# AQA GCSE COMBINED SCIENCE

# NOTEBOOK

ALL THE KEY CONTENT IN 64 PAGES!

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# CELL BIOLOGY

## EUKARYOTIC AND PROKARYOTIC CELLS

### EUKARYOTIC CELLS (ANIMAL & PLANT)

- DNA enclosed in a nucleus.
- Larger (10–100 µm).
- Found in animals, plants, fungi, protists.

**Animal Cells (Eukaryotic)**

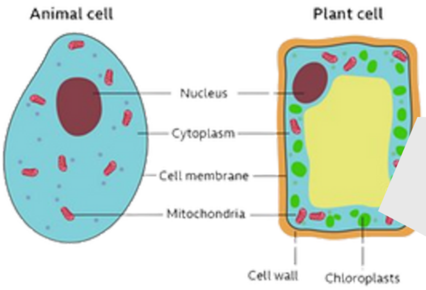
- Nucleus – contains genetic material, controls cell activities.
- Cytoplasm – site of chemical reactions.
- Cell membrane – controls substance movement.
- Mitochondria – site of aerobic respiration.
- Ribosomes – site of protein synthesis.

**Plant Cells (Eukaryotic) (Same as animal cells, plus:)**

- Cell wall (cellulose) – provides strength.
- Chloroplasts – photosynthesis, contain chlorophyll.
- Permanent vacuole – stores cell sap, maintains structure.

### PROKARYOTIC CELLS (BACTERIA)

- Smaller (~1 µm).
- No nucleus – DNA is a single circular strand in cytoplasm.
- May have plasmids (small rings of DNA).
- No mitochondria or chloroplasts.
- Cell wall (peptidoglycan) for support.



## SCALE & SIZE OF CEL

- Cells are very small and re microscope to be seen.
- Measured in micrometer
- 1 µm = 0.001 mm = 1 ×
- Be able to convert bet ent u
- 1 mm = 1000 µm (×10 µm, ÷1000 for µm → mm).
- 1 µm = 1000 nm (×1000 to con nm, ÷1000 for nm → µm).

### ORDER OF SIZE (FROM SMALLEST TO LARGEST)

- HIV Virus → 1
- Mitochondri lasts → 1.5 µm
- Cholera Ba
- Cheek Cell (Anim
- Palisade Mesophyll Cel

◆ Many subcell structures in cells are th larger than prokaryo

### ORDER AGNITU

- Us ompare si actors of 10:
  - iger → 10
- Metric
  - Centi- (cm)
  - Milli- (mm) → x 0.
  - (µm) → x 0.000 )
  - 0.00000000 (10⁻⁹)

- ry smal umbers to avo n.
  - Ex ersions:0.0015 → 1.5 × 10⁻³
  - 73.50 10⁴
- calculations as they

## CELL DIFFERENTIATION

Process where cells become specialised by swit rtain genes on

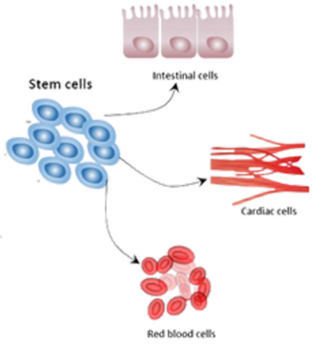
- Sp cells develop s s suited to ction.

### NTIATION IN ANIMALS

- Occurs early in velopment, then stops.
- n adults, only stem cells (e.g., bone marrow) can differentiate for repair & replacement.
- Red blood cells lose their nucleus, so cannot divide.

### DIFFERENTIATION IN PLANTS

- Occurs throughout life.
- Cells differentiate when positioned but can re-differentiate if moved.



## CELL SPECIALISATION (ANIMALS)

**SPERM CELL** -Function: Carries male DNA to the egg for fertilisation.

- Streamlined head and
- Mitochondria in mid movement.
- Acrosome (head) → cont es to b wn egg membrane.
- Haploid nucleus → restores no number after fertilisation.

**NERVE CELL (NEURONE)** -Function: T electrical signals oss the body.

- Long axon → impulses over long
- Dendrites with other nerve cells, s, and glan
- Myelin → insulate pulse transmi
- Mitocho → pro ergy for neurotra

**MUSCLE CELL** tracts to e vement.

- Contains protein laments → allow ion.
- Lots of mitochondria → release contraction.
- Stores glycogen → energy sourc mitochondria.

## CE SPECIALISATION (PLANTS)

**HAIR CELL** -Function: Absorbs water and minerals from soil.

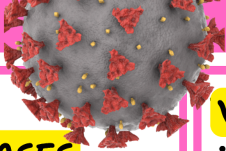
- Large surface area (root hairs) → increases water uptake.
- Thin cell wall → reduces diffusion distance.
- Large vacuole → maintains water movement.
- Mitochondria → provide energy for active transport of minerals.

**XYLEM CELL** -Function: Transports water and dissolved minerals from roots to leaves.

- Hollow (no organelles/cytoplasm) → free water movement.
- Walls thickened with lignin → provides strength and prevents collapse.
- End walls broken down → forms a continuous column of water.

**PHLOEM CELL** -Function: Transports sugars (from photosynthesis) around the plant.

- Joined end-to-end → forms continuous tubes.
- Sieve plates (holes in end walls) → allow easy flow of sugars.
- Few subcellular structures → reduces resistance to flow.
- Companion cells with mitochondria → provide energy for active transport.



## COMMUNICABLE (INFECTIOUS) DISEASES

- Caused by pathogens → transmissible (e.g. HIV, malaria, TB)

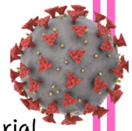
Pathogens include:

🔹 Bacteria → reproduce quickly → release toxins → damage tissue

🔹 Viruses → invade cells → replicate → burst cell → illness

🔹 Fungi → can produce spores → spread to others

🔹 Protists → often parasitic (live in host and cause damage)



**Transmission methods:**

- 🟢 Direct contact → touching skin/fluids/faeces/infected plant material
- 🟢 By water → dirty/contaminated water
- 🟢 By air → droplet infection (sneezing, coughing → inhaled)

### PREVENTING SPREAD OF DISEASE

🧼 Hygiene → wash hands, clean surfaces, cover sneezes

🍽️ Food hygiene → keep food cold, cook thoroughly, use clean utensils

🗑️ Waste disposal → cover bins, remove waste → stop flies (vectors)

🚽 Sanitation → safe water + sewage treatment

💉 Vaccination → triggers immune response → stops pathogen spreading

🪳 Destroy vectors → pesticides/insecticides remove habitats

# INFECTION & RESPONS

## VIRAL DISEASES

- Not living (no 7 life proces
  → no
  nucleus/cytoplasm/organ
- Reproduce rapidly → in
  DNA/RNA → host cell b
  viruses → cell bursts
  spread

### MEASLES

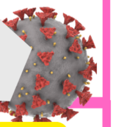
- Symptoms → fever + red rash → may cause blindness/brain damage
- Spread → droplet infection (cough/snee ery contagious
- Preventior childhood vacc

### HIV/AIDS

- Sympto virus
  attac
  bec d)
- Sp exual c ood
  ( , birth/bre ng
- on → condo
  lood, nc
  ugs
  st

### TOBACCO MOSAI

- ffects → plants (to
  tc.)
  oured
- contac
  p an stay in
  ~5C
- Preven ne + TMV-



## BACTERIAL DISEASES

- Bacterial pathogens → infect plar imals → produce toxins → da ells
- N bacteria rmful →
  mpete w nogens) →
  gest cel nake Vit K)
  h fission →
  ist + nutrient-
  rich

### SALMONELLA

- Symptor Fever + cramps +
  vomiti rrhoea (toxins
  irrita
  Spre
  ed/contaminated food
  eggs, chicken)
- on → UK chicken vaccin ted → Cook food thoroughly → Prevent raw meat cross-contamination → Hand + surface washing

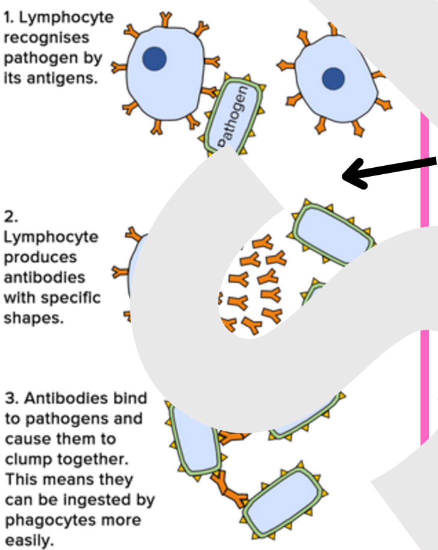
### GONORRHOEA

- Symptoms → Yellow/green discharge + pain urinating + possible infertility/blindness in babies
- Spread → Unprotected sex
- Prevention → Condoms → Antibiotics (some resistance) → Contact tracing & treatment

## FUNGAL DISEASES

### ROSE BLACK SPOT

- Symptoms → Purple/black spots on leaves → less photosynthesis → yellowing + early leaf drop
- Spread → Spores via winc
- Prevention → Use fungic
  Remove & burn infecte



## HU CE SYSTEMS

### NON-SPEC

- Skin → barrie cteria
- Nose → hairs + m thogens
- Trachea/Bronchi → cilia e mucus →
  estroy
- Stoma kills pathogens
- Gut/ natural flora outcompete
  path

### EM OVERVIEW

od cells (WBCs) → defend
athogens via:

- sis → WBC engulfs + digests
  p
- Ant ade by lymphocytes → bind to anti on pathogen surface) →
  e agg ination (clumping) →
  cytes digest
  ins → neutralise toxins (from
  )

### A ES & ANTITOXINS

- dies → Y-shaped → specific to 1
  gen → clump pathogens
  mory cells → quicker response if
  einfected
- Antitoxins → neutralise bacterial toxins

## PROTIST DISEASES

- Eukaryotic, mostly unicellular → few are pathogenic → spread via vector (e.g. mosquito) → infect host

### MALARIA OVERVIEW

- Cause → Protist from Plasmodium genus
- Spread → Female Anopheles mosquito (vector)
- Symptoms → Recurrent fever + shaking → due to bursting red blood cells → can be fatal
- Treatment → Antimalarial drugs (less effective due to resistance)
- Prevention →
- Insecticides in buildings → Insecticide-treated nets → Stop mosquito breeding (remove standing water) → Antimalarials for travellers

