

C10-12: Electrolysis, metals and reversible reactions Knowledge Organiser

Lesson sequence

1. Electrolysis
2. Half-equations (HT)
3. Products of electrolysis
4. Core practical – electrolysis of copper sulfate solution (CP10)
5. Reactivity
6. Displacement reactions
7. Extracting metals from their ores
8. Oxidation and reduction
9. Life-cycle assessment and recycling
10. Dynamic equilibrium
11. Changes to equilibrium systems (HT)

1. Electrolysis

*Electrolysis	Using direct current to break compounds down into their elements.
*Electrolyte	Liquid used for electrolysis because ions can move – either molten or dissolved ionic compounds
**Electrolysis of solids	Does not work as ions can't move.
*Electrodes	Conducting rods placed in electrolyte, connected to power supply.
*Cathode	Negative electrode where cations (+) are discharged.
*Anode	Positive electrode where anions (-) are discharged.

2. Half-equations (HT)

Oxidation (HT)	Loss of electrons (OIL)
Reduction (HT)	Gain of electrons (RIG)
AnOx	A node is for o xidation

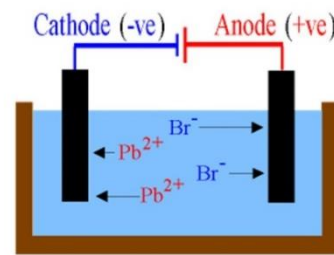
CaRe	C athode is for r eduction
***Half-equations	An equation that shows what happens to just one of the ions during chemical reaction. Two half-equations combine to give the overall ionic equation
***Half-equations in electrolysis	Show electron transfer: Cathode (reduction): $M^+ + e^- \rightarrow M$ Anode (oxidation): $X^- \rightarrow X + e^-$
***Electrons in half equations	Cations will gain the same number of electrons as their charge. Anions will lose the same number of electrons as their charge.
***Non-metals in half-equations	Most non-metals will form molecules: O ₂ , F ₂ , Cl ₂ , Br ₂ , I ₂ etc – so you will need two of them in the half-equation.

3. Products of electrolysis

*Discharged	When an ion loses its charge to become an atom
*Electrolysis of molten salts	Cathode: metal Anode: non-metal
**Ions in salt solutions	Metal, non-metal and H ⁺ and OH ⁻ because water partially ionises.
***Hydrogen half-equation	$2H^+(g) + 2e^- \rightarrow H_2(g)$
**Electrolysis of salt solutions - cathode	Metal, unless reactive metal such as K, Na, Li, Mg, Ca in which case hydrogen.
**Electrolysis of salt solutions - anode	Non-metal, unless sulphate salt in which case oxygen.
**Electrolysis of sulfuric acid	Cathode: hydrogen Anode: oxygen
**Purifying copper - setup	Anode: impure copper Cathode: pure copper Electrolyte: copper sulphate solution

***Purifying copper - explanation	Copper atoms leave the anode ($Cu \rightarrow Cu^{2+} + 2e^-$), travel through solution and go to cathode ($Cu^{2+} + 2e^- \rightarrow Cu$). Impure atoms on the anode fall to the bottom as sludge.
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Electrolysis of molten lead bromide

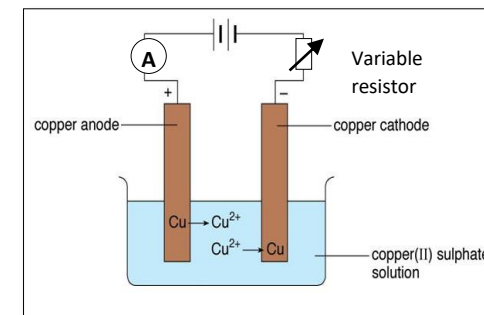


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4. Core practical – electrolysis of copper sulfate solution (CP10)

*CP10 - aim	To see how the changing the current affects the rate of electrolysis.
*CP10 – Prepare electrodes	Clean two copper electrodes, label one anode and one cathode, weigh each and record mass.
*CP10 - Setup	Connect a variable resistor to the negative terminal of a power supply then connect this to the cathode. Connect an ammeter to the positive terminal then connect this to the anode. Place both electrodes in a beaker of copper sulfate solution
*CP10 – Run the experiment	Switch the power supply on, adjust the variable resistor so the ammeter reads 0.2 A and leave for 20 minutes.
*CP10 – Record results	Carefully remove each electrode, rinse them with water and then with propanone. Re-weigh each and record.
*CP10 – Variations	Repeat the experiment with a current of 0.3 A, 0.4 A and 0.5 A.

