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| For GCSE exams 2018 onwards |  |  |  |
| **Higher Tier content in bold** |  |  |  |
| 1. ENERGY |  |  |  |
| 1.1 ENERGY CHANGES IN A SYSTEM, AND IN THE WAYS ENERGY IS STORED BEFORE AND AFTER SUCH CHANGES  *Learners should be able to:* |  |  |  |
| (a) describe all the changes involved in the way energy is stored when a system changes, for common situations: e.g. an object projected upwards or up a slope, a moving object hitting an obstacle, an object being accelerated by a constant force, a vehicle slowing down, bringing water to a boil in an electric kettle, a change of state | 8 | 8-12 | 10, 146-150 |
| (b) describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state | 10 | 13 | 12, 151 |
| (c) define the terms specific heat capacity and specific latent heat | 13, 44 | 13, 39 | 15, 46, 151, 177 |
| (d) calculate the amounts of energy associated with:  • a moving body (kinetic energy = 0.5 × mass × (velocity)2    • a stretched spring (energy transferred in stretching = 0.5 × spring constant × (extension)2    • object raised above ground level (potential energy = mass × gravitational field strength × height | 8-12 | 8-12 | 10-14, 146-150 |
| (e) calculate the change in energy involved when a system is changed by heating (in terms of temperature change, specific heat capacity    and specific latent heat | 13 | 13 | 15, 151 |
| (f) calculate the change in energy involved by work done by forces: work done = force × distance (along the line of action of the force) | 69-70 | 58 | 71-72, 196 |
| (g) calculate the change in energy involved by work done when a current flows  • energy transferred = power × time  • energy transferred = charge flow × potential difference | 36 | 30 | 38, 168 |
| (h) explain the definition of power as the rate at which energy is transferred e.g. lifting an object, calculate values for power using    and describe the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use e.g. in a kettle how the power is related to the increase in internal energy of the water | 16 | 14-5 | 18, 152-153 |
| SPECIFIED PRACTICAL WORK • SP1.1 Determination of the specific heat capacity of a material | 14 | 13 | 16, 151 |
| 1.2 CONSERVATION, DISSIPATION AND NATIONAL AND GLOBAL ENERGY SOURCES  *Learners should be able to:* |  |  |  |
| (a) describe how in all system changes, energy is dissipated, so that it is stored in less useful ways | 19 | 17 | 21, 155 |
| (b) describe where there are energy transfers in a system, that there is no net change to the total energy of a closed system e.g. mass oscillating on a spring | 17 | 16 | 19, 154 |
| (c) explain ways of reducing unwanted energy transfer e.g. through lubrication, thermal insulation; describe the effects, on the rate of cooling of a building, of thickness and thermal conductivity of its walls (qualitative only) | 19 | 17 | 21, 155 |
| (d) describe the processes of heat transfer by conduction, convection and radiation including the role of free electrons in thermal conduction in metals | 18 | 16 | 20, 154 |
| (e) calculate energy efficiency for any energy transfer using: output energy transfer    **and describe ways to increase efficiency** | 19 | 17 | 21, 155 |
| (f) describe the main energy sources available for use on Earth (e.g. fossil fuels, nuclear fuel, bio-fuel, wind, hydro-electricity, the tides and the Sun), compare the ways in which they are used and distinguish between renewable and nonrenewable sources | 21-3 | 18-9 | 23-5, 156-7 |
| (g) explain patterns and trends in the use of energy resources | 21-3 | 18-9 | 23-5, 156-7 |
| 1.3 ENERGY TRANSFERS  *Learners should be able to:* |  |  |  |
| (a) recall that, in the National Grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use, and explain how this system is an efficient way to transfer energy | 37 | 32-3 | 39, 170-1 |
| (b) describe how, in different domestic devices, energy is transferred from batteries and the a.c. mains to the energy of motors or of heating devices | 35-7 | 30 | 37-9, 168 |
| 2. PARTICLE MODEL OF MATTER  *Learners should be able to:* |  |  |  |
