PHYSICS REVISION NOTES

FOR AQA GCSE (9-1)

SIMPLE, CLEAR & MEMORABLE

PAPER 1

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USING THIS BOOK

This is **Higher Tier** only material – this means you will only need to revise this if you are sitting the higher tier Physics paper.

This is **Physics (separate science)** only material – this means you will only need to revise this if you are sitting the triple award separate science Physics paper (**8463**).

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THIS IS A SPECIFICATION CHAPTER

1.1 THIS IS A SPECIFICATION TOPIC

1.1.1 This is a specification subtopic

1.1.1.1 This is a section of a specification subtopic

1 ENERGY

1.1 ENERGY CHANGES IN A SYSTEM, AND THE WAYS ENERGY IS STORED BEFORE AND AFTER SUCH CHANGES

1.1.1 Energy stores and systems

- A system is an object or group of objects.
- When a force acts on an object, there is a transfer of energy, as follows:

- As an object is projected upwards:
  kinetic energy store → gravitational potential energy store

- As an object falls:
  gravitational potential energy store → kinetic energy store

- As a moving object hits an obstacle, e.g. the ground:
  kinetic energy store → thermal energy store

- As an object accelerates:
  chemical energy store → kinetic energy store

- As a vehicle decelerates:
  kinetic energy store → thermal energy store

- As a liquid is heated to boil:
  thermal energy store → kinetic energy store

- Law of conservation of energy: energy cannot be created or destroyed.

1.1.2 Changes in energy

- The kinetic energy of a moving object can be calculated using the equation:

kinetic energy (J) **= 0.5 x mass** (kg) **x (speed** (m/s)**)²**

$$E_k = \frac{1}{2} m v^2$$

- The amount of elastic potential energy stored in a stretched spring can be calculated using the equation:

elastic potential energy (J) **= 0.5 x spring constant** (N/m) **x (extension** (m/s)**)²**

$$E_e = \frac{1}{2} k e^2$$ (assuming the limit of proportionality has not been exceeded)

- The amount of gravitational potential energy gained by an object raised above ground level can be calculated using the equation:

gravitational potential energy (J) **= mass** (kg) **x gravitational field strength** (N/kg) **x height** (m)

$$E_p = m g h$$

1.1.3 Energy changes in systems

- The amount of energy stored in or released from a system as its temperature changes can be calculated using the equation:

change in thermal energy (J) **= mass** (kg) **x specific heat capacity** (J/kg °C) **x temperature change** (°C)

$$\Delta E = m c \Delta\theta$$

- The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.

1.1.4 Power

- Power is the rate of energy transfer.
- 1 watt means an energy transfer of 1 joule per second.

$$\textbf{power} \text{ (W)} = \frac{\textbf{energy transferred} \text{ (J)}}{\textbf{time} \text{ (s)}} = \frac{\textbf{work done} \text{ (J)}}{\textbf{time} \text{ (s)}}$$

$$P = \frac{E}{t} = \frac{W}{t}$$

1.2 CONSERVATION AND DISSIPATION OF ENERGY

1.2.1 Energy transfers in a system

- Energy can be transferred usefully, stored or dissipated.
- Law of conservation of energy: energy cannot be created or destroyed.
- In a closed system, energy may be transferred less usefully within the system, e.g. friction when a drill bit rotates causes energy to be transferred to the drill's thermal energy store.

- Energy can be dissipated, so that it is stored in less useful ways due to:
  - friction
  - air resistance
  - sound energy

- In a building, for example:
  - the higher the thermal conductivity of the walls, the higher the rate of energy transfer by conduction, and the faster it cools
  - the thicker the walls, the lower the rate of energy transfer by conduction, and the slower it cools

1.2.2 Efficiency

- The energy efficiency for any energy transfer can be calculated using the equation:

$$\textbf{efficiency} = \frac{\textbf{useful output energy transfer}}{\textbf{total input energy transfer}} = \frac{\textbf{useful power output}}{\textbf{total power input}}$$

$$\eta = \frac{W_{out}}{W_{in}} = \frac{P_{out}}{P_{in}}$$

- Ways to reduce unwanted energy transfers and improve efficiency:
  - **lubrication** to reduce friction
  - **thermal insulation** to reduce rate of energy transfer
  - **streamlined shaped** objects to oppose air resistance
  - **tighten loose parts** to reduce vibrations and sound energy

1.3 NATIONAL AND GLOBAL ENERGY RESOURCES

- A renewable energy resource is one that is being replenished as it is used.

