

Volume 35, Number 3, February 2026

Answers

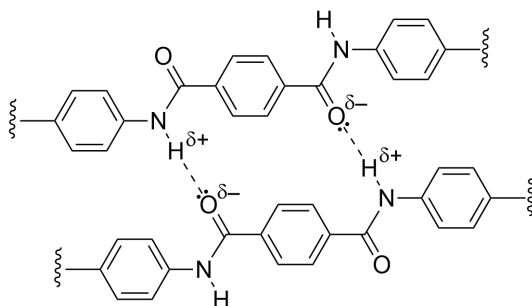
Practice exam questions

Andrew Parsons

Check your answers to the questions in this issue.

Chemistry at the movies (pp. 2–7)

- 1 In Kevlar the polyamide chains are arranged in parallel and packed closely together. The amide groups in the polymer backbone contain both a carbonyl (C=O) and an N–H group, which can form hydrogen bonds between adjacent chains. The close packing of chains and intermolecular interactions give Kevlar its high tensile strength and resistance to stretching.



- 2 Psilocybin has structural similarities to serotonin, including the aromatic rings and amine group. These features allow it to bind to the same serotonin receptors due to complementary shape, size, and functional groups capable of forming similar interactions (e.g. hydrogen bonding). As it occupies the receptor, it can activate it or block it, mimicking serotonin's effects and disrupting normal neurotransmission, leading to altered perception and hallucinations.
- 3 A primary amine group (–NH₂) and a substituted benzene or phenyl group (–C₆H₅).
- 4 Oxytocin's biological action depends on its complex three-dimensional structure, which is essential for binding precisely to oxytocin receptors. Its specificity and size make it difficult for small synthetic molecules to replicate its full biological effect. Mimicking it requires matching the sequence of nine amino acids, and its shape, which is challenging with simpler organic compounds.

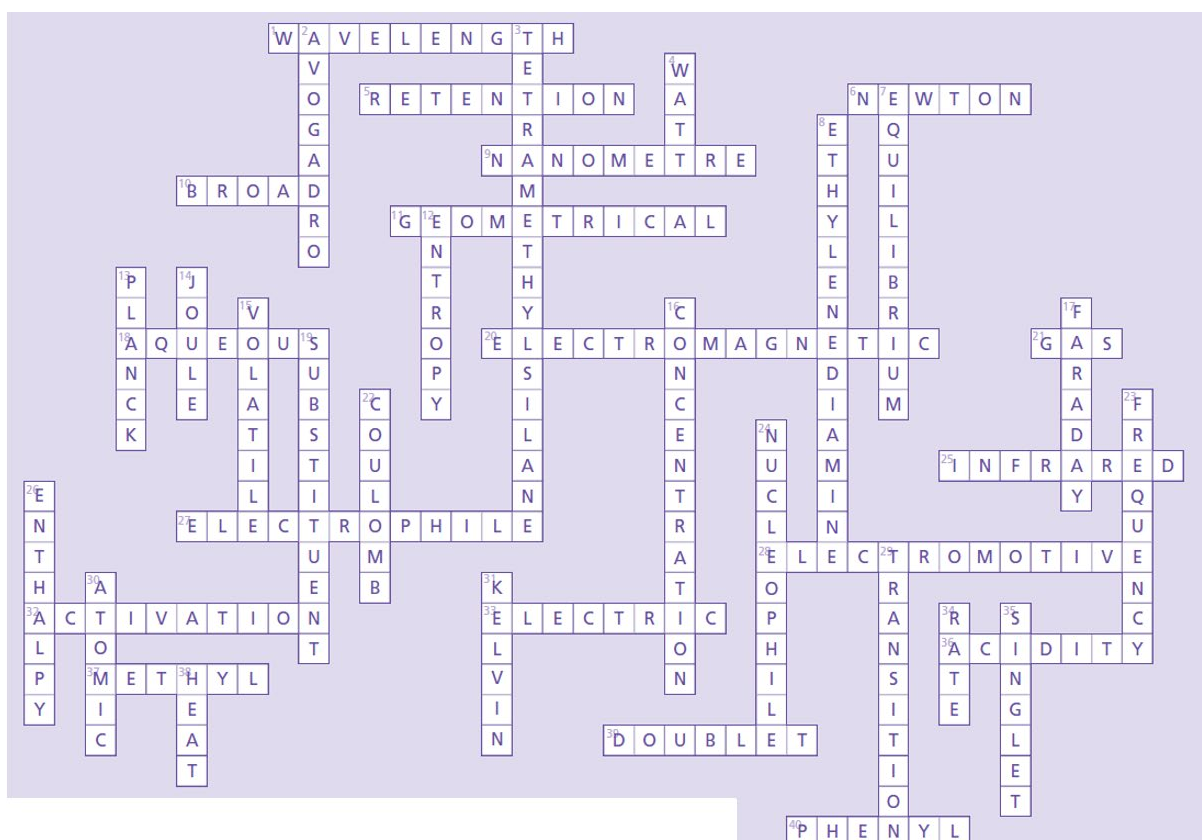
Learning chemistry with analogies (pp. 8–10)