### MALARIA LIFE CYCLE

- Mosquito bites human → parasite enters liver → asexual reproduction → enters blood → infects RBCs → mosquito feeds again → sexual reproduction in mosquito

## PHOTOSYNTHESIS

- Plants = autotrophs → make own food using light, $CO_2$ + $H_2O$
- Producers in food chains
- Endothermic reaction → energy from environment → chloroplasts via light
- Takes place in mesophyll cells (contain chlorophyll)
- Glucose → used for respiration + to make plant substances
- Oxygen → by-product, used in respiration / diffuses out

### 🧪 EQUATIONS

Word:

- $CO_2 + H_2O \rightarrow$ (light + chlorophyll) → Glucose + $O_2$

Balanced symbol:

- $6CO_2 + 6H_2O \rightarrow$ (light + chlorophyll) → $C_6H_{12}O_6 + 6O_2$

### 🌿 REACTANTS: HOW THEY ENTER

- $H_2O$ → absorbed by roots → xylem → leaves
- $CO_2$ → diffuses in through stomata

## FACTORS AFFECTING PHOTOSYNTHESIS

### LIGHT INTENSITY

- ↑ light → ↑ rate (more energy another factor limits
- Graph: linear ↑ → plateau

### $CO_2$ CONCENTRATION

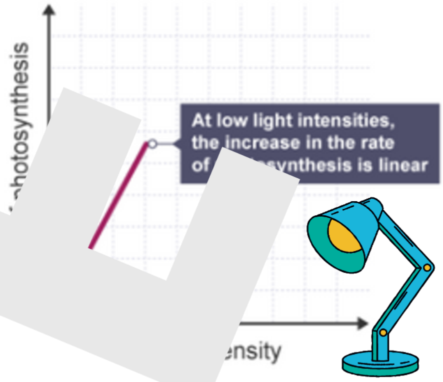
- ↑ $CO_2$ → ↑ rate (more raw material) → then levels off
- Graph: same pattern as light

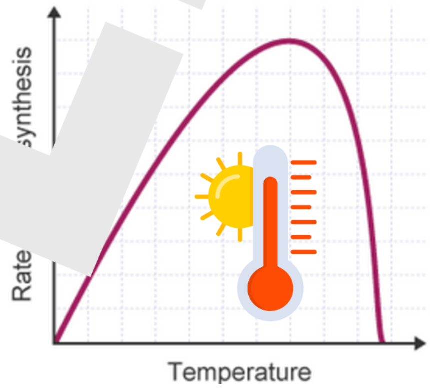
### TEMPERATURE

- ↑ temp → ↑ kinetic → ↑ rate
- Too high → enzymes denature
- Graph: curve wit peak

### CHLOROPHYLL

- More chlor faste
- ↓ chloroph e to dise $Mg^{2+}$, leaf loss) e





# BIOENERGETICS

## NS OF LIM TING FACTORS

tor can affect rate of photosynthesis.
cre sity, temp or $CO_2$ increases (until
ctor lim

### INVERSE LAW (HT ONLY)

- ate (more light ➜ more photosynthesis)
another factor becomes limiting

ight Intensity = 1 / Distance²
distance = 30cm ➜ Light intensity = 1/30² = 0.001 au
from lamp ➜ lower intensity

### 🏡 GROW GREENHOUSE

- Control lim factors to boost photosynthesis → increase yield →

ificial lighting, remove shades
raps heat, paraffin heaters
$CO_2$ → from heaters
Water → irrigation system
🦠 Pests/diseases → enclosed space, easier to manage
🧪 Nutrients → fertilisers
💸 Only increase factors until another becomes limiting → avoid wasting money

## REQUIRED PRACTICAL

**Aim** → Effect of light intensity on rate of photosynthesis (via oxygen production)

**Method:**

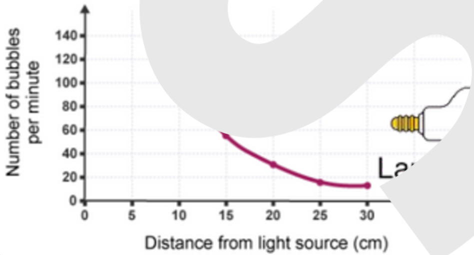
- → Pondweed in water → lamp a distance → count bubbles in 3 repeat at diff. distances → ca mean
- Variables
- → IV = Distance from lamp
- → DV = Bubbles/min
- → CVs = Temp (thermometer) → $CO_2$ ($NaHCO_3$) → same plant, time, volume of water

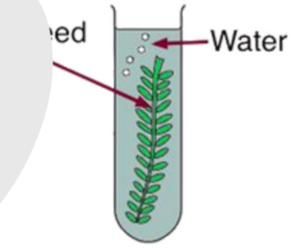
**Improvements**

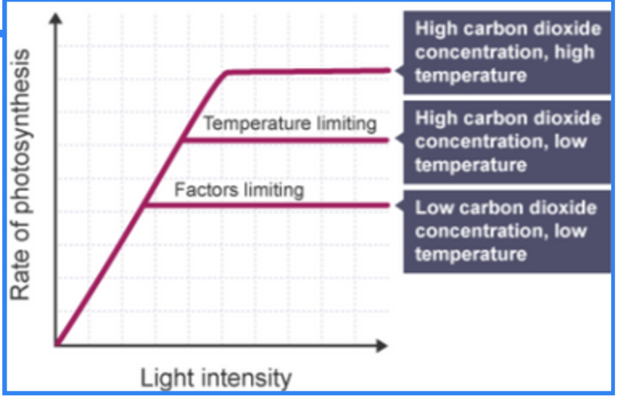
- → Use gas syringe
- → Repeat for accurac
- → Glass tank or LED to s changes

**Results**

- → Distance ↑ → light intensity ↓ bubbles/min ↓
- → Graph = ownwards
- → Suppor square law:
- Light y ∝ 1 / dis







# HOMEOSTASIS

= regulation of internal conditions → keeps conditions optimal for enzyme action and cell functions

- Controls:
- Blood glucose → Body temperature → Water levels

### CONTROL OF HOMEOSTASIS

- Involuntary (automatic) control → controlled by brain stem + spinal cord
- May involve: nervous or chemical responses
- Control system =
- Receptors (detect stimuli) → Coordination centres (brain/spinal cord/pancreas) → Effectors (muscles/glands bring response)

# ENDOCRINE SYSTEM

- Glands that secrete hormones directly into the bloodstream → hormones travel in blood → affect target organs.
- Compared to nervous system:
- Slower → longer-lasting effects.

### MAIN ENDOCRINE GLANDS & HORMONES:

- Pituitary gland → master gland → FSH, LH, TSH (stimulates other glands)
- Pancreas → insulin (↓ blood glucose)
- Thyroid → thyroxine (controls metabolism & growth)
- Adrenal glands → adrenaline (prepares body for action)
- Ovaries (females) → oestrogen (female sex hormone)
- Testes (males) → testosterone (male sex hormone)

### PITUITARY GLAND

- Master gland → releases hormones into blood in response to conditions
- → stimulates other glo (e.g. TSH → thyroid → thyroxine)
- Hormones only affect targe cells → must have complementary receptors
- Non-target cells = no effect

### HORMONE ACTION

- Process: Glar ituitary) → releases carried in blood → receptors on targe → causes a response

# HUMAN NERVOUS SYSTEM

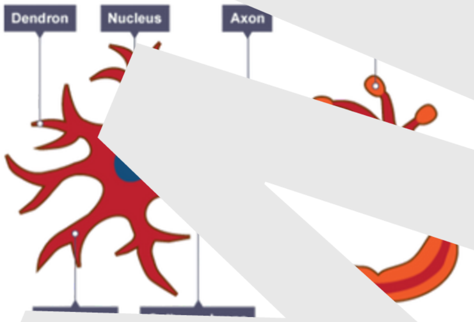
- CNS = brain + spinal cord
- PNS = all other nerves in body
- Info sent as electrical impulses → travel along neurones
- Bundle of neurones = nerve
- Enables responses to surroundings coordination of behaviour

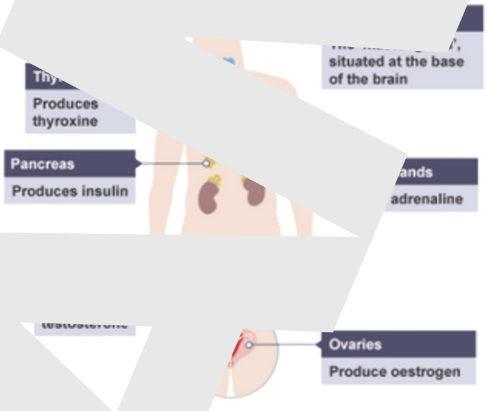
### ADAPTATIONS OF NEURONES

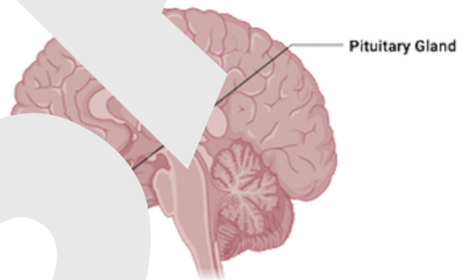
- Cell body → contains nucleus + organelles
- Axon + dendrites → extensions from cell body
- Long axons (up to 1m) → f ianal transfer, fewer synapses
- Myelin sheath → insulat impulse jumps between gaps (

### STRUCTURE OF THE NERVOUS SYSTEM

- Stimulus → receptor → effector → respons
- Receptor = detec change)
- CNS (brain + s rd) = coordinator
- Effectors = r ds → ca out respons







# FLEX ARC

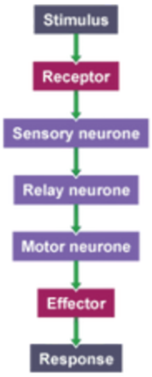
- omatic → Rapid → No nscious involvement nway:>>>>>

