SCH3U

Grade 11 Chemistry — Practice Workbook

Ontario Grade 11 Chemistry (SCH3U)

8 lessons • 119 multiple-choice • 43 short-answer questions

Work through each lesson's questions, then check the Answer Key at the back. Pairs with the interactive Grade 11 Study Hub.

Student notebook handouts

The video-distilled chemistry notebooks are linked here for quick printing or review.

Open Chemistry notebook index

Unit 1 Ionic Reactions: handwritten | visual notebook

Unit 2 Redox: handwritten | visual notebook

Unit 3 Moles & Concentration: handwritten | visual notebook

Unit 4 Periodic Law & Bonding: handwritten | visual notebook

Unit 5 Reaction Rates: handwritten | visual notebook

Unit 6 Molecular Structure: handwritten | visual notebook

1.1 Atomic Structure

Key formula / rule: Atomic number = protons ; mass number = protons + neutrons

Big idea: Chemistry starts with particles and their interactions.

Multiple choice

1. Which particle determines the atomic number?
A. Molecule
B. Proton
C. Neutron
D. Electron

2. An atom has 8 protons and 8 neutrons. What is its mass number?
A. 8
B. 16
C. 0
D. 4

3. An atom has 8 protons and 8 neutrons. What is its mass number?
A. 16
B. 8
C. 0
D. 4

4. Which particle sets the atomic number?
A. Electron
B. Proton
C. Neutron
D. Molecule

5. An atom with 6 protons and 6 electrons has a charge of…
A. 0 (neutral)
B. −6
C. +6
D. +1

6. An atom that gains extra electrons becomes a…
A. neutral atom
B. new element
C. negative ion
D. positive ion

7. Mass number equals…
A. neutrons + electrons
B. protons + neutrons
C. protons only
D. protons + electrons

8. What charge does a neutron carry?
A. positive
B. it varies
C. negative

D. none (neutral)

9. An atom has 11 protons and 12 neutrons. Its atomic number is…
A. 1
B. 12
C. 23
D. 11

10. Changing the number of neutrons (same protons) creates a different…
A. element
B. ion
C. isotope
D. molecule

11. What charge does an electron carry?
A. positive
B. none
C. neutral
D. negative

12. What charge does a proton carry?
A. none
B. negative
C. neutral
D. positive

13. A neutral atom has 17 protons and mass number 35. How many neutrons does it have?
A. 18
B. 52
C. 35
D. 17

14. Two atoms have the same number of protons but different numbers of neutrons. They are different…
A. ions
B. molecules
C. elements
D. isotopes

Short answer

1. Define atomic number, mass number, and charge in terms of subatomic particles.

2. An ion has 12 protons, 12 neutrons, and 10 electrons. Find its atomic number, mass number, and charge.

3. Explain the difference between an isotope and an ion.

4. Why does changing the number of electrons not change which element an atom is?

5. A particle has 17 protons, 18 neutrons, and 18 electrons. Identify the element, mass number, and charge.

1.2 Bonding

Key formula / rule: Ionic: transfer electrons ; Covalent: share electrons

Big idea: Bonding is about electron behavior.

Multiple choice

1. Which description matches covalent bonding?
A. Electrons are shared
B. Neutrons are removed
C. Protons are shared
D. Electrons are transferred

2. A bond forms between a metal and a non-metal. Which type is it most likely?
A. Ionic
B. No bond forms
C. Covalent
D. Always metallic

3. Covalent bonding involves…
A. adding neutrons
B. removing protons
C. transferring electrons
D. sharing electrons

4. Ionic bonding involves…
A. sharing electrons
B. removing protons
C. transferring electrons
D. adding neutrons

5. A metal and a non-metal usually form a…
A. metallic bond only
B. covalent bond
C. ionic bond
D. no bond

6. Two non-metals usually form a…

A. ionic bond
B. metallic bond
C. no bond
D. covalent bond

7. Transfer = ionic, share = …
A. metallic
B. nuclear
C. no bond
D. covalent

8. Ionic compounds tend to have … melting points.
A. very low
B. no
C. negative
D. high

9. A covalent bond involves which particles?
A. electrons
B. nuclei
C. protons
D. neutrons

10. Sodium chloride (Na + Cl) is an example of…
A. no bonding
B. covalent bonding
C. ionic bonding
D. metallic bonding only

11. Sharing two pairs of electrons is called a…
A. ionic bond
B. no bond
C. double bond
D. single bond

12. Bond type strongly affects a substance’s…
A. properties
B. atomic number
C. colour only
D. mass number

13. In the distilled molecular-structure unit, what is the first VSEPR step?
A. Count electron domains around the central atom
B. Choose a colour for the molecule
C. Find the molar mass first
D. Balance the equation first

