Revision practice

AQA · GCSE · Chemistry

Original open focus revision; complete specification coverage remains unfinished.

1 Atoms, elements and compounds: read the chemical symbols

- element
- compound

■ Question 1

Which substance is a compound?

- Water, H_2O
- Oxygen, O_2
- Helium, He

Available marks: 2.

Worked answer

Water, H_2O

- Symbols use an uppercase first letter and, where present, a lowercase second letter: Co is cobalt, whereas CO is carbon monoxide. For the first twenty elements learn H hydrogen, He helium, Li lithium, Be beryllium, B boron, C carbon, N nitrogen, O oxygen, F fluorine, Ne neon, Na sodium, Mg magnesium, Al aluminium, Si silicon, P phosphorus, S sulfur, Cl chlorine, Ar argon, K potassium and Ca calcium. Group 1 also includes Rb rubidium, Cs caesium and Fr francium; Group 7 includes F fluorine, Cl chlorine, Br bromine, I iodine and At astatine. Use the supplied periodic table for other specified elements, including Fe iron, Cu copper and Zn zinc. Very radioactive francium and astatine are names to interpret from the table, not school reaction specimens.

■ Question 2

How many oxygen atoms are represented by four formula units of $Ca(OH)_2$?

Available marks: 4.

Worked answer

8 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A molecule can contain only one element, and some compounds form lattices rather than separate molecules. Heating a mixture to separate it is not automatically a chemical reaction. New substances, rather than an energy change alone, establish chemical change.

exercises.lol exercises.com.cn

2 Balance equations by conserving each element

- coefficient
- reactant

■ Question 1

Which equation conserves Mg and O atoms?

- $2Mg + O_2 \rightarrow 2MgO$
- $Mg + O_2 \rightarrow MgO$
- $Mg + O_2 \rightarrow MgO_2$ for magnesium oxide

Available marks: 2.

Worked answer

$2Mg + O_2 \rightarrow 2MgO$

- Begin with the actual substance formulae and make an element-count table. Change coefficients to equalize the count for each element. Never change MgO to MgO_2 just to balance oxygen: that would identify a different substance. For hydrogen burning, $2H_2 + O_2 \rightarrow 2H_2O$ conserves four hydrogen atoms and two oxygen atoms. State symbols, when required, distinguish solid (s), liquid (l), gas (g) and aqueous solution (aq).

■ Question 2

In $4Al + 3O_2 \rightarrow 2Al_2O_3$, how many oxygen atoms are represented on either side?

Available marks: 4.

Worked answer

6 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A balanced equation cannot be obtained by changing a product formula or deleting an element. A coefficient of one is normally omitted. Equal atom counts do not mean equal numbers of molecules, and a balanced equation alone does not establish that a reaction occurs under all conditions.

3 Higher Tier: conserve charge in ionic and half equations

- half equation
- spectator ion

exercises.lol exercises.com.cn

■ Question 1

Which half equation balances both Mg atoms and charge?

- $Mg \rightarrow Mg^{2+} + 2e^-$
- $Mg + 2e^- \rightarrow Mg^{2+}$
- $Mg \rightarrow Mg^{2+} + e^-$

Available marks: 2.

Worked answer

$Mg \rightarrow Mg^{2+} + 2e^-$

- In the magnesium half equation, the right-hand total charge is $+2 - 2 = 0$, matching neutral Mg. In copper reduction, $+2 - 2 = 0$ on the left, matching neutral copper. Neutralization can be represented as $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$; the net charge is zero on each side. Electron numbers must match when combining half equations so no free electrons remain in the overall reaction.

■ Question 2

How many electrons are released when three Al atoms each form Al^{3+}?

Available marks: 4.

Worked answer

9 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Electrons appear on the product side for oxidation and the reactant side for reduction. Spectator ions are chemically present even though omitted from the net equation. This Higher-only treatment does not make common-tier atom counting, isotope calculations or relative atomic mass Higher-only.

4 Separate insoluble solids and recover dissolved solutes

- residue
- filtrate

■ Question 1

After filtering sand mixed with salt water, where is the dissolved salt?

- In the filtrate
- All trapped as dry residue
- Converted into a new element

Available marks: 2.

Worked answer

exercises.lol exercises.com.cn

In the filtrate

- For sand mixed with salt, add water and stir to dissolve the salt, filter the insoluble sand, then gently evaporate some water from the filtrate. Stop concentration before boiling dry and allow the solution to cool; filter and dry the crystals. Washing the sand removes adhering solution, and washing crystals with a little cold suitable solvent removes some surface impurity while limiting dissolution.

■ Question 2

A mixture initially contains 12.0 g salt; 9.0 g dry salt is recovered. Calculate percentage recovery.

Available marks: 4.

Worked answer

75 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Filtering salt solution does not remove dissolved salt. Crystallisation changes physical arrangement, not the chemical identity of the solute. A wet recovered mass overestimates dry solid mass. Heating every solution to dryness is not a universal purification method because some substances decompose.

5 Choose distillation or chromatography from the mixture

- distillate
- chromatography

■ Question 1

Which method is suitable for collecting water from salt solution?

- Simple distillation
- Filtration alone
- A magnet alone

Available marks: 2.

Worked answer

Simple distillation

- Paper chromatography separates soluble components according to their different distributions between the moving solvent and the paper. Draw the baseline in pencil above the solvent level, place a small sample spot and let solvent rise. Components that spend more time in the mobile phase generally travel farther under these conditions. Compare spots with known standards using the same solvent and paper; a single spot alone does not prove purity under every possible method.

exercises.lol exercises.com.cn

■ Question 2

A dye travels 24 mm and the solvent front 40 mm from the baseline. Calculate Rf.

Available marks: 4.

Worked answer

0.6

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A condenser liquefies vapour; it does not filter salt. Fractional distillation concerns boiling-point differences, not density ranking. A chromatogram baseline under solvent can let the sample dissolve directly into the reservoir. The method does not create new dye substances.

6 Atomic models change when evidence challenges predictions

- nuclear model
- alpha particle

■ Question 1

What best explains rare large deflections of positive alpha particles?

- A tiny dense positively charged nucleus
- Positive charge uniformly filling the whole atom
- No charge anywhere in the atom

Available marks: 2.

Worked answer

A tiny dense positively charged nucleus

- The nuclear model replaced diffuse positive charge with a dense nucleus and electrons outside it. Bohr added electrons at specific distances or energy levels; his theoretical predictions agreed with observations. Later work identified positively charged protons. Chadwick provided evidence for uncharged neutrons in the nucleus about twenty years after the nuclear idea became accepted. A scientific model can develop further without every earlier observation becoming wrong.

■ Question 2

In an illustrative sample, 12 of 24,000 alpha tracks return backwards. Calculate the percentage.

Available marks: 4.

Worked answer

0.05 %

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Most particles passing through does not mean atoms have no mass. Backscattering is rare because the dense nucleus occupies little space, not because most nuclei are negatively charged. Shell diagrams are models and do not show electrons following observable miniature planetary tracks.

7 Proton number identifies the element; electrons determine net charge

- atomic number
- ion

■ Question 1

Which count establishes an element's identity?

- Protons
- Electrons alone for every ion
- Protons plus electrons

Available marks: 2.

Worked answer

Protons

- Net relative charge = proton number − electron number. Losing electrons produces a positive ion; gaining electrons produces a negative ion. Ordinary chemical ion formation changes electrons, not the nucleus. An atom with eleven protons is sodium even when it has ten electrons; its net charge is +1. A model with ten protons is neon, regardless of a similar electron arrangement.

■ Question 2

A particle has 12 protons and 10 electrons. Calculate its net relative charge.

Available marks: 4.

Worked answer

2

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Atomic number is not the sum of every particle and cannot be read from electron count for an ion. Neutrality does not mean the proton and electron charges are individually zero. Neutrons affect mass and isotope identity without contributing to the net electric charge.

exercises.lol exercises.com.cn

8 Isotopes, ions and the scale of the nucleus

- isotope
- mass number

■ Question 1

What differs between chlorine-35 and chlorine-37 atoms?

- Neutron number
- Proton number
- Element symbol

Available marks: 2.

Worked answer

Neutron number

- In nuclide notation the upper-left number is A and the lower-left is Z. Protons=Z; neutrons=A−Z. A neutral atom has Z electrons; a positive ion has lost electrons and a negative ion has gained them. Chlorine-35 and chlorine-37 both have Z=17, with 18 and 20 neutrons respectively. Their mass numbers differ without a change in proton number.

■ Question 2

A magnesium-25 atom has atomic number 12. How many neutrons does it contain?

Available marks: 4.

Worked answer

13 neutrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Mass number is an integer particle count, whereas relative atomic mass is an abundance-weighted mean. Ions differ in electrons, isotopes in neutrons. Dividing two radii gives a length ratio; the volume ratio is different. Do not place neutrons outside the nucleus in a shell diagram.

9 Relative atomic mass: weight each isotope by its abundance

- relative atomic mass
- isotope abundance

exercises.lol exercises.com.cn

■ Question 1

Why is the weighted mean closer to the more abundant isotope's mass?

- That isotope contributes more atoms to the sample
- Its atoms contain fractional protons
- The rarer isotope is ignored completely

Available marks: 2.

Worked answer

That isotope contributes more atoms to the sample

- For a model chlorine sample containing 75% chlorine-35 and 25% chlorine-37, Ar=(35×75+37×25)/100=35.5. The mean is closer to 35 because that isotope is more abundant. An ordinary unweighted mean would give 36 and incorrectly treat both abundances as equal. Ar is a relative quantity without a gram unit; it is not the mass number of an individual atom.

■ Question 2

A fictional sample has 60% mass-10 and 40% mass-11. Calculate its relative atomic mass.

Available marks: 4.

Worked answer

10.4

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A percentage is divided by 100 once, not twice. Isotope abundance is not the proportion of neutrons inside a nucleus. A changing mean in different samples can reflect a different isotope mixture; it does not show that a single atom acquired a fractional neutron.

10 Electronic structure of the first twenty elements

- electron shell
- electronic structure

■ Question 1

Which is the electronic structure of a neutral calcium atom, Z=20?

- 2,8,8,2
- 2,8,10
- 2,8,8

Available marks: 2.

exercises.lol exercises.com.cn

Worked answer

2,8,8,2

- The first twenty arrangements are H 1; He 2; Li 2,1; Be 2,2; B 2,3; C 2,4; N 2,5; O 2,6; F 2,7; Ne 2,8; Na 2,8,1; Mg 2,8,2; Al 2,8,3; Si 2,8,4; P 2,8,5; S 2,8,6; Cl 2,8,7; Ar 2,8,8; K 2,8,8,1; Ca 2,8,8,2. Verify every sum against the neutral atom's proton number. This simplified sequence should not be extrapolated to every later element or used to claim the third shell can never contain more than eight.

■ Question 2

A neutral chlorine atom has structure 2,8,7. How many electrons are present altogether?

Available marks: 4.

Worked answer

17 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The second number in 2,8,6 is a count, not an electron charge or radius. Filling an outer shell while leaving an available inner level empty is incorrect for these ground-state atoms. Helium is stable with two electrons in its only shell; a full outer shell does not always mean eight.

11 Periodic positions follow proton number and electron structure

- group
- period

■ Question 1

Where does the main-group atom 2,8,7 belong in AQA notation?

- Period 3, Group 7
- Period 7, Group 3
- Period 2, Group 8

Available marks: 2.

Worked answer

Period 3, Group 7

- Group 1 atoms tend to lose one outer electron and form +1 ions; Group 7 atoms can gain one to form −1 ions. Predict similar reaction types within a group, then use the group-specific trend for relative reactivity. Helium has two outer electrons in a full first shell and belongs with Group 0, not Group 2. Hydrogen is an unusual

exercises.lol exercises.com.cn

non-metal and should not be described as an alkali metal simply from its printed position.

■ Question 2

How many occupied shells does a neutral atom with structure 2,8,8,1 have?

Available marks: 4.

Worked answer

4 shells

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A group is vertical and a period horizontal. Similar properties do not mean identical reaction rates. Outer-shell count is not always the printed modern 1–18 group number, and the simplified first-twenty rule must not be applied indiscriminately to every column.

12 Mendeleev: gaps and testable predictions

- prediction
- atomic weight

■ Question 1

What supported Mendeleev's gaps?

- Later elements matched predicted properties
- He ordered the elements strictly by atomic mass
- He used the proton numbers of all the elements

Available marks: 2.

Worked answer

Later elements matched predicted properties

- Later discoveries filled gaps with elements whose properties agreed with the predictions, supporting the classification. Modern order follows atomic number rather than relative atomic mass. Isotopes explain why average mass need not rise strictly with proton number: different isotope masses and abundances influence the mean. The historical improvement was evidence-based prediction, not knowledge of electron shells that had yet to be discovered.

■ Question 2

Find the midpoint of fictional densities 4.0 and 6.0 g/cm^3.

Available marks: 4.

Worked answer

exercises.lol exercises.com.cn

5 g/cm^3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Mendeleev did not arrange by known proton number. Leaving gaps was a reasoned prediction rather than accidental omission. Isotopes help explain mass-order anomalies; they do not imply the same element occupies several different proton-number positions.

13 Metals and non-metals: properties, position and ions

- metal
- non-metal

■ Question 1

How does a sodium atom form Na^+?

- It loses one electron
- It gains one proton
- It gains one electron

Available marks: 2.

Worked answer

It loses one electron

- Sodium, 2,8,1, loses its outer electron to form Na^+. Chlorine, 2,8,7, gains one to form Cl^-. Oppositely charged ions can form a compound. Non-metal atoms also share electrons in covalent molecules, rather than always becoming isolated negative ions. Characteristic property patterns have exceptions: graphite conducts electricity and mercury is a liquid metal. Use more than one line of evidence.

■ Question 2

How many electrons are lost when six neutral sodium atoms each form Na^+?

Available marks: 4.

Worked answer

6 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Losing negative electrons makes an ion positive. Metals do not lose protons during normal chemical reactions. Non-metal does not mean gas, and shiny appearance alone is insufficient evidence. The simplified GCSE ion classification describes the reactions in scope rather than every possible ion in advanced chemistry.

exercises.lol exercises.com.cn

14 Group 0: stable shells and boiling-point predictions

- noble gas
- boiling point

■ Question 1

Why is helium stable in this GCSE model?

- Its first shell is full with two electrons
- It has eight electrons outside its nucleus
- It has no electrons

Available marks: 2.

Worked answer

Its first shell is full with two electrons

- Neon is 2,8 and argon 2,8,8. Compare these stable structures with an alkali metal's one outer electron or a halogen's seven. Unreactivity and boiling point are different properties: a rising boiling point does not imply rising chemical reactivity. Given trend data, predict an ordering; a trend alone rarely determines an exact numerical value for an unmeasured element.

■ Question 2

Using rounded values −246 °C and −186 °C, calculate the boiling-point increase.

Available marks: 4.

Worked answer

60 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Noble gases are generally unreactive, not incapable of any reaction under any conditions. Helium belongs in Group 0 with two outer electrons. Boiling separates physical particles and does not remove electrons from atomic shells.

15 Group 1: reactions of lithium, sodium and potassium

- alkali metal
- shielding

■ Question 1

Why does Group 1 reactivity increase down the group?

- The outer electron is farther away and more shielded, so is lost more easily
- The atoms gain an electron more easily as they get larger
- The nucleus has fewer protons, so it holds the electrons less tightly

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

The outer electron is farther away and more shielded, so is lost more easily

- With oxygen, these metals tarnish and burn to form oxygen-containing solids; lithium burns crimson, sodium yellow and potassium lilac. The simple oxide model uses $4Li + O_2 \rightarrow 2Li_2O$; sodium and potassium burning products can include peroxide or superoxide, so do not invent a single oxide formula for every demonstration. Reactivity increases Li→Na→K because the outer electron is farther from the nucleus and more shielded by inner shells, so it is lost more easily despite increased nuclear charge.

■ Question 2

In $2K + 2H_2O \rightarrow 2KOH + H_2$, how many H_2 molecules correspond to ten K atoms?

Available marks: 4.

Worked answer

5 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The larger nuclear charge alone does not explain the down-group trend: distance and shielding matter. Group 1 reactions are not all identical in appearance. A purple flame is not evidence that potassium chloride itself is a purple solid, and a water-reaction equation must include hydrogen.

16 Group 7: molecules, compounds and opposite trends

- halogen
- diatomic molecule

■ Question 1

Which comparison is correct?

- Chlorine is more reactive than iodine, while iodine has the higher boiling point
- Iodine is more reactive than chlorine, and chlorine has the higher boiling point
- Chlorine is less reactive than iodine, and iodine has the lower boiling point

Available marks: 2.

Worked answer

Chlorine is more reactive than iodine, while iodine has the higher boiling point

- A halogen gains an electron to form a -1 halide ion when reacting with a metal, giving an ionic salt such as NaCl. With non-metals it generally forms covalent compounds through shared electron pairs, such as HCl. Down the group the outer

exercises.lol exercises.com.cn

shell is farther from the nucleus and more shielded, reducing attraction for an incoming electron despite greater nuclear charge. This is the opposite reactivity trend to Group 1, which loses an electron.

■ Question 2

Using iodine Ar=127, calculate the relative molecular mass of I_2.

Available marks: 4.

Worked answer

254

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A halogen element and its halide ion have different electron counts and properties. Chlorine, Cl_2, is not written as Cl^-. A rising boiling point does not establish a rising rate of electron gain. Solid sodium chloride is white even though chlorine gas is green.

17 Halogen displacement: predict before observing

- displacement reaction
- halide ion

■ Question 1

Which pair produces a displacement reaction?

- Chlorine with potassium iodide solution
- Iodine with potassium chloride solution
- Bromine with potassium chloride solution

Available marks: 2.

Worked answer

Chlorine with potassium iodide solution

- A displacement table should identify the added halogen, starting halide and expected product before recording colour. Bromine in water is orange/brown and iodine solutions can appear brown; observation must be compared with suitable blanks, because the added halogen also has colour. Same-halogen/halide combinations have no net displacement. A missing colour change alone may also reflect low concentration or observation limits.

■ Question 2

For $Cl_2 + 2KI \rightarrow 2KCl + I_2$, how many I_2 molecules correspond to six KI formula units?

Available marks: 4.

exercises.lol exercises.com.cn

Worked answer

3 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Displacement releases the less reactive halogen, not the more reactive one. A metal-ion spectator does not establish the reactivity order. Do not claim all orange solutions contain bromine without considering the starting reagents and reference observations. The separate HT ionic-equation lesson extends the both-tier prediction.

18 Chemistry-only: transition metals compared with Group 1

- transition metal
- density

■ Question 1

Which comparison is typical for the specified transition metals versus Group 1?

- Higher density and melting point, lower reactivity
- Lower density and melting point, higher reactivity
- Higher density, lower melting point and similar reactivity

Available marks: 2.

Worked answer

Higher density and melting point, lower reactivity

- Iron can react with steam under suitable conditions and can rust slowly in oxygen and water; copper does not react with cold water in the Group 1 manner. Many transition metals react with oxygen or halogens when heated, so less reactive does not mean incapable of reaction. Compare the same conditions and specify whether an observation is rapid burning, slow corrosion or no visible change.

■ Question 2

A supplied metal density is 8.0 g/cm^3 and its volume 3.0 cm^3. Calculate its mass.

Available marks: 4.

Worked answer

24 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The listed differences are typical comparisons, not universal laws for every metal. Density and hardness name different properties. Transition metals can react with halogens, and lack of an immediate cold-water reaction does not prove no reaction under different conditions.

exercises.lol exercises.com.cn

19 Chemistry-only: variable ions, colours and catalysts

- catalyst
- variable charge

Question 1

Why must iron's charge be specified when forming a chloride formula?

- Fe^{2+} and Fe^{3+} require different chloride ratios
- Every iron ion has zero charge
- Chloride ions can be omitted from a neutral salt

Available marks: 2.

Worked answer

Fe^{2+} and Fe^{3+} require different chloride ratios

- Catalysts increase reaction rate without being used up overall. Iron catalyses the Haber process; nickel is used in hydrogenation; manganese dioxide catalyses hydrogen peroxide decomposition. A catalyst changes the route and rate, not the balanced reaction's overall atom count. Variable charges require matching negative-ion charge: $FeCl_2$ contains Fe^{2+} and $FeCl_3$ contains Fe^{3+} with Cl^- in each case.