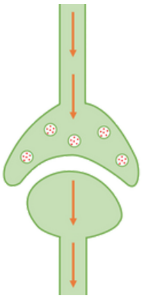
### NEURON

- ensor Cell bod eptor → C → Only in
- Mo nd → CNS →

### ⚡ SYNAPSES

- Gap between neurones → impulse can't c ses neurotransmi
- ps:
  - lse → release → Diffuse Bind to re impulse triggere rotransmitters destroyed/recycled
- 🧠 Only 1-way → avoids confusion
- 💊 Drugs affect synapses (e.g. heroin binds to receptors → overstimulation)


Stimulus
Receptor
Sensory neurone
Relay neurone
Motor neurone
Effector
Response



# IRED PRACTICAL

- → Investigate effect of a factor on man reaction time
- You will → Choose factor (e.g. caffeine, music) → Measure & compare reaction times

### ETHOD (RULER DROP)

- 👥 Work with a partner
- ✋ Person A holds out their hand, thumb + finger apart
- 📏 Person B holds ruler at 0 cm level with A's thumb
- ❗ Without warning, drop ruler → Person A catches it
- 📏 Record level ruler caught at → repeat ×10
- 🔁 Swap roles and repeat
- 📊 Use conversion table to find reaction time (ms) from distance (cm)
-
- Repeat → Calculate mean → Change 1 condition (IV) → Repeat
- Keep same: hand used → height of drop → ruler orientation → environment

### VARIABLES

- IV → Caffeine / Music / Age / Stress
- DV → Distance caught (converted to time)
- CV → Same hand → Same height → Same ruler → No prior caffeine/sound

INTERPRETING DATA

- Exclude anomalies (e.g. 573 ms)
- Correct mean = total of valid results ÷ number of results
- Lower time = faster reaction

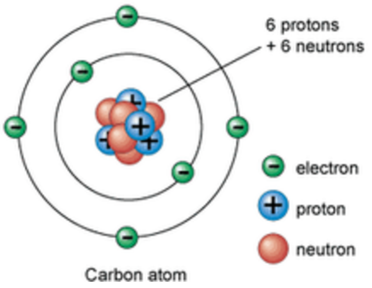
# HOMEOS ASIS & RESPONSE

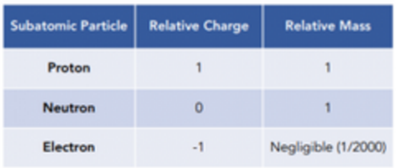
## ATOMS & ELEMENTS

- All substances → made of atoms (building blocks of matter)
- Atoms contain: protons (+1) / neutrons (0) / electrons (-1)
- Protons & neutrons in nucleus → most of atom's mass
- Electrons orbit nucleus in shells → tiny mass

### ATOMIC STRUCTURE

- Atomic number = no. of protons = no. of electrons (in neutral atom)
- Mass number = protons + neutrons
- To find neutrons → mass number – atomic number
- 🧠 Example:
- Sodium (Na): atomic number = 11 / mass number = 23 → neutrons = 23 – 11 = 12





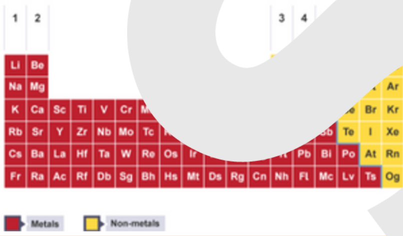
| Subatomic Particle | Relative Charge | Relative Mass |
|---|---|---|
| Proton | 1 | 1 |
| Neutron | 0 | 1 |
| Electron | -1 | Negligible (1/2000) |

### ELEMENTS & SYMBOLS

- Element = substance with only 1 type of atom → same no. of protons
- Atoms of same element → same atomic number
- Symbols → 1 or 2 letters (first = capital, second = lowercase)
- E.g. Carbon = C / Oxygen = O / Sodium = Na / Iron = Fe
- Some elements exist as molecules → $H_2$, $O_2$, $N_2$, $F_2$, $Cl_2$, $Br_2$, $I_2$

### PERIODIC TABLE BASICS

- Organises elements by
  number
- Groups (columns) → no. o
  electrons
- Periods (rows) → no. of electro
  shells
- Know names/symbols of first 20 elements
- Learn trends i
- Group 1 → alk
- Group 7 → h
- Group 0 →
  es



## COMPOUNDS

- Atoms react → fixed ratios → full out
  shells → new substances = compoun
- A compound = 2+ elements chemic
  combined → cannot be separated
  physical means
- Properties of compounds ≠ pro
  elements they're made from
- Chemical formula shows ratio of atom
- Example:
- $H_2O$ → 2 hydrogen, 1 oxygen
- $NH_3$ → 3 hydrogen, 1 nitrogen

### MOLECULE OF AMMONIA

- $NH_3$ = 1 nitrogen atom
  ed to 3 hydrogen atoms

### COMMON MISTAKE

- Elements = pure substan
  = also pure (NOT impure)

### NAMING COMPOUN
### + NON-METALS (Ionic)

- Metal named
- Non-metal
  endin
  oxygen is p
  '-ate')
- e.g. PbS =
  lphide | M
  magnesi
- $CuSO_4$
  sodium ca
- $NaNO_3$ = sodium
  $NaNO_2$ = sodium nitrite
- End
  ' = fewer oxygen
  '-

### NON-

- Use
  NO = ni
  oxide
  tetrachlor
- Some use com
  you must learn:
- $H_2SO_4$ = sulfuri
  = ammonia |
  =
  ames of
  $O_3$,
  tier

## HALF/ION
## IONS (HT)

electrons in a
reac
Repres
half the process:
or
s gains electrons (reduction)
pecies loses electrons
n)
s:
→ Pb (reduction)
- 2e⁻ (oxidation)

### IONIC E
### ONS

ow o
the ions that react in a
ion
e spectator ions (ions that don't
during the reaction)
uation:
NaOH → NaCl + $H_2O$
equation:
+ $OH^-$ → $H_2O$
$a^+$ and $Cl^-$ are spectator ions (present on both sides, unchanged)

## EQUATIONS

### WORD EQUATIONS

- E.g
  ium hydroxide + hydrochloric
  aci
  um chloride + water
- K
- ts = left
  oducts =
  e
- (→) = "f
  roduces"
  n be written

Exam

- $CO_2$ →
  oxygen
- $H_2SO_4$ → 2 hy
  en, 1 sulfur, 4 oxygen
- Ca(OH)
  lcium, 2 oxygen, 2 hydro
  ket applies to both O and H

### TIONS

cal formulae instead of full

- H (aq) + HCl (aq) → NaCl (aq) + $H_2O$ (l)
- Include state symbols: (s), (l), (g), (aq)
- Write non-metal molecules as pairs: $H_2$, $O_2$, $Cl_2$, etc.

### BALANCING EQUATIONS

- Atoms must be equal on both sides
- Balance by placing numbers in front of formulas (not changing subscripts!)
- Balance 1 element at a time → check → repeat

Word Equation:

- aluminium + copper(II) oxide → aluminium oxide + copper

Unbalanced Symbol Equation:

- Al + CuO → $Al_2O_3$ + Cu

Balanced Symbol Equation:

- 2Al + 3CuO → $Al_2O_3$ + 3Cu

1. Al: 2 on left, needed for $Al_2$
2. O: 3 on right (in $Al_2O_3$) → need 3 CuO
3. Cu: 3 on right to match CuO

Word Equation:

- magnesium oxide + nitric acid → magnesium nitrate + water
- Unbalanced Symbol Equation:
- MgO + $HNO_3$ → $Mg(NO_3)_2$ + $H_2O$
- Balanced Symbol Equation:
- MgO + $2HNO_3$ → $Mg(NO_3)_2$ + $H_2O$

Check:

- Reactants → 1Mg, 2H, $2NO_3$
- Products → 1Mg, 2H, $2NO_3$

✅ Balanced

**TIPS**

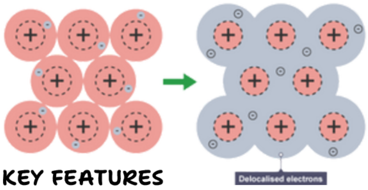
❌ Don't change small numbers in formulas (e.g. $H_2O$ → $H_2O_2$)

✅ Only change big numbers in front of substances

# ATOMIC STRUCTURE & PERIODIC TABLE

## METALLIC BONDING

- Metals form giant structures with atoms in a regular lattice.
- Outer shell electrons are lost → form positive metal ions.
- Delocalised electrons (free-moving) surround these ions.
- Metallic bonds = strong electrostatic forces between positive ions and delocalised electrons.
- Occurs in metals and alloys (mixtures of metals).
- This structure is often described as a "sea of electrons".



**KEY FEATURES**

- Electrons are not attached to specific atoms → move freely.
- Bonding is strong and acts in all directions.

Delocalised electrons allow:

- → Good electrical conductivity
- → Malleability (layers can slide)
- → High melting and boiling points (due to strong bonds)

## 3 STATES OF MATTER

Solids, liquids, gases

➤ Exist depending on temperature (and pressure)

➤ Change state at:

- Melting point: solid ⇌ liquid
- Boiling point: liquid ⇌ gas

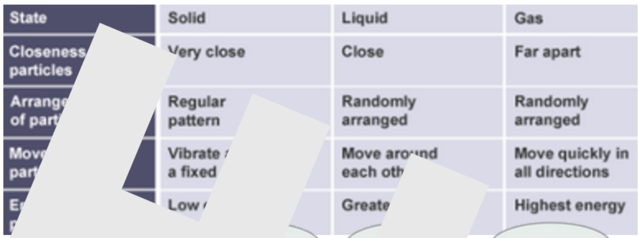
➤ Melting & freezing ⇨ m.p. | Boiling & condensing ⇨ b.p.

