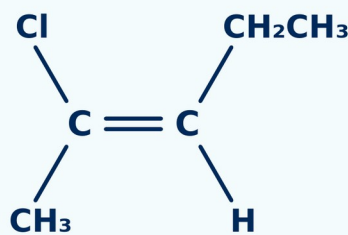


Figure 14B



TEST IT 14

a) For Figure 14A and Figure 14B, identify the higher-priority group at each carbon and assign E or Z. Give the priority reasoning for each figure. [6 marks]

.....

.....

.....

.....

.....

.....

✓ **DONE WHEN** you label E/Z only after selecting the two local priority winners.

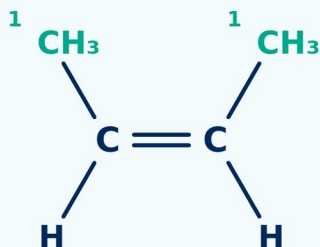
15. Draw a requested E/Z structure



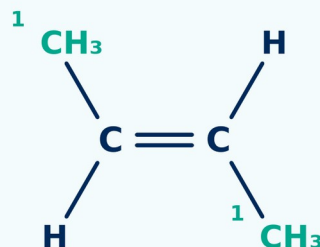
SPEC 3.3.1.3 Draw unambiguous structural formulae of specified E and Z isomers.



CRACK IT Start with a horizontal C=C. Add two branches from each carbon, one above and one below. Place the higher-priority groups as required, then fill the remaining positions.



(Z)-but-2-ene



(E)-but-2-ene

Worked method: the but-2-ene skeleton is $\text{CH}_3\text{CH}=\text{CHCH}_3$. At each C=C carbon, CH_3 has higher priority than H. For Z, place both CH_3 groups above; for E, place one above and one below. Keep the same groups on each carbon in both drawings.

REPRESENTATION MATTERS $\text{CH}_3\text{CH}=\text{CHCH}_3$ alone does not distinguish E from Z. Draw the groups around the C=C. Condensed groups such as CH_3 are suitable in this structural diagram; if fully displayed is requested, expand every H and bond.



TEST IT 15

a) Draw structural formulae showing (E)-hex-3-ene and (Z)-hex-3-ene. Label each and make the arrangement around C=C explicit. [4 marks]

b) State the higher-priority group at each C=C carbon and why it has higher priority. [2 marks]

Written answers for 15(b): use the lines below.

15(a) Draw and label (E)-hex-3-ene here.

15(a) Draw and label (Z)-hex-3-ene here.

✓ **DONE WHEN** your drawing conveys both connectivity and the requested spatial arrangement.

16. Mixed practice: apply, explain, correct



SPEC 3.3.1.3 Combine electron conventions with independent E/Z reasoning.



CRACK IT For (a), use CIP to analyse Figures 16A and 16B. For (b), draw the other isomer of 16A. For (c), draw H-Br bond breaking. For (d), complete the radical equation.

REFERENCE STRUCTURES FOR TEST IT 16(a) AND 16(b)

Use these structures to answer (a). Use Figure 16A again for (b). Write and draw your answers in the labelled spaces below TEST IT 16.

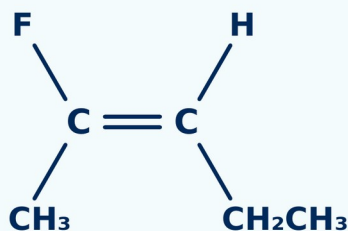


Figure 16A

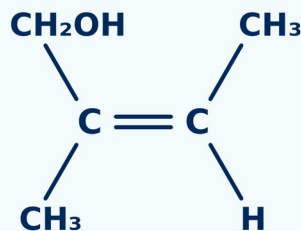


Figure 16B



TEST IT 16

- Using the two reference structures above, identify the higher-priority group on each C=C carbon and assign E or Z to Figure 16A and Figure 16B. Explain how you resolve the carbon-versus-carbon comparison in 16B. [4 marks]
- Draw the other E/Z isomer of Figure 16A and label it E or Z. Keep the same connectivity. [2 marks]
- Draw heterolytic fission of H-Br into H^+ and Br^- , including the curly arrow and product charges. [2 marks]
- Complete the balanced equation $\text{C}_2\text{H}_5\cdot + \text{Br}_2 \rightarrow \text{_____} + \text{_____}$. Write both product formulae and include the required radical dot. [2 marks]

Written answers for 16(a) and 16(d): use the lines below.