| (a) define density    and explain the differences in density between the three states of matter in terms of the arrangements of the atoms or molecules | 41 | 36 | 43, 174 |
| (b) describe how, when substances melt, freeze, evaporate, condense or sublimate, mass is conserved, but that these physical changes differ from chemical changes because the substance recovers its original properties if the change is reversed | 41-2 | 37, 39 | 43-4, 175, 177 |
| (c) explain how the motion of the molecules in a gas is related both to its temperature and its pressure: hence explain the relationship between the temperature of a gas and its pressure at constant volume (qualitative only) | 43-7 | 39 | 45-9, 177 |
| (d) recall that gases can be compressed or expanded by pressure changes and that the pressure produces a net force at right angles to any surface | 45-7 | 40-1 | 47-9, 178-9 |
| (e) explain how increasing the volume in which a gas is contained, at constant temperature can lead to a decrease in pressure | 45-7 | 40-1 | 47-9, 178-9 |
| (f) use and apply the relationship for gases: pressure × volume = constant (for a given mass of gas at a constant temperature) [*pV* = constant] | 46 | 40-1 | 48, 178-9 |
| **(g) explain how doing work on a gas can increase its temperature (e.g. bicycle pump)** | 47 | 40-1 | 49, 178-9 |
| SPECIFIED PRACTICAL WORK • SP2A Determination of the density of solids and liquids • SP2B Investigation of the variation of the volume of a gas with temperature | 45-7 | 36 | 47-9, 174 |
| 3. FORCES |  |  |  |
| 3.1 FORCES AND THEIR INTERACTIONS  *Learners should be able to:* |  |  |  |
| (a) recall examples of ways in which pairs of objects interact by:  • gravity  • electrostatics  • magnetism and  • contact (including normal contact force and friction)  and describe how such examples involve forces on each object using vector notation | 64 | 54-5 | 66, 192-3 |
| (b) define weight as the gravitational force acting on an object, describe how it is measured and describe the relationship between the weight of that body and the gravitational field strength  (weight = mass × gravitational field strength [*W = mg*]) | 65 | 55 | 67, 193 |
| **(c) describe examples of the forces acting on an isolated solid object or system; describe, using free body diagrams, examples where several forces lead to a resultant force on an object and the special case of balanced forces when the resultant force is zero: resolve a force into components at right angles** | 66 | 56-7 | 68, 194-5 |
| (d) explain that to stretch, bend or compress an object, more than one force has to be applied e.g. a stretched elastic band | 71 | 59-60 | 73, 197-8 |
| (e) describe the difference between elastic and inelastic distortions caused by stretching forces; calculate the work done in stretching; describe the relationship between force and extension for a spring (force = spring constant × extension [*F = k*]) and other simple systems; describe the difference between linear and non-linear relationships between force and extension, and calculate a spring constant in linear cases | 71 | 59-60 | 73, 197-8 |
| (f) use the relationship between work done, force, and distance moved (along the line of action of the force) i.e. work done = force × distance (along the line of action of the force) [*W = F*  ] and describe the energy transfer involved | 69 | 58 | 71, 196 |
| SPECIFIED PRACTICAL WORK • SP3.1 Investigation of the force-extension graph for a spring | 72 | 59-60 | 74, 197-8 |
| 3.2 PRESSURE AND PRESSURE DIFFERENCES IN FLUIDS Learners should be able to: |  |  |  |
| (a) recall that the pressure in fluids causes a force normal to any surface, and use the relationship between the force, the pressure, and the area in contact  (i.e. = force normal to a surface pressure area of that surface ) | 76-7 | 62-4 | 78-9, 200-2 |
| (b) describe a simple model of the Earth’s atmosphere and of atmospheric pressure, and explain why atmospheric pressure varies with height above the surface | 77 | 62-4 | 79, 200-2 |
| (c) explain why pressure in a liquid varies with depth and density and how this leads to an upwards force on a partially submerged object; describe the factors which influence floating and sinking | 76-7 | 62-4 | 78-79, 200-2 |
