

Material World Review – Science and Technology (ST)

This summary provides a quick overview of the Material World concepts that will be assessed during the ST ministry exam.




To explore a concept in more detail, scan its QR code. To see the summary of the Earth and Space and the Technological World, scan the large QR code at the bottom left

Concentration

Concentration is the ratio between the amount of solute and the amount of solution.

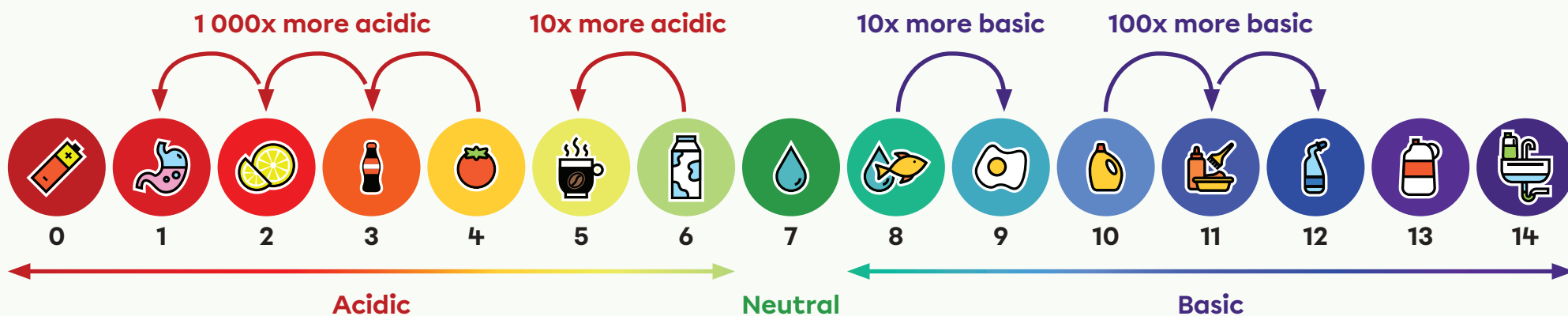
Example: 25.00 g of solute is dissolved in 800.0 mL of solution.

What is the concentration of the solution?

In g/L	In % m/V	In ppm
 $m = 25.00 \text{ g}$ $V = 800.0 \text{ mL} \times \frac{1 \text{ L}}{1\,000 \text{ mL}} = 0.800 \text{ L}$ $C = ? \text{ g/L}$ $C = \frac{m}{V}$ $C = \frac{25.00 \text{ g}}{0.800 \text{ L}}$ $C = 31.25 \text{ g/L}$	 $m = 25.00 \text{ g}$ $V = 800.0 \text{ mL}$ $C = ? \% \text{ m/V}$ $C = \frac{m}{V} \times 100$ $C = \frac{25.00 \text{ g}}{800.0 \text{ mL}} \times 100$ $C = 3.125 \% \text{ m/V}$	 $m = 25.00 \text{ g}$ $V = 800.0 \text{ mL}$ $C = ? \text{ ppm}$ $C = \frac{m}{V} \times 1\,000\,000$ $C = \frac{25.00 \text{ g}}{800.0 \text{ mL}} \times 1\,000\,000$ $C = 31\,250 \text{ ppm}$

The pH Scale

The **pH scale** is a logarithmic scale used to compare the acidic, neutral, or basic (alkaline) nature of solutions.