14. A double covalent bond contains…
A. one σ bond and one π bond
B. two σ bonds
C. two π bonds
D. one ionic bond

15. Why is H_2O polar in the VSEPR example pattern?

A. It is linear and symmetric
B. It has polar O-H bonds and a bent shape
C. It has no lone pairs
D. It contains an ionic bond

16. Hydrogen bonding requires hydrogen bonded directly to…

A. any metal
B. N, O, or F
C. C, Si, or Ge
D. Na, K, or Li

Short answer

1. Explain the difference between ionic and covalent bonding.

2. Predict the bond type for (a) sodium and chlorine and (b) two oxygen atoms.

3. How does bond type relate to a property such as melting point?

4. What is a double bond?

5. Use VSEPR to describe H_2O: electron-domain count, molecular shape, hybridization, and polarity.

6. Count σ and π bonds in a triple bond and explain the rule.

2.1 Balancing Equations

Key formula / rule: Balanced equation → same number of each atom on both sides
Big idea: Atoms are rearranged, not created or destroyed.

Multiple choice

1. When balancing equations, what is allowed to change?

A. Subscripts

B. Element symbols
C. Charges of atoms
D. Coefficients

2. In $2H_2 + O_2 \rightarrow 2H_2O$, how many oxygen atoms are on each side?
A. 1 left, 2 right
B. 3 left, 2 right
C. 4 on each side
D. 2 on each side

3. When balancing, what may you change?
A. symbols
B. subscripts
C. charges
D. coefficients

4. In $2H_2 + O_2 \rightarrow 2H_2O$, how many O atoms are on each side?
A. 2 and 1
B. 2 and 2
C. 1 and 2
D. 4 and 2

5. Balancing is based on conservation of…
A. energy
B. charge only
C. atoms (mass)
D. volume

6. You must never change a formula's…
A. place in the equation
B. subscripts
C. none of these
D. coefficient

7. In $2H_2 + O_2 \rightarrow 2H_2O$, how many H atoms are on each side?
A. 4 and 4
B. 2 and 2
C. 4 and 2
D. 2 and 4

8. Coefficients should be the smallest…
A. decimals
B. fractions
C. prime numbers
D. whole numbers

9. In a reaction, atoms are…
A. turned into energy
B. created
C. destroyed
D. rearranged, not created or destroyed

10. Is $C + O_2 \rightarrow CO_2$ already balanced?

A. No, needs 2 O_2
B. Yes
C. No, needs 2 C
D. No, needs 2 CO_2

11. A coefficient multiplies…
A. the whole formula after it
B. only the first atom
C. only subscripts
D. nothing

12. After balancing, you should…
A. add a subscript
B. stop immediately
C. change the symbols
D. recount every atom

13. For $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$, which is the net ionic equation?
A. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
B. $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(aq)$
C. $Ag^+(aq) + Na^+(aq) \rightarrow AgNa^{2+}(aq)$
D. $AgNO_3(aq) \rightarrow Ag^+(aq) + NO_3^-(aq)$

14. In a net ionic equation, when should spectator ions be cancelled?
A. Before checking solubility
B. Only after changing subscripts
C. After the complete ionic equation is written
D. Before writing any equation

15. In $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$, which species is the oxidizing agent?
A. Cu^{2+}
B. Zn^{2+}
C. Cu
D. Zn

16. Oxidation number increases mean…
A. reduction
B. spectator ion only
C. oxidation
D. no electron transfer

Short answer

1. Explain the rule for balancing equations and why subscripts cannot be changed.

2. Balance: $H_2 + O_2 \rightarrow H_2O$.

3. Balance: $N_2 + H_2 \rightarrow NH_3$.

4. Why must the number of each type of atom be equal on both sides of a balanced equation?

5. Write the net ionic equation for $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$.

6. For $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$, identify oxidation, reduction, oxidizing agent, and reducing agent.

2.2 Stoichiometry

Key formula / rule: Use balanced coefficients as mole ratios

Big idea: The balanced equation is a map of proportional relationships.