**CHANGES OF STATE (PHYSICAL)**

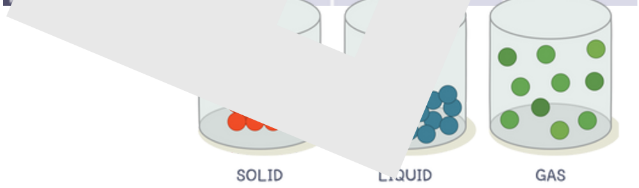
- Stronger forces → more energy needed → higher m.p. & b.p.
- Particles stay same – only arrangement/movement changes

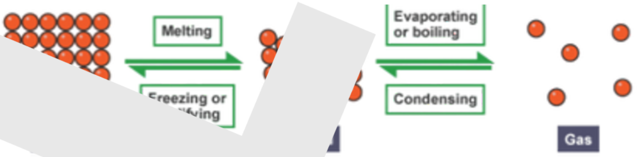
**STATE CHANGES SUMMARY**

- Melting → solid → liquid
  absorbed → ↑ KE → particles move
- Boiling → liquid → gas | Bubbles form inside liquid → g
  escapes
- Freezing → liquid
  Temp drops → pc
  op flowing
- Evaporation →
  gas | Surface only
  Faster if wa
- Condensation →
  Cooling → particles lo
  → form liquid
- Sublima
  lid → gas (e.g. iodine)
  desub



| State | Solid | Liquid | Gas |
|---|---|---|---|
| Closeness particles | Very close | Close | Far apart |
| Arrange of part | Regular pattern | Randomly arranged | Randomly arranged |
| Move part | Vibrate a fixed | Move around each oth | Move quickly in all directions |
| E | Low | Greate | Highest energy |





## TATES OF ER CONT.

**TATIONS OF PARTICLE THEORY**

es all particles are small, solid, inelastic spheres
esn't account for differences between atoms / ions
molecules / mixtures
gnores intermolecular forces between particles in different substances

**EDICTING PHYSICAL STATE**

melting point (mp) + boiling point (bp) →
at certain temp:

- → solid
- mp < bp → liquid
- Temp > p → gas

Example (25 °C):

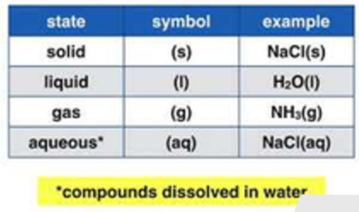
$O_2$: mp -219 °C, bp -183 °C → gas

$Br_2$: mp -7 °C, bp 59 °C → liquid

$N_2$: mp -210 °C, bp -196 °C → gas

## STATE SYMBOLS

- Show the physical state of a substance in an equation →
- (s) = solid | (l) = liquid | (g) = gas | (aq) = aqueous (dissolved in water)



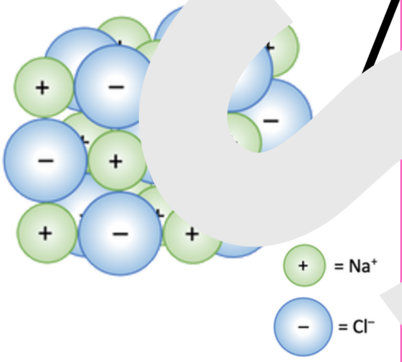
| state | symbol | example |
|---|---|---|
| solid | (s) | NaCl(s) |
| liquid | (l) | $H_2O(l)$ |
| gas | (g) | $NH_3(g)$ |
| aqueous* | (aq) | NaCl(aq) |

*compounds dissolved in water

- 🧪 Use in equations → p
  after formulas (e.g. H
  required in all chemical equations

📌 Example:

- $CuCO_3$ (s) + 2HCl (aq) → $CuCl_2$ (aq) + $CO_2$ (g) + $H_2O$ (l)



## IONIC CO DS

- Structure → Gian ce of oppositely charged gular 3D arrangement
- ling point → Due to str e number of bonds
- Charge & me ion charge = stronge er melting point
- e.g. $Mg^{2+}$ + $O^{2-}$ has stronge orces
- Solid → I in lattice → no movem conduction
- lte → Ions free to move arge → conducts
- or → Don't say "e e" → say "ions move and c"

**FORMULA COMPOUND**

tify io From the diagram
ross 3D lattice)
charges → Use the group
g. Group 1 → $1^+$, Group 6 →
2
3. B arges → Total positive =
ative → overall charge = 0

**EX $K_2O$**

up 1 → $1^+$ | O = Group 6 → $2^-$
2 $K^+$ to balance 1 $O^{2-}$ →
rmula: $K_2O$

## MALL MOLECULES

**ELTING & BOILING POINT OF SMALL MOLECULES**

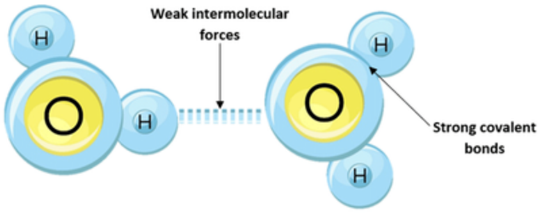
Small molecules = gases/liquids/solids with low m.p. & b.p.

- Strong covalent bonds (within molecules) → weak intermolecular forces (between molecules)
- e.g. $CO_2$, $CH_4$
- ➡ Weak intermolecular forces → low m.p./b.p. → require little energy to overcome
- ➡ Larger molecules → stronger intermolecular forces → higher m.p./b.p.
- Small covalent molecules = poor conductors (even when molten)
- ➡ No free ions/electrons to carry charge
- ➡ Most are insulators (e.g. plastic, rubber, wood)

**INTERMOLECULAR FORCES VS COVALENT BONDS**

- Covalent bonds → between atoms (strong)
- Intermolecular forces → between molecules (weak)
- ➡ When melting/boiling → intermolecular forces break, not covalent bonds
- ➡ Weak intermolecular forces = low m.p./b.p.

📌 When covalent molecules melt/boil, they do NOT split into atoms or new elements.



# ENERGY CHANGES

## ENERGY TRANSFER IN REACTIONS

- Energy is conserved → not created or destroyed, only transferred
- Measured with thermometer → indicates heat flow
- If energy released → products have less energy than reactants → exothermic
- If energy absorbed → products have more energy than reactants → endothermic

### EXOTHERMIC vs ENDOTHERMIC

- Exothermic → heat out → temp ↑ → e.g. combustion | neutralisation | respiration
- Endothermic → heat in → temp ↓ → e.g. thermal decomposition | photosynthesis | citric acid + $NaHCO_3$

### ENERGY FLOW SUMMARY

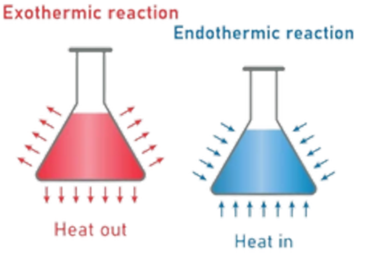
- Exothermic → surroundings get hotter → system energy ↓
- Endothermic → surroundings get cooler → system energy ↑

### EXAMPLES

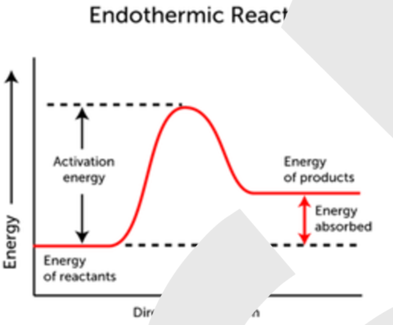
- Exothermic → self-heating cans | hand warmers
- Endothermic → cold packs

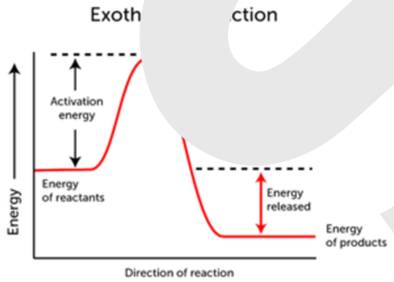
### TIP

- Use temperature change of surroundings to identify reaction type
- ↑ temp = exothermic | ↓ temp = endothermic



### REACTION PROFILES





## REQUIRED PRACTICAL: TEMP CHANGES

### OBJECTIVE

- → To investigate temperature change during neutralisation (HCl + NaOH)

### HYPOTHESIS

- → Temperature change depends on amount/concentration of reactants

### MATERIALS

- Dilute HCl → acid
- Dilute NaOH → alkali
- Styrofoam cup + lid → in
- Thermometer + stirrer
- 25 $cm^3$ measuring cylinder

### APPARATUS SET-UP

- Thermometer + stir
  through lid → in s
  holds reaction m
  prevents heat l

### METHOD

- Measure 25 dd t
  calorimeter
- Record initial tem
- Add 5 $cm^3$ HCl → stir →
  max ter
- Repeat ing volumes of
  HCl (
- Plot
  biggest

### RESULTS TABLE

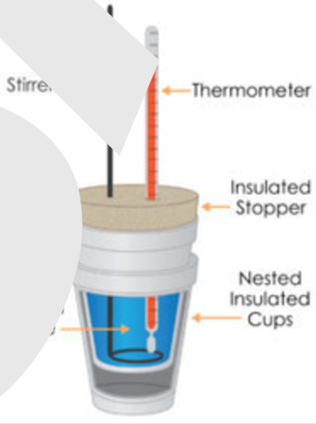
| Volume of acid ($cm^3$) | Te |
|---|---|
| | 19 |

### EVALUATION

- → Plot temp vs acid vo
  draw best fit line
  t

### CONCLUSIO

- → Bigg change = more
  erg erred
  s exothermic (temp



## REACTION PR

### ⚡ ACTIVATION ENERGY ($E_a$)

- Collision needed fo reaction → must have:
- Enough energy
- Correct orientati
  quent collisio
  n ene = minimum energy
  ction
- o start (more energy
  need
- $E_a$ shown as ergy rise at the start of a reaction profile

### ENERGY PROFILES

- Y-axis = energy | X-axis = progress of reaction
- Arrow shows overall energy change:
- 🔽 Exothermic → energy released (products have lower energy)
- Endothermic → energy absorbed (products
  gher energy)
- ce in height = overall energy change

## ENERGY CHANGE (BOND) (HT)

nd breaking → endothermic (energy in)

ond making → exothermic (energy out)

⚖️ Overall energy change = bond breaking − bond making

### 🔺 ENDOTHERMIC REACTIONS

- More energy absorbed than released → ΔH is positive
- Products have more energy than reactants

### 🔻 EXOTHERMIC REACTIONS

- More energy released than absorbed → ΔH is negative
- Products have less energy than reactants

### 🔗 BOND ENERGY CALCULATIONS

- Equation:

Energy change = Total energy in − Total energy out

Steps:

- Add all bond energies in reactants (breaking)
- Add all bond energies in products (making)
- Subtract: in − out

### 🧪 WORKED EXAMPLES

Example 1 - Reaction: $H_2 + Cl_2 \rightarrow 2HCl$

- Break: H–H (436) + Cl–Cl (242) = 678 kJ
- Make: 2 × H–Cl (431) = 862 kJ
- ΔE = 678 − 862 = −184 kJ → Exothermic

Example 2 -Reaction: $2HBr \rightarrow H_2 + Br_2$

- Bonds broken: 2 × H–Br = 732
- Bonds formed: H–H = 436, Br–Br = 193 → Total out = 629
- 732 − 629 = +103 kJ → Endothermic

### 🧠 TIP

- ✅ State whether overall energy change is + (endothermic) or − (exothermic)
- ✅ Use the word "energy is released/absorbed"

# RATE & EXTENT OF CHEMICAL CHANGE

## CALCULATING RATES OF REACTION

- Depends on: type of chemicals / physical state / temperature / concentration / catalysts.
- Measured by how fast → reactant used up / product formed.