Electrolytic Dissociation

An electrolyte is a substance that allows <u>current to flow</u> through an aqueous solution.	Type of Electrolyte			
	General Chemical Formula	(H) + Non-metal	Metal + (OH)	Metal + Non-metal
Electrolytic dissociation is the separation of an electrolyte into a cation and an anion.	Ions in Solution	A proton (H ⁺) and an anion	A cation and a hydroxide (OH ⁻)	A cation and an anion
	pH in Solution	Below 7	Above 7	Variable
	Examples	HCl, CH ₃ COOH, H ₂ SO ₄	NaOH, Ca(OH) ₂	MgCl ₂ , KNO ₃ , NaF



Groups in the Periodic Table of Elements

The common charges of ions formed by elements in groups I A to VII A

#period

Group	Characteristics
Alkali Metals	<ul style="list-style-type: none"> Soft metals Very reactive Good electrical conductors
Alkaline-Earth Metals	<ul style="list-style-type: none"> Soft metals Reactive Good electrical conductors Found in the Earth's crust
Halogens	<ul style="list-style-type: none"> Very reactive Disinfectants React with metals to form salts
Noble Gases	<ul style="list-style-type: none"> Non-metals Very stable Emit light when an electric current is passed through them





Rutherford-Bohr Atomic Model

- Atomic number = Number of p^+ in the nucleus = Number of e^- to be distributed
- Period number = Number of electron shells
- Group number as a Roman numeral = e^- valence number
- 1st shell: max. 2 e^-
- 2nd and other shells: max. 8 e^-

Example: magnesium atom (Mg)

Atomic number

Period: 3

Group: IIA



Mg
Magnesium

Valence e^-



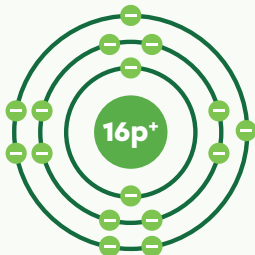
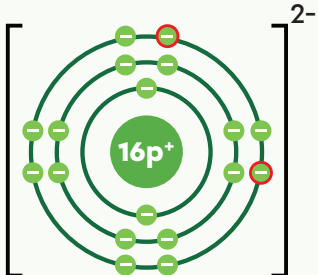
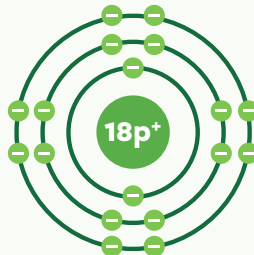

Nucleus

Electron shell



Ions

An **ion** is an atom that has lost or gained electrons, often to take on the same electronic configuration as a noble (or inert) gas and become more stable.

Cation: positively charged ion	Sulphur atom (S)	Sulphur ion (S^{2-})	Argon ion (Ar)
Anion: negatively charged ion			
Example: A sulphur atom (S) gains 2 electrons to form a sulphur ion (S^{2-}), obtaining the same electronic configuration as argon (Ar).			
Legend	 Electron gained		





Chemical Reactions

Oxidation is a reaction in which an element of one of the reactants loses electrons. This can happen in the presence of oxygen.

Example: Formation of iron (III) oxide (rust)



Combustion is an oxidation process that releases energy.

Example: Propane combustion



Cellular respiration is the slow combustion of glucose in animal cells, plant cells and other types of cells.

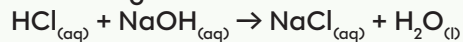


Photosynthesis is a glucose synthesis reaction that takes place in plant cells.



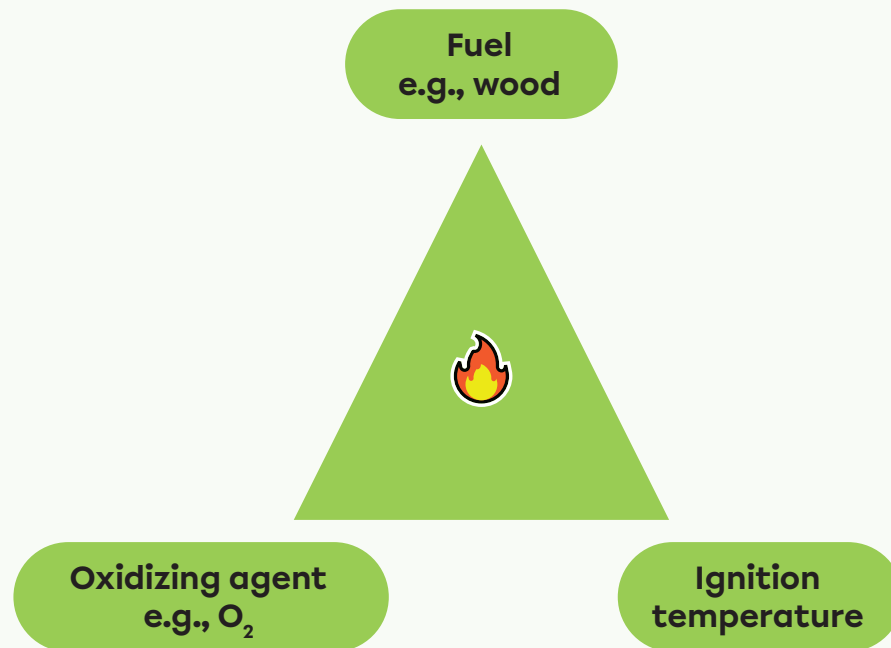
Acid-base neutralization is the reaction of an acid with a base. It can produce a salt and water.