- Non-renewable energy resources:
  - **fossil fuels:** burning coal, oil or gas to heat water to form rising steam
  - **nuclear fuel:** nuclear reactions produce heat

- Renewable energy resources:
  - **biofuel:** any fuel taken from living or recent organisms, e.g. manure
  - **wind power:** wind turns a wind turbine that turns a generator
  - **hydro-electricity:** rainwater collected in a reservoir flows downhill and turns a generator
  - **geothermal energy:** water pumped into hot rocks below the surface boils and rises as steam to drive a generator
  - **tidal power:** high tides are forced through generators in a barrage
  - **wave power:** waves are used to drive generators by a rocking motion
  - **the Sun:** converting solar energy into electricity using solar cells

- Uses of energy:
  - **transport:** vehicles burn petrol (oil) to provide energy
  - **electricity generation:** various methods used to provide electricity to the national grid
  - **heating:** solar heating panels use solar energy to heat water in houses

- Energy demands tend to be:
  - higher in the evening: when most people start heating their homes
  - higher in the winter: it is colder and more energy is needed for heating

- Reliability:
  - non-renewable energy is more reliable due to its availability
  - renewable energy is used to cope with high demand
  - wind power, wave power and tidal power all rely on the wind
  - hydro-electricity relies on the amount of precipitation
  - solar power relies on how much sunlight gets to the surface
  - geothermal energy is relatively reliable
  - pumped-storage schemes can be used when demand is low to store gravitational potential energy

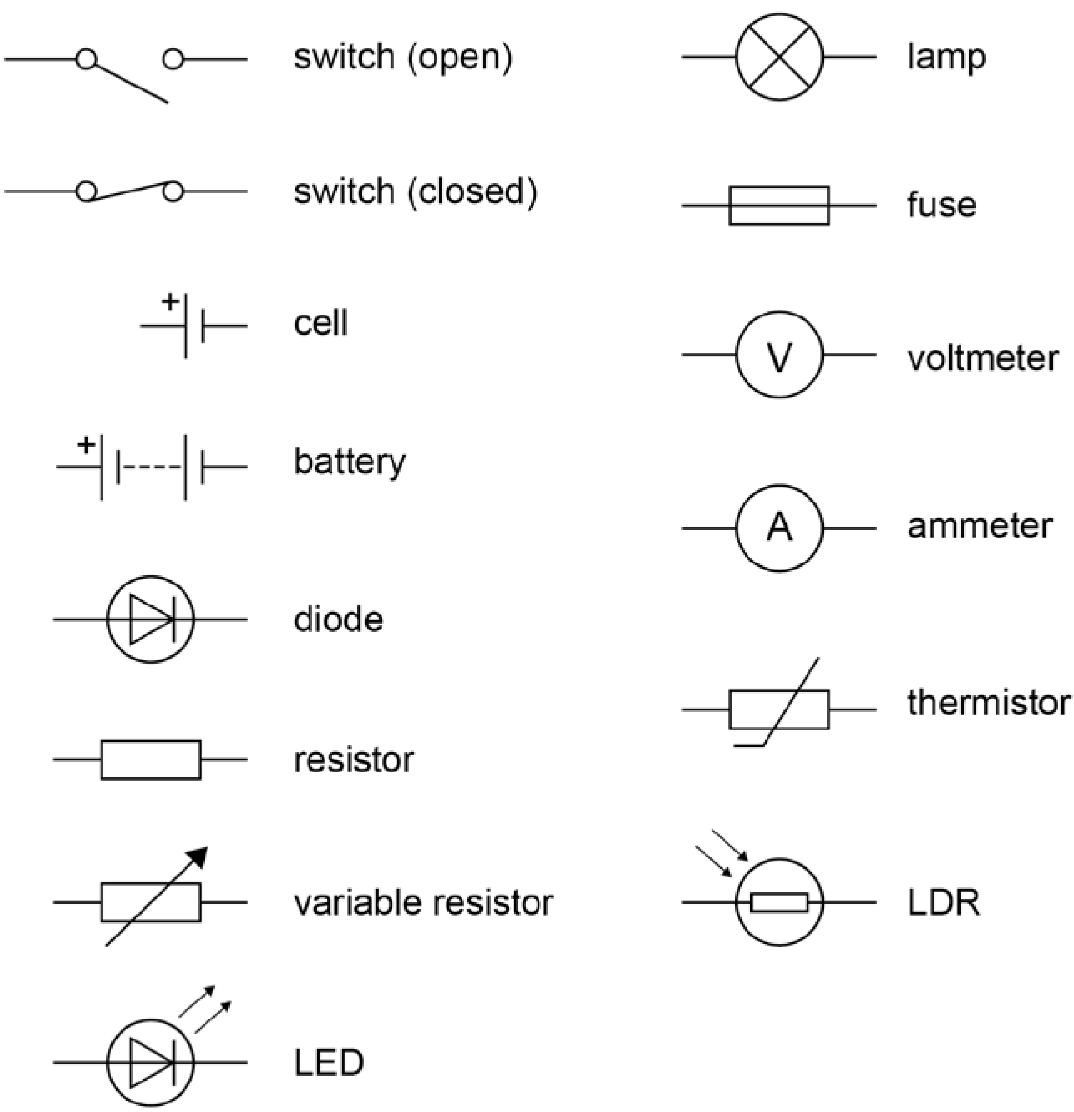
- Environmental impacts of energy resource use:
  - burning fossil fuels:
    - produces CO_2: global warming
    - produces SO_x: acid rain
    - limited
  - nuclear power:
    - produces radioactive waste to be stored for many years
    - an explosion could release radioactive waste over a wide area and have a long-lasting effect

