

The Periodic Table

Mark scheme and worked solutions for 30 questions: 15 multiple choice, 15 structured.

1 Core Arrangement of elements [1]

Answer: C

Worked solution

Every element has its own proton number, and the Periodic Table places the elements one after another as the proton number goes up by one each time: hydrogen 1, helium 2, lithium 3, and so on. Rows are called periods and columns are called groups. It is tempting to think the order is by mass, because relative atomic mass mostly rises across the table too, but there are exceptions such as argon and potassium, which are placed by proton number (18 then 19) even though argon has the larger relative atomic mass.

2 Core Arrangement of elements [1]

Answer: D

Worked solution

For metals in Groups I, II and III, the charge on the ion is positive and equal to the group number (1+, 2+, 3+). For non-metals in Groups V, VI and VII, the atoms gain electrons to reach a full outer shell, so the charge is negative and equal to (8 – group number): Group V gives 3–, Group VI gives 2–, Group VII gives 1–. Element X is in Group VI, so it forms X^{2-} ions, for example oxide O^{2-} and sulfide S^{2-} .

3 Core Group I properties [1]

Answer: C

Worked solution

Learn the three Group I trends down the group: melting point decreases, density increases and reactivity increases. For example, lithium reacts steadily with water, sodium reacts faster and potassium reacts violently. These metals are also unusually soft for metals; a piece of sodium can be cut easily with a knife.

4 Core Group VII properties

[1]

Answer: A

Worked solution

You need to recall the appearance of the three halogens at r.t.p.: chlorine is a pale yellow-green gas, bromine is a red-brown liquid and iodine is a grey-black solid. Notice that going down the group the state changes from gas to liquid to solid, and the colour gets darker.

5 Core Group VII properties

[1]

Answer: D

Worked solution

Reactivity decreases down Group VII: chlorine > bromine > iodine. A halogen can only take the place of a halogen below it in the group. In D, chlorine is above iodine, so the reaction is chlorine + potassium iodide → potassium chloride + iodine. In A, iodine is below bromine; in B, bromine is below chlorine; in C, iodine is below chlorine. So none of A, B or C reacts.

6 Core Transition elements

[1]

Answer: B

Worked solution

All metals conduct electricity, form positive ions and are shiny when freshly cut, so these properties cannot be used to tell a transition element from a Group I metal. The special properties of transition elements are: high density, high melting point, coloured compounds, and acting as catalysts (as the element or in compounds). Group I metals have low densities and low melting points, and their compounds, such as sodium chloride, are white.

7 Core Noble gases

[1]

Answer: A

Worked solution

Atoms react by losing, gaining or sharing electrons to obtain a full outer shell. Noble gas atoms already have a full outer shell (for example neon is 2,8 and argon is 2,8,8), so they do not need to react. This is also why they exist as single atoms (monatomic) rather than as molecules.

Mark scheme

(a) [1]

- V and Z (1)

(b) [2]

- Group II (1)
- Period 3 (1)

ALLOW group 2 for Group II

(c) [2]

- both have one electron in the outer shell (1)
- so they react in the same way / both lose one electron to form 1+ ions (1)

ALLOW same number of outer (shell) electrons for the first mark

REJECT same number of shells / same number of electrons

(d) [1]

- 2+ (1)

ALLOW +2 / W^{2+}

REJECT 2-

Worked solution

(a) The group number equals the number of electrons in the outer shell. V (2,1) and Z (2,8,1) both have one outer electron, so both are in Group I.

(b) W is 2,8,2. It has two outer electrons, so it is in Group II. It has three occupied shells, so it is in Period 3 (the period number equals the number of occupied shells).

(c) Chemical reactions involve the outer electrons. Because V and Z both have one outer electron, they react in similar ways: each atom loses its single outer electron to form an ion with a 1+ charge. Note that it is the number of outer electrons, not the total number of electrons or shells, that matters: V has two shells and Z has three.

(d) W is in Group II, so its atoms lose their two outer electrons and form ions with a 2+ charge.

Mark scheme

(a) [1]

- (melting point) decreases (down the group) (1)

(b) [1]

- any value from 15 °C to 38 °C (1)

REJECT any value of 39 °C or above

(c)(i) [1]

- caesium has a higher density (than rubidium) (1)

(c)(ii) [1]

- caesium is more reactive (than rubidium) (1)

Worked solution

(a) The melting points fall from 181 °C for lithium to 39 °C for rubidium, so the melting point decreases down the group.