Multiple choice

1. If 2 mol A reacts according to $2A \rightarrow 3B$, how many moles of B form?
A. 1 mol
B. 3 mol
C. 2 mol
D. 4 mol

2. For $A \rightarrow 2B$, how many moles of B come from 3 mol of A?
A. 2 mol
B. 1.5 mol
C. 6 mol
D. 3 mol

3. For $2A \rightarrow 3B$, how many moles of B come from 2 mol A?
A. 2 mol
B. 4 mol
C. 3 mol
D. 1 mol

4. For $A \rightarrow 2B$, how many moles of B come from 3 mol A?
A. 6 mol
B. 3 mol
C. 2 mol
D. 1.5 mol

5. The coefficients in a balanced equation give the...

A. charge
B. volume
C. mass only
D. mole ratio

6. The mole ratio comes from the…
A. a guess
B. units
C. balanced equation
D. periodic table

7. For 2A → 1C, how many moles of C come from 4 mol A?
A. 1 mol
B. 2 mol
C. 8 mol
D. 4 mol

8. To convert grams to moles, you use…
A. density
B. volume
C. molar mass
D. temperature

9. For 1A → 3B, how many moles of B come from 2 mol A?
A. 2 mol
B. 3 mol
C. 1.5 mol
D. 6 mol

10. The order of steps is given → moles → mole ratio → …
A. target amount
B. mass only
C. nothing
D. start over

11. For 3A → 2B, how many moles of B come from 6 mol A?
A. 3 mol
B. 2 mol
C. 4 mol
D. 6 mol

12. In every stoichiometry step you should keep the…
A. colours
B. units
C. names
D. dates

13. The distilled mole map says particles, mass, gas volume, and concentration should all convert through…
A. temperature only
B. charge only
C. moles n
D. colour

14. How many H_2O molecules are in 1.00 mol of H_2O?

A. 6.02×10^{23}
B. 22.4
C. 18.0
D. 1.00×10^{-23}

15. To convert 18.0 g H_2O to molecules, what is the best first step?

A. Cancel spectator ions
B. Use Boyle's law
C. Convert grams to moles using molar mass
D. Convert grams directly to pressure

Short answer

1. Explain how a balanced equation gives mole ratios.

2. For $2H_2 + O_2 \rightarrow 2H_2O$, how many moles of water form from 4 mol of H_2?

3. Describe the steps to convert grams of substance A to moles of substance B.

4. For $N_2 + 3H_2 \rightarrow 2NH_3$, how many moles of NH_3 form from 6 mol of H_2?

5. Use the mole bridge to find the number of molecules in 18.0 g of H_2O.

3.1 Solutions

Key formula / rule: $c = n / V$

Big idea: Concentration compares amount of solute to volume of solution.

Multiple choice

1. If 2.0 mol is dissolved in 1.0 L, what is the concentration?

A. 3.0 mol/L
B. 0.5 mol/L
C. 2.0 mol/L
D. 1.0 mol/L

2. The same amount of solute is dissolved in more water. The concentration…

A. increases

B. decreases
C. becomes zero
D. stays the same

3. If 2.0 mol is dissolved in 1.0 L, the concentration is…
A. 0.5 mol/L
B. 3.0 mol/L
C. 1.0 mol/L
D. 2.0 mol/L

4. The concentration formula is…
A. $c = n \times V$
B. $c = n + V$
C. $c = n / V$
D. $c = V / n$

5. Same solute, more volume → concentration…
A. stays the same
B. becomes zero
C. decreases
D. increases

6. If 1.0 mol is dissolved in 2.0 L, the concentration is…
A. 2.0 mol/L
B. 0.5 mol/L
C. 1.0 mol/L
D. 0.2 mol/L

7. The unit of concentration here is…
A. mol/L
B. g
C. mol
D. L

8. In a dilution, the amount of solute…
A. stays constant
B. increases
C. doubles
D. becomes zero

9. If 3.0 mol is dissolved in 1.5 L, the concentration is…
A. 0.5 mol/L
B. 1.5 mol/L
C. 4.5 mol/L
D. 2.0 mol/L

10. Convert 500 mL to litres.
A. 5000 L
B. 50 L
C. 0.5 L
D. 5 L

11. More solute in the same volume → concentration…

A. stays the same
B. decreases
C. becomes zero
D. increases

12. In c = n/V, what does n stand for?
A. mass in grams
B. moles of solute
C. volume
D. number of atoms only

13. What is the concentration of 0.500 mol solute in 250 mL solution?
A. 0.125 mol/L
B. 0.500 mol/L
C. 125 mol/L
D. 2.00 mol/L

14. In c = n/V, which unit must volume use in this course style?
A. L
B. g
C. mL left unchanged
D. mol

Short answer

1. State the concentration formula and define each term with units.

2. Find the concentration when 0.5 mol of solute is dissolved in 250 mL.

3. Explain what happens to concentration during a dilution and why.

4. How many moles of solute are in 2.0 L of a 1.5 mol/L solution?

5. Find c when 0.500 mol of solute is made into 250 mL of solution.

3.2 Gas Laws

Key formula / rule: At constant temperature: $P_1V_1 = P_2V_2$

Big idea: Gas particles respond strongly to space and temperature.

