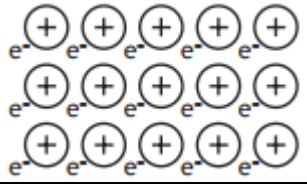
National 5 Chemistry
Unit 3.1a Metallic Bonding

Lesson | Traffic Light: Red | Amber | Green

1

Metallic bonding is the electrostatic force of attraction between positively charged ions and delocalised electrons.

- Positively charged ions consist of the nucleus and the inner shell of electrons
- The outer electrons are the delocalised electrons



2

Metallic elements are conductors of electricity because they contain delocalised electrons

- Electrons are free to move across the metal by jumping from outer shell to outer shell

National 5 Chemistry
Unit 3.1b Reaction of Metals

Lesson | Traffic Light: Red | Amber | Green

3a

The reaction of metals with oxygen can be written as:

metal + oxygen → metal oxide

Iron + Oxygen → Iron (III) oxide

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

3b

The reaction of metals with water can be written as:

metal + water → metal hydroxide + hydrogen

magnesium + water → magnesium hydroxide + hydrogen

$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$

3c

The reaction of metals with dilute acids can be written as:

metal + acid → salt + hydrogen

aluminium + hydrochloric acid → aluminium chloride + hydrogen

$2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

4

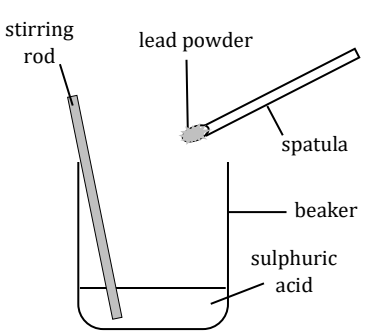
Metals can be arranged in order of reactivity by comparing the rates at which they react.

Metal	Potassium	Sodium	Lithium	Calcium	Magnesium	Aluminium	Zinc	Iron	Tin	Lead	Copper	Mercury	Silver	Gold	Platinum
Reaction With Oxygen	**Burn In Oxygen to Form Metal Oxide**								**Slowly React With Oxygen**			**No Reaction With Oxygen**			
Reaction With Water	**Fast Reaction With Water**				**Slow Reaction With Water Faster Reaction With Steam**						**No Reaction with Water or Steam**				
Reaction With Dilute Acids	**Violent Reaction With Acids**				**React With Acids**				**Slow Reaction**		**No Reaction With Acids**				

5

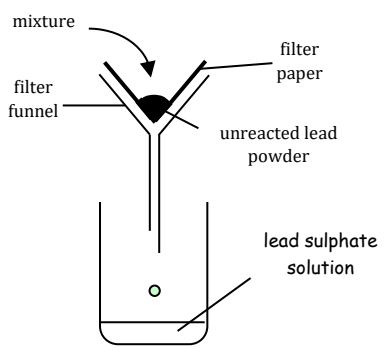
Metals can be used to produce soluble salts. Excess metal is added to the appropriate acid, the mixture is filtered and the filtrate evaporated to dryness.

1. Reaction with Acid



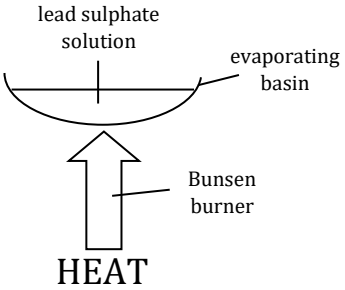
- metal reacts with dilute acid
- When all acid has been reacted, excess metal will lie on the bottom of the beaker

2. Filtration



- excess metal is removed by fitration
- *residue* in the filter paper is unreacted metal
- filtrate in beaker is solution of salt you are making

3. Evaporation



- The salt solution can be returned to the solid salt by evaporating the water

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Past Paper Question Bank
Unit 3.1a Metallic Bonding

JABchem

Outcome	Original Specimen Paper	New Specimen Paper	Nat5 2014	Nat5 2015	Nat5 2016	Nat5 2017	Nat5 2018	Nat5 2019	Nat5 2020	Nat5 2021						
1	mc14	mc15		mc15	mc4	mc15	mc23									
2			L2b				L15b(ii)									

