Counting Particles — Worksheet

Name: _____ **Date:** _____

Quick Review

Chemists work with extremely small particles that cannot normally be seen or counted individually. To make counting easier, they use special counting units.

In everyday life, we use counting units such as:

- **Pair:** 2 objects
- **Dozen:** 12 objects
- **Gross:** 144 objects

Chemists use a much larger counting unit called the **mole (mol)**.

1 mole = 6.02×10^{23} particles

This number is called the **Avogadro constant** (approximately 6.02×10^{23} mol^{-1}).

The particles being counted may be:

- **Atoms:** Individual particles of an element, such as He or Fe.
- **Molecules:** Groups of two or more atoms chemically bonded together, such as H_2O or O_2.
- **Ions:** Electrically charged atoms or groups of atoms, such as Na^+ or SO_4^{2-}.
- **Formula units:** The simplest whole-number ratio of ions in an ionic compound, such as NaCl or MgO.

Using the mole allows chemists to count enormous numbers of particles without counting each one individually.

Part A — Multiple Choice

Circle the correct answer.

1. Why do chemists use counting units such as the mole?

A. Atoms are too large to count.
B. Chemical particles are extremely small and numerous.
C. All chemical substances contain exactly 12 particles.
D. Molecules cannot be measured.

2. How many objects are in one dozen?

A. 6
B. 10
C. 12
D. 100

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3. Approximately how many particles are in one mole?

A. 6.02×10^{23}
B. 12
C. 1000
D. 3.00×10^{8}

4. Which of the following is an ion?

A. He
B. O_2
C. H_2O
D. Na^+

5. What does a formula unit represent?

A. One atom of a metal
B. The simplest whole-number ratio of ions in an ionic compound
C. A molecule containing only oxygen
D. A group of unbonded atoms

Part B — Matching

Match each term to its correct description.

Term	Answer
1. Atom	_____
2. Molecule	_____
3. Ion	_____
4. Formula unit	_____
5. Mole	_____

Descriptions

A. A charged atom or group of atoms
B. A counting unit containing approximately 6.02×10^{23} specified particles
C. The smallest unit of an element that retains its chemical identity
D. The simplest whole-number ratio of ions in an ionic compound
E. Two or more atoms chemically bonded together

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Part C — Identifying Particles

Classify each example using the following categories:

Atom, Molecule, Ion, or Formula Unit

Example	Classification
He	
H_2O	
Na^+	
O_2	
MgO	
Cl^-	
CO_2	
NaCl	

Part D — Counting Units

Complete the following questions.

1. How many eggs are in 3 dozen?

Calculation: _____ Answer: _____

2. How many objects are in 2 gross?

Calculation: _____ Answer: _____

3. How many atoms are in 2 moles of helium?

Use 1 mole = 6.02×10^{23} particles.

Calculation: _____ Answer: _____

4. How many molecules are in 0.5 mole of water?

Calculation: _____ Answer: _____

5. Explain how a mole is similar to a dozen.

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Part E — Understanding Chemical Particles

1. Explain the difference between an atom and a molecule.

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2. How is an ion different from a neutral atom?

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3. Why do chemists describe NaCl using formula units rather than individual NaCl molecules?

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4. Why would it be difficult to count the atoms in a small piece of iron individually?

Part F — Applying Your Knowledge

A chemistry student is given three samples:

- **Sample A:** Helium gas (He)
- **Sample B:** Water (H_2O)
- **Sample C:** Sodium chloride (NaCl)

1. What type of particle would the student count in Sample A?

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2. What type of particle would the student count in Sample B?

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3. What type of particle would the student count in Sample C?

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4. If each sample contains exactly one mole of its specified particles, how many particles does each sample contain?

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5. Explain why having a standard counting unit is useful when comparing different substances.

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Exit Ticket

1. What is a mole?

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2. How many particles are in one mole?

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3. Give one example of a molecule and one example of an ion.

Molecule: _____

Ion: _____

4. Why is it impractical to count chemical particles individually?

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5. Why is the mole important in chemistry?

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Counting Particles — Answer Key

Part A — Multiple Choice

1. B — Chemical particles are extremely small and numerous.
2. C — 12
3. A — 6.02×10^{23}
4. D — Na^+
5. B — The simplest whole-number ratio of ions in an ionic compound.