.....

.....

.....

.....

.....

16(b) Draw and label the other isomer of Figure 16A here.

16(c) Draw H-Br, its curly arrow and H^+ / Br^- here.

✓ **DONE WHEN** you can transfer the conventions to unfamiliar structures without changing their connectivity.

17. Lock in the rules that earn marks



SPEC 3.3.1.2 Retrieve the mechanism and stereoisomerism rules without relying on a worked diagram.



CRACK IT Name the rule that justifies your answer. A correct label with no reasoning can hide a fragile method.

AREA	READY WHEN YOU CAN...
Reaction patterns	Classify addition, substitution and elimination from supplied equations.
Electron language	Define nucleophile, electrophile and radical accurately.
Curly arrows	Begin at a lone pair or bond; show every required bond change.
Radicals	Balance individual steps and distinguish a dot from an ionic charge.
Stereoisomerism	Explain same structural formula / different spatial arrangement.
E/Z eligibility	Check for two different groups on each C=C carbon.
CIP	Compare atomic numbers, resolve ties and stop at the first difference.
Drawing	Show the arrangement around C=C and preserve the carbon skeleton.



TEST IT 17

a) Rewrite each statement so that it is chemically correct: (i) "E/Z is caused by rotation about a single C-C bond"; (ii) "CIP priority is decided by the total mass of a group"; (iii) "A bond-breaking curly arrow begins at the receiving atom"; (iv) "All nucleophiles must be negative"; (v) "An E/Z pair has different connectivity". [5 marks]

.....

.....

.....

.....

.....

NEXT IN THE SEQUENCE Alkanes develops the full free-radical substitution chain. Halogenoalkanes and Alkenes develop complete electron-pair mechanisms and their conditions. Return to these arrow and E/Z rules in each topic.

Specification reference

AQA Chemistry 7405: 3.3.1.2 Reaction mechanisms; the stereoisomerism / E-Z / CIP content of 3.3.1.3 Isomerism. Structural isomerism is taught in Organic I. The reaction-type and donor/acceptor vocabulary supports the established CrackingChem lesson sequence.

<https://www.aqa.org.uk/subjects/chemistry/a-level/chemistry-7405/specification/subject-content/organic-chemistry>

CIP reference: IUPAC Blue Book, P-92.1 (sequence rules and multiple-bond comparisons): <https://iupac.qmul.ac.uk/BlueBook/P9.html>

✓ **DONE WHEN** you can justify each convention and know which later pack extends it.

Answers: mechanism foundations

TEST IT 1 | 4 marks

a) C-Cl breaks [1]; C-O forms [1]. b) Total charge is -1 on each side [1]. A mechanism shows the electron movements / bond-making and bond-breaking steps that explain the overall change [1].

TEST IT 2 | 6 marks

(i) Addition: C=C becomes C-C as H is added across it [2]. (ii) Substitution: Br is replaced by OH, forming C-O in place of C-Br [2]. (iii) Elimination: H and OH are removed from adjacent carbons, forming C=C and water [2]. One mark for each type and one for its structural reason.

TEST IT 3 | 6 marks

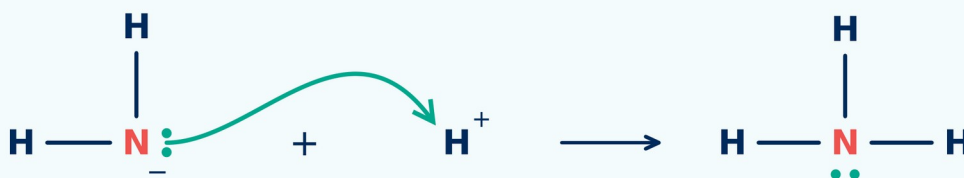
a) $I_2 \rightarrow 2I\cdot$: balanced iodine atoms [1] and a dot on each iodine radical [1]. b) H^+ [1] and I^- [1]. c) Homolytic: one bonding electron goes to each atom [1]. Heterolytic: both bonding electrons go to one atom [1].

