**A-Level Paper 2 Personal Learning Checklist**

**Thermal Physics (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| Define internal energy. |  |  |  |
| Describe how the internal energy of a system can be increased. |  |  |  |
| Define the first law of thermodynamics. |  |  |  |
| Explain what happens to a material when it changes state. |  |  |  |
| Calculations involving transfer of energy. |  |  |  |
| Define specific heat capacity. |  |  |  |
| Calculate the energy transferred using Q = mc Δ θ. |  |  |  |
| Define specific latent heat. |  |  |  |
| Calculate the energy needed to change state using Q = mL. |  |  |  |
| State Charles’ law. |  |  |  |
| State Boyle’s law. |  |  |  |
| Define the relationship between p, V, T, and the mass of the gas. |  |  |  |
| Define absolute zero of temperature. |  |  |  |
| Calculations involving the ideal gas equation: pV = nRT for n moles and pV = NkT for N molecules. |  |  |  |
| Calculate the work done = p ΔV |  |  |  |
| Define Avogadro constant. |  |  |  |
| Define the molar gas constant. |  |  |  |
| Define Boltzmann constant. |  |  |  |
| Calculate molar mass and molecular mass. |  |  |  |
| Describe Brownian motion. |  |  |  |
| Explain the significance of Brownian motion. |  |  |  |
| Explain the relationship between p, V and T in terms of a simple molecular model. |  |  |  |
| Explain why the gas laws are empirical in nature whereas the kinetic theory is not. |  |  |  |
| Derive pV = ⅓Nm (crms)2 including assumptions made. |  |  |  |
| Use pV = ⅓Nm (crms)2  in calculations. |  |  |  |
| Appreciate that the ideal gas internal energy is kinetic energy of the atoms. |  |  |  |
| Use the average molecular kinetic energy formula. |  |  |  |
| Appreciate how knowledge and understanding of the behaviour of a gas has changed over time. |  |  |  |
| ***Core Practical*** | | | |
| Investigation of Boyle’s (constant temperature) law and Charles’s (constant pressure) law for a gas. |  |  |  |

**Gravitational Fields (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| Describe what a force field is. |  |  |  |
| Represent a field. |  |  |  |
| State when a force field can arise. |  |  |  |
| Describe the gravitational force and what particles it affects. |  |  |  |
| State Newton’s law of gravitation in words. |  |  |  |
| Understand and use the gravitational force equation: F = Gm1m2 / r2. |  |  |  |
| Draw a gravitational field around a mass. |  |  |  |
| Define gravitational field. |  |  |  |
| Calculate the magnitude of the gravitational field by using either: g = F/m or g = GM / r |  |  |  |
| Define gravitational potential. |  |  |  |
| State the gravitational potential at infinity. |  |  |  |
| Explain why gravitational potential values are always negative. |  |  |  |
| Understand and use the equation for potential in a radial field: V = -GM / r |  |  |  |
| Sketch a graph of g against r. |  |  |  |
| Deduce what the area under a g against r graph represents. |  |  |  |
| Sketch a graph of V against r. |  |  |  |
| Deduce what the area under a V against r graph represents. |  |  |  |
| State what is meant by the term equipotential. |  |  |  |
| Explain how much work is done when moving along an equipotential surface. |  |  |  |
| Explain how much work is done in moving a mass between two potentials. |  |  |  |
| Calculate the work done in moving a mass between two potentials using: ΔW = mΔV |  |  |  |
| Define gravitational potential energy and how it related to the work done. |  |  |  |
| Explain the relationship between V and g by deriving g = − Δ V/ Δ r. |  |  |  |
| Describe how orbital speed is related to radius of a circular orbit. |  |  |  |
| Describe how orbital period is related to radius of a circular orbit. |  |  |  |
| Derive Keplar’s law: T2 is directly proportional to r3. |  |  |  |
| Describe the total energy, gravitational potential energy and kinetic energy of an orbiting satellite. |  |  |  |
| Define escape velocity. |  |  |  |
| Calculate escape velocity. |  |  |  |
| Define synchronous orbits. |  |  |  |
| Describe a geostationary orbit. |  |  |  |
| Describe a low orbit. |  |  |  |
| Describe some uses of satellites in low obits and geostationary orbits. |  |  |  |
| Describe the similarities and differences between gravitational fields and electric fields. |  |  |  |

