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Ionic and Covalent Bonding with the Valence card game

A 50-minute lesson on ionic, covalent and metallic bonds for Year 10 (Grades 9–11)

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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. In **Act 7**, the Glass Desert, every enemy carries a **bond lock** that students open by making compounds with the right kind of bond, in order.

Learning goals

1. Predict whether a substance is ionic, covalent or metallic from the kinds of elements in it.
2. Explain an ionic bond as electrons transferred and a covalent bond as electrons shared, using outer-shell electrons.
3. Work out the formula of an ionic compound from its ions, and draw a dot diagram of a small molecule.
4. Link bond type to melting point and conductivity, and say one way the game is simpler than real chemistry.

Before class

- Install Valence: free, no ads, no account, works offline.
- **Act 7 comes after Acts 1 to 6**, so few students reach it in one lesson. Parts A, B and D need no game; Part C prints the rule on page 3.
- Optional: a low-voltage bulb-and-battery tester with dry salt, salt solution, sugar solution and a copper strip.
- In Canada: covalent compounds are "molecular compounds", and the spellings are "aluminum" and usually "nonmetal".
- Print pages 2 and 3 for each student. Page 4 is the answer key.

HOW THE BOND LOCK WORKS IN ACT 7

- The lock is a row of 2 or 3 slots, each naming a bond type. Slots open **in order**, left to right.
- The game sorts each compound by its elements: **metal + non-metal = ionic** (NaCl, MgO, CaF_2), **non-metals only = covalent** (H_2O, CO_2, SiO_2, HCl), **metals only = metallic** (the alloy cards CuZn, NaK and MgAl, or one metal card thrown by itself).
- A compound that matches the next slot opens it, one slot per play. Any other compound does its normal damage but opens nothing. Open slots stay open between turns.
- When the whole lock is open the enemy skips a turn, loses its armour, takes 25% more damage and deals 30% less.
- At half health the boss, the Algae Bloom Giant, gains armour and attack, and gets a new lock with 4 slots. A noble gas, or a card that is two substances reacting (Na + H_2O), has no bond type.



Act 7 enemies and, on the right, the boss.

Example. The Sand Worm (on the left) has the lock covalent → ionic. H_2O opens the first slot and NaCl the second. Played the other way round, NaCl opens nothing and only H_2O counts. The Phosphoric Acid Mist has ionic → metallic: CaF_2, then the brass card CuZn or a single copper card.

Curriculum links

- **Australia**: Year 10 AC9S10U06 (atoms and outer-shell electrons) is the starting point. Bonding itself is senior Chemistry Unit 1 (Chemical fundamentals), so use this as Year 10 extension or a Year 11 opener
- **New Zealand**: Year 10 Science (Phase 4), compounds formed by transferring or sharing electrons. NCEA Level 2 Chemistry 91164 (Year 12) builds on this
- **Ontario**: Grade 11 SCH3U, B3.4 and B3.5 (how ionic and covalent bonds form; properties of ionic and molecular compounds); Grade 10 SNC2D C3.8 (identifying ionic and molecular compounds)
- **British Columbia**: Science 9, "the arrangement of electrons determines the compounds formed by elements"; Chemistry 11, chemical bonding

Descriptions are our paraphrases unless quoted. Not endorsed by any education authority.

Lesson plan

5 min	Hook. "Salt and sugar both dissolve in water. Why does only the salt solution light the bulb?"
10 min	Part A: sort substances into ionic, covalent and metallic from their elements.
13 min	Part B: electrons transferred (ions and formulas) or shared (dot diagrams).
12 min	Part C: bond locks, on paper or in Act 7 for pairs who have reached it.
10 min	Part D: four mystery substances (D1, D2), then the exit ticket. D3 is for discussion if time allows, or homework.

STUDENT WORKSHEET

Ionic and Covalent Bonding

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Name _____ Class _____ Date _____

Ionic bond
A metal atom gives outer electrons to a non-metal atom. The ions that form, + and −, attract each other.

Covalent bond
Two non-metal atoms share a pair of outer electrons. This makes a molecule, or sometimes a giant network.

Metallic bond
Metal atoms pool their outer electrons. The electrons move freely between the positive ions.

Metals on this sheet: Li, Na, K, Mg, Ca, Al, Cu, Zn. **Non-metals**: H, C, N, O, F, P, S, Cl, Br. Silicon (Si) is a metalloid; in compounds treat it as a non-metal.

