

How ions bond: transfer and lattices

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer gives the ion charges, the balance check and the final result in bold. Always check that the total positive charge equals the total negative charge, and that each ion has a full outer shell.

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Problem 1 Words for ions

1. An ion is an atom or group of atoms with an overall electrical charge, because it has gained or lost electrons.
2. A cation is a positive ion; an anion is a negative ion.
3. Metals usually lose electrons and form cations.

Cation = positive; anion = negative; metals form cations.

Problem 2 Charges from the group

Groups 1 to 3 lose electrons; Groups 6 and 7 gain electrons.

1. Li^+ .
2. Mg^{2+} .
3. Al^{3+} .
4. O^{2-} .
5. F^- .

1+, 2+, 3+, 2-, 1-.

Problem 3 Sodium becomes an ion

1. It loses 1 electron.
2. Protons stay at 11. Electrons are $11 - 1 = 10$.
3. 2,8 (like neon).

Na^+ has 11 protons, 10 electrons and arrangement 2,8.

Problem 4 Reading a lattice

1. Counting: 8 large ions and 8 small ions.
2. $8 : 8$ simplifies to $1 : 1$.
3. Opposite charges attract, so ions of opposite charge sit next to each other and like charges are kept apart.

8 large, 8 small; ratio 1 : 1.

Problem 5 Names and formulas

Ionic names end in -ide.

1. Lithium fluoride, LiF (Li^+ , F^-).
2. Magnesium oxide, MgO (Mg^{2+} , O^{2-}).
3. Potassium bromide, KBr (K^+ , Br^-).
4. Calcium chloride, CaCl_2 (Ca^{2+} , two Cl^-).

LiF, MgO, KBr, CaCl_2 .

Problem 6 Three properties

High melting points; brittle; conduct electricity when molten or dissolved but not when solid. They also often dissolve in water.

High melting point, brittle, conduct when molten or dissolved.

Problem 7 Lithium oxide diagram

1. Each Li atom transfers 1 electron (2,1 becomes 2).
2. The oxygen atom gains 2 electrons to become O^{2-} , so two Li^+ are needed to balance the charge.
3. Li_2O .
4. Li^+ is 2; O^{2-} is 2,8.

Li_2O ; Li^+ 2, O^{2-} 2,8.

Problem 8 Formulae from charges

Balance total positive and negative charge.

1. +2 needs $2 \times (-1)$: CaCl_2 .
2. +3 needs $3 \times (-1)$: AlCl_3 .
3. $2 \times (+1)$ balances -2 : Na_2S .
4. $3 \times (+2) = +6$ and $2 \times (-3) = -6$: Mg_3N_2 .
5. $2 \times (+3) = +6$ and $3 \times (-2) = -6$: Al_2S_3 .

CaCl_2 , AlCl_3 , Na_2S , Mg_3N_2 , Al_2S_3 .

Problem 9 When does salt conduct?

1. Solid 0.00 A; molten 0.62 A; solution 0.38 A.
2. In the solid the ions are fixed in the lattice, so no charge can flow.
3. When molten or dissolved the ions are free to move and carry charge between the electrodes.

0.00 A, 0.62 A and 0.38 A; mobile ions are needed.

Problem 10 Comparing melting points

1. Magnesium oxide (2852 °C), calcium oxide (2613 °C), lithium fluoride (845 °C), sodium

chloride (801 °C).

2. MgO has ions with charges 2+ and 2−, while NaCl has 1+ and 1−. The attraction is stronger, so more energy is needed to separate the ions.

MgO > CaO > LiF > NaCl; higher charges give a stronger attraction.

Problem 11 Why crystals shatter

1. The property is brittleness.

2. The blow moves one layer of ions by one position, so ions with the same charge are next to each other. They repel, and the crystal splits.

Brittle: like charges meet and repel.

Problem 12 Spot the errors

1. Sodium chloride is a giant lattice of ions, not molecules; NaCl gives the ratio of ions.

2. Solids do not conduct, because the ions cannot move. Molten or dissolved ions carry current.

3. Magnesium atoms lose two electrons to form Mg^{2+} .

Lattice not molecule; ions must move; magnesium loses electrons.

Problem 13 Counting ions in a crystal

1. The ratio is 1 Ca^{2+} : 2 F^- , so $\text{F}^- = 2 \times 1.2 \times 10^6 = 2.4 \times 10^6$.

2. Total = $1.2 \times 10^6 + 2.4 \times 10^6 = 3.6 \times 10^6$.

3. Positive charge = $2 \times 1.2 \times 10^6 = 2.4 \times 10^6$. Negative charge = $1 \times 2.4 \times 10^6 = 2.4 \times 10^6$. They cancel.

2.4×10^6 fluoride ions; 3.6×10^6 ions in total.

Problem 14 Electron arrangements of ions

1. Mg is 2,8,2. Mg^{2+} has 10 electrons: 2,8, like neon.

2. O is 2,6. O^{2-} has 10 electrons: 2,8, like neon.

Mg^{2+} and O^{2-} both match neon (2,8).

Problem 15 Forming calcium fluoride

1. Calcium loses its 2 outer electrons. Each fluorine atom gains 1 electron.

2. One Ca^{2+} has 2+ and each F^- has 1−, so two F^- are needed for balance.

3. Ca^{2+} is 2,8,8 and F^- is 2,8.

CaF_2 : Ca^{2+} (2,8,8) with two F^- (2,8).

Problem 16 Predict formulae

1. R^{3+} and S^- : RS_3 . Check: +3 and $3 \times (-1)$.

2. T^+ and U^{2-} : T_2U . Check: $2 \times (+1)$ and -2 .

3. V^{2+} and N^{3-} : V_3N_2 . Check: $3 \times (+2) = +6$ and $2 \times (-3) = -6$.
4. Each total is zero.

RS_3 , T_2U , V_3N_2 .

Problem 17 Dissolving salt

1. Maximum = $36 \div 100 \times 50 = 18$ g.
2. Undissolved = $25 - 18 = 7$ g.
3. Water molecules attract the ions at the surface of the lattice and surround them, pulling the ions into the solution.

18 g dissolves; 7 g remains.

Problem 18 Ranking melting points

1. KCl (770 °C), NaCl (801 °C), MgO (2852 °C).
2. K^+ is a bigger ion than Na^+ , so its charge is further from the neighbouring Cl^- . The attraction is a little weaker.
3. Mg^{2+} and O^{2-} have double charges and are smaller, so the attraction is much stronger.

KCl < NaCl < MgO.

Problem 19 Identify three white solids

1. Add each solid to water. Chalk does not dissolve. Salt and sugar dissolve. Then test the two solutions with a conductivity circuit (electrodes and a lamp or ammeter): the salt solution conducts and the sugar solution does not.
2. Salt is ionic: its dissolved ions are free to move and carry current. Sugar has no ions, so it does not conduct.

Chalk is insoluble; salt solution conducts; sugar solution does not.

Problem 20 Limits of the diagram

1. It shows which atom loses electrons and which gains them, and it shows the charge and full outer shells of each ion.
2. It does not show the three-dimensional lattice with many ions, and it does not show the relative size of the ions or the strength of the attraction. It can also wrongly suggest a separate pair of ions.

Good for electron transfer; poor for the lattice, size and strength.