Example: Neutralization of chlorhydric acid (HCl) by sodium hydroxide (NaOH)



Fire Triangle

Combustion requires 3 elements.
Without all 3, a fire goes out.





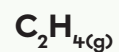
Law of Conservation of Matter

Matter is neither created nor destroyed, but transformed. The mass of the reactants is equal to the mass of the products.

Mass of reactants

=

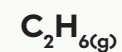
Mass of products



+



→



28.06 g

+

2.02 g

=

30.08 g

30.08 g

=

30.08 g



Balancing a Chemical Equation

Balancing a chemical equation means balancing the number of atoms in the reactants and products in keeping with the Law of Conservation of Matter.



+



→



N

2

0

2

2×1

H

0

6

6

3×2

2×3

Number of N atoms

Reactants

Products

2

2



Number of H atoms

Reactants

Products

6

6





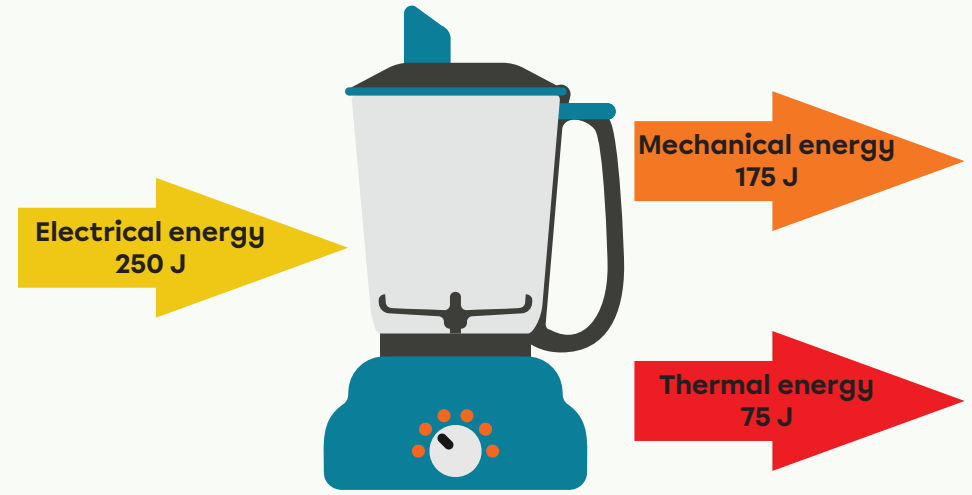
Law of Conservation of Energy

Energy cannot be created nor destroyed. It can only be transferred or transformed.