| (d) use and apply the relationship: pressure due to a column of liquid = height of column × density of liquid × gravitational field strength [*p = hρg*] | 76 | 62-4 | 78, 200-2 |
| 3.3 MOMENTS, LEVERS AND GEARS  *Learners should be able to:* |  |  |  |
| (a) describe examples in which forces cause rotation; define and calculate the moment of the force in such examples (moment = force × distance (normal to the direction of the force) [ *M = F d* ] ) | 74-5 | 61 | 76-7, 199 |
| (b) explain how levers and gears transmit the rotational effects of forces | 74-5 | 61 | 76-7, 199 |
| 4. FORCES AND MOTION |  |  |  |
| 4.1 SPEED AND VELOCITY, SPEED AS DISTANCE OVER TIME; ACCELERATION; DISTANCE-TIME AND VELOCITY-TIME GRAPHS  *Learners should be able to:* |  |  |  |
| (a) explain the vector-scalar distinction as it applies to displacement / distance and velocity / speed | 78-9 | 65-6 | 80-1, 203-4 |
| (b) recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems; recall the acceleration in free fall on Earth (10 m/s2 ) and estimate the magnitudes of everyday accelerations | 78-9 | 65-6 | 80-1, 203-4 |
| **(c) explain with examples that motion in a circular orbit involves a constant speed but changing velocity (qualitative responses only)** | 78-9 | 65-6 | 80-1, 203-4 |
| (d) recall and apply the relationships:  • distance travelled = speed × time | 82 | 65-8 | 84, 203-6 |
| (e) use motion graphs to describe and determine the speed, acceleration and distance travelled | 82-4 | 67-8 | 84-6, 205-6 |
| (f) apply the following equations to situations of uniform acceleration only • final velocity = initial velocity + acceleration × time    • distance = ½ (initial velocity + final velocity) × time    • (final velocity)2 = (initial velocity)2 + 2 × acceleration × distance    • **distance = initial velocity × time + ½ × acceleration × time2** | 80-4 | 69-70 | 82-6, 207-208 |
| 4.2 FORCES, ACCELERATIONS AND NEWTON’S LAWS OF MOTION  *Learners should be able to:* |  |  |  |
| (a) recall Newton’s First Law and apply it to explain the motion of objects moving with uniform velocity and also objects where the speed and/or direction change | 85-7 | 71-3 | 87-9, 209-211 |
| (b) recall Newton’s Second Law and apply it in calculations relating forces, masses and accelerations: resultant force = mass × acceleration [F = ma] | 85-7 | 71-3 | 87-9, 209-211 |
| **(c) explain that inertial mass is a measure of how difficult it is to change the velocity of an object and that it is defined as the ratio of force over acceleration** | 85-7 | 71-3 | 87-9, 209-211 |
| (d) recall and apply Newton’s Third Law | 85-7 | 71-3 | 87-9, 209-211 |
| **(e) define momentum (i.e. momentum = mass × velocity [ *p = mv*]), state the principle of conservation of momentum and apply it to one dimensional interactions** | 90-1 | 76-8 | 92-3, 214-6 |
| SPECIFIED PRACTICAL WORK • SP4.2 Determination of the acceleration of a moving object | 82 | 67-8 | 84, 205-6 |
| 4.3 SAFETY IN PUBLIC TRANSPORT Learners should be able to: |  |  |  |
| (a) explain methods of measuring human reaction times and its effect on thinking distances and recall values of typical reaction times | 88 | 74-5 | 90, 212-3 |
| (b) explain the factors which affect the braking distance required for road transport vehicles to come to rest in emergencies and the implications for safety | 88 | 74-5 | 90, 212-3 |
| (c) explain the dangers caused by large decelerations **and estimate the forces involved in everyday situations on a road e.g. vehicle braking to a halt** | 88 | 74-5 | 90, 212-3 |
| (d) apply the principles of forces, motion and energy to an analysis of safety features of cars e.g. air bags and crumple zones | 88 | 74-5 | 90, 212-3 |
| 5. WAVES IN MATTER |  |  |  |
| 5.1 WAVES IN AIR, FLUIDS AND SOLIDS Learners should be able to: |  |  |  |
| (a) describe wave motion in terms of amplitude, wavelength, frequency and period i.e.    define wavelength and frequency and describe and apply the relationship between these and the wave velocity (wave speed = frequency × wavelength [ *v = fλ* ] ) | 93-5 | 79 | 95-7, 217 |
