TEACHER NOTES · FREE TO COPY FOR CLASSROOM USE

Rust and Corrosion with Valence

A 50-minute lesson on rusting, oxidation and reduction for Years 9–10 (Grades 9–10)

Scan to get Valence
Free · iPhone and Android
valence-2b95b.web.app/get

Valence is a free chemistry card game. Every card is an element, and students combine cards into real compounds to fight. **Act 3**, the Rusty Steelworks, is full of iron, copper and zinc. Its enemies are either **shiny metals** or **rusted metals** (oxides), and each carries an oxygen gauge that students fill or empty with the right kind of compound.

The game is the hook and the practice; the worksheet does the chemistry.

Learning goals

1. State the two conditions iron needs to rust, and explain why salt speeds it up.
2. Identify oxidation (gaining oxygen) and reduction (losing oxygen) in word and symbol equations.
3. Explain how painting, oiling and galvanising slow corrosion.
4. Explain two ways the game is simpler than real chemistry.

HOW THE OXYGEN GAUGE WORKS IN ACT 3

- **Rusted enemies** (metal oxides such as Fe_2O_3 and CuO) need **reduction**: compounds that remove oxygen. H_2, CO or CH_4, or a single C card thrown.
- **Shiny metal enemies** (Fe, Zn, Na) need **oxidation**: compounds that add oxygen. O_2, H_2O_2, Cl_2 or CuO.
- Each matching attack moves the gauge one step (thermite counts as two on a rusted enemy). A full gauge stops the enemy for a turn, removes its armour, and it takes 25% more damage and deals 30% less.
- Rusted enemies are "already oxidised": oxidising attacks do only half damage.
- At half health the boss, the Rusted Steel Titan, is hit by rain and "starts to rust again": its gauge gains 2 oxygen back (only if the gauge is not yet full; it also gains armour and strength).



Six of the eight Act 3 enemies, as drawn in the game. The boss is on the right.

Curriculum links

- **Australia**: Year 9 word and balanced equations, AC9S9U07; Year 10 chemical reactions, AC9S10U07
- **New Zealand**: Years 9–10 Science (Phase 4), everyday oxidation–reduction reactions; looks ahead to NCEA Level 1 Chemistry and Biology 92021
- **Ontario**: Grade 10 Science SNC2D, C2.3 and C3.5 (displacement reactions)
- **British Columbia**: Science 10, types of chemical reactions (synthesis, single replacement, combustion)

Canada spells it "galvanizing"; both spellings are accepted. Full notes: valence-2b95b.web.app/teachers. Not endorsed by any education authority.

Before class

- Install Valence: free, no ads, no purchases, no account. Students under 14 play as guests and no data leaves the device. Works offline.
- **Act 3 comes after Acts 1 and 2 in the same run**, so few students reach it in one lesson. Parts A, B and D work without the game; Part C uses the enemies printed on page 3. Act 1 has a Rust Slime students meet early (it is weak to acid, not reduction).
- Optional demo: set up the four nail tubes in Part A a week before.
- Print pages 2 and 3 for each student. Page 4 is the answer key.

Lesson plan

`5 min`	Hook. "A steel bridge, a gold ring and a car near the beach: which will rust first, and why?"
`10 min`	Part A: predict the four nail tubes (or show the real ones). Agree on air + water.
`15 min`	Part B: oxidation and reduction as gaining and losing oxygen; balance two equations (B3 can be oral).
`10 min`	Part C: match each Act 3 enemy to oxidation or reduction. Students who reach Act 3 check in the game.
`10 min`	Discuss D1 and D2 (D3 is an extension), then the exit ticket at the bottom of page 3.

STUDENT WORKSHEET

Rust and Corrosion

Scan to get Valence
Free · iPhone and Android
valence-2b95b.web.app/get

Name _____ Class _____ Date _____

Corrosion
A metal slowly reacting with substances around it and wearing away.

Rust
The corrosion of iron: hydrated iron(III) oxide, $Fe_2O_3 \cdot nH_2O$.

Oxidation
A substance **gains** oxygen.
Iron + oxygen → iron oxide.

Reduction
A substance **loses** oxygen.
Iron oxide → iron.

A What does iron need to rust?

Four clean iron nails were left in test tubes for one week.



A
Tap water, tube left open to the air



B
Boiled water (air removed), a layer of oil on top, stoppered



C
Dry air: drying agent (calcium chloride) under cotton wool, stoppered



D
Salty water, tube left open to the air

TUBE	WHAT TOUCHES THE NAIL? (AIR, WATER, SALT)	RUST? (YES / NO)	REASON
A			
B			
C			
D			

A2. Which two substances must **both** be present for iron to rust? Which tube shows that each one is needed?

A3. Cars in coastal towns, or where salt is spread on icy roads, rust faster. Use tube D to explain why.

B Gaining and losing oxygen

For each reaction, name the substance that gains or loses oxygen, and say whether it is **oxidised** or **reduced**.

REACTION	SUBSTANCE THAT GAINS OR LOSES OXYGEN	OXIDISED OR REDUCED?
$4Fe + 3O_2 \rightarrow 2Fe_2O_3$	Fe gains O	oxidised
$2Cu + O_2 \rightarrow 2CuO$		
$CuO + H_2 \rightarrow Cu + H_2O$		
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$		
$Zn + CuO \rightarrow ZnO + Cu$		

B2. Balance these equations. The second one happens in a blast furnace.

___ Fe + ___ O_2 → ___ Fe_2O_3

___ Fe_2O_3 + ___ C → ___ Fe + ___ CO_2

B3. In $CuO + H_2 \rightarrow Cu + H_2O$, what happens to the hydrogen? Why do chemists say oxidation and reduction always happen together (a **redox** reaction)?