TEST IT 4 | 6 marks

a) Nucleophile: electron-pair donor [1]. Electrophile: electron-pair acceptor [1]. b) A neutral molecule can donate a lone pair [1]; the donating atom in water is O [1]. c) C is δ^+ [1]; the donor attacks that C atom [1].

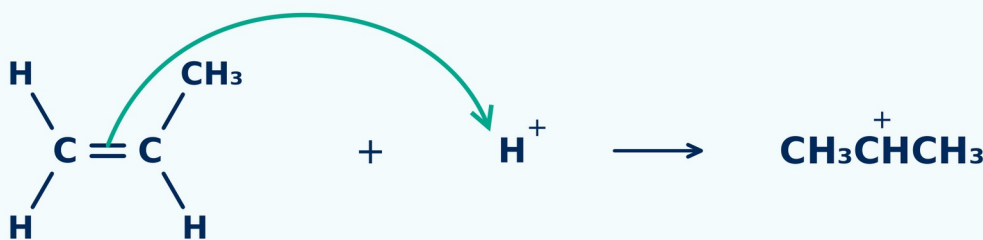
TEST IT 5 | 5 marks

a) NH_2^- with two N-H bonds, a reacting N lone pair and charge [1]; arrow starts at that pair [1] and points to H^+ [1]; NH_3 product has three N-H bonds and a remaining lone pair [1]. b) Total charge is 0 before and after [1]. The reactant has a second lone pair; showing only the reacting one is sufficient here.



TEST IT 6 | 4 marks

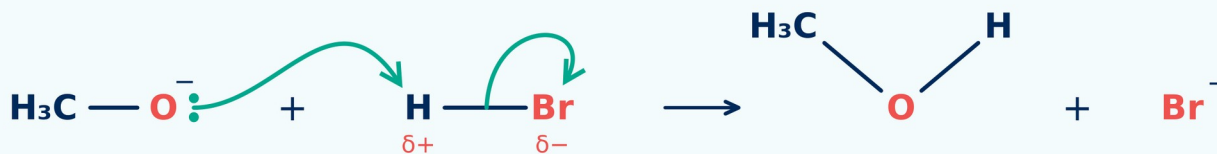
a) Arrow starts at C=C [1] and points to H^+ [1], as shown. b) The C-C bond order decreases from two to one [1]; the total charge remains +1 [1]. In the product shown in the equation, the middle carbon has three bonds and carries the positive charge.



Answers: electron movement and priorities

TEST IT 7 | 6 marks

a) The O lone pair and reactant charge are shown [1]; arrow from that pair to H [1]; arrow from H-Br to Br [1]; products are CH₃OH and Br⁻ with correct charges [1]. b) H-Br is the source of the pair [1]; both electrons go to Br, giving Br⁻ [1].

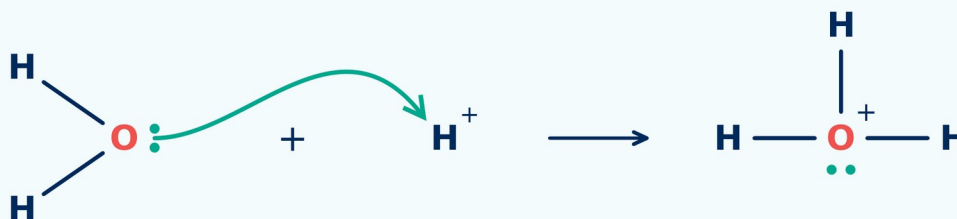


TEST IT 8 | 6 marks

a) Br• + C₂H₆ → HBr + C₂H₅•. C₂H₅ skeleton / atom balance [1]; radical dot [1]. b) C₂H₅• + Cl• → C₂H₅Cl: correct stable product [1]; balanced equation and radical notation [1]. c) A dot represents an unpaired electron [1]; AQA does not require curly arrows for radical mechanisms [1].

TEST IT 9 | 6 marks

a) H₂O has two O-H bonds and an O lone pair [1]; the curly arrow begins at that pair [1] and points to H⁺ [1]; H₃O⁺ has three O-H bonds, overall +1 and one remaining lone pair [1]. b) A curly arrow shows movement of an electron pair [1]. c) The - charge represents an anion; the dot represents the unpaired electron of a radical [1].



