International Chemistry Competition

Edition of 2026

Qualification Round – Solutions

Problem A: Elements around Us (5 Points)

Chemical elements are the building blocks of all matter around us, from the air we breathe to the devices we use every day. Each element has unique properties that make it essential for different applications. Identify each element and its symbol from the pictures below:



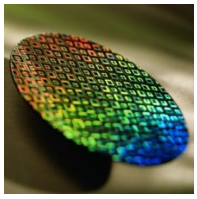
Element _____

Symbol _____



Element _____

Symbol _____



Element _____

Symbol _____



Element _____

Symbol _____



Element _____

Symbol _____



Element _____

Symbol _____



Element _____

Symbol _____



Element _____

Symbol _____

Basic Solution

1. Hydrogen (H) 2. Carbon (C) 3. Silicon (Si) 4. Calcium (Ca) 5. Iron (Fe) 6. Cobalt (Co) 7. Argon (Ar) 8. Sodium Chloride (NaCl) – Note: NaCl is a compound, not an element. Accept Sodium (Na) and Chlorine (Cl) as the constituent elements.

Problem B: Physical and Chemical Changes (5 Points)

During an ordinary day, you notice a series of changes happening in the world around you. Some of them only change the form of a substance, while others create something entirely new.

1. A steel bicycle left outside overnight develops a thin orange-brown layer after a rainy day.
2. A candle is lit in the evening and slowly gets shorter as it gives off light and heat.
3. A plastic bottle is squeezed flat and stays in that shape.
4. A block of chocolate melts in your hand on a warm day and becomes solid again later.
5. A gas stove is turned on and a blue flame appears above the burner.
6. A silver spoon stored for a long time in a kitchen drawer becomes dark and dull.

Problem: Determine whether each situation represents a *physical change* or a *chemical reaction*.

Basic Solution

1. **Chemical change** – The orange-brown layer is iron oxide (rust), formed by the reaction of iron with oxygen and water: $4\text{Fe} + 3\text{O}_2 + 6\text{H}_2\text{O} \rightarrow 4\text{Fe(OH)}_3$.
2. **Chemical change** – Burning a candle involves combustion of the wax (a hydrocarbon), producing CO_2 and H_2O.
3. **Physical change** – The plastic changes shape but no new substance is formed. The chemical composition remains the same.
4. **Physical change** – Melting and solidifying chocolate is a change of state. No new substance is created.
5. **Chemical change** – Combustion of natural gas (methane): $\text{CH}_4 + 2\,\text{O}_2 \longrightarrow \text{CO}_2 + 2\,\text{H}_2\text{O}$.
6. **Chemical change** – The silver reacts with sulfur compounds in the air to form silver sulfide (Ag_2S), causing tarnishing.

Problem C: Molecular Shapes and Polarity (5 Points)

Understanding the three-dimensional shape of molecules helps predict their properties and behavior. Consider the following four molecules:

CH_4	NH_3	H_2O	CO_2
(methane)	(ammonia)	(water)	(carbon dioxide)

Problem: Draw the Lewis structure for each molecule, showing all bonding pairs and lone pairs of electrons. Determine whether each molecule is polar or nonpolar.

Basic Solution

CH_4 (Methane): Lewis structure has C in center with 4 single bonds to H atoms. No lone pairs on C. Tetrahedral geometry. **Nonpolar** – symmetric shape, bond dipoles cancel.
NH_3 (Ammonia): Lewis structure has N in center with 3 single bonds to H atoms and 1 lone pair. Trigonal pyramidal geometry. **Polar** – the lone pair creates an asymmetric charge distribution.
H_2O (Water): Lewis structure has O in center with 2 single bonds to H atoms and 2 lone pairs. Bent geometry. **Polar** – the two lone pairs push the H atoms together, creating a net dipole moment.
CO_2 (Carbon Dioxide): Lewis structure has C in center with 2 double bonds to O atoms. No lone pairs on C. Linear geometry. **Nonpolar** – symmetric linear shape, bond dipoles cancel.