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Past Paper Question Bank
Unit 3.1b Reaction of Metals

JABchem

Outcome	Original Specimen Paper	New Specimen Paper	Nat5 2014	Nat5 2015	Nat5 2016	Nat5 2017	Nat5 2018	Nat5 2019	Nat5 2020	Nat5 2021						
3a																
3b																
3c		mc16			L3c(i)											
4	mc15		mc15			L8a(i) L8a(ii)	mc17	mc19								
5																

Nat5	Answer	% Correct	Reasoning
2014 MC 15	A	75	<table><tr><th>Metal</th><th>Potassium</th><th>Sodium</th><th>Lithium</th><th>Calcium</th><th>Magnesium</th><th>Aluminium</th><th>Zinc</th><th>Iron</th><th>Tin</th><th>Lead</th><th>Copper</th><th>Mercury</th><th>Silver</th><th>Gold</th><th>Platinum</th></tr><tr><td>Reaction With Oxygen</td><td colspan="8">Burn In Oxygen to Form Metal Oxide</td><td colspan="3">Slowly React With Oxygen</td><td colspan="4">No Reaction With Oxygen</td></tr><tr><td>Reaction With Water</td><td colspan="3">Fast Reaction With Water</td><td colspan="5">Slow Reaction With Water Faster Reaction With Steam</td><td colspan="4">No Reaction with Water or Steam</td></tr><tr><td>Reaction With Acids</td><td colspan="3">Violent Reaction With dilute acids</td><td colspan="4">React With dilute acids</td><td>Slow Reaction</td><td colspan="4">No Reaction With dilute acids</td></tr></table>
2015 MC 15	C	67	☒A negative and positive ions are only found in ionic bonding ☒B a shared pair of electrons and two nuclei are only found in covalent bonding ☑C metallic bonding has positive ions (nucleus & inner shells) and delocalised electrons ☒D metallic bonding has delocalised electrons not delocalised protons
2016 MC 4	B	77	☒A sulphur is a non-metal which forms molecules of S_8 with covalent bonds ☑B copper is a metal which contains metallic bonding ☒C oxygen is a non-metal which forms molecules of O_2 with covalent bonds ☒D hydrogen is a non-metal which forms molecules of H_2 with covalent bonds
2017 MC 15	D	77	☒A Structure shown is a covalent network ☒B Structure shown is an ionic lattice ☒C Structure shown is a molecular covalent ☑D Structure shown is a metallic lattice

2018 MC 17	A	-	☑A X is most reactive as it reacts with water. Y is least reactive as it reacts slowest with dilute acid. Z is more reactive than W as Z reacts faster with dilute acid ☒B Y must be the least reactive metal as it has slowest reaction with dilute acid ☒C Z is less reactive than X as Z does not react with water ☒D Y must be the least reactive metal as it has slowest reaction with dilute acid
2018 MC 23	D	-	☒A covalent bonding contains a shared pair of electrons and two nuclei ☒B there is no attraction between negative ions and electrons (they repel) ☒C ionic bonding is the force of attraction between negative ions and positive ions ☑D metallic bonding is the force of attraction between positive ions and delocalised electrons
2019 MC 19	B	-	☒A Metal Y is least reactive metal as it is only one which had no reaction with acid ☑B Metal Z is most react metal and Metal Y is least reactive metal ☒C Metal Y is least reactive metal as it is only one which had no reaction with acid ☒D Metal Z is most reactive metal as it is only one which reacts with water

Nat5	Answer	Reasoning
2014 2b	Electrons are delocalised	Graphene is made of carbon. Carbon has 4 outer electrons but in grapheme only 3 of these electrons are used up in covalent bonds. The 4th electron is delocalised and able to jump from carbon atom to carbon atom allowing the conduction of electricity across grapheme.
2016 3c(i)	$2Al(NO_3)_3$	$2Al + 6HNO_3 \longrightarrow 2Al(NO_3)_3 + 3H_2$ metal + acid ⟶ salt + hydrogen
2017 8a(i)	Glowed very brightly	Magnesium is more reactive than zinc so would react faster and brighter.
2017 8a(ii)	Faster reaction	Powders react faster than lumps as powder has lower particle size
2018 15b(ii)	Light bulb would not light up	Pressurised sodium becomes an insulator. Circuit will not be complete and the bulb will not light up.

