**OCR A – A2 Physics Checklist**

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| Unit |  |  |
| **Module 5: Newtonian World and Astrophysics** |
| 14 | Can you describe thermal equilibrium? |  |
|  | Can you explain the absolute scale of temperature? |  |
|  | Can you state temperature measurements in degrees Celsius and kelvin? |  |
|  | Can you calculate *T*(K) ≈ *θ*(°C) + 273? |  |
|  | Can you describe solids, liquids, and gases in terms of spacing, ordering, and motion of atoms or molecules? |  |
|  | Can you describe the simple kinetic model? |  |
|  | Can you explain Brownian motion? |  |
|  | Can you explain internal energy as the sum of kinetic and potential energies in a system? |  |
|  | Can you describe absolute zero (0 K)? |  |
|  | Can you explain increase in internal energy with temperature? |  |
|  | Can you describe changes in internal energy during changes of phase? |  |
|  | Can you explain constancy of temperature during changes of phase? |  |
|  | Can you calculate the specific heat capacity of a substance – *E* = *mc*Δ*θ*? |  |
|  | Can you describe an electrical experiment to determine the specific heat capacity of a metal or a liquid? |  |
|  | Can you calculate specific latent heat of fusion and specific latent heat of vaporisation; *E* = *mL*? |  |
|  | Can you describe an electrical experiment to determine the specific latent heat of fusion and vaporisation? |  |
| 15 | Can you understand an amount of substance, measured in moles? |  |
|  | Can you explain the Avogadro constant, *N*A? |  |
|  | Can you describe the model of the kinetic theory of gases and its assumptions? |  |
|  | Can you describe pressure in terms of the model of the kinetic theory of gases? |  |
|  | Can you calculate the equation of state of an ideal gas *pV* = *nRT*, where *n* is the number of moles? |  |
|  | Can you understand techniques and procedures used to investigate *pV* = constant (Boyle’s law) and  = constant? |  |
|  | Can you calculate an estimation of absolute zero using variation of gas temperature with pressure? |  |
|  | Can you explain the equationrelating the number of particles and the mean square speed? |  |
|  | Can you understand root mean square speed and mean square speed? |  |
|  | Can you understand the Boltzmann constant, ? |  |
|  | Can you calculate? |  |
|  | Can you describe the internal energy of an ideal gas? |  |
| 16 | Can you describe the radian as a measure of angle? |  |
|  | Can you explain the period and frequency of an object in circular motion? |  |
|  | Can you understand angular velocity *ω*, *ω* = , or *ω* = 2*πf*? |  |
|  | Can you calculate a constant net force perpendicular to the velocity of an object, which causes it to travel in a circular path? |  |
|  | Can you describe constant speed in a circle, *v* = *rω*? |  |
|  | Can you understand centripetal acceleration, *a* =  and *a* = *ω*2*r*? |  |
|  | Can you explain centripetal force,  and *F* = *mω*2*r*? |  |
|  | Can you describe techniques and procedures used to investigate circular motion? |  |
| 17 | Can you describe displacement, amplitude, period, frequency, angular frequency, and phase difference? |  |
|  | Can you calculate angular frequency *ω* = 2π/*T* or *ω* = 2π*f*? |  |
|  | Can you understand isochronous oscillators (the period of a simple harmonic oscillator is independent of its amplitude)? |  |
|  | Can you calculate simple harmonic motion, *a* = −*ω*2*x*? |  |
|  | Can you describe techniques and procedures used to determine the period and frequency of simple harmonic oscillations? |  |
|  | Can you calculate solutions to the equation *a* = −*ω*2*x*? |  |
|  | Can you calculate velocity *v* = ±*ω* , hence *v*max = *ωA*? |  |
|  | Can you explain graphical methods to relate the changes in displacement, velocity, and acceleration during simple harmonic motion? |  |
|  | Can you describe the interchange between kinetic and potential energy during simple harmonic motion? |  |
|  | Can you describe energy–displacement graphs for a simple harmonic oscillator? |  |
|  | Can you explain the effects of damping on an oscillatory system? |  |
|  | Can you define free and forced oscillations? |  |
|  | Can you explain natural frequency and resonance? |  |
|  | Can you describe observing forced and damped oscillations for a range of systems? |  |
|  | Can you describe amplitude-driving frequency graphs for forced oscillators? |  |
|  | Can you explain practical examples of forced oscillations and resonance? |  |
| 18 | Can you understand gravitational fields being due to mass? |  |
|  | Can you state the mass of a spherical object modelled as a point mass at its centre? |  |
|  | Can you describe gravitational field lines to map gravitational fields? |  |
|  | Can you calculate gravitational field strength; g = ? |  |
|  | Can you explain the concept of gravitational fields as one of a number of forms of field giving rise to a force? |  |