- Science cannot always deal with environmental issues because of:
  - **political instability** in oil-rich countries
  - high electricity demand with **little public interest** in these issues
  - **ethical issues** regarding combustion of fuels as a natural act
  - **little or no funding** for non-renewable energy stations

2 ELECTRICITY

2.1 CURRENT, POTENTIAL DIFFERENCE AND RESISTANCE

2.1.1 Standard circuit diagram symbols



2.1.2 Electrical charge and current

- Electric current is a flow of electrical charge.
- The size of an electric current is the rate of flow of electrical charge.
- A current has the same value at any point in a single closed loop.

charge flow (C) **= current** (A) **x time** (s)

Q = I t

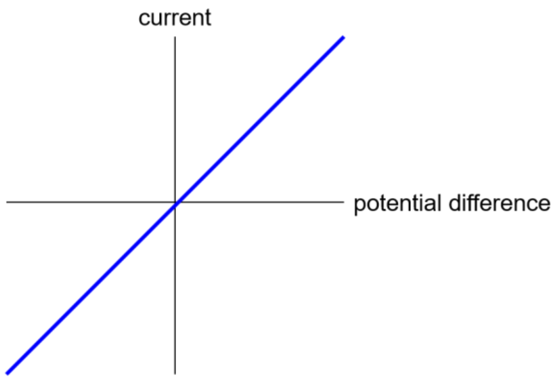
2.1.3 Current, resistance and potential difference

- The current through a component depends on the resistance of the component and the potential difference across the component.
- For a given potential difference, the greater the resistance of the component the smaller the current through the component.

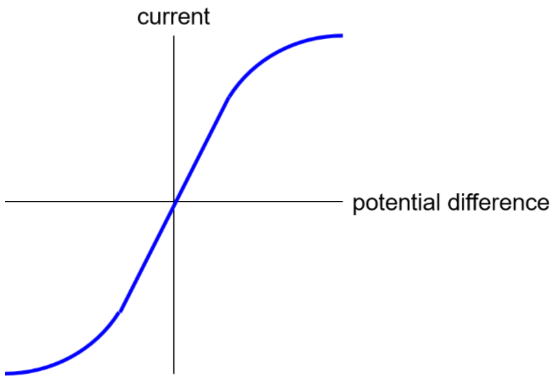
potential difference (V) **= current** (A) **x resistance** (Ω)

V = I R

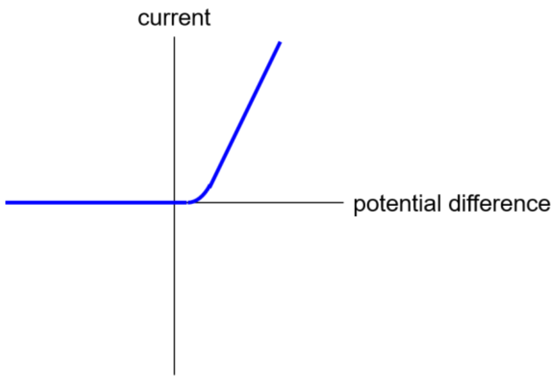
- Ohmic conductors:
  - at a constant temperature:
  - current $\propto$ potential difference



- Non-ohmic conductors:
  - potential difference increases
  - current increases
  - temperature increases
  - atoms in metal filament vibrate more so resist the passage of electrons more
  - resistance increases



- Diodes:
  - current only flows in one direction
  - very high resistance in reverse bias



- Thermistors:
  - as temperature increases, resistance decreases
  - used in thermostats, refrigerators, ovens, heat alarms

- LDRs:
  - as light intensity increases, resistance decreases
  - used in street lights, burglar alarm circuits, mobile phone brightness

2.2 SERIES AND PARALLEL CIRCUITS

- In series circuits:
  - current is the same through each component
  - total potential difference is shared between the components
  - total resistance is the sum of the resistance of each component
    $\mathbf{R_{total} = R_1 + R_2}$

- In parallel circuits:
  - total current is sum of currents through separate branches
  - total potential difference is the same as that through each branch
  - total resistance is less than resistance of smallest resistor

- Why adding resistors in series increases total resistance:
  - individual p.d. decreases, but total p.d. stays the same
  - current decreases because of the lower p.d.
  - R = V ÷ I (where I is lower), so R increases

- Why adding resistors in parallel decreases total resistance:
  - individual p.d. and total p.d. stay the same
  - current does **not** decrease due to a change in p.d., but depends on the resistances of the individual resistors
  - total current is sum of individual currents, so more current flows overall
  - R = V ÷ I (where I is greater), so R decreases

2.3 DOMESTIC USES AND SAFETY

2.3.1 Direct and alternating potential difference

- Direct potential difference has a non-changing value, in one direction.
- Alternating potential difference has a repeatedly changing value, alternating from -325V to +325V.

- UK electricity supply:
    - **frequency:** 50 Hz
    - **p.d.:** 230 V

2.3.2 Mains electricity

- Electrical appliances are connected to the mains using a three-core cable.