Multiple choice

1. If volume decreases and temperature stays constant, what happens to pressure?
A. It stays zero
B. It increases
C. It becomes negative
D. It decreases

2. A gas is compressed to half its volume at constant temperature. The pressure…
A. doubles
B. triples
C. stays the same
D. halves

3. If volume decreases and temperature stays constant, pressure…
A. becomes negative
B. increases
C. decreases
D. stays zero

4. Boyle’s law is written as…
A. $P_1 + V_1 = P_2 + V_2$
B. $P_1/V_1 = P_2/V_2$
C. $P_1 - V_1 = P_2 - V_2$
D. $P_1V_1 = P_2V_2$

5. Halving the volume (constant T) makes the pressure…
A. triple
B. double
C. stay the same
D. halve

6. At constant temperature, pressure and volume are…
A. always equal
B. directly related
C. unrelated
D. inversely related

7. Squeezing a gas into less space makes particles hit the walls…
A. at the same rate
B. less often
C. more often (higher pressure)
D. never

8. For gas-law calculations, temperature is best measured in…
A. grams
B. fahrenheit
C. kelvin
D. celsius

9. If $P_1 = 100$ kPa, $V_1 = 4$ L, and $V_2 = 2$ L, then P_2 is…
A. 200 kPa

B. 50 kPa
C. 100 kPa
D. 400 kPa

10. Doubling the volume (constant T) makes the pressure…
A. halve
B. become zero
C. stay the same
D. double

11. A common unit of pressure used here is…
A. L
B. mol
C. kPa
D. °C

12. Boyle’s law assumes which quantity is constant?
A. pressure
B. volume
C. temperature
D. mass keeps changing

13. In amount-of-gas calculations, the safest first question is…
A. What colour is the gas?
B. What gas condition is given?
C. Can I ignore units?
D. Can I change the formula subscripts?

14. Which variable is the bridge between gas volume and particles in the mole map?
A. charge only
B. surface area
C. n, amount in moles
D. mass number

Short answer

1. State Boyle’s law and the condition under which it applies.

2. A gas at 100 kPa and 6 L is compressed to 2 L at constant temperature. Find the new pressure.

3. Using particles, explain why reducing the volume increases the pressure.

4. Why is temperature measured in kelvin for gas-law calculations?

5. Why should you avoid using a gas-volume shortcut before reading the condition?

4.1 Reaction Rate Ideas

Key formula / rule: More successful collisions → faster reaction
Big idea: Reaction rate depends on successful collisions.

Multiple choice

1. Which change usually increases reaction rate?
   A. Lower concentration
   B. Lower temperature
   C. Smaller surface area
   D. Higher temperature
2. Which other change usually speeds up a reaction?
   A. Decreasing surface area
   B. Increasing concentration
   C. Removing reactants
   D. Lowering temperature
3. Which change usually increases reaction rate?
   A. lower temperature
   B. higher temperature
   C. smaller surface area
   D. lower concentration
4. Increasing concentration does what to the rate?
   A. no effect
   B. stops it
   C. increases it
   D. decreases it
5. Reaction rate depends on…
   A. volume only
   B. colour
   C. mass number
   D. successful collisions
6. Higher temperature makes particles…
   A. stop
   B. disappear
   C. move faster
   D. slow down
7. Increasing surface area does what to the rate?

A. increases it
B. decreases it
C. stops it
D. no effect

8. A catalyst does what to the rate?
A. decreases it
B. no effect
C. increases it
D. stops it

9. More frequent collisions usually means a…
A. slower reaction
B. colder mixture
C. stopped reaction
D. faster reaction

10. Lowering the temperature usually…
A. slows the reaction
B. has no effect
C. speeds it up
D. stops all motion

11. A “successful collision” means particles collide with enough…
A. colour
B. mass
C. energy
D. charge

12. Crushing a solid into powder increases its…
A. gas concentration
B. mass
C. temperature
D. surface area

13. A concentration changes from 0.80 mol/L to 0.50 mol/L in 30 s. What is the average disappearance rate?
A. 30 mol/(L·s)
B. 0.010 mol/(L·s)
C. 1.30 mol/(L·s)
D. 0.30 mol/(L·s)

14. In an energy diagram, the rate-determining step is usually the step with the…
A. smallest product energy
B. largest activation-energy barrier
C. largest overall ΔH only
D. most reactants

15. A catalyst should be identified by the fact that it…
A. raises activation energy
B. is regenerated overall
C. is always a product only
D. is consumed permanently

16. An intermediate is a species that is…
A. present before the reaction starts
B. formed in one elementary step and consumed later
C. never shown in mechanisms
D. always the final product

Short answer

1. Explain reaction rate using collision theory.

2. List factors that increase reaction rate and explain why each works.

3. Explain why a powdered solid reacts faster than a single lump of the same mass.

4. What makes a collision "successful"?

5. A reactant concentration drops from 0.80 mol/L to 0.50 mol/L in 30 s. Calculate the average disappearance rate.

6. Explain how to find the rate-determining step from a multi-step energy diagram.

4.2 Mixed Review

Key formula / rule: Review focus: identify the chemistry idea first, then use the matching model.

Big idea: Strong chemistry thinking starts by identifying the scale: particle, mole, or macroscopic observation.