Thermal energy transfer from coffee to hand



Transformation of electrical energy into mechanical and thermal energy



$$\begin{array}{rcl}
 \text{Energy consumed} & = & \text{Useful energy} + \text{Dissipated energy} \\
 250 \text{ J} & = & 175 \text{ J} + 75 \text{ J} \\
 250 \text{ J} & = & 250 \text{ J}
 \end{array}$$



Energy Efficiency

Example: A toaster consumes 270 000 J of electrical energy and transforms it into 197 100 J of useful thermal energy.
What is the energy efficiency of the toaster?

$$\begin{array}{l}
 \text{Energy efficiency} = ? \% \\
 E_{\text{consumed}} = 270\,000 \text{ J} \\
 E_{\text{useful}} = 197\,100 \text{ J}
 \end{array}$$

$$\text{Energy efficiency} = \frac{E_{\text{useful}}}{E_{\text{consumed}}} \times 100$$

$$\begin{array}{l}
 \text{Energy efficiency} = \frac{197\,100 \text{ J}}{270\,000 \text{ J}} \times 100 \\
 \text{Energy efficiency} \approx 73 \%
 \end{array}$$





Static Electricity

Law of Electric Charges

+ - = Attraction

++ or -- = Repulsion

Conduction: Contact between a charged and a neutral object.



Friction: One object pulls electrons from the other.

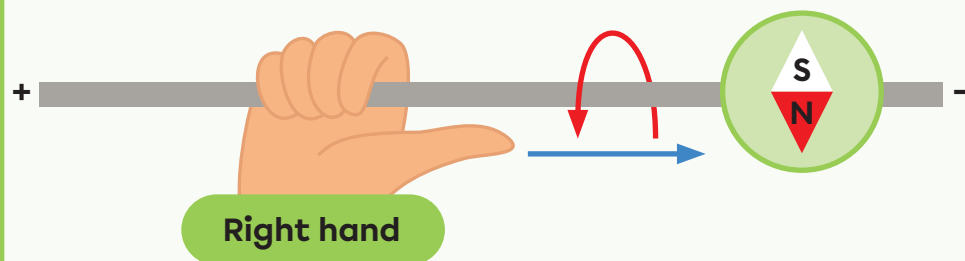


Induction: A nearby charge causes electrons to move temporarily.



Magnetic Field Around a Straight Wire

- Thumb: **conventional current direction**
- Fingers: **direction of magnetic field lines**



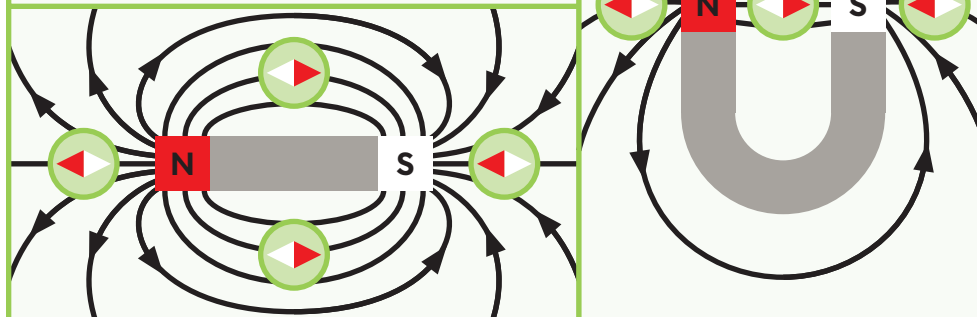
Magnetic Field Around Magnets

Magnetic field lines run from the magnetic north pole to the magnetic south pole.

Attraction and repulsion of two poles

N-S = Attraction

N-N or S-S = Repulsion





Ohm's Law ($V = RI$)

Example: A toaster with a resistance of 12.0Ω carries a current of $10\,000 \text{ mA}$. What is the potential difference, or voltage, of the toaster's outlets?

$$R = 12.0 \Omega$$

$$I = 10\,000 \text{ mA} \times \frac{1 \text{ A}}{1\,000 \text{ mA}} = 10.000 \text{ A}$$

$$V = ? \text{ V}$$

$$V = RI$$

$$V = 12.0 \Omega \times 10.000 \text{ A}$$

$$V = 120 \text{ V}$$



Electrical Power ($P = VI$)

Example: What is the electrical power of the toaster in the previous example?

$$V = 120 \text{ V}$$

$$I = 10.000 \text{ A}$$

$$P = ? \text{ W}$$

$$P = VI$$

$$P = 120 \text{ V} \times 10.000 \text{ A}$$

$$P = 1\,200 \text{ W or } 1.20 \text{ kW}$$



Electrical Energy Consumed ($E = P\Delta t$)

Example: The toaster runs for 3 min and 45 sec.
How much electrical energy does it consume?

