A-Level Paper 2 Personal Learning Checklist

6B. Thermal Energy

LO	Learning Objectives:	Confidence		
6B.01	Define internal energy.			
6B.02	Describe how the internal energy of a system can be increased.			
6B.03	Define the first law of thermodynamics.			
6B.04	Explain what happens to a material when it changes state.			
6B.05	Calculations involving transfer of energy.			
6B.06	Define specific heat capacity.			
6B.07	Calculate the energy transferred using $Q = mc\,\Delta\,\theta$.			
6B.08	Define specific latent heat.			
6B.09	Calculate the energy needed to change state using $Q = mL$.			
6B.10	State Charles' law.			
6B.11	State Boyle's law.			
6B.12	Define the relationship between p, V, T, and the mass of the gas.			
6B.13	Define absolute zero of temperature.			
6B.14	Calculations involving the ideal gas equation: $pV = nRT$ for n moles and $pV = NkT$ for N molecules.			
6B.15	Calculate the work done = $p\,\Delta V$			
6B.16	Define Avogadro constant.			
6B.17	Define the molar gas constant.			
6B.18	Define Boltzmann constant.			
6B.19	Calculate molar mass and molecular mass.			
6B.20	Describe Brownian motion.			
6B.21	Explain the significance of Brownian motion.			
6B.22	Explain the relationship between p, V and T in terms of a simple molecular model.			
6B.23	Explain why the gas laws are empirical in nature whereas the kinetic theory is not.			
6B.24	Derive $pV = \frac{1}{3}Nm\,(c_{rms})^2$ including assumptions made.			
6B.25	Use $pV = \frac{1}{3}Nm\,(c_{rms})^2$ in calculations.			
6B.26	Appreciate that the ideal gas internal energy is kinetic energy of the atoms.			
6B.27	Use the average molecular kinetic energy formula.			
6B.28	Appreciate how knowledge and understanding of the behaviour of a gas has changed over time.			
6B.29	***Core Practical: Investigation of Boyle's (constant temperature) law and Charles's (constant pressure) law for a gas.***			

7. Fields

LO	Learning Objectives:	Confidence		
7.001	Describe what a force field is.			
7.002	Represent a field.			
7.003	State when a force field can arise.			
7.004	Describe the gravitational force and what particles it affects.			
7.005	State Newton's law of gravitation in words.			
7.006	Understand and use the gravitational force equation: $F = Gm_1m_2 / r^2$.			
7.007	Draw a gravitational field around a mass.			

7.008	Define gravitational field strength.			
7.009	Calculate the magnitude of the gravitational field by using either: $g = F/m$ or $g = GM / r$			
7.010	Define gravitational potential.			
7.011	State the gravitational potential at infinity.			
7.012	Explain why gravitational potential values are always negative.			
7.013	Understand and use the equation for potential in a radial field: $V = -GM / r$			
7.014	Sketch a graph of g against r.			
7.015	Deduce what the area under a g against r graph represents.			
7.016	Sketch a graph of V against r.			
7.017	Deduce what the area under a V against r graph represents.			
7.018	State what is meant by the term equipotential.			
7.019	Explain how much work is done when moving along an equipotential surface.			
7.020	Explain how much work is done in moving a mass between two potentials.			
7.021	Calculate the work done in moving a mass between two potentials using: $\Delta W = m\Delta V$			
7.022	Define gravitational potential energy and how it related to the work done.			
7.023	Explain the relationship between V and g by deriving $g = -\Delta V / \Delta r$.			
7.024	Describe how orbital speed is related to radius of a circular orbit.			
7.025	Describe how orbital period is related to radius of a circular orbit.			
7.026	Derive Keplar's law: T^2 is directly proportional to r^3.			
7.027	Describe the total energy, gravitational potential energy and kinetic energy of an orbiting satellite.			
7.028	Define escape velocity.			
7.029	Calculate escape velocity.			
7.030	Define synchronous orbits.			
7.031	Describe a geostationary orbit.			
7.032	Describe a low orbit.			
7.033	Describe some uses of satellites in low obits and geostationary orbits.			
7.034	Describe the similarities and differences between gravitational fields and electric fields.			
7.035	Calculate the force between 2 point charges in a vacuum using the formula: $F = 1/(4\pi \varepsilon_0) Q_1Q_2/ r^2$			
7.036	State that air can be treated as a vacuum when calculating force between charges.			
7.037	Draw an electric field around a point charge (positive or negative).			
7.038	Draw an electric field around 2 point charges of equal magnitude.			
7.039	Define electric field strength.			
7.040	Calculate electric field strength using both $E = F/Q$ and $E = Q/4\pi \varepsilon_0 r^2$			
7.041	Draw a uniform electric field.			
7.042	Calculate the electric field in a uniform using $E = V/d$.			
7.043	Compare the size of gravitational and electrostatic forces between subatomic particles.			
7.044	Derive a formula for work done in moving a charge between 2 plates: $Fd = Q\Delta V$			
7.045	Draw the trajectory of a moving charged particle entering a uniform electric field; both parallel and initially at right angles.			
7.046	Describe the motion of a moving charged particle in a uniform electric field.			
7.047	Define electric potential.			
7.048	State the electric potential value at infinity.			
7.049	Define electric potential difference.			
7.050	Deduce whether the electric potential difference is positive or negative.			
7.051	Calculate the work done in moving a charge between two potentials using $\Delta W = Q \Delta V$.			
7.052	Calculate the electric potential of a radial field using $V = Q/4\pi \varepsilon_0 r$			
7.053	Sketch a graph of E against r.			