Multiple choice

1. Which formula is used for concentration?
A. $F = ma$
B. $c = n/V$
C. $V = IR$
D. $P_1V_1 = P_2V_2 + 1$

2. Which relationship connects the pressure and volume of a gas at constant temperature?
A. $E_k = \frac{1}{2}mv^2$
B. $P_1V_1 = P_2V_2$
C. $c = n/V$
D. $V = IR$

3. Which formula gives concentration?
A. $P_1V_1 = P_2V_2$
B. $c = n/V$
C. $F = ma$
D. $V = IR$

4. Which law links pressure and volume at constant temperature?
A. $P_1V_1 = P_2V_2$
B. $c = n/V$
C. $E_k = \frac{1}{2}mv^2$
D. $V = IR$

5. Atomic number equals the number of…
A. molecules
B. neutrons
C. protons
D. electrons only

6. Balancing an equation changes the…
A. charges
B. coefficients
C. symbols
D. subscripts

7. Covalent bonding is the … of electrons.
A. transferring
B. sharing
C. creating
D. removing

8. Mole ratios come from the…
A. units
B. balanced equation
C. periodic table
D. a guess

9. Higher temperature usually … the reaction rate.
A. increases
B. has no effect on
C. stops
D. decreases

10. Mass number equals…
A. neutrons only
B. protons + neutrons
C. protons only
D. protons + electrons

11. Ionic bonding is the … of electrons.

A. transferring
B. destroying
C. sharing
D. creating

12. Before using an equation, always check that it is…

A. colourful
B. short
C. memorized
D. balanced

13. Which teacher routine best matches the chemistry distillation overall?

A. Change formulas to make equations balance
B. Memorize isolated answers only
C. Ignore units until the end
D. Identify the model first, then calculate

14. Which pair is correctly matched?

A. Redox → no electron transfer
B. Net ionic → keep all spectator ions
C. VSEPR → electron domains
D. Rate → overall ΔH always decides speed

Short answer

1. Match each to its topic: $c = n/V$, $P_1V_1 = P_2V_2$, atomic number, mole ratio.

2. Describe a general approach to an unfamiliar chemistry question.

3. Explain how balanced equations connect the particle level to measurable amounts.

4. Give one everyday example each of a chemical reaction, a solution, and a gas behaviour.

5. Give one teacher move from net ionic equations, redox, mole calculations, and reaction rates.

Answer Key

SCH3U — Chemistry

1.1 Atomic Structure

Multiple choice

1. B (Proton) — The atomic number equals the number of protons — that is what identifies the element.

2. B (16) — Mass number = protons + neutrons = 8 + 8 = 16.

3. A (16) — Mass number = protons + neutrons = 8 + 8 = 16.

4. B (Proton) — The atomic number equals the number of protons.

5. A (0 (neutral)) — Equal protons and electrons cancel, giving a neutral atom (charge 0).

6. C (negative ion) — More electrons than protons gives a net negative charge — a negative ion.

7. B (protons + neutrons) — Mass number counts the heavy particles in the nucleus: protons + neutrons.

8. D (none (neutral)) — Neutrons are electrically neutral.

9. D (11) — Atomic number equals the number of protons, which is 11.

10. C (isotope) — Same element, different neutron count means a different isotope.

11. D (negative) — Electrons carry a negative charge.

12. D (positive) — Protons carry a positive charge.

13. A (18) — Mass number = protons + neutrons, so neutrons = 35 − 17 = 18.

14. D (isotopes) — Same proton count means the same element; different neutron counts mean different isotopes.

Short answer

1. Atomic number = number of protons. Mass number = protons + neutrons. Charge = protons − electrons.

2. Atomic number = 12 (protons). Mass number = 12 + 12 = 24. Charge = 12 − 10 = +2.

3. An isotope has the same number of protons but a different number of neutrons (different mass). An ion is an atom with unequal protons and electrons, so it carries a charge.

4. The element’s identity is set by its proton count (atomic number). Electrons only affect the charge, not the identity.

5. 17 protons means chlorine. Mass number = 17 + 18 = 35. Charge = protons − electrons = 17 − 18 = −1, so it is Cl^{-}.

1.2 Bonding

Multiple choice

1. A (Electrons are shared) — Covalent bonding is the sharing of electrons between atoms. Transferring electrons is ionic bonding.

2. A (Ionic) — Metal + non-metal usually means electrons are transferred from the metal to the non-metal — an ionic bond.

3. D (sharing electrons) — In covalent bonding atoms share electrons.

4. C (transferring electrons) — In ionic bonding electrons are transferred from one atom to another.

5. C (ionic bond) — Metal + non-metal typically transfers electrons, forming an ionic bond.

6. D (covalent bond) — Two non-metals share electrons, forming a covalent bond.

7. D (covalent) — Sharing electrons is covalent bonding.

8. D (high) — Strong ionic attractions give high melting points.

9. A (electrons) — Bonding involves the outer electrons of the atoms.

10. C (ionic bonding) — A metal (Na) and a non-metal (Cl) transfer electrons — ionic bonding.

11. C (double bond) — Two shared pairs make a double bond.

12. A (properties) — Bonding determines properties such as melting point and conductivity.

13. A (Count electron domains around the central atom) — The teacher move is to count electron domains first, then name the electron-domain geometry and molecular shape.