### CALCULATING RATE

Rate =

- → amount of reactant used ÷ time taken
- → amount of product made ÷ time taken

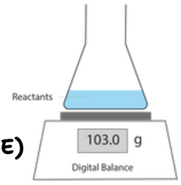
Units:

- → g/s (mass)
- → $cm^3$/s or $dm^3$/s (gas volume)

### METHODS TO MEASURE RATE

### 1. MASS LOSS (GAS RELEASED)

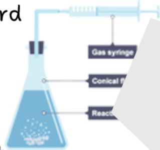
- Mass recorded every few seconds using a balance.
- E.g. $CaCO_3 + HCl \rightarrow CO_2$



✅ Pros: very accurate
❌ Cons: gas escapes to air

### 2. GAS COLLECTION (VOLUME)

- Gas volume collected in:
- → measuring cylinder (downward displacement)
- → gas syringe
- E.g. $Mg + HCl \rightarrow H_2$
- Volume recorded over time



✅Pros: accurate, allows graph plotting
❌Cons: syringe can pop off if vigorous

### 3. PRECIPITATION (CLOUDY MIXTURE)

- Precipitate clouds solution → marks (e.g. cross) disappear
- E.g. sodium thiosulfate + HCl → sul
- Time how long cross disappears

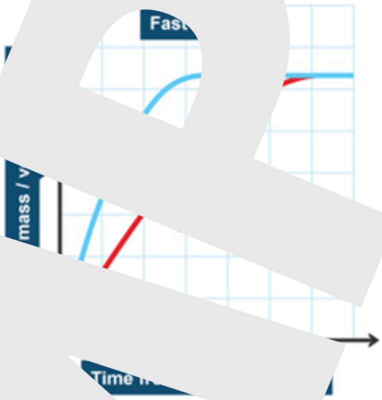
✅Pros: simple setup
❌Cons: subjective / only one data point / possible

## RATE GRAPHS

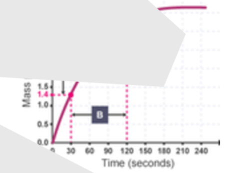
- Y-axis → Product f Reactant used
- X-axis → Time
- Steep line → Fast rate | Fla → Reaction complete
- More product at end → More reactants used

### GRAPH SHA ES

- Product → Positive curve (steep
- Reacta ve (steep fall the
- Initial rate → Straig origin
- St er reaction



**M E FROM GRA**
Mea ange in y / change in x betw oints



## TORS FECTING TE OF TION

ncentrati cions) / (ac

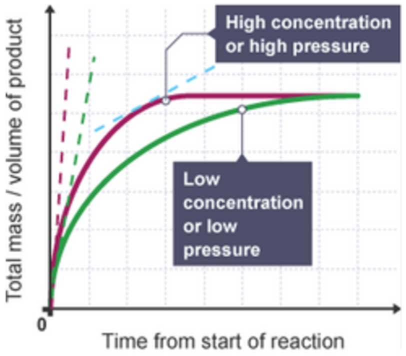
lids)
→ Cat ce
🧠 Higher ra faster product formation / faster reactant use

### 📈 G GRAPH PATTERN FOR RA GES

- ors below:
  eper gradient = faster rate
  rizontal sooner = reaction hes quicker
  Same final product amount

### CONCENTRATION / PRESSURE

- ⬆ Concentration/Pressure = more particles per $cm^3$→ ⬆ Frequency of collisions → ⬆ Rate



### TEMPERATURE

⬆ Temp → ⬆ Particle kinetic energy
→ ⬆ Frequency + Energy of collisions
→ ⬆ Rate

### SURFACE AREA

⬆ Surface area (e.g. powder not lumps) → ⬆ Area exposed → ⬆ Collision frequency → ⬆ Rate
🧮 Cube cut into smaller cubes = larger total surface area

### CATALYST

Catalyst → Provides alternative pathway with lower activation energy
→ More particles have enough energy to react
→ Reaction speeds up, catalyst remains unchanged
Graph: Same final amount, steeper initial slope

### 💡TIPS

✅ Always mention collision frequency/energy
✅ Use graph comparisons: gradient + final plateau
✅ State particles per unit volume for concentration/pressure questions
✅ Explain surface area as smaller particle size

## REACTION RATES USING MOLES

- Often more useful in m
- No direct way to mea moles → must convert mass/volume to moles

### TO CONVERT TO MOL/S

- Mass per unit time ÷ Molar mass = Moles per unit time
- Volume per unit time ÷ 24,000 $cm^3$/mol = Mol r unit time

### EXAMPLE

- Q: 6.0 g n 2.5 min. What's t in mol/s?

1. Time to s
   - 2.5 min
2. Mass to m
   - Moles = m 44.0 = 0.137 m
3. Rate = moles ÷ time:
   - Rate = 0.137 ÷ 150 = 9.1 × $10^{-4}$ mol/s

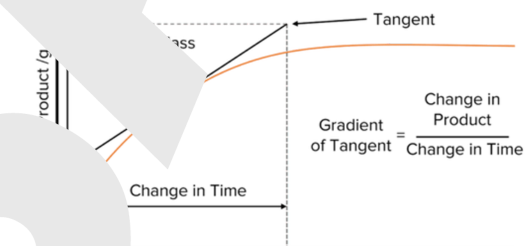
## CALCULATING G IENTS (HT)

### T (USING A

ne touching curve only

- Choos ar points on the tangent → meas ge in y (product/amount) and x

change in y / change in x



Apr la:

- radient) = ΔProduct ÷ ΔTime

the difference between mean rate (overall e ÷ time) and instantaneous rate (tangent dient at one point).

# CRUDE OIL, HYDROCARBONS & ALKANES

- Organic Chemistry: Chemistry of carbon compounds.
- Hydrocarbons: Compounds made of carbon and hydrogen only.

### TYPES OF FORMULAE

- General Formula: Shows the composition of any member of a homologous series (e.g. Alkanes: $C_nH_{2n+2}$).
- Displayed Formula: Shows all the atoms and bonds in a molecule.
- Molecular Formula: Shows the actual number of each atom in a molecule (e.g. Butane: $C_4H_{10}$).
- Structural Formula: Shows the structure without displaying all bonds (e.g. Pentane: $CH_3(CH_2)_3CH_3$).

### HOMOLOGOUS SERIES

Characteristics:

- Same functional group.
- Same general formula.
- Similar chemical properties.
- Each member differs by $-CH_2-$.
- Gradually changing physical properties (e.g. boiling point, density).

### CRUDE OIL

A complex mixture of hydrocarbons.

- Formation: From biomass (plants/animals) over millions of years under high pressure and temperature.
- Finite Resource: Formed much slower than it is used.

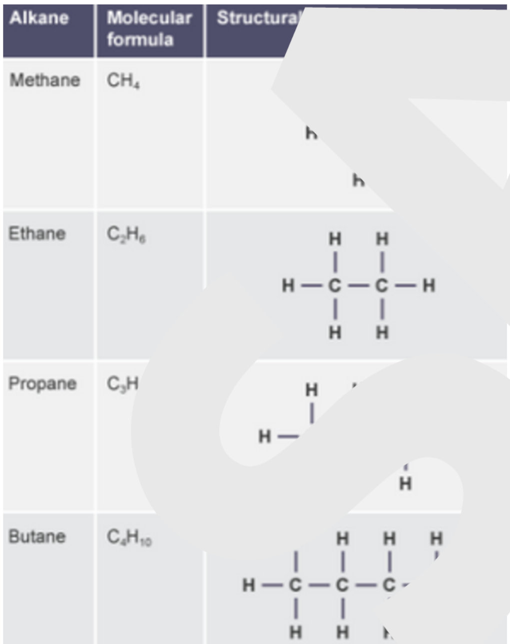
### ALKANES

Saturated Hydrocarbons:

- Single C–C bonds only.
- General Formula: $C_nH_{2n+2}$.
- Unreactive but undergo combustio

First Four Alkanes:

- Methane: $CH_4$ (gas)
- Ethane: $C_2H_6$ (gas)
- Propane: $C_3H_8$ (gas)
- Butane: $C_4H_{10}$ (gas)



| Alkane | Molecular formula | Structura |
|---|---|---|
| Methane | $CH_4$ | |
| Ethane | $C_2H_6$ | |
| Propane | $C_3H$ | |
| Butane | $C_4H_{10}$ | |

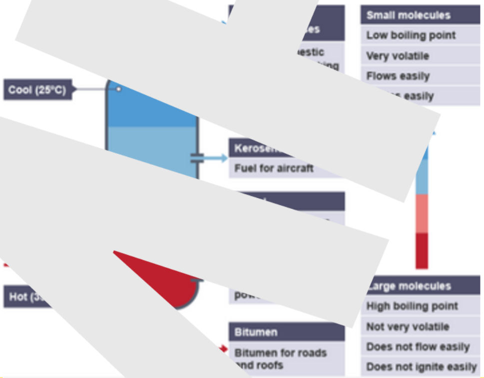
# FRACTIONAL DISTIL TION & PETROCHEMICAL

- Crude oil is a mixture of diff hydrocarbons, separated b nal distillation.
- Fractions have similar c nd similar boiling points.
- Larger molecules have high condense at the bottom.
- Smaller molecules have lower boiling poi condense at the top.
- Most fractions are alkanes (single bonds).