Problem D: Balloon Filling (5 Points)

A school science club wants to fill identical balloons for a festival using oxygen they generate in the lab. Their oxygen comes from heating a white solid labeled *potassium chlorate*. The reaction written on the container is:

$$2\ KClO_3\ (s) \longrightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$$

The club measures out 24.5 g of $KClO_3$ for the day's balloon-filling. Each balloon they use has a volume of 2.50 L when tied off, and the club assumes the oxygen behaves like an ideal gas at standard conditions for temperature and pressure.

Problem: How many balloons can the club fill completely with the oxygen produced, and approximately how many oxygen molecules will be inside one filled balloon?

Basic Solution

Step 1: Moles of $KClO_3$
Molar mass of $KClO_3$ = 39.1 + 35.5 + 3(16.0) = 122.6 g/mol
Moles = 24.5 / 122.6 = 0.200 mol
Step 2: Moles of O_2 produced
From the equation: 2 mol $KClO_3 \rightarrow$ 3 mol O_2
Moles of O_2 = $0.200 \times (3/2) = 0.300$ mol
Step 3: Volume of O_2 at STP
At STP, 1 mol of gas occupies 22.4 L
Volume = $0.300 \times 22.4 = 6.72$ L
Step 4: Number of balloons
Number of balloons = 6.72 / 2.50 = 2.688
They can fill **2 balloons** completely.
Step 5: Molecules per balloon
Moles per balloon = 2.50 / 22.4 = 0.1116 mol
Molecules = $0.1116 \times 6.022 \times 10^{23} \approx \mathbf{6.72 \times 10^{22}}$ **molecules**

Problem E: Experiment with Cola, Rust, and Aluminum (5 Points)

People claim that rubbing rusted iron with aluminum foil and cola makes the rust disappear. For this problem, you will perform a simple experiment to test whether this is really chemistry, or just scraping. For the experiment you will need: *A rusty iron/steel object (nail, bolt, paperclip), cola (any brand), aluminum foil, water, 3 cups, paper towel, timer/phone*








Prepare three tests using similar rusty areas or three similar objects, while keeping time, liquid amount, and rubbing as similar as possible:

1. Cola + no rubbing
2. Cola + aluminum rubbing
3. Water + aluminum rubbing

Problem: Write a short protocol including: your observations (before/after description); which condition removes rust best; explanation of what rust is, what cola does chemically, and why aluminum might change the result compared to water.

Basic Solution

Expected observations:

- Test 1 (Cola only): Some rust dissolves due to the phosphoric acid in cola, but significant rust remains.
- Test 2 (Cola + aluminum): Most rust is removed. The combination of acid dissolving and aluminum's reducing action is most effective.
- Test 3 (Water + aluminum): Some mechanical scraping effect, but much less rust removed than Test 2.

Explanation:

- **Rust** is iron(III) oxide (Fe_2O_3), formed when iron reacts with oxygen and water.
- **Cola** contains phosphoric acid (H_3PO_4), which reacts with rust: $Fe_2O_3 + 2\,H_3PO_4 \longrightarrow 2\,FePO_4 + 3\,H_2O$. The acid dissolves the oxide layer.
- **Aluminum** is more reactive than iron (higher in the activity series). It can reduce iron oxide back to iron via a displacement reaction, in addition to providing mechanical abrasion. This is why cola + aluminum works best – it combines chemical dissolution with electrochemical reduction.

Participation Instructions

- ✓ Write your solutions by hand on sheets of paper or type them on a computer.
- ✓ **Submit your solutions online by the deadline shown on the website.**
  Website: `https://intchc.org/submission`
- ✓ You do not need to include the problem statements in your solution document.
- ✓ Show your work to receive full marks. Maximum points: **25**.
- ✓ Clearly label each problem and highlight your final answers.
- ✓ You need to score at least **15/17/20 points** as Junior/Youth/Senior to qualify for the Semi-Final Round. See `https://intchc.org/age-groups` for details.
- ✓ If you have questions, reach out to us at: `info@intchc.org`

Good Luck!