- The insulation covering each wire is colour coded for easy identification:
    - **brown** live wire
    - **blue** neutral wire
    - **green and yellow striped** earth wire

- Functions of the wires:
    - **live:** carries alternating p.d. from supply, at 230 V
    - **neutral:** completes the circuit, carrying current but at 0 V
    - **earth:** safety wire to stop the appliance becoming live, at 0V

- Dangers of wiring:
    - a live wire can be dangerous even when a switch is open because it carries a large p.d. – if touched you will complete the circuit and a large current will flow through you to earth
    - any connection between the live wire and earth can result in the metal appliance becoming live – the earth wire carries the current away

2.4 ENERGY TRANSFERS

2.4.1 Power

power (W) **= potential difference** (V) **x current** (A)

P = V I

power (W) **= (current)^2** (A^2) **x resistance** (Ω)

P = I^2 R

2.4.2 Energy transfers in everyday appliances

- The amount of energy an appliance transfers depends on:
    - how long the appliance is switched on for
    - power of the appliance

- Appliances transfer energy from the chemical energy store of batteries or ac mains to the kinetic energy store of electric motors or the energy of heating devices.

- Work is done when charge flows in a circuit, transferring energy:

energy transferred (J) **= power** (W) **x time** (s)

E = P t

energy transferred (J) **= charge flow** (C) **x potential difference** (V)

E = Q V

- p.d. $\propto$ power   current $\propto$ power   power $\propto$ energy transferred

- Appliances with higher power ratings:
    - transfer more energy per second
    - have faster motors

- E.g. a railway engine uses 1 MJ/s (or 1MW), whereas a space rocket uses 100 MJ/s (or 100MW).

2.4.3 The National Grid

- The National Grid is a system of cables and transformers linking power stations to consumers.
- Electrical power is transferred via the National Grid.

- Step-up transformers increase p.d. from the power station to the transmission cables.
- Step-down transformers decrease p.d. for domestic use.
- Why the National Grid is an efficient method of energy transfer:
    - thick cables have a lower resistance
    - transmission cables have a high p.d., so a smaller current, therefore losing less power by resistance heating

2.5 STATIC ELECTRICITY

2.5.1 Static charge

- Static charge in detail:
    - two insulating materials are rubbed together
    - negatively charged electrons are rubbed off one material and onto the other
    - the material that gains electrons becomes negatively charged
    - the material that loses electrons becomes positively charged

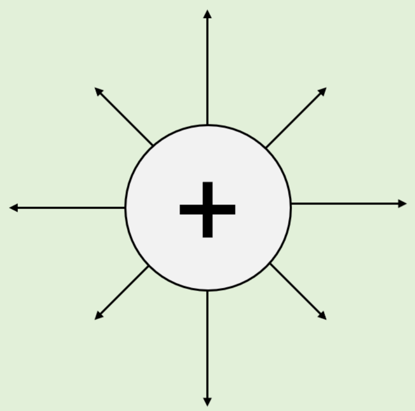
    - when the materials are brought close together they exert a force on each other
    - two objects with the same type of charge repel
    - two objects with different types of charge attract
    - attraction and repulsion are non-contact forces

- Evidence for static electricity:
    - rubbing a dry cloth with a polythene rod transfers electrons to the rod
    - rubbing a dry cloth with a perspex rod transfers electrons to the cloth
    - two charged polythene rods will repel
    - a charged polythene rod and perspex rod will attract
    - this can be demonstrated by suspending a rod and holding another close to it

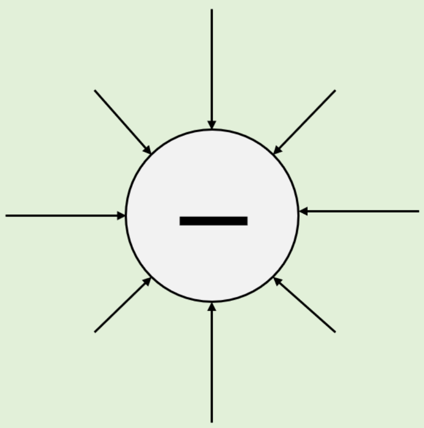
2.5.2 Electric fields

- A charged object creates an electric field around itself:
    - an electric field is strongest close to the charged object
    - it gets weaker further away from the charged object
    - a second charged object placed in the field experiences a force
    - the force between two objects gets stronger as the distance between them decreases

- Drawing electric fields:



Positive metal sphere



Negative metal sphere

- Bringing an object close to a charged sphere triggers the transfer of electrons, typically by visible sparks.

3 PARTICLE MODEL OF MATTER

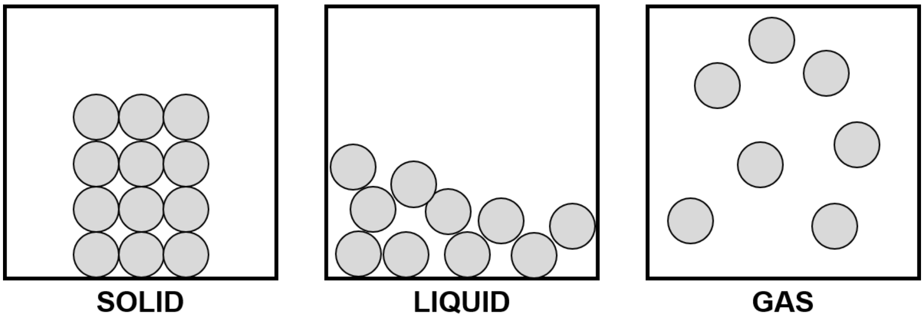
3.1 CHANGES OF STATE AND THE PARTICLE MODEL