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Past Paper Question Bank
Unit 3.1a Metallic Bonding

JABchem

Outcome	Int2 2000	Int2 2001	Int2 2002	Int2 2003	Int2 2004	Int2 2005	Int2 2006	Int2 2007	Int2 2008	Int2 2009	Int2 2010	Int2 2011	Int2 2012	Int2 2013	Int2 2014	Int2 2015
1		mc3			mc6				mc7	mc6	mc4					
2				mc7 L12a				L3a				mc7				

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Past Paper Question Bank
Unit 3.1b Reaction of Metals

JABchem

Outcome	Int2 2000	Int2 2001	Int2 2002	Int2 2003	Int2 2004	Int2 2005	Int2 2006	Int2 2007	Int2 2008	Int2 2009	Int2 2010	Int2 2011	Int2 2012	Int2 2013	Int2 2014	Int2 2015
3a																
3b																
3c													mc25	L3a	L1a	
4			mc24	mc19			L10a				mc24	mc27		L3c L14c L14d	mc25	
5	L15a L15b			L9a L9b L9c				$L15b_{(i)}$ $L15b_{(ii)}$							L11b	$L14a_{(ii)}$ $L14a_{(iii)}$

Int2	Answer	% Correct	Reasoning
2001 MC 3	A	29	Metallic bonding has positive ions (the nucleus and the inner electron shells) attracted to the delocalised electrons in the outer shell.
2002 MC 24	A	57	☑A copper is not a reactive enough metal to react with dilute acid ☒B zinc + hydrochloric acid → zinc chloride + hydrogen ☒C copper carbonate + hydrochloric acid → copper chloride + water + carbon dioxide ☒D zinc carbonate + hydrochloric acid → zinc chloride + water + carbon dioxide
2003 MC 7	B	81	☒A Bromine is a non metal and is a non-conductor ☑B Mercury is a metal and is a conductor of electricity ☒C Oxygen is a non metal and is a non-conductor ☒D Sulphur is a non metal and is a non-conductor
2003 MC 19	C	86	☒A copper is too unreactive to react with dilute acid to give hydrogen gas ☒B gold is too unreactive to react with dilute acid to give hydrogen gas ☑C magnesium + hydrochloric acid → magnesium chloride + hydrogen ☒D mercury is too unreactive to react with dilute acid to give hydrogen gas
2004 MC 6	D	52	☒A Non-polar covalent: pairs of electrons being shared equally between bonds ☒B Polar covalent: pairs of electrons being shared unequally between bonds ☒C Ionic: the attraction of oppositely charge ions for each other ☑D Metallic: the attraction of positively charged ions for delocalised electrons

2008 MC 7	A	70	☑A Metals have electrons which can jump from atom to atom ☒B Diagram shows a covalent molecular substance ☒C Diagram shows an ionic substance ☒D Diagram shows a covalent network substance
2009 MC 6	A	70	☑A Metallic Bonding: positive ions with delocalised electrons ☒B Metallic bonding has positive ions (the nucleus and the inner electron shells) ☒C Ionic bonding: negative ion and positive ions attracted to each other ☒D Covalent bonding: a shared pair of electrons between two nuclei
2010 MC 4	D	70	☒A Non-polar covalent bonding: Pairs of electrons shared equally between atoms ☒B Polar covalent bonding: Pairs of electrons shared unequally between atoms ☒C Ionic Bonding: attraction of oppositely charged ions for each other ☑D Metallic Bonding: attraction of positively charged ions for delocalised electrons
2010 MC 24	A	60	☑A copper is not reactive enough to react with dilute hydrochloric acid ☒B zinc + hydrochloric acid → zinc chloride + hydrogen ☒C copper carbonate + hydrochloric acid → copper chloride + water + carbon dioxide ☒D zinc carbonate + hydrochloric acid → zinc chloride + water + carbon dioxide
2011 MC 7	D	74	☒A All atoms are free to vibrate, not just atoms in conducting materials like copper ☒B The ability to conduct needs more than atoms to be in close contact to work ☒C This electron arrangement is not the key factor in electrical conduction ☑D The conduction of electricity is dependent on the ability of electrons to jump from atom to atom
2011 MC 27	B	63	Z is the *most* reactive as it is the only metal to react with water. — Z comes **last** Y is the *least* reactive as it is the only metal not to react with acid — Y comes **first**
2012 MC 25	D	44	☒A carbon does not react with hydrochloric acid to form an acid ☒B calcium oxide neutralises acid form salt and water but no gases are formed ☒C carbon dioxide gas is formed but CO_2 does not burn with a pop ☑D zinc reacts with acid to form hydrogen, which burns with a pop
2014 MC 25	A	79	See table below