- 1 The train analogy shows that even though there is constant movement (people boarding and leaving), the overall number of people stays the same. The train represents the system, and the passengers are the reactants and products. The getting on and off actions are the forward and reverse reactions. When the number of people getting on equals the number getting off, the total number of people on the train remains constant. This mirrors a chemical dynamic

equilibrium, where the rate of the forward reaction equals the rate of the reverse reaction, even though particles are continuously reacting.

- 2 If one side of the seesaw is pushed down (a change in concentration, pressure, or temperature), the system shifts to restore balance by favouring the forward or reverse reaction, just like the seesaw adjusts to maintain equilibrium.
- 3 A molecule is chiral if it cannot be superimposed on its mirror image, just like your left hand cannot fit properly into a right-hand glove. This analogy illustrates that chiral molecules exist in two forms (called enantiomers) that are mirror images of each other but not identical, like left and right hands. Enantiomers have the same atoms and bonds but differ in spatial arrangement, which can result in different chemical behaviours, especially in biological systems.

Chemistry crossword (p. 11)



Notes

Aqueous (18 Across)

The term 'aqueous', abbreviated as (aq) in chemical equations, comes from the Latin word *aqua*, meaning water. It refers to a substance dissolved in water, forming a solution. For instance, NaCl(aq) indicates that sodium chloride is dissolved in water and is not in its solid form. This distinction is crucial

because substances in aqueous form can behave very differently from their solid or gaseous states – ions are free to move, allowing for electrical conductivity, acid–base reactions and precipitation reactions to occur.

Recognising the aqueous state helps chemists to predict solubility, reactivity and even colour changes in solution. It is a small symbol with big significance in practical and theoretical chemistry.

Entropy (12 Down)

‘Entropy’ originates from the Greek word *entropia*, meaning ‘a turning towards’ or ‘transformation’, reflecting the idea of disorder or the spread of energy. Entropy (*S*) measures a system’s disorder or randomness. It describes how energy is distributed among particles, and how likely a system is to move towards a more probable (disordered) state.

Rudolf Clausius (1822–88) introduced the term entropy in the nineteenth century. Some speculate he chose the symbol *S* to honour thermodynamic pioneer Sadi Carnot, but Clausius did not explain his choice. Entropy increases in spontaneous processes and is central to predicting reaction feasibility using the Gibbs free energy equation: $\Delta G = \Delta H - T\Delta S$.

Geometrical (11 Across)

The word ‘geometrical’ comes from the Greek *geo* (earth) and *metron* (measure), originally used in mathematics to describe the shapes, sizes and positions of figures. In chemistry, geometrical isomerism refers to the different spatial arrangements of atoms or groups around a double bond or a ring structure, where rotation is restricted. A classic example is *cis–trans* isomerism, where the same atoms are bonded but have different positions in space, leading to distinct physical and chemical properties. Recognising geometrical isomers is vital for understanding molecular behaviour, especially in organic compounds like alkenes and in co-ordination complexes in inorganic chemistry.

Nucleophile (24 Down)

‘Nucleophile’ comes from Latin and Greek roots: *nucleus* meaning ‘kernel’ or ‘core’, and *philos* meaning ‘loving’ – so it literally means ‘nucleus-loving’. A nucleophile is a species that donates a pair of electrons to form a new covalent bond, typically attacking a positively charged or electron-deficient centre (often a carbon atom in an electrophile).

Nucleophiles are often negatively charged ions like OH^- or CN^- , or neutral molecules with lone pairs, such as ammonia (:NH_3) or water (H_2O). The term reflects the electron-rich nature of these species and their attraction to electron-poor nuclei. Understanding nucleophiles is essential in organic reaction mechanisms, such as substitution and addition reactions, where they play a central role in forming new bonds.