**Electric Fields (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| Calculate the force between 2 point charges in a vacuum using the formula: F = 1/(4π ε0) Q1Q2/ r2 |  |  |  |
| State that air can be treated as a vacuum when calculating force between charges. |  |  |  |
| Draw an electric field around a point charge (positive or negative). |  |  |  |
| Draw an electric field around 2 point charges of equal magnitude. |  |  |  |
| Define electric field strength. |  |  |  |
| Calculate electric field strength using both E = F/Q and E = Q/4π ε0r2 |  |  |  |
| Draw a uniform electric field. |  |  |  |
| Calculate the electric field in a uniform using E = V/d. |  |  |  |
| Compare the size of gravitational and electrostatic forces between subatomic particles. |  |  |  |
| Derive a formula for work done in moving a charge between 2 plates: Fd = QΔV |  |  |  |
| Draw the trajectory of a moving charged particle entering a uniform electric field; both parallel and initially at right angles. |  |  |  |
| Describe the motion of a moving charged particle in a uniform electric field. |  |  |  |
| Define electric potential. |  |  |  |
| State the electric potential value at infinity. |  |  |  |
| Define electric potential difference. |  |  |  |
| Deduce whether the electric potential difference is positive or negative. |  |  |  |
| Calculate the work done in moving a charge between two potentials using ΔW = Q ΔV. |  |  |  |
| Calculate the electric potential of a radial field using V = Q/4π ε0r |  |  |  |
| Sketch a graph of E against r. |  |  |  |
| Deduce what the area under an E against r graph represents. |  |  |  |
| Sketch a graph of V against r. |  |  |  |
| Deduce what the gradient of a V against r graph represents. |  |  |  |
| Derive E = Δ V/ Δ r |  |  |  |

**Capacitance (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| Define capacitance. |  |  |  |
| Calculate capacitance using the equation, C = Q/V. |  |  |  |
| Describe how the size of a capacitor relates to the cross sectional area of the plates, the space between the plates and permittivity of the material between the plates. |  |  |  |
| Describe what a dielectric is. |  |  |  |
| Describe how a dielectric is able to help a capacitor hold charge by explanation of a simple polar molecule. |  |  |  |
| Calculate relative permittivity and the dielectric constant. |  |  |  |
| Explain how a capacitor holds charge. |  |  |  |
| Describe how a capacitor is charged up. |  |  |  |
| Draw graphs relating to the charging of a capacitor (Q-t, V-t and I-t). |  |  |  |
| Explain the shape of the charging graphs. |  |  |  |
| Interpret the gradient and area under each of these graphs. |  |  |  |
| Describe how a capacitor can be discharged. |  |  |  |
| Draw graphs relating to the discharging of a capacitor (Q-t, V-t and I-t) |  |  |  |
| Explain the shape of the discharging graphs. |  |  |  |
| Interpret the gradient and area under each of these graphs. |  |  |  |
| Define time constant, τ. |  |  |  |
| Calculate time constant from the circuit (RC). |  |  |  |
| Determine the time constant from a charging graph. |  |  |  |
| Determine the time constant from a discharging graph. |  |  |  |
| Use and rearrange the equation for capacitor discharge, Q = Q0 e− t/RC. This includes being able to use the natural logarithmic, ln. |  |  |  |
| Use and rearrange the equation for capacitor charge, Q = Q0 (1- e− t/RC). This includes being able to use the natural logarithmic, ln. |  |  |  |
| Derive the time to halve as being T1/2 = 0.69RC. |  |  |  |
| ***Core Practical*** | | | |
| Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant RC. |  |  |  |