(b) Each step down the group lowers the melting point, but by smaller amounts each time (a fall of 83 °C, then 35 °C, then 24 °C). The next fall should be smaller again, perhaps about 10–15 °C, so caesium should melt at roughly 25–30 °C. (The real value is about 29 °C.) Any value a little below 39 °C follows the trend.

(c) The general trends down Group I are that density increases and reactivity increases. Caesium is below rubidium, so caesium should be denser and more reactive than rubidium.

Mark scheme

(a) [2]

- chlorine is more reactive than bromine (1)
- so chlorine displaces bromine (from the bromide / from sodium bromide) (1)

ALLOW chlorine is higher in Group VII than bromine for the first mark

(b) [1]

- chlorine + sodium bromide → sodium chloride + bromine (1)

(c) [2]

- correct formulae: Cl_2 , NaBr, NaCl, Br_2 (1)
- correctly balanced: $\text{Cl}_2 + 2\text{NaBr} \rightarrow 2\text{NaCl} + \text{Br}_2$ (1)

IGNORE state symbols

ALLOW $\text{Cl}_2 + 2\text{Br}^- \rightarrow 2\text{Cl}^- + \text{Br}_2$ (2)

(d) [1]

- iodine is less reactive than bromine, so it cannot displace bromine (1)

ALLOW iodine is below bromine in Group VII

Worked solution

(a) In Group VII, reactivity decreases down the group, so chlorine is more reactive than bromine. A more reactive halogen displaces a less reactive halogen from a solution of its halide. So chlorine takes the place of bromine in the compound and bromine is released.

(b) The chlorine ends up as chloride in sodium chloride, and bromine is set free: chlorine + sodium bromide → sodium chloride + bromine.

(c) Halogens are diatomic, so chlorine is Cl_2 and bromine is Br_2 . Sodium bromide is NaBr and sodium chloride is NaCl. One Cl_2 molecule contains two chlorine atoms, so it needs two NaBr: $\text{Cl}_2 + 2\text{NaBr} \rightarrow 2\text{NaCl} + \text{Br}_2$. Check: 2 Cl, 2 Na and 2 Br on each side.

(d) Iodine is below bromine in Group VII, so it is less reactive than bromine. A less reactive halogen cannot displace a more reactive one, so iodine would not react with the bromide ions.

11 Supplement Arrangement of elements

[1]

Answer: A

Worked solution

To identify a trend from given information, put the elements in order of proton number (this is their order down the group) and see how the other property changes. Magnesium 12 → calcium 20 → strontium 38 → barium 56, while the reaction with water changes from very slow to very rapid. So the rate of reaction, and therefore the reactivity, increases down Group II as proton number increases. This is the same direction as the trend in Group I.

12 Core Arrangement of elements

[1]

Answer: D

Worked solution

Across a period, the character of the elements changes from metallic to non-metallic. Metals conduct electricity; most non-metals, including solid non-metals such as sulfur, do not. Since Q is a non-conducting solid, it must be a non-metal, so it lies towards the right-hand side of Period 3. Of the options, only Group VI is on the non-metal side. Sodium (Group I), magnesium (Group II) and aluminium (Group III) are all metals and conduct electricity.

13 Core Arrangement of elements

[1]

Answer: B

Worked solution

Chemical reactions involve the electrons in the outer shell. Fluorine is 2,7 and chlorine is 2,8,7, so both atoms have seven outer electrons and each gains one electron to form a 1⁻ ion. This is why they react in similar ways. The number of shells, protons and neutrons are all different for the two elements.

14 Core Group I properties

[1]

Answer: C

Worked solution

Use the general trends in Group I to predict the properties of an element further down: melting point decreases and reactivity increases going down the group. Francium is at the bottom, well below potassium, so francium should melt at a lower temperature and react even more violently than potassium.

Answer: B

Worked solution

The halogen trends are the opposite of Group I for reactivity: in Group VII reactivity decreases down the group (chlorine is the most reactive of the three, iodine the least). Density increases down the group, which fits the change from a gas (chlorine) to a liquid (bromine) to a solid (iodine).