3.1.1 Density of materials

density (kg/m^3) = $\dfrac{\textbf{mass}\ \text{(kg)}}{\textbf{volume}\ (\text{m}^3)}$

$\rho = \dfrac{m}{v}$

- Simple diagrams to model the three states of matter:



- Densities of solids, liquids and gases:
    - solids are the densest, with the atoms/molecules arranged in a fixed pattern
    - liquids are usually less dense, as there are less molecules per unit of volume
    - gases are the least dense, with the atoms/molecules far apart

3.1.2 Changes of state

- Mass is conserved during changes of state:
    - when water freezes its density changes due to expansion, but the overall mass does not change
    - when water boils in a kettle, the mass of the steam produced is equal to that of the water that boiled

- Changes of state are physical changes (not chemical changes) because:
    - they can be reversed
    - the material recovers its original properties when the change is reversed

3.2 INTERNAL ENERGY AND ENERGY TRANSFERS

3.2.1 Internal energy

- Internal energy is the energy stored inside a system by the particles making up the system.
- Internal energy = kinetic energy + potential energy (of all the particles)

- As a system is heated:
    - particles vibrate more / move faster
    - their kinetic energy increases
    - internal energy increases
    - (a change of state may occur)

3.2.2 Temperature changes in a system and specific heat capacity

- The specific heat capacity of a substance is the amount of energy required to raise the temperature of 1 kg of the substance by 1°C.

change in thermal energy (J) **= mass** (kg) **x specific heat capacity** (J/kg°C) **x temperature change** (°C)

$\Delta E = m c \Delta \theta$

3.2.3 Changes of heat and specific latent heat

- Latent heat is the energy needed for a substance to change state.
- During a change of state, energy is transferred to the internal energy of the particles.

- The specific latent heat of a substance is the amount of energy required to change the state of 1 kilogram of the substance with no change in temperature.

energy for a change of state (J) **= mass** (kg) **x specific latent heat** (J/kg)

$E = m L$

- The specific latent heat of fusion, L_F, is for changes of state from liquid to solid.
- The specific latent heat of vaporisation, L_V, is for changes of state from liquid to vapour.

- When a pure substance is undergoing a change of state, its temperature remains constant until it the change is complete, meaning its temperature graph has a horizontal line on it.

3.3 PARTICLE MODEL AND PRESSURE

3.3.1 Particle motion in gases

- Gas molecules move in constant random motion, therefore colliding with the surface of the container.
- Higher temperatures mean more frequent, more forceful collisions, increasing pressure.

- As temperature increases:
  - particles gain kinetic energy
  - they move faster
  - there are more frequent, more forceful collisions with the surface of the container
  - pressure increases

3.3.2 Pressure in gases

- A gas can be compressed or expanded by pressure changes.
- Pressure produces a net force perpendicular to the wall of the container.

- As the volume of a gas container increases:
  - particles travel further between collisions
  - there are fewer collisions
  - there is a larger surface area
  - there are less impacts per unit of area, i.e. a lower pressure

For a fixed mass of gas held at a constant temperature: (Boyle's Law)

pressure (Pa) **x volume** (m^3) **= constant**

p V = constant

3.3.3 Increasing the pressure of a gas

- Work is the transfer of energy by a force.

- Doing work on a gas:
  - increases internal energy
  - thereby increases temperature

- E.g. in a bicycle pump:
  - work is done (via piston) is used to decrease volume and increase pressure
  - suddenly more frequent collisions, so more kinetic energy
  - some energy is not usefully transferred in the short time , so the surroundings (i.e. the pump) heat up instead

4 ATOMIC STRUCTURE

4.1 ATOMS AND ISOTOPES

4.1.1 The structure of an atom

- An atom consists of a central positively charged nucleus, composed of both protons and neutrons, surrounded by negatively charged electrons.

- Atoms have a radius of 1 x 10^{-10} m, or 0.1 nm.
- The radius of a nucleus is less than 1 / 10 000 of the radius of the atom.
- Most of the atom's mass is concentrated in the nucleus.

- Electrons: Note: a lower energy level is closer to the nucleus
    - orbit nucleus at different distances (different energy levels)
    - move to **higher** energy level when **absorbing** electromagnetic radiation
    - move to **lower** energy level when **emitting** electromagnetic radiation

4.1.2 Mass number, atomic number and isotopes

- Number of protons is equal to number of electrons, so there is no overall charge.
- Atoms of the same element have the same atomic number, i.e. number of protons.
- Mass number = number of protons + number of neutrons

- Atoms can be represented like this:

(Mass number)
(Atomic number) $^{23}_{11}\mathrm{Na}$

SUBATOMIC PARTICLES

Subatomic particle	Proton	Neutron	Electron
Relative mass	1	1	~ 0
Relative charge	+1	0	–1

