

A L e v e l P h y s i c s

OCR Physics Specification A - H156/H556

Module 4: Electrons, Waves and Photons

| **You should be able to demonstrate and**  **show your understanding of:** | **Progress and understanding:** | | | |
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| **1** | **2** | **3** | **4** |
| **4.1 Charge and Current** | | | | |
| Electric current as rate of flow of charge;  *I = ΔQ / Δt* |  |  |  |  |
| The coulomb as the unit of charge. |  |  |  |  |
| The elementary charge *e* equals 1.6 × 10-19C and that an electron has charge –*e* and a proton a charge +*e*. |  |  |  |  |
| Net charge on a particle or an object is quantised and a multiple of *e.* |  |  |  |  |
| Current as the movement of electrons in metals and movement of ions in electrolytes. |  |  |  |  |
| Conventional current and electron flow. |  |  |  |  |
| Kirchhoff’s first law; conservation of charge. |  |  |  |  |
| Mean drift velocity of charge carriers. |  |  |  |  |
| *I* = *Anev*, where *n* is the number density of charge carriers. |  |  |  |  |
| Distinction between conductors, semiconductors and insulators in terms of *n.* |  |  |  |  |
| **4.2 Energy, Power and Resistance** | | | | |
| Circuit symbols and circuit diagrams using these symbols. |  |  |  |  |
| Potential difference (p.d.); the unit volt. |  |  |  |  |
| Electromotive force (e.m.f.) of a source such as a cell or a power supply. |  |  |  |  |
| Distinction between e.m.f. and p.d. in terms of energy transfer. |  |  |  |  |
| Energy transfer;  *W = VQ W = εQ* |  |  |  |  |
| Energy transfer *eV = ½mv2* for electrons and other charged particles. |  |  |  |  |
| Resistance, the unit ohm;  *R = V / I* [not in the data book] |  |  |  |  |
| Ohm’s law. |  |  |  |  |
| *I*–*V* characteristics of resistor, filament lamp, thermistor, diode and light-emitting diode (LED). |  |  |  |  |
| Techniques and procedures used to investigate the electrical characteristics for a range of ohmic and non-ohmic components. |  |  |  |  |
| Light-dependent resistor (LDR); variation of resistance with light intensity. |  |  |  |  |
| Resistivity of a material, the equation:  *R=ρL / A* |  |  |  |  |
| Techniques and procedures used to determine the resistivity of a metal. |  |  |  |  |
| The variation of resistivity of metals and semiconductors with temperature. |  |  |  |  |
| Negative temperature coefficient (NTC) thermistor; variation of resistance with temperature. |  |  |  |  |
| The equations;  *P = VI P = I2R P = V2 / R* |  |  |  |  |
| Energy transfer;  *W* = *VIt* |  |  |  |  |
| The kilowatt-hour (kW h) as a unit of energy; calculating the cost of energy. |  |  |  |  |
| **4.3 Electrical Circuits** | | | | |
| Kirchhoff’s second law; the conservation of energy. |  |  |  |  |
| Kirchhoff’s first and second laws applied to electrical circuits. |  |  |  |  |
| Total resistance of two or more resistors in series;  *R = R1 + R2 + …* |  |  |  |  |
| Total resistance of two or more resistors in parallel;  *1/R = 1/R1 + 1/R2 + …* |  |  |  |  |
| Analysis of circuits with components, including both series and parallel. |  |  |  |  |
| Analysis of circuits with more than one source of e.m.f. |  |  |  |  |
| Source of e.m.f.; internal resistance. |  |  |  |  |
| Terminal p.d.; 'lost volts'. |  |  |  |  |
| The equations:  *ε = I(R+r)* and *ε = V + Ir* |  |  |  |  |
| Techniques and procedures used to determine the internal resistance of a chemical cell or other source of e.m.f. |  |  |  |  |
| Potential divider circuit with components. You will also be expected to know about a potentiometer as a potential divider. |  |  |  |  |
| Potential divider circuits with variable components, e.g. LDR and thermistor. |  |  |  |  |
| Potential divider equations;  Vout = *R2 x Vin* and *V1 = R1*  *R1 + R2 V2  R2* |  |  |  |  |
| Techniques and procedures used to investigate potential divider circuits which may include a sensor such as a thermistor or an LDR. |  |  |  |  |
| **4.4 Waves** | | | | |
| Progressive waves; longitudinal and transverse waves. |  |  |  |  |
| Displacement, amplitude, wavelength, period, phase difference, frequency and speed of a wave. |  |  |  |  |
| Techniques and procedures used to use an oscilloscope to determine frequency. |  |  |  |  |
| The equation;  *f= 1 / T* |  |  |  |  |
| The wave equation;  *v = f λ* |  |  |  |  |
| Graphical representations of transverse and longitudinal waves. |  |  |  |  |
| Reflection, refraction, polarisation and diffraction of all waves. You will be expected to know that diffraction effects become significant when the wavelength is comparable to the gap width. |  |  |  |  |