*CP10 - Results	The anode loses mass whilst the cathode gains mass. The higher the current the greater the mass change.
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5. Reactivity

*Reactivity series (most to least)	Potassium, sodium, calcium, magnesium, aluminium, zinc, iron, copper, silver, gold.
**Forming cations	The more reactive metals more easily lose electrons to form cations.
**Reaction with cold water (H₂O(l))	Metal + water → metal hydroxide + hydrogen - Potassium – violently - Sodium – very quickly - Calcium – slowly
**Reaction only with steam (H₂O(g))	Metal + water → metal oxide + hydrogen Magnesium, zinc, iron
**No reaction with water or steam	Copper, silver, gold
**Reaction with acid	Metal + acid → salt + hydrogen - Sodium, potassium – violent - Calcium, magnesium, zinc, iron – steady - Copper, silver, gold – no reaction

potassium	most reactive	K
sodium		Na
calcium		Ca
magnesium		Mg
aluminium		Al
carbon		C
zinc		Zn
iron		Fe
tin		Sn
lead		Pb
hydrogen		H
copper		Cu
silver		Ag
gold		Au
platinum	least reactive	Pt

6. Displacement reactions	
**Displacement reactions	Reactions in which a more reactive metal displaces a less reactive metal from a salt eg: $copper\ sulfate + zinc \rightarrow zinc\ sulfate + copper$ Does not work backwards as copper is less reactive than zinc.
***Redox reactions	Reactions in which an oxidation and reduction happen at the same time, such as displacement reactions.
***Redox during displacement	The more reactive metal gets oxidised, eg: • $Zn \rightarrow Zn^{2+} + 2e^{-}$ The less reactive metal gets reduced, eg: $Cu^{2+} + 2e^{-} \rightarrow Cu$
***Spectator ion	An ion that does not change during a chemical reaction.

7. Extracting metals from their ores	
*Native state	When metals are found naturally in their pure form, such as silver and gold.

*Ore	Rock containing enough of a metal compound to extract for profit. Normally oxides or sulphides of the metal.
*Extracting metals by heating with carbon	For extracting less reactive metals such as zinc, iron, copper. Works because carbon is more reactive, eg: iron oxide + carbon \rightarrow carbon dioxide + iron
**Extracting metals by electrolysis	Done with metals more reactive than carbon such as potassium, sodium, calcium, magnesium, aluminium, eg: Aluminium oxide \rightarrow aluminium + oxygen
*Bioextraction	Using living organisms to extract metals.
**Bioleaching	Growing bacteria on poor quality copper ore. The bacteria produce a solution of copper sulfate from which copper can be extracted by electrolysis.
**Phytoextraction	Plants are grown that absorb metal compounds as they grow. The plants are then burnt to produce ash that is rich in metal compounds.

8. Oxidation and reduction	
*Oxidation	Gaining oxygen
*Reduction	Losing oxygen
*Redox	When reduction and oxidation reactions happen together.
**Reduction of iron	Iron produced from iron oxide by heating with carbon: $iron\ oxide + carbon \rightarrow carbon\ dioxide + iron$ Iron is reduced, carbon is oxidised.
**Reduction of aluminium ore	Aluminium is produced from aluminium oxide by electrolysis: $Aluminium\ oxide \rightarrow aluminium + oxygen$ Aluminium is reduced, oxygen is oxidised

*Corrosion	When metals slowly react with oxygen, making them weaker.
**Rates of corrosion	More reactive metals corrode more quickly.
**Tarnish	A protective layer of oxide that stops the layers below from corroding.

9. Life-cycle assessment and recycling	
*Recycling	Converting old waste metal into new metal that can be reused
*Advantages of recycling	- Natural reserves last longer - Less pollution from mining - Less pollution from processing - Less waste in landfill - Often less energy used
*Disadvantages of recycling	- Can be expensive - Can use a lot of energy in transporting, collecting and sorting
**Life-cycle assessment (LCA)	Looks at environmental impact of all stages of a product's lifecycle. We should aim to reduce all damage.
**LCA stages	- Obtaining and processing raw materials - Making and packaging the product - Using the product - Disposal or recycling of the product

10. Dynamic equilibrium	
*Reversible reaction	Reactions that can go forwards as well as backwards (with products turning back into reactants)
*\rightleftharpoons	The arrow used for reversible reactions.
**Dynamic equilibrium	The point at which the rate of the forwards reaction and backwards reaction are equal, so the concentrations of reactants and products stops changing.
*Closed systems	Nothing can escape, so dynamic equilibrium can be reached.

*Open systems	Gases can escape so dynamic equilibrium can't be reached.
**Equation for making ammonia	Nitrogen + hydrogen \rightleftharpoons ammonia $N_2 + 3H_2 \rightleftharpoons 2NH_3$ exothermic
**Haber process	For making ammonia in factories: - 200 atm pressure – equilibrium shifts right, yield increases - 450°C – equilibrium shifts left, lower yield but MUCH faster reaction - Catalyst – increases reaction rate

11. Changes to equilibrium systems (HT)	
***Effect on equilibrium of increasing temperature	Exothermic reaction – equilibrium shifts left, yield decreases Endothermic reaction – equilibrium shifts right, yield increases
***Effect on equilibrium of decreasing temperature	Exothermic reaction – equilibrium shifts right, yield increases Endothermic reaction – equilibrium shifts left, yield decreases
***Effect on equilibrium of increasing gas pressure	Equilibrium shifts to side with fewer gas molecules
***Effect on equilibrium of decreasing gas pressure	Equilibrium shifts to side with more gas molecules
***Effect on equilibrium of increasing concentration...	...of products – equilibrium shifts left, yield decreases ...of reactants – equilibrium shifts right, yield increases
***Effect on equilibrium of decreasing concentration	...of products – equilibrium shifts right, yield increases ...of reactants – equilibrium shifts left, yield decreases