Question 2

How many Cl^- ions balance the charge of two Fe^{3+} ions?

Available marks: 4.

Worked answer

6 ions

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Many does not mean every transition compound is coloured or every metal has every charge. A catalyst may take part in intermediate steps while being regenerated overall. Its presence does not increase the theoretical amount of product from a fixed limiting reactant or prove an equilibrium composition has changed.

20 Particles, bonding and bulk properties

- ionic bond
- delocalized electron

exercises.lol exercises.com.cn

Question 1

Why does molten sodium chloride conduct?

- Its ions can move
- Its atoms become electrons
- Its molecules contain no charge

Available marks: 2.

Worked answer

Its ions can move

- To explain a bulk property, name the structure, particles, forces and mobile charge carriers. Simple molecular substances can have strong covalent bonds inside molecules but weak attractions between molecules.

Question 2

An atom has atomic number 17 and mass number 35. Find its number of neutrons.

Available marks: 4.

Worked answer

18

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Melting a simple molecular substance usually overcomes intermolecular attractions; it does not require breaking all covalent bonds within each molecule.

21 Three strong bonds: identify the attracted particles

- ionic bonding
- metallic bonding

Question 1

Which explanation identifies metallic bonding?

- Attraction between positive metal ions and delocalised electrons
- Attraction between positive ions and negative ions
- Shared pairs of electrons between metal atoms

Available marks: 2.

Worked answer

Attraction between positive metal ions and delocalised electrons

- Most non-metal elements and compounds of non-metals have covalent bonding, but their structures can be small molecules, very large molecules or giant networks. An ionic bond is the attraction after ion formation, not the electron transfer itself. A

exercises.lol exercises.com.cn

covalent pair is shared, not transferred completely to one nucleus. Metal electrons are free to move through the structure rather than assigned to one pair of atoms.

■ Question 2

How many O^{2-} ions balance three Mg^{2+} ions?

Available marks: 4.

Worked answer

3 ions

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Strong covalent bonds do not guarantee a high boiling point for a small-molecule substance, because boiling usually separates molecules rather than atoms. An ionic compound is not a collection of independent MgO molecules. Electrons are negative in all three bonding accounts.

22 Ionic dot-and-cross diagrams: transferred electrons and charges

- dot-and-cross diagram
- electron transfer

■ Question 1

What belongs in a final $MgCl_2$ outer-electron diagram?

- One Mg^{2+} and two Cl^- ions with completed outer shells
- One Mg^+ and one Cl^+
- One neutral Mg atom sharing two pairs with one Cl

Available marks: 2.

Worked answer

One Mg^{2+} and two Cl^- ions with completed outer shells

- Draw final ions in separate square brackets, with charges outside. A dot-and-cross diagram uses different marks for electrons originating from different atoms; transferred electrons keep their original marks. Mg^{2+} has no electrons left in its original third shell, while O^{2-} has six original outer electrons plus two transferred ones. If only outer electrons are shown, state whether the remaining filled shell of the cation is omitted by that convention.

exercises.lol exercises.com.cn

■ Question 2

How many electrons are transferred when five Mg atoms each form Mg^{2+}?

Available marks: 4.

Worked answer

10 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

An ion has the same proton number as its original atom. Do not write Na^{2+} just because two sodium ions appear, or put the transferred electron halfway between final ions as though it were covalently shared. A full shell in these ion examples does not change the element into the noble gas.

23 Giant ionic lattices: formulae and model limits

- ionic lattice
- empirical formula

■ Question 1

What does NaCl specify for the giant structure?

- A simplest 1:1 ratio of sodium and chloride ions
- Molecules made of one sodium and one chlorine atom
- One sodium atom sharing a pair with one chlorine

Available marks: 2.

Worked answer

A simplest 1:1 ratio of sodium and chloride ions

- To infer an empirical formula, count ions in a stated representative region and reduce the ratio to the smallest whole numbers. A model with six Mg^{2+} and twelve Cl^{-} gives $MgCl_2$ after reducing 6:12 to 1:2. Counts in an arbitrary boundary fragment need not themselves give the bulk ratio, so use the representative information or account for shared positions as specified. Knowledge of other named ionic crystal structures is not required.

■ Question 2

A representative region contains 10 magnesium ions and 20 chloride ions. After reducing to one magnesium, how many chloride ions remain in the ratio?

Available marks: 4.

Worked answer

2

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not count sticks as electron pairs in an ionic ball-and-stick model. Ions attract several neighbours rather than only the one from which an electron came. A simple lattice slice is a representation of a three-dimensional giant structure, not evidence that the real crystal is a flat sheet.

24 Shared pairs: hydrogen, chlorine, oxygen and nitrogen

- covalent bond
- lone pair

■ Question 1

How many shared pairs join the two nitrogen atoms in N_2?

- Three
- One
- Two

Available marks: 2.

Worked answer

Three

- Oxygen has six outer electrons, so O_2 has two shared pairs, a double bond, and two lone pairs on each atom. Nitrogen has five outer electrons, so N_2 has three shared pairs, a triple bond, and one lone pair on each atom. A line diagram writes H–H, Cl–Cl, H–Cl, O=O or N≡N. One line represents one shared pair, not one electron.

■ Question 2

How many shared electrons are present in the double bond of O_2?

Available marks: 4.

Worked answer

4 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A double bond contains four shared electrons, not two. A chlorine atom's six unshared electrons must not disappear just because a line diagram omits them. These simple electron pictures are models, not a claim that electron positions are fixed dots or that a bond is a literal rod.

exercises.lol exercises.com.cn

25 Water, ammonia, methane and larger covalent structures

- polymer
- repeat unit

■ Question 1

Which description of ammonia's outer-electron diagram is correct?

- Three shared pairs and one lone pair on nitrogen
- Four shared pairs and no lone pairs on nitrogen
- Three shared pairs and two lone pairs on nitrogen

Available marks: 2.

Worked answer

Three shared pairs and one lone pair on nitrogen

- Covalent substances can consist of small molecules, very large molecules such as polymers, or giant networks such as diamond and silicon dioxide. A polymer has many repeated units linked along each molecule: $[–CH_2–CH_2–]_n$ represents poly(ethene), with bonds passing through brackets and n large. A giant network diagram shows only a small part of continuing covalent connections, not a separate molecule with that exact pictured atom count.

■ Question 2

A simplified polymer contains 30 C_2H_4 repeat units. How many carbon atoms are in those units?

Available marks: 4.

Worked answer

60 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A lone pair is not a spare hydrogen or an additional bond. Do not apply molecular formula counting to a clipped giant network without understanding its continuation. The number n is a count of repeat units, not a charge or an electron shell number. Polymer formation is developed further in Organic chemistry.

26 Metallic bonding: a giant structure with mobile electrons

- delocalised electron
- electrostatic attraction

exercises.lol exercises.com.cn

■ Question 1

Which particles carry current through a solid metal?

- Delocalised electrons
- Positive ions drifting through the wire
- Neutral molecules with no charged particles

Available marks: 2.

Worked answer

Delocalised electrons

- The shared electrons extend throughout the structure, so shifting layers can preserve attraction and allow bending. When a potential difference is applied, mobile electrons carry charge; the positive ions remain in their positions in a solid rather than drifting through the wire. The drawing's ions and electron symbols are a model of the bulk bonding, not isolated metal ions mixed with a separate substance.

■ Question 2

A stated magnesium model has ten atoms contributing two electrons each. How many electrons are delocalised?

Available marks: 4.

Worked answer

20 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The metal does not have a net positive charge simply because the drawing labels positive ion centres. Electrons are delocalised, not lost from the entire piece. Electrical conductivity in a solid metal is different from ion mobility in molten salt. Do not use the sodium model to assign one free electron to every metal atom universally.

27 States and changes: energy overcomes particle attractions

- melting
- condensation

■ Question 1

At 40 °C, a substance with melting point 5 °C and boiling point 90 °C is normally in which state?

- Liquid
- Solid
- Gas

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

Liquid

- Stronger relevant forces require more energy to overcome and commonly give higher melting and boiling points. Identify the particles and forces before explaining: boiling a molecular liquid overcomes intermolecular attractions, while melting an ionic lattice overcomes strong ion attractions. Bulk properties belong to large collections, not an individual atom that is itself a tiny piece of solid or liquid. At a transition temperature more than one state can coexist.

■ Question 2

A substance melts at −5 °C and boils at 75 °C. Calculate the temperature span of its liquid interval.

Available marks: 4.

Worked answer

80 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A gas is not always invisible empty space without particles. Particles do not expand into larger atoms when heated. A single atom has no melting point in the bulk-material sense. Temperature need not rise throughout heating when energy is used in a change of state.

28 Higher Tier: what the solid-sphere particle model omits

- particle model
- model limitation

■ Question 1

Which missing feature prevents a sphere-only model explaining different boiling temperatures?

- Forces between particles
- A brighter colour for every sphere
- A larger page margin

Available marks: 2.

Worked answer

Forces between particles

- Without attractions, the drawing cannot explain energy needed to separate particles or the different melting and boiling temperatures of substances. Treat the

exercises.lol exercises.com.cn

balls as symbols for particles, not literal hard miniature pieces of bulk material. A model may succeed at showing close liquid particles while needing an extended force account to explain boiling. Individual particles do not acquire the substance's bulk hardness or melting point.

■ Question 2

A drawing changes from 16 to 22 spheres with no particles entering. How many excess spheres have been introduced?

Available marks: 4.

Worked answer

6 particles

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Saying only that the model is unrealistic gives no specific limitation. A force-free model cannot explain different attraction strengths, but this does not make every spacing inference invalid. The specification's explicit evaluation clause is Higher-only; ordinary state predictions remain both-tier.

29 State symbols: aqueous is a solution, not a pure liquid

- aqueous solution
- state symbol

■ Question 1

Which notation represents sodium chloride dissolved in water?

- NaCl(aq)
- NaCl(l) by definition
- NaCl(g) by definition

Available marks: 2.

Worked answer

NaCl(aq)

- For an aqueous precipitation reaction, $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$ distinguishes the new solid from dissolved substances. Magnesium reacting with acid can be written $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$. Correct state labels add evidence about the reaction while the coefficients still conserve atoms.

exercises.lol exercises.com.cn

■ Question 2

In $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$, how many distinct species entries are labelled aqueous?

Available marks: 4.

Worked answer

2 species

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Aqueous does not mean the solute has melted. A precipitate is solid even while surrounded by liquid. State symbols do not change an element symbol or balance a wrong equation. A state must be checked against the supplied temperature, pressure and solvent information.

30 Ionic properties: strong lattices and mobile ions

- mobile ion
- electrical conductivity

■ Question 1

Why does molten sodium chloride conduct?

- Its ions can move and carry charge
- All its ions become neutral atoms
- It becomes a metal with one shared pair per atom

Available marks: 2.

Worked answer

Its ions can move and carry charge

- The carrier is an ion, not a free electron travelling through the salt. Dissolution separates ions into the solution; it does not simply melt the salt. Not every ionic compound is readily soluble, so explain aqueous conductivity only when a dissolved sample is specified. High melting point supports a strong giant structure, while state-dependent conductivity strengthens the ionic interpretation.

■ Question 2

Two supplied currents are 0.24 A and 0.08 A. Calculate their ratio, larger/smaller.

Available marks: 4.

Worked answer

3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

exercises.lol exercises.com.cn

Solid ionic compounds still contain charged ions. Melting does not produce delocalised metallic electrons. Conductivity data must state the sample's form; testing an insoluble powder in water does not establish the properties of a genuinely dissolved solution.

31 Small molecules: distinguish bonds from intermolecular forces

- intermolecular force
- small molecule

■ Question 1

What is mainly overcome when a typical molecular liquid boils?

- Attractions between molecules
- Every covalent bond inside each molecule
- The bonds holding protons inside nuclei

Available marks: 2.

Worked answer

Attractions between molecules

- For comparable molecules, intermolecular forces generally increase with molecular size, so larger molecules tend to have higher melting and boiling points. Molecular shape and other interactions also matter; a size trend is not an exact universal temperature rule. A compound such as hydrogen chloride can form ions on dissolving, so the pure molecular substance and its reacting aqueous solution must be distinguished.

■ Question 2

A supplied related series has boiling points −20 °C and 15 °C. Calculate the increase.

Available marks: 4.

Worked answer

35 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Low boiling point does not mean weak covalent bonds. Molecules are usually electrically neutral overall, not devoid of protons and electrons. Dissolving a molecular solute does not always create ions, while a chemical reaction with water can change which particles are present.

exercises.lol exercises.com.cn

32 Polymers: long molecules and attractions between chains

- polymer chain
- covalent backbone

■ Question 1

Which diagram feature supports identifying a polymer?

- Many repeated units linked along a very large molecule
- A single free sodium ion
- A formula consisting only of one isolated atom

Available marks: 2.

Worked answer

Many repeated units linked along a very large molecule

- Distinguish bonds along a chain from attractions between separate chains. The size of polymer molecules gives many opportunities for intermolecular attraction. A simplified chain picture helps explain the solid material, but real polymer properties also depend on chain arrangement and other structural features. Do not replace intermolecular attractions with a claim that every neighbouring chain is necessarily joined by covalent bonds.

■ Question 2

Two model chains each contain 25 C_2H_4 repeat units. How many carbon atoms are in the stated units altogether?

Available marks: 4.

Worked answer

100 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The label n is not an atom symbol. Polymer molecules can be long while the material contains many separate chains. A drawn dotted attraction between chains is different from a line representing a covalent backbone bond. This lesson's simple solid-polymer model does not claim all polymer materials have identical softening temperatures.

33 Giant covalent structures: connections continue through the solid

- giant covalent structure
- silicon dioxide

exercises.lol exercises.com.cn

■ Question 1

Why does silica have a very high melting point?

- Many strong covalent connections in its giant structure must be overcome
- Only weak attractions between small SiO_2 molecules exist
- It is made of larger protons

Available marks: 2.

Worked answer

Many strong covalent connections in its giant structure must be overcome

- In silicon dioxide, each silicon is linked to four oxygens and each oxygen bridges two silicons, producing the overall Si:O ratio 1:2. A local drawing may show four surrounding oxygens because each is shared with another silicon elsewhere in the network. Graphite has strongly bonded layers but weaker attractions between layers; its high-temperature behaviour and layer sliding concern different connections.

■ Question 2

A representative silica region contains 18 silicon atoms. At the Si:O ratio 1:2, how many oxygen atoms does it contain?

Available marks: 4.

Worked answer

36 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Giant structure does not mean giant individual atoms. Melting a covalent network differs from boiling a small molecular substance because the relevant connections differ. Not all giant covalent substances are electrical insulators: graphite is a key exception with delocalised electrons.

34 Metals and alloys: distort the layers to resist sliding

- alloy
- hardness

■ Question 1

Why can an alloy be harder than its pure metal?

- Different-sized atoms disrupt layers and hinder sliding
- The atoms form strong covalent bonds between the layers
- The delocalised electrons are removed from the structure

Available marks: 2.

exercises.lol exercises.com.cn

Worked answer

Different-sized atoms disrupt layers and hinder sliding

- Different-sized atoms distort the regular layers and make sliding more difficult, so many alloys are harder than the corresponding pure metal. Hardness is resistance to indentation or scratching, while strength concerns resisting deformation or failure under a load; do not treat the words as identical measurements. An alloy still has metallic bonding and need not have one fixed compound formula.

■ Question 2

A supplied hardness rises from 50 to 80 units. Calculate the percentage increase.

Available marks: 4.

Worked answer

60 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

An alloy is a mixture, not automatically a new compound with fixed proportions. Added atoms hinder sliding without removing all delocalised electrons. A layer model omits real defects and three-dimensional detail, and high melting point is typical rather than universal for metals.

35 Metal conduction: electrons transfer charge and thermal energy

- thermal conduction
- charge carrier

■ Question 1

What explains electrical conduction in a solid copper wire?

- Mobile delocalised electrons carry charge
- Copper ions stream from one end to the other
- Covalent molecules melt before current can flow

Available marks: 2.

Worked answer

Mobile delocalised electrons carry charge

- Electrical conduction is transfer of charge; thermal conduction is transfer of energy from a hotter region toward a cooler region. Do not confuse electron drift with the whole wire moving or with electrons being permanently consumed. A metal can conduct thermal energy without being part of an electric circuit. The two explanations share mobile electrons but refer to different observations.

exercises.lol exercises.com.cn

■ Question 2

A supplied record shows 0.90 C passing in 3.0 s. Calculate charge-transfer rate.

Available marks: 4.

Worked answer

0.3 C/s

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Metals do not need mobile negative ions to conduct. Electron charge remains negative during heat transfer, and thermal energy is not itself a new particle substance added to the wire. Conductivity can change with temperature and composition, so geometry alone does not fix a universal value.

36 Diamond: four bonds per carbon in a rigid network

- diamond
- rigid network

■ Question 1

Why does diamond not conduct electricity?

- It has no delocalised electrons available to carry charge
- It contains no electrons at all
- Its carbon atoms are permanently positively charged

Available marks: 2.

Worked answer

It has no delocalised electrons available to carry charge

- Explain one property with the appropriate connection: resistance to deformation follows the rigid many-direction network; high melting point follows energy needed to overcome many strong covalent bonds; non-conductivity follows the absence of mobile charged carriers. A drawing with a carbon surrounded by four neighbours shows local coordination, not a complete diamond molecule.

■ Question 2

A boundary-free model has 40 carbon sites with four connections each. Dividing shared bond-end counts by two, how many bonds are represented?

Available marks: 4.

Worked answer

80 bonds

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

exercises.lol exercises.com.cn

Diamond is not an ionic lattice of carbon ions. The atoms do not become larger or lose their electrons entirely. An actual finite fragment has boundaries, so the bond-count formula needs the stated interior-equivalent assumption. No claim about current experimental high-pressure melting conditions is required for this GCSE structure explanation.

37 Graphite: strong layers, weak interlayer attractions and mobile electrons

- graphite
- hexagonal ring

■ Question 1

What explains graphite layers sliding?

- Weak attractions between layers without covalent bonds joining them
- Weak covalent bonds holding the atoms together within each layer
- Strong ionic bonds that break easily between the layers

Available marks: 2.

Worked answer

Weak attractions between layers without covalent bonds joining them

- Do not use weak interlayer forces to explain the high melting point: that property involves strong covalent bonding. Conversely, naming strong covalent bonds alone does not explain easy layer sliding. Graphite resembles metals in having delocalised electrons, but its bonding network is layered covalent rather than metallic. Conductivity directions in real graphite are not represented fully by one simple flat drawing.

■ Question 2

In the stated graphite model, 55 carbon atoms each contribute one delocalised electron. How many are represented?

Available marks: 4.

Worked answer

55 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Graphite does not have four covalent neighbours per carbon like diamond. Weak layer attractions are not absent attraction altogether. A cut edge in a model has fewer drawn neighbours and should not be treated as evidence against the interior three-bond pattern.

exercises.lol exercises.com.cn

38 Graphene: one strong conducting carbon layer

- graphene
- composite

■ Question 1

Which description identifies graphene?

- A single hexagonal carbon layer with delocalised electrons
- A hollow sphere of sixty separate sodium ions
- A three-dimensional four-bond diamond network

Available marks: 2.

Worked answer

A single hexagonal carbon layer with delocalised electrons

- A composite combines materials so their useful properties can contribute to a designed product. Graphene can reinforce a material, but strength claims need actual data for the particular composite, loading and manufacturing method. Conductivity supports electronic applications without proving every graphene-containing product is automatically a good conductor. A drawn lattice edge is a clipped boundary, not the full bulk bonding environment.

■ Question 2

A supplied load rises from 60 N to 75 N. Calculate the percentage increase.

Available marks: 4.

Worked answer

25 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Graphene is not a stack of many layers and is not the same as a hollow C_{60} molecule. A high-strength carbon sheet does not mean every graphene composite has diamond's hardness. Property explanations and commercial performance evidence answer different questions.

39 Fullerenes and nanotubes: hollow carbon shapes and uses

- fullerene
- carbon nanotube

exercises.lol exercises.com.cn

■ Question 1

Which description matches a carbon nanotube?

- A long hollow cylindrical fullerene
- A single flat sheet with no hollow geometry
- An ionic lattice of C^+ and C^-

Available marks: 2.