Metal	Potassium	Sodium	Lithium	Calcium	Magnesium	Aluminium	Zinc	Iron	Tin	Lead	Copper	Mercury	Silver	Gold	Platinum
Reaction With Oxygen	Burn In Oxygen to Form Metal Oxide								Slowly React With Oxygen			No Reaction With Oxygen			
Reaction With Water	Fast Reaction With Water				Slow Reaction With Water Faster Reaction With Steam							No Reaction with Water or Steam			
Reaction With Acids	Violent Reaction With dilute acids				React With dilute acids				Slow Reaction			No Reaction With dilute acids			

Int2	Answer	Reasoning
2000 **15a**	Neutralised when adding further solid it doesn't start fizzing again	$MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$ <u>or</u> $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$ When the sulphuric acid runs out, $MgCO_3$ or Mg is in excess. To be sure no acid is left, a little extra solid is added to check there is no fizzing (which would indicate that acid is left)
2000 **15b**	Filter excess solid Evaporate solution to get crystals	Filtration: Filtering removes the excess solid added in the neutralisation Evaporation: Boiling the solution removes the water leaving crystals of $MgSO_4$
2003 **9a**	Add solid until no more bubbles form	sulphuric acid + magnesium carbonate → magnesium sulphate + water + carbon dioxide sulphuric acid + magnesium → magnesium sulphate + hydrogen Solid is added and acid stirred until acid stops bubbling. Once enough solid has been added and the mixture doesn't start to bubble again, all the acid has been neutralised. The excess solid is removed by filtration and the salt solution is evaporated to make the new substance.
2003 **9b**	To ensure all acid is neutralised	
2003 **9c**	Step 2: filtration Step 3: evaporation	
2003 **12a**	metallic bonding (electrons free to move)	All metals have delocalised electrons which are able to jump from atom to atom. Electrons are free to move and this is conduction of electricity.
2006 **10a**	glows red or glows brightly	Zinc is more reactive than copper but not as reactive as magnesium. The description of zinc's reaction with oxygen would be somewhere between than of magnesium and copper.
2007 **3a**	Electrons able to move from atom to atom	Electrons are free to move from atom to atom because they are delocalised and not fixed to any bond or atom. All metals conduct electricity.
2007 **15b**(i)	to remove unreacted magnesium	magnesium + sulphuric acid → magnesium sulphate + hydrogen When all the sulphuric acid has reacted with the magnesium, there will be unreacted solid magnesium metal left over in the beaker as magnesium is insoluble in water. Unreacted magnesium is removed by filtration.
2007 **15b**(ii)	Evaporation or boil off water	Once the unreacted magnesium metal is removed by filtration, the magnesium sulphate filtrate can then be evaporated to leave solid magnesium sulphate.
2013 **3a**	Hydrogen	ACID + METAL → SALT + HYDROGEN sulphuric acid + magnesium → magnesium sulphate + hydrogen
2013 **3c**	0 cm^3	Copper, mercury, silver, gold and platinum are too unreactive to react with dilute sulphuric acid. No reaction ∴ no gas produced
2013 **14c**	Fast reaction Slow reaction	Magnesium is more reactive than zinc so magnesium would be faster than zinc's moderately fast reaction. Copper is less reactive than zinc so copper would be slower than zinc's moderately fast reaction.
2013 **14d**	Could explode	Potassium is more reactive than magnesium and the magnesium reaction is already a fast reaction.
2014 **1a**	Hydrogen	ACID + METAL → SALT + HYDROGEN hydrochloric acid + magnesium → magnesium chloride + hydrogen