TEST IT 10 | 6 marks

a) Same structural formula [1], different arrangement of atoms in space [1]. b) Rotation is restricted [1] about the planar C=C bond [1], so the arrangements do not freely interconvert. c) Structural (position) isomerism [1]: the C=C position, and therefore the structural formula / connectivity, differs [1].

TEST IT 11 | 6 marks

(i) Yes: each C=C carbon has H and CH₂CH₃ [2]. (ii) No: one C=C carbon has H/H [2]. (iii) Yes: one C carries CH₃/H; the other carries Cl/CH₃ [2]. One mark for each decision and one for the group comparison.

TEST IT 12 | 6 marks

(i) Br: atomic number 35 > Cl 17 [2]. (ii) NH₂: the attached N has atomic number 7 > C 6 [2]. (iii) F: atomic number 9 > O 8 [2]. One mark for each priority and one for the comparison.

TEST IT 13 | 6 marks

(i) CH₂Cl: [Cl,H,H] beats [O,H,H] because Cl > O [2]. (ii) CH₂CH₂CH₃: [C,H,H] beats [H,H,H] because C > H [2]. (iii) CHO: the double bond is treated as [O,O,H], which beats [C,H,H] at the first entry [2].

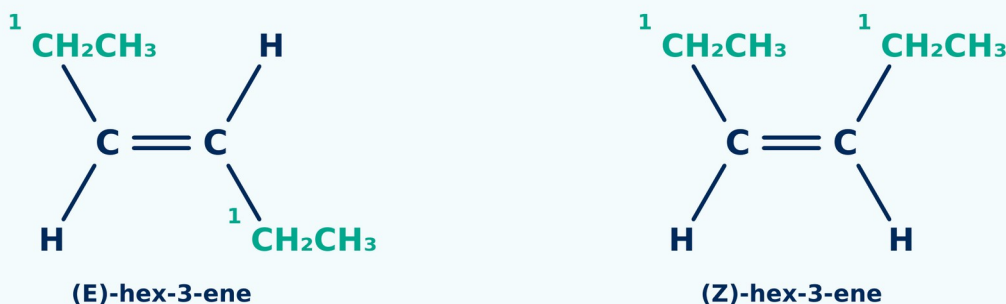
Answers: E/Z application and drawing

TEST IT 14 | 6 marks

Figure 14A: Br beats H; CH₃ beats H. The priority groups are opposite, so E [3]. Figure 14B: Cl beats the C in CH₃; the C in CH₂CH₃ beats H. The priority groups are on the same side, so Z [3]. One mark per correct local comparison and one per E/Z assignment.

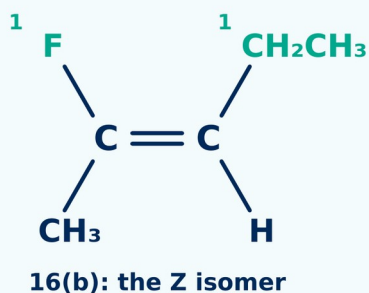
TEST IT 15 | 6 marks

a) For each isomer, correct hex-3-ene connectivity [1] and correct labelled E/Z arrangement [1]. b) CH₂CH₃ is the higher-priority group at each C=C carbon [1] because C has higher atomic number than H [1]. Rotating either whole diagram in the plane does not change its identity.



TEST IT 16 | 10 marks

a) 16A: F beats CH₃; CH₂CH₃ beats H; opposite → E [2]. 16B: CH₂OH beats CH₃ because [O,H,H] beats [H,H,H]; CH₃ beats H; same side → Z [2]. b) Other isomer of 16A: preserve the groups [1], place F and CH₂CH₃ on the same side and label Z [1]. c) Arrow starts at H-Br and ends at Br [1]; H⁺ and Br⁻ products [1]. d) C₂H₅• + Br₂ → C₂H₅Br + Br•: product formula / atom balance [1]; radical dot on Br only among the products [1].



TEST IT 17 | 5 marks

(i) E/Z arises from restricted rotation about a planar C=C with two different groups on each carbon [1]. (ii) CIP compares atomic numbers at the first point of difference [1]. (iii) A bond-breaking arrow begins at the bond [1]. (iv) A neutral species with an available electron pair can be a nucleophile [1]. (v) An E/Z pair has the same connectivity but different spatial arrangements [1].