| (b) describe the difference between transverse and longitudinal waves | 93-5 | 79 | 95-7, 217 |
| (c) describe how ripples on water surfaces are examples of transverse waves whilst sound waves in air are longitudinal waves; describe evidence that in both cases it is the wave and not the water or air itself that travels | 93-5 | 79 | 95-7, 217 |
| (d) recall that sound requires a medium for transmission | 98-9 | 83-4 | 100-1, 221-2 |
| SPECIFIED PRACTICAL WORK • SP5.1 Investigation of water waves | 95 | 79 | 97, 217 |
| 5.2 WAVES AT MATERIAL INTERFACES: APPLICATIONS IN EXPLORING STRUCTURES  *Learners should be able to:* |  |  |  |
| (a) describe the effects of reflection, transmission, and absorption of waves at material interfaces | 96-7 | 82 | 98-9, 220 |
| **(b) describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids, and explain why such processes only work over a limited frequency range, and the relevance of this to human audition; key structures in the human auditory system involved in these processes (i.e. outer ear, ear drum, chain of tiny bones in the middle ear (names not required), the membrane wall of cochlea, the cochlea, auditory nerve)** | 98-9 | 83-4 | 100-1, 221-2 |
| **(c) explain, in qualitative terms, how the differences in velocity, absorption and reflection of ultrasound allow it to be used for detection and exploration purposes in both bodies and in deep water** | 98-9 | 83-4 | 100-1, 221-2 |
| **(d) explain, in qualitative terms, how the differences in velocity, absorption and reflection between P and S waves in solids and liquids can be used both for detection and for the exploration of structures beneath the surface of the Earth** | 99 | 83-4 | 101, 221-2 |
| 6. LIGHT AND ELECTROMAGNETIC WAVES |  |  |  |
| 6.1 FREQUENCY RANGE OF THE SPECTRUM Learners should be able to: |  |  |  |
| (a) recall that light is an electromagnetic wave | 100-2 | 85-6 | 102-4, 223-4 |
| (b) recall that electromagnetic waves are transverse, are transmitted through space where all have the same velocity, and explain, with examples, that they transfer energy from a source to an absorber | 100-2 | 85-6 | 102-4, 223-4 |
| (c) describe the main groupings of the spectrum – radio, microwave, infra-red, visible (red to violet), ultraviolet, X-rays and gamma rays, that these range from long to short wavelengths and from low to high frequencies, and that our eyes can only detect a limited range | 100-2 | 85-6 | 102-4, 223-4 |
| 6.2 INTERACTIONS OF ELECTROMAGNETIC RADIATION WITH MATTER AND THEIR APPLICATIONS  *Learners should be able to:* |  |  |  |
| **(a) recall that radio waves can be produced by or can themselves induce oscillations in electrical circuits** | 101 | 85-6 | 103, 223-4 |
| (b) recall that the generation and absorption of radiations over a wide frequency range are associated with changes in atoms and nuclei | 52-3 | 46 | 54-5, 184 |
| (c) give examples of some practical uses of electromagnetic waves in the radio, microwave, infra-red, visible, ultraviolet, X-ray and gamma ray regions and describe how ultraviolet waves, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues | 100-2 | 85-6 | 102-4, 223-4 |
| (d) recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength; explain how some effects are related to differences in the velocity of the waves in different substances | 100-2 | 85-6 | 102-4, 223-4 |
| (e) use ray diagrams to illustrate reflection and refraction at plane surfaces | 96 | 82 | 98, 220 |
| SPECIFIED PRACTICAL WORK • SP6.2 Investigation of refraction in a glass block | 96, 100 | 82 | 98, 102, 220 |
| 6.3 LENSES  *Learners should be able to:* |  |  |  |
| (a) use ray diagrams to illustrate the effects of convex and concave lenses on light (qualitative only) | 103-5 | 87-8 | 105-7, 225-6 |
| (b) construct ray diagrams for convex and concave lenses to determine the image position, size, nature (real or virtual) and orientation, given the focal length, object distance and object size | 103-5 | 87-8 | 105-7, 225-6 |
| SPECIFIED PRACTICAL WORK • SP6.3 Investigation of the images in convex and concave lenses | 103-5 | 87-8 | 105-7, 225-6 |