Joules (J)

$$P = 1\,200 \text{ W}$$

$$\Delta t = \left(3 \text{ min} \times \frac{60 \text{ s}}{1 \text{ min}}\right) + 45 \text{ s} = 225 \text{ s}$$

$$E = ? \text{ J}$$

$$E = P\Delta t$$

$$E = 1\,200 \text{ W} \times 225 \text{ s}$$

$$E = 270\,000 \text{ J or } 270 \text{ kJ}$$

Kilowatt-hour (kWh)

$$P = 1.20 \text{ kW}$$

$$\Delta t = \left(3 \text{ min} \times \frac{1 \text{ h}}{60 \text{ min}}\right) + \left(45 \text{ sec} \times \frac{1 \text{ h}}{3\,600 \text{ s}}\right) = 0.0625 \text{ h}$$

$$E = ? \text{ kWh}$$

$$E = P\Delta t$$

$$E = 1.20 \text{ kW} \times 0.0625 \text{ h}$$

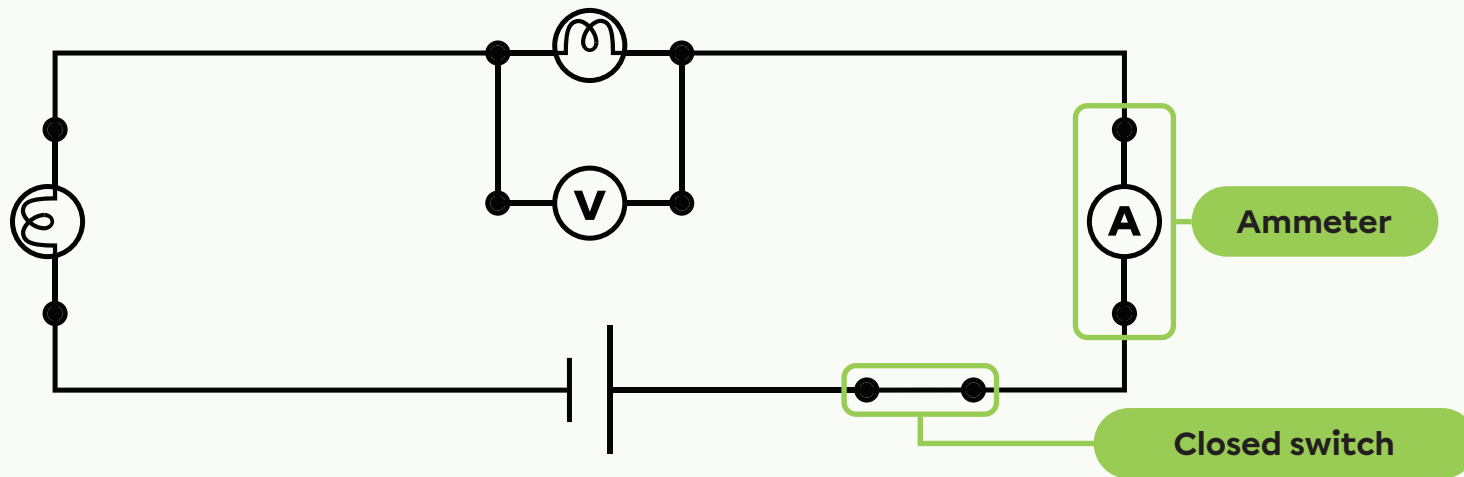
$$E = 0.0750 \text{ kWh}$$





Electrical Circuits

Series circuit



Parallel circuit