### HOW FRACTIONA DISTILLATION WORKS

- Crude oil is h pourises → enters fractionatin
- Column has /hot at the bottom, cool a
- Vapours rise, cool and con reach their ints.
- Larger her b.p.) cond lower
- Sma b.p.) condense hig

### CRU FRACTION



HEMISTRY

6
C
12.01
Carbon

# PROPERTIES OF HYDROCARBONS

### NDS IN PHYSICAL ERTIES

- Depend o ule size | Viscosity flow) | Flamma se of burning) | Colour ness of burn | as fuels

### T

- In with molecule size | Stronger intermolecular forces ed more energy to overcome

### Y

- of flow | High viscosity = k, flows less easily | creases with chain length more intermolecular forces) | Long-chain hydrocarbons used as lubricants to reduce friction

### FLAMMABILITY

- Smaller hydrocarbons | More flammable, ignite easily | Release more energy when burned

### COMBUSTION OF HYDROCARBONS

- Burn in air to form water and carbon dioxide | Oxidation: Hydrogen → water | Carbon → carbon dioxide

Examples:

- Methane: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
- Octane (Petrol): $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

### TIP:

- Balance elements in order: Carbon | Hydrogen | Oxygen | If oxygen is a fraction, multiply all coefficients by 2

# CRAC DROCARBONS & ALKENES

- Cracking → Co rts long-chain hydrocarbons (low demand) to short-chain igh demand).
- d: Supply = production from crude oil | Demand = customer chains (e.g. petrol, kerosene) have high demand | Long chains fuel oil) have low demand.

### OF CRACKING

- atalytic Cracking: Heat to 470 - 550ºC → Vapourise → Pass over hot catalyst (e.g. aluminium oxide) → Thermal decomposition.
- Thermal Cracking: Higher temperatures and pressures → Produces more lkenes → Involves steam and heat.

### TS OF CRACKING

- anes (saturated, single bonds) + Alkenes (unsaturated, double bonds).
- ample: Decane ($C_{10}H_{22}$) → Octane ($C_8H_{18}$) + Ethene ($C_2H_4$).

### VRITING EQUATIONS FOR CRACKING

- Atoms on each side must balance (Law of Conservation of Mass).
- Example: $C_{20}H_{42} \rightarrow C_{18}H_{38} + C_2H_4$ | Unknown product is an alkane ($CnH_2n+_2$).

**ALKENES** -Homologous series with at least one C=C double bond.

- General formula: $CnH_2n$ | More reactive than alkanes | Used in polymers and as starting materials.

**TEST FOR ALKENES** - Bromine water test → Alkane: Stays orange (no reaction) | Alkene: Decolourises (reaction with double bond).

# ENERGY

## ENERGY STORES & SYSTEMS

A system is an object or group of objects.

- Energy within a system can change when the system changes.

Systems can be:

- Open ➔ Energy and matter can enter or leave.
- Closed ➔ Only energy can enter or leave.
- Isolated ➔ Neither energy nor matter can enter or leave.

### ⚡ ENERGY STORES

- Energy is stored in different ways depending on the object's state:

1. Kinetic ➔ Moving objects
2. Gravitational Potential ➔ Raised objects in a gravitational field
3. Elastic Potential ➔ Stretched or compressed objects
4. Thermal ➔ Hot objects
5. Chemical ➔ Stored in fuels, food, batteries
6. Magnetic ➔ Interacting magnets or magnetic materials
7. Electrostatic ➔ Interacting electric charges
8. Nuclear ➔ Energy within atomic nuclei

### 🔄 ENERGY TRANSFER PATHWAYS

Energy is transferred between stores through:

- Mechanically ➔ By a force doing work (e.g. pushing, pulling)
- Electrically ➔ By a moving charge (e.g. in circuits)
- Heating (by particles) ➔ From hott[illegible] cooler objects (conduction)
- Heating (by radiation) ➔ By electromagnetic waves (e.g. light, infrared)

### ⚡ ENERGY TRANSFER EXAMPLES

🏐 OBJECT PROJECTED UPWARDS

Chemical store (muscles) ➔ Kinetic store (moving ball) ➔ Gravitational potential store (height increases)

🚗 MOVING OBJECT HITT[illegible] OBSTACLE

Chemical store (fuel) ➔ Kineti[illegible] (moving car) ➔ Thermal store (w[illegible] surroundings, dissipated)

- Also: Friction ➔ thermal (air, ground[illegible] Sound ➔ air vibrations

🚙 VEHICLE ACCE[illegible]NG

Chemical store[illegible] kinetic store (speeding up)

🚗 VEHICLE [illegible]G DOWN

Kinetic stor[illegible] car[illegible] (brakes, grou[illegible]

- Also: Frictio[illegible] d ➔ air vibrations

💧 BOILING WATER IN A KETTLE

Electrical store (mains) ➔ Thermal [illegible] (heating element) ➔ Thermal store (w[illegible]

## KINETIC ENERGY ($E_k$)

- Energy an object has due to it[illegible] mass and speed.

Energy Transfer:

- Speeds up ➔ energy transferred to kinetic stor[illegible]
- Slows down ➔ energy transferred away from ki[illegible] store

### 📝 EQUATION:

- $E_k = 1/2 \times m \times v^2$
- $E_k$ = Kinetic energy (Joules, J)
- m = Mass (kilograms, kg)
- v = Speed (metr[illegible] second, m/s)

### 🔍 EXAMPLE CALCU[illegible]

Car travelling (2500 kg) a[illegible] m/s:

- $E_k = 1/2 \times$ [illegible] 500,000[illegible]

Apple fallir[illegible]

- $E_k = 1$[illegible] × 6[illegible]

### 📝 TIP:

- Sq[illegible]ed ➔ C[illegible] m[illegible]p.
- Rea[illegible] a key skill i[illegible] regularly.

## E[illegible]TIAL E[illegible]

- En[illegible]d in an[illegible] objec[illegible]k is done to stretch[illegible] it.

Transfer:

[illegible]

[illegible]ased ➔ Energy transferred [illegible]m elastic potential

### 📝 EQUA[illegible]

- $E_e = 1/2 \times$ [illegible]
- $E_e$ = Elastic pot[illegible]l energy
- [illegible]nt (Newtons [illegible]
- [illegible]ension (metres, m)

### [illegible]PLE CALCULATIONS:

[illegible]ng (3 N/m) stretched by [illegible] m:

$E_e = 1/2 \times 3 \times 0.5^2 = 0.375$ J

[illegible]ing (5 N/m) compressed by [illegible]

[illegible]$2 \times 5 \times 0.2^2 = 0.1$ J

- [illegible] (250 N/m) extended by 0.[illegible]4 m:

$E_e = 1/2 \times 250 \times 0.014^2 = 0.025$ J (2 s.f.)

### [illegible]IP:

- Convert to metres if given in cm.
- Make sure the spring has not exceeded its limit of proportionality for this equation to be valid.

## GRAVITATIONAL POTENTIAL ENERGY ($E_p$)

Energy [illegible]n an object due to its height [illegible]vitational field.

Energy T[illegible]

- Lifte[illegible] Energy tr[illegible]d to [illegible]al potent[illegible]
- [illegible] Energ[illegible]erred away [illegible]al store

### 📝 EQUATIO[illegible]

- $E_p = m \times g \times h$
- $E_p$ = Gravitational potential energy (Joules, J)
- m = Mass ([illegible]s, kg)
- g = Gravit[illegible]ield strength (Newtons per kilog[illegible]g)
- [illegible]es, m)

### [illegible]AL FIELD STRENGTH:

- [illegible]kg
- Moon: [illegible]/kg (less than Earth ➔ easier to lift)
- Gas Giants (e.g. Jupiter): ~25 N/kg (more than Earth ➔ harder to lift)

### 🔍 EXAMPLE CALCULATIONS:

- Man (70 kg) climbing 3 m stairs (g = 9.8 N/kg):
  - $E_p = 70 \times 9.8 \times 3 = 2058$ J
- [illegible]annonball (5 kg) lifted 56 m (g = 10 N/kg):
  - $E_p = 5 \times 10 \times 56 = 2800$ J
- Book (0.5 kg) lifted 1.5 m (g = 10 N/kg):
  - $E_p = 0.5 \times 10 \times 1.5 = 7.5$ J

### 📝 TIP:

- Use g = 9.8 N/kg unless stated otherwise.
- Remember to convert mass to kg if given in grams.

## THERMAL ENERGY (ΔE)

Energy in the thermal store of an object, related to its temperature.

### 📝 SPECIFIC HEAT CAPACITY (c)

The amount of energy needed to raise the temperature of 1 kg of a substance by 1°C.

- Low Specific Heat Capacity: Heats up and cools down quickly (e.g. copper, 390 J/kg°C).
- High Specific Heat Capacity: Heats up and cools down slowly (e.g. water, 4200 J/kg°C).

### 📝 EQUATION:

- $\Delta E = m \times c \times \Delta\theta$
- ΔE = Change in thermal energy (Joules, J)
- m = Mass (kilograms, kg)
- c = Specific heat capacity (J/kg°C)
- Δθ = Temperature change (degrees Celsius, °C)

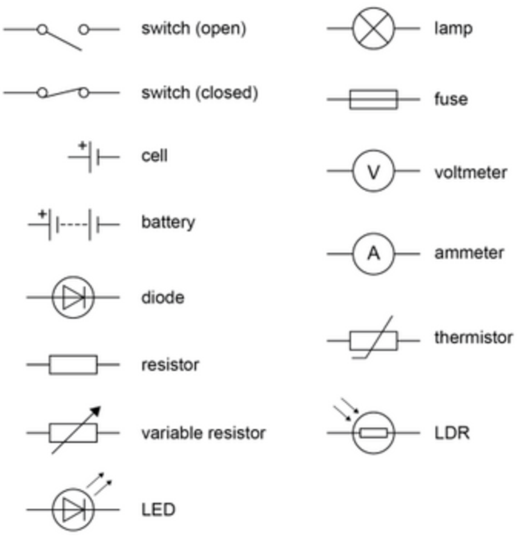
### 📝 EXAMPLE CALCULATION:

- Heat 2.00 kg of water from 10°C to 100°C (c = 4200 J/kg°C):
- Δθ = 100 - 10 = 90°C
- $\Delta E = 2.00 \times 4200 \times 90 = 756{,}000$ J

📝 **TIP:** Units Matter: Always check that mass is in kg and temp. change is in °C.