7.054	Deduce what the area under an E against r graph represents.			
7.055	Sketch a graph of V against r.			
7.056	Deduce what the gradient of a V against r graph represents.			
7.057	Derive $E = \Delta V / \Delta r$			
7.058	Define capacitance.			
7.059	Calculate capacitance using the equation, $C = Q/V$.			
7.060	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.			
7.061	Describe what a dielectric is.			
7.062	Describe how a dielectric is able to help a capacitor hold charge by explanation of a simple polar molecule.			
7.063	Calculate relative permittivity and the dielectric constant.			
7.064	Explain how a capacitor holds charge.			
7.065	Describe how a capacitor is charged up.			
7.066	Draw graphs relating to the charging of a capacitor (Q-t, V-t and I-t).			
7.067	Explain the shape of the charging graphs.			
7.068	Interpret the gradient and area under each of these graphs.			
7.069	Describe how a capacitor can be discharged.			
7.070	Draw graphs relating to the discharging of a capacitor (Q-t, V-t and I-t)			
7.071	Explain the shape of the discharging graphs.			
7.072	Interpret the gradient and area under each of these graphs.			
7.073	Define time constant, τ.			
7.074	Calculate time constant from the circuit (RC).			
7.075	Determine the time constant from a charging graph.			
7.076	Determine the time constant from a discharging graph.			
7.077	Use and rearrange the equation for capacitor discharge, $Q = Q_0 e^{-t/RC}$. This includes being able to use the natural logarithmic, ln.			
7.078	Use and rearrange the equation for capacitor charge, $Q = Q_0 (1 - e^{-t/RC})$. This includes being able to use the natural logarithmic, ln.			
7.079	Derive the time to halve as being $T_{1/2} = 0.69RC$.			
7.080	***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.***			
7.081	Define magnetic flux density.			
7.082	Define the tesla.			
7.083	Deduce the direction of magnetic field around a current carrying wire using the right hand grip rule.			
7.084	Deduce the direction of force acting on a current carrying wire in a magnetic field, where the field is perpendicular to the current.			
7.085	Explain why a force is present when a current carrying wire is in a magnetic field.			
7.086	Calculate the force acting on a current carrying wire in a magnetic field using $F = BIl$			
7.087	Explain how a motor rotates, including the need for a commutator.			
7.088	Calculate the force on a charged particle moving in a magnetic field, $F = BQv$.			
7.089	Deduce the direction of the force on positive and negative charged particles in a magnetic field.			
7.090	Explain the motion of particles in a magnetic field.			
7.091	Calculate the radius of a particle in a magnetic field using $F = BQv$ and circular motion equations.			
7.092	Explain what happens to the motion of a particle if mass of the particle is changed.			
7.093	Explain what happens to the motion of a particle if the magnetic field is changed.			
7.094	Explain what happens to the motion of a particle if the charge was changed.			
7.095	Describe how a cyclotron works.			

7.096	***Core Practical: Investigate how the force on a wire varies with flux density, current, and length of wire using a top pan balance.***			
7.097	Define magnetic flux.			
7.098	Define magnetic flux linkage.			
7.099	Calculate the flux and flux linkage passing through a rectangular coil rotated in a magnetic field using: $N\Phi = BAN\cos\theta$			
7.100	State and apply Faraday's law.			
7.101	State and apply Lenz's law.			
7.102	Explain what happens when a straight conductor is moved in a magnetic field.			
7.103	Calculate the emf is induced in a coil rotating uniformly in a magnetic field using: $\varepsilon = BAN\omega \sin \omega t$			
7.104	Describe how an AC generator is different to a dynamo.			
7.105	State what is meant by root mean square voltage/current.			
7.106	State and draw what is meant by peak voltage/current.			
7.107	State and draw what is meant by peak to peak voltage/current.			
7.108	Calculate root mean square current/voltage.			
7.109	Appreciate that main electricity is alternating current and 230V is the r.m.s voltage.			
7.110	Use an oscilloscope to measure ac and dc voltage and time intervals to obtain frequency of ac waveforms.			
7.111	Explain how a transformer works.			
7.112	Understand and use the transformer equation: $N_s/N_p = V_s/V_p$			
7.113	Calculate the efficiency of a transformer: $I_S V_S / I_P V_P$			
7.114	Explain eddy currents.			
7.115	Describe and explain the causes of inefficiencies in a transformer.			
7.116	Explain why transmission lines require high voltages.			
7.117	Calculate the power loss in transmission lines.			
7.118	***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.***			