<table>
<tr><td>2014
11b</td><td>2. Filtration
3. Evaporation</td><td>
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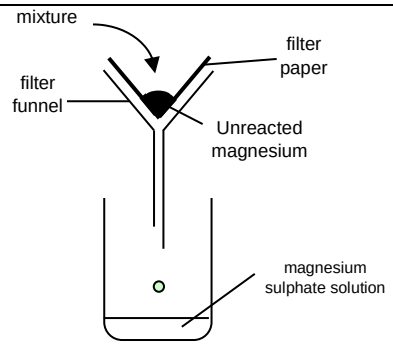
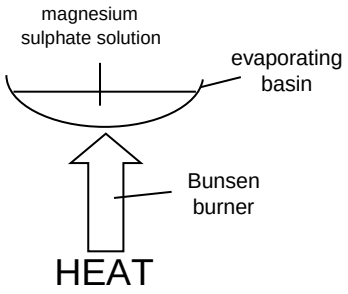
<tr><td> 
</td><td> 
</td></tr>
</table>
</td></tr>
<tr><td>2015
14a(ii)</td><td>No more bubbling</td><td>Any answer from:
<table>
<tr><td>No more bubbles of gas</td><td>Solid left at bottom</td><td>Unreacted magnesium left</td><td>Magnesium stops reacting</td></tr>
</table>
</td></tr>
<tr><td>2015
14a(iii)</td><td>Remove (unreacted/excess) magnesium</td><td>Magnesium added to the sulphuric acid will continue to react until there is no sulphuric acid left. At this point, all the additional magnesium added will lie on the bottom of the beaker as it is insoluble in water. Filtration will removed the solid from the liquid.</td></tr>
</table>

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Past Paper Question Bank
Unit 3.1a Metallic Bonding

Outcome	2000 Credit	2001 Credit	2002 Credit	2003 Credit	2004 Credit	2005 Credit	2006 Credit	2007 Credit	2008 Credit	2009 Credit	2010 Credit	2011 Credit	2012 Credit	2013 Credit		
1																
2																

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Past Paper Question Bank
Unit 3.1b Reaction of Metals

Outcome	2000 Credit	2001 Credit	2002 Credit	2003 Credit	2004 Credit	2005 Credit	2006 Credit	2007 Credit	2008 Credit	2009 Credit	2010 Credit	2011 Credit	2012 Credit	2013 Credit		
3a																
3b		11a								15b						
3c																
4		11b 11c								15a 15c						
5																