STUDENT WORKSHEET

Rust and Corrosion



C The Rusty Steelworks (Act 3)

In Act 3, **shiny metal** enemies are weakened by adding oxygen, and **rusted** enemies by removing it. Some compound cards you can use:

Add oxygen: O_2 H_2O_2 Cl_2 CuO Remove oxygen: H_2 CO CH_4 C (one card thrown)

C1. Fill in the table.

ENEMY	GAUGE	SHINY METAL OR RUSTED (OXIDE)?	OXIDISE OR REDUCE IT?	ONE CARD THAT WORKS
 Scrap Iron Hyena Fe	3			
 Rusty Iron Golem Fe_2O_3	3			
 Black Copper Beetle CuO	1			
 Zinc Dust Cloud Zn	2			
 Magnetite Turtle Fe_3O_4	4			

C2. Look at the three rusted enemies. How does the size of each gauge match its formula?

C3. At half health the boss, the Rusted Steel Titan, is hit by rain and "starts to rust again". Which two conditions from Part A does this match?

D Where the game simplifies



D1. In the game, Zn is an enemy that you oxidise.
In real life, steel is coated in zinc (galvanised) to protect it. Even when the coating is scratched, the iron does not rust. Zinc is more reactive than iron. Why does that protect the iron?



D2. A few H_2 or C cards turn a rusted enemy back into iron.
A real blast furnace runs at over 1500 °C. Why can't you turn a rusty bike back into iron by blowing hydrogen over it at room temperature?



D3. *Extension.* The game counts Cl_2 as a card that "adds oxygen".
Chlorine has no oxygen. Iron burns in chlorine to make $FeCl_3$. Chemists also call this oxidation. What else, besides oxygen, can iron lose or gain?



EXIT TICKET

Is rusting oxidation or reduction? Explain using the word "oxygen", and give one way to stop a steel gate from rusting.

Rust and Corrosion

A What does iron need to rust?

TUBE	TOUCHES THE NAIL	RUST?	REASON
A	air and water	yes	both oxygen and water are present
B	water only	no	boiling removes dissolved air; oil stops air getting back in
C	air only	no	the drying agent removes water vapour
D	air, water and salt	yes, the most rust	salt speeds up rusting

A2. Oxygen (from air) and water. Tube B shows oxygen is needed; tube C shows water is needed. Accept "a little rust in B": some air dissolves again before the oil goes on. This is why it is stoppered.

A3. Salt dissolved in water lets the water conduct electricity, which makes the reactions that form rust faster, as in tube D. Accept "salt water rusts iron faster". Sea spray and road salt put salt water on cars.

B Gaining and losing oxygen

REACTION	GAINS OR LOSES OXYGEN	ANSWER
$2Cu + O_2 \rightarrow 2CuO$	Cu gains O	oxidised (copper wire turning black)
$CuO + H_2 \rightarrow Cu + H_2O$	CuO loses O	reduced (H_2 is oxidised). Also accept "H_2 gains O, oxidised"
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$	Fe_2O_3 loses O	reduced (CO is oxidised). Also accept "CO gains O, oxidised"
$Zn + CuO \rightarrow ZnO + Cu$	Zn gains O; CuO loses O	Zn oxidised, CuO reduced. Accept either half.

B2. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ and $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$. Check: 4 Fe and 6 O on each side (and 3 C in the second). In a real blast furnace most of the reducing is done by CO made from the coke; accept a student who notes this.

B3. Hydrogen gains oxygen and becomes water, so it is oxidised. The oxygen that one substance loses must go to another, so one is reduced while the other is oxidised: reduction + oxidation = redox.

C The Rusty Steelworks (Act 3)

C1. Scrap Iron Hyena, Fe: shiny metal, **oxidise**. Rusty Iron Golem, Fe_2O_3: rusted, **reduce**. Black Copper Beetle, CuO: rusted (copper oxide, not rust: only iron rusts), **reduce**. Zinc Dust Cloud, Zn: shiny metal, **oxidise**. Magnetite Turtle, Fe_3O_4: rusted (iron ore), **reduce**. Cards: O_2, H_2O_2, Cl_2 or CuO to oxidise; H_2, CO, CH_4 or a thrown C to reduce. Accept any other card the game marks as adding or removing oxygen (e.g. KO_2, HNO_3, NaH, thermite). CuO appears twice: as an enemy it is an oxide to reduce; as a card it gives its oxygen to a more reactive metal (Zn + CuO → ZnO + Cu, Part B).

C2. The gauge equals the number of oxygen atoms in the formula: CuO 1, Fe_2O_3 3, Fe_3O_4 4. Each reducing attack "removes one oxygen". (For the metal enemies the gauge is set for game balance and has no such link.)

C3. Water (the rain) and oxygen (the air). Rusting is oxidation, the reverse of the reduction the student has been doing.

D Where the game simplifies

D1. Zinc is more reactive, so it reacts (is oxidised) in place of the iron. The zinc corrodes first and the iron is kept safe until the zinc is used up: sacrificial protection. Accept "zinc rusts instead" if the student means "corrodes instead"; point out only iron rusts. The coating also keeps air and water off, like paint or oil.

D2. Turning iron oxide back into iron needs a large input of heat energy. At room temperature it does not happen at all; the change goes the other way, which is why iron rusts. Accept "it needs heat" or "it needs a lot of energy".

D3. Electrons. Iron loses electrons to become Fe^{3+} whether it joins with oxygen or chlorine. The fuller definition: oxidation is loss of electrons, reduction is gain of electrons (OIL RIG). This is Act 4 of the game.

Exit ticket. Oxidation: iron gains oxygen to form iron oxide. Ways to stop it: paint, oil or grease, galvanise (zinc coating), plastic coating, or keep it dry. Watch for "rust is iron reacting with water" with no mention of oxygen.