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Mark scheme

(a)(i) [1]

- 2+ (1)

| **ALLOW** Ca²⁺ / +2

(a)(ii) [1]

- 3+ (1)

| **ALLOW** Al³⁺ / +3

(b) [2]

- the ions are positive (1)
- the charge is equal to the group number (1)

(c) [1]

- Group V (1)

| **ALLOW** group 5

(d) [2]

- (an atom of) G gains two electrons (1)
- to obtain a full outer shell / eight electrons in its outer shell / a noble gas electronic configuration (1)

| **REJECT** G loses electrons / G shares electrons

Worked solution

(a) Metals in Groups I, II and III lose all of their outer electrons to form positive ions. Calcium, in Group II, loses two electrons and forms Ca²⁺. Aluminium, in Group III, loses three electrons and forms Al³⁺.

(b) For these metals the ion is always positive, and its charge is equal to the group number: Group I forms 1+ ions, Group II forms 2+ ions and Group III forms 3+ ions.

(c) Non-metals gain electrons to fill their outer shell, so the charge is negative and equals (8 – group number). A charge of 3– means three electrons were gained, so the atom had five outer electrons and the element is in Group V (nitrogen, forming N^{3–}, is an example).

(d) G (2,8,6) has six electrons in its outer shell. It needs two more electrons to fill the shell with eight, so it gains two electrons. The ion then has two more electrons than protons, giving a charge of 2–. Its configuration becomes 2,8,8, the same as the noble gas argon.

Mark scheme

(a) [1]

- L (1)

(b) [2]

Any two of:

- high density (1)
- high melting point (1)
- forms coloured compounds (1)

ALLOW quoted values, e.g. density 7.19 g/cm^3 / melting point 1907°C / compounds are green, orange or yellow

(c) [1]

- acts as a catalyst (as the element or in its compounds) (1)

ALLOW has ions with variable oxidation numbers / forms ions with different charges

REJECT properties shared by all metals, e.g. conducts electricity / shiny / malleable

(d) [1]

- low density / density less than 1 g/cm^3 / low melting point (1)

ALLOW quoted value (0.86 g/cm^3 or 63°C)

Worked solution

(a) and (b) Transition elements are metals with high densities, high melting points and coloured compounds. Metal L has by far the highest density (7.19 g/cm^3) and melting point (1907°C) in the table, and it is the only metal whose compounds are coloured, so L is the transition element. (It is chromium.)

(c) The other typical property of transition elements is that they often act as catalysts, both as the elements themselves and in their compounds. Properties such as conducting electricity are true of all metals, so they do not identify a transition element.

(d) Group I metals are relatively soft metals with low melting points and low densities. J has a density of only 0.86 g/cm^3 (less than water) and melts at just 63°C , which fits a Group I metal. (It is potassium.)

Mark scheme

(a)(i)

[1]

- pale yellow-green gas (1)
- both colour and state needed

ALLOW greenish-yellow / yellow-green / pale green gas

(a)(ii)

[1]

- red-brown liquid (1)
- both colour and state needed

ALLOW reddish-brown / dark red / brown liquid

(a)(iii)

[1]

- grey-black solid (1)
- both colour and state needed

ALLOW black / dark grey / shiny grey solid

REJECT purple solid

(b)

[1]

- Cl_2 (1)

REJECT Cl / Cl_2 / Cl^{2-}

(c)

[1]

- (density) increases (1)

Worked solution

(a) At room temperature and pressure: chlorine is a pale yellow-green gas, bromine is a red-brown liquid and iodine is a grey-black solid. Going down the group the colour gets darker and the state changes from gas to liquid to solid. (Iodine gives a purple vapour when warmed, but the solid itself is grey-black.)

(b) Diatomic means each molecule is made of two atoms, so a chlorine molecule is Cl_2 . The same is true for the other halogens: Br_2 and I_2 .

(c) Density increases down Group VII, from chlorine gas to bromine liquid to iodine solid.

Mark scheme

(a) [1]

- (boiling point) increases (down the group / as proton number increases) (1)

(b) [2]

- sulfur (1)
- 200 °C is above its melting point (115 °C) and below its boiling point (445 °C) (1)
- second mark depends on sulfur being chosen

(c) [2]

- gas (1)
- 25 °C is above its boiling point (of –183 °C) (1)

ALLOW its boiling point is below 25 °C / below room temperature

(d) [1]

- the temperature range increases down the group / as proton number increases (1)

ALLOW the range gets larger / wider down the group

ALLOW correct ranges quoted to support a correct trend (35, 330, 464, 538 °C)

Worked solution

(a) The boiling points go from –183 °C (oxygen) to 445 °C, 685 °C and 988 °C (tellurium). Each value is higher than the one above it, so boiling point increases down Group VI.