**Magnetic Fields (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| Define magnetic flux density. |  |  |  |
| Define the tesla. |  |  |  |
| Deduce the direction of magnetic field around a current carrying wire using the right hand grip rule. |  |  |  |
| Deduce the direction of force acting on a current carrying wire in a magnetic field, where the field is perpendicular to the current. |  |  |  |
| Explain why a force is present when a current carrying wire is in a magnetic field. |  |  |  |
| Calculate the force acting on a current carrying wire in a magnetic field using F = BIl |  |  |  |
| Explain how a motor rotates, including the need for a commutator. |  |  |  |
| Calculate the force on a charged particle moving in a magnetic field, F = BQv. |  |  |  |
| Deduce the direction of the force on positive and negative charged particles in a magnetic field. |  |  |  |
| Explain the motion of particles in a magnetic field. |  |  |  |
| Calculate the radius of a particle in a magnetic field using F = BQv and circular motion equations. |  |  |  |
| Explain what happens to the motion of a particle if mass of the particle is changed. |  |  |  |
| Explain what happens to the motion of a particle if the magnetic field is changed. |  |  |  |
| Explain what happens to the motion of a particle if the charge was changed. |  |  |  |
| Describe how a cyclotron works. |  |  |  |
| ***Core Practical*** | | | |
| Investigate how the force on a wire varies with flux density, current, and length of wire using a top pan balance. |  |  |  |

**Electromagnetic Induction (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| Define magnetic flux. |  |  |  |
| Define magnetic flux linkage. |  |  |  |
| Calculate the flux and flux linkage passing through a rectangular coil rotated in a magnetic field using:  NΦ = BANcosθ |  |  |  |
| State and apply Faraday’s law. |  |  |  |
| State and apply Lenz’s law. |  |  |  |
| Explain what happens when a straight conductor is moved in a magnetic field. |  |  |  |
| Calculate the emf is induced in a coil rotating uniformly in a magnetic field using: ε = BAN ω sin ωt |  |  |  |
| Describe how an AC generator is different to a dynamo. |  |  |  |
| State what is meant by root mean square voltage/current. |  |  |  |
| State and draw what is meant by peak voltage/current. |  |  |  |
| State and draw what is meant by peak to peak voltage/current. |  |  |  |
| Calculate root mean square current/voltage. |  |  |  |
| Appreciate that main electricity is alternating current and 230V is the r.m.s voltage. |  |  |  |
| Use an oscilloscope to measure ac and dc voltage and time intervals to obtain frequency of ac waveforms. |  |  |  |
| Explain how a transformer works. |  |  |  |
| Understand and use the transformer equation: Ns/Np = Vs/Vp |  |  |  |
| Calculate the efficiency of a transformer: ISVS/ IPVP |  |  |  |
| Explain eddy currents. |  |  |  |
| Describe and explain the causes of inefficiencies in a transformer. |  |  |  |
| Explain why transmission lines require high voltages. |  |  |  |
| Calculate the power loss in transmission lines. |  |  |  |
| ***Core Practical*** | | | |
| Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction. |  |  |  |