Worked answer

A long hollow cylindrical fullerene

- A hollow molecular cage can be considered for carrying other substances in proposed delivery systems; nanotubes can be used as reinforcing fibres and in electronic materials. A use must be linked to supplied properties and tested for suitability. Do not claim every nanotube has identical conductivity or that a proposed medical use is automatically safe or effective. Graphene is a sheet, graphite stacked layers and a fullerene a hollow shape.

■ Question 2

A model nanotube is 1.5 micrometres long and 3.0 nm wide. Calculate length/diameter.

Available marks: 4.

Worked answer

500

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A hollow shape does not make every fullerene an empty container safe for any use. C_{60} is a molecular formula, not a polymer repeat label. Diagrams of cylinders need an explicit schematic label unless actual carbon bonds and topology are correctly shown.

40 Chemistry-only: nano sizes and surface-area-to-volume ratio

- nanoparticle
- surface-area-to-volume ratio

■ Question 1

How does area/volume change when cube side becomes ten times smaller?

- It becomes ten times larger
- It becomes ten times smaller
- It remains unchanged

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

It becomes ten times larger

- For a cube side L, area=$6L^2$, volume=L^3 and area/volume=6/L. Reducing side length tenfold raises area/volume tenfold. Nanoparticles can have different properties from the same bulk material because a much larger fraction interacts at the surface. More exposed area can improve catalytic effectiveness per mass, but particle shape, aggregation and surface chemistry also affect performance.

■ Question 2

Using area/volume=6/L, find the ratio for a cube of side 20 nm.

Available marks: 4.

Worked answer

0.3 per nm

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A high surface ratio does not mean a larger total mass. Prefix conversion can change an answer by factors of a thousand. Atom radius versus diameter must be stated in a comparison; the worked ratio explicitly compares length with radius. All risks and properties cannot be inferred from size alone.

41 Chemistry-only: evaluate a nanoparticle application from evidence

- nanotechnology
- exposure route

■ Question 1

Which conclusion is justified by lower mass achieving the same trial outcome?

- Lower quantity was needed in this stated trial; safety still needs evidence
- Every possible exposure route is now proven to be harmless
- All bulk versions of the substance should immediately be banned

Available marks: 2.

Worked answer

Lower quantity was needed in this stated trial; safety still needs evidence

- Consider useful performance, required quantity, cost and durability alongside possible human exposure, environmental release and uncertain long-term effects. Risk depends on the material, particle form, exposure route and amount. A contained particle in a product and an inhalable loose powder need separate exposure evi-

exercises.lol exercises.com.cn

dence. A proposed benefit is not proof of safety, while a possible risk is not proof that harm occurs at every dose.

■ Question 2

A fictional application reduces required mass from 2.0 g to 0.50 g. Calculate the percentage reduction.

Available marks: 4.

Worked answer

75 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not infer clinical effectiveness from a classroom surface calculation. Evaluate the provided data rather than claiming nano always means better or more dangerous. A conclusion can identify a promising function while requiring stronger exposure or disposal evidence before wider use.

42 Amounts, equations and limiting reagents

- mole
- limiting reagent

■ Question 1

Which step comes first in a reacting-mass calculation?

- Compare masses without an equation
- Use a balanced equation and convert mass to amount
- Assume every mole ratio is 1:1

Available marks: 2.

Worked answer

Use a balanced equation and convert mass to amount

- Calculate the amount available for each reactant and divide by its coefficient. The smaller ratio limits the reaction. Use that reactant to calculate the maximum product before comparing actual yield.

■ Question 2

Calculate amount in 5.0 g of a substance with molar mass 100 g per mole.

Available marks: 4.

Worked answer

0.05 mol

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Excess acid means acid does not limit the stated calculation. A coefficient of 2 before HCl does not double the hydrogen amount.

43 Conservation of mass: count the complete system

- conservation of mass
- system boundary

■ Question 1

What does the 2 before H_2O in a balanced equation mean?

- Two whole water molecules or formula amounts
- Two oxygen atoms in each water molecule
- A different compound with formula H_2O_2

Available marks: 2.

Worked answer

Two whole water molecules or formula amounts

- For $2H_2 + O_2 \rightarrow 2H_2O$, the coefficient 2 multiplies an entire formula. The subscript 2 belongs to the preceding element, so one water molecule contains two H atoms and one O atom. Both sides contain four H atoms and two O atoms. Using supplied relative atomic masses H=1 and O=16 gives reactant totals $2\times2 + 32 = 36$ and product total $2\times18=36$. The coefficients 2:1:2 are not gram ratios.

■ Question 2

A closed model reaction starts with 6 g and 9 g of reactants. One product weighs 11 g. Find the other product mass.

Available marks: 4.

Worked answer

4 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Conservation does not mean that every individual substance keeps its own mass. Reactants are converted into products. Altering a subscript to balance an equation changes the substance, whereas changing a coefficient changes the number of particles. Include material crossing the system boundary before calling a result a failure of conservation.

exercises.lol exercises.com.cn

44 Relative formula mass and the mass percentage of an element

- relative formula mass
- mass percentage

■ Question 1

Which expression gives Mr of $Ca(OH)_2$ using Ca=40, O=16 and H=1?

- 40+2×(16+1)
- 2×(40+16+1)
- 40+16+2

Available marks: 2.

Worked answer

40+2×(16+1)

- An element's percentage by mass is its total relative mass contribution divided by Mr, multiplied by 100. Calcium contributes 40 of the 74 units in $Ca(OH)_2$, giving 40/74×100=54.1% to three significant figures. Oxygen contributes 32 and hydrogen 2. These percentages describe the compound's fixed mass proportions, not the proportion of different atoms counted equally.

■ Question 2

With Ar C=12 and O=16, calculate the oxygen percentage by mass in CO_2 to three significant figures.

Available marks: 4.

Worked answer

72.7 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not multiply the whole formula by an internal subscript. A coefficient belongs to an equation amount, not the Mr of one formula unit. Percentages should total about 100, allowing rounding. A formula mass is not automatically a measured sample mass, and percentage by mass differs from percentage of atoms.

45 An open vessel: explain mass entering or escaping as gas

- open system
- thermal decomposition

exercises.lol exercises.com.cn

■ Question 1

Why can magnesium oxide weigh more than the starting magnesium?

- Oxygen from the surroundings becomes part of the oxide
- Magnesium atoms are created during heating
- Heat itself becomes additional magnesium

Available marks: 2.

Worked answer

Oxygen from the surroundings becomes part of the oxide

- Identify which material is on the balance at each reading. In the metal example, oxygen joins the weighed solid; in the carbonate example, gas leaves the weighed apparatus. In particle terms the same atoms are redistributed among substances, with some crossing the selected system boundary. A sealed-system total includes all products; an open-residue measurement does not.

■ Question 2

A carbonate sample starts at 25 g and leaves 14 g oxide. Assuming gas is the only lost material, find its mass.

Available marks: 4.

Worked answer

11 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A gas has mass even if it is invisible. Mass gain does not imply extra magnesium atoms were created. Cooling before weighing reduces temperature-related weighing problems. If apparatus mass changes or solid is spilled, the simple gas-only explanation needs revision rather than being forced to fit the result.

46 Repeated measurements: mean, spread and estimated uncertainty

- uncertainty
- range

■ Question 1

Which calculation gives the full range?

- Highest reading minus lowest reading
- Mean divided by number of readings
- Lowest reading minus mean

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

Highest reading minus lowest reading

- For 2.40, 2.42 and 2.44 g, the mean is 2.42 g and the full range is 0.04 g. Half-range is 0.02 g, so the stated estimate is 2.42±0.02 g. Here the mean lies midway between the extremes. For an asymmetric distribution the extreme deviations from the mean differ; display the actual results as well as the chosen uncertainty estimate.

■ Question 2

Readings are 8.2, 8.4 and 8.6 g. Using half-range, estimate the uncertainty magnitude.

Available marks: 4.

Worked answer

0.2 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Uncertainty is not the same as a mistake. Zero range from a coarse instrument does not establish perfect measurement. Do not halve an instrument resolution and label it repeat range. Compare like quantities and express uncertainty in the same unit as the measured value.

47 Higher Tier: moles connect mass to stated particles

- mole
- Avogadro constant

■ Question 1

What is equal in one mole of C atoms and one mole of CO_2 molecules?

- The number of stated particles
- The sample masses
- The total number of oxygen atoms

Available marks: 2.

Worked answer

The number of stated particles

- State what is being counted. A mole of CO_2 molecules contains one mole of carbon atoms and two moles of oxygen atoms, three moles of atoms altogether. A mole of NaCl formula units corresponds to one mole of Na^+ ions and one mole of Cl^- ions in the ionic lattice. Calling either sample simply a mole of particles without specifying which particles can make an answer ambiguous.

exercises.lol exercises.com.cn

■ Question 2

Calculate the amount in 22 g CO_2 using molar mass 44 g per mol.

Available marks: 4.

Worked answer

0.5 mol

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A mole is a counting amount, not a fixed gram mass for every substance. Do not use Mr as if it already contained a gram unit. The Avogadro value refers to stated particles, and multiplying by the number of atoms in each molecule is a separate step.

48 Higher Tier: use the equation ratio between two mole amounts

- mole ratio
- stoichiometry

■ Question 1

What is the first step when calculating MgO mass from Mg mass?

- Convert Mg mass into moles using its molar mass
- Multiply Mg grams by the MgO coefficient alone
- Change the formula MgO to balance the mass

Available marks: 2.

Worked answer

Convert Mg mass into moles using its molar mass

- For $2Mg + O_2 \rightarrow 2MgO$, supplied molar masses Mg=24, O_2=32 and MgO=40 g per mol give mass proportions 48:32:80. These differ from coefficients 2:1:2. A calculation from one reactant assumes sufficient other reactant and complete reaction unless the question supplies a limiting amount. If the known quantity is product mass, work backwards through the same ratio.

■ Question 2

Using $2Mg + O_2 \rightarrow 2MgO$, Mg=24 and MgO=40 g per mol, find theoretical MgO mass from 12 g Mg with excess oxygen.

Available marks: 4.

Worked answer

20 g

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Coefficients do not replace formula masses. A two-to-two coefficient ratio simplifies to one-to-one. A larger product mass can include atoms from another reactant rather than contradict conservation. The mass calculation is a theoretical prediction under stated assumptions, not proof that an experiment will recover every gram.

49 Higher Tier: derive balancing numbers from reacting masses

- balancing number
- reacting mass

■ Question 1

What should be done with a ratio 2:1.5:1?

- Multiply every term by two to get 4:3:2
- Round 1.5 up to 2 so that the ratio becomes 2:2:1
- Divide every term by 1.5 to get 1.3:1:0.7

Available marks: 2.

Worked answer

Multiply every term by two to get 4:3:2

- For Mg, O_2 and MgO with molar masses 24, 32 and 40 g per mol, supplied masses 2.4, 1.6 and 4.0 g give 0.10, 0.050 and 0.10 mol. Dividing by 0.050 gives 2:1:2, hence $2Mg + O_2 \rightarrow 2MgO$. The oxygen formula is O_2, so its molar mass is 32, not the atomic value 16.

■ Question 2

Amounts Al:O_2:Al_2O_3 are 0.4:0.3:0.2 mol. After finding the smallest whole-number ratio, give the O_2 coefficient.

Available marks: 4.

Worked answer

3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Whole-number coefficients are an equation ratio, not a demand to round every experimental amount independently. A product may contain a bracketed formula whose full molar mass must be calculated. Rearranging n=m/M gives M=m/n, but a derived M still needs the correct substance identity to interpret it.

exercises.lol exercises.com.cn

50 Higher Tier: find which reactant limits the product

- limiting reactant
- excess reactant

■ Question 1

For Mg + 2HCl → $MgCl_2$ + H_2, 0.20 mol Mg and 0.30 mol HCl are supplied. Which limits?

- HCl
- Mg
- Neither because masses are not equal

Available marks: 2.

Worked answer

HCl

- For Mg + 2HCl → $MgCl_2$ + H_2, 0.20 mol Mg would require 0.40 mol HCl. If only 0.30 mol HCl is supplied, acid limits and only 0.15 mol Mg can react. Maximum H_2 amount is 0.15 mol, and 0.05 mol Mg remains. This assumes reaction proceeds as written and does not describe incomplete conversion caused by slow rate or equilibrium.

■ Question 2

For the same reaction, 0.40 mol Mg and 0.50 mol HCl are supplied. Calculate the maximum H_2 amount.

Available marks: 4.

Worked answer

0.25 mol

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Excess means present beyond the required reacting amount, not an impurity. Adding more excess reactant alone does not raise the theoretical product after the limiting reactant is exhausted. Recovered yield can be lower than this maximum for other reasons; do not confuse limiting amount with percent recovery.

51 Solution concentration by mass: convert volume before calculating

- solute
- mass concentration

exercises.lol exercises.com.cn

■ Question 1

Which volume should be used with a concentration in grams per dm^3?

- 250 cm^3 converted to 0.250 dm^3
- 250 cm^3 treated as 250 dm^3
- Solute mass treated as a volume

Available marks: 2.

Worked answer

250 cm^3 converted to 0.250 dm^3

- For a uniformly mixed solution, the amount of solute taken is proportional to the sample volume. A 0.250 dm^3 sample of an 8.0 grams per dm^3 solution contains 2.0 g solute. The unit calculation cancels dm^3 and leaves grams. This shared-tier numerical task is distinct from the embedded Higher-only explanation of how changing mass or solution volume changes concentration.

■ Question 2

Find solute mass in 200 cm^3 of a 15 grams per dm^3 solution.

Available marks: 4.

Worked answer

3 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not multiply concentration by a cm^3 number when the concentration uses dm^3. Dissolved solute is still present even if invisible. A concentration is not the total mass of the bottle, and equal solution volumes need not contain equal solute masses when concentrations differ.

52 Higher Tier: explain how mass and volume change concentration

- dilution
- final solution volume

■ Question 1

At fixed solute mass, what happens when final solution volume doubles?

- Concentration halves
- Concentration doubles
- Solute mass doubles automatically

Available marks: 2.

exercises.lol exercises.com.cn

Worked answer

Concentration halves

- During simple dilution with pure solvent and no losses or reaction, the solute mass stays constant. Therefore $c_1V_1=c_2V_2$ when both concentrations use the same mass units and both volumes the same volume units. The final volume includes the original sample and added solvent; it is not the volume of water added alone. Dissolution and dilution should not be confused with a chemical transformation of solute.

■ Question 2

A solution contains 6 g solute and is diluted to 0.75 dm^3. Find its mass concentration.

Available marks: 4.

Worked answer

8 g per dm^3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not say concentration always rises when volume rises: the held quantity matters. The equation assumes a uniform solution and that the stated mass is dissolved. Evaporation may also remove volatile solute, so constant solute mass must be a stated condition rather than automatically inferred.

53 Chemistry-only: percentage yield compares recovered and possible product

- actual yield
- percentage yield

■ Question 1

Which can lower recovered yield without destroying atoms?

- Product remains dissolved during separation
- Every atom loses its identity by vanishing
- Balanced equations stop conserving atoms

Available marks: 2.

Worked answer

Product remains dissolved during separation

- Recovery may be below the maximum because a reversible reaction does not go to completion, product is lost during separation, or reactants undergo side reactions. Some atoms can remain in reactants or enter unwanted products; some desired product can remain dissolved or on apparatus. Conservation concerns all atoms

exercises.lol exercises.com.cn

and substances, while yield concerns the recovered desired product.

■ Question 2

Theoretical yield is supplied as 20 g; actual dry product is 16 g. Calculate percentage yield.

Available marks: 4.

Worked answer

80 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Divide actual by theoretical, not the reverse. A yield above 100% prompts a check for wet/impure product, incorrect mass data or assumptions; it does not prove extra atoms were created. A catalyst can speed reaching a result without changing the stoichiometric maximum from fixed limiting reactants.

54 Higher Tier, Chemistry-only: derive the theoretical yield first

- theoretical yield
- complete conversion

■ Question 1

For a 1:1 mole ratio, what must be done after finding product moles?

- Multiply by the product molar mass
- Use the reactant mass unchanged
- Multiply by every atom in the equation

Available marks: 2.

Worked answer

Multiply by the product molar mass

- For $CaCO_3 \rightarrow CaO + CO_2$, the amount ratio $CaCO_3$:CaO is 1:1. Supplied molar masses are 100 and 56 g per mol. A 10.0 g $CaCO_3$ sample contains 0.100 mol and can give 0.100 mol CaO, mass 5.60 g. The other 4.40 g is theoretical carbon dioxide, so the product-residue mass is lower than the original carbonate mass even at complete conversion.

exercises.lol exercises.com.cn

■ Question 2

$CaCO_3 \rightarrow CaO + CO_2$ has molar masses 100 and 56 g per mol for $CaCO_3$ and CaO. Find theoretical CaO mass from 25 g pure $CaCO_3$.

Available marks: 4.

Worked answer

14 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A smaller solid residue is not itself low yield when gas is an expected product. Impure starting material changes the available reactant mass. Do not use the actual product mass to calculate the theoretical amount and then claim an independent yield result.

55 Chemistry-only: atom economy follows the balanced reaction

- atom economy
- by-product

■ Question 1

Which quantity is needed for atom economy?

- Coefficient-weighted relative masses from the balanced equation
- Only the mass of dry product recovered in the experiment
- The reaction time and the percentage yield

Available marks: 2.

Worked answer

Coefficient-weighted relative masses from the balanced equation

- For $CaCO_3 \rightarrow CaO + CO_2$ with relative masses 100, 56 and 44, choosing CaO as desired product gives $56/100\times100=56\%$. Choosing CO_2 as the desired product for a different purpose gives 44%. Conservation still accounts for all 100 mass units. A high atom economy can reduce waste and raw-material cost, but it does not alone establish safety, energy demand or commercial suitability.

■ Question 2

Desired-product relative-mass contribution is 84 and total reactant contribution is 120. Find atom economy.

Available marks: 4.

Worked answer

70 %

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not use recovered product mass in the atom-economy formula. Do not omit a reactant just because it is a gas. High yield cannot remove a stoichiometric by-product. If a by-product has a use, that may improve the pathway's practical value, but keep the stated desired-product definition explicit.

56 Higher Tier, Chemistry-only: choose a reaction pathway from several criteria

- reaction pathway
- process criterion

■ Question 1

What makes a pathway choice justified?

- Comparing supplied criteria against the stated production priority
- Always selecting the largest atom-economy number alone
- Assuming every by-product has a profitable market

Available marks: 2.

Worked answer

Comparing supplied criteria against the stated production priority

- Imagine route A with atom economy 90%, yield 50% and a slow rate, and route B with atom economy 70%, yield 90% and a faster rate under supplied comparable conditions. Neither percentage alone decides every use. If equal starting mass could theoretically enter product according to these fractions, recovered desired mass per 100 g starting material is 45 g for A and 63 g for B under this simplified comparison.

■ Question 2

Under the stated mass basis, a route has 80% atom economy and 75% yield from 200 g total reactant feed. Find recovered desired-product mass.

Available marks: 4.

Worked answer

120 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Higher atom economy alone does not prove an entire process is sustainable. Toxicity, energy, separation and resource availability can matter when supplied. Keep yield and atom economy denominators separate, and avoid inventing cost or environmental facts

exercises.lol exercises.com.cn

absent from the evidence.

57 Higher Tier, Chemistry-only: concentration in moles per solution volume

- molar concentration
- aliquot

■ Question 1

Which sequence finds solute mass from molar concentration?

- n=cV, then m=nM
- m=cV without needing molar mass
- n=c/V with cm^3 left unconverted

Available marks: 2.

Worked answer

n=cV, then m=nM

- Convert cm^3 to dm^3 by dividing by 1,000. A 250 cm^3 portion of 0.20 moles per dm^3 solution contains $0.20 \times 0.250 = 0.050$ mol solute. If solute molar mass is 40 g per mol, that amount weighs 2.0 g. At fixed amount, greater final solution volume means lower molar concentration. At fixed final volume, more solute moles means higher concentration.

■ Question 2

A 200 cm^3 solution contains 0.30 mol per dm^3 solute. Calculate its amount.

Available marks: 4.

Worked answer

0.06 mol

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not substitute grams directly into c=n/V. Do not use the volume of solvent added when a final solution volume is specified. Molar concentration and mass concentration are related through molar mass, but their numerical values and units are different.

58 Higher Tier, Chemistry-only: titration concentrations follow the equation ratio

- titre
- end-point

exercises.lol exercises.com.cn

Question 1

For $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$, how is acid amount converted to NaOH amount?