|  | Can you state Newton’s law of gravitation? |  |
|  | Can you calculate the equation F = − ? |  |
|  | Can you calculate gravitational field strength g = −  for a point mass? |  |
|  | Can you understand the uniformity of gravitational field strength close to the surface of the Earth and its numerical equivalence to the acceleration of free fall? |  |
|  | Can you explain Kepler’s three laws of planetary motion? |  |
|  | Can you calculate the centripetal force on a planet from the gravitational force between it and the Sun? |  |
|  | Can you calculate the equation *T*2 = *r*2? |  |
|  | Can you describe the relationship for Kepler’s third law *T*2 ∝ *r*3 applied to systems other than our Solar System? |  |
|  | Can you explain geostationary orbit and the uses of geostationary satellites? |  |
|  | Can you describe gravitational potential at a point as the work done in bringing unit mass from infinity to the point? |  |
|  | Can you calculate the expression for gravitational potential at a distance *r* from a point mass *M*? |  |
|  | Can you describe a force–distance graph for a point or spherical mass; work done as area under graph? |  |
|  | Can you describe changes in gravitational potential? |  |
|  | Can you explain escape velocity? |  |
| 19 | Can you explain the terms planets, planetary satellites, comets, solar systems, galaxies, and the Universe? |  |
|  | Can you describe the formation of a star from interstellar dust and gas in terms of gravitational collapse, fusion of hydrogen into helium, radiation, and gas pressure? |  |
|  | Can you describe the evolution of a low-mass star like our Sun into a red giant and white dwarf? |  |
|  | Can you define a planetary nebula? |  |
|  | Can you describe the characteristics of a white dwarf; electron degeneracy pressure; and the Chandrasekhar limit? |  |
|  | Can you explain the evolution of a massive star into a red supergiant and then either a neutron star or black hole; and a supernova? |  |
|  | Can you describe the characteristics of neutron stars and black holes? |  |
|  | Can you understand the Hertzsprung–Russell (HR) diagram as luminosity–temperature plot? |  |
|  | Can you explain the main sequence, red giants, red supergiants, and white dwarfs? |  |
|  | Can you calculate the energy levels of electrons in isolated gas atoms? |  |
|  | Can you explain the idea that energy levels have negative values? |  |
|  | Can you describe emission spectral lines from hot gases in terms of transition of electrons between discrete energy levels and emission of photons? |  |
|  | Can you demonstrate the equations *hf* = Δ*E* and  = Δ*E*? |  |
|  | Can you explain that different atoms have different spectral lines, which can be used to identify elements within stars? |  |
|  | Can you describe continuous spectra, emission line spectra, and absorption line spectra? |  |
|  | Can you demonstrate the use of a transmission diffraction grating to determine the wavelength of light? |  |
|  | Can you understand the condition for maxima *d* sin*θ* = *n*λ, where *d* is the grating spacing? |  |
|  | Can you demonstrate the use of Wien’s displacement law λmax ∝  to estimate the peak surface temperature of a star? |  |
|  | Can you calculate the luminosity *L* of a star using Stefan’s law *L* = 4πr2σ*T*4, where σ is the Stefan constant? |  |
|  | Can you demonstrate the use of Wien’s displacement law and Stefan’s law to estimate the radius of a star? |  |
| 20 | Can you calculate distances measured in astronomical units, light-years, and parsecs? |  |
|  | Can you define stellar parallax? |  |
|  | Can you understand the equation relating the parallax *p* in seconds of arc and the distance *d* in parsec? |  |
|  | Can you explain the Doppler effect? |  |
|  | Can you describe the Doppler shift of electromagnetic radiation? |  |
|  | Can you demonstrate the Doppler equation for a source of electromagnetic radiation moving relative to an observer, ? |  |
|  | Can you demonstrate Hubble’s law, *v* ≈ *H0d*, for receding galaxies? |  |
|  | Can you explain galactic red shift and the model of an expanding Universe? |  |
|  | Can you explain Hubble constant *H*0 in km s−1 Mpc−1 and s−1? |  |
|  | Can you explain the Big Bang theory? |  |
|  | Can you describe the experimental evidence for the Big Bang theory from microwave background radiation? |  |
|  | Can you explain the idea that the Big Bang gave rise to the expansion of space-time? |  |
|  | Can you explain the estimation of the age of the Universe? |  |
|  | Can you demonstrate that *t* ≈ *H0−*1? |  |
|  | Can you describe the evolution of the Universe after the Big Bang to the present? |  |
|  | Can you explain current ideas about the composition of the Universe in terms of dark energy, dark matter, and a small percentage of ordinary matter? |  |
| **Module 6: Particle Physics and Medical Physics** |