**Radioactivity (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| Describe the Rutherford Scattering experiment. |  |  |  |
| Explain the results of the Rutherford Scattering experiment. |  |  |  |
| Appreciate how knowledge and understanding of the structure of the nucleus has changed over time. |  |  |  |
| Describe the properties α, β and γ radiation. |  |  |  |
| Explain how experiments can identify what type of radiation is being emitted. |  |  |  |
| Explain the application of α, β and γ radiation. |  |  |  |
| State the inverse-square law for gamma radiation. |  |  |  |
| Describe an experiment to verify the inverse-square law. |  |  |  |
| State what background radiation is. |  |  |  |
| State examples of the origins of background radiation. |  |  |  |
| Calculate experimental elimination of background radiation |  |  |  |
| Describe the safe handling of radioactive sources. |  |  |  |
| Appreciate the balance between risk and benefits in the uses of radiation in medicine. |  |  |  |
| State the random nature of radioactive decay. |  |  |  |
| Calculate the decay probability of a given nucleus using Δ N / Δt = - λN |  |  |  |
| Calculate and understand using the decay equation: N = N0e-λt |  |  |  |
| State what is meant by activity. |  |  |  |
| Calculate the activity using A = λN. |  |  |  |
| Describe the different models with a constant decay probability. |  |  |  |
| Calculate using molar mass or Avogadro constant. |  |  |  |
| State what is meant by half-life. |  |  |  |
| Calculate half-life using the equation T½ = ln2 / λ |  |  |  |
| Determine half-life from a graphical decay curve. |  |  |  |
| Determine half-life from a graphical log graph. |  |  |  |
| Describe how half-life is important in applications such as radioactive waste and radioactive dating. |  |  |  |
| Draw a graph of N against Z for stable nuclei. |  |  |  |
| Deduce possible decay modes of unstable nuclei including α, β+, β− and electron capture. |  |  |  |
| Represent changes radioactive decay by simple decay equations. |  |  |  |
| Understand nuclear energy level diagrams. |  |  |  |
| Describe what is meant by a nuclear excited state. |  |  |  |
| State what γ ray emission is. |  |  |  |
| Describe applications of γ ray emission, including the use of technetium-99m as a γ source in medical diagnosis. |  |  |  |
| Estimate the radius from closest approach of alpha particles. |  |  |  |
| Determine the radius from electron diffraction. |  |  |  |
| State typical values for nuclear radius. |  |  |  |
| Calculate the radius from nucleon number using R = R0A1/3. |  |  |  |
| State that this equation if derived from experimental data. |  |  |  |
| Interpret the equation as evidence for constant density of nuclear material. |  |  |  |
| Calculations involving nuclear density. |  |  |  |
| Sketch a graph of intensity against angle for electron diffraction by a nucleus. |  |  |  |
| Understand and use E = mc2. |  |  |  |
| Calculate mass difference. |  |  |  |
| Calculate binding energy. |  |  |  |
| State what the atomic mass unit is. |  |  |  |
| Convert between mass difference and binding energy. |  |  |  |
| Describe the process of fission. |  |  |  |
| Describe the process of fusion. |  |  |  |
| Calculate the energy released in fission and fusion reactions from the nuclear mass. |  |  |  |
| Understand and use the graph of average binding energy per nucleon against nucleon number. |  |  |  |
| Identify on the graph, regions where nuclei will release energy when undergoing fission/fusion. |  |  |  |
| Appreciate that knowledge of nuclear energy allows society to use science to inform decision making. |  |  |  |
| Describe how fission is induced. |  |  |  |
| State what is meant by a chain reaction. |  |  |  |
| State what is meant by critical mass. |  |  |  |
| ***Explain the functions of the following:*** | | | |
| * moderator |  |  |  |
| * control rods |  |  |  |
| * coolant |  |  |  |
| Understand a simple mechanical model of moderation by elastic collisions. |  |  |  |
| State and describe the factors affecting the choice of materials for the moderator, control rods and coolant. |  |  |  |
| State examples of materials used. |  |  |  |
| ***Describe the safety aspects of the following:*** | | | |
| * fuel used. |  |  |  |
| * remote handling of fuel. |  |  |  |
| * shielding. |  |  |  |
| * emergency shut-down. |  |  |  |
| * production. |  |  |  |
| * radioactive waste materials. |  |  |  |
| Appreciate the balance between risk and benefit in the development of nuclear power. |  |  |  |
| ***Core Practical*** | | | |
| Investigation of the inverse-square law for gamma radiation. |  |  |  |