- Multiply acid moles by two
- Divide acid grams by two regardless of formula
- Assume equal moles for every acid and alkali

Available marks: 2.

Worked answer

Multiply acid moles by two

- A pipette supplies the measured sample volume and a burette delivers the titre. The titre is final minus initial burette reading, not the final reading alone. Use consistent close results under the school's stated concordance rule and exclude a rough trial from the accurate mean. A suitable indicator end-point approximates the required neutralisation condition; it is not evidence that every solution must be pH 7.

Question 2

25.0 cm^3 NaOH reacts with 15.0 cm^3 of 0.200 mol per dm^3 H_2SO_4. Using the stated 1:2 ratio, find NaOH concentration.

Available marks: 4.

Worked answer

0.24 mol per dm^3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Use the correct unknown volume in the final division. Mean titres must be selected from appropriate trials; averaging a rough result can spoil an accurate calculation. Keep practical skill evidence separate from written calculations and do not invent measurements as if they were collected by students.

59 Higher Tier, Chemistry-only: gas volumes at room temperature and pressure

- molar gas volume
- room temperature and pressure

exercises.lol exercises.com.cn

■ Question 1

When do balanced coefficients give gas-volume ratios?

- For gases compared at the same temperature and pressure
- For any gases, whatever their temperature and pressure
- For gases whose masses are equal at room temperature

Available marks: 2.

Worked answer

For gases compared at the same temperature and pressure

- Equal gas amounts occupy equal volumes at identical conditions, so balanced coefficients give gaseous volume ratios. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ gives ratio 1:3:2 for gas volumes measured at the same temperature and pressure. This ratio does not apply to a liquid or solid volume. A predicted product volume assumes sufficient reactants and the stated complete-conversion model; real equilibrium can reduce conversion.

■ Question 2

At RTP, find the volume of 8.8 g CO_2 using molar mass 44 g per mol and 24 dm^3 per mol.

Available marks: 4.

Worked answer

4.8 dm^3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The number 24 is not a universal gas volume at every temperature and pressure. Coefficients concern gas volume only under matched conditions. Equal gas volumes can have different masses, and a reduction in total gas volume does not mean atoms disappeared.

60 Redox and electrolysis

- oxidation
- reduction

■ Question 1

What happens to Cu^{2+} at the cathode?

- It gains electrons
- It loses two protons
- It gains neutrons

Available marks: 2.

exercises.lol exercises.com.cn

Worked answer

It gains electrons

- Predict products using the specified electrolyte and electrode material. In an aqueous solution, hydrogen or oxygen may form because water-related species compete. Molten salts contain only the ions of the salt.

■ Question 2

How many moles of electrons reduce 0.20 mol of Cu^{2+} to copper?

Available marks: 4.

Worked answer

0.4 mol

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Electrode signs depend on the cell type. In an electrolytic cell the cathode is negative; reduction remains the defining process at a cathode in every cell.

61 Titration and a defensible concentration

- titre
- equivalence point

■ Question 1

Why rinse the pipette with the solution it will transfer?

- To avoid dilution by residual water
- To create more moles of analyte
- To make the solution neutral

Available marks: 2.

Worked answer

To avoid dilution by residual water

- Calculate the known amount first, apply the stoichiometric ratio, then divide by the unknown solution volume in cubic decimetres. Use concordant titres as required by the school method and report the accepted values.

■ Question 2

Burette readings are 1.40 and 23.65 cubic centimetres. Calculate titre.

Available marks: 4.

Worked answer

22.25 cm^3

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Adding distilled water to the flask changes volume but not the transferred amount of analyte. Do not average a rough titre with carefully measured concordant values.

62 Metal oxides: oxidation gains oxygen, reduction loses it

- oxidation by oxygen gain
- reduction by oxygen loss

■ Question 1

In $2CuO + C \rightarrow 2Cu + CO_2$, which substance is reduced?

- Copper oxide, because it loses oxygen
- Carbon, because it gains oxygen
- Carbon dioxide, because it contains oxygen

Available marks: 2.

Worked answer

Copper oxide, because it loses oxygen

- For $2CuO + C \rightarrow 2Cu + CO_2$, copper oxide loses oxygen and is reduced, while carbon gains oxygen and is oxidised. The same oxygen atoms leave the oxide and appear in carbon dioxide. The two changes occur together in this reaction. Oxygen is an element; oxide is a compound containing oxygen with another element, so the names are not interchangeable.

■ Question 2

A metal starts at 4.5 g and gives 7.5 g oxide without losses. Find oxygen mass gained.

Available marks: 4.

Worked answer

3 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Reduction does not mean every mass decreases, and oxidation does not mean every colour change. The common-tier oxygen account is distinct from the wider electron definition taught in the separate HT lesson. Some redox changes involve no oxygen and therefore need that other definition.

exercises.lol exercises.com.cn

63 The reactivity series: compare reactions at room temperature

- reactivity series
- positive ion

Question 1

Which listed metal does not release hydrogen from dilute hydrochloric acid under the stated conditions?

- Copper
- Magnesium
- Zinc

Available marks: 2.

Worked answer

Copper

- Potassium, sodium and lithium react vigorously with cold water to produce hydroxides and hydrogen, with potassium generally most vigorous. Calcium also reacts, producing hydrogen and calcium hydroxide. Magnesium reacts very slowly with cold water, while zinc, iron and copper show no appreciable reaction under this school comparison. With dilute hydrochloric or sulfuric acid, Mg, Zn and Fe produce hydrogen, with Mg more vigorous and Fe slower; Cu does not. Very reactive alkali metals are not student acid-test samples.

Question 2

A supervised model test collects 48 cm^3 gas in 80 s. Find mean collection rate.

Available marks: 4.

Worked answer

0.6 cm^3 per s

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

No visible reaction does not mean a substance can never react under any condition. A protective layer or unequal surface area can affect observations. Hydrogen and carbon are comparison positions, not metals. Do not mix the source's room-temperature scope with magnesium-steam reactions.

64 Displacement evidence: build a consistent metal order

- displacement reaction
- comparison control

exercises.lol exercises.com.cn

■ Question 1

Zinc displaces iron, and iron displaces copper. Which order fits?

- Zn > Fe > Cu
- Cu > Fe > Zn
- Fe > Cu > Zn

Available marks: 2.

Worked answer

Zn > Fe > Cu

- For supplied results, translate each successful displacement into a comparison arrow: A displaces B implies A>B. Combine comparisons into an order and check for contradictions. If A displaces B and B displaces C, A>B>C is consistent. Lack of visible reaction alone needs care because an unsuitable method, protective layer or short observation time can hide a reaction.

■ Question 2

A supplied deposit model could give 15 g metal; 12 g is recovered. Find percentage recovery.

Available marks: 4.

Worked answer

80 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A metal cannot normally displace itself to produce a net change. Do not call the solution deposit the newly formed more reactive metal. Half and ionic equations belong to the separate HT treatment; the common-tier displacement conclusion can be explained using compounds and the series.

65 Extracting metals: carbon can reduce suitable metal oxides

- native metal
- metal extraction

■ Question 1

Which oxide is suitable for the stated carbon-reduction rule?

- An oxide of a metal less reactive than carbon
- Every oxide regardless of metal reactivity
- Aluminium oxide because aluminium is above carbon

Available marks: 2.

exercises.lol exercises.com.cn

Worked answer

An oxide of a metal less reactive than carbon

- For $2CuO + C \rightarrow 2Cu + CO_2$, copper oxide is reduced and carbon oxidised in oxygen terms. Carbon cannot be assumed to reduce every metal oxide under useful extraction conditions. Aluminium is more reactive than carbon and its extraction uses electrolysis, not simply this copper-oxide route. Detailed blast-furnace process recall is not required by this section's stated limits.

■ Question 2

A supplied ore contains 5% recoverable metal. Find that metal mass in 360 kg ore before losses.

Available marks: 4.

Worked answer

18 kg

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Native means occurring as the elemental metal, not merely being dug from a mine. Oxygen loss identifies oxide reduction; lower ore mass alone does not. A process may be chemically possible while poor economically or environmentally under supplied conditions.

66 Higher Tier: displacement as electron loss and gain

- oxidation by electron loss
- reduction by electron gain

■ Question 1

In $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$, which species gains electrons?

- Cu^{2+}
- Zn^{2+} after it has formed
- Neutral Zn

Available marks: 2.

Worked answer

Cu^{2+}

- Check both atom counts and total charge. The combined left charge is +2 and the right charge is +2. Zinc atoms become positive ions by losing electrons; copper ions become neutral metal atoms by accepting them. Identify the actual species reduced, Cu^{2+}, rather than saying the already-neutral copper product gains further electrons.

exercises.lol exercises.com.cn

■ Question 2

How many electrons are released when four Al atoms each become Al^{3+}?

Available marks: 4.

Worked answer

12 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Oxidation and reduction occur together in the overall electron transfer. Positive-ion formation by a metal is electron loss, not loss of protons. Electrons cancel from the full reaction but remain useful in each half equation. This entire source section is Higher-only.

67 Acids with metals: choose the salt and hydrogen products

- acid–metal reaction
- iron(II) salt

■ Question 1

Which products are expected from zinc and dilute sulfuric acid?

- Zinc sulfate and hydrogen
- Zinc chloride and oxygen
- Zinc carbonate and water

Available marks: 2.

Worked answer

Zinc sulfate and hydrogen

- The metal must be suitable relative to hydrogen. Copper does not normally release hydrogen from these dilute acids. Do not extend this acid–metal pattern to nitric acid or concentrated acid reactions, which are outside the stated scope and can produce different outcomes. With a metal oxide, the usual products are salt and water instead of hydrogen.

■ Question 2

In $Fe + 2HCl \rightarrow FeCl_2 + H_2$, how many HCl molecules react with six represented Fe atoms?

Available marks: 4.

Worked answer

12 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

exercises.lol exercises.com.cn

Not every acid–solid reaction releases hydrogen. Carbonates release carbon dioxide, while many bases produce water. Salt formulae need correct ion charges. Common-tier product prediction remains separate from the embedded Higher-only electron redox interpretation.

68 Higher Tier: hydrogen ions are reduced in acid–metal reactions

- hydrogen ion
- net ionic reaction

■ Question 1

Which species is reduced when Mg reacts with dilute hydrochloric acid?

- H^+
- Mg atoms
- Spectator Cl^-

Available marks: 2.

Worked answer

H^+

- Charge is +2 on both sides of the net equation. Two H^+ ions are needed to form one H_2 molecule; gaining one electron each makes their total gain two electrons. The metal product is an ion, while the hydrogen product is a neutral diatomic molecule. Electron gain must be assigned to hydrogen ions, not to chloride ions just because hydrochloric acid was used.

■ Question 2

How many electrons reduce twelve H^+ ions to hydrogen molecules?

Available marks: 4.

Worked answer

12 electrons

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Hydrogen gas formation is reduction in this account, even though no oxygen has been removed. Oxidation does not mean gaining positive charge by adding protons. This embedded HT explanation does not make common-tier salt names and product equations HT-only.

exercises.lol exercises.com.cn

69 Neutralisation: select products and balance salt charges

- base
- alkali

■ Question 1

Which products form when calcium carbonate reacts with hydrochloric acid?

- Calcium chloride, water and carbon dioxide
- Calcium chloride and hydrogen only
- Calcium oxide, water and chlorine

Available marks: 2.

Worked answer

Calcium chloride, water and carbon dioxide

- Use charges to make a neutral formula: Cu^{2+} and $SO_4{}^{2-}$ give $CuSO_4$; Mg^{2+} and $NO_3{}^-$ give $Mg(NO_3)_2$. $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$ is balanced. $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ has two chloride ions per calcium ion and one carbon dioxide molecule per carbonate formula unit.

■ Question 2

How many nitrate ions $NO_3{}^-$ balance the charge of four Mg^{2+} ions?

Available marks: 4.

Worked answer

8 ions

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Water is a product of oxide/hydroxide neutralisation, while carbonate neutralisation also produces carbon dioxide. A base need not dissolve in water to react with acid. A salt's name depends on both ions, and the polyatomic-ion subscript inside its own formula must not be altered to balance charge.

70 Required Practical 1: prepare pure, dry soluble salt crystals

- crystallisation
- excess insoluble solid

■ Question 1

Why filter after adding excess copper oxide?

- To remove unused insoluble oxide while salt solution passes through
- To keep the dissolved copper sulfate on the filter paper
- To speed up the reaction between the acid and the oxide

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

To remove unused insoluble oxide while salt solution passes through

- Allow cooling and filter to remove excess insoluble oxide. The filtrate contains dissolved copper sulfate, so it passes through filter paper. Gently concentrate it in an evaporating basin using a water bath or electric heater, then allow cooling to form crystals. Separate the crystals and dry gently as directed. Evaporating completely to dryness is not the crystal-preparation endpoint.

■ Question 2

An empty vessel weighs 22.30 g and vessel plus dry crystals weighs 26.85 g. Find crystal mass.

Available marks: 4.

Worked answer

4.55 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Filtration removes excess solid, not the dissolved salt. Heating concentrates the solution; cooling promotes crystals rather than a new neutralisation reaction. A written sequence and fabricated observations do not establish that RP1 was completed: retain the student's actual supervised work and records.

71 The pH scale and hydrogen–hydroxide neutralisation

- pH scale
- neutralisation

■ Question 1

Which supplied pH identifies an alkaline solution on the stated school scale?

- 11
- 7
- 3

Available marks: 2.

Worked answer

11

- Neutralisation between acid and alkali forms water: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$. The positive and negative charges cancel, and atoms are conserved. Excess acid after mixing leaves the solution acidic; excess alkali leaves it alkaline. Neutralisation does not automatically mean that equal volumes of every pair of solutions will

exercises.lol exercises.com.cn

produce pH 7.

■ Question 2

A particle model has 15 H^+ and 9 OH^- ions. After complete neutralisation, how many excess H^+ ions remain?

Available marks: 4.

Worked answer

6 ions

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A neutral solution contains ions; neutral does not mean ion-free. Alkali is not the same word as any insoluble base. A pH difference is not a simple gram-mass difference, and the tenfold hydrogen-concentration interpretation is in the separate HT strong/weak-acid lesson.

72 Chemistry-only Required Practical 2: measure reacting volumes

- titration
- concordant titres

■ Question 1

Which reading gives a titre?

- Final burette reading minus initial reading
- Final reading alone regardless of the start
- The water volume used to rinse the flask

Available marks: 2.

Worked answer

Final burette reading minus initial reading

- Titre equals final burette reading minus initial reading. Read the appropriate meniscus at eye level, with the burette vertical and the filling funnel removed. A rough trial locates the endpoint; subsequent careful trials supply an accurate mean under the school's stated concordance rule. Phenolphthalein is pink in alkali and becomes permanently colourless at the handbook's acid-into-alkali endpoint. Universal indicator is unsuitable for a sharply defined accurate endpoint.

exercises.lol exercises.com.cn

Question 2

A trial starts at 2.35 cm^3 and finishes at 22.70 cm^3. Find the titre.

Available marks: 4.

Worked answer

20.35 cm^3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not average the rough trial automatically or read only the final burette value. Adding water to the flask does not change the amount of pipetted solute if nothing is lost. Written methods are preparation/review; they do not replace the student's actual titration performance.

73 Higher Tier, Chemistry-only: determine acid concentration from RP2 data

- known concentration
- titration concentration

Question 1

For $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$, how do acid and alkali amounts relate?

- Acid amount is half alkali amount
- Acid amount is twice alkali amount
- They always have equal amounts

Available marks: 2.

Worked answer

Acid amount is half alkali amount

- The acquired handbook PDF page 35 correctly states the equation and the 2:1 ratio, but prints a reversed half-mole statement afterwards. The correct inference is acid moles = half alkali moles. The balanced equation gives the correct amount relationship. The common-tier RP2 task still concerns accurate reacting volumes, while this numerical determination is Higher-only.

Question 2

An inferred H_2SO_4 concentration is 0.150 mol per dm^3. With molar mass 98 g per mol, find its mass concentration.

Available marks: 4.

Worked answer

14.7 g per dm^3

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not multiply the alkali amount by two for this acid. Do not use centimetre-cubed volumes without conversion when concentration uses dm^3. The result assumes the stated pure-solution reaction, correct endpoint and sufficiently accurate measurements.

74 Higher Tier: acid strength differs from acid concentration

- acid strength
- partial ionisation

■ Question 1

Which statement correctly distinguishes strength and concentration?

- Strength concerns ionisation; concentration concerns amount per volume
- Strength concerns amount per volume; concentration concerns ionisation
- A strong acid is always concentrated, and a weak acid is always dilute

Available marks: 2.

Worked answer

Strength concerns ionisation; concentration concerns amount per volume

- At a given concentration under comparable conditions, the stronger acid has lower pH because it produces greater hydrogen-ion concentration. Each decrease of one pH unit corresponds to a tenfold increase in H^+ concentration. A decrease of two units means a hundredfold increase. Use whole-number pH comparisons in this source scope; do not treat pH as a linear concentration scale.

■ Question 2

Compare pH 3 with pH 6. How many times greater is H^+ concentration at pH 3?

Available marks: 4.

Worked answer

1000 times

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Weak does not mean harmless and strong does not mean concentrated. Dilution does not change an acid's named strong/weak classification. A neutral pH 7 solution is not ion-free; it has balanced acid–alkali character in the school account. Avoid predicting pH from a label alone without concentration and conditions.

exercises.lol exercises.com.cn

75 Electrolysis: mobile ions move to oppositely charged electrodes

- electrolyte
- cathode

■ Question 1

Where do positive ions move in a powered electrolytic cell?

- Towards the negative cathode
- Towards the positive anode
- Only through the external metal wire

Available marks: 2.

Worked answer

Towards the negative cathode

- Charge travels through the electrolyte by moving ions and through the external circuit by electrons. Positive ions are not positive electrons, and solid salt ions do not become mobile simply because a wire touches the solid. Electrolysis uses electrical energy to drive chemical change. The polarity names here apply to an externally powered electrolytic cell, not a blanket rule for every electrochemical cell.

■ Question 2

How many Cl^- ions balance the total charge of seven Cu^{2+} ions?

Available marks: 4.

Worked answer

14 ions

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The electrode signs attract ions but do not imply that every positive ion forms its metal in an aqueous solution; water-derived species can compete. That product-selection rule is separate. Higher-only half equations are also separate from this common-tier movement and apparatus model.

76 Molten binary compounds: metal at the cathode, non-metal at the anode

- molten electrolyte
- binary ionic compound

exercises.lol exercises.com.cn

Question 1

What forms at the cathode from molten lead bromide with inert electrodes?

- Lead metal
- Bromine
- Hydrogen automatically because every electrolyte contains water

Available marks: 2.

Worked answer

Lead metal

- Identify the positive metal ion and negative non-metal ion from the formula. The cathode product is the metal element, while a halogen anode product is diatomic, such as Br_2 or Cl_2. Do not write bromide as the elemental product. The formula's ratio is determined by charge, and the product equation must preserve every atom.

Question 2

In $ZnCl_2 \rightarrow Zn + Cl_2$, how many chlorine atoms are contained in the products from eight represented $ZnCl_2$ formula units?

Available marks: 4.

Worked answer

16 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Molten is not the same as aqueous. Water changes the available species and product rules. Inert means the electrode is not intended to take part in the stated reaction, not that every material survives all conditions. Products need both the element name and the correct electrode.

77 Aluminium extraction: a molten mixture and a consumed carbon anode

- cryolite
- anode

Question 1

Why must carbon anodes be replaced?

- They react with oxygen products and are consumed
- They are necessarily inert and unchanged
- They supply all the aluminium metal directly

Available marks: 2.

exercises.lol exercises.com.cn

Worked answer

They react with oxygen products and are consumed

- Aluminium forms at the negative cathode. Oxygen associated with oxide discharge at the positive carbon anode reacts with carbon, forming carbon dioxide in the GCSE account. The carbon anode is consumed and needs continual replacement. It is therefore not an inert electrode like the one assumed in a simple product-prediction exercise.

■ Question 2

Supplied heating demands are 800 units and 600 units on the same basis. Find percentage reduction.

Available marks: 4.

Worked answer

25 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Cryolite does not provide the aluminium metal being extracted from the alumina feed in the simplified account. Lower heating demand does not remove the electrical-current requirement. Carbon consumption follows its chemical reaction at the anode, not simply mechanical wear. Do not predict oxygen collection unchanged at an anode that reacts with it.