A Which kind of bond?

A1. For each substance, write whether its elements are metals or non-metals, then the bond type: ionic, covalent or metallic.

SUBSTANCE	ELEMENTS IN IT	METAL OR NON-METAL?	BOND TYPE
NaCl, table salt	*Na, Cl*	*metal + non-metal*	*ionic*
H_2O, water			
MgO, magnesium oxide			
CO_2, carbon dioxide			
CuZn, brass			
CaF_2, calcium fluoride			
SiO_2, sand			
NH_3, ammonia			

B Transferred or shared?



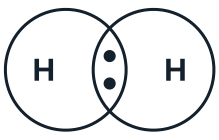
B1. Atoms are stable with a full outer shell. A metal atom loses its outer electrons; a non-metal atom gains enough to reach 8. Finish the table.
Salt crystals are cubes because Na^+ and Cl^- ions stack in a regular grid.

ATOM	ELECTRON ARRANGEMENT	LOSES OR GAINS HOW MANY?	ION FORMED
Na (11)	*2, 8, 1*	*loses 1*	*Na^+*
Cl (17)	2, 8, 7		
Mg (12)	2, 8, 2		
O (8)	2, 6		
Al (13)	2, 8, 3		

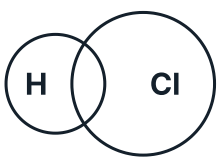
B2. In an ionic compound the charges add up to zero. Use your ions to write the formula of each compound.

magnesium chloride	sodium oxide	aluminium oxide

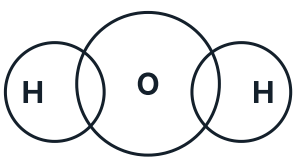
B3. Non-metal atoms share electrons instead. Each circle is an outer shell. Draw the outer electrons as dots, with each shared pair in the overlap. (H has 1 outer electron, O has 6, Cl has 7.)



H_2 · example: one shared pair



HCl



H_2O



STUDENT WORKSHEET

Ionic and Covalent Bonding



C Bond locks (Act 7)



The rule. Each Act 7 enemy has a lock: a row of bond types to open **in order**. The game sorts compounds by their elements: metal + non-metal is **ionic**, non-metals only is **covalent**, metals only is **metallic** (an alloy card such as CuZn, or one metal card thrown by itself). A compound that does not match the next slot opens nothing. Open the whole lock and the enemy skips its next turn.

C1. Write an order that opens the whole lock. **One hand has a compound you do not need: cross it out.**

ENEMY	LOCK	YOUR COMPOUNDS	ORDER TO PLAY
Sand Worm	covalent → ionic	**NaCl, H_2O**	*H_2O, then NaCl*
Phosphoric Acid Mist	ionic → metallic	**CuZn, CaF_2**	
Broken Glass Golem	ionic → covalent → ionic	**CO_2, MgO, KBr**	
Quartz Spider	covalent → ionic → covalent	**LiF, NaK, SiO_2, NH_3**	
Algae Bloom Giant	covalent → ionic → metallic	**MgAl, MgO, P_2O_5**	

C2. Against the Sand Worm (covalent, then ionic) a student plays NaCl first and H_2O second. How many slots are open now, and what kind of compound should they play next?

D Bonds and properties, and where the game simplifies

D1. Four substances were tested for conducting electricity. Is each one ionic, covalent or metallic?

SUBSTANCE	MELTING POINT	CONDUCTS SOLID?	CONDUCTS MELTED?	BONDING
W	801 °C	no	yes	
X	−182 °C	no	no	
Y	1085 °C	yes	yes	
Z	about 1700 °C	no	no	

D2. X is methane, CH_4, and Z is sand, SiO_2. Both are covalent. In methane each molecule is separate; in sand every atom is bonded to its neighbours in one giant network. Use this to explain the difference in melting point.

D3. The game calls every metal + non-metal compound ionic. Aluminium chloride, $AlCl_3$, turns to vapour at about 180 °C. Is that what you expect of an ionic compound? What does it tell you about the game's rule?



EXIT TICKET

Calcium oxide, CaO, and carbon monoxide, CO. For each, say whether electrons are transferred or shared and name the bond type. Which has the higher melting point?

Ionic and Covalent Bonding

A Which kind of bond?