Forever chemicals (pp. 12–15)

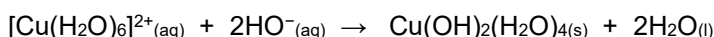
- 1 $\text{CF}_3(\text{CF}_2)_6\text{COOH}$
- 2 ‘Essential use’ defines applications where PFAS are critical and have no safe alternatives. Limiting use to essential applications helps reduce environmental release while allowing necessary societal benefits, such as use in medical devices or aviation fire-fighting foam.

- 3 Alternatives include natural polymers such as starch or cellulose derivatives, which provide water resistance without persistent, bioaccumulative properties. These are biodegradable and do not form harmful, long-lived residues in the environment.

Transition metals and their fascinating colours (pp. 18–21)

- 1 a $[\text{Cu}(\text{H}_2\text{O})_6]^+$ (the Cu^{2+} ion is reduced to Cu^+).

b The precipitate colour is pale blue, and the reaction is as follows:



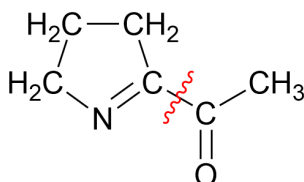
c When ammonia is added dropwise, a pale blue precipitate forms. On excess addition of ammonia, a deep blue solution forms, giving a complex with the formula $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]$.

- 2 D = FeBr_3 . FeBr_3 forms a green solution, which shifts from green to yellow when reduced – indicating the presence of Fe^{2+} ions. The formation of a cream precipitate upon addition of AgNO_3 confirms the presence of Br^- ions (as AgBr is formed, together with $\text{Fe}(\text{NO}_3)_3$).

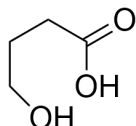
E = MnSO_4 . MnSO_4 forms a pale pink solution. The appearance of a pale brown precipitate indicates the presence of Mn^{2+} ions, while the formation of a white precipitate upon addition of $\text{Ba}(\text{NO}_3)_2$ confirms the presence of SO_4^{2-} ions (as BaSO_4 is formed, together with $\text{Mn}(\text{NO}_3)_2$).

Poppin' good chemistry (pp. 22–26)

- 1 The peak is due to the $[\text{CH}_3\text{CO}]^+$ ion, which has a mass of 43. (Don't forget that it is an ion, with a positive charge.) It is formed by breaking the C–C bond shown below.