Part B — Matching

Term	Answer	Description
1. Atom	C	The smallest unit of an element that retains its chemical identity
2. Molecule	E	Two or more atoms chemically bonded together
3. Ion	A	A charged atom or group of atoms
4. Formula unit	D	The simplest whole-number ratio of ions in an ionic compound
5. Mole	B	A counting unit containing approximately 6.02×10^{23} specified particles

Part C — Identifying Particles

Example	Classification
He	Atom
H_2O	Molecule
Na^+	Ion
O_2	Molecule
MgO	Formula unit
Cl^-	Ion
CO_2	Molecule
NaCl	Formula unit

Part D — Counting Units

1. How many eggs are in 3 dozen?

$3 \times 12 = 36$ eggs

2. How many objects are in 2 gross?

$2 \times 144 = 288$ objects

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3. How many atoms are in 2 moles of helium?

Number of atoms = moles × Avogadro constant

= $2 \times 6.02 \times 10^{23}$

= 1.204×10^{24} atoms

4. How many molecules are in 0.5 mole of water?

Number of molecules = moles × Avogadro constant

= $0.5 \times 6.02 \times 10^{23}$

= 3.01×10^{23} molecules

5. Explain how a mole is similar to a dozen.

Both are counting units that represent a fixed number of items.

- One dozen represents 12 objects.
- One mole represents approximately 6.02×10^{23} specified particles.

The difference is that a mole represents a much larger number.

Part E — Understanding Chemical Particles

1. Explain the difference between an atom and a molecule.

An atom is the smallest unit of an element that retains its chemical identity.

A molecule consists of two or more atoms chemically bonded together.

For example, He is an atom, while H_2O is a molecule.

2. How is an ion different from a neutral atom?

An ion has an electrical charge because it has gained or lost electrons.

A neutral atom has equal numbers of protons and electrons, so its overall charge is zero.

3. Why do chemists describe NaCl using formula units rather than individual NaCl molecules?

Sodium chloride is an ionic compound consisting of a large, repeating crystal lattice of Na^+ and Cl^- ions.

A formula unit represents the simplest whole-number ratio of these ions, which is 1:1.

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NaCl does not normally exist as separate molecules within the solid crystal.

4. Why would it be difficult to count the atoms in a small piece of iron individually?

Iron atoms are extremely small, and even a tiny piece of iron contains an enormous number of atoms.

Counting each atom individually would be impractical, so chemists use the mole to describe large quantities of particles.

Part F — Applying Your Knowledge

1. What type of particle would the student count in Sample A (helium)?

Atoms

2. What type of particle would the student count in Sample B (water)?

Molecules

3. What type of particle would the student count in Sample C (sodium chloride)?

Formula units

4. If each sample contains exactly one mole of its specified particles, how many particles does each sample contain?

Each sample contains approximately 6.02×10^{23} specified particles.

- Sample A: 6.02×10^{23} helium atoms
- Sample B: 6.02×10^{23} water molecules
- Sample C: 6.02×10^{23} NaCl formula units

5. Explain why having a standard counting unit is useful when comparing different substances.

A standard counting unit allows chemists to compare substances using the same number of specified particles, even when the substances have different masses or structures.

For example, one mole of helium atoms and one mole of water molecules contain the same number of specified particles, although their masses are different.

Exit Ticket

1. What is a mole?

A mole is the SI unit for amount of substance. One mole contains exactly $6.02214076 \times 10^{23}$ specified elementary entities, such as atoms, molecules, ions, or formula units.

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2. How many particles are in one mole?

Approximately 6.02×10^{23} particles.

3. Give one example of a molecule and one example of an ion.

- Molecule: H_2O
- Ion: Na^+

Other correct examples are acceptable.

4. Why is it impractical to count chemical particles individually?

Chemical particles are extremely small, and even small samples contain enormous numbers of them. Counting each particle directly would be impractical.

5. Why is the mole important in chemistry?

The mole provides a standard way to count and compare extremely large numbers of chemical particles. It also connects the number of particles to measurable quantities, such as mass, which is essential for chemical calculations.

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