Revision summary

Use the following summary of syllabus dot points and key knowledge within Module 8 to ensure that you have thoroughly reviewed the content. Provide a brief definition or comment for each item to demonstrate your understanding or code them using the traffic light system – green (all good); amber (needs some review); red (priority area to review). Alternatively, write a follow-up strategy.

Origins of the elements	
Identify the Big Bang theory as an explanation for the origin and development of the Universe.	
Explain what is meant by a singularity.	
Describe in general terms how energy is transformed into particles.	
State that the amount of energy present at the Big Bang is the same as the energy in the Universe currently.	
Describe the timeline for the formation of particles after the Big Bang.	
Describe the significance of Henrietta Leavitt's discovery of Cepheid variables.	
Describe how Hubble used Cepheid variables to determine that the further away a galaxy is, the faster it is moving away from us, including: • use of the Doppler effect (red and blue shift) • wavelength of spectral lines.	
Describe the Doppler effect in terms of both light and sound.	
Explain how red and blue shifts occur.	
Explain how we use red and blue shifts to determine if stars are moving closer or further away and the speed at which they do so (translational velocity).	

››

››

Describe Hubble's law, mathematically and graphically.	
Describe how emission spectra are produced, including: • energy levels around a nucleus • electrons absorbing energy and moving to higher levels • electrons emitting specific energy photons when moving down energy levels • why specific atoms produce light of particular wavelengths only.	
Describe the production of absorption spectra.	
Compare the appearance and production of emission and absorption spectra.	
Describe the continuous spectra produced by black bodies and similar objects.	
Recall how Wien's law is used to identify the peak wavelength for a black body spectrum.	
Describe the O B A F G K M classification of stars as a measure of temperature.	
Define 'black body'.	
Explain why stars are considered black bodies.	
Explain how a star's apparent colour can be used to determine its surface temperature.	
Relate colours of stars to temperature (rank them, do not learn numbers).	

››

››

Describe key features in a star's life, including: • nebula • main sequence • post-main sequence (small, large and giant stars).	
Explain the conditions necessary for a star to be stable and become a main sequence star.	
Describe Einstein's mass–energy equivalence and explain why it does not contradict the conservation laws of mass and energy.	
Compare the processes of fission and fusion and recall use of $E = mc^2$ to solve simple problems involving energy release from nuclear reactions.	
Identify that fusion is a common process in stars that produces energy.	
Define 'nucleosynthesis'.	
Explain why nucleosynthesis in stars is possible.	
Identify that fusion reactions that synthesise elements up to iron (element 26) are self-sustaining.	
Identify that fusion reactions that synthesise elements above element 26 are not self-sustaining.	
Describe, including writing nuclear equations, the processes of energy production in main sequence stars: • the proton–proton chain • the CNO (carbon–nitrogen–oxygen) cycle.	
Compare the energy production and key features of the proton–proton chain and the CNO cycle.	
Outline the key features of the triple-alpha process.	

››

››	Identify that the post-main sequence stage of a star depends upon its mass.	
	Compare the key features of the post-main sequence life of: • smaller stars (finishing in white dwarf) • large stars (finishing in neutron star) • massive stars (finishing in black hole).	
	Describe how larger mass elements (heavier than iron) are produced during post-main sequence life events of stars.	
	Structure of the atom	
	Describe the structure and operation of a cathode ray tube including the need for low pressure and high voltage.	
	Describe and explain how cathode rays were used to observe: • travel in straight lines (Maltese cross) • fluorescence (green glow) • deflection by magnetic fields • deflection by electric fields (parallel plates) • the carry and transfer of momentum (paddle wheel) • the identical nature of rays regardless of material used for cathode.	
	Describe Thomson's plum pudding model of the atom.	
	Describe the aim, set-up and operation of Thomson's charge-to-mass experiment. • Explain how the velocity of the electrons could be measured by equating the force on the electrons due to the electric and magnetic fields. • Show that the speed of the electrons in the field is $v = \frac{E}{B}$. • Explain the shape of the cathode ray when the electric field is turned off. • Explain how to calculate the q/m ratio of the electrons, using the radius of the cathode ray arc.	››

››

Describe the significance of Thomson's charge-to-mass experiment, including: • its contribution to electron discovery • the identical nature of cathode rays • how it was used to determine the mass of electrons.	
Describe the aim, set-up and operation of Millikan's oil drop experiment.	
Show how the charge of an electron can be determined using Millikan's experiment.	
Describe the significance of Millikan's experiment: • quantisation of charge confirmed • charge on an electron determined.	
Describe the Geiger–Marsden experiment, including the: • experimental set-up • results of the experiment.	
Explain how the results of the Geiger–Marsden experiment suggest the existence of a nucleus.	
Describe Rutherford's atomic model derived from the Geiger–Marsden experiment.	
Describe how Rutherford's model improved upon previous models including that of Thomson.	
Describe limitations of Rutherford's model: • could not explain composition of nucleus • did not suggest electron arrangement • could not explain why electrons did not collapse into nucleus.	
Analyse the significance of Rutherford's model for future work by Bohr.	
Describe (briefly) how protons were discovered.	

››

›› Explain why scientists initially believed the nucleus was composed of protons and electrons.	
Describe the experiment that led to Chadwick's discovery of the neutron. • Describe and draw the experimental set-up. • Explain what particles/radiation was released at each stage of the experiment.	
Explain why it is difficult to directly measure properties of neutrons.	
Explain how conservation of momentum and energy was used to determine properties of neutrons.	
Write the nuclear equation for the reaction that occurs when alpha particles are fired at beryllium atoms.	
Quantum mechanical nature of the atom	
Recall (from section 4.2) the limitations of the Rutherford model of the atom.	
Describe generally how electrons are arranged in energy levels around the nucleus of an atom.	
Describe what happens, in terms of energy, when electrons move (both up and down) between energy levels when a photon is incident on an atom.	
Relate the movement of electrons in different energy levels to the energy of incoming photons.	
Describe Bohr's model of the atom in terms of his four postulates.	
Explain how Bohr's model was able to overcome the limitations of the Rutherford model.	