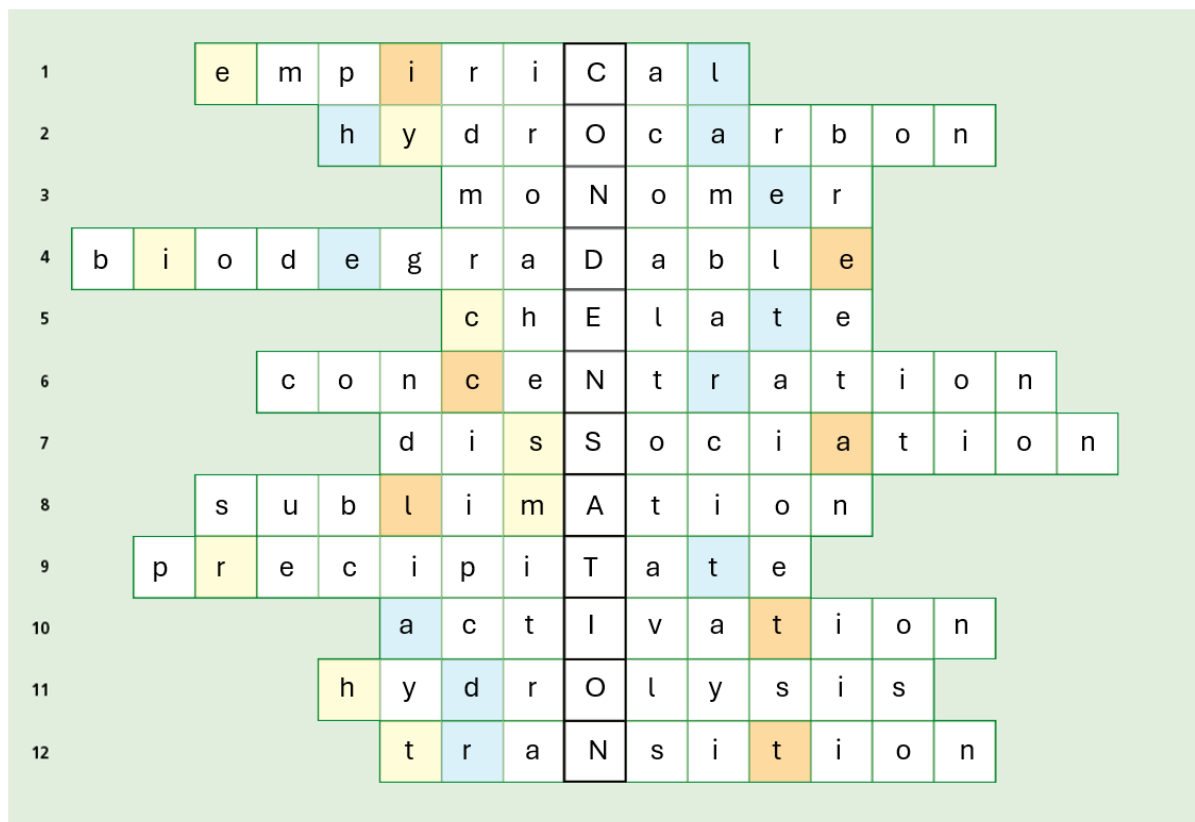


- 2 Lactones are cyclic esters. Since esters are formed through esterification reactions, the corresponding open-chain starting material must contain both a hydroxyl ($-\text{OH}$) group and a carboxylic acid ($-\text{COOH}$) group.



- 3 2,5-dimethylpyrazine and 2-ethylpyrazine. Both have the same molecular formula, $\text{C}_6\text{H}_8\text{N}_2$, but differ in the arrangement of the carbon substituents on the pyrazine ring.

Key terms puzzle (p. 27)



Orange boxes term: Lattice

Blue boxes term: Tetrahedral

Notes

Lattice

The term 'lattice' originates from the mathematical concept of a regularly repeating arrangement of points, and its importance lies in describing the highly ordered structures found in crystalline solids. Imagine atoms, ions or molecules as individual building blocks; in a lattice, these blocks are arranged in a precise, repeating pattern extending in three dimensions. This ordered arrangement is not random; it is a direct consequence of the forces of attraction between the constituent particles, minimising their energy and providing stability.

Understanding the lattice structure is crucial for chemists as it directly impacts a substance's physical and chemical properties, such as its melting point, density, conductivity, and even how it reacts with other chemicals. For example, the strength of the ionic lattice in salts dictates their high melting points, while the metallic lattice in metals explains their excellent electrical conductivity.

Tetrahedral

The term 'tetrahedral' describes a specific molecular geometry where a central atom is bonded to four other atoms or groups, arranged at the vertices of a tetrahedron. This concept gained prominence in

1874 with the independent proposals by Jacobus Henricus van 't Hoff (1852–1911) and Joseph Achille Le Bel (1847–1930), who used the idea of a tetrahedral carbon atom to explain the phenomenon of optical isomerism.

Understanding tetrahedral geometry is fundamental to predicting and explaining the shapes of countless molecules, particularly organic compounds. This shape, with bond angles of approximately 109.5° , arises from the repulsion between electron pairs around the central atom, which strive to maximise their distance from one another (as explained by VSEPR theory). The fixed, three-dimensional arrangement of atoms in a tetrahedral molecule is crucial for its chemical properties, including its polarity, reactivity and biological activity, making it a cornerstone of stereochemistry.

Seeds of change (pp. 28–29)

- 1 The L- (for laevorotatory or levorotatory) indicates the stereochemistry of arginine, and it specifies the naturally occurring enantiomer.
- 2 Arginine is basic because its sidechain contains a guanidine group that can accept a proton (H^+) to form a stable cation (called a guanidinium ion, $-NHC(=NH_2^+)NH_2$).
- 3 Arginine's charged side chain (guanidinium ion) can form strong hydrogen bonds and electrostatic interactions with water molecules, making arginine much more water-soluble than alanine, which has a non-polar methyl side chain.
- 4 Excess aluminium can remain in the treated water, which has been linked to health concerns (e.g. potential neurotoxicity).
- 5 As they are negatively charged, the particles repel each other, which stops them from clumping together into larger particles that could settle under gravity.

This resource is part of CHEMISTRY REVIEW, a magazine written for A-level students by subject experts. To subscribe to the full magazine, go to www.hachettelearning.com/chemistryreview