SUBSTANCE	ELEMENTS	METAL OR NON-METAL?	BOND TYPE
H_2O	H, O	non-metals only	covalent
MgO	Mg, O	metal + non-metal	ionic
CO_2	C, O	non-metals only	covalent
CuZn	Cu, Zn	metals only	metallic
CaF_2	Ca, F	metal + non-metal	ionic
SiO_2	Si, O	non-metals only (Si is a metalloid)	covalent
NH_3	N, H	non-metals only	covalent

Also accept "molecular" for covalent (the Ontario term). Brass is a mixture of metals (an alloy), not a compound: the game writes it CuZn only as a card name.

B Transferred or shared?

B1. Cl gains 1 → **Cl^-**. Mg loses 2 → **Mg^{2+}**. O gains 2 → **O^{2-}**. Al loses 3 → **Al^{3+}**. Accept 2+ written as +2, and Cl^{1-}.

B2. $MgCl_2$ (one 2+ needs two 1−), **Na_2O** (two 1+ for one 2−), **Al_2O_3** (two 3+ make 6+, three 2− make 6−). Al_2O_3 is the hard one: give credit for a method that balances charges even if the formula slips.

B3. HCl: one shared pair in the overlap (one electron from each atom), and 6 more electrons, three pairs, on the Cl shell. H_2O: one shared pair in each overlap, and 4 more electrons, two pairs, on the O shell. Check the totals: every H has 2, O and Cl have 8. Accept dots and crosses, and electrons drawn singly instead of in pairs.

C Bond locks (Act 7)

C1. Phosphoric Acid Mist: **CaF_2** (ionic), then **CuZn** (metallic). Broken Glass Golem: **MgO, CO_2, KBr** or **KBr, CO_2, MgO** (ionic, covalent, ionic). Quartz Spider: **SiO_2, LiF, NH_3** or **NH_3, LiF, SiO_2**; NaK is the one not needed (metals only, so metallic). Algae Bloom Giant: **P_2O_5, MgO, MgAl**.

C2. One slot. NaCl is ionic, but the first slot needs covalent, so it does damage and opens nothing. H_2O then opens the covalent slot. Next they need any ionic compound: a metal with a non-metal, such as NaCl again, MgO or KBr. Accept a named example.

One metal card. A single metal card thrown by itself opens a metallic slot. That is fair chemistry: in a piece of copper the atoms pool their outer electrons, which move freely between the positive ions, so one element on its own has metallic bonds. Covalent elements such as H_2, O_2 and diamond are the same idea.

D Bonds and properties, and where the game simplifies

D1. W ionic (high melting point; conducts only when melted, because then the ions are free to move): it is sodium chloride. X covalent (very low melting point, never conducts). Y metallic (conducts as a solid): it is copper. Z covalent, a giant network: very high melting point but it never conducts, so it is not ionic or metallic. Do not accept ionic; point to the "melted" column.

D2. To melt methane you only separate molecules from each other, and the attractions between molecules are weak, so little energy is needed; the covalent bonds inside each molecule do not break. To melt sand you must break strong covalent bonds all through the network, which takes a great deal of energy. Accept "giant covalent" or "covalent network" for sand. Diamond is another network, which is why it is so hard. In the game the Quartz Spider is this network: armoured and slow to wear down.

D3. No: ionic compounds have high melting and boiling points (compare W, 801 °C), so $AlCl_3$ behaves like a covalent substance. Its liquid also conducts very poorly. "Metal + non-metal = ionic" is a good first rule, not a law. Real bonds lie on a scale from fully shared to fully transferred, and chemists use the difference in electronegativity and the measured properties to decide. Accept any answer that says the rule has exceptions.

Also worth discussing. The game gives each compound one bond type, but NaOH and $CaCO_3$ contain both: ionic bonds between the metal ion and the OH^- or CO_3^{2-} ion, and covalent bonds inside that ion. HCl is covalent as a gas, as the game says, yet in water it splits into H^+ and Cl^- ions and conducts.

The hook. Salt solution contains Na^+ and Cl^- ions that are free to move and carry the current. Sugar is covalent: it dissolves as whole neutral molecules, so there is nothing to carry charge. Dry salt does not light the bulb either, because its ions are locked in place.

Exit ticket. CaO: ionic, electrons transferred from Ca to O (Ca^{2+} and O^{2-}). CO: covalent, electrons shared. CaO has the much higher melting point (about 2600 °C; CO melts at −205 °C), because the whole solid is held together by strong attractions between ions.