| 6.4 COLOUR AND FREQUENCY; DIFFERENTIAL EFFECTS IN TRANSMISSION, ABSORPTION AND DIFFUSE REFLECTION  *Learners should be able to:* |  |  |  |
| (a) explain how colour is related to differential absorption, transmission, specular reflection and scattering e.g. how the appearance of a coloured object changes when viewed under different colour lights or viewed through colour filters | 106-7 | 89-90 | 108-9, 227-228 |
| 6.5 BLACK BODY RADIATION (QUALITATIVE ONLY)  *Learners should be able to:* |  |  |  |
| (a) explain that all bodies emit radiation and that the intensity and wavelength distribution of any emission depends on their temperatures | 108-9 | 91-3 | 110-1, 229-231 |
| (b) explain how the temperature of a body is related to the balance between incoming radiation absorbed and radiation emitted; illustrate this balance using everyday examples of the factors which determine the temperature of the earth | 108-9 | 91-3 | 110-1, 229-231 |
| 7. ELECTRICITY |  |  |  |
| 7.1 CURRENT, POTENTIAL DIFFERENCE AND RESISTANCE  *Learners should be able to:* |  |  |  |
| (a) recall that current is the rate of flow of charge, that for charge to flow, a source of potential difference and a closed circuit are needed and that a current has the same value at any point in a single closed loop | 27 | 21 | 29, 159 |
| (b) recall and use the relationship between quantity of charge, current and time (charge flow = current × time [*Q = It*]) | 27 | 21 | 29, 159 |
| (c) recall that current (*I*) depends on both resistance (*R*) and potential difference (*V*) and the units in which these are measured | 28-9 | 23-5 | 30-1, 161-3 |
| (d) recall and apply the relationship between *I*, *R* and *V*, and know that for some components the value of R remains constant but for lamps it changes as the current changes (potential difference = current × resistance [*V = IR*]) | 28-9 | 23-5 | 30-1, 161-3 |
| (e) explain how the power transfer in any circuit device is related to the p.d. across it and the current, and to the energy changes over a given time: • power = potential difference × current = (current)2 × resistance  [*P = IV = I2R*]    • energy transferred = charge flow × potential difference [ *E = Q V*] | 36 | 31 | 38, 199 |
| (f) explain the design and use of circuits to explore the variation of resistance – including for lamps, diodes, ntc thermistors and LDRs | 30-1 | 23-5 | 32-3, 161-3 |
| SPECIFIED PRACTICAL WORK • SP7.1 Investigation of the current – voltage (I-V) characteristics of a component | 31 | 23-5 | 33, 161-3 |
| 7.2 SERIES AND PARALLEL CIRCUITS Learners should be able to: |  |  |  |
| (a) describe the differences between series and parallel circuits, including the properties of currents and potential differences | 32-3 | 26 | 34-5, 164 |
| (b) explain why, if two resistors are in series the net resistance is increased, and calculate the net resistance of two resistors in series | 30-1 | 23-5 | 32-3, 161-3 |
| (c) explain why, if two resistors are in parallel the net resistance is decreased **and calculate the net resistance of two resistors in parallel** | 30-1 | 23-5 | 32-3, 161-3 |
| (d) calculate the currents, potential differences and total resistance in d.c. series circuits, and explain the design and use of such circuits for measurement and testing purposes; represent them with the conventions of positive and negative terminals, and the symbols that represent common circuit elements, including diodes, LDRs and thermistors | 28-9 | 23-5 | 30-1, 161-3 |
| SPECIFIED PRACTICAL WORK • SP7.2 Investigation of the characteristics of series and parallel circuits | 29, 33 | 26 | 31, 35, 164 |
| 7.3 STATIC ELECTRICITY – FORCES AND ELECTRIC FIELDS Learners should be able to: |  |  |  |
| (a) describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact | 38-9 | 34-5 | 40-1, 172-3 |
| (b) explain how the transfer of electrons between objects can explain the phenomena of static electricity | 38-9 | 34-5 | 40-1, 172-3 |
| (c) explain the concept of an electric field and how it helps to explain the phenomena of static electricity | 38-9 | 34-5 | 40-1, 172-3 |