| 21 | Can you explain capacitance, *C* = ? |  |
|  | Can you define the unit farad? |  |
|  | Can you describe charging and discharging of capacitors in terms of the flow of electrons? |  |
|  | Can you demonstrate the total capacitance of capacitors in series, …? |  |
|  | Can you demonstrate the total capacitance of capacitors in parallel, *C* = *C*1 + *C*2 + …? |  |
|  | Can you describe an analysis of circuits containing capacitors? |  |
|  | Can you understand an investigation of circuits containing capacitors? |  |
|  | Can you understand p.d.–charge graphs for capacitors? |  |
|  | Can you describe how energy is stored by capacitors? |  |
|  | Can you demonstrate that *W* =  *QV* = *V2C*? |  |
|  | Can you describe the use of capacitors to store energy? |  |
|  | Can you describe discharging a capacitor through a resistor? |  |
|  | Can you investigate the charge and the discharge of a capacitor? |  |
|  | Can you explain the time constant *CR* of a capacitor–resistor circuit? |  |
|  | Can you demonstrate *x* = *x0* and *x* = *x0* (1 – ) for capacitor–resistor circuits? |  |
|  | Can you demonstrate the modelling of the equation  for a discharging capacitor? |  |
|  | Can you explain exponential decay and the constant-ratio property of decay graphs? |  |
| 22 | Can you explain electric fields being due to charges? |  |
|  | Can you understand a uniformly charged sphere modelled as a point charge at its centre? |  |
|  | Can you describe using electric field lines to map electric fields? |  |
|  | Can you demonstrate that electric field strength is E = ? |  |
|  | Can you demonstrate Coulomb’s law, *F* = , for the force between two point charges? |  |
|  | Can you calculate electric field strength, *E* = , for a point charge? |  |
|  | Can you describe the similarities and differences between the gravitational field of a point mass and the electric field of a point charge? |  |
|  | Can you calculate uniform electric field strength, *E* = ? |  |
|  | Can you explain parallel-plate capacitor and permittivity: *C* = , *C* = , *ε* = ? |  |
|  | Can you describe the motion of charged particles in a uniform electric field? |  |
|  | Can you describe electric potential as the work done in bringing a unit charge from infinity to a point? |  |
|  | Can you calculate electric potential, *V* = ? |  |
|  | Can you calculate capacitance, *C* = 4πε0*R*, for an isolated sphere? |  |
|  | Can you demonstrate force–distance graphs for point or spherical charges? |  |
|  | Can you calculate electric potential energy, *E* = *Vq* = ? |  |
| 23 | Can you explain moving charges or permanent magnets as causes of magnetic fields? |  |
|  | Can you demonstrate using magnetic field lines to map magnetic fields? |  |
|  | Can you describe magnetic field patterns for a long straight current-carrying conductor, a flat coil, and a long solenoid? |  |
|  | Can you define Fleming’s left-hand rule? |  |
|  | Can you calculate the force on a current-carrying conductor, *F* = *BIL* sinθ? |  |
|  | Can you describe the techniques and procedures used to determine the uniform magnetic flux density between the poles of a magnet using a current-carrying wire and digital balance? |  |
|  | Can you define magnetic flux density and the unit tesla? |  |
|  | Can you calculate the force on a charged particle travelling at right angles to a uniform magnetic field, *F* = *BQv*? |  |
|  | Can you describe the movement of charged particles in a uniform magnetic field? |  |
|  | Can you describe the movement of charged particles moving in a region occupied by both electric and magnetic fields? |  |
|  | Can you define velocity selector? |  |
|  | Can you explain magnetic flux ϕ, the unit weber and ϕ = *BAcosθ*? |  |
|  | Can you define magnetic flux linkage? |  |
|  | Can you describe Faraday’s law of electromagnetic induction? |  |
|  | Can you define Lenz’s law? |  |
|  | Can you demonstrate that e.m.f. = − rate of change of magnetic flux linkage, *ε* = − , and explain techniques and procedures used to investigate magnetic flux using search coils? |  |
|  | Can you describe a simple a.c. generator? |  |
|  | Can you describe a simple laminated, iron-cored transformer? |  |
|  | Can you explain  =  =  for an ideal transformer? |  |
|  | Can you explain the techniques and procedures used to investigate transformers? |  |
| 24 | Can you explain the alpha-particle scattering experiment? |  |
|  | Can you describe the simple nuclear model of the atom; protons, neutrons, and electrons? |  |
|  | Can you describe the relative sizes of the atom and the nucleus? |  |
|  | Can you define proton number, nucleon number and isotopes, and explain the notation for the representation of nuclei? |  |
|  | Can you explain the strong nuclear force and its short-range nature? |  |
|  | Can you calculate the radius of nuclei, *R* = ? |  |