(b) A substance is a liquid when the temperature is above its melting point but below its boiling point. At 200 °C: oxygen is a gas (200 is above its boiling point); sulfur has melted (200 > 115) but not boiled (200 < 445), so it is a liquid; selenium and tellurium have not melted yet (221 and 450 are both above 200), so they are solids. Only sulfur is a liquid.

(c) Oxygen boils at –183 °C. 25 °C is far above this, so oxygen has already boiled and is a gas at 25 °C.

(d) Work out boiling point minus melting point for each element: oxygen $-183 - (-218) = 35$ °C; sulfur $445 - 115 = 330$ °C; selenium $685 - 221 = 464$ °C; tellurium $988 - 450 = 538$ °C. The liquid range gets larger down the group.

Mark scheme

(a) [1]

- 2,8,8 (1)

| **ALLOW** 2.8.8

(b) [2]

- (argon atoms have a) full outer shell (of electrons) (1)
- so they do not need to lose, gain or share electrons / have no tendency to form bonds (1)

| **ALLOW** has eight electrons in its outer shell for the first mark

| **REJECT** full shells of electrons without reference to the outer shell for the first mark

(c) [1]

- exists as single atoms (not joined to other atoms / not as molecules) (1)

| **REJECT** has one atom in its nucleus / one electron

(d) [1]

- its (only / first) shell is full (with two electrons) (1)

| **ALLOW** its outer shell is full

Worked solution

(a) Argon has 18 electrons. The first shell holds 2, the second holds 8, and the remaining 8 go in the third shell: 2,8,8.

(b) Atoms react by losing, gaining or sharing electrons to obtain a full outer shell. An argon atom already has a full outer shell of eight electrons, so it has no tendency to lose, gain or share electrons, and it does not react.

(c) Monatomic means that the element exists as single, separate atoms rather than as molecules. The noble gases are monatomic because their atoms do not bond to each other. This is different from the halogens, which are diatomic (for example Cl₂).

(d) The first shell can hold only two electrons. Helium has two electrons, so its only shell is already full. Like the other noble gases it has no tendency to gain, lose or share electrons, so it is unreactive.

21 Core Group VII properties

[1]

Answer: A

Worked solution

To predict the properties of a halogen, apply the group trends in the right direction. Going **up** Group VII the halogens become more reactive, less dense and change from solid towards gas. Fluorine is at the top of the group, so it is the most reactive halogen, it is a gas at room temperature and it has a low density. Like every halogen it is made of diatomic molecules, F_2 .

22 Supplement Transition elements

[1]

Answer: D

Worked solution

Work out the charge on the iron ion from the known charges of the other ions: Cl^- is $1-$, SO_4^{2-} is $2-$, O^{2-} is $2-$ and S^{2-} is $2-$.

- $FeCl_2$: $2 \times (1-) = 2-$, so iron is Fe^{2+} . $FeCl_3$: $3 \times (1-) = 3-$, so iron is Fe^{3+} . Different, so D is correct.
- $FeSO_4$: one SO_4^{2-} , so iron is Fe^{2+} (same as $FeCl_2$).
- Fe_2O_3 : $3 \times (2-) = 6-$ shared between two Fe, so each is Fe^{3+} (same as $FeCl_3$).
- FeO : iron is Fe^{2+} . FeS : iron is Fe^{2+} .

Only D contains iron in two different oxidation states, which is what "variable oxidation numbers" means.

23 Core Arrangement of elements

[1]

Answer: B

Worked solution

Read the electronic configuration 2,8,8,2 in two ways. The number of occupied shells (four numbers) gives the period: Period 4. The number of electrons in the outer shell (the last number, 2) gives the group: Group II. Group II is on the left-hand side of the Periodic Table, where the metals are, and Group II metals lose their two outer electrons to form $2+$ ions. So T is a metal in Period 4 forming T^{2+} ions. (T is calcium.)

Mark scheme

(a) [2]

- L, E, J, G
- L before E before J (1)
- G last (1)

(b) [1]

- Group VI (1)

ALLOW group 6

(c) [2]

- (the elements change) from metallic to non-metallic (across the period) (1)
- evidence: L, E and J conduct electricity / form positive ions, but G (furthest right) does not conduct / forms a negative ion (1)

REJECT from non-metallic to metallic for the first mark

Worked solution

(a) In Period 3, the metals in Groups I, II and III form ions whose charge equals the group number: L (1+) is in Group I, E (2+) is in Group II and J (3+) is in Group III. G forms a 2- ion, so it has six outer electrons and is in Group VI. Across a period the proton number increases from left to right, so the order is L, E, J, G. (They are sodium, magnesium, aluminium and sulfur.)