<table>
<tr><th>SG Credit</th><th>Answer</th><th>Reasoning</th></tr>
<tr><td>2001C
11a</td><td>hydrogen</td><td>very reactive metal + water ⟶ salt + hydrogen
potassium, sodium, lithium and calcium all react with water this way.</td></tr>
<tr><td>2001C
11b</td><td>W: Pt, Au, Ag or Hg
Y: K, Na, Li, Ca or Mg</td><td>W must be the least reactive metals if heating alone releases the metal from the ore.
Y must be the most reactive metals if they react with cold water.</td></tr>
<tr><td>2001C
11c</td><td>Y, X, Z, W</td><td>Y is most reactive as it is the only one which reacts with water
W is the least reactive as it is the only metal which releases it metal when heated
X is more reactive than Z as X displaces X from a solution of X</td></tr>
<tr><td>2009C
15a</td><td>Y - X - W - Z</td><td rowspan="3">
<table>
<tr><th>Metal</th><th>Reasoning</th><th>Possible Metals</th></tr>
<tr><td>Y</td><td>Y is most reactive metal as it is the only one which reacts with cold water. Magnesium, and the metals above magnesium in the reactivity series, react with cold water</td><td>Potassium
Sodium
Lithium
Calcium
Magnesium</td></tr>
<tr><td>X</td><td>X is 2nd most reactive metal:
<table>
<tr><td>Reacts with dilute acid</td><td>Above copper in reactivity series</td></tr>
<tr><td>No Reaction with cold water</td><td>Below magnesium in reactivity series</td></tr>
</table></td><td>Aluminium
Zinc
Iron
Tin
Lead</td></tr>
<tr><td>W</td><td>W is 3rd most Reactive metal:
<table>
<tr><td>No reaction with dilute acid</td><td>Copper or below in reactivity series</td></tr>
<tr><td>No Reaction on heating metal oxide</td><td>Above Mercury in reactivity series</td></tr>
</table></td><td>Copper</td></tr>
<tr><td>Z</td><td>Z is least reactive metal is it is the only metal to release the metal when its metal oxide is heated.</td><td>Mercury
Silver
Gold
Platinum</td></tr>
</table>
</td></tr>
<tr><td>2009C
15b</td><td>Hydrogen</td></tr>
<tr><td>2009C
15c</td><td>
<table>
<tr><td>Metal Y
One from:</td><td>Potassium
Sodium
Lithium
Calcium
Magnesium</td></tr>
<tr><td>Metal Z
One from:</td><td>Mercury
Silver
Gold
Platinum</td></tr>
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</table>

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Past Paper Question Bank
Unit 3.1a Metallic Bonding

Outcome	2000 General	2001 General	2002 General	2003 General	2004 General	2005 General	2006 General	2007 General	2008 General	2009 General	2010 General	2011 General	2012 General	2013 General		
1																
2	18c															

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Past Paper Question Bank
Unit 3.1b Reaction of Metals

Outcome	2000 General	2001 General	2002 General	2003 General	2004 General	2005 General	2006 General	2007 General	2008 General	2009 General	2010 General	2011 General	2012 General	2013 General		
3a																
3b																
3c				14a				13b	21c					12b		
4	14b		12a 12c 16c	14b				13a	13a(i)					12a 12c(i)		
5																

SG General	Answer	Reasoning
2000G 14b	glows very brightly	The halogens get more and more reactive as you go up group 7. Magnesium fluoride should be reacting faster than magnesium chloride
2000G 18c	lithium metal conducts	The lithium metal produced by the molten electrolysis could conduct electricity between the electrodes even after the molten lithium chloride freezes back to a solid.
2002G 12a	T R S most reactive ↔ least reactive	T is the most reactive as it gives of the biggest volume of gas. S is the least reactive as it did not react with acid at all
2002G 12c	potassium floats or catches fire	Potassium floats on water and catches fire.
2002G 16c	copper too unreactive	Copper, mercury, silver, gold and platinum are very unreactive and do not react with dilute acids.
2003G 14a	hydrogen	ACID + METAL → SALT + HYDROGEN
2003G 14b	copper, mercury, silver or gold	Metals below hydrogen in the electrochemical series (copper, mercury, silver and gold) are not reactive enough the react with dilute acids.
2007G 13a	magnesium-zinc-lead	Most reactive has most bubbles ∴ magnesium is most reactive Least reactive has least bubbles ∴ lead is least reactive
2007G 13b	hydrogen	ACID + METAL → SALT + HYDROGEN
2008G 13a(i)	speed increases	Powdered zinc has a smaller particle size than lumps of zinc so powdered zinc reacts faster than lumps of zinc.
2008G 21c	zinc chloride	Acid + Metal ⟶ Salt + hydrogen hydrochloric acid + zinc ⟶ zinc chloride + hydrogen $2HCl + Zn \longrightarrow ZnCl_2 + H_2$
2013G 12a	**B A C**	The most reactive (B) reacts to give off the most bubbles The least reactive (C) reacts to give off the least bubbles
2013G 12b	Hydrogen	ACID + METAL → SALT + HYDROGEN
2013G 12c(i)	Copper, mercury, silver, gold or platinum	The least reactive metals do not react with dilute acids like hydrochloric acid. Copper and the metals below it in the reactivity series (mercury, solver gold and platinum) are not reactive enough to react with dilute acids