8. Nuclear

LO	**Learning Objectives:**	**Confidence**		
8.01	Describe the Rutherford Scattering experiment.			
8.02	Explain the results of the Rutherford Scattering experiment.			
8.03	Appreciate how knowledge and understanding of the structure of the nucleus has changed over time.			
8.04	Describe the properties α, β and γ radiation.			
8.05	Explain how experiments can identify what type of radiation is being emitted.			
8.06	Explain the application of α, β and γ radiation.			
8.07	State the inverse-square law for gamma radiation.			
8.08	Describe an experiment to verify the inverse-square law.			
8.09	State what background radiation is.			
8.10	State examples of the origins of background radiation.			
8.11	Calculate experimental elimination of background radiation			
8.12	Describe the safe handling of radioactive sources.			
8.13	Appreciate the balance between risk and benefits in the uses of radiation in medicine.			
8.14	State the random nature of radioactive decay.			
8.15	Calculate the decay probability of a given nucleus using $\Delta N / \Delta t = -\lambda N$			
8.16	Calculate and understand using the decay equation: $N = N0e^{-\lambda t}$			
8.17	State what is meant by activity.			

8.18	Calculate the activity using $A = \lambda N$.			
8.19	Describe the different models with a constant decay probability.			
8.20	Calculate using molar mass or Avogadro constant.			
8.21	State what is meant by half-life.			
8.22	Calculate half-life using the equation $T_{½} = \ln 2 / \lambda$			
8.23	Determine half-life from a graphical decay curve.			
8.24	Determine half-life from a graphical log graph.			
8.25	Describe how half-life is important in applications such as radioactive waste and radioactive dating.			
8.26	Draw a graph of N against Z for stable nuclei.			
8.27	Deduce possible decay modes of unstable nuclei including α, β+, β− and electron capture.			
8.28	Represent changes radioactive decay by simple decay equations.			
8.29	Understand nuclear energy level diagrams.			
8.30	Describe what is meant by a nuclear excited state.			
8.31	State what γ ray emission is.			
8.32	Describe applications of γ ray emission, including the use of technetium-99m as a γ source in medical diagnosis.			
8.33	Estimate the radius from closest approach of alpha particles.			
8.34	Determine the radius from electron diffraction.			
8.35	State typical values for nuclear radius.			
8.36	Calculate the radius from nucleon number using $R = R_0 A^{1/3}$.			
8.37	State that this equation if derived from experimental data.			
8.38	Interpret the equation as evidence for constant density of nuclear material.			
8.39	Calculations involving nuclear density.			
8.40	Sketch a graph of intensity against angle for electron diffraction by a nucleus.			
8.41	Understand and use $E = mc^2$.			
8.42	Calculate mass difference.			
8.43	Calculate binding energy.			
8.44	State what the atomic mass unit is.			
8.45	Convert between mass difference and binding energy.			
8.46	Describe the process of fission.			
8.47	Describe the process of fusion.			
8.48	Calculate the energy released in fission and fusion reactions from the nuclear mass.			
8.49	Understand and use the graph of average binding energy per nucleon against nucleon number.			
8.50	Identify on the graph, regions where nuclei will release energy when undergoing fission/fusion.			
8.51	Appreciate that knowledge of nuclear energy allows society to use science to inform decision making.			
8.52	Describe how fission is induced.			
8.53	State what is meant by a chain reaction.			
8.54	State what is meant by critical mass.			
	Explain the functions of the following:			
8.55	• moderator			
8.56	• control rods			
8.57	• coolant			
8.58	Understand a simple mechanical model of moderation by elastic collisions.			
8.59	State and describe the factors affecting the choice of materials for the moderator, control rods and coolant.			
8.60	State examples of materials used.			

	Describe the safety aspects of the following:			
8.61	• fuel used.			
8.62	• remote handling of fuel.			
8.63	• shielding.			
8.64	• emergency shut-down.			
8.65	• production.			
8.66	• radioactive waste materials.			
8.67	Appreciate the balance between risk and benefit in the development of nuclear power.			
8.68	***Core Practical: Investigation of the inverse-square law for gamma radiation.***			