| (d) describe the effect of points on a charged conductor | 38-9 | 34-5 | 40-1, 172-3 |
| 7.4 DOMESTIC USES AND SAFETY Learners should be able to: |  |  |  |
| (a) recall that the domestic supply in the UK is a.c. at 50 Hz and 230 V, explain the difference between direct and alternating voltage | 35-7 | 31 | 37-9, 169 |
| (b) recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires; hence explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and earth | 34 | 29 | 36, 167 |
| (c) explain the function of a fuse and from calculations select an appropriate rating for a particular appliance | 25, 35 | 20, 23 | 27, 37, 158, 161 |
| 8. MAGNETISM AND ELECTROMAGNETISM |  |  |  |
| 8.1 PERMANENT AND INDUCED MAGNETISM, MAGNETIC FORCES AND FIELDS  *Learners should be able to:* |  |  |  |
| (a) describe the attraction and repulsion between unlike and like poles for permanent magnets and describe the difference between permanent and induced magnets | 111-2 | 94 | 113-4, 232 |
| (b) describe the characteristics of the magnetic field of a bar magnet, showing how strength and direction change from one point to another | 111-2 | 94 | 113-4, 232 |
| (c) explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic | 112 | 94 | 113-4, 232 |
| 8.2 MAGNETIC EFFECTS OF CURRENTS AND THE MOTOR EFFECT  *Learners should be able to:* |  |  |  |
| (a) describe how to show that an electric current can create a magnetic effect and draw the magnetic fields due to currents in a straight conducting wire, a plane coil and a solenoid, including the relationship between the directions of the current and field | 113-6 | 95 | 115-8, 233 |
| (b) recall that the strength of the field depends on the current and the distance from the conductor, and explain how solenoid arrangements can enhance the magnetic effect | 113-6 | 95-6 | 115-8, 233-4 |
| **(c) describe how a magnet and a current-carrying conductor exert a force on one another and apply Fleming’s left-hand rule to the relative orientations of the force, the current in the conductor and the magnetic field** | 113-6 | 95-6 | 115-8, 233-4 |
| **(d) apply the equation that links the force on a conductor to the strength of the field, the current and the length of conductor to calculate the forces involved i.e. force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length**  **[*F = BIl*]** | 114 | 95-6 | 116, 233-4 |
| **(e) explain how this force is used to cause rotation in electric motors** | 115 | 98 | 117, 236 |
| SPECIFIED PRACTICAL WORK • SP8.2 Investigation of the force due to the magnetic field of coils | 113-6 | 98 | 115-8, 236 |
| 8.3 INDUCED POTENTIAL AND TRANSFORMERS  *Learners should be able to:* |  |  |  |
| **(a) recall that a change in the magnetic field through a coil can give rise to an induced potential difference across its ends which could drive a current, generating a magnetic field that would oppose the original change** | 117-120 | 98-9 | 119-122, 236-7 |
| **(b) explain how this effect is used in an alternator to generate a.c. and in a dynamo to generate d.c., and describe how changes to the coil, magnetic field and rate of rotation affect the output potential difference** | 117-120 | 98-9 | 119-122, 236-7 |
| **(c) explain how the effect of an alternating current in one circuit in inducing a current in another is used in transformers and how the ratio of the p.d.’s across the two depends on the ratio of the numbers of turns in each:** | 121 | 100 | 123, 238 |
| (d) use the relationship: potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil [V1I1 = V2I2] | 121 | 100 | 123, 238 |
| SPECIFIED PRACTICAL WORK • SP8.3 Investigation of the output of an iron-cored transformer | 121-3 | 100 | 123-5, 238 |
| 8.4 MICROPHONES AND SPEAKERS; OSCILLATING CURRENTS IN DETECTION AND GENERATION OF RADIATION  *Learners should be able to:* |  |  |  |
| **(a) explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits and the reverse effect as used in loudspeakers and headphones** | 120 | 100 | 122, 238 |
| 9. ATOMIC STRUCTURE |  |  |  |
| 9.1 NUCLEAR ATOM AND ISOTOPES  *Learners should be able to:* |  |  |  |
| (a) describe how the model of the atom has changed over time i.e. plum pudding and Bohr models | 51 | 45 | 53, 183 |