- You do not need to memorise specific heat capacity values, they will be given in exams.

## CIRCUIT DIAGRAMS



- Cell/Battery: Provides potential difference (battery = 2 or more cells)
- Switch: Turns circuit on (closed) or off (open)
- Fixed Resistor: Limits current, fixed resistance
- Variable Resistor: Adjusts resistance (e.g., volume controls, dimmer switches)
- Thermistor: Resistance changes with temperature (↓ temp = ↑ resistance)
- LDR: Resistance changes with light intensity (↓ light = ↑ resistance)
- Diode: Current flows in one direction only (used for AC to DC conversion)
- LED: Emits light when current passes throu (e.g., indicators)
- Ammeter: Measures current (connected in series)
- Voltmeter: Measures potential difference (connected in parallel)

## REQUIRED PRACTICAL

**⚙️ EQUIPMENT LIST**

- Power Supply → Source of potentia
- Wires → Connect all components in the
- Crocodile Clips → Connect different lengths o resistance wire
- Ammeter → Measure current (A)
- Voltmeter → Measure potential difference (V)
- Thin Resistance Wire → Measure resistance at different lengths
- Metre Ruler → Measur

**EFFECT OF WIRE LENGTH O NCE**

**🔍 VARIABLES**

- Independent → Length of wir
- Dependent → Resistance (R)
- Control → Potential difference of p supply, wire temperature

**📝 METHOD**

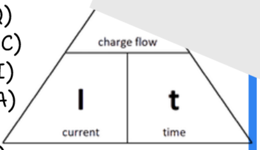
1. Set up the c power supply, ammeter, voltmeter stance wire.
2. Attach o dile clip at at a chos h (e.g. 10
3. Record t tial di current (
4. Move the s along the (e.g. 20 cm, epeat measur
5. Calculate resistance using R = V / I f length.
6. Plot a graph of resistance (y-ax wire length (x-axis).

## CHARGE & CURREN

**⚡ CURRENT AND CHARGE**

- Current = Flow of elect charge
- Measured in amperes g an ammeter

Formula: Q = I × t



- Charge (Q)

in coulombs (C)

- Current (I)

in amperes (A)

- Time (t)

in seconds (s)

**📝 WORKED E LE (CHARGE)**

- A current through a wire f charge flows

Step 1: Write down the quantities

- Curre
- Tin

Step

Ste ostitute th

- × 200 = 6

**CE (V**

- The e unit charge acro Measured in volts r (connected in

s

- (W) in joul
- C coulombs (C)

**E)**

- used to move 80 C of charge through a cuit, what is the potential ce?

wn the known qu

- Wor = 400 J
- Charge ( 0 C

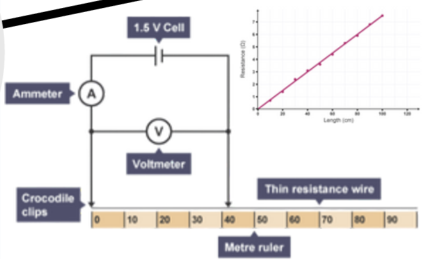
ormula

ute the values

80 = 5 V

**CONVENTIONAL CURRENT ND ELECTRON FLOW**

- Conventional current flows from positive to negative ➡️
- Electron flow (actual flow) is from negative to positive ⬅️
- urrent is the same at all points in a closed loop (e.g. a series circuit)

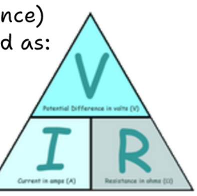


## CURRENT, RESISTANCE & POTENTIAL DI ENCE

- stance - ition to t ol: R. Me n Ohms (Ω) = 1 volt pere (1 V / A) ugh a s on its the potential differen ross it.
- High resistanc = Low current (e.g., thin, l g wires, insulators)
- Low ce = High current (e.g., thic wires, good co )

R (Potential difference = × Resistance)

- e rearranged as:
- I = V / R
- R = V / I



**WORKED EXAMPLES**

📝 Example 1:

- Problem: A resistor of 10 Ω has a current of 0.3 A flowing through it. What is the potential difference?

Calculation:

- V = I × R
- V = 0.3 × 10 = 3 V

📝 Example 2:

- Problem: A voltmeter reads 6.0 V and the resistor is 4.0 Ω. What is the current through the circuit?
- Calculation:
- I = V / R

**TIP**⚠️ Voltage and potential difference are the same thing - both are measured in volts (V).

# ELECTRICITY

## PRACTICAL CONT.

**📊 ANALYSIS OF RESULTS**

- The graph should be a straight line through the origin → resistance is directly proportional to wire length.
- Longer wires have higher resistance as electrons collide more frequently with metal ions.

**🔧 EVALUATING THE EXPERIMENT**

- Systematic Errors → Ensure crocodile clip is at 0 cm to avoid zero error | Check meters start at 0
- Random Errors → Use low currents to avoid heating the wire | Allow wire to cool between readings | Repeat for reliable results

**⚠️ SAFETY CONSIDERATIONS**

- Avoid touching live wires – risk of burns if wire overheats
- Turn off power if burning is detected
- Keep liquids away from the equipment

# PARTICLE M DEL OF ER

## DENSITY

- Density = mass per unit volume

Formula → ρ = m / V

- ρ = density (kg/$m^3$) | m = mass (kg) | V = volume ($m^3$)

Key Points

- Low density → small mass in large volume | High density → large mass in small volume

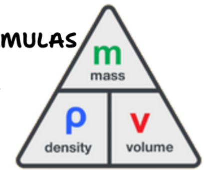
E.g. feathers vs lead (same volume) | air balloon vs metal bar (same volume)

- Gases < Liquids < Solids (in density) → particles are more spread out in gases
- Ice is less dense than water (unusual!) 🧊

Unit Conversions

- g/$cm^3$ to kg/$m^3$ → ×1000
- kg/$m^3$ to g/$cm^3$ → ÷1000
- 1 $cm^3$ = 1 × $10^{-6}$ $m^3$

**DENSITY FORMULAS**



Rearranged:

- m = ρ × V
- V = m ÷ ρ

To calculate volume (when not given):

- ➤ Cube = $d^3$
- ➤ Cylinder = $\pi r^2 l$
- ➤ Sphere = $(4/3)\pi r^3$

**APPROX. DENSITIES (kg/$m^3$):**

Air → 1.3
Wood → 300 to 800 (varies)
Water 💧 → 1000
Granite (stone) → 2700

- 💡 If density > 1000 kg/$m^3$ → sinks in water
- 💡 If density < 1000 kg/$m^3$ → floats in water

**EXAMPLE** 🧪

- A metal block has:
- m = 73 kg | dimensions = 0.85 × 0.5 × 0.04 m
- V = 0.017 $m^3$
- ρ = 73 ÷ 0.017 = 4294 → rounded = 4300 kg/$m^3$

**TIPS** 🎯

- Use formula triangle fo rearranging → cover the variable you want

Don't confuse:

- ✦ Mass = amount of matter (kg)
- ✦ Weight = force due to gravity (N)
- ✦ Density = lume (kg/$m^3$)

Visualise:

- ✦ More in less space = ensity
- ✦ Compr Expanding
- Common mis up $cm^3$ & $m^3$ → convert properly
- In state change questions: mass stays the same, even if volume or pressure changes

## SOLIDS, LIQUIDS & GASES

**THE PARTICLE MODEL**

All matter is made of tiny particles called atoms

- Explains:
- → States of matter (solid, liquid, gas)
- → Physical properties e.g. density

**SOLIDS**

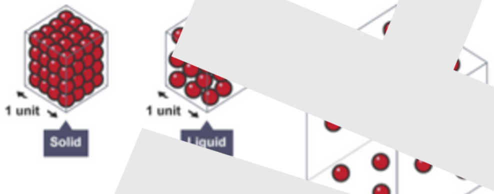
➡️ Particles: closely packed 🔒 | vibrate only | strong forces
➡️ Properties: fixed shape & volume | highest density

**LIQUIDS**

➡️ Particles: still close but irr past each other ↔️ | weaker
➡️ Properties: flows, takes contai fixed volume | medium density

**GASES**

➡️ Particles: far apart randomly | almost no
➡️ Properties: no fixe or volu easily compressible density



**PARTICLE ENER NGEM**

Solids → high density arrangemen low energy
Liquids → medium density ar
G |
in place | Liquids move past
e move in all directions

## CHANGES OF

- Physical change → reversi ame

r of particles earranged

Melting – Liquid
ling/E on – Liquid → Gas
olid → Gas

- quid → Solid
- C Gas → Liquid

▯ Energ red to break bonds (heating) to form bonds (cooling).

**MISC EPTIONS**

don't break apart → only es do that
❌ M ot change – unless a gas escape tainer.
✅ Alw to the same substance in a differ (e.g., ice, water, steam = $H_2O$).