14. A (one σ bond and one π bond) — A double bond has one σ bond plus one π bond.

15. B (It has polar O-H bonds and a bent shape) — Molecular polarity needs both bond polarity and shape. H_2O is bent, so its bond dipoles do not cancel.

16. B (N, O, or F) — The distilled notes flag the condition: H attached to N, O, or F plus a nearby lone-pair acceptor.

Short answer

1. Ionic bonding transfers electrons (usually metal + non-metal, forming ions). Covalent bonding shares electrons (usually between two non-metals).

2. (a) Ionic — a metal (Na) and a non-metal (Cl) transfer electrons. (b) Covalent — two non-metals share electrons.

3. Ionic compounds have strong attractions between ions, giving high melting points (and they conduct when molten or dissolved). Simple covalent (molecular) substances usually have lower melting points.

4. A covalent bond in which the two atoms share two pairs of electrons.

5. O has four electron domains: two bonding pairs and two lone pairs. The molecular shape is bent, the O center is sp^3, and the molecule is polar because the O-H bond dipoles do not cancel.

6. A triple bond has one σ bond and two π bonds. Every multiple bond keeps one σ bond; the extra shared pairs are π bonds.

2.1 Balancing Equations

Multiple choice

1. D (Coefficients) — You only adjust the coefficients (the numbers in front). Changing subscripts or symbols would change the substance itself.

2. D (2 on each side) — Left: O_2 = 2 oxygen atoms. Right: 2 × H_2O = 2 oxygen atoms. Both sides have 2, so oxygen is balanced.

3. D (coefficients) — You only adjust the coefficients in front of formulas.

4. B (2 and 2) — Left: O_2 = 2 O. Right: 2 × H_2O = 2 O. Balanced.

5. C (atoms (mass)) — The same number of each atom must appear on both sides — mass is conserved.

6. B (subscripts) — Changing a subscript changes the substance, so only coefficients may change.

7. A (4 and 4) — Left: 2 × H_2 = 4 H. Right: 2 × H_2O = 4 H. Balanced.

8. D (whole numbers) — A balanced equation uses the smallest whole-number coefficients.

9. D (rearranged, not created or destroyed) — Atoms are only rearranged; matter is conserved.

10. B (Yes) — 1 C and 2 O on each side — it is already balanced.

11. A (the whole formula after it) — A coefficient applies to every atom in the formula that follows it.

12. D (recount every atom) — Always recount each element on both sides to confirm the balance.

13. A ($Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$) — Na^+ and NO_3^- are spectator ions. The changing particles are Ag^+ and Cl^- forming AgCl(s).

14. C (After the complete ionic equation is written) — The video teacher move is: molecular equation → complete ionic equation → cancel spectator ions → check atoms and charge.

15. A (Cu^{2+}) — Cu^{2+} gains electrons and is reduced, so it acts as the oxidizing agent.

16. C (oxidation) — The redox bookkeeping rule is: increase = oxidation, decrease = reduction.

Short answer

1. You only change the coefficients in front of formulas. Changing a subscript changes the substance's identity. Balancing keeps the number of each kind of atom equal on both sides.

2. $2H_2 + O_2 \rightarrow 2H_2O$.

3. $N_2 + 3H_2 \rightarrow 2NH_3$.

4. Conservation of mass — atoms are only rearranged in a reaction, never created or destroyed.

5. Complete ionic: $Ag^+ + NO_3^- + Na^+ + Cl^- \rightarrow AgCl(s) + Na^+ + NO_3^-$. Cancel Na^+ and NO_3^-. Net ionic: $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$.

6. Zn goes 0 → +2, so Zn is oxidized and is the reducing agent. Cu^{2+} goes +2 → 0, so Cu^{2+} is reduced and is the oxidizing agent.

2.2 Stoichiometry

Multiple choice

1. B (3 mol) — The coefficients 2A → 3B give a 2:3 mole ratio, so 2 mol A produces 3 mol B.

2. C (6 mol) — The ratio is 1:2, so mol B = 3 × (2 ÷ 1) = 6 mol.

3. C (3 mol) — The 2:3 ratio gives 3 mol B from 2 mol A.

4. A (6 mol) — The 1:2 ratio gives 3 × 2 = 6 mol B.

5. D (mole ratio) — Coefficients are the mole ratio between substances.

6. C (balanced equation) — Mole ratios are read directly from the balanced equation's coefficients.

7. B (2 mol) — The 2:1 ratio gives 4 ÷ 2 = 2 mol C.

8. C (molar mass) — Dividing mass by molar mass gives moles.

9. D (6 mol) — The 1:3 ratio gives 2 × 3 = 6 mol B.

10. A (target amount) — After applying the mole ratio you reach the target amount.

11. C (4 mol) — The 3:2 ratio gives 6 × (2/3) = 4 mol B.

12. B (units) — Tracking units in each step prevents mistakes.

13. C (moles n) — The teacher move is to use amount of substance, n, as the bridge variable.

14. A (6.02×10^{23}) — N = nNA, so 1.00 mol contains Avogadro's number of molecules.

15. C (Convert grams to moles using molar mass) — Mass connects to amount through molar mass: n = m/M. Then moles convert to particles using NA.