- Ions are atoms which gain or lose electrons (by ionisation):
    - **positive ion:** lost electrons
    - **negative ion:** gained electrons

- Isotopes are atoms of the same element with a different number of neutrons.
- Different isotopes of chlorine, for example:

$^{37}_{17}\mathrm{Cl}$ $^{35}_{17}\mathrm{Cl}$ $^{36}_{17}\mathrm{Cl}$ $^{38}_{17}\mathrm{Cl}$ ← mass number is different
← atomic number is the same

4.1.3 The development of the model of the atom

- Before the discovery of the electron, atoms were thought to be **tiny spheres** that could not be divided.
- The **discovery of the electron led to the plum pudding model** of the atom in which the atom is a ball of positive charge with embedded negative electrons.
- The **alpha particle scattering experiment led to the nuclear model** in which the **mass of the atom was concentrated at the centre** (charged nucleus) because some alpha particles were repelled back to their source and did not penetrate the gold foil.
- **Niels Bohr** adapted the nuclear model by suggesting that **electrons orbit the nucleus** at specific distances; theoretical calculations agreed with this.
- Further experiments led to the idea that the **nucleus contained smaller particles** (protons) each having the same amount of positive charge.
- **James Chadwick** provided evidence to show the **existence of uncharged particles** (neutrons) in the nucleus.

Plum pudding model	Nuclear model
sphere of positive charge	protons in nucleus
equal mass across sphere	mass concentrated at nucleus
electrons embedded	electrons orbit nucleus

4.2 ATOMS AND NUCLEAR RADIATION

4.2.1 Radioactive decay and nuclear radiation

- Radioactive decay is the random process where an unstable nucleus emits radiation to become more stable.

- Activity is the rate of decay, measured in Becquerels (Bq).
- An activity of 1 Bq means one nucleus decays per second.
- Count-rate is the number of decays recorded per second by a detector.

- Nuclear radiation (emitted) can be:
  - **alpha particle (α):** two neutrons and two protons (equivalent of a helium nucleus)
  - **beta particle (β):** one electron, ejected at high speed when a neutron becomes a proton and an electron
  - **gamma ray (γ):** electromagnetic radiation from nucleus
  - **neutron (n):** uncharged subatomic particle

- Ionisation in living cells can damage or kill a cell:

Type of radiation	Alpha	Beta	Gamma
Penetrating power	stopped by paper	stopped by thin metal	stopped by thick lead
Range in air	few centimetres	a metre	unlimited
Ionising power	greatest	less than alpha	weakest

4.2.2 Nuclear equations

Type of radiation	Alpha	Beta
Symbol in a nuclear equation	$^{4}_{2}He$ (mass no. = 2 + 2 = 4) (2 positive charges)	$^{0}_{-1}e$ (no mass) (1 negative charge)
General nuclear equation	$^{A}_{Z}X \longrightarrow ^{A-4}_{Z-2}Y + ^{4}_{2}He$	$^{A}_{Z}X \longrightarrow ^{A}_{Z+1}Y + ^{0}_{-1}e$

- Alpha and beta decay can be represented by nuclear equations:

  E.g. a radon atom loses two protons and two neutrons to produce polonium:

$$^{219}_{86}Ra \longrightarrow ^{215}_{84}Po + ^{4}_{2}He$$

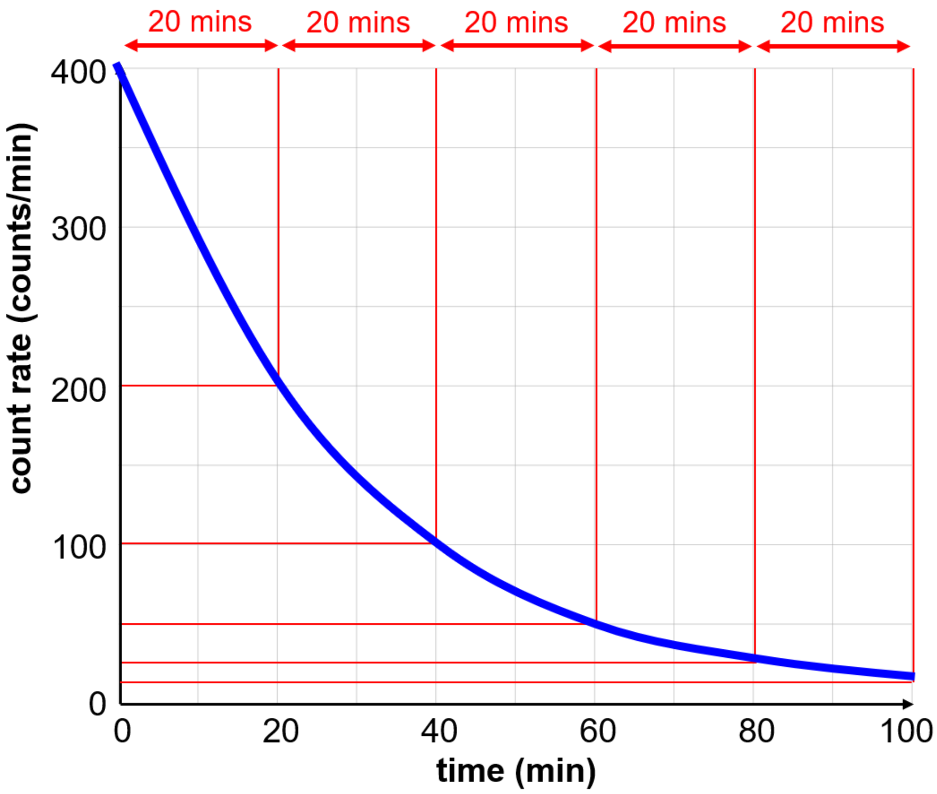
  E.g. a carbon atom loses one electron to produce nitrogen:

$$^{14}_{6}C \longrightarrow ^{14}_{7}N + ^{0}_{-1}e$$

4.2.3 Half-lives and the random nature of radioactive decay

- The half-life of a radioactive isotope is the time it takes for the number of nuclei (or count-rate) to halve.
- As radioactive decay is random, you cannot predict **which** atom will decay, or **when**, but you can predict how many atoms will decay in a given time.

- You can determine the half life of a radioactive isotope from its graph:



The number of remaining unstable nuclei in the sample halves every 20 minutes, as shown on the graph. This means the half life of this isotope is 20 minutes.

- Net decline is a ratio expressing count rate : initial count rate
- E.g. at 60 minutes the net decline is 50:400, so 1:8.

count rate after n half-lives (counts/min) **=** $\frac{\textbf{initial count rate (counts/min)}}{\mathbf{2^n}}$

- E.g. at 40 minutes, count rate = $\frac{400}{2^2}$ = 100

4.2.4 Radioactive contamination

- **Radioactive contamination** is the unwanted presence of materials containing radioactive atoms on other materials.
- Contaminating atoms decay, causing a hazard.
- The type of radiation emitted determines the level of hazard.

- **Irradiation** is the process of exposing an object to nuclear radiation without the object becoming radioactive.

- Hazards of contamination and irradiation:

Contamination	Irradiation
- object becomes radioactive - radiation emitted **cannot** be blocked - can damage living cells	- object does **not** become radioactive - radiation emitted can be blocked - can damage living cells

- Peer review is when the findings of studies into the effects of the radiation on humans to be published and shared with other scientists to be checked.

4.3 HAZARDS AND USES OF RADIOACTIVE EMISSIONS AND OF BACKGROUND RADIATION

4.3.1 Background radiation

- Background radiation is around us all of the time, from:
  - **natural sources:** rocks, cosmic rays from space
  - **man-made sources:** fallout from nuclear weapons testing, nuclear accidents

- The level of background radiation and radiation dose may be affected by occupation and/or location; e.g. a person working near a nuclear power station may be more susceptible to radiation than someone working in a farm.

4.3.2 Different half-lives of radioactive isotopes

- Radioactive isotopes have a very wide range of half-life values.
- An isotope with a long half-life:
  - damaging effects of radiation last too long
  - radiation dose stays high
  - hazard is therefore worse

4.3.3 Uses of nuclear radiation

- Nuclear radiation is used in medicine for the:

  - **exploration of internal organs**:
    - patient drinks water containing radioactive isotope
    - detectors are used to detect the emission of gamma rays
    - the detectors have holes in a thick grid to ensure only rays from nuclei directly in front of the detector are counted
    - the signals are used to build an image of where the radioactive isotope is, and therefore the structure of an organ
    - when using beta radiation, a constantly high count-rate indicates blockage

  - **control or destruction of unwanted tissue:**
    - gamma radiation emitted in a narrow beam
    - its high penetrating power allows it to destroy cancerous cells
    - its long half-life increases damage to cancerous cells

- Radiation used in medicine should typically have:
  - **short half-life:** less damage to cells
  - **low ionising power:** less damage to cells
  - **high penetration power:** can be detected outside the body

- Risks of using radiation in medicine:
    - can damage surrounding tissue
    - high ionising power can cause cancer
    - long half-life brings damage for longer
    - high penetration power can mean radiation enters the body through skin

4.4 NUCLEAR FISSION AND FUSION

4.4.1 Nuclear fission

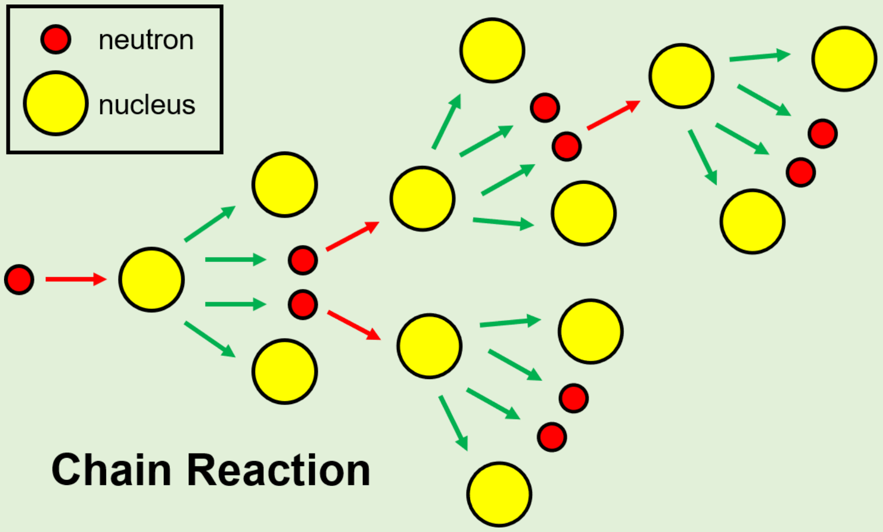
- Nuclear fission is the splitting of a large and unstable nucleus (e.g. uranium).