(b) G gains two electrons to form a 2- ion, so it has six outer electrons: Group VI.

(c) Across a period the elements change from metals on the left to non-metals on the right. The table supports this: L, E and J, which are on the left, are shiny, conduct electricity and form positive ions, which are metallic properties. G, which is further right, is a dull yellow solid that does not conduct electricity and forms a negative ion, which are non-metallic properties.

Mark scheme

(a) [2]

- metal (1)
- Group II is on the left-hand side of the Periodic Table / of a period, where the metals are (1)
ALLOW elements change from metallic to non-metallic across a period and X is near the start of its period
- second mark depends on metal being chosen

(b) [1]

- $2+$ (1)
ALLOW X^{2+} / +2

(c) [1]

- XCl_2 (1)
REJECT X_2Cl / XCl

(d) [1]

- XO (1)
REJECT XO_2 / X_2O

Worked solution

(a) Across every period the elements change from metals on the left to non-metals on the right. Group II is the second column from the left, so X is a metal (it is strontium).

(b) X is in Group II. Group II metals lose their two outer electrons, so X forms X^{2+} ions.

(c) Chlorine is in Group VII and forms Cl^- ions. To balance one X^{2+} ion you need two Cl^- ions, so the formula is XCl_2 .

(d) Oxygen is in Group VI and forms O^{2-} ions. One X^{2+} ion balances one O^{2-} ion, so the formula is XO .

Mark scheme

(a) [3]

- (in order of) increasing proton number / atomic number (1)
- vertical columns are called groups (1)
- horizontal rows are called periods (1)

REJECT in order of relative atomic mass / mass number for the first mark

(b) [2]

- elements are arranged in order of proton number (not relative atomic mass) (1)
- tellurium has fewer protons (52) than iodine (53), so it comes first (1)

(c) [2]

- (Group I because) it has one electron in its outer shell (1)
- (Period 4 because) it has four occupied (electron) shells (1)

Worked solution

(a) The Periodic Table lists the elements in order of increasing proton number (atomic number). The vertical columns are groups; elements in the same group have the same number of outer electrons and similar chemical properties. The horizontal rows are periods; across a period the elements change from metals to non-metals.

(b) If the table were in order of relative atomic mass, iodine (127) would come before tellurium (128). But the order is by proton number. Tellurium has 52 protons and iodine has 53, so tellurium must come first. This order also puts iodine in Group VII with the other halogens, where its chemical properties fit.

(c) The group number equals the number of electrons in the outer shell. Potassium (2,8,8,1) has one outer electron, so it is in Group I. The period number equals the number of occupied shells. Potassium has four shells in use, so it is in Period 4.

Mark scheme

(a) [1]

- reactivity increases down the group (1)

| **ALLOW** potassium most reactive, lithium least reactive

(b) [1]

- any one observation showing a more vigorous reaction than potassium, e.g. fizzes even more rapidly / bursts into flame / explodes / reacts violently / melts / floats and moves very quickly (1)

| **REJECT** any observation suggesting a slower reaction than potassium, e.g. does not melt / fizzes steadily

(c) [2]

- sodium has a lower melting point than lithium (1)
- sodium reacts more vigorously / faster, so heat is released more quickly (1)

| **ALLOW** sodium is more reactive than lithium for the second mark

(d) [1]

- they are less dense than water / have low densities (1)

| **ALLOW** density less than 1 g/cm³

Worked solution

(a) Going from lithium to sodium to potassium, the fizzing gets faster and the reaction more violent, ending with potassium bursting into flame. So reactivity increases down Group I.

(b) Rubidium is below potassium, so it should react even more violently. Suitable predictions include: it fizzes even more rapidly than potassium, it bursts into flame, or it explodes.

(c) The reaction of a Group I metal with water releases heat. Two differences explain why sodium melts but lithium does not. First, melting point decreases down Group I, so sodium (98 °C) melts at a lower temperature than lithium (181 °C). Second, sodium is more reactive than lithium, so it reacts faster and releases heat more quickly, making the metal hotter.

(d) Anything that floats on water is less dense than water. So these three metals all have low densities, lower than that of water. They are unusual metals, being relatively soft with low densities and low melting points.