Outline limitations of the Bohr model: • Zeeman effect • inability to explain atoms other than hydrogen • hyperfine spectral lines • relative spectral line intensity • lack of explanation of quantised nature of electrons.	
Describe and compare the appearance of the emission and absorption spectra of hydrogen.	
Describe the following features of the hydrogen emission spectrum: • emission in the UV, visible and infrared wavelengths • multiple spectral series – know Lyman, Balmer, Paschen.	
Sketch a diagram to describe the formation of the Lyman, Balmer and Paschen series in terms of electron movement between energy levels.	
Solve problems involving electron movement, emission spectra and spectral series.	
Use the Rydberg equation to solve problems involving emission spectra of the hydrogen atom.	
Describe the concept of wave–particle duality.	
Describe de Broglie's theory of electron waves.	
Describe the significance of de Broglie's equation.	
Explain why only small particles have a measurable wavelength.	
Solve mathematical problems involving matter waves.	

››

Describe the role of the Davisson–Germer experiment in providing evidence for de Broglie's matter waves.	
Explain why there must be an integer number of wavelengths in the orbital circumference for electron waves to exist.	
Explain how an electron wave model progresses the model of the atom. • Explains electrons not emitting radiation (Rutherford's limitation) • Explains Bohr's third postulate • Founded quantum mechanics (linking waves and particles)	
Explain the terms 'probabilistic' and 'deterministic' in reference to subatomic particles.	
Describe the outcome of Schrödinger's use of wave mechanics to the location of electrons in an atom.	
Properties of the nucleus	
Describe the balance between the strong nuclear force and electrostatic force in the nucleus that allows for a stable nucleus to form.	
Explain, in terms of forces or other factors, why a nucleus can be unstable (radioactive).	
Sketch and annotate the curve of stability (N–Z graph).	
Explain why the ratio of neutrons to protons (n : p ratio) increases as the size of a nucleus increases.	
Define 'nucleons', 'atomic mass number' and 'atomic number'.	
Represent nuclides using the international standard notation and use to solve problems involving nuclide structure.	

››

›› Define/recall ‘binding energy’ and ‘mass defect’.	
Describe why nuclei can store energy and release energy upon decay/reaction.	
Explain the difference between isotopes of the same element.	
Identify radioactive decay (nuclear transformation/transmutation/disintegration) as a random, uncontrollable and spontaneous process.	
Identify that radioactive atoms can emit particles (alpha, beta) or electromagnetic radiation (gamma).	
Identify that neutrinos or antineutrinos can be emitted during radioactive decay.	
Describe key features of alpha and beta particles: mass and charge, symbol and notation.	
Describe the conservation of mass (nucleon number) and charge that occurs during nuclear decay and relate to writing nuclear equations.	
Write equations to represent alpha decay of a nucleus.	
Describe beta-minus and beta-plus particles (electrons and positrons).	
Write equations to represent beta decay of a nucleus – both positron and electron emission, including emission of neutrinos and antineutrinos	
Explain and compare the properties of alpha, beta and gamma radiation, including ionising ability, penetrating ability and range in air.	››

›› Identify and explain materials required to stop penetration of alpha, beta and gamma radiation.	
Describe and explain the motion of alpha, beta and gamma radiation in electric fields and magnetic fields.	
Define 'half-life' in terms of radioactive decay.	
Solve problems involving half-life using appropriate equations.	
Describe nuclear binding energy.	
Explain why and how binding energy per nucleon is used to compare stability of nuclides.	
Explain why fission occurs, in terms of binding energies.	
Describe the process of fission of a nucleus.	
Write equations to represent fission of a nucleus given appropriate data.	
Define 'chain reaction' and explain how it occurs in fission reactions.	
Compare controlled and uncontrolled fission chain reactions.	
Solve problems involving mass defect and energy release in nuclear fission examples.	
Describe the process of nuclear fusion.	››

Explain, in terms of binding energy, why fusion is favoured for elements up to iron-56, but fission is favoured for elements with nuclei larger than iron-56.	
Solve problems involving mass defect and energy release in nuclear fusion examples.	
Deep inside the atom	
Describe the evidence that protons and neutrons have internal structures and hence are not fundamental particles. • Neutron – analysis of its magnetic field and its radioactive decay • Proton – analysis of radioactive decay	
Describe what is meant by antiparticles and how they are different from their particles.	
Describe the process of annihilation of matter and antimatter.	
Solve mathematical problems involving annihilation of matter and antimatter.	
Describe the need for high-energy particles to collide and react, allowing new particles to be detected.	
Describe the operation of a linear particle accelerator, specifically the use of electric fields and alternating current.	
Describe the operation of a cyclotron, specifically use of electric and magnetic fields.	
Describe the outcome of high-energy particle collisions.	
Describe the Standard Model of matter in flowchart form, including: • matter particles (quarks – baryons and mesons/leptons) • force particles (bosons).	

››	Describe how quarks combine to form hadrons – both baryons and mesons.	
	Identify common baryons (proton, neutron) and justify their quark composition.	
	Describe the properties of leptons.	
	Identify the electron and the electron-neutrino as common leptons and state their symbols and charges.	
	Identify that quarks and leptons are categorised as 1st, 2nd and 3rd generation.	
	Describe the four bosons (force particles) and the fundamental force they are linked to.	