- Spontaneous fission happens without absorbing a neutron, and is rare.
- Induced fission happens when an unstable nucleus absorbs a neutron.

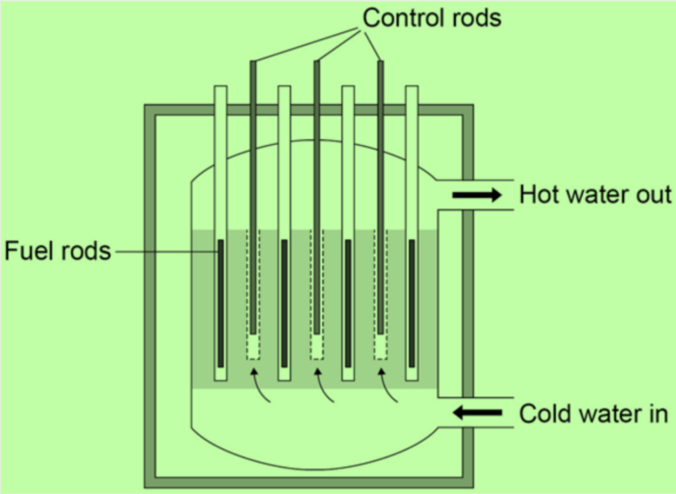
- During nuclear fission, the nucleus:
    - absorbs a neutron
    - splits into two smaller nuclei, roughly equal in size
    - emits two or three neutrons
    - emits energy in the form of gamma rays

- All of the products have kinetic energy, and the neutrons may go on to start a chain reaction, meaning they trigger another fission.

- Chain reaction:
    - controlled in a nuclear reactor to control energy released
    - an uncontrolled chain reaction can cause an explosion



- In a nuclear reactor:
  - **fuel rods** are made of a fissionable radioactive isotope
  - **control rods** absorb neutrons; the more they absorb, the less energy is released
  - **cold water** acts as a coolant, so gets heated and flows as steam to turbines



4.4.2 Nuclear fusion

- Nuclear fusion is the joining of two light nuclei to form a heavier nucleus.
- During this process, some of the mass may be converted into energy as radiation.

WORD EQUATIONS

kinetic energy (J) **= 0.5 x mass** (kg) **x (speed** (m/s)**)^2**

elastic potential energy (J) **= 0.5 x spring constant** (N/m) **x (extension** (m/s)**)^2**

gravitational potential energy (J) **= mass** (kg) **x gravitational field strength** (N/kg) **x height** (m)

change in thermal energy (J) **= mass** (kg) **x specific heat capacity** (J/kg °C) **x temperature change** (°C)

power (W) = $\dfrac{\textbf{energy transferred (J)}}{\textbf{time (s)}} = \dfrac{\textbf{work done (J)}}{\textbf{time (s)}}$

efficiency = $\dfrac{\textbf{useful output energy transfer}}{\textbf{total input energy transfer}} = \dfrac{\textbf{useful power output}}{\textbf{total power input}}$

charge flow (C) **= current** (A) **x time** (s)

potential difference (V) **= current** (A) **x resistance** (Ω)

power (W) **= potential difference** (V) **x current** (A)

power (W) **= (current** (A)**)^2 x resistance** (Ω)

energy transferred (J) **= power** (W) **x time** (s)

energy transferred (J) **= charge flow** (C) **x potential difference** (V)

density (kg/m^3) **=** $\dfrac{\textbf{mass (kg)}}{\textbf{volume (m}^3\textbf{)}}$

change in thermal energy (J) **= mass** (kg) **x specific heat capacity** (J/kg°C) **x temperature change** (°C)

energy for a change of state (J) **= mass** (kg) **x specific latent heat** (J/kg)

count rate after n half-lives (counts/min) **=** $\dfrac{\textbf{initial count rate (counts/min)}}{2^n}$

SYMBOL EQUATIONS

$E_k = \frac{1}{2} m v^2$

$E_e = \frac{1}{2} k e^2$

$E_p = m g h$

$\Delta E = m c \Delta\theta$

$P = \frac{E}{t} = \frac{W}{t}$

$\eta = \frac{W_{out}}{W_{in}} = \frac{P_{out}}{P_{in}}$

$Q = I t$

$V = I R$

$P = V I$

$P = I^2 R$

$E = P t$

$E = Q V$

$\rho = \frac{m}{v}$

$\Delta E = m c \Delta \theta$

$E = m L$

count rate after n half-lives (counts/min) **=** $\frac{\textbf{initial count rate (counts/min)}}{2^n}$

PHYSICS PAPER 1

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