78 Aqueous electrolysis: water-derived species change the products

- aqueous electrolyte
- inert electrode

■ Question 1

Which products are predicted for aqueous copper(II) sulfate with inert electrodes?

- Copper at cathode, oxygen at anode
- Hydrogen at cathode, sulfur at anode
- Copper sulfate crystals at both electrodes

Available marks: 2.

Worked answer

Copper at cathode, oxygen at anode

- Aqueous copper(II) chloride therefore gives copper at the cathode and chlorine at the anode. Sodium chloride solution gives hydrogen and chlorine under the approved handbook conditions. Copper(II) sulfate gives copper and oxygen, while

exercises.lol exercises.com.cn

sodium sulfate gives hydrogen and oxygen. State that these are the specified single-solute, inert-electrode predictions; concentration and electrode material can affect actual competing reactions outside this simple rule.

■ Question 2

Under the stated rules, how many of aqueous $CuCl_2$, NaCl, $CuSO_4$ and Na_2SO_4 have hydrogen cathode predictions?

Available marks: 4.

Worked answer

2 solutions

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Dissolved chloride gives chlorine, not solid chloride ions, at the anode in the stated model. Aqueous sulfate does not produce sulfur by simply stripping its name from the formula. Do not apply the molten binary rule to water-containing solutions.

79 Required Practical 3: test an electrolysis-product hypothesis

- hypothesis
- electrode observation

■ Question 1

Which observation most directly supports copper at the cathode?

- A brown/red deposit on the negative electrode with appropriate supporting evidence
- Bubbles of gas forming at the positive electrode during electrolysis
- The blue colour of the solution getting darker during electrolysis

Available marks: 2.

Worked answer

A brown/red deposit on the negative electrode with appropriate supporting evidence

- The acquired handbook uses carbon rods, low-voltage direct current and approved $CuCl_2$/NaCl solutions. A brown/red deposit supports copper at the negative electrode; gas at the positive electrode bleaches damp blue litmus under the approved test. A bubble observation alone does not identify a gas. Label each observation with electrode sign and keep the products separate.

exercises.lol exercises.com.cn

■ Question 2

A supplied model records 21 cm^3 gas in 7 min. Find mean collection rate.

Available marks: 4.

Worked answer

3 cm^3 per min

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not label invented measurements as a completed practical. Inert-electrode predictions need review if the electrode material reacts. Changes in concentration, spacing or supply can alter the comparison. The handbook notes chlorine production and short controlled operation; follow the current school risk assessment rather than treating a written lesson as full practical permission.

80 Higher Tier: electrode half equations conserve atoms and charge

- electrode half equation
- discharge

■ Question 1

Which equation correctly represents chloride oxidation?

- $2Cl^- \rightarrow Cl_2 + 2e^-$
- $Cl_2 + 2e^- \rightarrow 2Cl^-$ as anode oxidation
- $Cl^- \rightarrow Cl_2 + e^-$

Available marks: 2.

Worked answer

$2Cl^- \rightarrow Cl_2 + 2e^-$

- For $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$, oxygen count is four on each side and hydrogen count four on each side. Charge is -4 on both sides. For $2Cl^- \rightarrow Cl_2 + 2e^-$, chlorine is diatomic and the electron total balances the two negative charges. A correct formula is needed before balancing; changing Cl_2 to Cl would misidentify the product.

■ Question 2

How many electrons reduce five Al^{3+} ions to aluminium atoms?

Available marks: 4.

Worked answer

15 electrons

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Electrons do not disappear from charge accounting just because they are not atoms. Anode oxidation is electron loss in this powered electrolysis model. Positive-ion discharge does not mean gaining positive electrons. The entire 4.4.3.5 section and the half-equation requirement across 4.4.3 are Higher-only.

81 Energy transfers: explain warming and cooling

- exothermic
- endothermic

■ Question 1

A solution cools during a reaction with no external cooling. Which description fits?

- Endothermic: energy is taken from the surroundings
- Exothermic: energy is destroyed
- Endothermic: the products must have less energy

Available marks: 2.

Worked answer

Endothermic: energy is taken from the surroundings

- Distinguish the reacting chemicals from their surroundings. A thermometer in a reacting solution measures the temperature of that solution, which receives or supplies energy during the chemical change. A temperature rise supports an exothermic interpretation under the stated conditions; a fall supports endothermic behaviour. Heating a vessel externally can obscure this evidence. Not every process involving cooling is a chemical reaction: new substances must also be formed.

■ Question 2

A reaction starts at 19.5 °C and reaches 27.0 °C. Find the temperature rise.

Available marks: 4.

Worked answer

7.5 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

AQA 4.5.1.1 requires measuring temperature changes, not calculating transferred energy using heat capacity or calculating molar enthalpy. Those quantities are not substitutes for the required temperature evidence. A warmer that becomes hotter is not necessarily more suitable if it can burn skin or runs out too quickly.

exercises.lol exercises.com.cn

82 Energy transfers: explain warming and cooling

- exothermic
- endothermic

■ Question 1

A solution cools during a reaction with no external cooling. Which description fits?

- Endothermic: energy is taken from the surroundings
- Exothermic: energy is destroyed
- Endothermic: the products must have less energy

Available marks: 2.

Worked answer

Endothermic: energy is taken from the surroundings

- Distinguish the reacting chemicals from their surroundings. A thermometer in a reacting solution measures the temperature of that solution, which receives or supplies energy during the chemical change. A temperature rise supports an exothermic interpretation under the stated conditions; a fall supports endothermic behaviour. Heating a vessel externally can obscure this evidence. Not every process involving cooling is a chemical reaction: new substances must also be formed.

■ Question 2

A reaction starts at 19.5 °C and reaches 27.0 °C. Find the temperature rise.

Available marks: 4.

Worked answer

7.5 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

AQA 4.5.1.1 requires measuring temperature changes, not calculating transferred energy using heat capacity or calculating molar enthalpy. Those quantities are not substitutes for the required temperature evidence. A warmer that becomes hotter is not necessarily more suitable if it can burn skin or runs out too quickly.

83 Required practical 4: investigate temperature changes in solutions

- temperature change
- best-fit intersection

exercises.lol exercises.com.cn

■ Question 1

Why can temperature fall after all the acid has reacted?

- Extra cooler liquid and heat loss can lower it without further neutralisation warming
- Neutralisation changed to an endothermic reaction once the acid ran out
- The thermometer stops working accurately once the reaction ends

Available marks: 2.

Worked answer

Extra cooler liquid and heat loss can lower it without further neutralisation warming

- After each addition, replace the lid, stir gently and record the highest temperature. Repeat the whole investigation with fresh starting solutions and calculate means at each added volume. Plot mean temperature against total alkali volume added. Draw appropriate best-fit lines through the rising and falling regions and estimate their intersection. It estimates the peak between discrete readings; do not join every noisy point and call the highest measured point exact.

■ Question 2

Two repeat temperatures are 29.2 °C and 29.8 °C. Find their mean.

Available marks: 4.

Worked answer

29.5 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not prepare concentrated stock chemicals independently, heat this mixture to force a peak, or remove inconvenient repeats without recording a reason. A greater added volume changes both reactant amount and total liquid volume, so the graph is not a simple measure of reaction energy per mole. No heat-capacity calculation is required here. Bond-breaking explanations belong to the separate Higher lesson.

84 Reaction profiles: distinguish the barrier from the overall change

- activation energy
- reaction profile

exercises.lol exercises.com.cn

■ Question 1

A profile has products above reactants. What does it show?

- An endothermic overall change
- An exothermic overall change
- No possible activation barrier

Available marks: 2.

Worked answer

An endothermic overall change

- In an exothermic profile products lie below reactants, showing an overall energy decrease of the reacting chemicals and transfer to surroundings. In an endothermic profile products lie above reactants, showing energy taken from surroundings. Both profiles can have an activation barrier. The vertical difference between reactants and products is the overall change, distinct from the larger climb to the peak. Horizontal distance is not elapsed time or a measured reaction rate.

■ Question 2

Relative reactant level is 25 and peak level is 90. Find the activation-energy difference.

Available marks: 4.

Worked answer

65 relative units

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A peak is not an intermediate product that must be collected. Do not label reaction progress as time, equate activation energy to overall energy change or assume exothermic reactions always occur rapidly at room temperature. The source requires qualitative profiles; numerical relative levels are a way to practise reading their geometry.

85 Higher Tier: count bonds before calculating the energy change

- bond energy
- overall energy change

■ Question 1

Breaking costs 700 kJ and forming releases 950 kJ. What is the signed overall change?

- −250 kJ, exothermic
- +250 kJ, exothermic
- −1650 kJ, endothermic

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

−250 kJ, exothermic

- Use the balanced equation and actual bond types. A coefficient multiplies all bonds in that molecule. For $H_2 + Cl_2 \rightarrow 2HCl$, break one H–H and one Cl–Cl and form two H–Cl bonds. For $2H_2 + O_2 \rightarrow 2H_2O$, break two H–H bonds and one O=O bond, and form four O–H bonds. An O=O double bond uses its supplied double-bond value once; do not double a single-bond value.

■ Question 2

For $H_2 + Cl_2 \rightarrow 2HCl$, use H–H 430, Cl–Cl 240, H–Cl 420 kJ per mole of bonds. Find the signed change for the equation amounts.

Available marks: 4.

Worked answer

-170 kJ

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not call breaking bonds exothermic, subtract formed from broken in the reverse order, or count atoms as if each were a bond. A negative energy change is not negative activation energy. This entire source section is Higher-only, while drawing the profiles remains common-tier content.

86 Separate Chemistry: cells produce a potential difference

- chemical cell
- battery

■ Question 1

What distinguishes the simple chemical cell from the electrolysis apparatus?

- It produces a potential difference from chemical reactions
- It requires an external supply to drive the intended reaction
- Its electrolyte conducts by free electrons alone

Available marks: 2.

Worked answer

It produces a potential difference from chemical reactions

- Use supplied readings or reactivity information to compare cells under specified conditions. Do not promise a universal voltage from a metal pair alone: electrolyte choice and conditions also matter. Connecting identical cells in series adds their potential differences in the ideal stated model; reversed orientation subtracts

exercises.lol exercises.com.cn

one cell's contribution. Voltage measures potential difference, not the amount of chemical reactant remaining or the rate of all reactions.

■ Question 2

Four identical 0.75 V cells are aligned in series. Find the ideal total voltage.

Available marks: 4.

Worked answer

3 V

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The electrolyte does not carry free electrons in the same way as the wire. A battery is not just any one cell in this specification's terminology. An externally powered electrolytic cell has a different purpose and electrode context. Do not transfer an electrode sign rule between the two apparatus without identifying how it is operating.

87 Separate Chemistry: choose cells using lifespan and charging evidence

- non-rechargeable cell
- rechargeable cell

■ Question 1

Why can an appropriate rechargeable cell be used again?

- An external current reverses its chemical reaction
- The electrolyte is replaced each time it is charged
- The reactants are never used up while it supplies current

Available marks: 2.

Worked answer

An external current reverses its chemical reaction

- Choose a cell for its intended use. Compare required voltage, available operating time, mass, initial cost, replacement frequency, charging access and disposal information supplied. Repeated use can make a rechargeable option cheaper over time despite greater initial cost. A rarely used emergency device might place more weight on storage performance and immediate availability. These conclusions depend on stated data, not a universal rule that one cell type is always best.

exercises.lol exercises.com.cn

■ Question 2

A fictional rechargeable option costs £15 plus £0.20 per use. Find total cost at 20 uses.

Available marks: 4.

Worked answer

19 £

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not call recharging the replacement of consumed chemicals with no energy input. Non-rechargeable does not mean unable to produce electricity repeatedly before exhaustion. A rechargeable lifetime is finite; a cost projection beyond supplied cycle life is unsupported. This is both-tier separate Chemistry, without advanced electrode mechanisms.

88 Separate Chemistry: evaluate a continuously supplied fuel cell

- fuel cell
- lifecycle boundary

■ Question 1

Which claim follows directly from $2H_2 + O_2 \rightarrow 2H_2O$?

- Water is the product of the local hydrogen–oxygen reaction
- Hydrogen production always emits no carbon dioxide
- No external fuel supply is needed

Available marks: 2.

Worked answer

Water is the product of the local hydrogen–oxygen reaction

- Compare both devices against a purpose. Supplied information may include mass, operating time, refuelling or charging time, infrastructure, fuel storage and cost. Water is the direct product of the hydrogen–oxygen reaction; hydrogen production and transport may have other environmental effects. A conclusion about total emissions needs data for those stages. Do not infer zero lifecycle carbon emissions merely from the absence of carbon in the local equation.

exercises.lol exercises.com.cn

■ Question 2

In $2H_2 + O_2 \rightarrow 2H_2O$, how many O_2 molecules react with ten represented H_2 molecules?

Available marks: 4.

Worked answer

5 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A fuel cell does not manufacture its own limitless hydrogen, and oxygen is a reactant, not its waste product. A rechargeable battery requires charging energy while the fuel cell needs a continuing external fuel supply. Neither device is automatically the best under every combination of cost, storage and environmental conditions.

89 Higher Tier: combine hydrogen fuel-cell half equations

- fuel-cell anode
- fuel-cell cathode

■ Question 1

Which acidic hydrogen half equation shows oxidation?

- $H_2 \rightarrow 2H^+ + 2e^-$
- $H_2 + 2e^- \rightarrow 2H^+$
- $O_2 \rightarrow 2H_2O$ without other species

Available marks: 2.

Worked answer

$H_2 \rightarrow 2H^+ + 2e^-$

- Check atoms and charges separately. The hydrogen half equation has four hydrogen atoms on each side and zero net charge because $+4$ from H^+ balances -4 from electrons. The oxygen half equation has two oxygen atoms and four hydrogen atoms on each side, again zero net charge. In this generating cell electrons leave the hydrogen anode through the external circuit and reach the oxygen cathode. The anode is negative and the cathode positive while the cell supplies electricity.

■ Question 2

Each represented H_2 molecule releases two electrons in the stated half equation. How many are released by eight H_2 molecules?

Available marks: 4.

Worked answer

16 electrons

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not put electrons on the reactant side for hydrogen oxidation, allow them to remain in the overall reaction, or say they pass through the electrolyte like they do through a metal wire. Common-tier students still need the overall reaction and fuel-cell evaluation, but these half equations and charge reasoning are Higher-only.

90 Rates, catalysts and reliable endpoints

- activation energy
- rate

■ Question 1

Two reactions reach the same final gas volume. Which can still differ?

- Their rates
- Their total mass of products
- Their limiting reactant amount

Available marks: 2.

Worked answer

Their rates

- A product-time graph has a steeper gradient where rate is larger. A tangent estimates instantaneous rate; a secant gives average rate over an interval. The final plateau reflects the total collected product under the stated conditions.

■ Question 2

A reaction makes 24 cubic centimetres of gas in 40 s. Find average rate.

Available marks: 4.

Worked answer

0.6 cm^3/s

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A catalyst does not change the final equilibrium composition at fixed conditions. A mass-loss method cannot detect all reactions, and losing gas through a leak biases a collection experiment.

91 Dynamic equilibrium: equal rates, continuing reactions

- equilibrium
- reversible reaction

exercises.lol exercises.com.cn

■ Question 1

Which pair must be equal at dynamic equilibrium?

- Forward and reverse reaction rates
- Reactant and product concentrations
- Masses of every substance

Available marks: 2.

Worked answer

Forward and reverse reaction rates

- Beginning with mostly reactants, the forward rate may be high while the reverse rate is initially low. As products accumulate, reverse reaction becomes possible more often until the rates match under the stated model. A reaction-rate graph should show convergence to the same non-zero rate. A composition graph can level off at different reactant and product amounts. Identify which quantity is on the axis before claiming two curves must meet.

■ Question 2

In a one-to-one A $\rightleftharpoons$ B model, 22 forward and 22 reverse events occur in one second. Find net change in B count.

Available marks: 4.

Worked answer

0 particles

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Constant amounts do not mean particles are motionless or reaction has stopped. A steady open-flow system can also have constant measured amounts, so constancy alone does not establish closed-system equilibrium. Equal mass, concentration and molecule count are not the required equality: rates are. Condition-change predictions are separately Higher-only.

92 Mean rates: use the change over the chosen interval

- mean reaction rate
- tangent

■ Question 1

Gas volume rises from 10 to 30 cm^3 between 20 and 60 s. Which calculation gives the interval mean rate?

- $(30-10)/(60-20)$
- $30/(60-20)$

exercises.lol exercises.com.cn

- (60−20)/(30−10)

Available marks: 2.

Worked answer

(30−10)/(60−20)

- Plot time on the horizontal axis and measured quantity on the vertical axis with labelled units and sensible scales. A steeper product-time curve means faster formation; a horizontal plateau means no further measured product forms. A tangent touches the local curve direction at the chosen point and its steepness indicates rate there. Drawing and interpreting tangents is both-tier; calculating their numerical gradients is in the Higher lesson. A straight chord between distant points gives an interval mean, not the local rate.

■ Question 2

Gas volume increases from 8 to 32 cm^3 between 10 and 50 s. Find mean rate.

Available marks: 4.

Worked answer

0.6 cm^3 per s

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not divide 36 by 40 for the interval calculation or call a final volume a rate. A tangent line is a graphical model of the local direction, not a new experimental trace. Mol/s calculations are Higher-only. Curves with the same plateau can have different rates, and a larger plateau alone does not prove a faster initial reaction.

93 Higher Tier: calculate tangent gradients and molar rates

- instantaneous rate
- molar rate

■ Question 1

Where should the two points for a tangent-gradient calculation be selected?

- On the tangent line itself
- On any two distant parts of the original curve
- Only at the final plateau

Available marks: 2.

Worked answer

On the tangent line itself

- First mark the requested time, draw a tangent following the smooth curve's local direction, then select two readable points on that line. They need not be measured

exercises.lol exercises.com.cn

data points or lie on the curve elsewhere. A larger triangle reduces the relative effect of reading uncertainty. Tangent estimates can differ slightly between reasonable drawings. A chord linking two curve points measures an interval mean and must not be presented as the tangent gradient.

■ Question 2

A supplied tangent passes through (10 s,16 cm^3) and (50 s,44 cm^3). Find its gradient.

Available marks: 4.

Worked answer

0.7 cm^3 per s

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not take points from the original curve when a tangent calculation is requested. A negative gradient of reactant remaining does not mean particles react backwards. Do not convert cm^3 to moles without supplied conditions or an appropriate relation. The tangent contact time must be distinguished from the endpoints used for the gradient triangle.

94 Five rate factors: change the conditions, keep comparisons fair

- rate factor
- surface area

■ Question 1

Equal carbonate masses react with excess acid. Smaller pieces reach the same final volume sooner. What changed?

- Rate, without necessarily changing total product
- The mass of carbonate must have doubled
- Carbon dioxide changed into hydrogen

Available marks: 2.

Worked answer

Rate, without necessarily changing total product

- State exactly what changes and what is controlled. For equal masses of the same carbonate with acid in excess, smaller pieces can reach the same final carbon dioxide amount sooner. If increasing acid concentration also changes the limiting reactant amount, both speed and final amount can change; this is a different comparison. Higher gas pressure is relevant to reacting gases, not automatically a general explanation for every liquid reaction.

exercises.lol exercises.com.cn

■ Question 2

A fixed 36 cm^3 gas endpoint is reached in 24 s. Find mean rate to that endpoint.

Available marks: 4.

Worked answer

1.5 cm^3 per s

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not confuse concentration with total volume or pressure with temperature. Cutting a solid raises exposed area without changing the identity of its atoms. A hotter reaction can still have the same limiting-reactant yield. This source section is both-tier; detailed equilibrium shifts are separate Higher content.

95 Required practical 5: test concentration with gas-volume curves

- gas-volume method
- start delay

■ Question 1

Which change would undermine a concentration-only comparison?

- Using different magnesium masses in the two trials
- Keeping the starting temperature the same in both trials
- Keeping the acid volume the same in both trials

Available marks: 2.

Worked answer

Using different magnesium masses in the two trials

- Fit the collector and check for unobstructed movement and an open gas path into the collector. Add magnesium, replace the bung promptly and start timing consistently. Record gas volume at suitable intervals, for example every 10 s, until it becomes constant. Plot both volume–time curves on the same axes and compare steepness at comparable times. Identical final volumes require equal limiting magnesium and enough acid; real collection losses or sample differences can change recorded plateaux.