|  | Can you calculate the mean densities of atoms and nuclei? |  |
|  | Can you define particles and antiparticles, including electron–positron, proton–antiproton, neutron–antineutron, and neutrino–antineutrino? |  |
|  | Can you describe relative masses and charges of particles and their corresponding antiparticles? |  |
|  | Can you describe the classification, examples, and behaviour of hadrons? |  |
|  | Can you describe the classification, examples, and behaviour of leptons? |  |
|  | Can you explain the simple quark model of hadrons in terms of up and down, and strange quarks and their anti-quarks? |  |
|  | Can you explain the quark model of the proton and the neutron? |  |
|  | Can you explain the charges of the up, down, strange, anti-up, anti-down, and anti-strange quarks as fractions of the elementary charge *e*? |  |
|  | Can you describe beta-minus (β−) and betaplus (β+) decay, and the quark models for these decays? |  |
|  | Can you demonstrate quark transformation equations balanced in terms of charge? |  |
|  | Can you explain decay of particles in terms of the quark model? |  |
| 25 | Can you define radioactive decay? |  |
|  | Can you describe the spontaneous and random nature of decay? |  |
|  | Can you define α-particles, β-particles and γ-rays? |  |
|  | Can you describe the nature, penetration and range of these radiations, and the techniques used to investigate their absorption? |  |
|  | Can you demonstrate the nuclear decay equations for alpha, beta-minus and beta-plus decays? |  |
|  | Can you demonstrate balancing nuclear transformation equations? |  |
|  | Can you define activity of a source? |  |
|  | Can you calculate the decay constant λ of an isotope, *A* = λ*N*? |  |
|  | Can you calculate the half-life of an isotope, = ln(2)? |  |
|  | Can you describe the techniques used to determine the half-life of an isotope? |  |
|  | Can you explain the equations *A* = *A*0*e*−λ*t* and *N* = *N*0*e*−λ*t*? |  |
|  | Can you understand a simulation of radioactive decay? |  |
|  | Can you demonstrate the graphical methods and spreadsheet modelling of the equation  = −λ*N* for radioactive decay? |  |
|  | Can you define radioactive dating, such as carbon-dating? |  |
| 26 | Can you demonstrate Einstein’s mass–energy equation, Δ*E* = Δ*mc*2? |  |
|  | Can you understand how energy is released or absorbed in simple nuclear reactions? |  |
|  | Can you describe the creation and annihilation of particle–antiparticle pairs? |  |
|  | Can you define mass defect; binding energy; and binding energy per nucleon? |  |
|  | Can you explain the binding energy per nucleon against nucleon number curve; and energy changes in reactions? |  |
|  | Can you calculate the binding energy of nuclei using Δ*E* = Δ*mc*2, and calculate the masses of nuclei? |  |
|  | Can you define induced nuclear fission and chain reaction? |  |
|  | Can you describe the basic structure of a fission reactor (components: fuel rods, control rods and moderator)? |  |
|  | Can you explain the environmental impact of nuclear waste? |  |
|  | Can you define nuclear fusion, fusion reactions and temperature? |  |
|  | Can you demonstrate balancing nuclear transformation equations? |  |
| 27 | Can you describe the basic structure of an X-ray tube (components: heater (cathode), anode, target metal and high-voltage supply)? |  |
|  | Can you describe the production of X-ray photons from an X-ray tube? |  |
|  | Can you define these X-ray attenuation mechanisms: simple scatter, photoelectric effect, Compton effect, and pair production? |  |
|  | Can you explain the attenuation of X-rays? |  |
|  | Can you demonstrate that *I* = *I*0*e*−μx? |  |
|  | Can you describe X-ray imaging with contrast media? |  |
|  | Can you describe computerised axial tomography (CAT) scanning and the necessary components? |  |
|  | Can you explain the advantages of a CAT scan over an X-ray image? |  |
|  | Can you describe the medical tracers technetium-99m and fluorine-18? |  |
|  | Can you describe the gamma camera and its components, and the formation of gamma camera images? |  |
|  | Can you explain diagnosis using the gamma camera? |  |
|  | Can you define positron emission tomography (PET)? |  |
|  | Can you explain diagnosis using PET scanning? |  |
|  | Can you explain ultrasound frequency? |  |
|  | Can you define the piezoelectric effect? |  |
|  | Can you define ultrasound transducers? |  |
|  | Can you describe ultrasound A-scans and B-scans? |  |
|  | Can you calculate the acoustic impedance of a medium, *Z* = *ρc*? |  |
|  | Can you explain the reflection of ultrasound at a boundary? |  |
|  | Can you demonstrate that ? |  |
|  | Can you describe impedance (acoustic) matching? |  |
|  | Can you explain the use of gel in ultrasound scanning? |  |
|  | Can you describe the Doppler effect in ultrasound? |  |
|  | Can you calculate the speed of blood *v* in the body: ? |  |