| (b) describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus | 49-50 | 42-4 | 51-2, 180-2 |
| (c) recall the typical size (order of magnitude) of nuclei, atoms and small molecules | 49-50 | 42-4 | 51-2, 180-2 |
| (d) recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge, but that atoms of the same element can differ in nuclear mass by having different numbers of neutrons | 49-50 | 42-4 | 51-2, 180-2 |
| (e) use atomic notation    to relate differences between isotopes of the same and different elements to their charges and masses | 49-50 | 42-4 | 51-2, 180-2 |
| 9.2 ABSORPTION AND EMISSION OF IONISING RADIATIONS AND OF ELECTRONS AND NUCLEAR PARTICLES  *Learners should be able to:* |  |  |  |
| (a) recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer electrons | 52-3 | 46 | 54-5, 184 |
| (b) recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays; relate these emissions to possible changes in the mass or the charge of the nucleus, or both | 52-3 | 46 | 54-5, 184 |
| (c) use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay | 54 | 47 | 56, 185 |
| (d) explain the concept of half-life and how this is related to the random nature of radioactive decay | 56-7 | 48 | 58-9, 186 |
| **(e) calculate the net decline in radioactive emission as a ratio by using the half-life** | 56-7 | 48 | 58-9, 186 |
| (f) recall the differences in the penetration properties of alpha particles, beta particles and gamma rays (g) recall the differences between contamination and irradiation effects and compare the hazards associated with these two effects | 53 | 46 | 55, 184 |
| 9.3 HAZARDS AND USES OF RADIOACTIVE EMISSIONS AND OF BACKGROUND RADIATION  *Learners should be able to:* |  |  |  |
| (a) explain why the hazards associated with radioactive material differ according to the half-life involved | 59-60 | 49-51 | 61-2, 187-9 |
| (b) describe the different uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted body tissue | 59-60 | 49-51 | 61-2, 187-9 |
| 9.4 NUCLEAR FISSION AND FUSION  *Learners should be able to:* |  |  |  |
| (a) recall that some nuclei are unstable and may split and relate such effects to radiation which might emerge, to transfer of energy to other particles and to the possibility of chain reactions | 61-2 | 53 | 63-4, 191 |
| (b) recall that nuclear fission reactions result in the release of energy and explain why nuclear fission reactors need to control the chain reaction (details of control mechanisms not required) | 61-2 | 53 | 63-4, 191 |
| (c) describe the process of nuclear fusion and recall that in this process some of the mass may be converted into the energy of radiation | 61-2 | 53 | 63-4, 191 |
| 10. SPACE PHYSICS |  |  |  |
| 10.1 SOLAR SYSTEM; STABILITY OF ORBITAL MOTIONS; SATELLITES  *Learners should be able to:* |  |  |  |
| (a) recall the main features of our solar system, in terms of their order, size, orbits and composition to include the Sun, terrestrial and gaseous planets, minor planets, comets and asteroids | 125-6 | 102 | 127-8, 240 |
| (b) recall the similarities and differences between planets, their moons and artificial satellites | 125-6 | 102 | 127-8, 240 |
| **(c) explain for circular orbits how the force of gravity can lead to changing velocity of an orbiting body but unchanging speed, and explain qualitatively how the orbital speed depends upon the radius of the orbit and the mass of the central object** | 125-6 | 105 | 127-8, 243 |
| (d) recall that our Sun was formed from dust and gas drawn together by gravity and explain how this caused fusion reactions, leading to equilibrium between gravitational collapse and expansion due to the fusion energy | 127 | 104 | 129, 242 |
| 10.2 RED SHIFT AS SOURCES MOVE AWAY; THE ‘BIG BANG’ AND UNIVERSAL EXPANSION  *Learners should be able to:* |  |  |  |
| (a) explain the red shift of light from galaxies which are receding (qualitative only), that the change with distance of each galaxy’s speed is evidence of an expanding universe and hence explain the link between this evidence and the Big Bang model | 128-130 | 107 | 130-2, 245 |