| Techniques and procedures used to demonstrate wave effects using a ripple tank. |  |  |  |  |
| Techniques and procedures used to observe polarising effects using microwaves and light. |  |  |  |  |
| Intensity of a progressive wave;  *I = P / A*  *intensity ∝ (amplitude)2* |  |  |  |  |
| Electromagnetic spectrum; properties of electromagnetic waves. |  |  |  |  |
| Orders of magnitude of wavelengths of the principal radiations from radio waves to gamma rays. |  |  |  |  |
| Plane polarised waves; polarisation of electromagnetic waves. You will be expected to know about polarising filters for light and metal grilles for microwaves in demonstrating polarisation. |  |  |  |  |
| Refraction of light; refractive index;  *n = c /v*  *n sin* θ = constant at a boundary where θis the angle to the normal |  |  |  |  |
| Techniques and procedures used to investigate refraction and total internal reflection of light using ray boxes, including transparent rectangular and semi-circular blocks. |  |  |  |  |
| Critical angle;  *sin C = 1 / n*  Total internal reflection for light. |  |  |  |  |
| The principle of superposition of waves. |  |  |  |  |
| Techniques and procedures used for superposition experiments using sound, light and microwaves. |  |  |  |  |
| Graphical methods to illustrate the principle of superposition. |  |  |  |  |
| Interference, coherence, path difference and phase difference. |  |  |  |  |
| Constructive interference and destructive interference in terms of path difference and phase difference. |  |  |  |  |
| Two-source interference with sound and microwaves. |  |  |  |  |
| Young’s double-slit experiment using visible light. This experiment gave a classical confirmation of the wave-nature of light. |  |  |  |  |
| *λ = ax / D* for all waves where *a << D* |  |  |  |  |
| Techniques and procedures used to determine the wavelength of light using a double-slit and a diffraction grating. |  |  |  |  |
| Stationary (standing) waves using microwaves, stretched strings and air columns. |  |  |  |  |
| Graphical representations of a stationary wave. |  |  |  |  |
| Similarities and the differences between stationary and progressive waves. |  |  |  |  |
| Nodes and antinodes. |  |  |  |  |
| Stationary wave patterns for a stretched string and air columns in closed and open tubes. |  |  |  |  |
| Techniques and procedures used to determine the speed of sound in air by formation of stationary waves in a resonance tube. |  |  |  |  |
| The idea that the separation between adjacent nodes (or antinodes) is equal to λ/2 where λ is the wavelength of the progressive wave. |  |  |  |  |
| Fundamental mode of vibration (1st harmonic); harmonics. |  |  |  |  |
| **4.5 Quantum Physics** | | | | |
| The particulate nature (photon model) of electromagnetic radiation. |  |  |  |  |
| Photon as a quantum of energy of electromagnetic radiation. |  |  |  |  |
| Energy of a photon;  *E = hf* and *E= hf / λ* |  |  |  |  |
| The electronvolt (eV) as a unit of energy. |  |  |  |  |
| Using LEDs and the equation *eV = hc / λ* to estimate the value of Planck constant *h.* |  |  |  |  |
| Determine the Planck constant using different coloured LEDs. |  |  |  |  |
| Photoelectric effect, including a simple experiment to demonstrate this effect and that the photoelectric effect provides evidence for the particulate nature of electromagnetic radiation. |  |  |  |  |
| Demonstration of the photoelectric effect using a gold-leaf electroscope and zinc plate. |  |  |  |  |
| A one-to-one interaction between a photon and a surface electron. |  |  |  |  |
| Einstein’s photoelectric equation;  *hf =* φ *+ KEmax* |  |  |  |  |
| Work function; threshold frequency. |  |  |  |  |
| The idea that the maximum kinetic energy of the photoelectrons is independent of the intensity of the incident radiation. |  |  |  |  |
| The idea that rate of emission of photoelectrons above the threshold frequency is directly proportional to the intensity of the incident radiation. |  |  |  |  |
| Electron diffraction, including experimental evidence of this effect. |  |  |  |  |
| Diffraction of electrons travelling through a thin slice of polycrystalline graphite by the atoms of graphite and the spacing between the atoms. |  |  |  |  |
| The de Broglie equation;  λ = h / p |  |  |  |  |

The material in this checklist is based on the OCR Physics A Specification published at [ocr.org.uk/**alevelphysicsa**](http://www.ocr.org.uk/qualifications/as-a-level-gce-physics-a-h156-h556-from-2015/) by Oxford, Cambridge and RSA Examinations.