## REQUIRED PRACTICAL

**🧪 PRACTICAL GULARLY SHAPED OBJECTS**

Steps:

→ digital balance
ensions → ruler / caliper /
olume using formula (e.g. V = l × w × h)
Convert to SI units (kg, $m^3$)
Use ρ = m ÷ V

Variables:

- IV = Shape / volume → DV = Mass

**🧪 PRACTICAL 2 – IRREGULARLY SHAPED OBJECTS**

Steps:

Measure mass
Fill Eureka can to just below spout
Place empty measuring cylinder under spout
Lower object → collect displaced water
Volume of water = volume of object
Use ρ = m ÷ V

Variables:

- IV = Object shape/mass → DV = Volume of displaced water

**🧪 PRACTICAL 3 – LIQUIDS**

Steps:

Place empty cylinder on balance → record mass
Add known volume of liquid → record new mass
Subtract to find mass of liquid
Use ρ = m ÷ V

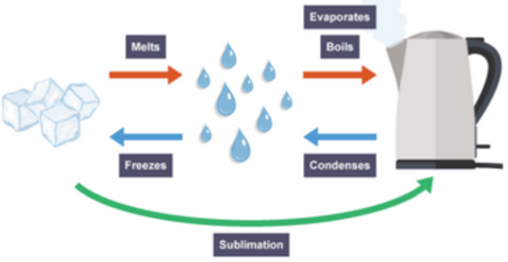
Variables:

- IV = Volume of liquid → DV = Mass of cylinder

📉 ERRORS

Systematic:
❌ Balance not zeroed → ✓ Always zero before use

Random:
❌ Inaccurate length readings → ✓ Take repeats & average
❌ Splashing from Eureka can → ✓ Lower object carefully



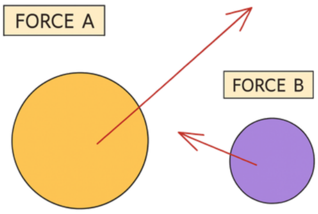
## SCALARS & VECTORS

- Scalars → have magnitude only (e.g. speed, distance, mass)
- Vectors → have magnitude & direction (e.g. velocity, displacement, force)

Key comparisons
- Speed ⇔ Velocity | Distance ⇔ Displacement | Mass ⇔ Weight
- → Scalars = no direction | Vectors = include direction

### VECTOR REPRESENTATION

- Vector shown as an arrow →
- Length = magnitude | Direction = direction of quantity
- E.g. Force A > Force B in magnitude | A points up-right, B points up-left



### SCALAR VS VECTOR CONFUSION

- Displacement < Distance (displacement = straight line, distance = total path)
- Velocity ≠ Speed (same speed, different direction = different velocity)

### RESULTANT FORCE – SAME DIRECTION

- Forces add if in same direction →
- E.g. 2 N + 3 N → Resultant = 5 N (same direction)

# FORCE

## RESULTANT FORCES

- Resultant force = single overall force from combining all individual forces on a body

Also known as → net force or unbalanced force

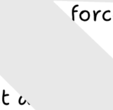
Balanced Forces:
- → Equal and opposite
- e.g. weight down = nor force up → resultant force = 0

Unbalanced Forces:
- → Forces don't cancel → object in direction of larger force
- e.g. Person A pulls 80 N left, Person 100 N right → re ltant = 20 N right

### CALCULATING T FORCE:

- Same dire d forces
- Opposite s → subtra
- If equal osite → r (balance
- Always s ion (e. N to the ri

### FREE BODY DIAGRA



- Show all forces on an object
- Each force = arrow (→) scaled e → labelled → shows direction

## CONTACT & NON-CONTACT FORCES

- A force = a push or pull interaction with anothe

### TYPES OF FORCES

- 🔹 Contact = objects → e.g. friction, tension, ai resistance, reaction force
- 🔹 Non-contact = no contact needed → e.g. gravity, electrostatic, magnetic

### EFFECTS OF FOR

- Forces can peed | direction |

### EXAMPLES OF CHAN

- Thrust → changes spee
- Gravita ction → chan
- Co hape

### CONT RCE SUM

- → opposes rub)
- → f n air
- strin
- Reaction surface (normal

### RCE SUMMAR

ive force

tati

/repulsive

ch

- Mag active/repulsive betwee

### TON'S

hen two objects interact → they ual and opposite forces on

- (gravitational) | Cha contact)

### AVOID COMMO MISTAKES

ity" → use raction nd resistance" or essure" → correct = air ance (drag)

### RCES AS VECTORS

Forces are vector quantities → have both magnitude (N) and irection

### E PAIRS (INTERACTIONS)

hen two objects interact, they exert equal & opposite forces (Newton's 3rd Law).

Examples:
- Pushing rock → person pushes rock ⬅, rock pushes back ➡
- Standing on ground → foot pushes down ⬇, ground pushes back up ⬆
- All force pairs shown as arrows in diagrams.

## GRAVITY, WEIGHT & MASS

**MA** ount of matter in an object| Sc direction | Measured in kg | S same ev e (e.g. Earth )

Forc gravity acting downwards) | (N)

- M a newtonmeter (spring b ) | Changes with location

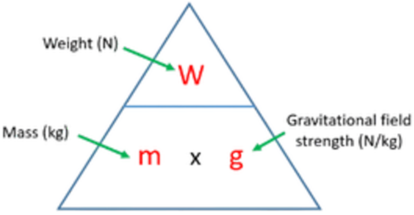
### GRAVI AL FIELD STRENGTH

- Fo g | Measured in N/kg
- E .8 N/kg | Moon ≈ 1.6 N g → ↑ weight

### MASS–GRAVITY NSHIP

W = g

- W = weight in N | m = mass in kg | g = gravitational field strength in N/kg



### EXAMPLES

1. Calculate weight
   - Mass = 70 kg | g = 9.8 N/kg → W = 70 × 9.8 = 686 N
2. Calculate mass from weight
   - Weight = 98 N | g = 9.8 → m = 98 ÷ 9.8 = 10 kg

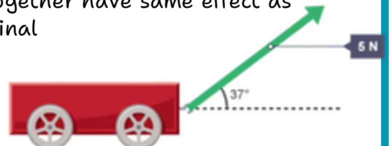
### MEASURING MASS VS WEIGHT

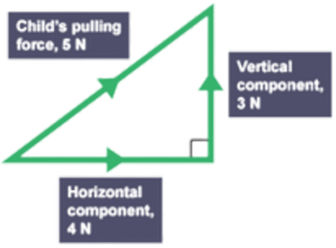
- Mass → measured with balance (compares mass to known mass)
- Weight → measured with spring balance/newtonmeter (measures force)

## RESOLVING FORCES

Breaking a single force into components at right angles (horizontal and vertical) -> Makes it easier to analyse forces acting at angles
- e.g. 5 N force at 37°
- → Horizontal = 4 N
- → Vertical = 3 N

→ Together have same effect as original



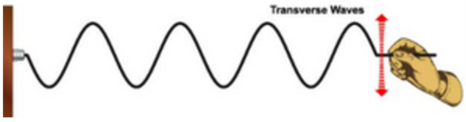


# TRANSVERSE & LONGITUDINAL WAVES

Waves transfer energy, not matter → 2 types:

🔹 Transverse → vibrations perpendicular to energy transfer

🔹 Longitudinal → vibrations parallel to direction of energy transfer



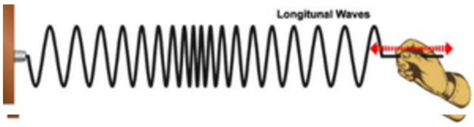
### 📈 TRANSVERSE WAVES

Definition: Vibrate at right angles (90°) to direction of energy transfer → e.g. EM waves, ripples, S-waves, guitar strings

🔸 Crest = highest point | Trough = lowest

🔸 Can move through solids, liquid surfaces, and vacuum (EM only)

🧶 Seen on a rope → move hand up/down → wave travels across



### 🌀 LONGITUDINAL WAVES

Definition: Vibrate parallel to energy transfer → e.g. sound, P-waves, pressure waves

🔸 Compression = close particles | Rarefaction = spread out

🔸 Travel through solids, liquids, gases → not vacuum

🔴 Seen in a slinky → push/pull coil → wave travels forward

### 🧷 REPRESENTING WAVES

📘 Transverse: drawn as continuous curves

🪗 Longitudinal: drawn as lines → compressions close, rarefactions spre

### 🌐 WAVEFRONTS

🔹 Wavefront = top view of wave

🔹 Transverse: 1 line = crest or trough | Longitudinal: 1 line = compression or rarefaction

🔹 Close lines = short wavelength → Far apart = long wavelength

**TIP**✅ Know the difference
→ wavefront diagram (li
→ wave shape diagram (sid

# WAVES

# WAVE MOTION

- Waves transfer energy, not ma through a medium → particles but remain in the same place

### AMPLITUDE (A)

- Maximum displacement fr position to peak/trough.
- Measured in metres (m) → bigge amplitude = more energy.

### WAVELENGTH (λ)

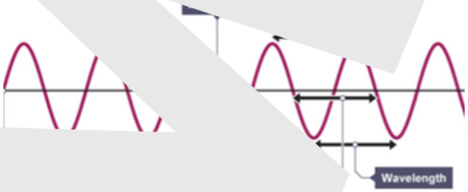
- Distance between same points on two adjacent waves (e.g. peak to peak or trough to trough
- Measured in me
- Transverse: cr h to trough
- Longitudinal: centre of c next compression

### FREQUENCY

- Number int each second
- Unit = (Hz) → 1 H ve per seco
- Hi ncy → m gy

### TIME P

- Time for on oint or one full cycle.
- seconds (s)
- T → T = 1 ÷ f
- in Hz, T = time



# RING WAVE SPEED

### WEEN TWO POINTS

- Tw m apart → distance h trundle wheel → one bangs blocks above head → other uses stopw tch to time delay ring 🔔 ge time d = distance ÷ time

### OD 2: USING AN OSCILLOSCOPE

2 microphones ~5 m apart asured with tape measure) → nnect to oscilloscope → loud sound ar 1st mic (e.g. clap) → oscilloscope s time delay between microphones d of sound = distance between time between peaks

### ALT SCILLOSCOPE METHOD – USING NAL GENERATOR

Attach signal generator to speaker → onnect to 2 microphones + oscilloscope → move one mic until waves align (1 wavelength apart)
→ Measure distance (λ), use known frequency (f)

- → Speed = f × λ

# WAVE EQUATION

- Wave Speed = Frequency × elength

v ave speed (m/s) → how fast gy is tran frequenc number of ves pass econd ) → distance nding points on

🟦 Appl ve types (transverse & gitudinal)

### 🔄 REA GING THE EQUATION

### 📊 W RKED EXAMPLE

A wave has speed 0.12 m/s, and a time period of 4 s

- a) Find frequency
- b) Find wavelength

Part (a):

- T = 4 s → f = 1 ÷ T = 1 ÷ 4 = 0.25 Hz

Part (b):

- v = 0.12 m/s f = 0.25 Hz
- λ = v ÷ f = 0.12 ÷ 0.25 = 0.48 m

### 🎯 TIPS

✅ Use correct symbols: v, f, λ (not L or W)

✅ Watch for kHz → 1 kHz = 1000 Hz

✅ If units are in cm, convert speed to cm/s

# MEASURING CONT.

### 💧 MEASURING SPEED OF WATER WAVES

- In calm water → measure distance between 2 people with tape measure → one creates ripple → second times ripple travel using stopwatch
- → Repeat 10× for average
- → Wave speed = distance ÷ time

### 🧠 TIP – ACCURACY

- Most accurate → oscilloscope (automatic timing)
- Least accurate → direct timing (short interval + human reaction error)

Z

MR. ZEE’S RESOURCES