Short answer

1. The coefficients show the proportions in which substances react and form, which can be read directly as a mole ratio.

2. The ratio H_2 : H_2O is 2 : 2 = 1 : 1, so 4 mol H_2 produces 4 mol H_2O.

3. Grams of A → moles of A (divide by molar mass of A) → moles of B (multiply by the mole ratio from the balanced equation) → optionally grams of B (multiply by molar mass of B).

4. The ratio H_2 : NH_3 is 3 : 2, so 6 × (2/3) = 4 mol NH_3.

5. $M(H_2O)$ = 18.0 g/mol, so n = 18.0/18.0 = 1.00 mol. $N = nN_A = 1.00 \times 6.02 \times 10^{23} = 6.02 \times 10^{23}$ molecules.

3.1 Solutions

Multiple choice

1. C (2.0 mol/L) — Concentration c = n / V = 2.0 mol ÷ 1.0 L = 2.0 mol/L.

2. B (decreases) — In c = n/V, if n stays the same and V increases, c gets smaller — the solution is more dilute.

3. D (2.0 mol/L) — c = n/V = 2.0 / 1.0 = 2.0 mol/L.

4. C (c = n / V) — Concentration is moles of solute over litres of solution: c = n/V.

5. C (decreases) — A larger V with the same n gives a smaller c.

6. B (0.5 mol/L) — c = n/V = 1.0 / 2.0 = 0.5 mol/L.

7. A (mol/L) — Concentration is measured in moles per litre (mol/L).

8. A (stays constant) — Adding water changes volume, not the moles of solute.

9. D (2.0 mol/L) — c = n/V = 3.0 / 1.5 = 2.0 mol/L.

10. C (0.5 L) — Divide by 1000: 500 mL = 0.5 L.

11. D (increases) — A larger n with the same V gives a larger c.

12. B (moles of solute) — n is the amount of solute in moles.

13. D (2.00 mol/L) — Convert 250 mL to 0.250 L. c = n/V = 0.500/0.250 = 2.00 mol/L.

14. A (L) — The distilled notes repeatedly flag the teacher move: convert solution volume to litres before using c = n/V.

Short answer

1. c = n / V, where c = concentration (mol/L), n = moles of solute (mol), V = volume of solution (L).

2. Convert 250 mL = 0.25 L. c = n/V = 0.5 / 0.25 = 2.0 mol/L.

3. Concentration decreases. The moles of solute stay the same, but the volume increases, so c = n/V gets smaller.

4. n = c × V = 1.5 × 2.0 = 3.0 mol.

5. Convert 250 mL = 0.250 L. c = n/V = 0.500/0.250 = 2.00 mol/L.

3.2 Gas Laws

Multiple choice

1. B (It increases) — At constant temperature, pressure and volume are inversely related, so squeezing the gas into less volume raises the pressure.

2. A (doubles) — $P_1V_1 = P_2V_2$. Halving the volume means the pressure must double to keep the product constant.

3. B (increases) — At constant temperature, P and V are inversely related, so less volume means more pressure.

4. D ($P_1V_1 = P_2V_2$) — At constant temperature, the product P × V is constant: $P_1V_1 = P_2V_2$.

5. B (double) — P and V are inverse, so halving V doubles P.

6. D (inversely related) — As one goes up the other goes down — an inverse relationship.

7. C (more often (higher pressure)) — In less space collisions with the walls happen more often, raising pressure.

8. C (kelvin) — Gas laws require absolute temperature in kelvin.

9. A (200 kPa) — $P_2 = P_1V_1 / V_2 = (100 \times 4) / 2 = 200$ kPa.

10. A (halve) — P and V are inverse, so doubling V halves P.

11. C (kPa) — Pressure is given in kilopascals (kPa).

12. C (temperature) — Boyle's law holds at constant temperature (and fixed amount of gas).

13. B (What gas condition is given?) — The distilled notes warn not to use gas-volume shortcuts unless the gas condition matches the problem.

14. C (n, amount in moles) — Gas volume, particles, mass, and concentration all connect through amount of substance n.

Short answer

1. $P_1V_1 = P_2V_2$, for a fixed amount of gas at constant temperature.

2. $P_2 = P_1V_1 / V_2 = (100 \times 6) / 2 = 300$ kPa.

3. In a smaller space the particles strike the container walls more often each second, and more frequent collisions mean higher pressure.