■ Question 2

A gas trial starts at zero and collects 27 cm^3 in 30 s. Find mean collection rate.

Available marks: 4.

Worked answer

0.9 cm^3 per s

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A written graph answer cannot certify practical participation. Do not ignore gas lost before fitting the bung, interpret a smaller collected plateau automatically as slower chemistry, or use unequal magnesium pieces as a concentration-only test. The molar concentration labels identify provided solutions; calculating a mol/s rate remains Higher-only.

96 Required practical 5: compare a defined disappearing-cross endpoint

- turbidity
- reciprocal-time proxy

■ Question 1

Why keep the total diluted thiosulfate volume constant before adding acid?

- To avoid also changing liquid depth and total mixture volume
- To force every trial to have the same concentration
- To remove the need for an endpoint definition

Available marks: 2.

Worked answer

To avoid also changing liquid depth and total mixture volume

- The concentration labels refer to the 50 cm^3 pre-acid dilution; adding acid further dilutes the mixture consistently. Maintain total volumes, flask, viewing depth, lighting, temperature and endpoint judgement. Repeat and calculate mean endpoint time. For a comparable fixed turbidity threshold, 1/mean time is a relative rate proxy: a shorter time means a larger proxy. It does not measure a known mass of sulfur per second or the exact completion time of the entire reaction.

■ Question 2

A comparable fixed endpoint takes 40 s. Find the reciprocal-time proxy.

Available marks: 4.

Worked answer

0.025 per s

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A disappearing cross is not a direct gas-volume reading, and one method alone does not fulfil both RP5 approaches. Do not dilute stock by reducing solution volume without replacing water, because depth and total volume would also change. A subjective

exercises.lol exercises.com.cn

endpoint needs consistent judgement; repeat averaging cannot correct a systematic viewing difference.

97 Collision theory: concentration and reacting-gas pressure

- collision frequency
- activation energy

■ Question 1

At constant temperature, increasing solution concentration primarily changes which feature?

- Frequency of reactant collisions
- The activation energy of the original pathway
- Every particle's energy by the same factor

Available marks: 2.

Worked answer

Frequency of reactant collisions

- Keep frequency distinct from collision energy. At unchanged temperature, raising concentration alone does not mean particles move faster or each has more energy. In a simple stated model with one collision partner held fixed, doubling the other partner's particle concentration can double encounter opportunities. It is not a universal measured rate law for every mechanism or for simultaneous changes to both reactants. Different reactions require suitable evidence for exact proportional relationships.

■ Question 2

A fixed gas sample is compressed from 180 to 60 cm^3 at the same temperature. Find the factor increase in particles per unit volume.

Available marks: 4.

Worked answer

3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not say greater concentration lowers activation energy or that any collision necessarily reacts. Pressure reasoning concerns gas reactants. Solvent volume changes, temperature drift and changed chemical species can invalidate a simple model comparison. The model explains a direction of change; an exact numerical rate ratio needs its stated assumptions or measured evidence.

exercises.lol exercises.com.cn

98 Temperature and solid size: explain two different rate effects

- energetic collision
- surface-area-to-volume ratio

Question 1

Why does higher temperature commonly increase rate?

- Collisions become more frequent and a greater fraction are energetic enough
- The activation energy of the same pathway falls as the temperature rises
- Particles become larger, so they collide more often with each other

Available marks: 2.

Worked answer

Collisions become more frequent and a greater fraction are energetic enough

- A cube model makes the size comparison explicit. A cube side L has area $6L^2$ and volume L^3. Cutting it into eight half-side cubes preserves total volume but doubles total area. This model assumes newly exposed faces are accessible and not clumped or coated. Real powders need appropriate containment; aggregate formation can reduce accessible area. Do not claim every ten-degree temperature rise always doubles rate: exact effects depend on reaction and conditions.

Question 2

One 2 cm cube is cut into eight 1 cm cubes with all faces accessible. Find total surface area of the eight cubes.

Available marks: 4.

Worked answer

48 cm^2

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not say hot particles become physically larger, or that smaller pieces have intrinsically lower activation energy. Surface area and total amount are different. Raising temperature changes the energy distribution; cutting changes geometry. Both can increase successful collision frequency, but explanations should not swap their causes.

99 Catalysts: a lower barrier, the same overall energy change

- catalyst
- catalysed pathway

exercises.lol exercises.com.cn

■ Question 1

Which feature changes on the profile when a suitable catalyst is added?

- The activation barrier becomes lower
- The products must have lower energy
- The reactants become different elements

Available marks: 2.

Worked answer

The activation barrier becomes lower

- At the same temperature more colliding particles can meet the smaller activation requirement. This does not mean the catalyst adds energy to every particle or increases temperature by definition. Evidence for catalytic behaviour combines rate increase and regeneration/no net consumption. An unchanged small sample alone does not prove catalysis unless the reaction-rate effect is shown. The overall equation omits a regenerated catalyst from its stoichiometric reactant and product lists.

■ Question 2

The same fixed endpoint takes 72 s without catalyst and 24 s with it. Find the factor increase in mean rate.

Available marks: 4.

Worked answer

3

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not lower the product energy when drawing the catalysed path or describe the catalyst as consumed in the overall reaction. A catalyst does not increase the fixed limiting-reactant amount of product. At equilibrium it speeds both directions without changing the final composition under fixed conditions; this statement does not require equilibrium-constant calculations.

100 Reversible reactions: the products can reform the reactants

- reversible reaction
- reversible arrow

exercises.lol exercises.com.cn

■ Question 1

What makes the specified chemical reaction reversible?

- The products can react to reform ammonium chloride
- Heating ammonium chloride breaks it into new products
- The solid changes state when heated and then cools

Available marks: 2.

Worked answer

The products can react to reform ammonium chloride

- The symbol does not mean that all substances must be present in equal quantities or that the reaction continually switches completely from one side to the other. A reversible reaction may reach equilibrium when substances are contained under suitable fixed conditions, but reversibility alone is not proof that an open apparatus has reached equilibrium. Melting/freezing is a reversible physical change; it does not by itself demonstrate this chemical product-to-reactant relationship.

■ Question 2

In $NH_4Cl \rightleftharpoons NH_3 + HCl$, ten represented formula units decompose. Find the total number of gas molecules formed.

Available marks: 4.

Worked answer

20 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The gases do not need to have the same mass merely because their molecule counts match. A reversible arrow does not give equal rates at every moment. White solid forming on cooling must be interpreted with the identified gases; colour alone cannot establish the reaction. Written interpretation does not replace safe supervised observations.

101 Reverse reactions: energy transfers reverse direction

- hydrated copper sulfate
- anhydrous copper sulfate

■ Question 1

The forward change is endothermic. What describes the exact reverse change?

- Exothermic with the same transferred amount
- Also endothermic with no energy transfer
- Exothermic only if all activation energy vanishes

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

Exothermic with the same transferred amount

- Products with greater energy in the forward endothermic reaction become the higher-energy starting materials for the reverse exothermic reaction. Reversing the equation swaps the levels. The equal transferred amounts do not mean equal activation energies for the two directions: the climb to the same peak starts from different levels. That distinction can be read qualitatively without introducing an advanced thermodynamic calculation.

■ Question 2

A model forward change takes in six equal energy packets. How many packets does its exact reverse release?

Available marks: 4.

Worked answer

6 packets

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Compare the same reaction amount and conditions before claiming equal transferred amounts. A temperature rise in one wet sample and a smaller temperature fall in a different heated sample are not directly comparable energy measurements. Do not confuse total energy change with activation barrier or use the example to calculate an unrequired heat-capacity quantity.

102 Dynamic equilibrium: equal rates, continuing reactions

- dynamic equilibrium
- closed system

■ Question 1

Which pair must be equal at dynamic equilibrium?

- Forward and reverse reaction rates
- Reactant and product concentrations
- Masses of every substance

Available marks: 2.

Worked answer

Forward and reverse reaction rates

- Beginning with mostly reactants, the forward rate may be high while the reverse rate is initially low. As products accumulate, reverse reaction becomes possible

exercises.lol exercises.com.cn

more often until the rates match under the stated model. A reaction-rate graph should show convergence to the same non-zero rate. A composition graph can level off at different reactant and product amounts. Identify which quantity is on the axis before claiming two curves must meet.

■ Question 2

In a one-to-one A ⇌ B model, 22 forward and 22 reverse events occur in one second. Find net change in B count.

Available marks: 4.

Worked answer

0 particles

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Constant amounts do not mean particles are motionless or reaction has stopped. A steady open-flow system can also have constant measured amounts, so constancy alone does not establish closed-system equilibrium. Equal mass, concentration and molecule count are not the required equality: rates are. Condition-change predictions are separately Higher-only.

103 Higher Tier: predict the response to an equilibrium disturbance

- Le Chatelier's Principle
- equilibrium shift

■ Question 1

After a disturbance, which statement describes a new equilibrium?

- The forward and reverse rates become equal again
- The reactions stop once the new concentrations are reached
- The forward and reverse rates both become zero

Available marks: 2.

Worked answer

The forward and reverse rates become equal again

- Begin with the system already at equilibrium, identify one imposed change and select the appropriate response rule. Increased reactant concentration favours its consumption; removing product favours forming more. Warming favours the endothermic direction. Compression of a gaseous equilibrium favours the side with fewer gas molecules. These are composition responses, not the same as saying every faster reaction makes a larger final yield.

exercises.lol exercises.com.cn

■ Question 2

A supplied mixture changes from 55 to 68 product particles after re-equilibration. Find the product-count increase.

Available marks: 4.

Worked answer

13 particles

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not describe counteracting as entirely cancelling the original disturbance. A catalyst does not count as a concentration addition of reactant. A shift toward products does not mean all reactants are consumed, and equal rates at the new equilibrium do not require the old mixture ratio. Different perturbations can produce the same direction of observed composition change.

104 Higher Tier: add a reactant or remove a product

- concentration disturbance
- re-equilibration

■ Question 1

At fixed temperature, B is removed from A $\rightleftharpoons$ B. Which net response is favoured?

- A reacts to form more B
- B reacts to form more A
- All reaction must stop permanently

Available marks: 2.

Worked answer

A reacts to form more B

- Separate the immediate imposed change from the response. If product is removed, its amount first falls; a subsequent net forward change can raise it from that lowered value without necessarily restoring the original level. At the new equilibrium both directions again occur at equal rates. A plot may show a sudden jump in the changed species followed by slower adjustment; the other species need not have the same immediate jump.

■ Question 2

A supplied model has 75 B particles, removes 25, then forms a net 12 more during adjustment. Find final B count.

Available marks: 4.

Worked answer

exercises.lol exercises.com.cn

62 particles

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not claim the product-removal operation itself immediately increases product concentration. A forward shift need not mean the final product amount exceeds its pre-removal value. Adding an unrelated substance is not automatically the same as adding a reactant. This whole section is Higher-only and requires qualitative interpretation, not memorised K calculations.

105 Higher Tier: warming favours the endothermic direction

- endothermic direction
- exothermic direction

■ Question 1

The written forward reaction is exothermic. What is the equilibrium response to warming?

- A shift toward reactants
- A shift toward products in every case
- No possible composition change

Available marks: 2.

Worked answer

A shift toward reactants

- Both forward and reverse reactions can become faster on warming, yet their relative rate balance changes, causing a net shift before a new equilibrium is reached. For an exothermic forward industrial reaction, a low temperature may favour yield while slowing production; an appropriate temperature choice can be a compromise. A catalyst can help rate without turning that exothermic forward direction into an endothermic one or increasing its equilibrium yield at fixed conditions.

■ Question 2

A supplied product fraction falls from 64% to 49% on warming. Find the decrease in percentage points.

Available marks: 4.

Worked answer

15 percentage points

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not write heating always increases equilibrium yield. The term exothermic must

exercises.lol exercises.com.cn

attach to a direction, not to the reversible pair without qualification. Percentage-point change is not the same as percentage change relative to the original value. A faster approach to equilibrium does not prove a more product-rich equilibrium.

106 Higher Tier: count gaseous coefficients before predicting a shift

- gas-coefficient count
- compression

■ Question 1

For $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, compression at fixed temperature favours which side?

- Ammonia: two gas molecules rather than four
- Reactants: there are fewer nitrogen atoms
- Neither side because all atoms balance

Available marks: 2.

Worked answer

Ammonia: two gas molecules rather than four

- If the gas-molecule counts are equal on both sides, changing pressure by compression gives no pressure-driven composition shift in this model. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ has two on each side. If solids or liquids occur in a supplied equation, do not count their coefficients as gas molecules. Compression can also affect rates by increasing gas particle concentration; a rate effect alone is not proof of an equilibrium shift.

■ Question 2

For $N_2 + 3H_2 \rightleftharpoons 2NH_3$ with all species gaseous, find the total gaseous coefficient count on the reactant side.

Available marks: 4.

Worked answer

4

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not count oxygen atoms to decide the gas-count rule. A higher pressure does not always favour products; it favours the smaller gaseous count. Equal counts mean no pressure-driven shift under the stipulated compression model, not that rate can never change. This entire source section is Higher-only.

exercises.lol exercises.com.cn

107 Organic structures and reaction pathways

- functional group
- isomer

Question 1

What happens to the carbon skeleton when bromine adds to ethene?

- It remains two carbons long
- It becomes one carbon long
- It becomes a six-carbon ring

Available marks: 2.

Worked answer

It remains two carbons long

- Distinguish addition, substitution, oxidation and polymerization by tracing bonds before and after reaction. Conditions and reagents belong to the reaction arrow; they are not interchangeable labels.

Question 2

How many moles of bromine react completely with 0.15 mol ethene?

Available marks: 4.

Worked answer

0.15 mol

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Bromine decolourization provides evidence of unsaturation in an appropriate test. It is not proof that an unknown sample is specifically ethene.

108 Crude oil: a finite mixture, not one compound

- crude oil
- hydrocarbon

Question 1

Which formula represents a hydrocarbon?

- C_4H_{10}
- C_2H_5OH
- CO_2

Available marks: 2.

Worked answer

exercises.lol exercises.com.cn

C_4H_{10}

- A mixture contains different substances together without a fixed bonding ratio between those substances. Each individual compound still has its own definite formula. C_3H_8 is a hydrocarbon; C_2H_5OH contains oxygen and therefore is not a hydrocarbon, even though it contains carbon and hydrogen. Carbon dioxide is not a hydrocarbon either. Finite describes a limited resource, not a prediction that every deposit will disappear on one exact date.

■ Question 2

A model has 24 hydrocarbon molecules among 40 molecules in all. Find the hydrocarbon number percentage.

Available marks: 4.

Worked answer

60 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not call crude oil pure, renewable on a human timescale, or a single alkane. Biomass origin does not make every biomass-derived fuel a fossil fuel. A substance containing carbon is not automatically a hydrocarbon: all of its elements must satisfy the definition. Models and percentages describe only the supplied sample.

109 Alkanes: connect the formula to the displayed bonds

- alkane
- displayed formula

■ Question 1

Which is the correct molecular formula for propane?

- C_3H_8
- C_3H_6
- C_3H_{10}

Available marks: 2.

Worked answer

C_3H_8

- For a straight chain, each end carbon has three hydrogen atoms, while an internal carbon has two. Methane has no carbon neighbour and so has four hydrogens. Count the bond lines at each carbon to check a displayed structure rather than adding hydrogen randomly. The general formula identifies the expected molecular composition of this series; molecular composition alone need not establish a unique arrangement of atoms.

exercises.lol exercises.com.cn

■ Question 2

An alkane molecule has seven carbon atoms. Find its hydrogen atom count.

Available marks: 4.

Worked answer

16 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not confuse the small subscript with the coefficient in an equation. C_2H_4 does not satisfy the alkane formula. A carbon with five ordinary covalent bonds is not a valid displayed alkane here. These flat drawings represent bonding, not actual straight planar molecules, bond angles or relative atomic sizes.

110 Fractional distillation: separate by evaporation and condensation

- fraction
- feedstock

■ Question 1

Why does a higher-boiling component generally condense lower in the column?

- The lower region is hotter and it condenses before reaching cooler regions
- It cools more slowly, so it condenses further up the column
- Higher-boiling molecules are smaller, so they sink to the bottom

Available marks: 2.

Worked answer

The lower region is hotter and it condenses before reaching cooler regions

- Evaporation and condensation are physical changes: molecules are separated without breaking their carbon chains. A sufficiently volatile fraction can remain gaseous at the top; heavy material can remain near the base. Fuels include petrol, diesel oil, kerosene, heavy fuel oil and liquefied petroleum gases. Fractions also provide feedstock for the petrochemical industry, producing materials such as solvents, lubricants, polymers and detergents. Carbon atoms can bond to each other in families of related structures; this helps explain the wide variety of natural and synthetic carbon compounds.

exercises.lol exercises.com.cn

■ Question 2

Two supplied component boiling points are 220 °C and 80 °C. Find their difference.

Available marks: 4.

Worked answer

140 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not say large molecules rise farther because they are heavier or that the column creates new alkanes. Position depends on boiling behaviour within a temperature gradient. A collected fraction is not necessarily pure, and industrial temperatures vary. Cracking is a later chemical process, not another name for fractional distillation.

111 Hydrocarbon size: boiling point, viscosity and flammability

- viscosity
- flammability

■ Question 1

Which trend is expected as comparable hydrocarbon molecules become larger?

- Boiling point and viscosity increase; flammability decreases
- All three decrease
- Boiling point decreases while flammability increases

Available marks: 2.

Worked answer

Boiling point and viscosity increase; flammability decreases

- Keep the three comparisons separate. Boiling point concerns liquid becoming gas, viscosity concerns flow, and flammability concerns ignition and burning. Stronger intermolecular attractions in larger comparable hydrocarbon molecules help explain higher boiling points. Boiling does not normally break the covalent bonds within the molecules. The acquired section limits recalled property trends to these three; density or a precise energy-per-molecule trend is not required here.

■ Question 2

Comparable flow times are 10 s and 35 s. Find the larger/smaller time ratio.

Available marks: 4.

Worked answer

3.5

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not confuse high viscosity with low boiling point or say every fuel's ignition behaviour is controlled by molecular size alone. A longer flow time is evidence tied to the apparatus and conditions. These broad trends apply to comparable hydrocarbons; they are not universal predictions for every carbon compound or mixed commercial fuel.

112 Complete combustion: conserve atoms when hydrocarbons burn

- complete combustion
- oxygen supply

■ Question 1

What are the products of complete combustion of a hydrocarbon?

- Carbon dioxide and water
- Carbon monoxide and water
- Carbon dioxide and hydrogen

Available marks: 2.

Worked answer

Carbon dioxide and water

- One carbon atom requires one carbon dioxide molecule, while each pair of hydrogen atoms forms one water molecule. Oxygen atoms on the product side come from both products, so count both before finding O_2. If an intermediate oxygen coefficient is a half number, multiply every coefficient by two for smallest whole-number coefficients. Never alter the given hydrocarbon's subscripts to force balance.

■ Question 2

In $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$, find the O_2 molecules needed for three propane molecules.

Available marks: 4.

Worked answer

15 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Equal atom totals do not imply equal numbers of molecules or equal masses of carbon dioxide and water. A smoky flame is not proof of complete combustion. This task needs the supplied formula and atom conservation, not memorised combustion equations for

exercises.lol exercises.com.cn

every named fuel or an unrequired enthalpy calculation.

113 Cracking: chemical change makes useful smaller molecules

- cracking
- alkene

■ Question 1

What distinguishes cracking from fractional distillation?

- Cracking makes new smaller molecules; distillation separates existing compounds
- Distillation makes new smaller molecules; cracking separates existing ones
- Cracking separates molecules by boiling point, like distillation does

Available marks: 2.

Worked answer

Cracking makes new smaller molecules; distillation separates existing compounds

- High demand for small-molecule fuels makes some cracking products useful as fuels. Alkenes can be used to make polymers and other chemicals. A cracking equation is an atom-conservation example; different products can form depending on conditions. A formula supplied in the equation must be preserved. The full named alkene structures and addition reactions are separate Chemistry-only 4.7.2 requirements, not evidence that this introductory lesson completes them.

■ Question 2

For $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$, five starting molecules react. Find the total product molecule count.

Available marks: 4.