Mark scheme

(a)

[2]

- solid (1)
- melting point increases down the group, so astatine's melting point is above 114 °C / above room temperature (1)

ALLOW the state changes from gas to liquid to solid down the group, and iodine is already a solid

- second mark depends on solid being chosen

(b)

[1]

- any value from 220 °C to 450 °C (1)

(c)

[2]

- no reaction / astatine would not react (1)
- astatine is less reactive than iodine / reactivity decreases down the group, so astatine cannot displace iodine (1)
- second mark depends on no reaction being predicted

Worked solution

(a) The melting points increase down the group: -101 °C, -7 °C, 114 °C. Astatine is below iodine, so its melting point should be even higher than 114 °C. Room temperature (about 20–25 °C) is well below this, so astatine should be a solid.

(b) The boiling points increase down the group, and each step is larger than the one before: from chlorine to bromine the rise is 93 °C, and from bromine to iodine it is 125 °C. The next rise should be larger again, perhaps about 150 °C, giving a boiling point for astatine of about 330 °C. Any sensible value clearly above 184 °C that follows this pattern is a good prediction.

(c) Reactivity decreases down Group VII, so astatine is less reactive than iodine. A halogen can only displace a halogen that is less reactive than itself. Astatine cannot displace iodine from potassium iodide, so there is no reaction.

Mark scheme

(a) [1]

- chlorine, bromine, iodine (1)

(b) [2]

- bromine is more reactive than iodine, so it displaces iodine (from potassium iodide) (1)
- bromine is less reactive than chlorine, so it cannot displace chlorine (from potassium chloride) (1)

(c) [2]

- correct formulae: Br_2 , KI, KBr, I_2 (1)
- correctly balanced: $\text{Br}_2 + 2\text{KI} \rightarrow 2\text{KBr} + \text{I}_2$ (1)

IGNORE state symbols

ALLOW $\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$ (2)

(d) [1]

- iodine (1)

ALLOW I_2

REJECT iodide

Worked solution

(a) Chlorine displaced both bromine and iodine, so it is the most reactive. Bromine displaced iodine but not chlorine, so it is in the middle. Iodine displaced neither, so it is the least reactive. Order: chlorine > bromine > iodine.

(b) A halogen displaces a less reactive halogen from its halide. Bromine is more reactive than iodine, so it pushes iodine out of potassium iodide. Bromine is less reactive than chlorine, so it cannot push chlorine out of potassium chloride and there is no change.

(c) Bromine is Br_2 and iodine is I_2 (halogens are diatomic). Potassium iodide is KI and potassium bromide is KBr. One Br_2 needs two KI: $\text{Br}_2 + 2\text{KI} \rightarrow 2\text{KBr} + \text{I}_2$. Check: 2 Br, 2 K and 2 I on each side.

(d) The iodine released makes the solution brown. (The potassium bromide formed is colourless in solution.) Note that iodide ions are colourless; it is the element iodine that is coloured.

Mark scheme

(a)(i) [1]

- FeO (1)

(a)(ii) [1]

- Fe₂O₃ (1)

(b) [1]

- Fe²⁺ (1)

ALLOW Fe+2

REJECT Fe³⁺ / Fe²⁻

(c) [2]

- CuCl: copper(I) chloride (1)
- CuCl₂: copper(II) chloride (1)

REJECT copper chloride without an oxidation number

(d) [1]

- iron forms ions with more than one charge / different oxidation numbers (Fe²⁺ and Fe³⁺) (1)

ALLOW iron has variable oxidation numbers

Worked solution

(a) The Roman numeral in the name gives the oxidation number, which equals the charge on the iron ion. Oxide ions are O²⁻. Iron(II) is Fe²⁺: one Fe²⁺ balances one O²⁻, giving FeO. Iron(III) is Fe³⁺: two Fe³⁺ (total 6+) balance three O²⁻ (total 6-), giving Fe₂O₃.

(b) In iron(II) chloride the iron has oxidation number +2, so the ion is Fe²⁺. (The compound is FeCl₂.)

(c) Chloride ions are Cl⁻. In CuCl, one Cl⁻ balances one copper ion, so copper is Cu⁺ with oxidation number +1: copper(I) chloride. In CuCl₂, two Cl⁻ ions balance one copper ion, so copper is Cu²⁺ with oxidation number +2: copper(II) chloride.

(d) Sodium, a Group I metal, only ever forms Na⁺ ions. Iron, a transition element, can form ions with different charges, Fe²⁺ and Fe³⁺, so it has variable oxidation numbers. This is a typical property of transition elements.