4. Gas laws need an absolute temperature scale. Kelvin starts at absolute zero, so the proportional relationships work correctly (unlike Celsius, which can be negative).

5. Gas-volume shortcuts depend on the stated condition, such as standard molar volume or a specified gas law setup. If the condition does not match, convert through moles using the formula that the question gives.

4.1 Reaction Rate Ideas

Multiple choice

1. D (Higher temperature) — Higher temperature makes particles move faster, so they collide more often and harder — usually a faster reaction.

2. B (Increasing concentration) — More concentrated reactants mean more particles in the same space, so collisions happen more often — a faster rate.

3. B (higher temperature) — Higher temperature speeds up particles and collisions, increasing the rate.

4. C (increases it) — More particles in the same space means more frequent collisions.

5. D (successful collisions) — Reactions happen through collisions with enough energy — successful collisions.

6. C (move faster) — Heat gives particles more energy, so they move faster.

7. A (increases it) — More exposed surface means more places for collisions to occur.

8. C (increases it) — A catalyst speeds up a reaction without being used up.

9. D (faster reaction) — More collisions per second generally increases the reaction rate.

10. A (slows the reaction) — Cooler particles move slower and collide less, slowing the reaction.

11. C (energy) — Particles must meet with enough energy (and correct orientation) to react.

12. D (surface area) — Powder exposes much more surface area for collisions.

13. B (0.010 mol/(L·s)) — Use the magnitude of concentration change over time: 0.30/30 = 0.010 mol/(L·s).

14. B (largest activation-energy barrier) — The distilled teacher move is to subtract valley-to-peak energies and choose the largest barrier.

15. B (is regenerated overall) — A catalyst changes the pathway and is regenerated overall.

16. B (formed in one elementary step and consumed later) — Intermediates appear in the middle of a mechanism: produced in one step, consumed in a later step.

Short answer

1. Reactions happen when particles collide with enough energy and the correct orientation (successful collisions). More frequent or more effective collisions give a faster rate.

2. Higher temperature (faster, more energetic collisions); higher concentration (more frequent collisions); larger surface area (more contact points); a catalyst (lowers the energy needed for a successful collision).

3. Powder has a much greater surface area, so far more particles are exposed for collisions, speeding up the reaction.

4. The colliding particles must have enough energy (the activation energy) and the correct orientation so that they actually react.

5. $\Delta c = 0.50 - 0.80 = -0.30$ mol/L. For disappearance rate, use the positive magnitude: 0.30/30 = 0.010 mol/(L·s).

6. For each elementary step, calculate activation energy as peak energy minus the current valley or intermediate energy. The largest activation-energy barrier marks the slow or rate-determining step.

4.2 Mixed Review

Multiple choice

1. B ($c = n/V$) — Concentration is $c = n/V$ (moles of solute over litres of solution). The others are not concentration formulas.

2. B ($P_1V_1 = P_2V_2$) — Boyle's law, $P_1V_1 = P_2V_2$, links pressure and volume when temperature is held constant.

3. B ($c = n/V$) — Concentration is $c = n/V$.

4. A ($P_1V_1 = P_2V_2$) — Boyle's law: $P_1V_1 = P_2V_2$.

5. C (protons) — Atomic number = number of protons.

6. B (coefficients) — Only coefficients change when balancing.

7. B (sharing) — Covalent bonding shares electrons; ionic transfers them.

8. B (balanced equation) — The coefficients of the balanced equation give the mole ratios.

9. A (increases) — More energetic, frequent collisions raise the rate.

10. B (protons + neutrons) — Mass number = protons + neutrons.

11. A (transferring) — Ionic bonding transfers electrons from one atom to another.

12. D (balanced) — Mole ratios are only valid once the equation is balanced.

13. D (Identify the model first, then calculate) — Across the distilled units, the repeated move is to classify the problem type, choose the model, and then calculate with units.

14. C (VSEPR → electron domains) — VSEPR starts by counting electron domains. The other choices contradict the distilled teacher moves.

Short answer

1. $c = n/V$ → solutions; $P_1V_1 = P_2V_2$ → gases (Boyle's law); atomic number = protons → atomic structure; mole ratio → stoichiometry (from the balanced equation).

2. Identify the category (particles, bonding, reaction, amount, solution, or gas); recall the matching model or formula; make sure the equation is balanced; and use the correct units.

3. The coefficients are particle/mole ratios, so they let you scale up from individual particles to moles, masses, and volumes that you can actually measure.

4. Sample answers — reaction: iron rusting or wood burning; solution: salt dissolved in water; gas behaviour: a balloon shrinking when you squeeze it (pressure increases as volume decreases).

5. Examples: net ionic — cancel spectator ions only after writing the complete ionic equation; redox — track oxidation-number increase/decrease before balancing; mole calculations — convert through n; rates — explain changes using successful collisions or the largest activation-energy barrier.