Worked answer

10 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not put oxygen into this supplied cracking equation or call it combustion. Steam in steam cracking does not require inventing water as a product in every simplified equation. Bromine water becoming colourless supports an alkene interpretation in the specified hydrocarbon comparison; the observation is not universal identification of any unknown substance.

exercises.lol exercises.com.cn

114 Chemistry-only: recognise the first four alkenes

- alkene
- unsaturated

Question 1

Which displayed feature identifies the alkene functional group?

- A carbon–carbon double bond
- Only an oxygen–hydrogen bond
- A carbon–carbon single bond with no multiple bond

Available marks: 2.

Worked answer

A carbon–carbon double bond

- A displayed formula shows all atoms and all bond lines. Count a double bond as two of carbon's four bonds. In the terminal-double-bond structures shown, the first carbon has two hydrogens and the next has one, except ethene where each has two. A longer chain finishes with CH_3. Butene and pentene can have different atom arrangements; the diagrams show one stated straight-chain arrangement, rather than claiming their molecular formula uniquely fixes a structure.

Question 2

A supplied open-chain alkene has nine carbon atoms and one C=C. Find its hydrogen count.

Available marks: 4.

Worked answer

18 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not draw an extra hydrogen on a carbon already making four bonds, or identify every CnH2n formula as an alkene without checking structure: other families can share a molecular formula. Unsaturated does not mean the sample contains no hydrogen. This is separate Chemistry content on both tiers, not a Higher-only extension.

115 Chemistry-only: hydrogen addition and alkene combustion

- hydrogenation
- addition reaction

exercises.lol exercises.com.cn

■ Question 1

What happens when hydrogen adds across the one C=C of propene?

- One H attaches to each affected carbon and C=C becomes C–C
- The carbon chain splits into two molecules
- The double bond and all hydrogen counts stay unchanged

Available marks: 2.

Worked answer

One H attaches to each affected carbon and C=C becomes C–C

- An addition reaction joins atoms to the molecule across the multiple bond without removing the existing carbon skeleton. Check the new bond counts: each carbon still makes four bonds. Separately, alkenes burn in oxygen like other hydrocarbons. With sufficient oxygen, complete combustion gives carbon dioxide and water. In air they tend to burn with smoky flames because incomplete combustion produces carbon particles; smoke does not establish complete combustion.

■ Question 2

Eight represented ethene molecules undergo complete addition, each using one H_2. Find H_2 molecules consumed.

Available marks: 4.

Worked answer

8 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not add two hydrogen atoms to only one carbon or leave the double bond unchanged after addition. A catalyst is not a stoichiometric reactant. The hydrogenation example does not prescribe universal operating conditions for every industrial alkene. A smoky flame indicates incomplete combustion in the stated context, not that water can never form.

116 Chemistry-only: chlorine, bromine and iodine addition

- halogen addition
- decolourisation

■ Question 1

What is retained when bromine adds to an alkene?

- Its carbon skeleton and original hydrogen atoms
- Its carbon–carbon double bond unchanged
- No bromine atoms in the product

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

Its carbon skeleton and original hydrogen atoms

- For ethene plus bromine, $CH_2{=}CH_2$ becomes $BrCH_2{-}CH_2Br$. Each carbon retains its two hydrogen atoms and gains one bromine, giving four bond contributions. Bromine water changes orange to colourless in the specified reaction; an alkane control does not give the same rapid addition under these conditions. A carbon skeleton and hydrogen count are retained while two halogen atoms are added. The displayed panels distinguish chlorine, bromine and iodine products for all four named starting alkenes.

■ Question 2

Five alkene molecules each add one Br_2. Find the bromine atoms added in total.

Available marks: 4.

Worked answer

10 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not remove a hydrogen in an addition drawing, or claim UV light is the required catalyst for the alkene test. That confuses addition with alkane substitution. Decolourisation is evidence for unsaturation in the controlled comparison, not unique proof of ethene or universal identification of any unknown liquid. A colourless endpoint alone cannot demonstrate that a sample is safe.

117 Chemistry-only: steam addition forms an alcohol

- hydration
- steam

■ Question 1

Which combination describes the taught industrial ethene hydration?

- Steam, high temperature/pressure and phosphoric-acid catalyst
- Hydrogen, a nickel catalyst and a temperature of about 60 °C
- Sugar solution, yeast and warm conditions without oxygen

Available marks: 2.

Worked answer

Steam, high temperature/pressure and phosphoric-acid catalyst

- The product is an alcohol, not a hydrocarbon, because it now contains oxygen. Count the H inside OH as well as those bonded directly to carbon. Ethene's two

exercises.lol exercises.com.cn

carbons are equivalent in this simple addition. Unsymmetrical starting alkenes can give different OH positions: the longer terminal-chain panels show the usual secondary-alcohol arrangement with OH on the second carbon. These drawings identify stated products without adding a required advanced mechanism or demanding positional product names beyond the course scope.

■ Question 2

The product of adding one water molecule to C_4H_8 is $C_4H_{10}O$. Find its total atom count.

Available marks: 4.

Worked answer

15 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not use cold liquid water alone as the specified ethene hydration condition or substitute nickel for phosphoric acid. Hydrogen addition gives an alkane; steam addition gives an alcohol. Industrial reaction need not convert every molecule in one pass. Hydration is distinct from the yeast fermentation route to an aqueous ethanol solution.

118 Chemistry-only: alcohol structures, names and uses

- alcohol
- functional group

■ Question 1

Which formula makes the alcohol group explicit?

- CH_3CH_2OH
- CH_3COOH
- C_2H_4

Available marks: 2.

Worked answer

CH_3CH_2OH

- The first-four alcohols are used as fuels, solvents and starting materials for making other chemicals. Methanol is an industrial fuel/feedstock and solvent; ethanol is used as a fuel and solvent in suitable formulations; propanol and butanol serve as solvents and chemical feedstock. The selected use must be tied to actual product information, concentration and purpose. None of these industrial uses implies a sample is suitable to drink or apply to skin.

exercises.lol exercises.com.cn

■ Question 2

Three represented ethanol molecules each contain nine atoms. Find their total atom count.

Available marks: 4.

Worked answer

27 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not label every molecule with oxygen an alcohol: an OH within COOH has a different functional-group context. The alcohol OH is covalently bonded, not a free hydroxide ion. The displayed primary propanol/butanol examples do not claim every possible atom arrangement with the same molecular formula has the same reactions.

119 Chemistry-only: four observations for the first alcohols

- alcohol oxidation
- solubility

■ Question 1

Which statement is correct for the taught primary ethanol example?

- Sodium reaction releases hydrogen; complete combustion makes carbon dioxide and water
- Sodium reaction releases carbon dioxide; combustion makes hydrogen and water
- Sodium reaction releases oxygen; complete combustion makes carbon monoxide

Available marks: 2.

Worked answer

Sodium reaction releases hydrogen; complete combustion makes carbon dioxide and water

- For the displayed primary examples, methanol can give methanoic acid, ethanol ethanoic acid, propanol propanoic acid and butanol butanoic acid. The OH carbon's position matters; a different alcohol arrangement cannot automatically be assigned the same oxidation product. In an approved test, acidified potassium dichromate(VI) can change orange to green as it oxidises the primary alcohol. The acquired GCSE requirement asks for observations/descriptions, not aldehyde mechanisms or balanced equations for these non-combustion reactions.

exercises.lol exercises.com.cn

■ Question 2

Complete ethanol combustion uses three O_2 per ethanol molecule. Find O_2 needed for four ethanol molecules.

Available marks: 4.

Worked answer

12 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not forget the oxygen already in the alcohol when balancing combustion, or call the hydrogen from sodium reaction carbon dioxide. Methanol and other alcohols can be toxic and flammable; miscibility does not establish safety. A written response or a supplied colour change does not certify completion of an actual school practical.

120 Chemistry-only: yeast fermentation produces aqueous ethanol

- fermentation
- anaerobic conditions

■ Question 1

Which conditions support the taught ethanol fermentation?

- Sugar solution, yeast, warm conditions and oxygen excluded
- Ethene, steam, high pressure and a phosphoric-acid catalyst
- Sugar solution, yeast, a high temperature and plenty of oxygen

Available marks: 2.

Worked answer

Sugar solution, yeast, warm conditions and oxygen excluded

- Maintain the school-selected temperature and sugar concentration, use the prepared yeast and record actual gas or mass observations over time. An airlock can let gas leave without freely admitting outside air; it is not a licence to tightly seal a gas-producing bottle. The rate can change as substrate runs low or ethanol inhibits yeast. Gas bubbling is qualitative unless quantity is measured, and a silent vessel is not by itself proof that no ethanol is present.

■ Question 2

Repeat gas volumes over one fixed interval are 24, 27 and 27 cm^3. Find their mean.

Available marks: 4.

Worked answer

26 cm^3

exercises.lol exercises.com.cn

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not replace yeast with nickel, use the industrial hydration temperature for living yeast or describe fermentation as requiring an oxygen supply. A mass loss can include escaping gas but needs its own controls. No balanced fermentation equation is required by this acquired alcohol section, and the task is preparation for authentic supervised work rather than a replacement written examination.

121 Chemistry-only: recognise acids and explain carbonate observations

- carboxylic acid
- carboxyl group

■ Question 1

Which carbon must be counted when naming CH_3CH_2COOH?

- The carbon in COOH as well as the two in CH_3CH_2
- Only the two in CH_3CH_2
- Neither carbon because oxygen determines the name

Available marks: 2.

Worked answer

The carbon in COOH as well as the two in CH_3CH_2

- These first-four acids dissolve in water to make acidic solutions. A suitable indicator or measured pH demonstrates acidity under the stated conditions. They react with carbonates to form a salt, carbon dioxide and water. For example, ethanoic acid with sodium carbonate forms sodium ethanoate plus the gas and water. Carbon dioxide can turn limewater milky in an approved product test. Reaction with alcohols forms an ester and water, developed in the separate ester lesson.

■ Question 2

Two represented butanoic acid molecules each have formula $C_4H_8O_2$. Find their total oxygen atoms.

Available marks: 4.

Worked answer

4 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not omit the carboxyl carbon or require a balanced carbonate equation where the specification asks only for a description. Common-tier acidity and reaction observa-

exercises.lol exercises.com.cn

tions remain separate from the Higher explanation of partial ionisation. A weak-acid description does not establish low concentration or safe handling, and acidity alone does not prove that an unknown is ethanoic acid.

122 Chemistry-only: an acid and an alcohol form an ester

- ester
- esterification

■ Question 1

What forms from ethanoic acid and ethanol in the taught reaction?

- Ethyl ethanoate and water
- Only carbon dioxide
- An alkane and hydrogen

Available marks: 2.

Worked answer

Ethyl ethanoate and water

- The illustrated product contains a C(=O)–O–C connection. The acid-derived carbon framework and alcohol-derived carbon framework both remain. It is different from simply mixing an acid with water, from sodium carbonate reaction and from alkene addition. Formation need not be complete in one trial. A characteristic smell may be supplied as reference evidence but is not a unique identification test or a reason to inhale concentrated vapour.

■ Question 2

Ethyl ethanoate is $C_4H_8O_2$. Find the total atoms in three represented molecules.

Available marks: 4.

Worked answer

42 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not confuse the acid catalyst with a substance consumed in the overall word equation, or name the product ethanol because an alcohol was used. An ester is not the same functional group as its parent acid. The water product does not prove every condensation process or polymer structure has been taught; those are separate 4.7.3 requirements.

exercises.lol exercises.com.cn

123 Higher Tier: carboxylic acids are only partially ionised

- acid strength
- partial ionisation

■ Question 1

Why can a carboxylic acid be acidic yet weak?

- Only some acid particles ionise, producing H^+
- No particles can ever ionise
- Weak means its solution must be very dilute

Available marks: 2.

Worked answer

Only some acid particles ionise, producing H^+

- Concentration describes the amount of acid in a volume; strength describes its extent of ionisation. These are independent labels. Comparing a dilute strong acid with a concentrated weak acid does not establish the simple same-concentration pH ordering. For whole-number pH differences, a decrease of one pH unit means ten times the hydrogen-ion concentration. No equilibrium constant, pKa calculation or advanced weak-acid approximation is required here.

■ Question 2

Compare pH 3 and pH 5. How many times greater is H^+ concentration at pH 3?

Available marks: 4.

Worked answer

100 times

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not say weak acids cannot react with carbonates or have no hydrogen ions. A concentrated weak acid may still have substantial hazards. The pH ratio concerns free H^+, not automatically the ratio of total acid concentrations. This whole explanatory clause is Higher-only; recognising acids and describing their water/carbonate/alcohol reactions remain both-tier.

124 Chemistry-only: an alkene becomes an addition polymer

- monomer
- addition polymerisation

exercises.lol exercises.com.cn

Question 1

Which feature belongs in the poly(ethene) repeating unit?

- A two-carbon single-bond backbone with continuation bonds
- An intact C=C double bond in every repeating unit
- A water molecule removed for each unit that joins the chain

Available marks: 2.

Worked answer

A two-carbon single-bond backbone with continuation bonds

- Draw the two-carbon backbone horizontally, keep both hydrogens on each carbon and show a single bond extending out of each side of the brackets. Put n outside the brackets to represent many repeats. A continuation bond joins the neighbouring unit; it is not an extra hydrogen or a separate monomer still containing C=C. Carbon has four bonds when the continuation bonds are counted. The bracketed unit represents the repeating interior of the chain, not its complete end-group structure.

Question 2

Thirty ethene-derived repeating units contain two carbon atoms each. Count their carbon atoms.

Available marks: 4.

Worked answer

60 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The polymer does not retain a double bond in every repeating unit, and addition polymerisation does not release water. Do not draw disconnected brackets around a complete alkane molecule: the chain must continue through single bonds. This separate Chemistry objective applies to both tiers. Detailed industrial mechanisms and named initiators are not required by this section.

125 Chemistry-only: keep side groups when drawing a repeating unit

- repeating unit
- side group

exercises.lol exercises.com.cn

■ Question 1

What happens to the CH_3 group when propene forms poly(propene)?

- It remains a side group on the corresponding backbone carbon
- It is lost as methane when the double bond opens
- It becomes part of the main chain of the polymer

Available marks: 2.

Worked answer

It remains a side group on the corresponding backbone carbon

- Trace the two C=C carbons first and label their attached atoms or groups before changing any bond. In the repeat, the CH_2 carbon bonds to two hydrogens and two backbone neighbours. The CH carbon bonds to one hydrogen, the CH_3 group and two backbone neighbours. Both have four bonds. A supplied CH_2=CHCl example similarly gives –CH_2–CHCl–: chlorine stays attached. This supplied structure is for transferring the model, not an extra list of commercial names to memorise.

■ Question 2

Sixteen propene-derived repeating units contain three carbon atoms each. Count all their carbon atoms.

Available marks: 4.

Worked answer

48 atoms

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not change CH_3 into CH_2 while leaving it attached as a side group, add water as an addition product or keep the original C=C. A polymer drawing does not establish biodegradability, recycling availability or mechanical strength by itself. Those claims require separate property and life-cycle evidence. The monomer-to-repeat representation applies on both tiers.

126 Higher Tier: two-ended monomers form a polyester

- condensation polymerisation
- polyester

■ Question 1

Why can the stated diol and diacid continue forming a chain?

- Each has two reactive functional groups
- Each contains a carbon–carbon double bond
- Each loses a water molecule from a double bond

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

Each has two reactive functional groups

- Read the ideal repeating interior as –O–CH_2–CH_2–O–C(=O)–$(CH_2)_4$–C(=O)–. The CH_2–CH_2 segment came from the diol, and the four-CH_2 segment and carbonyl carbons came from the diacid. At each joining event, H from an alcohol OH and OH from an acid COOH make water. The remaining oxygen links the carbonyl carbon to the diol segment. Unlike addition polymerisation, the repeat therefore does not retain every atom of the original monomer pair.

■ Question 2

A finite open chain joins eight monomer molecules through seven condensation links, losing one H_2O per link. Count water molecules.

Available marks: 4.

Worked answer

7 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A polyester contains many ester links; the name does not mean every polymer is an ester. Condensation can form other link types, and the lost small molecule need not always be water. Retain the carbonyl double bond in C(=O)–O. This whole objective is Higher Tier Chemistry-only content; it must not make common-tier addition polymerisation Higher-only.

127 Higher Tier: amino acids join to form polypeptides

- amino group
- peptide link

■ Question 1

Which link joins amino-acid residues in the stated polypeptide?

- C(=O)–NH
- An intact alkene C=C between every residue
- A free unbonded sodium ion

Available marks: 2.

Worked answer

C(=O)–NH

- Each joining event loses OH from one carboxylic-acid group and H from one amino group as H_2O. A chain can extend because functional groups remain at its ends.

exercises.lol exercises.com.cn

Different amino acids can combine in the same chain to make proteins; their order and folding affect the resulting protein. Glycine-only repetition is a simple model, not a claim that every natural protein contains one repeating amino-acid type. Detailed zwitterion, stereochemistry and protein-structure classifications are not required here.

■ Question 2

Five glycine molecules form an open chain with four links. Given relative masses 75 and water 18, calculate chain relative mass.

Available marks: 4.

Worked answer

303

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A peptide link C(=O)–NH differs from an ester link C(=O)–O. Do not remove the carbonyl oxygen or lose an entire amino group. The one-water-per-link finite-chain calculation excludes cyclic or branched arrangements. Amino-acid condensation chemistry is HT only, while recognising amino acids as protein monomers in 4.7.3.4 applies on both tiers.

128 Chemistry-only: DNA is made from nucleotide monomers

- nucleotide
- double helix

■ Question 1

Which monomers form the two chains in the stated DNA model?

- Nucleotides
- Only glucose molecules
- Amino acids joined as a polypeptide

Available marks: 2.

Worked answer

Nucleotides

- The chains provide a repeated structural framework while the sequence of nucleotide types varies. A ladder model can distinguish the two continuous chains from paired positions across them. In the familiar double-stranded DNA model, A pairs with T and C with G. Twisting that ladder models the double helix. Colour-coded blocks are a representation: they are not actual nucleotide shapes, accurate atom arrangements or a diagram of separate bases joined without a backbone.

exercises.lol exercises.com.cn

■ Question 2

A double-stranded DNA model has 24 paired positions. Count all its nucleotides.

Available marks: 4.

Worked answer

48 nucleotides

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A nucleotide is not an amino acid, and four nucleotide types does not mean DNA is only four nucleotides long. A double helix has two polymer chains, not one chain split into four. Recognising DNA and its monomers is Chemistry-only content on both tiers. Additional molecular detail is an explanatory model, not a new requirement to reproduce advanced nucleotide chemistry.

129 Chemistry-only: match natural polymers to their monomers

- natural polymer
- glucose

■ Question 1

Which statement correctly matches these natural polymers to monomers?

- Starch and cellulose both use glucose
- Proteins and DNA both use sugars
- Starch uses amino acids; DNA uses glucose

Available marks: 2.

Worked answer

Starch and cellulose both use glucose

- Proteins can use different amino acids in the same chain, with sequence and folding contributing to their functions. Starch and cellulose use glucose but differ in how their building blocks are joined and arranged, producing different properties. Starch stores carbohydrate in plants; cellulose gives strength to plant cell walls. The required Chemistry comparison is monomer identity and polymer recognition, not memorising advanced alpha/beta linkage names or complete structural formulae of carbohydrates.

exercises.lol exercises.com.cn

■ Question 2

Two supplied carbohydrate chain models contain 18 and 14 glucose-derived units. Count their total units.

Available marks: 4.

Worked answer

32 units

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not say cellulose has different monomers merely because its properties differ from starch, or that all proteins contain only glycine. A polymer's monomer type and arrangement are separate evidence. Common-tier recognition of amino-acid protein monomers does not require the HT condensation mechanism, and common-tier DNA recognition does not require an invented written practical examination.

130 Chemical tests and analytical confidence

- chromatography
- Rf

■ Question 1

Why use pencil for a chromatography baseline?

- Graphite is less likely to dissolve and move with the solvent
- Pencil marks move with the solvent and help separate the dyes
- Ink is invisible under the UV light used to see the spots

Available marks: 2.

Worked answer

Graphite is less likely to dissolve and move with the solvent

- Rf is distance travelled by a component divided by distance travelled by the solvent front, both measured from the baseline. Compare under the same conditions; an Rf value alone does not establish identity across different solvents.

■ Question 2

A spot travels 4.2 cm while the solvent front travels 7.0 cm. Find Rf.

Available marks: 4.

Worked answer

0.6

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

exercises.lol exercises.com.cn

A single spot can conceal substances that co-elute. Ink on the baseline can dissolve and create extra spots.

131 Chemical purity: use melting and boiling evidence

- chemical purity
- melting interval

■ Question 1

Which sample can be chemically pure?

- Water containing only H_2O
- Milk with no added sugar
- Air containing several gases

Available marks: 2.

Worked answer

Water containing only H_2O

- Compare the measured transition with a reference at the same pressure and with calibrated apparatus. A sharp matching melting point supports purity and identity, while a broadened or shifted interval can indicate an impurity. Boiling temperature depends on pressure and the mixture; do not claim every impurity must shift every boiling point in the same direction. A single matching temperature is supporting evidence rather than unique proof of identity, because different substances can have similar values.

■ Question 2

A sample begins melting at 63 °C and finishes at 69 °C. Find its melting-interval width.

Available marks: 4.

Worked answer

6 °C

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Pure does not mean natural, harmless, colourless or a single type of atom. A compound can be pure. Do not identify an impurity solely by the size of the melting-point change or ignore pressure when comparing boiling data. This section applies on both tiers.

exercises.lol exercises.com.cn

132 Formulations: each measured component has a purpose

- formulation
- component proportion

Question 1

What makes the supplied paint a formulation?

- Its measured components are selected for useful properties
- It contains only one compound, so it is a pure substance
- Its components are mixed in any amounts without measuring

Available marks: 2.

Worked answer

Its measured components are selected for useful properties

- Use the supplied information to connect component, quantity and intended property. Too much solvent may make a paint spread easily but reduce coating thickness, while the right binder/pigment balance affects coverage and adhesion. These are product-specific trade-offs rather than a universal recipe. A formulation's measured composition is different from the fixed chemical proportions inside a compound. Proprietary component names are not required knowledge.

Question 2

A fictional 250 g mixture contains 12% pigment by mass. Calculate pigment mass.

Available marks: 4.

Worked answer

30 g

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Formulation does not mean chemically pure, and not every accidental mixture is designed for a useful purpose. A label saying natural gives no evidence about the proportions or safety of its components. Do not infer an exact formulation from colour alone. Both-tier students identify and reason from supplied composition and purpose.

133 Chromatography: phases, spot positions and Rf

- mobile phase
- stationary phase

exercises.lol exercises.com.cn

■ Question 1

What distances are used to calculate Rf?

- Spot centre and solvent front, both from the origin
- Spot centre from the origin and solvent front from the paper top
- The spot's distance from the origin and the spot's diameter

Available marks: 2.

Worked answer

Spot centre and solvent front, both from the origin

- Rf is distance moved by the substance divided by distance moved by the solvent. Measure both from the origin line, using the centre of the spot for the substance. The ratio has no unit and ordinarily lies between zero and one in this model. Compare unknown and reference spots using the same paper, solvent and conditions. A different solvent can change the separation and Rf; it is not a universal identifying number for one substance.

■ Question 2

A spot centre travels 28 mm and the solvent front 40 mm from the origin. Calculate Rf.

Available marks: 4.

Worked answer

0.7

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not measure from the paper edge, divide solvent distance by spot distance or attach millimetres to Rf. Higher travel is not evidence that a molecule weighs more or that the paper is moving. This both-tier objective includes calculation and appropriately rounded answers; an unreviewed advanced chromatographic technique is not required.

134 Required practical 6: separate and identify actual food dyes

- origin line
- solvent front

■ Question 1

Why must the spotted origin stay above the initial water level?

- To avoid washing the samples directly into the reservoir
- To stop the water moving up the paper before the samples dry
- To make the spots travel the same distance as the solvent front

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

To avoid washing the samples directly into the reservoir

- Draw a horizontal pencil origin 2 cm above the lower paper edge. Mark positions away from the edges, place small concentrated spots using separate clean tubes and label in pencil. The handbook aims for 2–3 mm spots and no more than 1 cm water depth, keeping the origin above the water while the paper bottom dips into it. Support the paper without touching the beaker walls and avoid moving the vessel during the run.

■ Question 2

In an actual run a spot centre travels 33 mm and the front 60 mm from the origin. Calculate Rf.

Available marks: 4.

Worked answer

0.55

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Ink can move and interfere, so the baseline and labels use pencil. An origin submerged in solvent lets samples dissolve into the reservoir. Large spots can overlap; touching walls can distort the front. No spot matching A–D does not mean the unknown contains no dye. RP6 applies on both tiers and assesses actual separation skills alongside written interpretation.

135 Gas identification: hydrogen gives a squeaky pop

- burning splint
- positive test

■ Question 1

Which pair describes the hydrogen test?

- Burning splint at the open end; pop
- Glowing splint inside; relights
- Damp litmus; bleaches white

Available marks: 2.

Worked answer

Burning splint at the open end; pop

- A reaction prediction and a gas test answer different questions. A known reactive metal with dilute acid can produce hydrogen, but bubbles alone could be another

exercises.lol exercises.com.cn

gas in a different system. A positive pop supports hydrogen under the approved test conditions. A weak or absent observation can reflect a small or diluted sample as well as absence of hydrogen, so an inconclusive trial should not be rewritten as a definite negative.

■ Question 2

A supplied record has eight clear positives out of ten trials. Calculate positive percentage.

Available marks: 4.

Worked answer

80 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not insert a glowing splint and call any relighting a hydrogen test. Colourless appearance does not distinguish hydrogen from other colourless gases. The identifying pop is rapid combustion, not evidence that a metal itself popped. This both-tier lesson teaches the specified test and its interpretation; it does not require an invented written practical qualification component.

136 Gas identification: oxygen relights a glowing splint

- glowing splint
- relighting

■ Question 1

What is the positive oxygen-test observation?

- A glowing splint relights
- A burning splint gives a pop
- Limewater becomes cloudy

Available marks: 2.

Worked answer

A glowing splint relights

- Oxygen supports combustion but is not itself described as a flammable fuel in this test. Increased burning is evidence about combustion conditions; the school identification relies on the characteristic relighting observation. Colourless gas or a known source reaction alone is weaker evidence than a correctly performed test. A sample mixed with air or contaminated during collection may give less clear observations, so retain uncertain results rather than inventing an identification.

exercises.lol exercises.com.cn

Question 2

A supplied table records six clear relightings in eight observations. Calculate their percentage.

Available marks: 4.

Worked answer

75 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A splint already burning cannot demonstrate relighting from a glow. Do not write oxygen burns with a pop, or assume every gas that permits some burning is pure oxygen. The qualitative test gives identification support under suitable conditions and has observation limits. Both tiers need the specified test; performing it in school remains distinct from answering a written gas question.

137 Gas identification: carbon dioxide clouds limewater

- limewater
- cloudy result

Question 1

Which reagent and result support carbon dioxide?

- Limewater turns milky
- A glowing splint relights
- Dry litmus stays unchanged

Available marks: 2.

Worked answer

Limewater turns milky

- State the reagent and the positive result together. A flame going out is not a unique carbon-dioxide test because several gases fail to support combustion. Under continued excess carbon dioxide the cloudiness can eventually disappear by further reaction; that optional observation does not invalidate the initial specified milky result. Do not substitute that extension for the basic test or make students memorise an unrequired second equation.

Question 2

Eight of ten supplied observations show cloudy limewater. Calculate the cloudy-result percentage.

Available marks: 4.

Worked answer

exercises.lol exercises.com.cn

80 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Limewater is not just any calcium-containing liquid, and cloudiness is not a green flame. Do not report a carbonate ion as a gas: the carbonate reaction produces carbon dioxide, whose test provides the observation. The source equation conserves Ca, C, O and H, but a balanced equation does not replace the actual school evidence record.

138 Gas identification: chlorine bleaches damp litmus

- bleaching
- damp litmus

■ Question 1

Which observation is the specified positive chlorine result?

- Damp litmus is bleached white
- A glowing splint relights
- Silver iodide gives a yellow flame

Available marks: 2.

Worked answer

Damp litmus is bleached white

- Chlorine is Cl_2, a molecular element, while chloride is Cl^-, a negative ion in compounds and solutions. Their tests are different: gas bleaching identifies chlorine under suitable conditions, whereas acidified silver nitrate precipitates chloride ions. Pale green gas appearance can support the description but does not justify smelling a sample. Not every substance containing chlorine atoms releases chlorine gas or bleaches paper in the same way.

■ Question 2

Six of eight supplied damp-litmus records show clear bleaching. Calculate the percentage.

Available marks: 4.

Worked answer

75 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not confuse bleaching with the simple red/blue indicator response, write dry litmus as the required reagent or use a smell test. Chloride precipitation is a separate solution-

exercises.lol exercises.com.cn

ion test. A written explanation does not authorise chlorine handling or certify a supervised task was performed. The gas-test objective applies on both tiers.

139 Chemistry-only: identify five metal ions by flame colour

- flame test
- cation

■ Question 1

Which required flame colour supports potassium ions?

- Lilac
- Crimson
- Green

Available marks: 2.

Worked answer

Lilac

- A sample is introduced into a suitable flame using the school-approved wire or soaked-splint method. Compare its emission with known references under the same conditions. A mixture may have masked colours; intense sodium emission can obscure another response. Yellow therefore supports sodium in the tested conditions but does not prove no other ions are present. Contamination of the wire, sample or apparatus can produce a misleading result.

■ Question 2

Four of ten supplied unknown samples give a lithium-crimson flame. Calculate their sample percentage.

Available marks: 4.

Worked answer

40 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not identify chloride ions from a sodium-yellow flame or infer a salt's complete formula from its cation alone. A negative or masked result may be inconclusive. A flame colour is qualitative evidence; concentration measurement requires a calibrated instrument and appropriate data. Separate Chemistry flame-test content applies to both tiers.

exercises.lol exercises.com.cn

140 Required practical 7: identify both ions in an actual unknown salt

- unknown salt
- reference matrix

Question 1

Why use separate fresh unknown portions for different tests?

- To avoid reagents from one test contaminating the next
- To make the compound change cation in every portion
- To avoid recording any reference results

Available marks: 2.

Worked answer

To avoid reagents from one test contaminating the next

- Establish reference results with labelled known cation compounds and carbonate/sulfate/chloride/bromide/iodide salts. Use fresh unknown portions for different tests. Keep flame-wire cleaning, dilute-acid identities and precipitating reagents exact. Record carbonate gas and limewater, sulfate with dilute HCl/barium chloride, and halides with dilute nitric acid/silver nitrate. Compare subtle silver-halide colours side by side. The handbook suggests potassium sulfate as a convenient unknown; the school can choose another suitable single compound.

Question 2

Seven K_2SO_4 formula units contain two potassium ions each. Count potassium ions.

Available marks: 4.

Worked answer

14 ions

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not reuse an HCl-treated portion for the silver-nitrate halide test, or infer the anion from a flame. A matrix can leave ambiguity or conflicting evidence; report that honestly instead of inventing a unique salt. The practical uses actual supervised tasks and both-ion reasoning, not an invented written performance exam or an automatically certified completion checkbox.

141 Chemistry-only: colour and excess alkali identify metal hydroxides

- precipitate
- excess reagent

exercises.lol exercises.com.cn

Question 1

Which result supports aluminium within the supplied six-cation reference set?

- White precipitate dissolving in excess sodium hydroxide
- White precipitate remaining unchanged in excess
- Brown precipitate on initial addition

Available marks: 2.

Worked answer

White precipitate dissolving in excess sodium hydroxide

- Record initial precipitation separately from what happens on adding excess reagent. A white precipitate that dissolves in excess supports aluminium; one remaining supports calcium or magnesium within the supplied set. Use additional suitable evidence, such as calcium's orange-red flame, when a single observation leaves alternatives. The Roman numerals in iron(II) and iron(III) distinguish ion charges and their different hydroxides. Colour should be compared with known results in similar conditions.

Question 2

Six of eight supplied white-precipitate samples dissolve in excess sodium hydroxide. Calculate their percentage.

Available marks: 4.

Worked answer

75 %

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not treat all white precipitates as aluminium, mix up iron hydroxide colours or call an original blue solution a blue precipitate without observing a solid. Excess reagent and initial addition are different test stages. The classification applies on both tiers; the separate equation lesson teaches the required balanced formation equations.

142 Chemistry-only: balance insoluble-hydroxide formation equations

- hydroxide formula
- formation equation

exercises.lol exercises.com.cn

Question 1

Which formula is correct for iron(III) hydroxide?

- $Fe(OH)_3$
- $Fe(OH)_2$
- $FeOH_3$

Available marks: 2.

Worked answer

$Fe(OH)_3$

- The divalent examples have form $MCl_2(aq) + 2NaOH(aq) \rightarrow M(OH)_2(s) + 2NaCl(aq)$, with M the stated Mg, Ca, Cu or Fe(II). For Al and Fe(III), $MCl_3(aq) + 3NaOH(aq) \rightarrow M(OH)_3(s) + 3NaCl(aq)$. These are full symbol equations, suitable for the both-tier requirement. Separate HT ionic-equation work may simplify them, but it is not needed to recognise the common-tier formation equations here.

Question 2

In $FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaCl$, four $FeCl_3$ formula units require how many NaOH units?

Available marks: 4.

Worked answer

12 units

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

A coefficient before NaOH counts complete formula units; a subscript in $Fe(OH)_3$ gives composition. Do not write $FeOH_3$ or remove sodium/chloride from a full symbol equation without explicitly changing to an ionic representation. These particle counts do not require a mole calculation or imply that any unknown chloride should be handled without the approved school method.

143 Chemistry-only: identify carbonate through its carbon dioxide

- carbonate test
- effervescence

exercises.lol exercises.com.cn

Question 1

Which combined evidence supports carbonate in the tested salt?

- Dilute acid gives gas that clouds limewater
- The dry sample is white
- A flame goes out with no other test

Available marks: 2.

Worked answer

Dilute acid gives gas that clouds limewater

- For sodium carbonate and hydrochloric acid, $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$ illustrates the source of the gas. The CO_2 test uses aqueous calcium hydroxide and forms insoluble calcium carbonate. Effervescence means gas bubbles, not a unique gas identity. A flame being extinguished is also non-specific: several gases do not support combustion, so it is weaker than the specified limewater result.

Question 2

In the stated sodium-carbonate reaction, six Na_2CO_3 formula units give one CO_2 molecule each. Count CO_2 molecules.

Available marks: 4.

Worked answer

6 molecules

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

The handbook's optional alternative mentions a lit splint going out; preserve its source text, but do not treat that as unique CO_2 identification. The student method and specification explicitly use limewater. Do not confuse carbonate with carbon dioxide or infer the cation from the acid test. Both-tier Chemistry-only students need the correct two-stage interpretation.

144 Chemistry-only: acidified silver nitrate distinguishes three halides

- halide test
- silver halide

Question 1

Which reagent pair belongs to the halide test?

- Dilute nitric acid followed by silver nitrate
- Hydrochloric acid followed by silver nitrate
- Only a glowing splint

exercises.lol exercises.com.cn

Available marks: 2.

Worked answer

Dilute nitric acid followed by silver nitrate

- Nitric acid does not introduce a halide ion that would contaminate this test. Using hydrochloric acid instead introduces chloride and can produce a misleading white precipitate with silver nitrate. Acidification also removes carbonate interference in the standard comparison. The school method governs quantities and handling. Silver-halide colours are subtle, so compare known results side by side under the same light rather than relying on a tiny colour difference from memory.

■ Question 2

Five NaI formula units react one-to-one with silver nitrate. Count AgI units formed in the stated model.

Available marks: 4.

Worked answer

5 units

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not say chloride gives a yellow precipitate, replace nitric acid with hydrochloric acid or confuse precipitation colour with a flame colour. No visible result may reflect concentration or contamination limits and should be recorded honestly. A single anion test cannot identify the unknown's cation. This separate Chemistry section applies on both tiers.

145 Chemistry-only: acidified barium chloride detects sulfate

- sulfate test
- test interference

■ Question 1

Which result supports sulfate with the stated method?

- White precipitate after dilute HCl and barium chloride
- Cream precipitate after nitric acid and silver nitrate
- Lilac flame alone

Available marks: 2.

Worked answer

White precipitate after dilute HCl and barium chloride

- Dilute hydrochloric acid helps remove carbonate interference before barium chloride is added. Barium salts can otherwise precipitate with carbonate as well. Do not

exercises.lol exercises.com.cn

use sulfuric acid to acidify the sample: it introduces sulfate and could produce a false positive. This requirement differs from the halide test, where nitric acid avoids introducing chloride. The acid choice is therefore part of the chemical evidence, not a interchangeable label.

■ Question 2

In $Na_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2NaCl$, four Na_2SO_4 units give how many NaCl units?

Available marks: 4.

Worked answer

8 units

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not identify sulfate from a white precipitate produced by silver nitrate, or use sulfuric acid before barium chloride. A carbonate gas test and an acidified sulfate precipitation test use different observations. Negative or uncertain results remain qualified by sampling and detection limits. Both tiers learn the specific reagent/result pair; no extra advanced barium chemistry is imposed.

146 Chemistry-only: accuracy, sensitivity and speed of instruments

- analytical sensitivity
- detection threshold

■ Question 1

Which supplied feature demonstrates greater analytical sensitivity?

- A lower detectable concentration
- A prettier display colour
- A longer sample name

Available marks: 2.

Worked answer

A lower detectable concentration

- Compare an instrument and a chemical test against the same task. Detecting a small metal-ion concentration is different from identifying a high-concentration salt by flame colour. Instrumental outputs can be numerical and easier to compare objectively than a subtle cream/white judgement. Instruments still need appropriate references, calibration, clean samples and correct operation. A fast result can be wrong if contamination or an unsuitable reference invalidates the method.

exercises.lol exercises.com.cn

■ Question 2

A reference concentration is 12.0 units and the measured value is 11.7. Find the absolute error.

Available marks: 4.

Worked answer

0.3 units

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not call a lower detection threshold greater accuracy without comparison to a known value. Repeated readings can be precise but systematically wrong. A negative result below a detection threshold does not prove zero analyte. Instrumental advantages do not erase the need for supervised practical work or justify inventing a qualification performance exam.

147 Chemistry-only: match emission lines and use calibration data

- line spectrum
- calibration data

■ Question 1

Which evidence supports the identity of a metal ion in the supplied spectrum?

- Several matching line positions in the reference
- The concentration-axis label alone
- An arbitrary increase in overall brightness

Available marks: 2.

Worked answer

Several matching line positions in the reference

- Separate line position from signal strength. Position supports identity; intensity at a suitable line, compared with known concentrations, supports quantity. Use the supplied wavelength scale or reference table, not a memorised list of invented atomic wavelengths. The original figure's reference X/Y positions are explicitly fictional teaching data. Check several lines and overlapping signals; one shared line alone can leave alternatives. No electron-transition or advanced instrument mechanism is required here.

exercises.lol exercises.com.cn

■ Question 2

A supplied linear zero-background calibration has signal 20 at 2 mg/L and 40 at 4 mg/L. Read concentration for signal 35.

Available marks: 4.

Worked answer

3.5 mg/L

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

Do not infer concentration from the horizontal line position, or identify a spectrum by total brightness alone. A matching line pattern supports identity only within the supplied references and resolution. Record uncertain or unexplained lines. The current section limits interpretation to flame emission with appropriate reference data; it does not demand an advanced mass-spectrum or infrared-spectrum course.

148 Atmosphere, resources and life-cycle decisions

- life-cycle assessment
- functional unit

■ Question 1

Which comparison uses a consistent functional unit?

- One bottle versus any number of bags
- The same volume delivered the same number of times
- Two items with the same colour

Available marks: 2.

Worked answer

The same volume delivered the same number of times

- Define the functional unit before comparing products. The same delivered service, such as carrying one litre of water a hundred times, is fairer than comparing one object with another regardless of lifetime.

■ Question 2

A reusable item costs 600 energy units initially and 5 per use; disposables cost 35 per use. Find break-even uses.

Available marks: 4.

Worked answer

20 uses

- Appropriate relation; consistent substitution; correct result; meaningful unit and interpretation.

exercises.lol exercises.com.cn

A break-even model is sensitive to cleaning, transport and disposal assumptions. Recyclable does not guarantee that an item is actually collected and recycled.

exercises.lol exercises.com.cn